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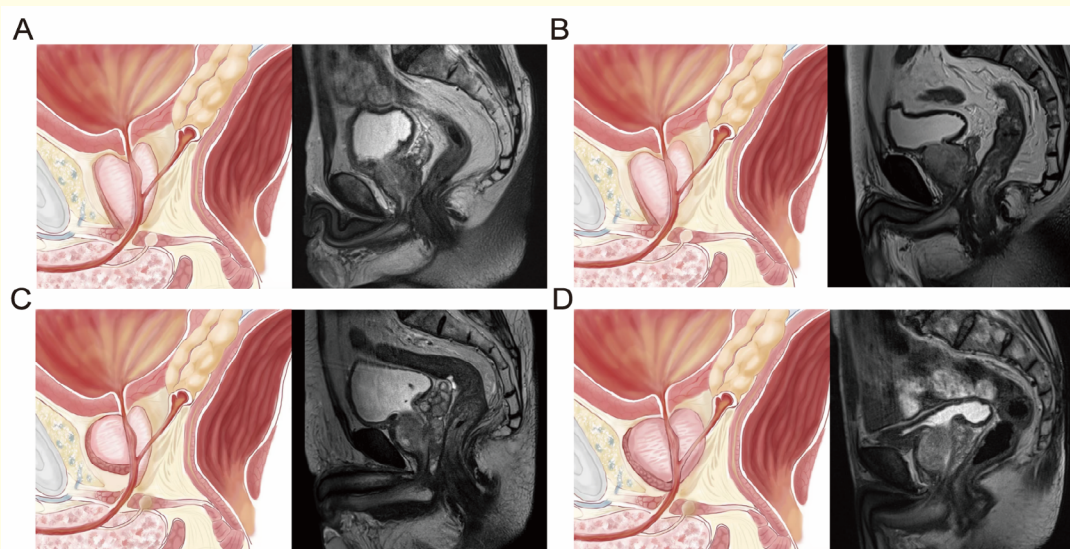


Figure 3 - A schema illustrating the four types of prostatic apex.

A) Lee-type A: the prostate apex covers the anterior and posterior parts of the membranous urethra; B) Lee-type B: the prostate apex covers the anterior part of the membranous urethra; C) Lee-type C: the prostate apex covers the posterior part of the membranous urethra; D) Lee-type D: the prostate apex does not cover the membranous urethra

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EDITORIAL IN THIS ISSUE

- e20260601** Once again, the highlight of this edition (November-December 2026) of International Brazilian Journal of Urology is robotic surgery

Luciano A. Favorito

REVIEW ARTICLE

- e20260353** Patency, Pregnancy, and Live Birth Outcomes of Microsurgical Vasovasostomy Compared with Vasoepididymostomy for Vasectomy Reversal: A Systematic Review and Meta-Analysis

Azza Fithra Alhanifa, Putu Thio Mahapradana, Putu Krisna Agastya Artawan, Made Oka Negara, Gede Wirya Kusuma Duarsa

- e20260413** Robot-Assisted Radical Cystectomy: Recommendations from Latin American Experts Consensus on Surgical Strategy, Urinary Reconstruction, and Oncological and Functional Outcomes

Eliney Ferreira Faria, Alejandro Rodriguez, Alexandre Pompeo, Arnaldo Fazoli, Carlos Vaz, Carlos Watanabe, Clovis Fraga, Daher Chade, Eder Brazão, Elias Bodden, Fernando Korkes, Flávio Cárcano, Francisco Hidelbrando Filho, Gilberto Almeida, Gustavo Guimarães, Hamilton Zampoli, Joan Palou, Jose Alexandre Pedrosa, Lucas Fornazieri, Marcelo Kerkebe, Marcio Moschovas, Marcos Tobias-Machado, Matheus Nister, Matheus Paiva, Murilo Luz, Nilo Jorge, Pablo Melo, Pedro Romanelli, Peter Wiklund, Rafael Coelho, Raphael Rocha, Rene Sotelo, Reza Mehrazin, Roberto Machado, Rodolfo Borges, Rodrigo Valente, Ronald Kool, Stenio Zequi, Sérgio Zacchi, Vipul Patel, Wenceslao Villamil, Rodrigo Gualberto

- e20269905** Influence of Epididymal Anomalies and Development of Processus Vaginalis on Testicular Migration And Cryptorchidism. A Narrative Review

Feridun C. Tanyel, Luciano A. Favorito

- e20260196** Energy sources in percutaneous surgery. Are lasers ready to become the gold standard? A narrative review

João Pedro Leal Puppim, Vinicius Ravena Lourenço, Anderson Pellanda, Alexandre Danilovic, Fabio Carvalho Vicentini, Carlos Alfredo Batagello, Fabio C.M. Torricelli, Rodrigo Perrella, Giovanni S. Marchini, William C. Nahas, Eduardo Mazzucchi

ORIGINAL ARTICLE

- e20250741** Robot-assisted Partial Nephrectomy with the new HugoRAS System: single center matched-pair analysis

Guilherme Guimarães Gonçalves, Nuno Vinagre, Martinha Magalhães, Avelino Fraga, Miguel Silva-Ramos

- e20260081** Are redo urethroplasties prone to failure? Objective success rates and patient satisfaction in recurrent urethral stricture repair

Yishai H. Rappaport, Sarit Cohen, Boris Chertin, Ofer Z. Shenfeld

- e20260218 Bladder Cancer Management in Brazil's Supplementary Health System: Real-World Practice Patterns**
Isabella Freitas Astua, Caio Vinícius Suartz, Daher C. Chade, Daniel de Freitas Gomes Soares, Augusto Modesto de Souza Neto, Roni de Carvalho Fernandes, Fernando Korkes
- e20260221 Precise Robotic Y-V Plasty for Vesico-Urethral Anastomotic Stenosis: Avoiding Urinary Incontinence**
Lin Wang, Fuhao Ji, Chao Yang, Chen Zhu, Yinglong Sa, Yidong Liu, Xiangguo Lv
- e20260376 Could the preoperative urethral curve be used to predict immediate urinary continence following Retzius-sparing robot-assisted radical prostatectomy? A retrospective multicenter study**
Bo-Han Lin, Yang Chen, Zhi-Bin Ke, Chen-Hao Wang, Ye-Hui Chen, Xiao-Li Yan, Jian-Zhou Liu, Jun-Jie Fan, Qi-Jun Xu, Shao-Bin Zhuang, Zhong-Hua Zhu, Shao-Hao Chen, Qing-Shui Zheng, Xue-Yi Xue, Jun-Long Zhuang, Yong Wei, Ning Xu

UPDATE IN UROLOGY

- e20269915 Editorial Comment: Multiparametric Magnetic Resonance Imaging and Vesical Imaging-Reporting and Data System (VI-RADS) for Bladder Cancer Diagnosis and Staging: A Guide for Clinicians from the American College of Radiology VI-RADS Steering Committee**
Luciano A. Favorito

VIDEO SECTION

- e20260335 Safety and Efficacy of the SHURUI Single-Port Robot-Assisted System via Transmesenteric Approach for Pyeloplasty in Upper Ureteral Stricture: A Single-Center Prospective Cohort Study**
Jiyu Yang, Bing Wang, Linsong Yang, Wenzhi Gao, Zihui Gao, Zhihua Li, Yaming Gu, Xuesong Li, Kunlin Yang
- e20260364 Conversion of Total Intracorporeal Ileal Conduit to Studer Orthotopic Ileal Neobladder Using the Kangduo 2000 Robotic System**
Caiyong Lai, Guohao Wu, Dongdong Fan, Wenhao Cui, Bing Wang, Rengong Liu, Honglei Liu, Yaming Gu, Zhihui Gao, Xuesong Li
- e20260541 Robotic Flexible Ureteroscopy: A Step-by-Step Guide to the ILY® Platform**
Giovanni Scala Marchini, Gabriel K. Jahchan Alvesa, Rodrigo Javier Sánchez Sepúlveda, Alexandre Danilovic, Fábio Cesar Miranda Torricelli, Fábio Carvalho Vicentini, Carlos Alfredo Batagello, Rodrigo Perrella, Pedro Antonio Araújo Simões, Alexandre Gilberto Silva, William Carlos Nahas, Eduardo Mazzucchi

LETTER TO THE EDITOR

- e20260508 Digital Rectal Examination in the Imaging Era: Not Abandoned, but Repositioned**
Anil Eker, Serdar Çelik
- e20260516 The rising cost of litigation for urological tumors in the Brazilian Public Health System: an analysis of e-NatJus technical notes (2020–2026)**
Fernando Korkes, Carlos Pedrotti, Flavio Tocci

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Once again, the highlight of this edition (November-December 2026) of International Brazilian Journal of Urology is robotic surgery

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The November-December number of International Brazilian Journal of Urology presents original contributions with a lot of interesting papers in different fields: Prostate cancer, Robotic Surgery, Kidney cancer, UPJ obstruction, Infertility, Bladder Cancer, Cryptorchidism, Endourology and Reconstructive Urology. The papers came from many different countries such as Brazil, China, Israel, Indonesia, Turkey and Portugal, and as usual the editor's comment highlights some of them. The editor in chief would like to highlight the work about Robot surgery. Robotic surgery in the last 5 years is responsible for more than 10% of submissions and 15% of accepted articles in International Brazilian Journal of Urology (1-7) and in this number more than 50% of the paper are about robotic surgery showing the importance of this technique in urology. We will comment below on a paper about radical prostatectomy that is the cover of this edition.

Dr. Lin and colleagues from China, presented in id e20260376 (8) an interesting study about the preoperative urethral curve and this use to predict immediate urinary continence (UC) following Retzius-sparing robot-assisted radical prostatectomy (RS-RARP). The authors studied 580 patients in a multicenter study and concluded that this study proposes a novel quantitative method for assessing urethral curvature and validates its reliability in predicting immediate UC recovery following RS-RARP. This method is simple, reproducible, and highly feasible for implementation in routine clinical practice. This model provides a valuable quantitative tool for preoperative risk stratification and personalized surgical planning.

The Editor-in-chief expects everyone to enjoy reading.

CONFLICT OF INTEREST

None declared.

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Patency, Pregnancy, and Live Birth Outcomes of Microsurgical Vasovasostomy Compared with Vasoepididymostomy for Vasectomy Reversal: A Systematic Review and Meta-Analysis

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ABSTRACT

Purpose: To compare patency, pregnancy, and overall live-birth outcomes after microsurgical vasovasostomy (VV) versus vasoepididymostomy (VE), and to evaluate mixed bilateral procedures as a distinct analytic category.

Materials and Methods: A systematic search of four databases was conducted. Eligible studies were observational cohorts reporting patency, pregnancy, or overall live-birth outcomes of men undergoing microsurgical VV, VE, or mixed bilateral reversal for post-vasectomy obstructive azoospermia. The quality of studies was assessed using the Newcastle-Ottawa Scale. Random-effects meta-analysis using restricted maximum likelihood was performed in R, reporting pooled odds ratios (OR) for dichotomous outcomes and mean differences (MD) for continuous outcomes, both with 95% confidence intervals (CI). Heterogeneity was quantified using I^2 . The protocol was registered in PROSPERO (CRD420261357366).

Results: Thirteen studies encompassing 6,867 patients (4,053 VV; 1,430 VE; 1,384 mixed) were included. VV was associated with significantly higher patency than VE (OR 6.98, 95% CI 4.23 to 11.50; $I^2=52.6\%$), higher natural pregnancy odds (OR 2.01, 95% CI 1.38 to 2.91), higher overall live-birth odds (OR 2.79, 95% CI 1.67 to 4.67), and earlier sperm return (MD -1.95 months). Mixed procedures yielded intermediate patency. Findings were robust across all sensitivity analyses; small-study effects could not be fully excluded given the limited number of studies contributing to some outcomes.

Conclusions: VV is associated with higher patency, pregnancy, and overall live-birth rates than VE, reflecting more favorable anatomical conditions. Mixed bilateral procedures yield intermediate outcomes from asymmetric anatomy. These findings support VV and VE as complementary techniques selected according to intraoperative vasal fluid findings.

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INTRODUCTION

Vasectomy is the most common sterilization procedure worldwide, and approximately 6% of patients later seek reversal because of remarriage, desire for more children, or post-vasectomy pain (1). Microsurgical vasovasostomy (VV) remains the leading technique for reversing vasectomy-induced obstruction, restoring fertility directly and costing less than sperm retrieval with intracytoplasmic sperm injection (ICSI) (2, 3).

The two main techniques are VV, which directly reconnects the severed vas deferens, and vasoepididymostomy (VE), which bypasses secondary epididymal obstruction by connecting the vas to an epididymal tubule (4). Vasal fluid quality guides intraoperative selection; abundant sperm-containing fluid favors VV, whereas thick, sperm-free fluid requires VE (5, 6). Frequently, asymmetrical intraoperative findings require a mixed bilateral reconstruction, defined as unilateral VE performed concurrently with contralateral VV.

Separate meta-analyses have reported patency rates for VV and VE (7, 8). Pregnancy outcomes vary with obstructive interval, female partner age, and unilateral reconstruction (6). Other studies have assessed sperm return and postoperative failure for each procedure separately (9). However, no previous meta-analysis has synthesized the comparative patency of VV and VE within the same cohorts, nor has any evaluated the effect of using both procedures bilaterally as a distinct analysis group.

This systematic review and meta-analysis compared microsurgical VV and VE in terms of five clinical parameters: overall patency rates, natural pregnancy rates, overall live-birth rates, time to patency, and late failure in patients who underwent vasectomy reversal (VR) for post-vasectomy obstructive azoospermia. We also evaluated mixed bilateral surgical technique as a distinct analysis group.

MATERIALS AND METHODS

Search Strategy

The present systematic review and meta-analysis were conducted according to the Preferred Report-

ing Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 checklist (10). Databases including PubMed, Scopus, Europe PMC, and Epistemonikos were accessed from their inception until 31 March 2026 without language limitations. Search strategy was performed based on the Population, Intervention, Comparison, Outcomes, and Study design (PICOS) principle, using controlled vocabulary terms and free text key words for VR, such as vasovasostomy, vasoepididymostomy, and related synonyms (e.g., "vas deferens reversal," "epididymovasostomy"). We applied Boolean operators (AND, OR) to link search terms systematically across all databases. All the exact Boolean search strings used are available in Supplementary Material. Unpublished or grey literature was sought through registries and conference proceedings. Additionally, studies were manually screened to identify additional eligible studies.

Eligibility Criteria

Eligibility criteria followed the PICOS methodology. We included adult males undergoing microsurgical VR for obstructive azoospermia secondary to vasectomy. The comparison was microsurgical VV versus VE, whether unilateral, bilateral, or mixed combination technique. The primary outcome of interest was the overall patency rate. For the purposes of this review, anatomical patency was defined as the presence of any spermatozoa, whether motile or immotile, in the ejaculate following surgery. Functional patency was defined on the basis of motile spermatozoa or specified motile sperm concentrations, according to the thresholds reported or prespecified by the original study authors. Secondary outcomes included natural pregnancy rate, overall live birth rate, time to patency, and late failure after initial sperm return. Eligible designs were randomized controlled trials and cohorts.

We excluded studies of non-vasectomy obstruction without stratified data and non-comparative reports, including case reports and case series. We also excluded reviews, editorials, abstracts, animal studies, and reports without accessible full text. Duplicate records were removed before screening. Two reviewers (IPTM and IPKAA) conducted the screening independently.

Data Extraction

Two reviewers (IPTM and IPKAA) independently extracted data using a structured form; disagreements were resolved by consensus with AFA, IMON, and/or GWKD. Extracted variables included publication year, country, study design, sample size, procedure types (VV/VE), surgical techniques, vasal fluid quality, female partner age, follow-up duration, previous reversal failures, patency definitions, selection criteria, pregnancy type (ART/natural), patent-only denominators, and clinical outcomes.

Quality Assessment

Methodological quality of included non-randomized studies was evaluated using the Newcastle-Ottawa Scale (NOS). The studies were later classified into good, fair, or poor quality based on the criteria established by the Agency for Healthcare Research and Quality (AHRQ). Two reviewers (IMON and GWKD) independently rated each study; disagreements were resolved by a third reviewer (AFA).

Statistical Analyses

All analyses were performed in R, with statistical significance set at $p < 0.05$. Pooled estimates used random-effects models with restricted maximum likelihood. Categorical data were presented as pooled unadjusted odds ratios (OR), whereas continuous data were presented as pooled mean differences (MD), both with 95% confidence intervals (CI). Although several primary studies reported multivariable analyses using heterogeneous covariate sets, adjusted estimates were not consistently available for the VV-versus-VE comparison and could not be harmonized; therefore, an adjusted-estimate-only sensitivity analysis was not feasible. Aggregated crude event proportions across contributing studies were also calculated by summing events and denominators per group. Heterogeneity was assessed with I^2 and classified as low (0-25%), moderate (26-50%), substantial (51-75%), or considerable (>75%). Pregnancy and overall live birth outcomes were analyzed across patients with available reproductive follow-up and, as a post hoc exploratory analysis, restricted to patent cases;

natural pregnancy rates were analyzed separately from ART-inclusive rates, with the ART-inclusive analysis also considered post hoc, as it was not prespecified in the study protocol. Subgroup analyses examined differences by surgery type, patency definition, VE technique, and intraoperative selection criteria. Exploratory post-hoc meta-regression assessed the influence of female partner age, follow-up duration, and prior failed reversal proportion. Sensitivity analyses excluded high-risk-of-bias studies, applied leave-one-out analysis, and removed the largest cohorts. Publication bias was assessed using Egger's test. Certainty of evidence for each outcome was assessed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) framework.

Ethical Approval and Registration

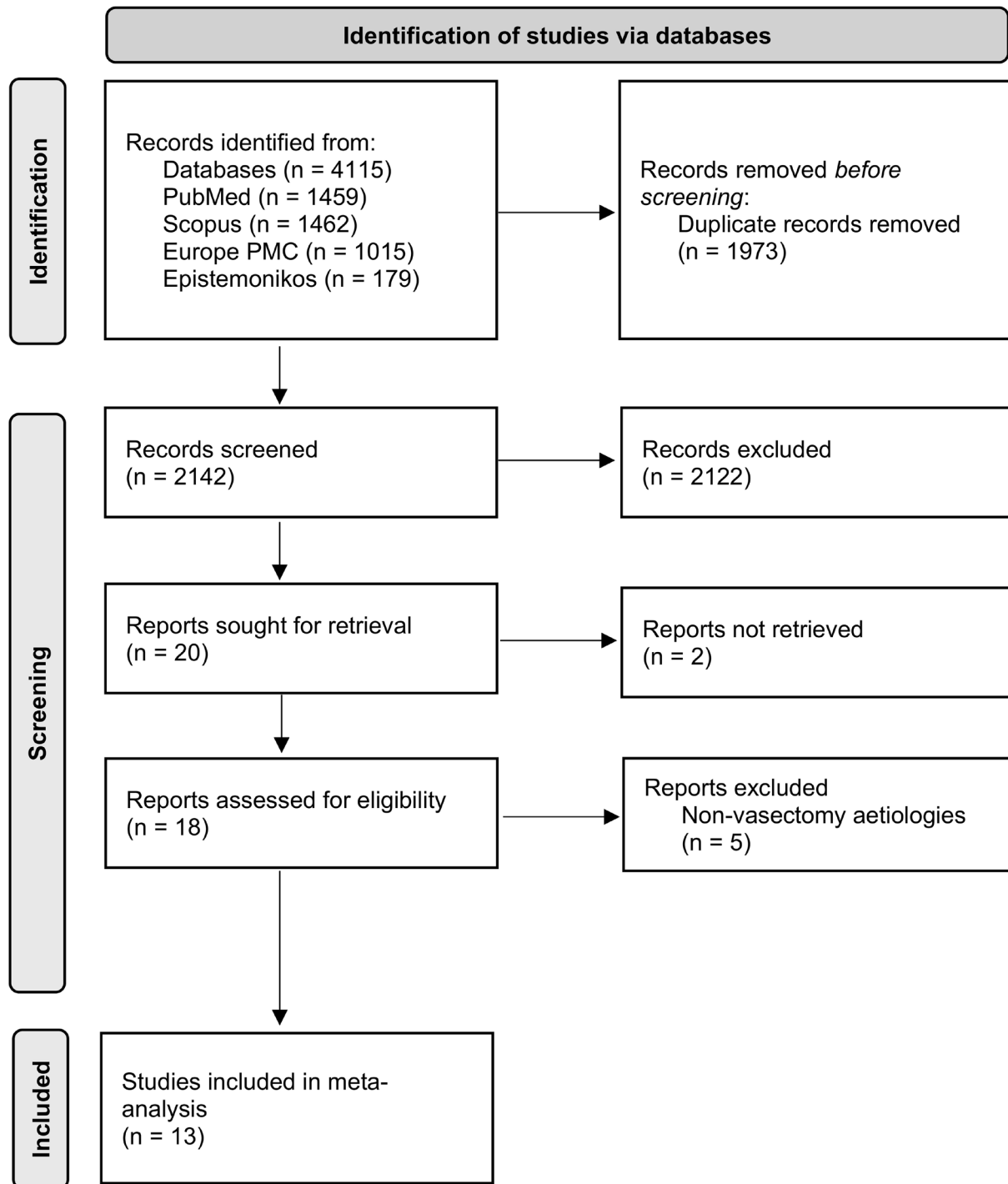
In line with The Council for International Organizations of Medical Sciences (CIOMS) Guideline 23, studies using publicly available data are exempt from ethics review (11). The protocol was prospectively registered in PROSPERO (CRD420261357366).

RESULTS

Study Selection and Characteristics

A systematic search of four databases identified 4,115 records, of which 2,142 unique records underwent title and abstract screening after duplicate removal (Figure-1). Of 2,142 screened records, 2,122 were excluded. Twenty full texts were sought; two were unavailable and five were excluded for non-vasectomy obstruction, leaving 13 studies (6, 12-23). All were observational (twelve retrospective cohorts, one multicenter prospective cohort), encompassing 6,867 patients: 4,053 VV, 1,430 VE, and 1,384 mixed bilateral procedures. Mean male age ranged from 37 to 47 years, female partner age from 29 to 34 years, and obstructive interval from 7.0 to 18.0 years. All procedures used microsurgery. VV techniques included two-layer, modified one-layer, multilayer, and microdot approaches; VE techniques included end-to-side, end-to-end, intussusception, and combined approaches. One study exclusively enrolled repeat-reversal patients (Table-1).

Figure 1 - PRISMA Flow Diagram.



Overview of the literature search, study screening, and selection process for the systematic review and meta-analysis.

Table 1 - Baseline characteristics of included studies.

Study	Country	Study Design	Total N	VV, n	VE, n	Mixed, n	Mean Male Age, y	Mean Female Partner Age, y	Mean OI, y	VV Anastomosis Technique	VE Anastomosis Technique	Previous Failed Reversal %
Alhamam et al., 2024 (19)	Canada	Retrospective cohort	136	101	12	23	41.0 ± 6.2	34.0 ± 4.6	8.0 ± 5.5	Microdot 2-layer	Longitudinal intussusception (LIVE)	NR
Belker et al., 1991 (6)	USA	Multicenter prospective cohort	1,158	1,061	38	59	36.9 (range 20.3–67.4)	29.6 (range 17.0–46.0)	7.0 (range <1.0–33.0)	2-layer or modified 1-layer	End-to-end or end-to-side	15.1%
Boorjian et al., 2004 (21)	USA	Retrospective cohort	213	159	36	18	NR	NR	NR	Multilayer	Multilayer	0%
Fuchs and Burt, 2002 (15)	USA	Retrospective cohort	116	44	42	30	46.6†	34.3	18.0	2-layer	End-to-side	NR
Hertz et al., 2021 (18)	USA	Retrospective cohort	423	385	16	22	36.6 (range 23–76)	31.0 (range 19–46)	7.9 (range 0–34)	Modified 2-layer	End-to-side intussusception	6.5%
Magheli et al., 2010 (22)	Germany	Retrospective cohort	312	242	24	46	41.1 ± 6.7	31.6 ± 5.1	NR	Multilayer	NR	NR
Maloney et al., 2026 (16)	USA	Retrospective cohort	326	248	33	45	38.4 ± 5.8 (VV); 40.0 ± 6.2 (Mixed); 40.4 ± 7.4 (VE)	NR	7.8 ± 4.5 (VV); 10.9 ± 4.5 (Mixed); 12.4 ± 5.6 (VE)	2-layer	Intussusception	9.0%
Matthews et al., 1995 (12)	USA	Retrospective cohort	200	100	100	0	NR	NR	NR	Multilayer	End-to-end (n=85); end-to-side (n=15)	NR
Matthews et al., 1997‡ (13)	USA	Retrospective cohort	64	28	27	9	NR	NR	NR§	Multilayer	End-to-side or end-to-end	100%
Schrepferman et al., 2001 (23)	USA	Retrospective cohort	84	46	18	20	NR	NR	NR	2-layer	End-to-side	NR
Schwarzer et al., 2004(14)	Germany	Retrospective cohort	307	192	48	67	42.0 (range 24–67)	NR	8.0 (range 0–27)	3-layer, end-to-end	End-to-side, 2–3-layer	12.0%
Silber & Grotjan, 2004 (20)	USA	Retrospective cohort	3,378	1,357	1,013	1,008	40.0 ± 7.1	31.0 ± 5.0	10.0 ± 5.4	2-layer	End-to-end or end-to-side	22.3%
Yang et al., 2007 (17)	USA	Retrospective cohort	150	90	23	37	42.9 (range 27–61)	NR	11.1 (range 1–29)	2-layer	4 or 6-point invagination	NR

VV = vasovasostomy; VE = vasoepididymostomy; Mixed = bilateral procedure with VV on one side and VE on the other; OI = obstructive interval (time since vasectomy); NR = not reported; y = years; n = number.

† Median value reported.

‡ Repeat reversal cohort (all patients had prior failed vasectomy reversal).

§ Interval from vasectomy to initial reversal: 10.7 ± 5.2 years (complete failures), 8.7 ± 5.5 years (late failures).

All procedures were performed using microsurgical techniques. Data are presented as mean ± SD, mean (range), or n/N (%) where available

Quality Assessment

Nine studies were rated good quality and four poor quality (Table-2). Poor ratings reflected unadjusted baseline differences in comparability domains. Good quality studies included five that utilized multivariable regressions and four using stratified bivariate analyses based on obstruction periods. Regardless of quality, the major limitation in all studies was insufficient patient follow-up in pregnancy outcomes, even among the two largest samples, which lost more than 20% of patients for fertility analysis.

1004/1330) (OR 3.52, 95% CI 2.78 to 4.45; $P < 0.0001$; $I^2 = 0.0\%$) (Figure-2C). In two studies, sperm returned earlier after VV (MD -1.95 months; 95% CI -2.59 to -1.31; $P < 0.0001$; $I^2 = 0.0\%$).

Pregnancy Rate and Overall Live Birth

Substantial loss to follow-up was noted for reproductive outcomes. Natural pregnancy occurred in 69.0% (1636/2372) of VV cases and 65.5% (461/704) of VE cases among patients with available reproductive follow-up. A detailed breakdown of patient attrition from

Table 2 - Newcastle-Ottawa scale quality assessment of studies.

Study	Selection	Comparability	Outcome	Quality	AHRQ classification
Alhamam et al., 2024 (19)	2	0	3	5	Poor quality
Belker et al., 1991 (6)	3	1	2	6	Good quality
Boorjian et al., 2004 (21)	4	2	2	8	Good quality
Hertz et al., 2021 (18)	4	2	3	9	Good quality
Magheli et al., 2010 (22)	3	2	2	7	Good quality
Fuchs & Burt, 2002 (15)	2	0	3	5	Poor quality
Maloney et al., 2026 (16)	3	2	2	7	Good quality
Matthews et al., 1995 (12)	4	1	2	7	Good quality
Matthews et al., 1997 (13)	4	1	3	8	Good quality
Schrepferman et al., 2001 (23)	2	0	3	5	Poor quality
Schwarzer et al., 2004 (14)	3	1	1	5	Poor quality
Silber & Grotjan, 2004 (20)	4	1	2	7	Good quality
Yang et al., 2007 (17)	4	1	2	7	Good quality

Agency for Healthcare Research and Quality.

Overall Patency Rate

Aggregated event proportions for clinical outcomes are summarized in Table-3. The overall patency rate was significantly higher following VV (91.6%, 3714/4053) compared to VE (74.7%, 1069/1430) (OR 6.98, 95% CI 4.23 to 11.50; $P < 0.0001$; $I^2 = 52.6\%$) (Figure-2A). The advantage of VV over mixed procedures was smaller, yet it remained significant (OR 2.02, 95% CI 1.29 to 3.17; $P = 0.0022$; $I^2 = 49.4\%$) (Figure-2B). At the same time, mixed procedures (91.1%, 1261/1384) resulted in significantly higher patency than VE alone (75.5%,

initial surgery to final reproductive follow-up is provided in Supplementary Table-1, 2, and 3. The pooled odds of natural pregnancy were higher after VV compared to VE (OR 2.01, 95% CI 1.38 to 2.91; $P = 0.0002$; $I^2 = 38.7\%$) (Figure-3A). Including pregnancies achieved through assisted reproductive technology (ART) similarly showed higher pooled odds in favor of VV (74.9%, 1225/1635) compared to VE (67.2%, 420/625) (OR 2.92, 95% CI 1.77 to 4.82; $P < 0.0001$; $I^2 = 51.6\%$). Overall live-birth data (including both natural and ART-assisted conceptions) were available from only three studies.

Table 3 - Summary of aggregated event proportions by surgical technique.

Clinical Outcome	Vasovasostomy (VV)	Vasoepididymostomy (VE)	Mixed Bilateral (VV/VE)
Overall Patency Rate	91.6% (3714/4053)	74.7% (1069/1430)	91.1% (1261/1384)
Natural Pregnancy Rate†	69.0% (1636/2372)	65.5% (461/704)	—
Natural Pregnancy Rate (Patent-Only)	64.8% (476/734)	54.1% (98/181)	—
ART-Inclusive Pregnancy Rate†*	74.9% (1225/1635)	67.2% (420/625)	—
ART-Inclusive Pregnancy Rate (Patent-Only)*	86.9% (835/960)	81.0% (350/432)	—
Overall Live Birth Rate†	78.4% (551/703)	58.2% (258/443)	—
Overall Live Birth Rate (Patent-Only)	78.7% (483/614)	69.4% (218/314)	—

VV = vasovasostomy; VE = vasoepididymostomy; Mixed = bilateral procedure with VV on one side and VE on the other.

*Overall pregnancy includes pregnancies achieved via natural conception and Assisted Reproductive Technology (ART).

† All patients with available reproductive follow-up.

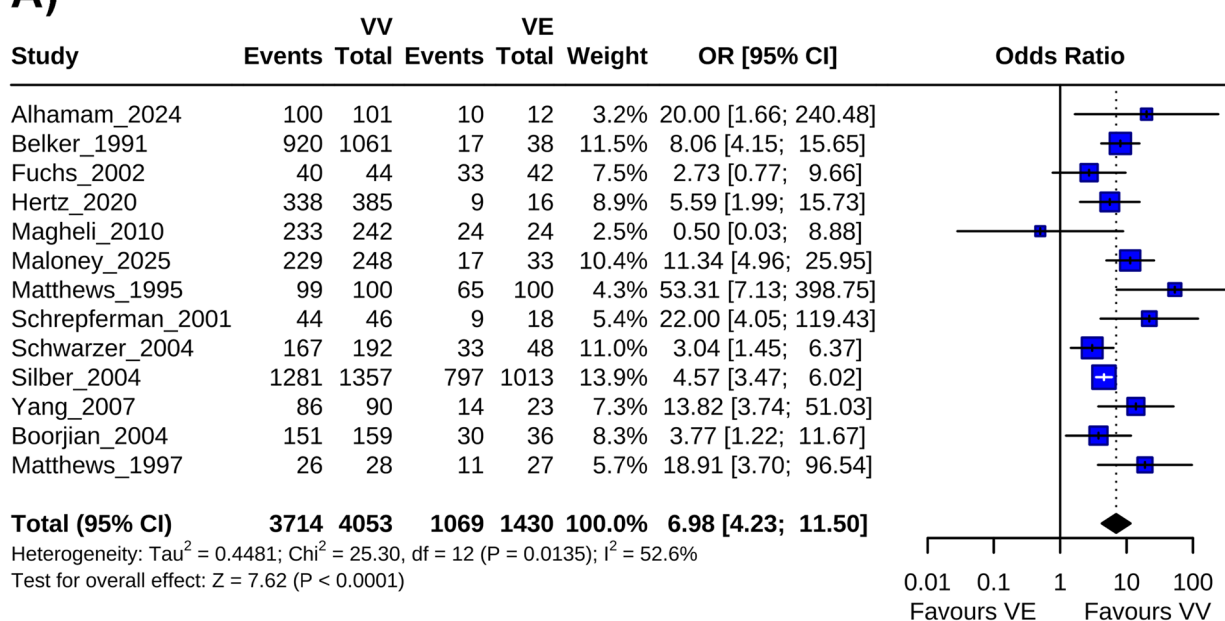
Figure 2A - Forest plots of overall patency rates.**A)**

Figure 2B - Forest plots of overall patency rates.

B)

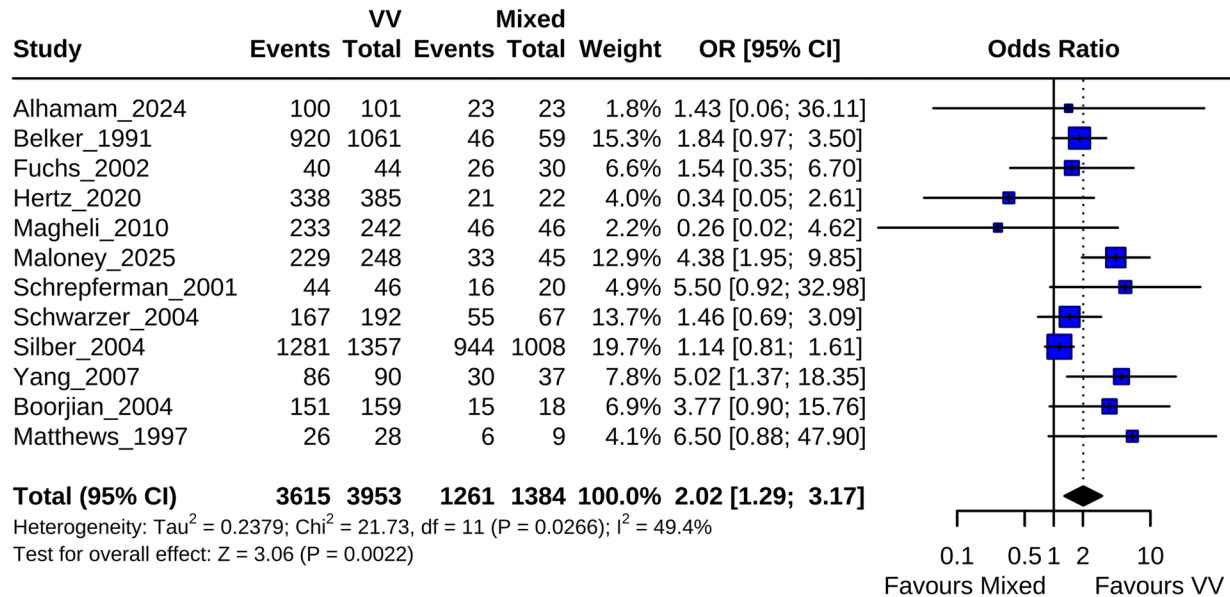
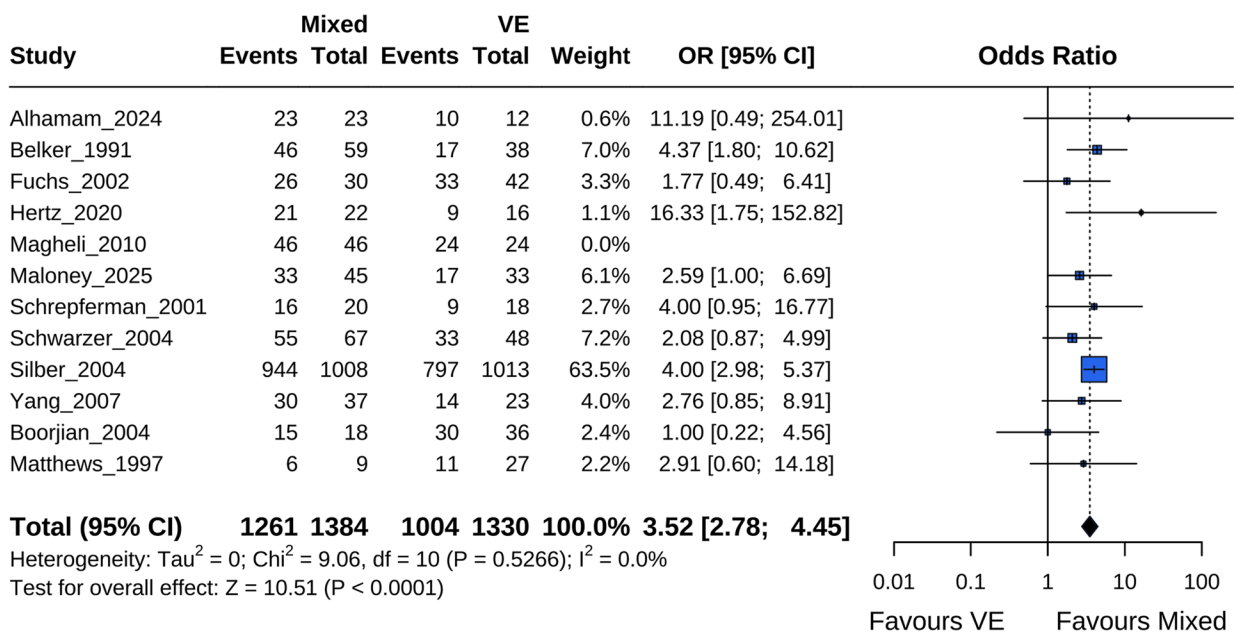


Figure 2C - Forest plots of overall patency rates.

C)



Comparison of postoperative patency outcomes across surgical techniques. A) Microsurgical vasovasostomy (VV) versus vasoepididymostomy (VE). B) Isolated VV versus mixed bilateral procedures. C) Isolated mixed bilateral procedures versus VE.

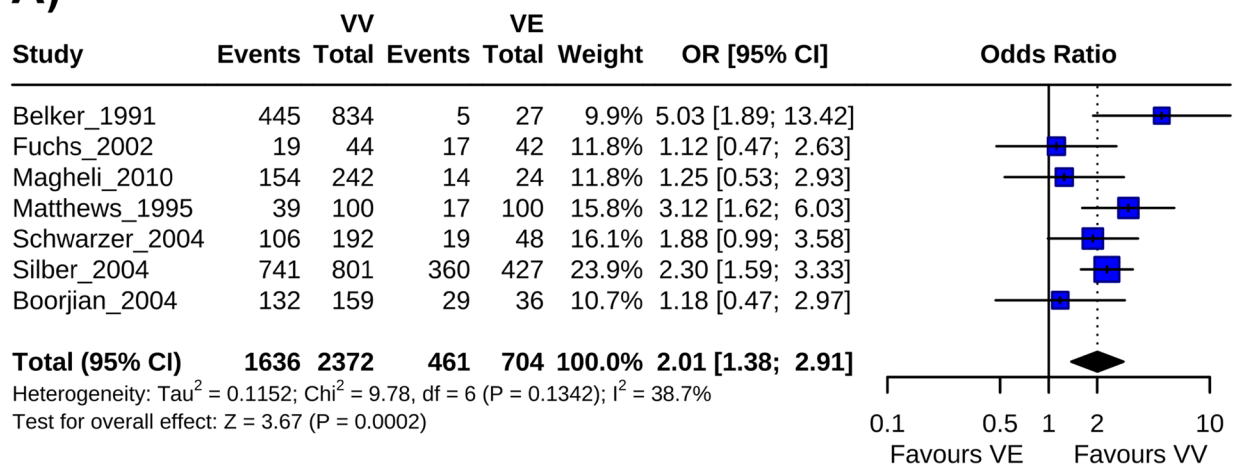
Each of these studies defined this outcome simply as a pregnancy leading to a live birth or the delivery of a baby, confirming that comparable clinical endpoints were pooled. Results favored VV (78.4%, 551/703) over VE (58.2%, 258/443) (OR 2.79, 95% CI 1.67 to 4.67; $P < 0.0001$; $I^2 = 59.0\%$) (Figure-3B). Pooling late failure data (15.1%, 19/126 for VV vs. 16.5%, 13/79 for VE) resulted in a non-significant estimate with massive heterogeneity (OR 1.30, 95% CI 0.17 to 9.84; $P = 0.80$; $I^2 = 78.3\%$).

In a post hoc analysis restricted to patent-only patients, the differences in reproductive outcomes

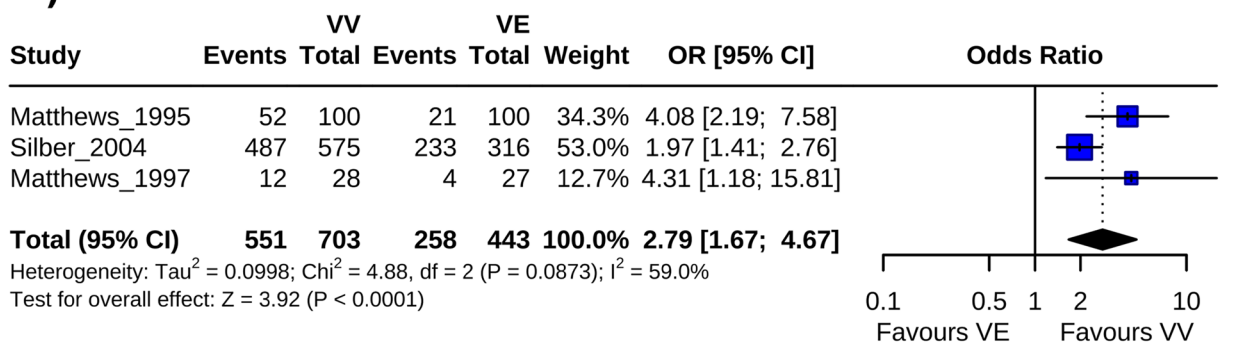
between VV and VE were attenuated. After excluding non-patent patients, natural pregnancy (64.8%, 476/734 for VV vs. 54.1%, 98/181 for VE; OR 1.24, 95% CI 0.76 to 2.03; $I^2 = 15.5\%$) and ART-inclusive pregnancy (86.9%, 835/960 for VV vs. 81.0%, 350/432 for VE; OR 1.52, 95% CI 0.80 to 2.89; $P = 0.201$; $I^2 = 26.4\%$) were not significantly different between VV and VE groups. Thus, the reproductive difference associated with VV appears largely explained by greater patency; among men who achieve patency, couple-level factors may predominate. Overall live birth, however, remained higher after VV

Figure 3 - Forest plots of reproductive outcomes.

A)



B)



Comparison of reproductive success between patients undergoing microsurgical vasovasostomy (VV) versus vasoepididymostomy (VE).
 A) Natural pregnancy rates. B) Overall live birth rates (natural and ART-assisted conceptions combined).

among patent patients (78.7%, 483/614 vs. 69.4%, 218/314; OR 1.73, 95% CI 1.25 to 2.41; $P = 0.001$; $I^2 = 0.0\%$).

Subgroup, Meta-Regression, and Sensitivity Analyses

Stratification by VE technique showed that both intussusception (91.4%, 753/824 for VV vs. 59.5%, 50/84 for VE; OR 9.82, 95% CI 5.59 to 17.26; $I^2 = 0\%$) and traditional approaches (91.3%, 2684/2941 for VV vs. 75.6%, 986/1304 for VE; OR 5.92, 95% CI 3.04 to 11.54; $I^2 = 54.1\%$) significantly favored VV (Figure-4A). There was no between-subgroup difference ($P = 0.26$). Heterogeneity was absent in the intussusception subgroup and substantial among traditional technique studies. Subgroup analyses based on intraoperative criteria further demonstrated that VV consistently achieved higher patency compared with VE across varying sperm quality and fluid conditions (Figure-4B). In cases where intact sperm were present and selection was fluid-dependent, VV showed a pooled OR of 7.55 (95% CI 4.13 to 13.78; $I^2 = 60.1\%$) with a patency rate of 94.4% (1696/1796) compared to 77.5% (838/1081) for VE. Liberal VV selection and strict azoospermia subgroups also demonstrated higher patency for VV (86.7%, 920/1061 and 93.7%, 760/811, respectively) over VE (44.7%, 17/38 and 69.5%, 205/295, respectively), with ORs of 8.06 (95% CI 4.15 to 15.65; I^2 not applicable for a single study) and 6.36 (95% CI 2.24 to 18.08; $I^2 = 62.8\%$), respectively. Stratification by patency definition showed no significant subgroup difference between anatomical (92.2%, 3013/3268 for VV vs. 76.4%, 960/1256 for VE; OR 7.27; $I^2 = 59.9\%$) and functional patency (90.1%, 534/593 for VV vs. 60.3%, 76/126 for VE; OR 8.56; $I^2 = 37.1\%$; $P = 0.77$) (Figure-4C).

Exploratory post-hoc meta-regression suggested that longer follow-up duration was associated with attenuation of the advantage of VV over VE for natural pregnancy (coefficient = -0.085, $P = 0.014$), supporting the view that pregnancy outcomes are time dependent. In contrast, follow-up duration was not a significant moderator for overall live birth or patency outcomes. Mean female partner age correlated negatively with natural pregnancy (coefficient = -0.283, $P = 0.026$). The proportion of prior failed reversals did not moderate patency or pregnancy outcomes in any comparison. Despite a clinically plausible positive coefficient, mod-

erate-to-high residual heterogeneity suggests that vasal fluid quality, technique, and surgeon expertise may be more influential.

Leave-one-out analysis for the primary comparison of VV versus VE overall patency yielded OR estimates ranging from 6.25 to 7.70 (all $P < 0.0001$). Excluding the two largest cohorts (OR 7.52, 95% CI 3.97 to 14.23; $I^2 = 53.6\%$) or restricting the analysis to higher-quality studies (OR 7.65, 95% CI 4.24 to 13.79; $I^2 = 55.6\%$) did not change the direction or magnitude of the effect favoring VV over VE for patency outcomes.

Publication Bias

Egger's test did not show funnel plot asymmetry for the main pairwise patency comparisons; VV vs VE ($P = 0.15$) supported by all 13 studies, and VV vs mixed ($P = 0.26$) and VE vs mixed ($P = 0.46$), each supported by 12 studies. However, formal assessment of small-study effects was underpowered for the reproductive outcomes, because fewer than ten studies contributed to natural pregnancy (7 studies) and overall live birth (3 studies); therefore, publication bias could not be reliably excluded for these outcomes.

Evidence Certainty

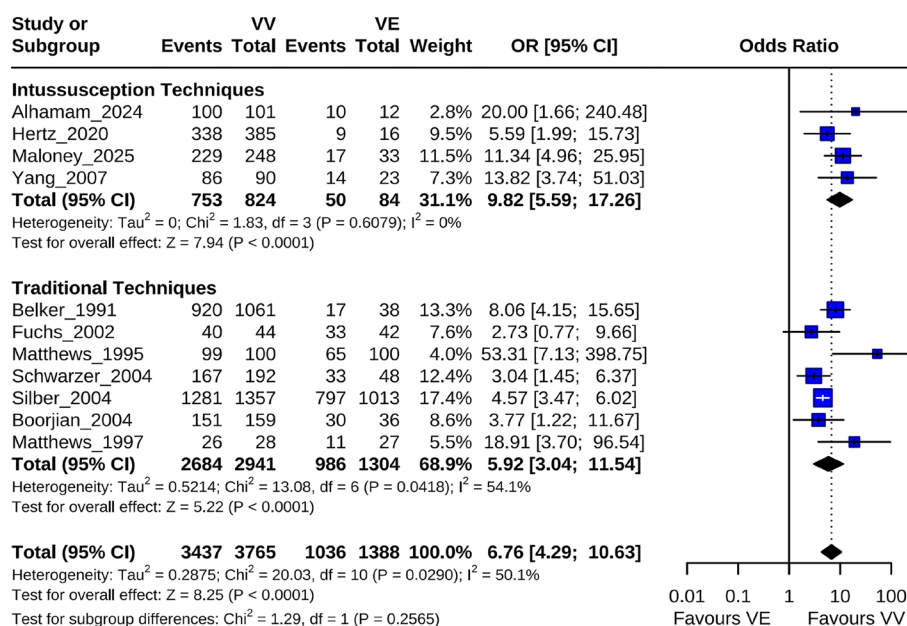
Certainty of evidence was very low for all five outcomes (overall patency, natural pregnancy, overall live birth, time to patency, and late failure), representing the observational, non-randomized design of all included studies; substantial confounding by indication inherent to intraoperative technique selection; and, for the reproductive outcomes, considerable missing outcome data. The Summary of Findings table (Table-4) presents relative and absolute effects with certainty ratings and supporting footnotes for each outcome.

DISCUSSION

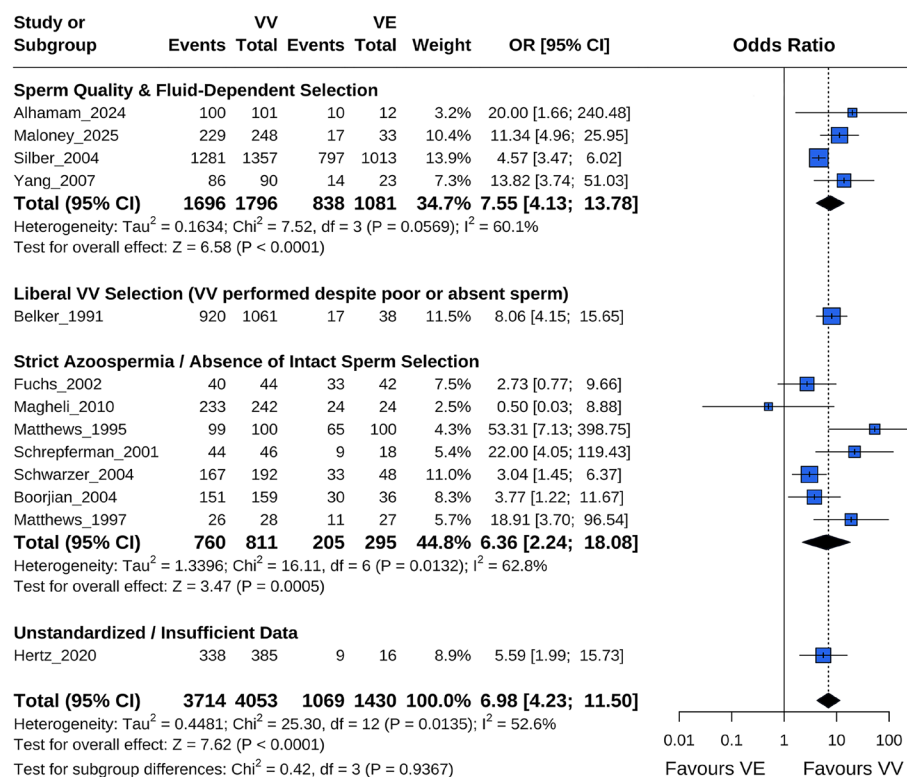
This current meta-analysis of 13 observational studies and 6,867 patients showed higher overall patency rates for VV compared with VE for VR (OR 6.98; 95% CI 4.23 to 11.50). VV patency in our analysis (91.6%) was comparable to pooled estimates of 87.5% for microsurgical VV and 94.4% for robot-assisted VV reported

Figure 4 - Forest plots of subgroup analyses for overall patency.

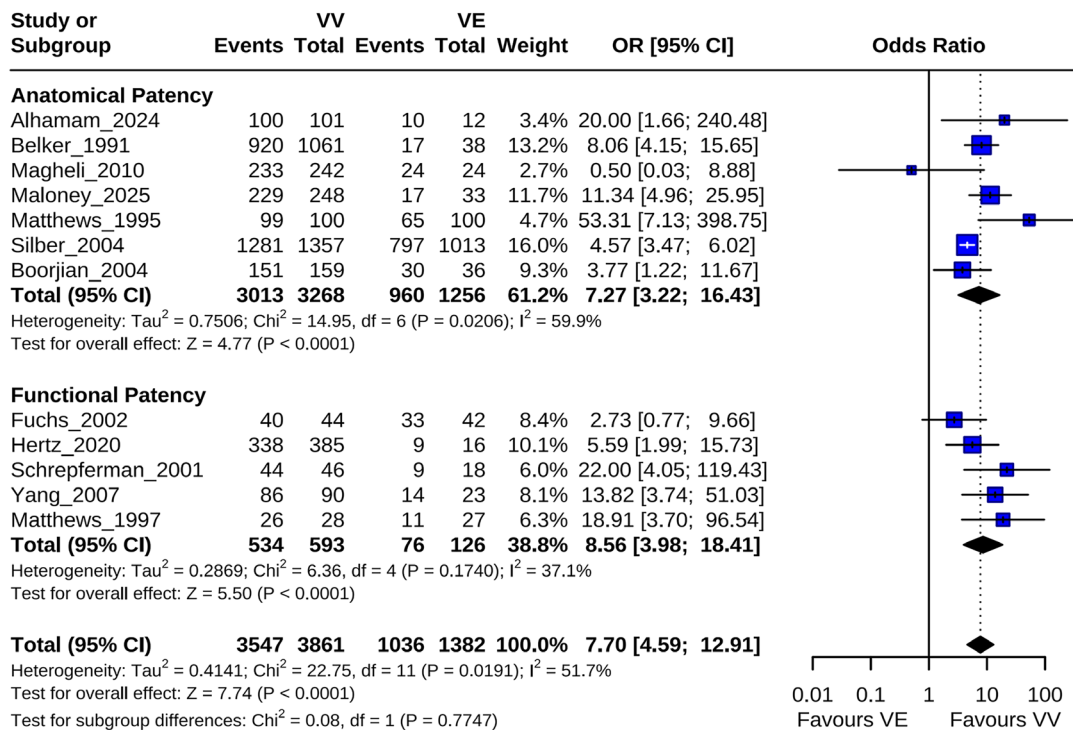
A)



B)



C)



A) VE surgical technique (intussusception versus traditional approaches); B) intraoperative selection criteria (sperm quality and fluid-dependent selection, liberal VV selection, strict azoospermia/absence of intact sperm, and unstandardized data); and C) definition of patency (anatomical versus functional)

by Seth et al. (24), as well as 89.4% for microsurgical VV reported by Herrel et al. (25). Biologically, these higher patency rates reflect the anatomical reliability of suturing the thicker vas deferens wall, compared to the fragile VE anastomosis on a delicate epididymal duct (26). At the same time, 74.7% (1069/1430) patency of VE is close to the range of 64 to 70% obtained in intussusception-related systematic reviews (7, 8). Consistent leave-one-out, large-cohort-exclusion, and quality-restricted analyses, together with no detected funnel-plot asymmetry, support the direction of effect, although residual confounding and heterogeneity remain.

Crucially, the observed differences in outcomes between VV and VE must be interpreted through the lens of confounding by indication and obstruction severity. VV and VE are not simply competing options for a uniform clinical scenario; rather, they are complementary techniques applied to different anatomical and biological

conditions. VV is preferentially performed in more favorable anatomical conditions, particularly when a direct vasa reconstruction is possible and intact sperm or sperm fragments are present in the vasa fluid (5, 27). Conversely, VE is a technically more demanding bypass procedure used when epididymal obstruction is suspected, especially when vasa fluid findings suggest absent sperm or secondary epididymal obstruction (27–29). Thus, lower outcomes after VE may reflect confounding by indication because VE is used for more severe or distal obstruction.

The likelihood of epididymal obstruction and the need for VE increase with longer obstructive interval and have been linked to epididymal blowout or dysfunction after prolonged blockage (28). Therefore, the lower statistical success rates observed after VE should be interpreted as partly reflecting selection into a more severe obstructive phenotype, rather than a simple deficiency of the surgical technique itself.

Table 4 - Summary of findings for microsurgical vasovasostomy versus vasoepididymostomy in adult men with post-vasectomy obstructive azoospermia: Key outcomes, absolute and relative effects per 1000 patients, and GRADE certainty ratings.

Outcome	Absolute difference with VV per 1000 patients (95% CI)	VE per 1000	Relative effect (95% CI)	Participants (studies)	Certainty (GRADE)	Comments
Overall patency	207 more (179 to 224 more)	747	OR 6.98 (4.23 to 11.50)	5483 (13 observational)	VERY LOW ⊕○○○	Serious risk of bias; confounding by indication*
Natural pregnancy	137 more (69 to 192 more)	655	OR 2.01 (1.38 to 2.91)	3076 (7 observational)	VERY LOW ⊕○○○	Very serious risk of bias and missing data†
Overall live birth	213 more (117 to 285 more)	582	OR 2.79 (1.67 to 4.67)	1146 (3 observational)	VERY LOW ⊕○○○	Very serious risk of bias, inconsistency, and indirectness‡
Time to patency	1.95 months earlier (–2.59 to –1.31 months)	-	MD –1.95 (–2.59 to –1.31)	313 (2 observational)	VERY LOW ⊕○○○	Serious risk of bias and imprecision§
Late failure	39 more (132 fewer to 495 more)	165	OR 1.30 (0.17 to 9.84)	205 (2 observational)	VERY LOW ⊕○○○	Very serious inconsistency and imprecision¶

*Certainty started at LOW (observational studies) and was downgraded for risk of bias (crude/unadjusted estimates; confounding by indication inherent to intraoperative VV/VE selection). Large effect upgrade not applied because confounding by indication plausibly explains the magnitude observed, yielding a VERY LOW certainty rating.

†Certainty started at LOW (observational studies) and was downgraded to two levels for risk of bias (crude estimates, confounding by indication, and ~60% missing outcome data) and one level for dissemination bias. No factors met the criteria for upgrading, yielding a VERY LOW certainty rating.

‡Certainty started at LOW (observational studies) and was downgraded for risk of bias (~73% missing outcome data), inconsistency ($I^2=59\%$, discordant point estimates), indirectness (non-uniform live-birth definitions), imprecision, and dissemination bias. No factors met the criteria for upgrading, yielding a VERY LOW certainty rating.

§Certainty started at LOW (observational studies) and was downgraded due to serious risk of bias, serious imprecision (only 2 studies, $N=313$), and dissemination bias. No factors met the criteria for upgrading, yielding a VERY LOW certainty rating.

¶Certainty started at LOW (observational studies) and was downgraded due to serious risk of bias, very serious inconsistency (opposite-direction point estimates), very serious imprecision (CI spans large effects in both directions), and dissemination bias. No factors met the criteria for upgrading, yielding a VERY LOW certainty rating.

CI = Confidence interval; OR = Odds ratio; MD = Mean difference; VV = Vasovasostomy; VE = Vasoepididymostomy; GRADE = Grading of Recommendation Assessment, Development, and Evaluation.

Intraoperatively, the choice between VV and VE is dictated by vasal fluid analysis; the absence of sperm or presence of thick, paste-like fluid suggests secondary epididymal obstruction caused by chronic back-pressure, necessitating VE (20, 26, 30). This rationale supports analyzing mixed bilateral reconstructions as a separate group. Mixed bilateral approaches showed intermediate patency, lower than bilateral VV but higher

than bilateral VE, reflecting asymmetric intraoperative findings rather than a therapeutic compromise. This supports unilateral VE when fluid analysis requires it, provided contralateral VV remains feasible. This point is especially important during preoperative counseling for patients with prolonged obstructive intervals, typically >10 to 15 years, who are more likely to require at least unilateral VE (6, 20).

Because the appropriate reconstruction cannot be definitively selected until intraoperative vasal fluid assessment is performed, these findings have an important implication for surgical training. Reproductive urologists performing VR should be proficient in both microsurgical VV and VE. A surgeon limited to VV may be unable to provide the indicated reconstruction when epididymal obstruction is encountered, reducing the patient's chance of fertility restoration (31).

Subgroup analyses based on intraoperative criteria indicate that the higher observed patency after VV is consistent across varying fluid conditions and selection stringencies. Although prior failed reversal may signal complex obstruction, it did not significantly moderate patency or pregnancy in our exploratory meta-regression. Thus, intraoperative vasal fluid assessment remains more informative for surgical selection than preoperative history alone.

Pregnancy outcomes were numerically higher after VV but require cautious interpretation because they depend on patency and couple-level factors. Patient-only analyses suggest that greater patency largely accounts for this difference. Among patent patients, natural and overall pregnancy did not differ by technique, although overall live birth remained higher after VV; the overall live birth estimate was based on few studies and should be interpreted cautiously. The pooled odds of natural pregnancy were higher in patients with available reproductive follow-up for VV (OR 2.01), and the overall live birth analysis similarly favored VV (OR 2.79). We hypothesize that the widened advantage of VV in ART-inclusive pregnancy rates (OR 2.92) may stem from selection bias. Couples pursuing ART after VE often do so to bypass persistent patency failures, whereas couples utilizing ART after VV may do so for unrelated female-factor infertility, which generally carries more favorable conception odds. Ultimately, overall reproductive success depends on multiple couple-level factors, notably the female partner's age (20). Exploratory meta-regression further indicated that longer follow-up duration attenuated the VV advantage for natural pregnancy. However, this finding is hypothesis-generating given the limited number of studies and risk of ecological

bias. In addition, sperm return occurred earlier after VV, by approximately 2 months. This corresponds to the reported values of time to patency of 1.7 to 4.3 months in VV compared to 2.8 to 6.6 months in VE (9). Overall, patency may explain the initial pregnancy difference, whereas couple-level factors, baseline fertility, and ART use shape outcomes among patent men.

The observed patency and pregnancy differences associated with VV also carry economic implications. Pavlovich and Schlegel reported a cost per live delivery of \$25,475 for VR versus \$72,521 for IVF, accounting for direct and indirect costs (3). Kolettis and Thomas reported comparable figures of \$31,099 versus \$51,024 per live delivery (32). In women older than 37 years, Deck and Berger found a cost per live delivery of \$28,530 with VR compared with \$103,940 with IVF (33). These differences are most pronounced when at least unilateral VV is feasible; when bilateral VE is required, patency rates fall to 54-72%, and the economic case for VR weakens accordingly. Insurance coverage and access to fellowship-trained microsurgeons modify this comparison and should be addressed during preoperative counselling, particularly for patients with prolonged obstructive intervals who are more likely to require VE.

Results from the subgroup analysis by VE technique suggested that intussusception was associated with no heterogeneity compared to moderate heterogeneity for traditional VE techniques. By inserting the smaller epididymis into the vas deferens to create a watertight closure, intussusception minimizes complications like leakage, granuloma formation, and strictures associated with older techniques (26, 34). It may therefore yield more consistent outcomes than end-to-side or end-to-end techniques (7, 35). Neither definition of patency (anatomical or functional) appeared to affect the VV benefit, but the lack of uniform patency criteria still poses problems in the methodology (25). Overall, differences likely reflect case complexity and indication rather than intrinsic technique superiority; technique determines patency, while couple-level factors modify subsequent fertility.

Strengths and Limitations

This is the first systematic three-way pooled comparison of VV, VE, and mixed procedures, supported by rigorous sensitivity analyses. However, several limitations warrant mention. First, all data came from observational cohorts, and pooled estimates were based on crude, unadjusted odds ratios; important confounders such as female partner age, obstructive interval, vasal fluid quality, and laterality were therefore not captured. Second, substantial statistical heterogeneity ($I^2 > 50\%$) across several outcomes reduces the reliability of the pooled estimates and underscores the inherent variability in surgical techniques, patient populations, and surgeon expertise. Third, significant loss to follow-up across even the largest cohorts limits the robustness of pooled pregnancy and overall live birth estimates. Fourth, studies did not consistently distinguish ART pregnancies using ejaculated sperm after reversal from those using surgically retrieved sperm; ART-inclusive estimates are therefore exploratory and should not be interpreted as technique-specific efficacy. This same limitation applies to the overall live birth outcome, which combines natural and ART-assisted deliveries across studies with inconsistent reporting of conception mode. Fifth, baseline characteristics regarding previous failed reversals varied widely, and the definitive impact of prior failed reversal on subsequent mixed bilateral procedure outcomes remains difficult to isolate despite exploratory meta-regression. Finally, considerable heterogeneity precluded meaningful interpretation of the pooled late failure estimate, highlighting a critical gap in the tracking of secondary azoospermia. Future research must prioritize prospective registries with standardized follow-up protocols for both patency and couple-level pregnancy outcomes.

CONCLUSIONS

When intraoperative vasal fluid analysis permits direct anastomosis, microsurgical VV is associated with higher patency, natural pregnancy, and overall live birth rates compared to VE. However, these differences are likely influenced by patient selection and

baseline obstruction severity. Conversely, VE remains the essential and appropriate reconstructive procedure when secondary epididymal obstruction is encountered. Patency after mixed bilateral reconstruction is intermediate, accurately reflecting asymmetric intraoperative anatomy rather than a therapeutic compromise. These findings establish intraoperative vasal fluid assessment as the central decision point for matching each vasal unit to the appropriate technique.

ABBREVIATIONS

AHRQ = Agency for Healthcare Research and Quality
 ART = Assisted reproductive technology
 CI = Confidence interval
 CIOMS = Council for International Organizations of Medical Sciences
 ICSI = Intracytoplasmic sperm injection
 LIVE = Longitudinal intussusception
 MD = Mean difference
 Mixed = Bilateral procedure with VV on one side and VE on the other
 n = Number
 NOS = Newcastle-Ottawa Scale
 NR = Not reported
 OI = Obstructive interval (time since vasectomy)
 OR = Odds ratio
 PICOS = Population, Intervention, Comparison, Outcomes, and Study design
 PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses
 SD = Standard deviation
 VE = Vasoepididymostomy
 VR = Vasectomy reversal
 VV = Vasovasostomy
 y = Years

CONFLICT OF INTEREST

None declared.

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Robot-Assisted Radical Cystectomy: Recommendations from Latin American Experts Consensus on Surgical Strategy, Urinary Reconstruction, and Oncological and Functional Outcomes

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ABSTRACT

Purpose: To develop contemporary evidence-informed recommendations for robot-assisted radical cystectomy (RARC), urinary reconstruction, and perioperative management, integrating current evidence with the experience of Latin American experts in uro-oncology and robotic surgery.

Materials and methods: A modified Delphi consensus process was conducted involving 42 experts with extensive experience in RARC. Topics included patient selection, perioperative optimization, enhanced recovery after surgery (ERAS), lymph node dissection, urinary reconstruction, functional preservation, perioperative systemic therapy, complex clinical scenarios, and emerging robotic technologies. A comprehensive literature review was performed using Medline, Scopus, and Web of Science through November 2025, following PRISMA principles and incorporating recommendations from EAU, AUA/ASCO/SUO, and NCCN guidelines. Consensus was defined as $\geq 75\%$ agreement.

Results: Consensus supported routine implementation of ERAS protocols, structured frailty and nutritional assessment, extended pelvic lymph node dissection, and perioperative systemic therapy in eligible patients. Intracorporeal urinary diversion was associated with improved recovery and lower wound-related morbidity. Nerve-sparing and organ-preserving approaches were recommended in selected patients to optimize continence, sexual function, and quality of life. Orthotopic neobladder reconstruction should be individualized according to oncologic safety, functional status, renal function, and patient preference. RARC was considered feasible in complex settings, including obesity, bulky lymphadenopathy, locally advanced disease, and salvage surgery, when performed in experienced high-volume centers. Areas without consensus included urinary drainage strategies and antibiotic prophylaxis duration.

Conclusions: This expert consensus provides recommendations for RARC and urinary reconstruction, aiming to standardize practice, optimize perioperative care, and improve oncological and functional outcomes. Future prospective studies are needed.

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INTRODUCTION

Radical cystectomy with urinary reconstruction remains the standard of care for patients with localized muscle-invasive bladder cancer and for selected cases of high-risk non-muscle-invasive disease refractory to conservative therapies (1, 2).

Despite these advances, robotic-assisted radical cystectomy (RARC) remains a highly complex procedure, encompassing not only extirpative surgery but also pelvic lymphadenectomy and urinary reconstruction, often performed intracorporeally. As a result, significant variability persists across institutions and surgeons regarding patient selection, surgical technique, perioperative management, and reconstructive strategies (3-5).

This heterogeneity is further compounded by differences in surgical experience, institutional volume, and the lack of standardized technical frameworks, particularly in areas such as nerve-sparing approaches, extent of lymphadenectomy, intracorporeal urinary diversion (ICUD), and management of complex cases. In addition, the learning curve associated with robot-assisted radical cystectomy represents a significant barrier to its widespread adoption, particularly outside high-volume, specialized centers. Although multiple guidelines address the oncologic management of bladder cancer, specific procedural aspects of RARC remain insufficiently standardized.

In this context, the development of an expert consensus is essential to provide structured, evidence-informed recommendations that reflect both current literature and real-world surgical practice. The aim of this consensus is to define key principles and technical considerations in RARC, identify areas of agreement and controversy, and support the standardization of care across different practice settings.

MATERIALS AND METHODS

This consensus was developed by a multidisciplinary panel of 42 experts in urologic oncology with extensive experience in RARC. Panelists were selected based on predefined criteria, including recognized expertise in robotic surgery, high surgical volume, aca-

demically productivity, and experience in the critical appraisal of scientific literature.

A structured consensus process based on a modified Delphi methodology was conducted, consisting of a single round of online voting. Initially, key topics were identified, including patient selection, surgical technique, lymphadenectomy, urinary reconstruction, perioperative management, complications, and oncologic and functional outcomes.

A comprehensive literature review was performed using Medline, Scopus, and Web of Science databases, including studies published up to November 2025, with updates incorporated when relevant. Search terms included "robot-assisted radical cystectomy," "robotic cystectomy," and related keywords. The review followed PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure methodological rigor, transparency, and reproducibility. In addition, current international guidelines from major societies, including the NCCN, AUA, and EAU, were reviewed.

Based on the available evidence and expert input, the working groups drafted preliminary questions and consensus statements, which were subsequently distributed to the panelists for voting. Agreement was assessed using structured voting, and consensus was defined as $\geq 75\%$ agreement among respondents. Statements not reaching this threshold were identified as areas of controversy and are explicitly discussed in the manuscript.

Following the voting process, the statements were refined through expert discussion, and a final set of recommendations was established, integrating both the best available evidence and panel consensus.

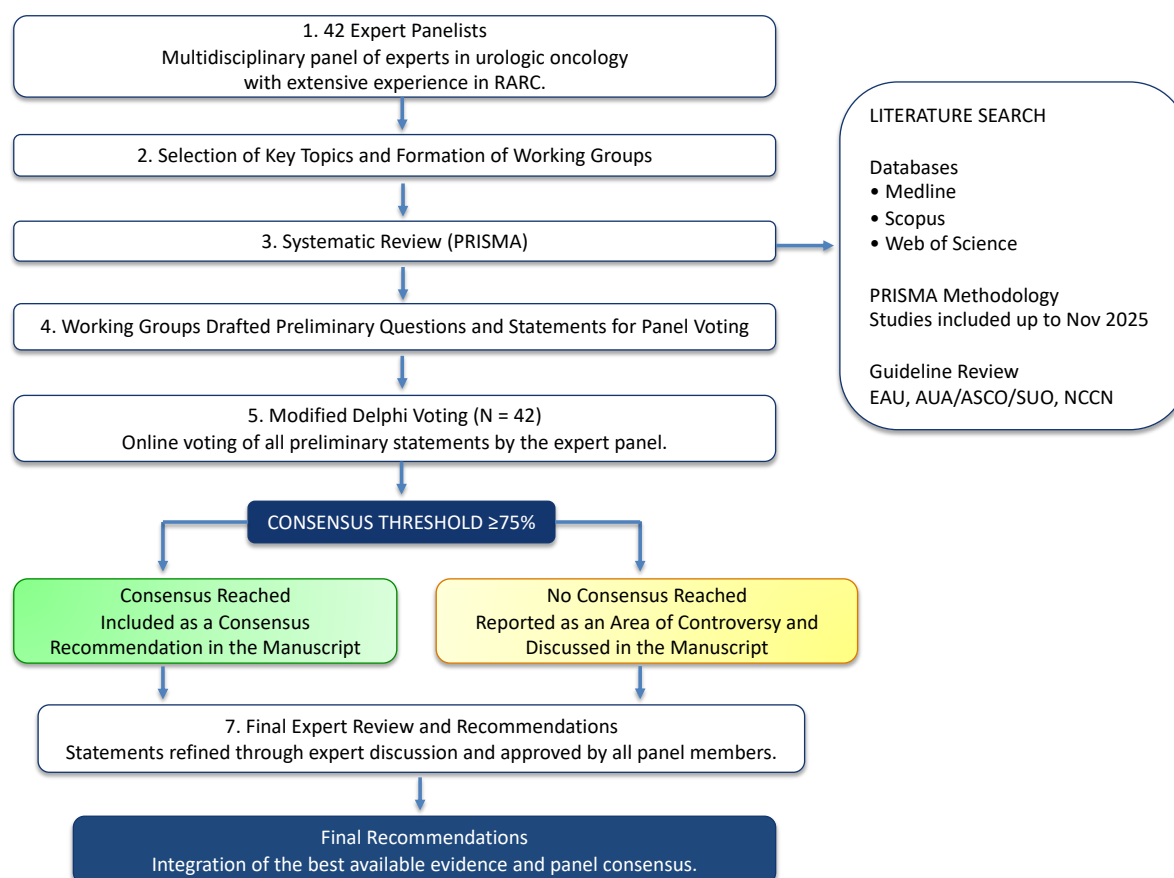
Finally, a designated subgroup of experts was responsible for drafting the preliminary manuscript, which was subsequently reviewed, discussed, and approved by all panel members prior to final consolidation (Figure-1).

RESULTS

Surgical preparation

Patient Selection

RARC shares the same indications as the open approach, and, according to the majority of panelists,

Figure 1 - Flowchart of the modified Delphi methodology used for consensus development.

patient involvement in the decision-making process is essential when selecting the surgical approach (Table-1). There are few absolute or relative contraindications to RARC; however, certain clinical scenarios require advanced surgical expertise and should be approached with caution (6).

According to our consensus, contraindications to RARC include extensive tumor invasion of the pelvic wall, peritoneal carcinomatosis, severe ventilatory impairment incompatible with pneumoperitoneum, and technical inability to achieve safe patient positioning. Relative contraindications—dependent on surgical experience and institutional expertise—include prior pelvic surgery or radiotherapy, very high tumor burden, bulky fixed lymphadenopathy, and selected non-urothelial histology associated with unfavorable prognosis, all of which require careful individualized assessment (1, 2).

The panelists also emphasized that significant medical comorbidities—such as chronic obstructive pulmonary disease, heart failure, morbid obesity (BMI > 35 kg/m²), and extensive prior abdominal surgery with severe adhesions—may complicate robotic access, require advanced surgical expertise, or increase the risk of perioperative complications. These factors should be carefully weighed during surgical planning (1, 2).

Our consensus aligns with the available evidence, which suggests that patients with greater clinical frailty or an anesthetic risk classification of ASA ≥ III may achieve perioperative and oncologic outcomes comparable to those of lower-risk patients when managed with the robotic approach in high-volume centers. (7).

In addition, structured assessment of patient frailty is recommended as part of the preoperative evaluation. Frailty has emerged as an independent predictor

Table 1 - Indications for Robot-Assisted Radical Cystectomy (RARC).

Category	Clinical Situation	Recommendation / Comment
Primary (Curative) Indication	Non-metastatic MIBC	RARC has the same indications as ORC for curative intent.
	Refractory or recurrent disease after BCG	Considered a valid option in cases of intravesical therapy failure.
	Extensive, high-risk, multifocal tumors or tumors not controllable with TURBT + intravesical therapy	Radical treatment with RARC.
Muscle-invasive Variant Histologies	Pure bladder adenocarcinoma	May be treated with RARC, provided oncologic principles are strictly respected.
	Pure squamous cell carcinoma	RARC is a valid option when radical resection is indicated.
	Small cell neuroendocrine carcinoma	Indicated after NAC, maintaining strict oncologic principles.
Palliative Indication	Locally advanced or metastatic disease without curative potential	RARC may be considered for symptomatic control.
	Massive, intractable hematuria	May justify palliative RARC.
	Refractory pelvic pain, urinary fistulas, or symptom control	Goal: symptom relief and improvement of quality of life.

MIBC – Muscle-invasive bladder cancer; RARC – Robot-assisted radical cystectomy; ORC – Open radical cystectomy; TURBT – Transurethral resection of bladder tumor; NAC – Neoadjuvant chemotherapy

of postoperative complications, prolonged hospitalization, and mortality in patients undergoing radical cystectomy. Our panelists agree that comprehensive geriatric assessment tools—including evaluation of functional status, cognition, nutritional status, and comorbidity burden—may provide more accurate risk stratification than chronological age alone. Importantly, frailty should not be considered an absolute contraindication to RARC. On the contrary, there was clear consensus that elderly and/or frail patients may benefit from a minimally invasive approach when managed in experienced, high-volume centers.(1, 2).

Obesity, particularly morbid obesity, represents a relevant clinical scenario in which RARC may offer potential perioperative advantages, provided that the procedure is performed in experienced, high-volume centers (8-10).

ERAS Protocols and Perioperative Management

The systematic implementation of Enhanced Recovery After Surgery (ERAS) protocols is associated with

reduced surgical stress, faster functional recovery, shorter length of hospital stay, and a lower incidence of postoperative complications. Nearly all panelists routinely adopt ERAS principles in their clinical practice (Table-2).

Nutritional Aspects

It is estimated that up to one-third of patients undergoing this procedure present with nutritional risk, a condition associated with increased postoperative complications, impaired functional recovery, and higher mortality rates (11). An overwhelming majority of panelists recommend that nutritional assessment should be comprehensive and multifactorial, incorporating body mass index (BMI) as well as relevant clinical and biochemical parameters (11). Immunonutrition—including arginine, glutamine, omega-3 fatty acids, and nucleotides—has been associated with a reduction in infectious complications and improved metabolic response to surgical trauma. The panel recommends preoperative nutritional supplementation with immunonutrients for a minimum period of 5 to 7 days prior to radical cystectomy (12, 13).

Table 2 – Perioperative recommendations in RARC.

Domain	Consensus Recommendation	Comment / Rationale
ERAS Protocols	Systematic implementation of ERAS protocols in RARC is recommended.	Associated with reduced surgical stress, faster functional recovery, shorter hospital stay, and lower complication rates.
Functional Stratification	Structured functional assessment and comprehensive geriatric evaluation are recommended in elderly or frail patients.	Particularly in patients ≥ 70 years or ASA III–IV.
	Elderly/frail patients may benefit from the robotic approach.	Potentially less surgical trauma and improved recovery.
Nutritional Assessment	Multifactorial preoperative nutritional assessment is recommended.	Up to one-third of patients present nutritional risk, associated with higher morbidity and mortality.
	Assessment should include BMI, clinical, and biochemical parameters.	Early identification of malnutrition.
	Preoperative immunonutrition for 5–7 days before surgery is recommended.	Arginine, glutamine, omega-3, and nucleotides may reduce infectious complications.
Bowel Preparation	Routine mechanical bowel preparation is not recommended.	A low-residue liquid diet may be used the day before surgery.
Perioperative Fasting	Solids allowed until 6 hours before; clear carbohydrate-rich fluids until 2 hours before anesthesia.	Aligned with ERAS guidelines.
	Early oral feeding (within the first 24 hours) is recommended.	Associated with reduced postoperative ileus.
	Postoperative chewing gum may be used.	Stimulates peristalsis.
	Intraoperative pneumatic compression and postoperative compression stockings are recommended.	Reduces thromboembolic risk.
VTE Prophylaxis	Pharmacologic thromboprophylaxis is recommended for up to 4 weeks.	Initiation between 6–24 hours after surgery.
	LMW heparin is preferred; apixaban (prophylactic dose) may be an alternative.	Institutional variation applies.
	Combined anesthesia (general + regional) is recommended.	Contributes to reduced ileus and improved recovery.
Anesthetic Management	Restrictive, goal-directed fluid therapy is recommended.	Reduces bowel edema.
	Opioid-sparing or opioid-free protocols are recommended.	Associated with fewer pulmonary complications and gastrointestinal dysfunction.
	Antibiotic prophylaxis is recommended for up to 24 hours after incision.	Prolonged prophylaxis shows no additional benefit.
	Continuation of antibiotics until drain/catheter removal is not recommended.	Increase risk of resistance and adverse events.
Antimicrobial Prophylaxis	Common regimens: 2nd/3rd generation cephalosporin + metronidazole; or ampicillin-sulbactam; or piperacillin-tazobactam.	Adjust according to institutional profile.
	Colonization with multidrug-resistant organisms requires tailored adjustment based on prior cultures.	Individualized management.
Surgical Drainage	Routine placement of pelvic surgical drains is commonly performed.	The benefit is still under debate
	No consensus on the ideal urinary drainage model.	Varies according to type of diversion.
Urinary Drainage	In ONB, adequate temporary drainage is recommended.	Protects urinary anastomosis.

BMI – Body Mass Index; LMW – Low-molecular-weight; ONB – Orthotopic Neobladder

Sarcopenia is a frequent finding in patients with bladder cancer undergoing radical cystectomy, with an estimated prevalence of half of patients, as demonstrated by a recent meta-analysis. The presence of sarcopenia was independently associated with worse oncological outcomes, with a significant increase in the risk of all-cause mortality, consolidating its role as a relevant prognostic marker in this population. Systematic assessment of body composition — preferably through computed tomography — along with nutritional evaluation in the preoperative setting of patients candidates for radical cystectomy, may identify individuals at higher risk (14).

Bowel Preparation and Perioperative Fasting in Robot-Assisted Radical Cystectomy

Routine mechanical bowel preparation is no longer recommended. As an alternative, a low-residue liquid diet may be adopted on the day prior to surgery.

Regarding preoperative fasting, consensus supports discontinuation of solid food intake up to 6 to 8 hours before the procedure and clear liquids up to 2 hours before anesthetic induction, including carbohydrate-containing beverages. This approach departs from the traditional concept of prolonged absolute fasting (15). Early postoperative oral feeding within the first 24 hours is also recommended (15). Chewing gum may be used as an adjunct to stimulate bowel motility and reduce the risk of postoperative ileus.

Venous Thromboembolism Prophylaxis

All panelists recommend the use of intermittent pneumatic compression devices from the beginning of surgery, followed by postoperative graduated compression stockings, combined with extended pharmacologic thromboprophylaxis for up to four weeks after RARC (15, 16). Pharmacologic thromboprophylaxis should be initiated between 6 and 24 hours after surgery. In the consensus, most specialists favored the use of low-molecular-weight heparin; however, some reported the use of oral anticoagulants, such as apixaban, at a prophylactic dose of 2.5 mg twice daily (17, 18). The review provides evidence that a fully intracorporeal approach during RARC may be associated with a lower thrombotic and inflammatory risk, potentially due to a reduced systemic

inflammatory response, decreased postoperative pain, and faster functional recovery (19). Thromboprophylaxis is particularly important in patients who have received neoadjuvant chemotherapy, as venous thromboembolism (VTE) rates are higher in this population compared with those treated with cystectomy alone (12% vs. 8%) (18, 20). Almost all panelists recommend early postoperative physiotherapy, including both respiratory and mobilization exercises, during the in-hospital period.

Anesthetic Management, Fluid Therapy, and Opioid Use

The consensus recognizes that the adoption of combined anesthesia (general anesthesia plus regional techniques) and goal-directed, restrictive fluid management contributes to reduced intestinal edema, lower risk of postoperative ileus, and improved gastrointestinal recovery.

Opioid-sparing or opioid-free anesthetic protocols are recommended within ERAS pathways, as they are associated with a lower incidence of pulmonary complications, reduced postoperative ileus, and improved gastrointestinal recovery, potentially contributing to shorter hospital stay. In patients requiring perioperative opioid administration, the use of alvimopan may be considered, as it has been shown to accelerate bowel function recovery and reduce length of hospitalization (15).

Antimicrobial Management

Antibiotic selection should be guided by the institutional microbiological profile, prior colonization status, and individual patient risk factors, including previous hospitalizations, recent antibiotic exposure, and the type of urinary diversion performed. In addition, there was clear consensus among all panelists that RARC is associated with lower rates of surgical site infections and shorter length of hospital stay compared with the open approach.

A recent randomized clinical trial demonstrated that 24-hour antibiotic prophylaxis was non-inferior to prolonged prophylaxis (continued until removal of catheters and stents) in preventing surgical site infection within 90 days after cystectomy with urinary diversion (21). Among panelists, there was no consensus regarding the

duration of antibiotic prophylaxis, which varied from up to 24 hours to 5 days, until hospital discharge, or until removal of catheters. However, current evidence supports limiting antibiotic prophylaxis to no more than 24 hours after surgical incision. Routine continuation of antibiotics until removal of drains, urinary catheters, or ureteral stents is not recommended by the majority of panelists. Prolonged use is associated with increased risk of bacterial resistance, drug-related adverse events, *Clostridioides difficile* infection, and higher hospital costs (1, 15, 21).

Recommended regimens include a second- or third-generation cephalosporin plus metronidazole, ampicillin-sulbactam, or piperacillin-tazobactam in higher-risk settings. Antibiotic prophylaxis should be administered 30–60 minutes before skin incision, with intraoperative redosing based on the drug's half-life and procedure duration. Prolonged antibiotic use beyond 24 hours is not recommended.

The panel agrees that, in cases of orthotopic neobladder reconstruction, an additional prophylactic antibiotic dose at the time of urethral catheter removal may be considered, according to institutional protocols. In patients with documented colonization by multidrug-resistant organisms, antibiotic selection should be tailored based on prior culture results. Asymptomatic patients with a positive preoperative urine culture should receive targeted antimicrobial therapy directed at the identified microorganism prior to RARC (1, 21).

Surgical and Urinary Drainage

Routine placement of pelvic surgical drains was reported by most panelists. However, no consensus was reached regarding the optimal type of drain, reflecting institutional variability and the influence of the type of urinary reconstruction performed. Routine use of nasogastric tubes was also discouraged.

With respect to urinary drainage, although the optimal duration of ureteral stents or catheters remains a matter of debate, no consensus was reached among panelists regarding the routine use, type, or duration of urinary drainage in either ileal conduit or orthotopic neobladder reconstruction. Similarly, no consensus was achieved regarding several technical aspects of ureteroenteric anastomosis, including the choice between

Bricker and Wallace techniques, the extent of ureteral spatulation, continuous versus interrupted suturing, the routine use of transanastomotic ureteral stents, and the optimal duration of stenting. These findings reflect the considerable variability in surgical practice and the limited high-level evidence supporting one specific approach over another. Preservation of ureteral vascularization appears to be more important than the choice of ureteroenteric anastomotic technique (Bricker versus Wallace) or stenting strategy in minimizing the risk of ureteroenteric strictures and related complications. (15, 19, 22). Additionally, no consensus was achieved regarding the optimal duration of urethral catheterization following orthotopic neobladder reconstruction.

ROBOTIC VS. OPEN APPROACH IN ONCOLOGIC OUTCOMES

Randomized clinical trials and contemporary meta-analyses confirm comparable outcomes between robotic and open radical cystectomy in terms of overall survival (OS), recurrence-free survival (RFS), locoregional disease control, and rates of positive surgical margins (4, 19, 23).

Surgical Margins

Robot-assisted radical cystectomy (RARC) demonstrates positive surgical margin (PSM) rates comparable to those of open radical cystectomy. These rates vary according to disease stage, ranging from approximately 3% to 8% in organ-confined disease and from 15% to 20% in locally advanced cases (1, 2, 4, 19).

The main independent predictors of positive surgical margins include advanced clinical and pathological stage, lymph node positivity, variant histology (such as micropapillary or sarcomatoid features), lymphovascular invasion, lack of response to neoadjuvant chemotherapy, and a history of prior pelvic radiotherapy (1, 2, 4, 19, 23).

When a positive ureteral margin is identified on intraoperative frozen section analysis (FSA), sequential cranial ureteral resections are recommended until carcinoma in situ or invasive disease is excluded. (24). Despite evidence that routine intraoperative FSA of

the urethral margin reduces the risk of positive surgical margins and, when combined with the absence of prostatic stromal invasion, enables safe urethral preservation in candidates for orthotopic neobladder reconstruction, only 48% of panelists reported performing it routinely, while others reserve its use for cases of locally advanced disease (1, 2).

Extent of Pelvic Lymphadenectomy

Pelvic lymph node dissection (PLND) remains a fundamental component of radical cystectomy, providing both staging and potential therapeutic benefit. The extent of lymphadenectomy continues to be a matter of debate, particularly in the setting of robot-assisted radical cystectomy (RARC) (4, 19).

The panel supports the performance of at least an extended pelvic lymph node dissection in patients undergoing RARC, given its established role in accurate staging and its potential impact on oncologic outcomes. Although randomized evidence has not demonstrated a significant overall survival benefit with super-extended templates compared to extended dissection, improved staging accuracy remains a consistent finding. The anatomical boundaries are defined proximally by the bifurcation of the common iliac artery, distally by the node of Cloquet (Cooper's ligament), laterally by the genitofemoral nerve, medially by the pelvic visceral structures, and posteriorly by the obturator fossa. The dissection includes the external iliac, internal iliac, and obturator lymph node basins (1, 2, 25).

Extended lymphadenectomy maintains the same distal and lateral boundaries but expands proximally to include the entire length of the common iliac arteries up to the aortic bifurcation, as well as the presacral region. Super-extended lymphadenectomy extends beyond the common iliac bifurcation and includes the lower para-aortic and para-caval lymph nodes up to the level of the inferior mesenteric artery (26).

Recent evidence suggests that performing PLND before or after radical cystectomy results in comparable lymph node yield, blood loss, and operative outcomes. In robotic surgery, however, PLND performed before cystectomy may facilitate the procedure by reducing cystectomy time, overall operative time,

and blood loss, supporting the use of either sequence according to surgeon preference or technical considerations (27).

The panel emphasizes that the quality and completeness of lymphadenectomy are critical factors, potentially more relevant than the absolute anatomical extent. Standardization of surgical templates, meticulous dissection, and adequate lymph node yield are essential to optimize oncologic outcomes. In addition, the panel considers robot-assisted lymphadenectomy to be a safe and feasible approach, even in the presence of bulky nodal disease or following perioperative systemic therapy, provided that the procedure is performed in experienced, high-volume centers.

Perioperative Systemic Therapy in the Management of Muscle-Invasive Bladder Cancer (MIBC)

The vast majority of panelists considered RARC to be safe following perioperative systemic therapy. In addition, the panel supports the routine use of perioperative systemic therapy in eligible patients. This position is consistent with recommendations from the European Association of Urology (EAU) and other major international societies, which endorse perioperative systemic therapy as a standard component of care in appropriately selected patients (1), as well as the American Urological Association (AUA/ASCO/SUO) (2) and National Comprehensive Cancer Network (NCCN) (28), recommend the use of perioperative chemotherapy and/or immunotherapy for all eligible patients with cT2–T4a N0 M0 tumors. Adjuvant chemotherapy (AC) is reserved for patients with high-risk pathological findings after surgery, such as pT3/pT4 disease or lymph node involvement, particularly in the absence of prior chemotherapy (Table-3).

Cisplatin-based regimens remain the standard for neoadjuvant chemotherapy (NAC), with gemcitabine plus cisplatin (GC) and MVAC (methotrexate, vinblastine, doxorubicin, and cisplatin) being the most extensively studied protocols (1, 2, 28). The dose-dense MVAC regimen has demonstrated improved progression-free survival (29).

Adjuvant nivolumab is approved and has been shown to significantly improve disease-free survival

Table 3 – Perioperative Systemic Treatment (MIBC).

Domain	Consensus Recommendation	Clinical Comment
Neoadjuvant Chemotherapy (NAC)	Recommended for cT2–T4a N0 M0 eligible patients. Cisplatin-based regimens (GC or MVAC).	Supported by EAU, AUA/ASCO/SUO, and NCCN guidelines. Dose-dense MVAC improves PFS
Adjuvant Chemotherapy (AC)	Indicated in pT3/pT4 or N+ patients without prior NAC.	Based on pathological risk stratification.
Adjuvant Nivolumab	Recommended in high-risk patients (pT2–4 and/or N+).	Improves DFS and OS
Durvalumab + GC	Promising perioperative strategy.	Potential paradigm shift in management.
NAC and Surgical Complications	NAC does not increase surgical morbidity.	Multicenter evidence (30- and 90-day outcomes).
Surgical Timing	Surgery within 10–12 weeks after NAC is considered safe.	Does not compromise oncologic or surgical outcomes.
Enfortumab Vedotin + Pembrolizumab	Improves EFS, OS, and pCR rates.	Strongly recommended by the 2026 EAU Guidelines as perioperative therapy for patients with MIBC who are ineligible for cisplatin-based chemotherapy

EAU – European Association of Urology; **AUA** – American Urological Association; **ASCO** – American Society of Clinical Oncology; **SUO** – Society of Urologic Oncology; **NCCN** – National Comprehensive Cancer Network; **GC** – Gemcitabine plus Cisplatin; **MVAC** – Methotrexate, Vinblastine, Doxorubicin, and Cisplatin; **N+** – Lymph Node-Positive Disease; **NAC** – Neoadjuvant Chemotherapy; **DFS** – Disease-Free Survival; **OS** – Overall Survival; **EFS** – Event-Free Survival; **pCR** – Pathological Complete Response

and overall survival in high-risk patients (pT2–4 and/or N+) following cystectomy (1, 30). Adjuvant nivolumab should be offered to selected patients who did not receive or declined platinum-based chemotherapy.

The use of durvalumab in combination with gemcitabine plus cisplatin prior to surgery, followed by adjuvant maintenance therapy, has been shown to improve overall survival and event-free survival compared with chemotherapy alone and has been adopted in several countries in Latin America (31).

Retrospective studies and meta-analyses have consistently demonstrated that neoadjuvant chemotherapy is not associated with an increased risk of surgical complications. A multicenter study further evaluated this association (32) In a cohort of 878 patients (302 of whom received NAC), no significant differences were observed in 30- and 90-day complication rates between groups. An interval of 10 to 12 weeks between completion of chemotherapy and surgery does not compromise surgical or oncologic outcomes (33). Most panelists

consider that neoadjuvant chemotherapy does not increase surgical morbidity and can be regarded as safe following neoadjuvant chemoimmunotherapy.

The perioperative combination of enfortumab vedotin plus pembrolizumab has demonstrated significant improvements in event-free survival, overall survival, and pathological complete response rates in patients with MIBC who are ineligible for cisplatin-based chemotherapy (34). Based on these findings, this regimen has been incorporated into the 2026 EAU Guidelines as a strongly recommended perioperative treatment option for cisplatin-ineligible patients. The panel acknowledges the relevance of these findings and their potential to reshape perioperative treatment strategies in MIBC.

The majority of panelists agreed that robot-assisted radical cystectomy should be performed within 30 to 60 days following completion of neoadjuvant systemic therapy, provided that the patient's clinical and laboratory conditions are adequate.

FUNCTIONAL ASPECTS

Nerve-Sparing Approach in Men

RARC provides enhanced anatomical visualization compared with open surgery and facilitates preservation of the neurovascular bundles as well as the endopelvic fascia (Endopelvic Fascia Sparing – EPFS). This approach has been associated with improved urinary continence and sexual function outcomes (35, 36). The majority of panelists agreed that preservation of the endopelvic fascia, puboprostatic ligaments, dorsal venous complex, and neurovascular bundles, using an athermal dissection technique, is associated with improved urinary continence and erectile function outcomes (Table-4) (35).

The best candidates are younger patients with organ-confined disease ($\leq pT2$) and no involvement of the bladder neck or urethra. In cases of locally advanced, multifocal, or high oncologic risk disease, tumor control remains the priority, and functional preservation strategies should be avoided (1, 35-37). The vast majority of panelists reported routinely using polymer clips for ligation of the lateral pedicles, whereas only a minority prefer energy-based devices for this purpose.

Sexual dysfunction is a common treatment-related consequence of urological cancers and should be addressed during pre-treatment counseling (38).

Urethra / Urethrectomy

The panel recommends circumferential urethral dissection should be performed at the level of the prostatic apex using blunt dissection and only after complete bladder mobilization. Bladder decompression is recommended, followed by placement of a polymer clip or ligature as proximally as possible on the urethra to prevent urinary spillage.

In candidates for orthotopic neobladder reconstruction, preservation of the maximal urethral length is recommended whenever oncologically safe (6, 39). The urethra-ileal anastomosis should be performed using a technique similar to the Van Velthoven method (40) and, in most cases, should be completed prior to isolation of the neobladder segment.

The AUA/ASCO/SUO guidelines further address this aspect (2) and also the EAU Guidelines 2025 (1). Current evidence and international guidelines recognize that prophylactic urethrectomy should not be routinely performed. According to the available literature and the present consensus, urethrectomy is primarily indicated in patients with confirmed urethral involvement, advanced tumor stage (T3–T4), presence of carcinoma in situ (CIS), positive intraoperative urethral frozen section, or documented residual urethral disease. There was strong consensus among panelists that concomitant urethrectomy should be reserved for cases with confirmed involvement or high-risk features for urethral disease, although some differences in decision-making were observed between male and female patients (1, 2, 41).

The decision to perform intraoperative frozen section analysis of the urethral margin should take into account the individual oncologic risk and the experience of the surgical team. When a positive urethral margin is identified, additional resection may convert the margin to negative, which has been associated with a lower risk of urethral recurrence. Conversely, a final positive urethral margin is associated with a significantly increased risk of urethral recurrence within the first three years of follow-up (1, 42).

Regarding the panelists' responses, in men, the highest levels of agreement were observed for documented urethral invasion and distal urethral involvement, while the presence of CIS was also frequently considered. Other factors, such as bladder neck involvement and multifocal disease, were less consistently regarded as absolute indications, suggesting a more individualized approach in these scenarios. In contrast, among women, a more consistent pattern of responses was observed, with confirmed urethral involvement, urethral compromise, and the presence of CIS reaching higher levels of agreement among panelists. Trigonal involvement was also more frequently considered relevant, whereas multifocal disease appeared to have a more limited impact on decision-making.

The procedure may be performed through an abdominal or perineal approach, particularly in cases of extensive local invasion. The guidelines emphasize that the decision to perform urethrectomy should be selective

and based on individual oncologic risk, intraoperative assessment of surgical margins, and the planned urinary diversion strategy. (1, 2, 43). In addition, assessment of vaginal support and the impact of urethral resection on pelvic stability should be considered, since the concomitant removal of the urethra and anterior vaginal wall may significantly alter pelvic anatomy and increase the risk of functional and structural complications.”

RARC in Women and Concomitant Hysterectomy and Vaginal Wall Resection

In postmenopausal women with an atrophic uterus or endometrial abnormalities, concomitant hysterectomy remains the standard approach. Conversely, in younger patients without cervical or anterior vaginal wall invasion, uterine preservation may be considered, provided that oncologic principles are strictly maintained. In this context, there was consensus among panelists that younger women, particularly those aiming to preserve sexual function, may benefit from RARC when organ-preserving strategies are appropriately applied (Table-4).

Resection of the anterior vaginal wall and urethra during female radical cystectomy is primarily indicated in cases of locally advanced disease or when there is evidence of tumor invasion compromising oncologic safety and the achievement of negative surgical margins, particularly in T3 or T4 tumors with extension to adjacent pelvic structures and/or aggressive histologic variants (1, 2, 43).

Preservation of the anterior vaginal wall and urethra is associated with orthotopic neobladder reconstruction. Maintenance of the urethra, vaginal support structures, and surrounding fascia reduces the risk of vaginal dehiscence, pelvic organ prolapse, and vaginal failure following cystectomy (43, 44). Nerve-sparing in selected women is appropriate for patients undergoing intracorporeal orthotopic neobladder reconstruction, with the aim of optimizing functional outcomes, particularly urinary continence. The consensus panel recognizes that, when oncologically safe, female nerve-sparing and organ-preserving strategies may also contribute to better sexual and pelvic functional outcomes. Preservation of the autonomic pelvic plexus, anterior vaginal wall,

Table 4 - Urinary Diversion Strategy in RARC.

Technical Domain	Consensus Recommendation	Technical Considerations
Ileal Conduit	Remains the most reproducible and reliable diversion.	Preferred in frail patients, significant comorbidities, or limited functional reserve.
Neobladder	Recommended in selected patients with favorable oncologic and functional criteria. Should be strict and individualized.	Requires preserved urethra, negative margins, adequate sphincter function, and renal function (CrCl > 50–60 mL/min). Motivated patients with ability to perform self-care and possible intermittent catheterization.
Contraindications to Neobladder	Renal impairment, bowel disease, sphincter dysfunction, and inability to perform self-catheterization should be considered relative contraindications (higher risk of metabolic complications and suboptimal functional outcomes).	
Intracorporeal Diversion (ICUD)	Increasingly adopted in high-volume centers.	Associated with less bowel manipulation and improved perioperative recovery.
Extracorporeal Diversion (ECUD)	Remains a valid alternative.	May be preferred in selected complex or high-risk cases.
Mesentery-Sparing Technique	Recommended during intracorporeal reconstruction.	Preserves vascular supply, reduces mesenteric defects, and lowers risk of internal hernias.
Bilateral Cutaneous Ureterostomy	Valid alternative in selected patients.	Consider frail patients, high surgical risk, limited life expectancy, or solitary kidney.

uterus and supporting structures has been associated in the literature with reduced vaginal shortening and dyspareunia, improved vaginal lubrication, better preservation of sexual function, and lower risk of pelvic floor dysfunction after radical cystectomy (44).

Vaginal Closure and Prevention of Prolapse and Fistula

There was consensus among panelists that uterine preservation and maintenance of its supporting structures may improve sexual function, preserve pelvic floor support, and reduce the risk of prolapse following orthotopic neobladder reconstruction. Patient preference should be explicitly considered in the decision-making process.

Panelists agreed that preservation of the anterior vaginal wall facilitates orthotopic neobladder reconstruction. In addition, this approach was considered to be associated with improved body image, psychosexual outcomes, sexual function, patient-reported outcomes, and overall quality of life. Furthermore, proper vaginal closure techniques using absorbable sutures, along with reinforcement of the anterior compartment, are considered important to reduce late complications and optimize functional outcomes after continent urinary reconstruction (44, 45). In selected cases, peritoneal coverage or the use of pedicled omental flaps over the suture line may be considered to reduce the risk of neobladder–vaginal fistula. Techniques such as prophylactic sacrocolpopexy or suspension to the pectineal (Cooper's) ligament, combined with primary vaginal closure, represent effective strategies to prevent vaginal vault prolapse (44, 45).

Posterior Reconstruction Technique

The aim of this technique is to restore pelvic floor anatomy, minimize tension on the anastomosis, and provide support to the neobladder. The consensus panel recognized that posterior reconstruction (Rocco's stitch) offers technical benefits, particularly in reducing tension on the urethra–ileal anastomosis and contributing to its stabilization. However, no consensus was reached regarding its impact on early functional recovery or long-term urinary continence outcomes (40).

URINARY RECONSTRUCTION

The choice of urinary diversion following radical cystectomy should be individualized and based on shared decision-making, taking into account oncologic, anatomical, and functional factors, as well as the patient's overall condition, cognitive status, and quality-of-life expectations.

The panel agrees that the ileal conduit remains the most reproducible and technically reliable form of urinary diversion, particularly in patients with significant comorbidities, frailty, limited functional or cognitive reserve, or higher surgical risk. Although advanced age alone is not an absolute contraindication to orthotopic neobladder, it is associated with an increased risk of complications and lower likelihood of optimal functional outcomes and should therefore be considered in the decision-making process.

Orthotopic neobladder is preferably indicated in patients with a preserved urethra and negative margins, adequate sphincter function, and sufficient renal function—typically defined as a creatinine clearance above 50–60 mL/min—given the metabolic risks associated with intestinal urinary reconstruction. Motivated patients with good functional status and the ability to understand and perform clean intermittent catheterization, if necessary, are more likely to achieve favorable functional outcomes.

In women, preservation of the urethra, anterior vaginal wall, and adequate urethral support are key determinants of eligibility and functional success. The panel emphasizes that careful patient selection is critical to optimize both oncologic safety and functional outcomes.

Major contraindications to continent urinary diversion include significant renal impairment, relevant intestinal disease, sphincter dysfunction, inability to perform self-catheterization, neurological disorders affecting voiding function, and, in selected cases, prior pelvic radiotherapy. In addition, clinically significant hepatic dysfunction—particularly conditions associated with impaired ammonia metabolism—should be considered a contraindication, given the increased risk of hyperammonemia and metabolic complications related to

urinary contact with intestinal segments. These factors are associated with increased risks of metabolic disturbances, urinary retention, and functional failure, and should be carefully considered during patient selection.

Various neobladder techniques have been described in the literature, without definitive evidence demonstrating clear superiority of one approach over another in terms of oncologic or functional outcomes. As such, the choice of technique remains largely dependent on surgeon experience and institutional expertise.

The panel recommends preoperative stoma site marking in patients undergoing ileal conduit (Bricker) urinary diversion. Marking should be performed with the patient awake, ideally in both sitting and standing positions, to optimize placement and reduce postoperative complications. This process may be performed by a trained stoma therapist or by the surgeon.

The panel also recognizes bilateral cutaneous ureterostomy as a valid alternative in selected scenarios, particularly in frail patients, those with high anesthetic risk, limited performance status, reduced life expectancy, or a solitary functioning kidney (46, 47).

Intracorporeal versus Extracorporeal Reconstruction

From a perioperative perspective, intracorporeal urinary diversion (ICUD) has been associated with a lower incidence of gastrointestinal complications, reduced rates of hospital readmission at 30 and 90 days, and a decreased risk of surgical site infection (48). Additionally, ICUD may facilitate faster gastrointestinal recovery, including earlier return of bowel function, earlier resumption of oral intake, and a reduction of approximately one to two days in length of hospital stay when compared with extracorporeal urinary diversion (ECUD) (49, 50); however, no significant differences have been consistently demonstrated between ICUD and ECUD in terms of functional outcomes, including daytime or nighttime continence, or recovery of erectile function (49, 50).

The panel acknowledges that the adoption of ICUD is increasing, particularly in high-volume centers, and reflects a trend toward complete minimally invasive management of radical cystectomy.

Importantly, fully intracorporeal urinary diversion avoids extensive bowel externalization and manipulation. In this context, the panel reached consensus regarding the adoption of mesentery-sparing techniques, which aim to preserve mesenteric vascular integrity, minimize the creation of mesenteric defects, and reduce the risk of internal hernias (51).

Neobladder Techniques Utilized by the Panelists

All panelists reported using the terminal ileum for orthotopic neobladder reconstruction. The terminal ileum remains the preferred segment for both ileal conduit and neobladder construction due to its favorable distensibility, lower peristaltic activity, and suitability for intracorporeal manipulation with robotic and laparoscopic instruments. However, considerable heterogeneity was observed regarding the specific techniques employed in clinical practice. The most frequently reported techniques were the modified Studer neobladder (52) and the "Bordeaux" variant (53), each utilized by approximately 40% of respondents. Other techniques were significantly less commonly used. Notably, 13.8% of panelists reported not performing intracorporeal orthotopic neobladder reconstruction in their practice. These findings highlight the lack of universal technical standardization and reinforce that the choice of technique remains largely dependent on surgeon experience and institutional expertise.

Ileal Segment Length for Intracorporeal Neobladder

Regarding the length of ileum used for intracorporeal orthotopic neobladder construction, variability among specialists was also observed. Most panelists reported using segments ranging from 45 to 60 cm, with 45 cm being the most frequently selected option (34.5%), followed by 60 cm (27.6%) and 50 cm (24.1%). Longer segments, such as 55 cm or greater than 70 cm, were less commonly utilized, while 40 cm was rarely selected. These findings suggest a practical trend concentrated between 45 and 60 cm, although without formal consensus, reflecting adaptation of the technique to individual surgeon preference as well as patient-specific anatomical and functional characteristics.

Urinary Continence and Voiding Function After Robotic Neobladder

Available data demonstrate that urinary continence rates following orthotopic neobladder reconstruction in robotic radical cystectomy are overall comparable to those observed with the open approach, although considerable heterogeneity exists among studies due to differences in study design, continence definitions, follow-up duration, and surgical techniques. In general, when stricter definitions and longer follow-up periods are considered, daytime continence rates range approximately from 60% to 90%, while nighttime continence ranges from 40% to 70%.

These outcomes are multifactorial and depend on factors such as nerve preservation, residual urethral length, sphincter function integrity, reservoir capacity and low-pressure characteristics, as well as the ability to achieve complete bladder emptying. Temporal evolution also plays a significant role, with progressive improvement in functional outcomes observed over the first 12 to 24 months following surgery (54). Retrospective studies with limited sample sizes evaluating nerve-sparing RARC report mean daytime continence rates of approximately 90% and nighttime continence rates around 80% (35, 37, 54).

In a systematic analysis involving different orthotopic neobladder techniques performed intracorporeally in high-volume centers, approximately 88% of patients achieve daytime continence at 1 year (defined as the use of no more than one pad per day), with variability across techniques—for example, 88% for Studer neobladder, 90% for Y-shaped neobladder, and up to 95% for Pyramid and Hautmann techniques. Night-time continence demonstrates greater variability, with generally lower rates that are technique-dependent, being highest in the Hautmann neobladder. The need for clean intermittent catheterization is relatively low, ranging from 0% to 7% in most series, reflecting adequate voiding function in the majority of patients (55).

Overall, the best continence outcomes are observed in high-volume centers and in series with greater technical standardization, and are influenced by factors such as reconstruction technique, surgical experience,

and structured functional rehabilitation protocols. The panel recommends that patients be counseled preoperatively regarding the need for pelvic floor rehabilitation and the potential requirement for clean intermittent catheterization during the early phases of functional recovery.

Intracorporeal urinary diversion requires extensive intestinal mobilization, a step that can be particularly challenging when associated with the mesentery-sparing technique (51). This approach aims to preserve mesenteric vascularization, limiting excessive bowel deflection and reducing the risk of internal hernias. In addition, preserving segmental intestinal perfusion may decrease the likelihood of anastomotic complications, even though it limits mesenteric mobilization and contributes to greater reconstructive safety.

COMPLEX CASES IN ROBOT-ASSISTED RADICAL CYSTECTOMY

Obesity

Obesity represents a relevant technical challenge during robot-assisted radical cystectomy (RARC), particularly due to limited visualization, reduced bowel mobility, and restricted instrument maneuverability related to increased abdominal wall thickness and deeper pelvic anatomy. In this context, the panel recommends technical adjustments to optimize surgical exposure and stability, including more cranial positioning of robotic trocars, controlled increases in pneumoperitoneum pressure. Intracorporeal urinary diversion may further enhance visualization and facilitate surgical control in these patients.

Despite the increased technical complexity and higher baseline risk of perioperative complications, there was agreement among panelists that patients with elevated BMI, including those with BMI >40 kg/m², may benefit from RARC, likely due to reduced abdominal wall trauma, lower wound-related morbidity, decreased post-operative pain, and faster functional recovery. In appropriately selected cases, the robotic approach may also facilitate orthotopic neobladder reconstruction, preserving the option of continent urinary diversion despite the challenges traditionally associated with open surgery

in obese individuals. Accordingly, obesity should not be considered an absolute contraindication to RARC but rather a condition that requires meticulous pre-operative planning and management by experienced surgical teams in high-volume centers (8-10).

Locally Advanced and High-Volume Tumors

In patients with locally advanced bladder cancer (T3-T4) considered resectable, the panel recognizes that RARC may be a feasible approach in high-volume centers with experienced surgeons, even in the presence of adjacent organ involvement or when extended resections are anticipated. Adequate pre-operative imaging is essential to guide surgical planning, including anticipation of extended resections and early definition of the urinary diversion strategy. In anterior or lateral tumors, initiating dissection on the contralateral side may improve vascular control and anatomical orientation. Direct tumor traction and excessive manipulation of bulky bladder masses should be avoided.

In cases of significant bleeding, loss of oncologic planes, or unexpected extensive invasion, conversion to open surgery should be promptly considered to ensure patient safety and oncologic adequacy. In the presence of pelvic sidewall invasion, the panel noted considerable divergence in opinion. This scenario should be regarded as a relative, experience-dependent contraindication, and many experts consider the open approach to remain an appropriate alternative (1, 2, 19, 56).

Bulky Lymphadenopathy

Bulky pelvic lymphadenopathy can significantly distort anatomy, increase adherence to vascular structures, and raise the risk of intraoperative vascular injury.

The panel emphasizes the importance of performing clear vascular dissection above and below the enlarged lymph nodes to ensure precise identification of anatomical landmarks prior to tumor mobilization, thereby reducing the risk of complications (25, 26).

Salvage Robot-Assisted Radical Cystectomy

Salvage RARC following prior trimodal therapy represents an increasingly common clinical scenario, accounting for approximately 6%-18% of cystectomies in high-volume centers (57).

Available evidence demonstrates higher rates of major complications (Clavien $\geq$ III), ranging from 20% to 32%, and positive surgical margins in approximately 10% of cases (23). Prior radiation therapy has been identified as an independent predictor of increased postoperative complications, longer operative time, and prolonged hospital stay (58).

Almost all panelists agreed that RARC is feasible and may be indicated in salvage settings. In this context, the panel recommends a lateral-to-medial dissection approach and the use of advanced energy devices. Patients with prior pelvic irradiation should be carefully counseled regarding the increased risks of bowel complications, ureteroenteric strictures, and urinary or vaginal fistulas (59).

Additionally, intraoperative fluorescence imaging with indocyanine green (ICG) may be considered to assess ureteral and bowel perfusion, potentially reducing the risk of ischemia-related complications (60).

COST-EFFECTIVENESS ANALYSIS OF ROBOTIC RADICAL CYSTECTOMY

Robot-assisted radical cystectomy (RARC) is associated with higher initial costs, primarily related to robotic technology and longer operative time. However, when performed in high-volume centers by experienced surgeons, and combined with intracorporeal urinary diversion (ICUD) and enhanced recovery after surgery (ERAS) protocols, RARC may achieve cost-effectiveness comparable to -or even exceeding- that of open radical cystectomy.

The panel recognizes that improved perioperative outcomes, including reduced complications, shorter hospital stay, and lower readmission rates, may offset the initial procedural costs. Therefore, appropriate patient selection, surgical expertise, and institutional efficiency are key determinants of cost-effectiveness (61-63).

EMERGING ROBOTIC AND TELEPRESENCE PLATFORMS IN RADICAL CYSTECTOMY

New robotic platforms for radical cystectomy are currently undergoing expansion and validation (64). However, the consensus recognizes that clinical evidence specifically in RARC remains limited. Continuous evaluation of safety and efficacy, team experience, and strict adherence to oncologic principles remain more critical determinants of outcomes than the specific robotic platform employed. In parallel, the evolution of telesurgery and telepresence systems represents a potential next frontier for complex oncologic procedures, including radical cystectomy. Recent literature highlights the feasibility of ultra-long-distance robotic surgery supported by high-bandwidth, low-latency networks such as 5G infrastructure, with emphasis on communication redundancy, real-time data transmission stability, and structured governance frameworks for remote implementation. Clinical guidelines for telesurgery stress rigorous validation, defined backup protocols, and clear medico-legal accountability before broader adoption. Although most published human experiences have focused on procedures such as radical prostatectomy, the same technological principles—network reliability, dual-console integration, tele-mentoring capability, and human supervision—are directly translatable to RARC. At present, telesurgery in cystectomy remains investigational, and its safe expansion will depend on robust infrastructure, institutional oversight, and preservation of core oncologic standards (65).

Finally, despite its strengths, this consensus has limitations that should be acknowledged. First, although the recommendations were informed by a review of the current literature and the clinical experience of participating experts, many aspects of radical cystectomy management remain supported primarily by observational studies rather than high-level randomized evidence. As a result, some statements reflect expert interpretation of available data rather than definitive evidence-based conclusions. In addition, practice patterns may vary across institutions depending on surgical expertise, available technology, and patient population, which may limit the generalizability

of certain recommendations. As surgical techniques and perioperative management strategies continue to evolve, particularly with the increasing adoption of minimally invasive approaches and enhanced recovery protocols, these recommendations should be interpreted within the context of ongoing developments in bladder cancer care. Future prospective multicenter studies will be essential to validate and refine these recommendations.

CONCLUSIONS

Radical cystectomy remains the optimal approach of curative treatment for patients with high-risk non-muscle-invasive and muscle-invasive bladder cancer. Despite significant advances in surgical techniques, perioperative management, and patient selection, substantial variability persists in clinical practice across institutions and regions. This consensus provides a structured framework for the contemporary management of patients undergoing radical cystectomy, integrating current evidence with expert clinical experience. By addressing key aspects such as patient selection, surgical approach, perioperative optimization, and postoperative outcomes, these recommendations aim to support standardized, high-quality care and improve oncologic and functional outcomes. Future research should focus on prospective studies evaluating surgical innovations, enhanced recovery strategies, and patient-centered outcomes to further refine the role of radical cystectomy within multidisciplinary bladder cancer care.

CONFLICT OF INTEREST

None declared.

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Influence of Epididymal Anomalies and Development of Processus Vaginalis on Testicular Migration And Cryptorchidism. A Narrative Review

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ABSTRACT

The objective of this narrative review is to show the most relevant aspects of the structure of epididymal anomalies (EAs) and processus vaginalis (PV) during testicular migration and in patients with undescended testis. Smooth and striated muscles develop around the processus vaginalis (PV) within the gubernaculum during fetal life. The testis migrates through the PV by the means of peristaltic activity generated by those muscles. After migration is completed, the smooth muscle undergoes programmed cell death, resulting in obliteration of PV and leaving only the dartos muscle. Initiation of programmed cell death requires a shift in autonomic balance characterized by a decrease in sympathetic tone and a concomitant increase in parasympathetic tone. The shift represents a critical step in the migration process. If the shift occurs prematurely, smooth muscle mass decreases before migration is completed, potentially preventing adequate propulsion of the testis and resulting in undescended testis. Premature shift is persistent. Persistence of this shift links the clinical features associated with failed migration. Conversely, if the shift fails to occur or is insufficient, smooth muscle persists and inhibits obliteration of the PV, leading to inguinal hernia or hydrocele depending on the remaining amount of smooth muscle. Epididymal disjunction anomalies and epididymis atresia could be associated with infertility and are very usual in undescended testis. We can divided EAs in 3 groups: normal variant, disjunction anomalies and epididymis atresia. In the normal variant the epididymis is attached to the testis at the head and tail and totally attached to the testis. The transient presence of SM, its programmed elimination, and regulation by autonomic tone together offer a coherent model that integrates developmental, physiological, and clinical observations. EAs are frequently found in cryptorchidism. Knowledge of anomalies associated with cryptorchidism is relevant in clinical practice, both to prevent accidents during orchidopexy and to counsel and predict infertility in the future, such as in cases of epididymis atresia and total disjunction between the testis and the epididymis.

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INTRODUCTION

Undescended testis can be associated with several anatomical anomalies, but epididymal anomalies (EAs) and patency of the processus vaginalis (PV) are among the most frequent with a very variable incidence in the literature: from 36 to 79% (1-4). Knowledge of EA associated to cryptorchidism is relevant in clinical practice to prevent accidents during orchidopexy and to counsel and predict infertility in the future, such as in cases of epididymis atresia, disjunction of epididymal head and total disjunction between the testis and the epididymis (5, 6).

Some studies show an association of the patency of the PV with EAs and cryptorchidism, suggesting that there is a common stimulus, probably androgenic, participating in the epididymis development, testicular migration and closure of the PV (3, 7). The objective of this review is to show the most relevant aspects of the structure of EAs and PV during testicular migration and in patients with undescended testis.

PROCESSUS VAGINALIS AND TESTICULAR MIGRATION

Despite centuries of attempts to explain testicular migration, none has provided a fully satisfactory account. A paradigm shift offers a more coherent mechanistic explanation (8, 9). Migration of the testis can be conceptualized as work, defined as force multiplied by displacement. Hormones alone do not generate force; therefore, migration requires a structure capable of producing force under hormonal modulation. Failure of migration results in an undescended testis, and any explanation must integrate both the mechanism of descent and the reason for its inhibition.

The processus vaginalis (PV) serves as the pathway for testicular migration. Following descent, the PV should undergo obliteration; failure of this process leads to inguinal hernia or hydrocele. Undescended testis is associated with vaso-epididymal anomalies, disrupted mini-puberty, reduced fertility,

and increased risk of malignancy. A testis that has initially descended may later retract or ascend (10). A comprehensive mechanism should therefore provide a unified explanation for these associated observations.

Patent processus vaginalis and smooth muscle persistence

Sacs obtained from boys with inguinal hernia or hydrocele consistently present smooth muscle (SM) and myofibroblasts beneath the mesothelial layer, whereas obliterated PV lacks these structures (11-13). Multiple independent studies have confirmed that persistence of SM inhibits obliteration of PV (14-23).

Residual SM not only prevents obliteration but may also contribute to clinical complications. For example, persistence of SM may be associated with an increased risk of incarceration in preterm infants and elevated hydrocele pressures (24-26).

Muscular development in the gubernaculum

The PV develops into the gubernaculum. Youssef and Raslan have reported the development of SM in gubernaculum, which disappears after descent (27).

Our studies have demonstrated that striated muscle fibers and myofibroblasts appear within the gubernaculum at 22 weeks of gestation, whereas SM develops around the PV at approximately the 27th week. Cremaster muscle may transdifferentiate from the vascular SM. Myofibroblasts appear to represent an intermediate stage within the differentiation-de-differentiation continuum of SM (28).

The gubernaculum that is described as primitive mesenchymal tissue ceases to exist after development of muscles. We have speculated that INSL3 takes part in myogenesis (8). Yuan et al. subsequently provided support for this proposal (29).

The physiological role of smooth muscle

The transient presence of SM around the PV serves a specific physiological role: propulsion of the testis during migration. This propulsion explains both successful descent and the risk of intrauterine torsion (8-10). Once migration is completed, the SM

undergoes programmed cell death, leaving only the dartos muscle. This interpretation provides a framework that integrates the mechanical, developmental, and pathological aspects of testicular descent.

Programmed cell death of smooth muscle depends on shift in autonomic tonus

After a structure completes its function, it disappears through programmed cell death (PCD). PCD involves both intrinsic and extrinsic pathways. The intrinsic pathway involves calcium signaling that increases cytosolic calcium and promotes mitochondrial calcium loading, leading to opening of permeability transition pores (9).

Maintenance of SM appears to depend on sympathetic tone, whereas activation of the inositol 1,4,5-trisphosphate pathway releases calcium from the intracellular stores and initiate PCD.

These observations suggest that a transient decrease in sympathetic tone combined with an increase in parasympathetic tone may represent the physiological mechanism responsible for PV obliteration.

Silencing of the central catecholaminergic activity may contribute to this shift (9). The key to inguinal hernia, hydrocele and undescended testis lie in this shift of autonomic tone. Deviations in the timing, intensity, or duration of this may lead to pathological outcomes. Because sympathetic tone is sexually dimorphic, this shift may occur more readily in females.

Early shift inhibits migration whereas ineffective shift results in inguinal hernia or hydrocele

If the autonomic shift occurs before testicular migration is completed, premature PCD may reduce the amount of SM surrounding the PV. Remaining SM may not suffice to propel the testis. Minimal SM content results in an undescended testis located at a higher position (8).

If the intensity or duration of shift in autonomic tone is not as effective as required, SM does not undergo PCD and persists (30-32). Persistence of SM inhibits the obliteration of PV, resulting in inguinal hernia or hydrocele depending on the remaining amount of SM (Figure-1) (9,10).

Persistence of autonomic imbalance forms basis for the associated features encountered in undescended testis

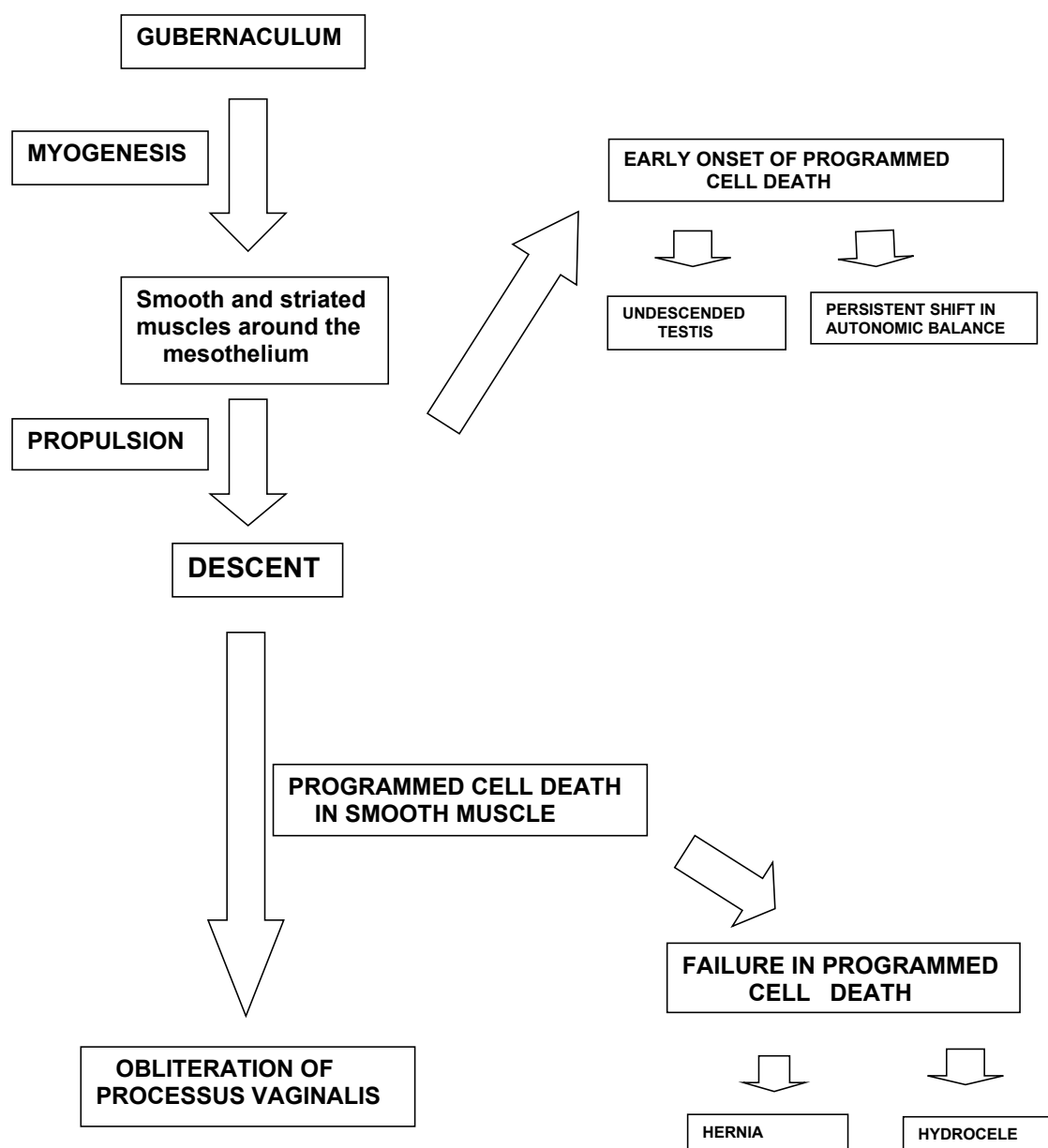
Sacs, cremaster muscles and heart rate variability analysis from boys with undescended testis reveal evidence of defective autonomic innervation via increase in parasympathetic but decrease in sympathetic tones (33-40). Persistence of shift in autonomic tone provides basis for the associated occurrences such as decrease in fertility, increase in risk of malignancy, vaso-epididymal anomalies, disrupted mini-puberty and retractility and ascent.

While parasympathetic tone acts through generating phospholipase C, sympathetic tone acts by generating cyclic adenosine monophosphate (cAMP). Continuous stimulation of phospholipase C pathway by phorbol esters results in the development of tumors. On the other hand, the cAMP pathway is important for spermatogenesis. Differences in signaling pathways with dominance of phospholipase C and decrease in cAMP pathways explain the increase in the risk of malignancy and decrease in fertility (Figure-2) (8, 9). Persistence of signaling towards inducing PCD may also play a role in the reduction of number of germ cells associated with undescended testes.

The gubernaculum also supports the muscular layer of vaso- epididymal structures. Signals towards inducing programmed cell death in SM explains both the reason of vaso-epididymal anomalies and their association with undescended testis (9).

Central catecholaminergic activity also takes place in the regulation of hypothalamic- pituitary-gonadal axis. Since catecholamines take place in the control of pulsatile release of gonadotropin releasing hormone, silencing of central catecholaminergic activity may also affect the hypothalamic- pituitary- gonadal axis (9, 41). On the other hand, testosterone release is also regulated by an efferent neural pathway from the hypothalamus to the testes under the influence of catecholamines (42). Chemical sympathectomy reduces the concentration of testosterone (43). The silencing of central catecholaminergic activity satisfactorily explains the decrease in release of testosterone from the Leydig cells in response to hCG.

Figure 1 - Schematic summary of Testicular Migration.

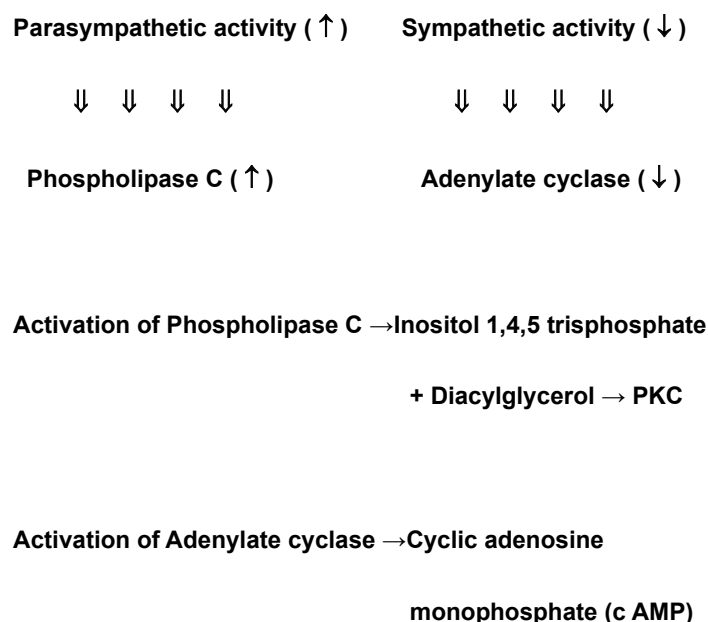


Hypogonadism may result from central catecholaminergic changes directed to shift the autonomic tone. Disrupted mini puberty does not provide basis to inhibit descent but shares the persistent shift in autonomic tone (44).

A migrated testis may subsequently retract or ascend. Retractable testis has traditionally been ex-

plained by a hyperactive cremaster reflex. However, the cremaster reflex cannot be repeatedly induced without a refractory period due to desensitization. Induction of an already induced superficial reflex is not possible until reflex arc is completed. If the retraction results from a reflex arc, the testis should move up and down and stay in the scrotum after de-

Figure 2 - Signaling during persistent shift in autonomic tonus explains the increase in risk of malignancy and decrease in fertility.



sensitization. However, there are no such testes (45-47). The increase in parasympathetic but decrease in sympathetic tones increases cytosolic calcium. Increase in cytosolic calcium contracts a striated muscle. Increased contractility and contracture define the place in the spectrum as retraction or ascent. Cremaster muscles associated with retractile testes share similar alterations as in patients with undescended testis (48, 49). Retraction or ascent does not reflect a hyperactive reflex but reflects the increase of cytosolic calcium in cremaster muscles due to shift in autonomic tones.

EPIDIDYMIS AND TESTICULAR MIGRATION

Testicular migration is a complex process mediated by endocrine and mechanical factors. The integrity of the axis between the testis, hypothalamus and pituitary, which regulates testosterone production, is important for this process.

Cryptorchidism is a common event in pathologies on this axis, such as hypogonadotropic

hypogonadism and 5-alpha reductase deficiency (50). Testosterone appears to play an active role in testicular migration, inducing the development of important structures for testicular migration such as the vaginal process, the vas deferens, the epididymis, the inguinal canal and the scrotum. Another mechanism of action of testosterone would be through stimulation of the genitofemoral nerve, which would induce the production of calcitonin gene-related peptide (CGRP) that acts by stimulating the development of the testicular gubernaculum (51).

Fetal and placental gonadotropins are also implicated in the process of testicular migration. These substances act by stimulating the production of testicular androgens, which induce the growth and development of the vas deferens, the epididymis, the vaginal process and the gubernaculum, itself (52). It is well known that the treatment of cryptorchidism with gonadotropins induces testicular migration at levels ranging from 25 to 55% of cases (53).

Another endocrine substance involved in testicular migration would be descendin. This an-

drogen-independent secreted substance in the testis would play an important role in the growth of the gubernaculum mesenchymal cells. The gubernaculum would therefore be one of the fetal structures implicated in testicular migration, most modified by hormonal action.

Problems with the hypothalamus-pituitary axis are associated with cryptorchidism, which explains the high incidence of this anomaly in patients with Prader-Willi syndrome, Kallman syndrome, pituitary hypoplasia and anencephaly.

Analysis of the nerves of the cremaster muscle of patients with retractile testis also revealed significant differences. These patients had a lower concentration of nerve fibers compared to those with inguinal hernia, but no differences in relation to the group with cryptorchidism. The innervation of the cremaster muscle and the gubernaculum testis originates in the genitofemoral nerve (53). This nerve, through androgenic regulation and the influence of the calcitonin gene-related peptide (CGRP), plays an important role during the testicular migration process, by neuromuscular junction stimulation of the rhythmic contractions of the cremaster muscle during the fetal period (52).

The epididymis is anatomically connected to the gubernaculum, which in turn is attached to the testicle and scrotum (Figure-3). The gubernaculum seems to be the most important anatomical structure in the testicular migration process, by means of contraction and shortening, thus imposing traction strength on the testis and facilitates the transition of the testis by through the inguinal canal (53, 54) (Figure-3).

The growth of the vaginal process divides the gubernaculum into three parts: (a) the main gubernaculum, which corresponds to the portion covered by the visceral layer of the peritoneum of the vaginal process; (b) the vaginal gubernaculum, which corresponds to the portion that externally surrounds the parietal portion of the vaginal process, and (c) the infra-vaginal gubernaculum, corresponding to the caudal region of the gubernaculum, which has not been invaded by the vaginal process (55).

Both the gubernaculum and vaginal process change in harmony during testicular migration. The

maintenance of this undifferentiated mesenchyme along the inguinal canal and scrotum is essential for the downward extension of the vaginal process to occur, during which it follows the pathway created by dilation of the gubernaculum, forming the canal through which the testis will reach the scrotum (53, 55).

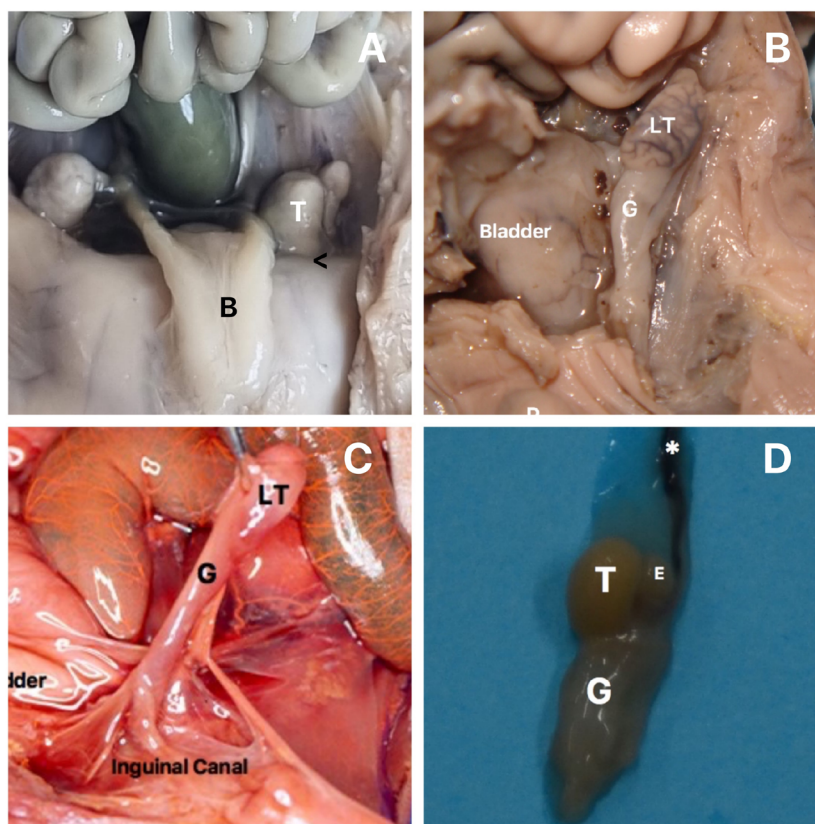
An interesting and controversial theory suggests that the epididymis would be one of the responsible for testicular migration, through its peristaltic and secretory activity in the second gestational trimester (56). This theory would explain some cases of cryptorchidism, where the epididymis is separated and located more inferiorly than the testis (57). Several observations support the theory described above. The epididymis precedes the testicle in the scrotum; the epididymis is in a privileged position to influence testicular migration, as it is anatomically connected to the gubernaculum, which in turn is attached to the testicle and scrotum. Morphological and functional changes occur in epididymis at the time of migration in certain animal species (58, 59).

EPIDIDYMAL ANOMALIES AND UNDESCENDED TESTIS

There are several classifications to analyze the relations between the testis and epididymis (60, 61). We can divide this relationship in 3 groups: normal variant, disjunction anomalies and epididymis atresia. In the normal variant the epididymis is attached to the testis at the head and tail (Figure-4) and totally attached to the testis (Figure-5).

We can observe three types of epididymal disjunction anomalies: Epididymis attached to the testis only at the head (Figure-5); epididymis attached to the testis only at the tail (Figure-6) and no visible connection between the testis and epididymis (Figure-6). The EAs with head disjunction and total disjunction are associated to infertility (62). We can observe example of epididymal atresia in Figure-7.

Mollaeian (1) studied 652 undescended testes and observed epididymal disjunction in 16.87% of the cases. Caterino (63) in a study with 895 patients and Kim (2) in a study with 110 patients reports EAs,

Figure 3 - Testicular migration and gubernaculum.

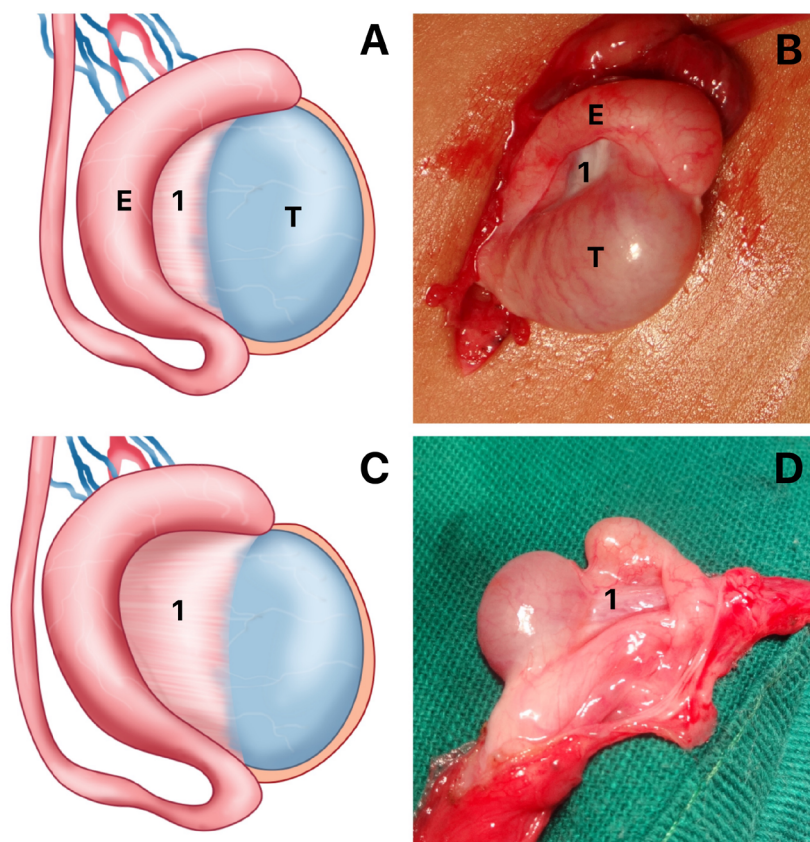
A) The figure shows a fetus with 18 weeks post-conception (WPC) showing the testis (T) beginning its transition in internal inguinal ring (<), B- bladder; B) The figure shows the dissection of the inguinal canal in a fetus with 17WPC. We can observe the gubernaculum (G) attachments with the left testis (LT) and epididymis proximally and with the inguinal region distally; C) In this figure we can observe the dissection of the gubernaculum (G) in a fresh human fetus with 18 WPC, LT - left testis, C- colon and D) The testis (T), epididymis (E) and gubernaculum (G) were removed from a fetus with 20WPC, observe the testicular vessels (*) in proximal position of the testis

respectively, in 96% and 65% - a very high index and probably this high number is associated to a classification that considers normal relationships between testis and epididymis as an anomaly. In a previous study of our group, we observed EAs in 43.7% of the cases; the disjunction of epididymal tail was observed in 25,3%, and disjunctions of epididymal head and total disjunction of epididymis were observed in 18.4% of the cases (62).

The discordant number of EAs associated to undescended testis in several studies can be justified by the lack of definition of the normal pattern of the anatomy of the epididymis in several studies (60, 61). The major risk of infertility in patients with undescended testis may be result from obstruction

associated to epididymal disjunctions anomalies and epididymis atresia (64, 65). The disjunction of epididymal head and total disjunction of epididymis are usual in undescended testes and more frequent in testes situated in high position and with patency of the PV (64, 65). The PV is usually obliterated after the end of the testicular migration (66-68). The patency of the PV in patients with cryptorchidism ranges from 21.3 to 81.3% (2, 66).

The epididymal anomalies of disjunction can be explained by the difference in the embryological origin of the epididymis from the mesonephric duct or by changes in the vascularization during the development of the mesonephric tubules and their fusion with the testicular tubules (69). So we suggest

Figure 4 - Relationship between testis and epididymis - Normal variant.

A) Schematic drawing showing a normal variant of epididymal anatomy - the epididymis (E) is attached to the testis (T) at the head and tail, and we can observe the mesorchium (1); B) We can observe in a undescended testis patient with 3 years old a normal variant of the epididymis (E) - Epididymis is attached to the testis (T) at the head and tail, 1- mesorchium; C) Schematic drawing showing an elongated epididymis with a long mesorchium (1) and D) The same situation in a undescended testis patient with 4 years-old, an elongated epididymis with long mesorchium.

the classification of the epididymal anomalies in disjunctions anomalies, epididymal atresia and elongated epididymis.

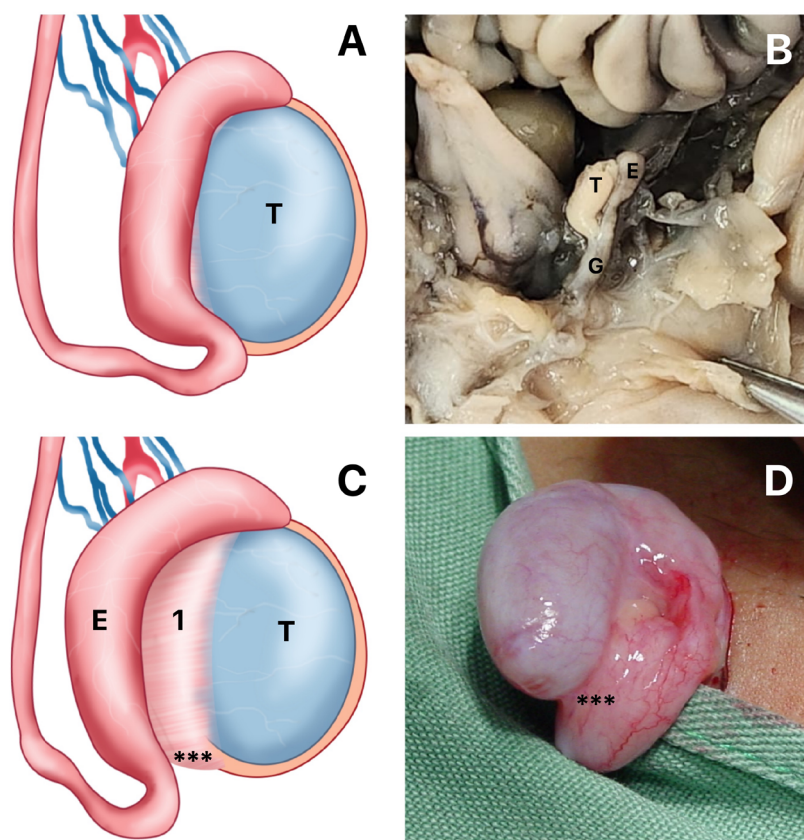
EPIDIDYMAL ANOMALIES AND TESTICULAR TORSION

The testicular torsion is an anomaly resulting from changes in the implantation of the tunica vaginalis or epididymal disjunction (70). Normally, the testis is united to the tunica vaginalis, and if the tunica is implanted too high, the testis can present excessive mobility (bell clapper testis) (70). Mesorchium is the ligament that unites the testis to the epididymis (58). In cases of

epididymal disjunction or elongated epididymis, conditions that are highly frequent in cryptorchism (69, 71, 72) the mesorchium is long and can contribute to the testicular torsion (58) (Figures 5 and 6).

The type of testicular torsion was classified in three groups according to the anatomy of the tunica vaginalis and the relationship between testis and epididymis (73) (Figure-8): Group A - bell clapper testicular deformity (leading to intravaginal torsion); Group B - torsion of spermatic cord (leading to extravaginal torsion) and Group C - torsion due to long mesorchium (Figure-8). Bell clapper deformity (intravaginal torsion) is the most commonly found type of testicular torsion (80%).

Figure 5 - Testis attached to epididymis and Epididymal tail disjunction.



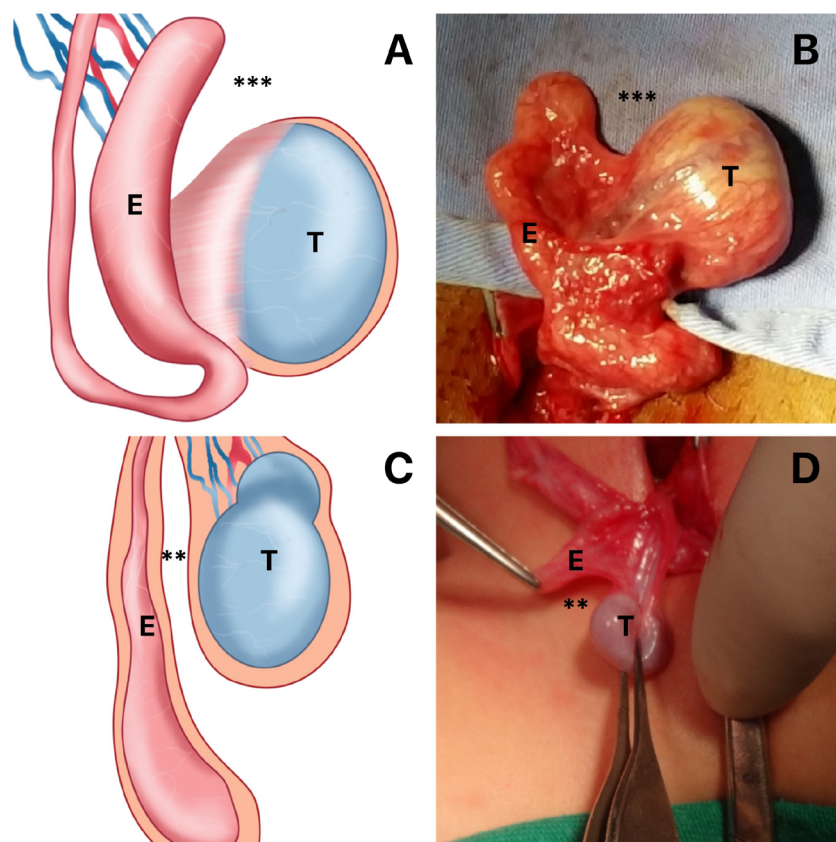
A) Schematic drawing showing a normal variant of the epididymis anatomy - the epididymis is attached to the testis (T) at the head and tail; B) We can observe in a fetus with 16 weeks post-conception a normal variant of the epididymis anatomy - the epididymis (E) is attached to the testis (T), G- gubernaculum; C) Schematic drawing of an epididymal anomaly - disjunction of the epididymal tail (***), T- testis, E- epididymis and 1 - mesorchium and D) We can observe a disjunction anomaly of the epididymal tail (*** in an undescended testis patient with 1 year-old.

Testes present a normal layering of tunica vaginalis. They are involved by this structure on both sides and on their upper portion. The posterior region of testis is not covered by tunica vaginalis. United to the lower pole region of the testis and the epididymal tail, there is the testicular gubernaculum or its remnant, the testicular ligament, which is covered by tunica vaginalis only in its anterior and lateral portions (58). Intravaginal testicular torsion does not occur in testes presenting normal anatomy as described above, because the posterior testicular segment is firmly united to the scrotum, preventing the organ from moving (58, 70).

Normal anatomy of tunica vaginalis or epididymis at the side contralateral to the torsion is very

rare and anatomic anomalies occur bilaterally in the vast majority of cases. These findings stress the need for bilateral orchiopexy in cases of testicular torsion (73). Cases of torsion due to long mesorchium most often occur as a consequence of anomalies of epididymal disjunction or elongated epididymis, conditions that are highly frequent in cryptorchism (58). Of the 8 cases with long mesorchium, 3 (37.5%) had cryptorchid testes.

Approximately 20% of cases of testicular torsion occur in patients with cryptorchism (58). Epididymal anomalies associated with long mesorchium are frequent in patients with cryptorchism, with an incidence ranging from 36 to 72% (71) and rare in in-

Figure 6 - Epididymal anomalies.

A) Schematic drawing showing the epididymal anomalies of head disjunction (***), T- testis, E- epididymis; B) We can observe in a undescended testis patient with 4 years-old the epididymal anomalies of head disjunction (***), T- testis, E- epididymis; C) Schematic drawing showing the total disjunction (**) between the testis (T) and epididymis (E) and D) We can observe in a undescended testis in a patient with 2 years-old the total disjunction (**) between the testis (T) and epididymis (E)

dividuals with topic testes (less than 4%) (60). Due to these changes in mesorchial region, the possibility of testicular torsion must be considered in cryptorchid patients presenting acute scrotal or inguinal pain.

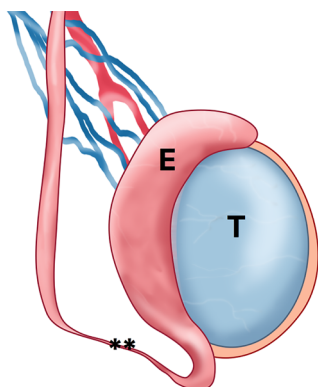
The intravaginal torsion (bell clapper tunica vaginalis) is the most frequent type of torsion, and torsion due to long mesorchium is associated with cryptorchism. The most frequently found anatomical relation between testis and epididymis in the study group was type I (epididymis united to the testis by its head and tail). Historically the bell-clapper deformity is the only anatomical risk factor for the intravaginal torsion but the epididymal dysjunction, despite rare, also play a role in the pathology. In approximate 90%

of the time, a vestigial of Müllerian duct keeps present attached to the upper pole of the testis and is called appendix testis or hydatid of Morgani. This appendix can also twist during lifetime, mimics the testicular torsion clinical presentation and sometimes also requires surgical treatment (74, 75).

CONCLUSIONS

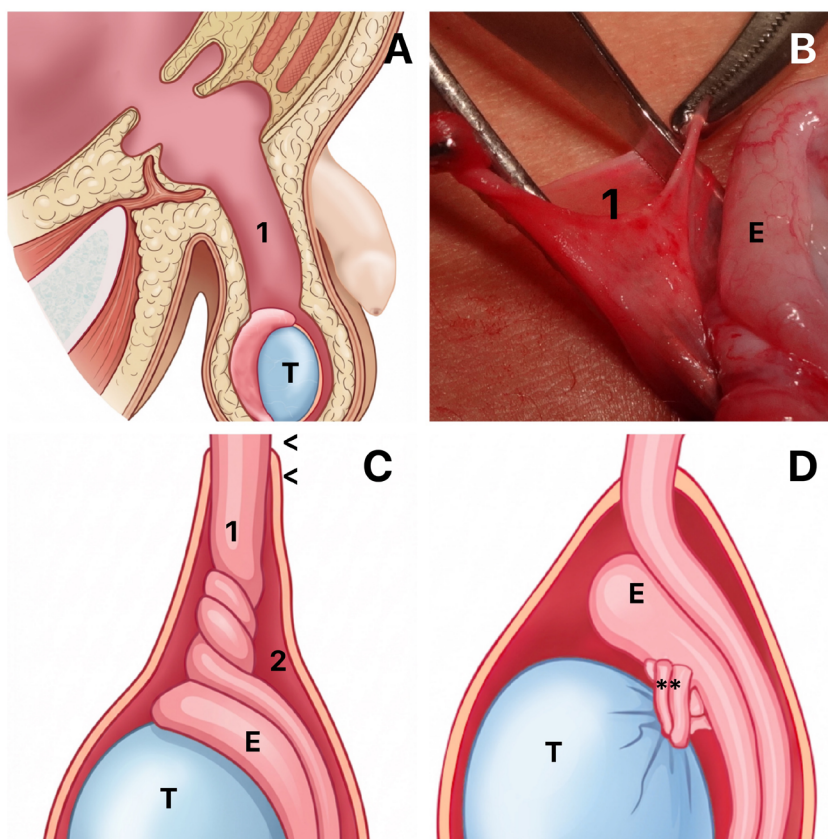
Evaluating testicular migration within this mechanistic framework provides a unified explanation for both successful descent and its associated disorders. The transient presence of SM, its programmed elimination, and regulation by auto-

Figure 7 - Schematic drawing showing the epididymal atresia.



T- testis, E-epididymis and ** - atresia of the epididymal tail.

Figure 8 -Patency of Processus vaginalis.



A) Schematic drawing showing the patency of Processus vaginalis (1), T- testis; B) We can observe in a undescended testis patient with 6 years-old the patency of processus vaginalis (1), E- Epididymis; C) schematic drawing showing the high implantation (<<) of the tunica vaginalis (2) in spermatic vessels (1): the bell clapper testicular deformity (leading to intravaginal torsion), T- testis, E- epididymis and D) Schematic drawing showing the testicular torsion due to long mesorchium (**), T- testis, E- epididymis.

nomic tone together offer a coherent model that integrates developmental, physiological, and clinical observations.

EAs are frequently found in cryptorchidism. Knowledge of anomalies associated with cryptorchidism is relevant in clinical practice, both to prevent accidents during orchidopexy and to counsel and predict infertility in the future, such as in cases of epididymis atresia and total disjunction between the testis and the epididymis.

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CONFLICT OF INTEREST

None declared.

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Energy sources in percutaneous surgery. Are lasers ready to become the gold standard? A narrative review

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ABSTRACT

Introduction: Nephrolithiasis is a prevalent and recurrent condition affecting approximately 10–11% of the population. Percutaneous nephrolithotomy (PCNL) and mini-PCNL are established treatments for large renal stones. Outcomes are influenced by the choice of lithotripsy energy source. Available technologies include pneumatic, ultrasonic, Holmium:YAG (Ho:YAG), and thulium fiber laser (TFL), each with specific advantages and limitations. This review summarizes current evidence on these energy sources in PCNL and mini-PCNL.

Materials and methods: A narrative review was performed using PubMed and Cochrane Library, including studies published between 2014 and 2024. The search included terms related to PCNL and lithotripsy energy sources. Studies involving pediatric populations, anomalous kidneys, or non-standard energy sources were excluded. After screening 95 articles, 32 studies were included, of which 13 provided comparative data on different energy sources and were analyzed.

Results: Differences were observed in operative time, stone-free rates (SFR), bleeding, transfusion rates, complications, and hospital stay. In PCNL, ultrasonic and Ho:YAG lithotripsy showed comparable outcomes, while pneumatic demonstrated slightly lower SFR. In mini-PCNL, ultrasonic and laser technologies yielded similar efficacy. TFL displayed shorter operative time and reduced bleeding and transfusion rates compared to Ho:YAG, although many differences did not reach statistical significance.

Conclusion: Ultrasonic and Holmium:YAG lithotripsy provide comparable outcomes in PCNL, while pneumatic devices may correlate with slightly lower stone-free rates. In mini-PCNL, ultrasonic and laser modalities show similar outcomes. TFL demonstrates potential advantages in operative time and bleeding, however, evidence remains heterogeneous, and further high-quality studies are needed.

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INTRODUCTION

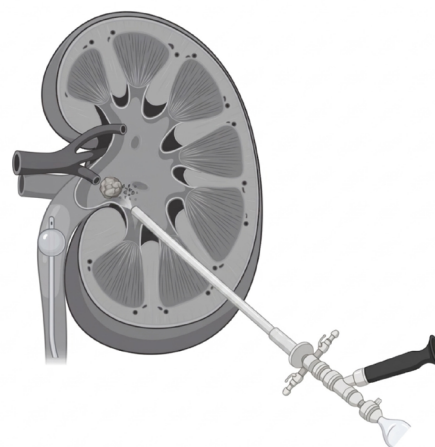
Nephrolithiasis is a common condition affecting millions of individuals worldwide. Epidemiological data from the United States demonstrate a marked increase in both incidence and prevalence over recent decades. Analyses from the National Health and Nutrition Examination Survey (NHANES) estimate a kidney stone prevalence of approximately 10–11%, with an annual incidence approaching 1%. Although rates remain higher in men (1), the incidence among women has increased progressively, suggesting a narrowing gender gap (2). Historically, prevalence increased from 3.8% in the late 1970s to 5.2% in the early 1990s, highlighting a sustained upward trend over time (3). Globally, urolithiasis affects approximately 116 million individuals currently, particularly in low- and middle-income countries, reflecting the impact of urbanization, dietary changes, and metabolic risk factors (4). Furthermore, kidney stone disease is characterized by a high recurrence rate, with approximately 30–50% of patients experiencing recurrence within 5 years (5), reinforcing its chronic and relapsing nature.

Percutaneous nephrolithotomy (PCNL) is the standard treatment for large renal stones (6). Since its introduction in the 1970s, the technique has undergone notable evolution, particularly with the development of miniaturized approaches such as mini-percutaneous nephrolithotomy (mini-PCNL). These techniques aim to reduce surgical morbidity while maintaining efficiency. Compared with standard PCNL, mini-PCNL is associated with shorter hospital stay and lower bleeding rates, although it may be associated with longer operative times (7) (Figure-1).

One crucial factor for the success of PCNL and mini-PCNL is the selection of the appropriate energy sources for lithotripsy, as each modality presents specific advantages and limitations. The main energy sources currently used include pneumatic (ballistic), ultrasonic, and laser technologies like Holmium:YAG and Thulium laser (6, 8).

Pneumatic lithotripsy relies on the rapid forward movement of a projectile, generating a jackhammer effect on the stone. This mechanism may be driven by compressed air, carbon dioxide, or electrokinetic en-

Figure 1 - Schematic illustration of laser lithotripsy during percutaneous nephrolithotomy (PCNL).



ergy. It is considered a safe and effective modality, particularly for the fragmentation of harder stones (9, 10).

Ultrasonic lithotripsy is based on the transmission of ultrasonic vibrations generated by a piezoceramic crystal to a metallic probe in direct contact with the stone. This technique is low-cost, highly effective, and associated with minimal tissue injury, with the additional advantage of allowing simultaneous fragmentation and aspiration of stone debris (8). However, its efficacy may be reduced in certain stone compositions, such as cystine and calcium oxalate monohydrate, as well as in smoother calculi (9).

Lasers represent an alternative energy sources for lithotripsy in PCNL, acting through the thermal expansion and vaporization of water within the calculus (photothermal effect). Two main laser systems are currently used for stone treatment: the Holmium:YAG laser and the thulium laser (11, 12).

The Holmium:YAG laser is generated by excitation of holmium ions embedded in a yttrium-aluminum-garnet (YAG) crystal, typically using a flashlamp, resulting in the emission of pulsed infrared laser energy. High-power lasers (>30 Hz) are generally associated with the production of fine particles that can be cleared spontaneously, whereas low-power lasers (≤ 15 –20 Hz) tend to generate larger fragments requiring active retrieval or suction (13, 14).

Thulium lasers utilize thulium ions excited directly by high-power laser diodes. Two main types of thulium laser systems are available. Thulium:YAG lasers operate at a wavelength of 2010–2013 nm and are effective for both lithotripsy and soft tissue cutting and coagulation (12). In contrast, Thulium fiber lasers operate at a wavelength of 1940 nm and employ a fiber-based amplification system, enabling more precise and flexible energy delivery. This technology allows for higher pulse frequencies and lower pulse energies compared with thulium:YAG systems (11, 15).

These differences in design and emission characteristics result in distinct operational profiles, with clinical implications under investigation (11, 15). A potential limitation of both Holmium:YAG and thulium laser systems is the lack of integrated suction, important in the management of larger stone burdens.

The choice of energy sources in PCNL and mini-PCNL should take into account the nephroscope size, stone characteristics and surgeon experience. In this context, a comprehensive understanding of the available technologies becomes essential. Therefore, the aim of this article is to review the current literature on the various energy sources used for lithotripsy in PCNL and mini-PCNL, in order to assist urologists in selecting the most appropriate option for each clinical scenario.

MATERIALS AND METHODS

A structured literature review was performed in PubMed and the Cochrane Library between June and September 2024. The search strategy included combinations of Medical Subject Headings (MeSH) terms and key words related to percutaneous nephrolithotomy and lithotripsy energy sources, including: "percutaneous nephrolithotomy", "ultrasonic lithotripsy", "pneumatic lithotripsy", "holmium laser", and "thulium laser", combined using the Boolean operators AND and OR.

Articles published between 2014 and 2024 were considered. A total of 95 records were initially identified. After initial review, 63 studies were excluded: 17 for involving pediatric populations, stones in anomalous or transplanted kidneys, and 46 for not providing direct comparative analysis, or use of energy sources other

than ultrasonic, pneumatic, Holmium:YAG laser, or thulium laser.

A total of 32 articles supported this review, among these, 13 provided comparative data on different energy sources in PCNL and mini-PCNL and were included in the scope of this analysis (Figure-2).

RESULTS

This review comprised 32 studies, including 13 that performed comparative evaluations of different energy sources in PCNL and mini-PCNL, most of which were non-randomized. Comparative evidence comprised three randomized controlled trials (RCTs), a limited number of prospective non-randomized comparative studies, and predominantly retrospective studies.

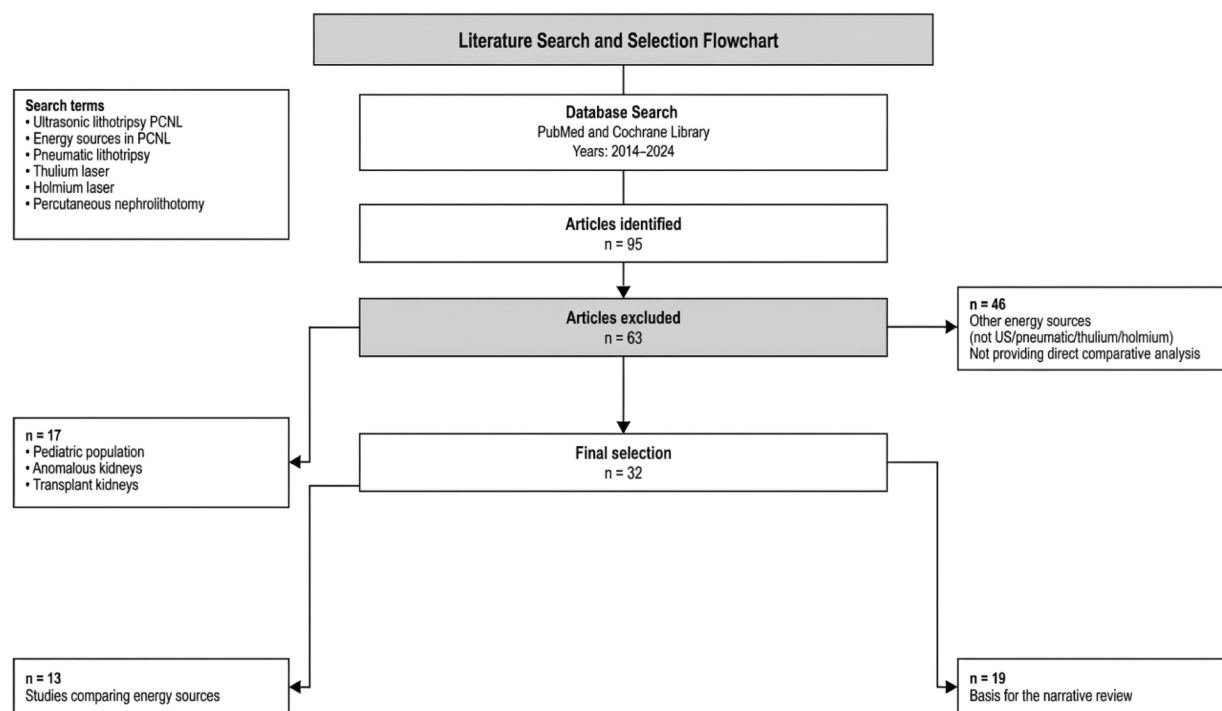
In PCNL, two studies compared Holmium laser and ultrasonic lithotripsy, three evaluated ultrasonic versus pneumatic lithotripsy, and two assessed laser versus pneumatic energy sources. In the mini-PCNL subgroup, two studies compared laser and ultrasonic lithotripsy, one compared laser and pneumatic modalities, and three studies directly compared Thulium Fiber Laser (TFL) and Holmium:YAG laser.

PCNL

The main outcomes evaluated were operative time, stone-free rate (SFR), blood loss, complications, and hospital stay.

Two studies (one retrospective and one randomized trial) compared Holmium:YAG laser and ultrasonic lithotripsy. Timm et al. (16) reported a shorter operative time with Holmium:YAG laser, whereas El-Nahas et al. (17) reported a shorter operative time in the ultrasonic group (130 ± 34 minutes vs. 148.7 ± 35 minutes). Stone-free rates, transfusion rates and complications were similar between groups. Blood loss was lower in the Holmium:YAG laser group (1.3 g/dL vs. 1.7 g/dL). (Table-1).

Three randomized studies (8, 18, 19) compared ultrasonic and pneumatic lithotripsy in PCNL. Operative time was shorter and stone-free rates were slightly higher in the ultrasonic group in two of the three stud-

Figure 2 - Literature Search and Selection Flowchart.

ies; however, these differences did not reach statistical significance. Blood loss and complication rates were similar between groups. (Table-1).

Two studies (20, 21) compared Holmium:YAG laser and pneumatic lithotripsy in PCNL. Dua et al. (20) reported shorter operative time with pneumatic lithotripsy, whereas Hong et al. (21) did not confirm this finding. Stone-free rates were higher in the Holmium:YAG laser groups in both studies. Results regarding bleeding and hospital stay were inconsistent (Table-2).

Mini-PCNL

Two studies (22, 23) compared ultrasonic lithotripsy and laser in mini-PCNL. Ultrasonic lithotripsy showed shorter operative time compared to Holmium:YAG laser, but longer operative time compared to TFL. Stone-free rates, blood loss, and complication rates were similar across groups. (Table-3).

One study (24) compared Holmium:YAG laser and pneumatic lithotripsy in mini-PCNL, reporting

comparable outcomes across all evaluated parameters (Table-3).

Three studies (25,15,26) compared Holmium:YAG laser and thulium fiber laser. TFL was associated with shorter operative time, lower blood loss, and reduced transfusion rates. (15, 25). Complication rates, hospital stay, and stone-free rates were similar between groups. In contrast, Vergamini et al. (26) reported shorter operative time with the Holmium:YAG laser (Table-4).

Overall, most studies showed comparable stone-free rates and complication profiles across different energy sources, while operative time and bleeding outcomes varied between techniques.

DISCUSSION

This narrative review highlights the advancements and challenges in energy sources for PCNL and mini-PCNL, based on the evaluation of 13 studies of direct comparative analysis, emphasizing their impact on procedural outcomes, patient safety, and clinical efficacy.

Table 1 - Comparative outcomes of Holmium:YAG laser and Ultrasonic lithotripsy in PCNL.

Study	Surgery Time (minutes), mean $\pm$ SD.	Stone-Free Rate (%)	Bleeding (hemoglobin deficit, g/ dL), mean $\pm$ SD or Estimated Blood Loss	Complications (% of patients)	Transfusion (%)	Median Hospital Stay (days)
Timm et al. (16)	Ho: 80.2 $\pm$ 16.7 US: 90.9 $\pm$ 28.1	Ho: 62.5 US: 55.5	NR	Ho: 9.1 G-II US: 6.25 G-IIIa	Ho: 9.1 US: 6.25	Ho: 3 US: 3
El-Nahas et al. (17)	Ho: 148.7 $\pm$ 35* US: 130.1 $\pm$ 34*	Ho: 66 US: 60	Ho: 1.3* US: 1.7*	Ho: 6 G-I, 11 G-II, 6 G-IIIa. US: 6 G-I, 17.9 G-II, 9 G-IIIa, 3 G-IVa	Ho: 11 US: 17	Ho: 5.1 US: 5.6
Radfar et al. (8)	US: 66.14 $\pm$ 30.11 Pneumatic: 68.17 $\pm$ 34.12	US: 90. Pneumatic: 93	US: 1.89 $\pm$ 0.47 Pneumatic: 1.76 $\pm$ 0.18	US: 11.95 G-I, 6.52 G-II. Pneumatic: 10.22 G-I, 7.95 G-II, 1.13 G-III.	NR	US: 3.19 $\pm$ 0.55 Pneumatic: 3.23 $\pm$ 0.77
Cauni et al. (18)	US: 43.5 Pneumatic: 77.13	US: 89.3 Pneumatic: 78	NR	US: 17.9 Pneumatic: 23	US: 0,071 Pneumatic: 0	NR
York et al. (19)	US: 152.2 Pneumatic: 129.8	US: 56.5 Pneumatic: 51.6	US: (>400mL) 4.4 Pneumatic: (>400mL) 6.7	US: 16.7 Pneumatic: 17.5	US: 2.9 Pneumatic: 4.0	US: 2.6 Pneumatic: 1.9

Ho: holmium laser; US: ultrasonic lithotripsy; SD: standard deviation; Hb: hemoglobin; min: minutes; NR: Not reported. *: statistically significant ($p < 0.05$). G-I, G-II, G-III, G-IIIa, G-IVa: Clavien-Dindo Grade I, Grade II, Grade III, Grade IIIa, and Grade IVa complications, respectively.

Table 2 - Comparative outcomes of Holmium laser and Pneumatic lithotripsy in PCNL.

Study	Surgery Time (minutes), mean $\pm$ SD.	Stone-Free Rate (%)	Bleeding (hemoglobin deficit, g/ dL), mean $\pm$ SD or patients with deficit > 0.5 g/dL	Complications (% of patients)	Transfusion (%)	Median Hospital Stay (days)
Dua et al. (20)	Ho: 59.7 $\pm$ 12.3* Pneumatic: 54.9 $\pm$ 13.2*	Ho: 94% Pneumatic: 88%	Ho: 13 patients Pneumatic: 11 patients	Ho: 14 Pneumatic: 16	Ho: 2 Pneumatic: 2	Ho: 5.9 $\pm$ 1.5 Pneumatic: 5.5 $\pm$ 1.7
Hong et al. (21)	Ho-YAG: 134.27 $\pm$ 53.38 Pneumatic: 137.7 $\pm$ 47.79	Ho-YAG: 59.09 Pneumatic: 48.15	Ho-YAG: 12 $\pm$ 15.42* Pneumatic: 19 $\pm$ 11.23*	NR	NR	Ho-YAG: 7.73 $\pm$ 2.75* Pneumatic: 8.94 $\pm$ 4.2*

Ho: Holmium laser; SD: standard deviation; Hb: hemoglobin; min: minutes; NR: Not reported. *: statistically significant ($p < 0.05$).

Table 3 - Comparative outcomes of Ultrasonic lithotripsy, TFL, and Holmium:YAG laser in mini-PCNL.

Study	Surgery Time (minutes), mean $\pm$ SD.	Stone-Free Rate (%)	Bleeding (hemoglobin deficit, g/ dL), mean $\pm$ SD	Complications (% of patients)	Transfusion (%)	Median Hospital Stay (days)
Akbulut et al. (22)	US: 107 $\pm$ 34.9 Ho-YAG: 113.5 $\pm$ 50.5	US: 68.1 Ho-YAG: 81.8	US: 1.15 $\pm$ 1.15 Ho-YAG: 0.93 $\pm$ 1.0	US: 18.2 G-IIIa Ho-YAG: 3.64 G-II, 9.1 G-III	NR	US: 79.6 $\pm$ 38.7 Ho-YAG: 74.2 $\pm$ 22.1
Patil et al. (23)	US: 32.48 $\pm$ 15.39 TFL: 28.63 $\pm$ 18.56	US: 96.6 TFL: 76.6	US: 1.19 $\pm$ 0.76 TFL: 0.99 $\pm$ 0.74	US: 10 G-II TFL: 6.67 G-II	US: 0. TFL: 0.	NR
Sharma et al. (24)	Ho-YAG: 52 $\pm$ 7.56 Pneumatic: 56 $\pm$ 7.84	Ho-YAG: 92.5 Pneumatic: 86.67	Ho-YAG: 0.88 $\pm$ 0.16 Pneumatic: 0.89 $\pm$ 0.23	NR	NR	Ho-YAG: 1.67 $\pm$ 0.45 Pneumatic: 1.73 $\pm$ 0.45

Ho-YAG: Holmium:YAG laser; US: ultrasonic lithotripsy; SD: standard deviation; Hb: hemoglobin; min: minutes; NR: Not reported; TFL: thulium fiber laser.*: statistically significant ($p < 0.05$).

G-II, G-III, G-IIIa: Grade II, Grade III, and Grade IIIa Clavien-Dindo complications, respectively.

Table 4 - Comparative outcomes of Holmium and Holmium:YAG Lasers versus Thulium Fiber Laser in mini PCNL.

Study	Surgery Time (minutes), mean $\pm$ SD.	Stone-Free Rate (%)	Bleeding (hemoglobin deficit, g/dL), mean $\pm$ SD.	Complications (% of patients)	Transfusion (%)	Median Hospital Stay (median-range, days)
Patil et al. (25)	Ho: 41.86 $\pm$ 13.2* TFL: 23.68 $\pm$ 11.34*	Ho: 78.43 TFL: 68.63	Ho: 1.04 $\pm$ 0.445 TFL: 1.05 $\pm$ 0.711	Ho: 5.88 G-II TFL: 5.88 G-II	NR	NR
Mahajan et al. (15)	Ho-YAG: 68* TFL: 55*	Ho-YAG: 90.9 TFL: 94.9	Ho-YAG: 1.1* TFL: 0.9*	Ho-YAG: 6.1 G-I, 3 G-II TFL: 17.5 G-I, 1.8 G-II	Ho-YAG: 2.5* TFL: 0*	Ho-YAG: 1.5 TFL: 1.3
Vergamini et al. (26)	Ho-YAG: median of 67* TFL: median of 91*	Ho-YAG: 54.9 TFL: 67.3	Ho-YAG: 1.1 TFL: 1.0	Ho-YAG: 1.9 G-I, 1.9 G-II TFL 4 G-I, 2.2 G-II	NR	Ho-YAG: 1 (1-5) TFL 1 (1-3)

Ho-YAG: Holmium:YAG laser; SD: standard deviation; Hb: hemoglobin; min: minutes; NR: Not reported; TFL: thulium fiber laser. *: statistically significant ($p < 0.05$).

G-I, G-II: Grade I and Grade II Clavien-Dindo complications, respectively.

Ultrasonic lithotripsy is one of the most used energy sources in PCNL and has been the gold standard especially for large stones, with devices like the Lithoclast Master (or Lithoclast Ultra®), Trilogy® and Shock Pulse-SE® offering distinct characteristics that influence

their advantages and disadvantages in renal stone treatment. The Lithoclast Master®, a device combining pneumatic and ultrasonic energy, with suction, is effective for fragmenting hard stones. In contrast, Trilogy® represents a next-generation system that integrates ultrasonic and

electromagnetic impact energy with active suction in a single probe. Studies have shown that Trilogy® trends toward faster stone clearance rates due to its optimized energy delivery and suction capabilities, reducing the risk of fragment blockage when compared to the Lithoclast Master (7, 27, 28). It also offers customizable settings for different stone types, with low complications rates (7, 27, 28). However, Trilogy has reported drawbacks, including less ergonomic design, occasional probe failures and higher cost, potentially limiting its accessibility (28). The ShockPulse-SE, which combines continuous ultrasonic energy with intermittent ballistic impact and integrated suction, also indicates efficient performance in stone fragmentation and removal, with operative times and safety profiles comparable to or better than traditional devices (8, 29, 30). Experimental studies and animal models have shown that both Trilogy and ShockPulse-SE outperform the Lithoclast Master in stone clearance efficiency, especially when larger-caliber probes are used (8, 30). In direct comparisons, Trilogy often achieves faster clearance times than ShockPulse-SE, although both are superior to previous-generation devices (8, 30). The choice between devices may depend on institutional factors, availability, cost, and surgeon preference, as both offer relevant technical advantages.

In this analysis, studies comparing Holmium:YAG laser and ultrasonic lithotripsy in standard PCNL (Table-1) demonstrate heterogeneous results. Operative time showed conflicting findings, with Timm et al. (16) reporting shorter procedures with the Holmium:YAG laser, whereas El-Nahas et al. (17) observed longer operative times with this modality. Stone-free rates were similar between groups. Regarding bleeding, El-Nahas et al. (17) reported a statistically significant lower hemoglobin drop in the Holmium:YAG group. Complications, transfusion rates and length of stay were comparable between modalities, with no clear advantage for either technique. Overall, these findings suggest equivalent efficacy, with a potential advantage of Holmium:YAG laser in reducing blood loss.

The comparison between ultrasonic and pneumatic lithotripsy in standard PCNL (Table-1), also revealed equivalent outcomes. Operative time was similar,

although Cauni et al. (18) reported shorter procedures with ultrasonic devices, while York et al. (19) observed longer operative times compared to pneumatic lithotripsy. Stone-free rates were comparable across studies. Despite slight variations in reported hemoglobin drop, estimated blood loss, transfusion rates and overall complications were similar in both techniques. Overall, both modalities demonstrate similar efficacy and safety profiles, with no clear superiority.

Finally, studies comparing Holmium:YAG laser and pneumatic lithotripsy in standard PCNL (Table-2) suggest a trend toward improved stone clearance with laser technology. Operative time, complications and transfusion rates were similar between groups. Notably, Hong et al. (21) reported a statistically significant decrease in bleeding and hospital stay associated with Holmium:YAG lithotripsy. Overall, these findings suggest a potential advantage of Holmium:YAG laser in stone clearance.

In mini-PCNL, the use of ultrasonic energy is less prevalent compared to other modalities, primarily due to the limitations associated with probe size. Reduction in size of the ultrasound probes can lead to technical challenges, such as decreased power and efficiency in stone fragmentation, which are critical for effective lithotripsy (31). The study by Tabib et al. (32) highlights the performance of various lithotrites in a benchtop model, showing that mechanical lithotrites like the Trilogy 1.9 mm probe demonstrated superior stone clearance rates compared to smaller probes and laser fibers (32). These technical limitations can make ultrasound less favorable compared to other energy sources that can be more effectively miniaturized without significant loss of performance. Therefore, while ultrasound energy can be used in mini-PCNL, the preference for laser lithotripsy is often due to the superior performance and efficiency of these technologies. Operative time was similar between groups across studies. However, stone-free rates were inconsistent, with Akbulut et al. (22) favoring Holmium:YAG laser, whereas Patil et al. (23) reported higher clearance rates with ultrasonic lithotripsy. Hemoglobin drop tended to be slightly lower in laser groups but no significant differences in transfusion rates were observed, and complication rates were comparable.

Hospital stay was also similar between modalities. As no statistical significance was obtained, these findings suggest that both techniques are effective, with no consistent superiority.

In the realm of laser lithotripsy for mini-PCNL, this analysis reveals a heterogeneous set of findings, where the Holmium:YAG laser is challenged by newer technologies, particularly the Thulium Fiber Laser.

The Holmium:YAG laser is a cornerstone in mini-percutaneous nephrolithotomy due to its proven efficacy and versatility. These systems operate at a wavelength of 2120 nm, providing efficient stone fragmentation and tissue ablation with minimal thermal damage. High-power lasers offer adjustable pulse durations and high-power settings where low power lasers, on the other hand, are known for their reliability and low cost, making it a popular choice for urologists performing both conventional and miniaturized PCNL. However, the results from comparative studies suggest that its dominance is not absolute. While equivalent stone-free rates (SFR) and complications between Holmium and ultrasonic lithotripsy are reported, the comparison with TFL is more informative. Two studies demonstrated a statistically significant reduction in operative time with TFL, and one of them observed a statistically significant decrease in bleeding and transfusion rates (15, 25). This may be explained by the TFL's higher absorption in water, leading to potentially less thermal spread to surrounding tissue.

Conversely, the study by Vergamini et al. (26) presented a contrasting outcome, reporting a shorter surgical time for a Holmium:YAG laser system with MOSES technology compared to TFL. This finding suggests an important aspect: the performance of a laser is not solely defined by its wavelength but also by its specific pulse modulation technology (e.g., MOSES, Vapor Tunnel) and the surgeon's technique. This conflict in the evidence indicates that the choice between Holmium systems with pulse modulation and TFL may, in some cases, be influenced by factors beyond the laser source itself.

Thulium Fiber Laser has gained traction due to its low weight and efficient profile. Operating at a wavelength of 1940 nm, TFL systems excel in water absorption, enabling finer stone dusting and reduced retro-

pulsion during percutaneous and mini-percutaneous nephrolithotomy. On the other hand, TFL has a lower peak-power, making it less efficient in hard stones. The available evidence suggests TFL's favorable profile for mini-PCNL. It's better in operative time and bleeding align with its theoretical advantages. The more efficient "dusting" capability of TFL appears to be well suited for procedures utilizing suction sheaths, where the goal is to clear the field continuously without the need for fragment removal. However, it is crucial to balance this enthusiasm with practical considerations. The TFL's lower peak power, compared to Holmium:YAG, may translate into less efficiency when facing very hard stones. This potential limitation was not directly assessed in the included studies but remains a relevant factor for surgical planning.

As for the Thulium:YAG laser, the current body of evidence is insufficient to draw definitive conclusions about its role in PCNL and mini-PCNL. This review identified a notable lack of clinical studies directly comparing Tm:YAG with Ho:YAG or TFL in the percutaneous setting. While its wavelength of 2013 nm and uniform pulse profile present a relevant theoretical profile, the absence of robust clinical data prevents any meaningful comparison of its efficacy and safety against the established options. Therefore, its promise, though attractive, remains largely unvalidated in clinical practice for this specific application.

In summary, while the Holmium:YAG laser continues to be a reliable and effective standard, the TFL is associated with improved outcomes in some parameters for mini-PCNL. The choice between them may depend on stone characteristics, available technology, and surgeon expertise. The role of Tm:YAG, however, awaits further clinical validation.

Despite these advancements, several limitations in the current evidence must be acknowledged. The heterogeneity of study designs, patient populations, and surgical settings introduces variability that may limit the generalizability of findings. Future research should prioritize large-scale randomized controlled trials comparing newer laser technologies to the traditional methods like ultrasound and ballistic lithotrites. Cost-effectiveness analyses and studies incorporating patient-

reported outcomes will also be essential to guide clinical decision-making.

CONCLUSIONS

This narrative review elucidates the comparative efficacy, safety, and practical considerations of various energy sources in PCNL and mini-PCNL, providing evidence-based insights to guide clinical decision-making.

In PCNL, ultrasonic lithotripsy and Holmium-Yag laser demonstrates comparable SFR with reduced blood loss with Holmium laser. Ultrasound provides shorter operative times and higher SFR when compared to pneumatic devices. Holmium laser also demonstrated superior stone-free rates compared to pneumatic lithotripsy.

In mini-PCNL ultrasound and Laser are equivalent with similar SFR, surgery times and complications. TFL provides reduced operative time, bleeding, and transfusion rates compared to Holmium:YAG, not evidenced when Holmium:YAG is coupled with MOSES technology.

ABBREVIATIONS

PCNL = Percutaneous nephrolithotomy

mini-PCNL = Mini-percutaneous nephrolithotomy

Ho:YAG / Ho-YAG = Holmium:yttrium-aluminum-garnet (laser)

TFL = Thulium fiber laser

Tm:YAG = Thulium:yttrium-aluminum-garnet (laser)

SFR = Stone-free rate

RCT = Randomized controlled trial

NHANES = National Health and Nutrition Examination Survey

MOSES = Modulated Output Synchronized Energy System (pulse modulation technology for Holmium laser)

EMS = Electro Medical Systems (LithoClast manufacturer)

NR = Not reported

SD = Standard deviation

G-I, G-II, G-IIIa, G-IVa = Clavien-Dindo complication grades I, II, IIIa, and IVa

YAG = Yttrium-aluminum-garnet

CONFLICT OF INTEREST

None declared.

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Robot-assisted Partial Nephrectomy with the new HugoRAS System: single center matched-pair analysis

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ABSTRACT

Purpose: Robotic-assisted surgery represents a leading innovation in kidney-sparing procedures across specialized urology centers. As new robotic platforms continue to emerge, comparisons with conventional laparoscopy remain necessary. This study focuses on comparing oncological, perioperative and functional outcomes of robot-assisted partial nephrectomy (RAPN) with the Hugo™ RAS system and laparoscopic partial nephrectomy (LPN) within a tertiary institution.

Materials and Methods: A retrospective single-center study included 165 patients who underwent LPN (n=95) or RAPN (n=70). Perioperative clinical data, tumor characteristics, oncological and functional outcomes were obtained. Propensity score matching (1:1) was implemented to mitigate selection bias. Trifecta and pentafecta were assessed as composite surgical success endpoints. Multivariate logistic regression analyses were performed to identify the predictive factors for each.

Results: Following propensity score matching, 70 patients were included in each group. Operative time, WIT and estimated blood loss did not differ significantly. RAPN was associated with a shorter length of stay (3 days vs 5 days, $p<0.001$) without increased complication rate. Renal functional outcomes, including $\geq 90\%$ eGFR preservation and CKD upstaging, were similar. Trifecta (LPN 84.3% vs. RAPN 85.7%) and pentafecta (LPN 48.6% vs. RAPN 57.4%) achievement were comparable. On multivariate analysis, higher RENAL score was the only independent predictor of trifecta failure (OR 1.410, $p=0.027$). For pentafecta, higher RENAL score (OR 1.396, $p=0.030$), older age (OR 0.929, $p=0.001$), and lower pre-operative eGFR (OR 0.981, $p=0.049$) were independent predictors of failure.

Conclusions: The study reinforced the effectiveness and safety of the new Hugo™ RAS platform for partial nephrectomy, without compromising oncological and functional success.

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INTRODUCTION

Minimally invasive partial nephrectomy (MIPN) has become the gold standard treatment for T1 RCCs and in specific cases of T2 renal masses if technically feasible, halting the development of chronic kidney disease (CKD) and the need for hemodialysis (1-4).

Robotic-assisted methods are leading the way in the advancements of kidney-sparing procedures. Robotic-assisted surgery offers superior three-dimensional (3D) visualization, tremor mitigation and better ergonomics, potentially facilitating the learning curve during the transition from laparoscopic surgery (5-7). Recent comparative studies between laparoscopic partial nephrectomy (LPN) and robot-assisted partial nephrectomy (RAPN) favor the latter due to reduced operative and warm ischemia time, shorter hospital stay, and lower conversion rates, without compromising oncological control or increasing complications (8-10).

While most studies assessing trifecta and pentafecta outcomes included patients operated by the da Vinci Surgical platform in high surgical volume centers, the generalizability of these findings to novel robotic systems remains largely unexplored. The Hugo™ RAS system was introduced as a modular robotic platform combining wristed instruments with independent robotic arm carts and an open console with 3D visualization. Although early reports suggest favorable perioperative, functional and safety outcomes, variability across platforms and the predominance of small retrospective series with unbalanced cohorts limit rigorous comparisons, underscoring the need for further studies (11-13).

We hypothesized that RAPN using the Hugo™ RAS system would provide comparable perioperative, oncological and functional results to LPN without added morbidity. Therefore, we performed a matched-pair analysis comparing these outcomes, including trifecta and pentafecta achievement and identified independent predictors of failure.

MATERIALS AND METHODS

Patient Selection

We retrospectively collected data on all patients eligible for minimally invasive partial nephrectomy who un-

derwent RAPN since the introduction of the technique in the department [May 2023 to June 2025] and from a database of patients submitted to LPN [February 2015 to June 2025]. The study was approved by the institutional review board (No. 2024.061) and conducted according to the Declaration of Helsinki. A total of 165 patients were included, of which 95 and 70 underwent LPN and RAPN for renal tumors, respectively. Patients who underwent retroperitoneal PN, off-clamp or selective clamp procedures, bilateral lesions, and concomitant surgeries conducted during the same operative session were excluded from this analysis to maintain cohort homogeneity and minimize confounding variables that could influence operative time, warm ischemia time, complication rates, and length of stay.

Surgeries were performed by a team of three surgeons experienced in laparoscopic partial nephrectomy, initiating Hugo™ robot-assisted procedures. They had alternating roles between the console and the assistant surgeon. Medtronic provided in-depth technical training to the entire surgical team.

Variables

Baseline and postoperative clinical and surgical data were collected from the patients' health records. Evaluation of tumor complexity was based on the RENAL Nephrometry Score and stratified as low (4-6), intermediate (7-9) and high risk (10-12). The MDRD equation was applied to calculate the estimated glomerular filtration rate (eGFR) both preoperatively and at 12-months follow-up. Total operative time encompassed docking and console time. Visual estimation of blood loss (EBL) was recorded. The Clavien-Dindo classification was used to stratify postoperative complications. Trifecta outcome measurement, defined as the presence of WIT $\leq$ 25 min, negative surgical margins, and the absence of postoperative complications, and Pentafecta, defined as trifecta plus eGFR preservation $\geq$ 90% and absence of CKD upstaging to stage III or higher, were used to standardize the surgical success rate into an integrated scoring system.

Surgical Technique

Patients were positioned in a 90° full flank position in LPN and 60° modified flank position for RAPN. A standardized transperitoneal approach was adopted in both

groups. LPN was performed using four trocars, including a 12 mm periumbilical camera port and additional 12 mm and 5 mm working ports arranged in a triangulated configuration. In the RAPN group, an 11 mm camera port was placed along the mid-clavicular line below the costal margin. Three 8 mm robotic ports were positioned approximately 8 cm apart to prevent arm collision, with a 12 mm Air-SEAL trocar placed inferior to the camera port for the assistant. Trocar placement and docking were adjusted according to tumor laterality.

Partial nephrectomy steps were similar in both approaches (14). In summary: colon mobilization, hilar dissection, tumor identification, arterial clamping, tumor enucleation or enucleoresection, renorrhaphy with barbed suture (one or 2 layers at surgeon discretion), hemostasis verification, and specimen retrieval. A perirenal drain was routinely placed and removed when drainage was under 50cc.

Statistical Analyses

A propensity scores matching method using the nearest-neighbor matching technique was used to address selection bias. In this regard, a multivariate logistic regression including age, gender, ASA score, BMI, preoperative eGFR, preoperative Cr, preoperative Hb, and tumor characteristics (size, laterality, RENAL nephrometry score, and clinical stage) was calculated.

Patients were matched at a 1:1 ratio, without replacement, using a caliper width of 0.20 standard deviations (SD) to minimize poor matches while preserving sample size. Patients lacking adequate covariate overlap were excluded to avoid positivity violations. Post-matching balance was assessed using standardized mean differences (threshold <0.2), variance ratios (0.5-2), and IQR ratios (0.5-2), according to variable distribution, and proportions were compared using the Chi-square test for categorical variables. Sensitivity analysis included repeated matching with alternative caliper specifications (0.15, 0.25).

Descriptive statistics were reported as mean $\pm$ SD or median and interquartile ranges (IQR) based on normality assessment and compared using independent t-test and Mann-Whitney U test, respectively. Proportions of categorical variables were assessed with the Pearson chi-square or Fisher's exact test when appropriate. Univariate and mul-

tivariate logistic regression analyses were performed to identify independent predictors of trifecta and pentafecta achievement. Data were analyzed using IBM SPSS Statistics version 31. Statistical significance was defined as $p < 0.05$ (two-sided).

RESULTS

Following propensity score matching ($n=140$), 70 patients were included in each group. Patients' baseline data before and after matching are summarized in Table-1. Before matching, the LPN group had a lower RENAL nephrometry score median (6 vs. 7, $p=0.008$), with no significant differences across remaining covariates. After matching, patients were successfully matched with an enhanced balance for all preoperative characteristics, eliminating any difference in the RENAL nephrometry score.

Perioperative, functional and oncological outcomes are summarized in Table-2. Operative time, WIT, and EBL were similar in both groups. Length of stay was significantly shorter in the RAPN group (3 days vs 5 days, $p<0.001$). Overall complication rates were higher in the LPN group, though not statistically significant (20% vs. 12.9%, $p=0.178$), with the majority being Clavien-Dindo I-II. When analyzing each complication, both approaches demonstrated similar incidences of urinary tract infections and postoperative fever, which were managed conservatively. Four patients (2.8%) had Clavien-Dindo III-IV complications, three in the LPN group and one in the RAPN group, all due to pseudoaneurysms requiring selective angioembolization.

No significant differences were observed across pathological T staging distribution, histology subtypes and positive surgical margin rate. Trifecta (84.3% vs. 85.7%, $p=0.813$) and Pentafecta (48.6% vs. 57.4%, $p=0.310$) achievement were comparable, with no significant differences across RENAL score categories. During follow-up, similar rates of $\geq 90\%$ eGFR preservation and absence of CKD upstaging were observed. On multivariate analysis, higher RENAL score was the only independent predictor of trifecta failure (OR 1.410, $p=0.027$) (Table-3). For pentafecta, older age (OR 0.929, $p=0.001$), higher RENAL score (OR 1.396, $p=0.030$), and lower pre-operative eGFR (OR 0.981, $p=0.049$) were independent predictors of failure (Table-4). Key perioperative outcomes are summarized in Figure-1.

Table 1 - Baseline characteristics before and after propensity score matching.

Variables	Before propensity score matching			After propensity score matching		
	LPN (n=95)	RAPN (n=70)	P value	LPN (n=70)	RAPN (n=70)	P value
Age, y, median (IQR)	63 (54-71)	64 (53-72)	0.627	63 (55-71)	65 (53-72)	0.782
Gender (male), n (%)	62 (65.3)	39 (55.7)	0.239	49 (70.0)	39 (55.7)	0.080
BMI, kg/m ² , mean, (SD)	27.3 ± 4.5	27.2 ± 4.7	0.935	27.8 ± 4.5	27.2 ± 4.7	0.461
ASA Score, n (%)			0.316†			0.506 †
I	6 (6.3)	2 (2.9)		3 (4.3)	2 (2.9)	
II	67 (69.7)	45 (64.3)		50 (71.4)	45 (64.3)	
III	23 (24.0)	23 (32.8)		17 (24.3)	23 (32.9)	
RENAL Score, median (IQR)	6 (5-7)	7 (6-8)	0.008	7 (6-8)	7 (6-8)	0.130
RENAL Score category, n (%)			0.083			0.285
Low (4-6)	51 (53.1)	28 (40.0)		35 (50.0)	28 (40.0)	
Intermediate (7-9)	42 (43.8)	35 (50.0)		32 (45.7)	35 (50.0)	
High (10-12)	3 (3.1)	7 (10.0)		3 (4.3)	7 (10.0)	
Side (Right), n (%)	45 (46.9)	28 (40.0)	0.430	36 (51.4)	27 (38.6)	0.126
Tumor Size, mm, median (IQR)	28 (20-39)	32 (21-43)	0.104	27 (21-40)	32 (22-42)	0.105
Clinical Stage, n (%)			0.504 †			0.317 †
cT1a	74 (77.9)	54 (77.1)		53 (75.7)	54 (77.1)	
cT1b	21 (22.1)	15 (21.5)		17 (24.3)	14 (20.0)	
cT2a	0 (0)	1 (1.4)		0 (0)	2 (2.9)	
Pre-operative Hb, g/dL, mean (SD)	14.1 ± 1.5	14.1 ± 1.4	0.934	14.3 ± 1.5	14.1 ± 1.4	0.560
Pre-operative Cr, mg/dL, median (IQR)	0.88 (0.75-1.05)	0.84 (0.7-0.99)	0.434	0.88 (0.77-1)	0.84 (0.7-0.99)	0.498
Pre-operative eGFR, mL/min/1.73 m ² , mean (SD)	87.2 ± 24.2	85.8 ± 21.2	0.693	87.6 ± 22.4	85.5 ± 21.6	0.561

LPN = Laparoscopic PartialNephrectomy; RAPN= Robot-Assisted PartialNephrectomy; IQR =Interquartile Range; BMI = Body Mass Index; SD = Standard Deviation; ASA = American Society of Anesthesiology; Hb = Hemoglobin; Cr = Creatinine; eGFR = Estimated Glomerular Filtration Rate.

† Fisher Exact Test

Table 2 - Perioperative, oncological and renal functional outcomes for LPN and RAPN.

Variables	LPN (n=70)	RAPN (n=70)	P value
Perioperative data			
Operative Time, min, median (IQR)	115 (95-141)	118 (96-145)	0.736
EBL, mL, median (IQR)	100 (50-300)	100 (50-260)	0.497
WIT, min, median (IQR)	18.5 (15.3-20)	17.3 (14.9-22)	0.594
Length of Stay, days, median (IQR)	5 (4-6)	3 (3-5)	<0.001
Postoperative complications, n (%)	14 (20.0)	9 (12.9)	0.178
Clavien-Dindo I-II	11	8	
Clavien-Dindo III-V	3	1	
Post-operative Hb, g/dL, mean (SD)	12.9 ± 1.48	12.5 ± 1.63	0.081
Post-operative Cr, mg/dL, median (IQR)	0.90 (0.8-1.2)	0.94 (0.75-1.2)	0.662
12-months follow up eGFR, mL/min/1.73 m ² , mean (SD)	82.4 ± 23.4	80.3 ± 21.2	0.581
Oncological and renal functional data			
Pathology, n (%)			0.254 †
Benign lesions	14 (20.0)	9 (12.9)	
Clear Cell RCC	27 (38.6)	35 (50.0)	
Non-clear Cell RCC	29 (41.4)	26 (37.1)	
Pathologic Stage, n (%)			0.542 †
pT1a	57 (81.4)	59 (84.3)	
pT1b	12 (17.1)	10 (14.3)	
≥ pT2	1 (1.4)	1 (1.4)	
Positive Surgical Margin, n (%)	7 (10.0)	4 (5.7)	0.326
Trifecta Achievement, n (%)	59 (84.3)	60 (85.7)	0.813
According to RENAL Score category, n (%)*			0.058
Low (4-6)	32/35 (91.4)	25/28 (89.3)	
Intermediate (7-9)	25/32 (78.1)	30/35 (85.7)	
High (10-12)	2/3 (66.7)	5/7 (71.4)	
> 90% Preservation of eGFR at 12 months follow up, n (%)	42 (60.0)	50 (71.4)	0.154
No CKD upstaging, n (%)	61 (87.1)	64 (91.4)	0.412
Pentafecta Achievement, n (%)	34 (48.6)	40 (57.4)	0.310
According to RENAL Score category, n (%)*			0.586
Low (4-6)	19/35 (54.3)	17/28 (60.7)	
Intermediate (7-9)	13/32 (40.6)	19/35 (54.3)	
High (10-12)	2/3 (66.7)	4/7 (57.1)	

LPN: Laparoscopic Partial Nephrectomy; RAPN: Robot-Assisted Partial Nephrectomy; IQR: Interquartile Range; SD: Standard Deviation; EBL: Estimated Blood Loss; WIT: Warm Ischemia Time; Hb: Hemoglobin; Cr: Creatinine; eGFR: Estimated Glomerular Filtration Rate; RCC: Renal Cell Carcinoma.

*Stratified rows show achievers/total within RENAL score category; p for trend (linear-by-linear)

† Fisher's exact test

Table 3 - Univariate and multivariate logistic regression analyses for factors associated with trifecta achievement.

Variables	Univariate		Multivariate	
	OR (95% CI)	P value	OR (95% CI)	P value
Age	1.015 (0.975-1.056)	0.477	1.017 (0.978-1.058)	0.395
Gender (Female vs. Male)	0.822 (0.309-2.191)	0.695		
BMI	0.932 (0.836-1.039)	0.206		
ASA Score (III vs. I-II)	1.303 (0.483-3.514)	0.601		
Tumor size	1.025 (0.992-1.060)	0.143		
Side (right vs left)	1.132 (0.447-2.868)	0.794		
RENAL Score	1.377 (1.024-1.852)	0.034	1.410 (1.041-1.910)	0.027
Pre-operative eGFR	1.007 (0.985-1.029)	0.534		
EBL	1.002 (1.000-1.004)	0.125		
Operative Time	1.004 (0.991-1.018)	0.535		
Procedure (RAPN vs. LPN)	0.894 (0.353-2.263)	0.813	0.751 (0.287-1.966)	0.560

LPN = Laparoscopic Partial Nephrectomy; RAPN = Robot-Assisted Partial Nephrectomy; BMI = Body Mass Index; SD = Standard Deviation; ASA = American Society of Anesthesiology; eGFR = Estimated Glomerular Filtration Rate; OR = odds ratio; CI = Confidence interval

*Variables selected for multivariate analysis were based on statistical significance ($p < 0.05$) and clinical relevance

DISCUSSION

Nephron-sparing surgery (NSS) has emerged as an established standard of care in the management of localized renal cell carcinoma, as preserving kidney function more effectively has the potential to halt the progression of CKD (2, 15). Additionally, NSS has been associated with a lower risk of adverse cardiovascular events by slowing atherosclerosis progression, reducing inflammatory activity, and improving endothelial function compared with radical nephrectomy. These effects lead to improved overall survival and reduced mortality (4).

Minimally invasive approaches offer lower morbidity and faster recovery while achieving comparable oncological outcomes compared to open partial nephrectomy (OPN). Several studies on RAPN have been published, demonstrating excellent perioperative and functional results, without compromising oncological success, making it the preferred approach mainly for

complex renal masses (5, 13, 16-18). Few studies have assessed the performance of RAPN with the Hugo™ RAS platform.

Over the last decades, the da Vinci Surgical System™ has garnered substantial experience, leading the current evidence supporting NSS for localized RCC (19, 20). Recently, new robotic platforms have been developed, offering alternative technical features designed not only to address cost constraints but also to provide tailored solutions for challenging cases. Particularly helpful in cases of prior abdominal surgery, higher tumor complexity, or unfavorable tumor location where ergonomic systems are advantageous (21).

To date, few reports of MIPN with Hugo™ RAS system have been published; initial studies, such as Gallioli et al. and Chierigo et al. highlight some particularities of this system, such as the versatility of the modular system, 3D visualization, easier integration and direct communication within the surgical team (6, 7). They also provided

Table 4 - Univariate and multivariate logistic regression analyses for factors associated with pentafecta achievement.

Variables	Univariate		Multivariate	
	OR (95% CI)	P value	OR (95% CI)	P value
Age	0.950 (0.921-0.980)	0.001	0.929 (0.895-0.964)	0.001
Gender (Female vs. Male)	1.205 (0.605-2.399)	0.596		
BMI	1.017 (0.945-1.094)	0.654		
ASA Score (III vs. I-II)	1.128 (0.540-2.356)	0.748		
Tumor size	1.025 (0.992-1.060)	0.143	1.023 (0.991-1.057)	0.167
Side (right vs left)	0.766 (0.393-1.494)	0.794		
RENAL Score	0.870 (0.705-1.072)	0.191	1.396 (1.033-1.885)	0.030
Pre-operative eGFR	1.007 (0.985-1.029)	0.534	0.981 (0.962-1.000)	0.049
EBL	0.999 (0.997-1.001)	0.206		
Operative Time	0.986 (0.975-1.012)	0.120		
Procedure (RAPN vs. LPN)	0.894 (0.353-2.263)	0.813	1.484 (0.714-3.081)	0.290

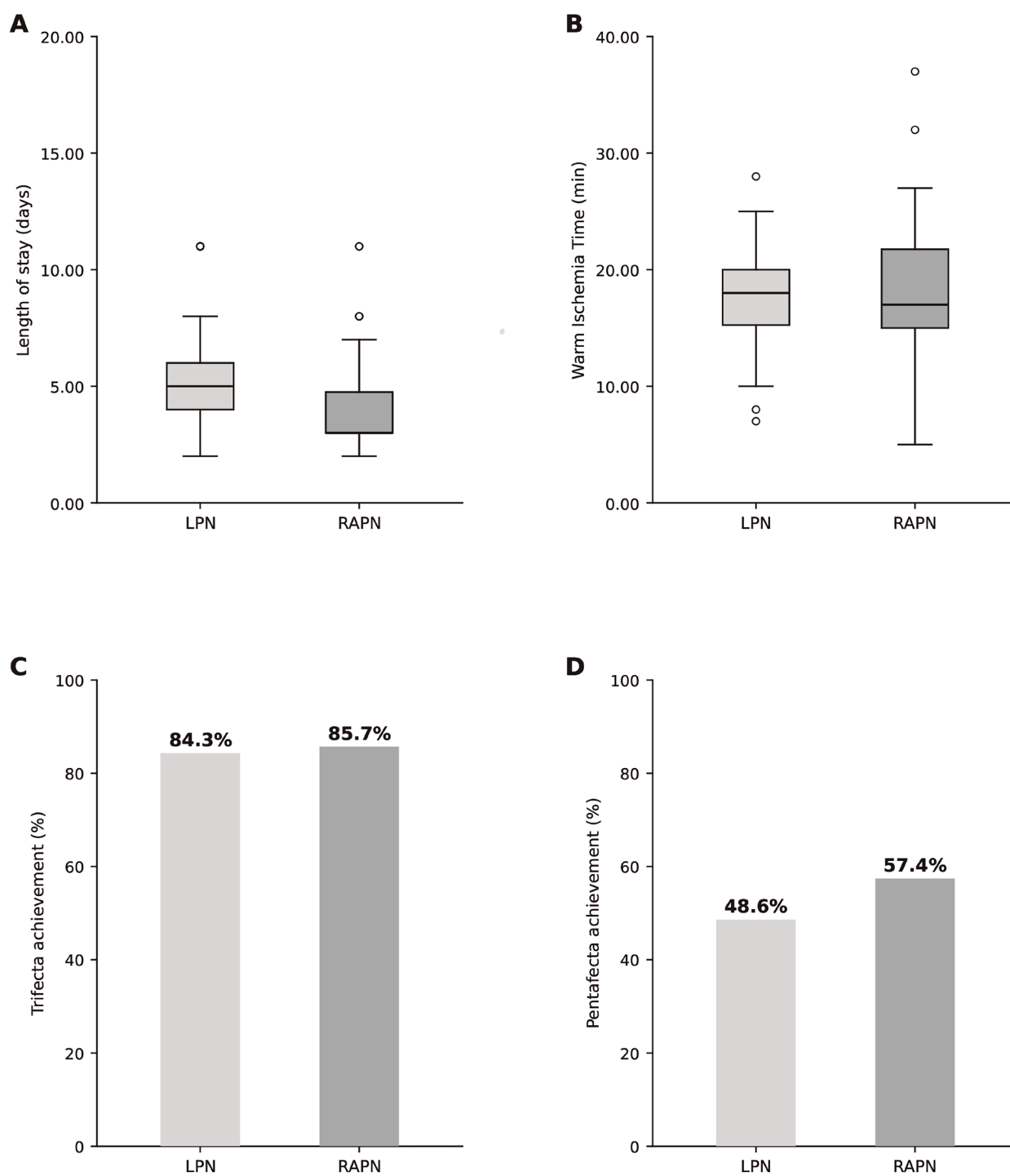
LPN = Laparoscopic Partial Nephrectomy; RAPN = Robot-Assisted Partial Nephrectomy; BMI = Body Mass Index; SD: Standard Deviation; ASA = American Society of Anesthesiology; eGFR = Estimated Glomerular Filtration Rate; OR = odds ratio; CI = Confidence interval

*Variables selected for multivariate analysis were based on statistical significance ($p < 0.05$) and clinical relevance.

valuable insight into the operative room layout and docking configurations while addressing potential setbacks.

Recent studies support smooth skill transfer and docking proficiency during the transition for surgeons with over a decade of laparoscopic experience, without compromising trifecta or pentafecta achievement. Early involvement of a consistent surgical team allows for better expertise of the technique without compromising safety (6, 22). Although modular arm carts may initially prolong docking time, workflow optimization in our series was achieved through standardized trocar placement, predefined arm cart positioning and a consistent surgical team. According to our previous experience, CUSUM analysis confirmed rapid skill acquisition with the Hugo™ RAS system, with docking proficiency achieved by the 5th case and console time stabilizing within 7–8 procedures, supporting a safe and effective transition (23). Operative time remained comparable, suggesting that docking variability did not affect surgical efficiency.

Rojo et al. conducted the first head-to-head comparison of both Da Vinci and Hugo™ RAS platforms for RAPN. As expected, docking time was shorter in the Da Vinci group (12.56min vs. 20.08min, $p < 0.01$), reflecting the necessary adaptation and anticipated learning curve. Conversely, a significant reduction in re-orrhaphy time was observed in the Hugo™ RAS group (14.33min vs. 18.94min), possibly related to improved instrument articulation and motion scaling, which may enhance suturing precision (24). Nevertheless, perioperative and oncological outcomes were comparable, without impairing safety. Although this study did not include a direct economic comparison between robotic platforms, acquisition and maintenance costs may differ. Overall financial impact remains highly dependent on institutional case volume and operating room expenses. In our institution, despite higher consumable expenses in RAPN cohort, the significant reduction in length of stay may offset this additional expenditure.

Figure 1 - Perioperative outcomes and Trifecta/Pentafecta achievement according to surgical approach.

Box plots represent the median (line), interquartile range (box) and range (whiskers).
LPN: Laparoscopic Partial Nephrectomy; RAPN: Robot-Assisted Partial Nephrectomy.

Prata et al. published the first head-to-head comparison between RAPN with Hugo™ RAS system (n=27) and LPN (n=62). They showed that the evolution from laparoscopic to robotic PN with this system did not result in increased PSM or complications; instead, it may be characterized by shorter operative times and length of stay (5). However, these findings should be interpreted with caution, owing to the heterogeneity of baseline characteristics and smaller sample size.

Recognizing these limitations, in our study, patients were matched to their nearest neighbor based on a propensity score (1:1), mitigating any potential baseline differences. Length of stay was significantly shorter in the RAPN group (3 days vs 5 days, $p<0.001$), consistent with prior reports (5, 16, 25). This difference may reflect subtle variations in early postoperative recovery not captured by the analyzed variables. Standardized postoperative pain scores were not prospectively recorded, limiting rigorous comparison, although an opioid-sparing protocol was routinely applied. Drain placement and removal protocols were standardized across both groups. Notably, both cohorts followed identical perioperative pathways, including one day prior surgery admission, ensuring institutional practices did not differentially influence the comparison. While complication rates were comparable, the higher rate observed in the LPN cohort (20% vs. 12.9%, $p=0.178$) may have influenced discharge timing in selected cases.

Despite comparable eGFR at 12-months follow-up, $\geq 90\%$ eGFR preservation was only achieved in 60% of LPN and 71.4% of RAPN patients, highlighting that mean follow-up eGFR underestimates clinically relevant functional decline. Comparably, Wang et al. did not detect an effect of surgical approach on renal function preservation (17).

Focusing on oncological outcomes, pathological tumor stage (pT) and PSM status were comparable (10% vs. 5.7%, $p=0.326$), consistent with previous reports (5, 26). This highlights that RAPN is equally effective at enucleoresection with renal parenchyma preservation, without compromising adequate resection margins. Malkoc et al. showed that surgeon volume (≥ 25 cases/year) was a stronger predictor of surgical margin status than tumor complexity or surgical approach (27). In our series, surgeons did not reach that reported case load.

Trifecta and Pentafecta achievement represent standardized composite measures of surgical and functional success. Trifecta was comparable between groups (84.3% LPN vs. 85.7% RAPN, $p=0.813$) and consistent with published data, where it ranges between 60 and 90% (5, 28). However, caution is warranted when comparing series, as it lacks a standardized definition and omits some surgical factors. Furthermore, off-clamp or selective clamp procedures were not included, as surgical quality cannot be adequately assessed by trifecta. Higher RENAL score was the only independent predictor of trifecta failure in our multivariate analysis (OR 1.410, $p=0.027$), reflecting the association with longer WIT and greater surgical complexity (29). Tumor size alone was not an independent predictor, reflecting the predominant influence of surgical expertise over individual tumor characteristics in determining trifecta achievement.

Pentafecta was achieved in 48.6% of LPN and 57.4% of RAPN patients ($p=0.310$), within the range reported in the literature (29, 30). No significant differences were observed across RENAL score categories, supported by Kahn et al. (29). On multivariate analysis, Higher RENAL score (OR 1.396, $p=0.030$), older age (OR 0.929, $p=0.001$) and lower baseline eGFR (OR 0.981, $p=0.049$) were independent predictors of pentafecta failure, highlighting that patient-related factors appear more influential than surgical approach in determining long-term renal preservation (30).

Our study has several limitations that warrant acknowledgment. The main shortcomings are inherent to the retrospective design, conducted at a single center, with limited sample size. Longer follow-up is required to assess preserved renal parenchymal volume and long-term oncological outcomes given the recent implementation of RAPN in our institution. Furthermore, exclusion of data regarding the learning curve may have influenced postoperative outcomes. A further limitation is the different recruitment periods between cohorts, which may introduce temporal bias related to the evolving characteristics of surgical techniques and later adoption of RAPN in our institution, although propensity score matching mitigates this concern. Although ASA score was incorporated in the matching algorithm as a surrogate of comorbidity burden, validated indices such

as Charlson Comorbidity Index were not available, limiting comorbidity adjustment. Furthermore, larger prospective and multicentric studies, including cost-effectiveness analyses and comparisons with other robotic platforms, are necessary to establish its long-term value.

Notwithstanding these limitations, our study is the largest head-to-head series between Hugo-RAS RAPN and LPN evaluating perioperative and functional outcomes. The propensity score matching method we employed enhances the strength of our conclusions.

CONCLUSIONS

In conclusion, RAPN with the Hugo™ RAS system achieves comparable perioperative, trifecta and pentafecta outcomes to laparoscopy even during the early institutional adoption, with a shorter hospital stay.

ABBREVIATIONS

ASA = American Society of Anesthesiology
 BMI = Body Mass Index
 CKD = Chronic Kidney Disease
 Cr = Creatinine
 EBL = Estimated blood loss
 eGFR = Estimated Glomerular Filtration Rate
 Hb = Hemoglobin
 IQR = Interquartile Ranges
 LPN = Laparoscopic Partial Nephrectomy
 MDRD = Modification of Diet in Renal Disease
 MIPN = Minimally invasive partial nephrectomy
 NSS = Nephron-sparing surgery
 OT = Operative Time
 PN = Partial nephrectomy
 PSM = Positive surgical margins
 RAPN = Robot-Assisted Partial Nephrectomy
 RAS = Robot-Assisted Surgery
 RCC = Renal Cell Carcinoma
 SD = Standard Deviation
 WIT = Warm-ischemia time

STATEMENTS AND DECLARATIONS

Informed Consent Statement

Informed consent was granted by all participants prior to study enrollment. Informed consent for publication was also obtained.

CONFLICT OF INTEREST

None declared.

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Are redo urethroplasties prone to failure? Objective success rates and patient satisfaction in recurrent urethral stricture repair

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ABSTRACT

Objective: To evaluate long term success rates and patient reported outcomes of redo urethroplasty (RU), a technically challenging urological procedure that may be associated with lower success rates due to increased scarring, compromised blood supply and poor surgical planes from prior surgery.

Materials and methods: We retrospectively reviewed RU patients between 2010–2023, excluding failed hypospadias repair, and compared with a cohort of primary urethroplasty patients. Failure was defined as need for urethral intervention or imaging/cystoscopy-confirmed stricture recurrence prompted by symptoms. Primary endpoint was stricture-free survival. Secondary endpoints included patient-reported outcomes (USS-PROM), satisfaction, and subgroup analysis by stricture location. Statistical tests included T-tests, Wilcoxon signed-rank, and Fisher's exact test.

Results: Sixty redo urethroplasty patients (median age 48.5) were compared to 316 primary cases (median age 45, $p=0.84$). Median follow-up was 35 (IQR 14–81) vs. 51 (IQR 20–114) months for redo and primary cases, respectively ($p=0.07$). Failure rates were not significantly different: 23% in redo vs. 15% in primary cases ($p=0.12$). However, time to failure was significantly shorter in the redo group (median 6 vs. 17 months, $p=0.01$). USS-PROM questions 1–6 favored the primary group, although bother scores (Q7) were similar. Overall satisfaction was high in both groups but slightly higher after primary repair (95% vs. 87%, $p=0.04$).

Conclusion: Despite greater complexity, redo urethroplasty demonstrates similar long-term success rates to primary urethroplasty. Patient-reported bother was similar, supporting redo urethroplasty as a viable option for recurrent urethral stricture after previous repair. However, recurrences occurred significantly earlier in the redo group.

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INTRODUCTION

Although Urethroplasty is considered the gold standard treatment for urethral strictures, recurrence remains a significant issue. This has been observed in long-term follow up (15 years), in 14-58% of patients, depending on stricture location, pathogenesis and the reconstructive technique used (1). Management of recurrent strictures varies widely among urologists with standardized guidelines lacking (2). Direct vision internal urethrotomy (DVIU) is a reasonable option mostly for short recurrent strictures (≤ 1 cm) (3, 4) and has been shown to be superior to urethral dilation (5). However, approximately half of these patients experience further recurrence, highlighting the limitations of endoscopic management. Newer endoscopic options such as drug coated balloons have been recently reported, however post-urethroplasty strictures were generally excluded (6).

Redo urethroplasty is technically demanding due to scarring, loss of normal surgical planes, reduced vascularity and spongiofibrosis (7). Several studies have reported success rates for repeat urethroplasty, with a minority directly comparing primary to redo procedures (7-10). These reports generally show comparable stricture free rates, although definitions of success varied. We present our experience regarding success rate of primary vs. redo urethroplasty using a stringent definition of stricture free survival and unique to this study, patient reported outcomes, as recorded by the USS-PROM questionnaire (11-13). We hypothesized that redo cases would demonstrate inferior objective and subjective outcomes.

MATERIALS AND METHODS

This retrospective study analyzed data from our prospectively maintained urethroplasty database, approved by the institutional review board (IRB 0155-19-SZMC). All patients undergoing redo urethroplasty between 2010 and 2023 were included. Redo urethroplasty was defined as urethroplasty performed for recurrent stricture after 1 or more failed previous urethroplasties, regardless of the number of previous dilations/endoure-

throtomies. A contemporaneous cohort of patients who underwent primary urethroplasty served as the comparison group.

Exclusion criteria included patients with failed hypospadias repairs, and those lacking post-operative follow up.

Pre-operative evaluation included history, physical examination, lab analysis (urine analysis and culture, creatinine levels) and a combination of uroflowmetry, post-void residual volume (PVR) in patients that did not present with urinary retention, retrograde urethrography (RUG) and voiding cystourethrography (VCUG). Cystourethroscopy was performed when indicated.

All procedures were performed by a single surgeon (O.Z.S).

Peri-operative complications (infection, extravasation, etc.) were recorded. Data were prospectively entered at the time of surgery in the center's urethroplasty database and updated at each follow up visit.

A urethral catheter and suprapubic tube (SPT) were routinely placed during surgery. Urethral catheter was removed and VCUG performed, 21-28 days post-operatively. In the absence of extravasation, the SPT was removed shortly thereafter. In case of extravasation repeated VCUG was performed 7-14 days later. The patients were seen at 1, 3, 6 and 12 months after the surgery, and annually thereafter. Follow up included a review of patient's symptoms, USS-PROM questionnaire, when possible, uroflowmetry and PVR. Cystourethroscopy was performed routinely 1 year after surgery and once more based on worsening symptoms, uroflowmetry, PVR, or PROM scores.

A stringent definition of surgical failure was used: either the need for additional urethral intervention due to stricture recurrence (reduced urinary stream or urinary retention), the demonstration of stricture on imaging (retrograde urethrography) or cystourethroscopy (inability to advance 16Fr flexible cystoscope).

The primary endpoint was absence of stricture recurrence. Secondary endpoints included patient satisfaction and USS-PROM questionnaire scores.

T-test and Wilcoxon signed-rank tests were conducted for continuous data and Fisher's exact test for categorical data. Statistical significance was defined as $p < 0.05$.

RESULTS

Sixty patients underwent redo urethroplasty between 2010 to 2023 and were compared with 316 primary urethroplasty cases. Median age at surgery was 48.5 years (IQR 32-61) in the redo urethroplasty group and 45 years (IQR 32-61) in the primary group ($p=0.84$). Median follow up was 35 months (IQR 14-81) and 51 months (IQR 20-114), respectively ($p=0.07$). Stricture length, pre-op maximal urinary flow (Qmax), PVR, rates of urinary retention and urethral rest with suprapubic drainage preoperatively did not differ between groups. Baseline demographic, clinical parameters and stricture location are presented in Table-1.

Stricture location differed significantly, with 67% of primary patients and 38% of redo patients having a bulbar urethral stricture ($p=0.0001$). Intra and post-operative complication rates were similar ($p=0.82$) and all complications were considered minor (Clavien-Dindo 1-3).

Stricture recurrence occurred in 14 redo patients (23%) and 47 (15%) primary patients ($p=0.12$). However, time to stricture recurrence was significantly shorter after redo urethroplasty (median 6 months, IQR 2-11) vs. 17 months (IQR 6-52) in primary cases ($p=0.01$; Figure-1). This was also reflected in the higher recurrence rate at the 12-month time point.

Post-operative Qmax (18.6 ± 10.5 vs. 16.8 ± 12.1 , $p=0.23$) and PVR (85.7 ± 126.6 vs. 96.9 ± 135.2 , $p=0.53$) were comparable.

The sum score of questions 1 through 6 in the USS-PROM questionnaire and the bother scores (Q7) did not differ between the groups. Overall satisfaction was high for both groups though higher in the primary group (95% vs. 87%, $p=0.04$). Erectile function (IIEF-5) scores did not differ between the primary (19 ± 8) and redo groups (18.6 ± 7.5 , $p=0.72$).

Surgical techniques used are shown in Table-2.

Subgroup analysis of by stricture location was underpowered; however, results suggest no significant differences with $p=0.08$, $p=0.1$, $p=0.35$ and $p=1$ for bulbar, membranous, pan-anterior and penile/peno-bulbar strictures, respectively.

DISCUSSION

Redo urethroplasty is challenging due to several factors including scarring, lack of clear surgical planes, compromised vascularity and spongiofibrosis. Thus, surgeon knowledge and competency in numerous reconstructive techniques is required.

Redo urethroplasty success rates have varied in the literature while often been indirectly compared to primary urethroplasty results (3, 7, 9, 10). Furthermore, defining surgical failure and success has also been inconsistent across reports. Direct comparisons have been described (8, 10, 14) demonstrating redo cases to be feasible with results slightly favoring primary urethroplasty. Patient satisfaction can therefore be expected to correlate with stricture free survival.

Stricture location influences recurrence risk. Our findings align with previous reports demonstrate an increased risk of stricture recurrence for penile and pan-anterior strictures (15, 16). Possible contributing factors may include presence of Lichen Sclerosus, predominantly located in the penile urethra that is associated with higher failure rates, and the reliance on more complex substitution reconstructive techniques (17-19). Indeed, lichen sclerosus was present in (12%) of redo cases whereas only in 5% of primary patients. We excluded patients who had surgery for recurrent stricture after previous hypospadias repair due to the sparsity of data in our database regarding the number and type of previous hypospadias operations. Additionally, one may argue that hypospadias is a different disease process to urethral stricture disease, with a deficient corpus spongiosum, adding significant heterogeneity that may have confounded analysis. In our study, stricture location varied significantly between the groups, two thirds of primary urethroplasties were a bulbar urethral stricture whereas in only 38% of the redo patients ($p=0.0001$) was the stricture located in the bulbar urethra. Indeed, suggesting that non-bulbar strictures are at an increased risk for recurrence. We acknowledge this baseline imbalance as a potential source of confounding. However, sub-group analysis based on stricture location did not demonstrate significant differences in recurrence between redo and primary groups. The location imbalance

Table 1 - Patient characteristics, stricture features, and outcomes of redo versus primary urethroplasty.

Parameter	Redo urethroplasty (N=60)		Primary urethroplasty (N=316)		P value
	Mean (SD)/ Median (IQR)	Min, Max	Mean (SD)/Median (IQR)	Min, Max	
Patient characteristics					
Age (years)	48.5 (32-61)	7-75	45 (30-62)	5-93	0.84
Follow-up (months)	35 (14-81)	1-202	51 (20-114)	1-264	0.07
Pre-operative parameters					
Qmax (mL/s)	3.7 ± 4.0	0-13	3.8 ± 4.1	0-16	0.86
PVR (mL)	250 ± 309	0-700	160 ± 191	0-2000	0.003
Urethral rest with suprapubic catheter, n (%)	18 (30)		110 (35)		0.55
Stricture characteristics					
Stricture length (cm)	4.5 ± 3.9	1-18	5.2 ± 4.3	1-23	0.24
Stricture location, n (%)					
Bulbar	23 (38)		211 (67)		<0.001
Membranous	12 (20)		35 (11)		0.09
Pan-anterior	13 (22)		36 (11)		0.04
Penile/penobulbar	12 (20)		34 (11)		0.05
Post-operative outcomes					
Good VCUG at 3–4 weeks, n (%)	55 (92)		304 (96)		0.12
Qmax at 1 month (mL/s),	15.6 ± 10.4	0-51	17.7 ± 8.4	0-47	0.09
PVR at 1 month (mL)	11.5 ± 28.2	0-150	16.9 ± 47.5	0-500	0.39
Stricture recurrence at 12 months, n (%)	9 (15)		16 (5)		0.009
Last follow-up					
Qmax (mL/s)	16.8 ± 12.1	0-64	18.6 ± 10.5	0-50	0.23
PVR (mL)	96.9 ± 135.2	0-700	85.7 ± 126.6	0-700	0.53
Stricture recurrence, n (%)	14 (23)		47 (15)		0.12
Time to recurrence (months)	6 (2-11)	1-79	17 (6-52)	2-147	0.01
Patient-reported outcomes					
USS-PROM sum questions 1-6	6.5 ± 5.4	0-18	5.7 ± 4.6	0-21	0.23
Satisfaction with surgery, n (%)	52 (87)		300 (95)		0.04
IIEF-5 score	18.6 ± 7.5	5-25	19 ± 8	0-25	0.72

IQR = Interquartile range; PVR = post-void residual volume; Qmax = maximum urinary flow rate; VCUG = voiding cystourethrography; USS-PROM = Urethral Stricture Surgery Patient-Reported Outcome Measure; IIEF-5 = International Index of Erectile Function-5.

Table 2 - Surgical techniques used for redo urethroplasty and primary urethroplasty.

		Redo urethroplasty (n=60)	Primary urethroplasty (n=316)	P-value
Anastomotic repair		23 (38%)	143 (45%)	0.4
	Buccal mucosa graft	18 (30%)	132 (42%)	0.11
Substitution	Sublingual graft	2 (3%)	-	0.03
	Skin flap	2 (3%)	14 (4%)	>0.99
Staged repair		5 (8%)	11 (3%)	0.15
Multiple techniques		6 (10%)	40 (13%)	0.67
Perineal urethrostomy		12 (20%)	19 (6%)	0.001

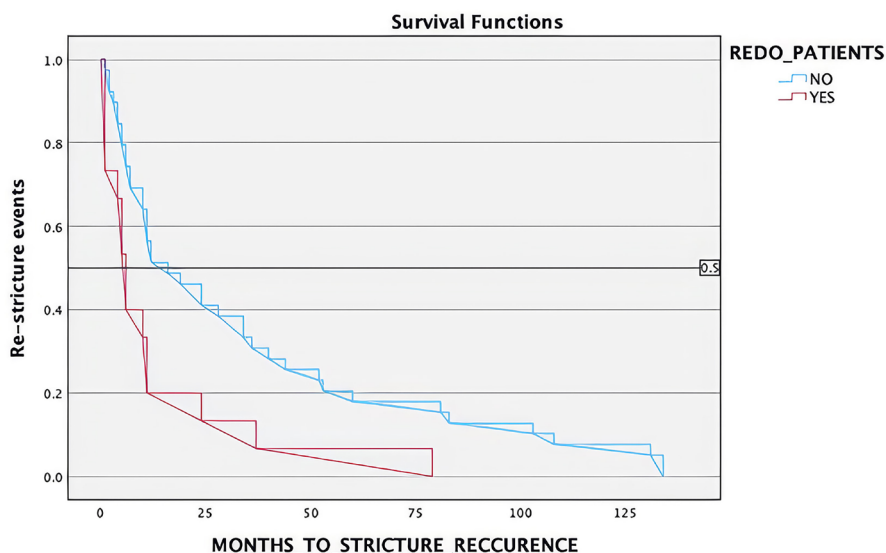
In several cases more than one surgical technique was used concomitantly, causing sum of procedures to be more than 100%.

would, if anything, bias against finding favorable outcomes in the redo cohort given the higher proportion of non-bulbar strictures.

Surgical technique was chosen according to stricture location, length, complexity and the availability and quality of tissues. In primary cases, anastomotic repair and substitution repair using buccal mucosa graft tended to be more common. Perineal urethrostomy, was used more frequently in redo cases as appropriate for

complex recurrent strictures. This reflects real-world case selection rather than bias; prior reports confirm comparable success and satisfaction with urethrostomy in select patients (20).

Patient satisfaction rates with redo urethroplasty were studied by Pfalzgraf et al. who demonstrated relatively high satisfaction and quality of life rates with acceptable rates of glans sensory alterations and subjective penile shortening (21). Results from our study

Figure 1 - Kaplan-Meier survival curves for re-stricture rates after redo urethroplasty (red, n=60) and primary urethroplasty (blue, n=316) for anterior urethral strictures.

Re-stricture events were defined as either worsening urinary symptoms requiring intervention or stricture non-accommodating a flexible 16Fr cystoscope. Months to stricture recurrence was defined as the time from surgery to recurrent urethral stricture or last follow-up. The log-rank test was used to compare groups ($p=0.13$). Time to stricture recurrence was shorter after redo urethroplasty ($p=0.01$).

are comparable to the literature, with high satisfaction rates to both primary (95% satisfied or very satisfied) and redo urethroplasties (87%), the difference reaching significance ($p=0.04$).

In support of overall patient satisfaction, erectile function rates as reported by IIEF-5 scores did not differ between RU and PU patients.

Minor complications (Clavien-Dindo categories 1-3) were observed in 7 (12%) patients in the redo group (2 wound infection, 2 UTI, 1 hematuria, 1 intra-operative bleeding, 1 catheter sutured resolved with suture absorption, 1 leg neuropathy), none required re-intervention. In the primary group 34 (11%) intra/post-operative complications occurred ($p=0.82$): 4 wound infection, 22 UTI, 1 trismus, 3 sutured catheters, 4 leg neuropathies. Neither major complications (Clavien-Dindo 4-5) nor re-intervention occurred in either group.

Median follow-up was shorter in the redo group (35 vs. 51 months). This may underestimate very late failures; however, time-to-event analysis and fixed time-point comparisons (e.g., 12-month recurrence) were used to mitigate this. The significantly earlier recurrences in redo cases (median 6 vs. 17 months) remain a sound finding and may reflect more aggressive disease biology, greater spongiositis, or compromised tissue quality from prior interventions (e.g., higher lichen sclerosus prevalence: 12% vs. 5%). Clinically, this underscores the need for vigilant early surveillance in redo patients.

Post-operative follow-up included office visits at 1, 3, 6 and 12 months with uroflowmetry, PVR and USS-PROM. Cystourethroscopy was performed one year post operatively. Routine office cystourethroscopy has been demonstrated to be a poor predictor of functional outcomes (22) in that not all patients with anatomic recurrence on cystoscopy reported symptoms suggesting stricture, therefore further anatomical assessment of the urethra, beyond the cystourethroscopy at 12 months, was limited to patients who reported decline in their urinary flow, either subjectively or objectively by uroflowmetry and PVR parameters or by USS-PROM results (1). It is reasonable to assume that our study was more sensitive for urethral stricture recurrence compared to other studies using

less stringent criteria such as only the need for additional treatment. This is in concordance with Erickson et al. who reported lack of clinical recurrence in 35% of those with anatomical stricture recurrence prompting re-treatment (23). We have previously shown that the Peeling voiding diagram that has been incorporated into the USS-PROM is not sensitive enough to pick up reliably on changes in patient uroflowmetry parameters (24). It is thus obvious that simply using avoidance of additional procedures, patient satisfaction and subjective PROM scores, each on its own, is not sufficient to determine urethral stricture recurrence and that a multimodal assessment provides a more accurate outcome evaluation for research purposes. Pre-operative USS-PROM data were incomplete, limiting paired comparisons. Post-operative scores were therefore compared cross sectionally. Both scores (Q7) were similar between groups. We acknowledge this limitation in the retrospective design. In some instances, a salvage endoscopic procedure after stricture recurrence can offer patients a reasonable outcome. Blaschko et al. reported total success rates rising from 67% to 78% after such procedures (7).

Our study limitations include its retrospective nature, differential follow-up duration, baseline imbalances in stricture location, incomplete pre-operative PROM data, heterogeneity of surgical techniques, and limited statistical power for sub-group analysis. Multivariable adjustment or propensity matching was not performed to avoid overfitting in this modest redo cohort. Future prospective studies with larger samples are warranted.

CONCLUSIONS

Redo urethroplasty while challenging is feasible with similar recurrence rates to primary cases, though not statistically powered to exclude modest differences; however, stricture recurrence tends to occur earlier after redo surgery. Patient satisfaction after surgery is slightly diminished after repeat urethroplasty, even though patient reported outcomes and bother were similar. These findings support redo urethroplasty as an effective option for recurrent urethral strictures.

ABBREVIATIONS

RU = redo urethroplasty

USS-PROM = Urethral stricture surgery – patient reported outcome measure

PVR = post-void residual

VCUG = voiding cystourethrography

Qmax = maximal flow rate

CONFLICT OF INTEREST

None declared.

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Bladder Cancer Management in Brazil's Supplementary Health System: Real-World Practice Patterns

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ABSTRACT

Purpose: The objective of the present study was to evaluate real-world practices of Brazilian urologists regarding bladder cancer management within the supplementary healthcare system.

Materials and Methods: A cross-sectional, survey-based study was conducted among Brazilian urologists. A structured questionnaire assessed demographics, practice characteristics, and management strategies for non-muscle-invasive (NMIBC) and muscle-invasive bladder cancer (MIBC). Data were collected during the 2025 Brazilian Congress of Urology and via electronic distribution. Descriptive statistics were used, and exploratory comparisons were performed.

Results: A total of 914 urologists from 25 federative units (24 states and the federal district) participated in the study. Cystoscopy was nearly universal (93.8%), but access to enhanced imaging (17.9%) and office-based flexible cystoscopy (19.3%) was limited. In NMIBC, most urologists maintained patient care (82.9%), but management was heterogeneous. Immediate postoperative intravesical chemotherapy was rarely used. Bacillus Calmette-Guérin (BCG) was prescribed in most cases of recently treated NMIBC by 39.3% of respondents, while 54.2% referred patients for administration. Although 74.5% reported access to it, only 14.3% had availability for all patients. Preference flow analysis showed BCG as the main first-line therapy (65.4%), intravesical chemotherapy as second-line (51.2%), and pembrolizumab (31.3%) and radical cystectomy (30.2%) as third-line options. Radical cystectomy is annually performed by 65.1% of respondents; however, most reported low annual volumes, with 95% performing fewer than ten cases per year.

Conclusions: Bladder cancer management in the Brazilian supplementary healthcare system is heterogeneous, with important gaps in access, technology availability, and adherence to recommended practices. Despite limitations inherited to survey-based research, including potential selection bias, reliance on self-reported data, and possible overlap between public and private practice settings, these findings highlight opportunities for educational initiatives and system-level improvements.

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INTRODUCTION

Brazil has a complex healthcare structure composed of a universal public healthcare system (SUS), and a large supplementary private healthcare sector that covers approximately one quarter of the population. While SUS provides universal access to medical care, the supplementary health system offers private insurance-based coverage that often provides broader access to diagnostic technologies and advanced treatments (1, 2). More recently adopted treatments for bladder cancer, such as immunotherapy or antibody-drug conjugates, are only available in the private system. Differences between these two systems can influence physician practice patterns, access to therapies, and the organization of oncological care.

Bladder cancer represents a clinically relevant disease due to its high recurrence rate, the need for long-term surveillance, high mortality, and financial impact (3). Management of non-muscle invasive bladder cancer (NMIBC) and muscle-invasive bladder cancer (MIBC) requires access to diagnostic procedures such as cystoscopy, transurethral resection of bladder tumors (TURBT), intravesical chemotherapy, and complex surgical procedures, including radical cystectomy (RC). The availability of these resources and reimbursement models may vary considerably within the supplementary healthcare system (4).

Brazil has one of the largest urology communities in the world, with around 6,600 practicing urologists distributed across the country (5). It also represents one of the largest markets for the pharmaceutical industry. Understanding how these specialists diagnose and treat bladder cancer within the private healthcare environment is important for identifying barriers, technological gaps, and variations in treatment strategies. We hypothesized that there is substantial heterogeneity in the real-world management of bladder cancer in the Brazilian supplementary healthcare system.

The objective of the present study was to evaluate the real-world practices of Brazilian urologists regarding bladder cancer management within this setting.

MATERIALS AND METHODS

This study was designed as a cross-sectional, descriptive, survey-based study aimed at evaluating the real-world clinical practice patterns of Brazilian urologists regarding the management of bladder cancer in the supplementary (private) healthcare setting. The primary objective was to characterize diagnostic and therapeutic strategies used in routine practice, with particular emphasis on the treatment of non-muscle-invasive bladder cancer and muscle-invasive bladder cancer within the Brazilian private healthcare system.

The target population consisted of practicing urologists in Brazil. Based on data from the Federal Medicine Council (CFM), the total population of active urologists in Brazil is approximately 6,600 at the time of study design (5). Eligible participants included board-certified urologists and urology practitioners from all geographic regions of the country, regardless of years in practice or institution affiliation, who were involved in bladder cancer care in the private setting.

A structured questionnaire was developed by the study investigators based on clinically relevant aspects of bladder cancer management in Brazil, focusing on areas where practice variation is expected due to differences in access, reimbursement, institutional protocols, and the adoption of new technologies. The questionnaire included items related to physician demographics, geographic region, practice setting, years in practice, number of bladder cancer patients, and therapeutic preferences in specific clinical scenarios. Questions addressed diagnostic work-up, intravesical therapy, management of BCG-unresponsive disease, perioperative strategies, referral patterns for radical cystectomy, use of systemic therapy, and access to newer treatments in the supplementary healthcare setting. The questionnaire was not formally validated. However, it underwent pilot-testing with five urologists who completed the survey and provided feedback regarding question clarity, comprehensiveness, and relevance to clinical practice. Minor adjustments were made based on their suggestions before final distribution.

To ensure adequate representativeness of bladder cancer management practices among Brazilian urologists, the sample size was calculated based on an estimated population of 6,600 active urologists in Brazil (5). A 95% confidence level, 5% margin of error, and 50% response distribution were assumed; the latter was chosen to provide the most conservative estimate. The sample size for an infinite population was first calculated using the standard formula for proportions and subsequently adjusted using the finite population correction. Under these assumptions, the minimum required sample size was 364 respondents. To account for potential nonresponse and incomplete questionnaires, the survey sought to exceed this threshold, thereby enhancing the reliability of the findings and enabling exploratory subgroup analyses across different geographic regions and practice settings.

Data were collected during the Brazilian Congress of Urology in 2025 through a structured questionnaire. The survey was administered by ten trained interviewers, who invited attending urologists to participate in the study. Although the exact number of urologists approached in person was not recorded, according to the reports from the Brazilian Society of Urology (SBU), the congress had more than 3,000 participants. A total of 604 responses were obtained during the event. In addition to in-person recruitment, the questionnaire was distributed electronically via email and WhatsApp using existing databases of Brazilian urologists. A total of 4,397 urologists received the electronic invitation, of whom 1,115 opened the message and 310 completed the questionnaire. Participants were asked to voluntarily complete the survey and the responses were collected anonymously, while ensuring that each participant completed the survey only once. All responses were compiled into a centralized database for descriptive statistical analysis.

All questionnaire items were configured as mandatory; therefore, no missing data occurred in the conventional sense, and all 914 participants completed the survey in full. However, for questions that included an open-ended response option ("Other"), a small number of responses were excluded from analysis due to lack of meaningful content (e.g., isolated characters or

non-interpretable symbols such as "" or "-"). These exclusions were treated as part of data cleaning rather than missing data. The number of excluded responses was low across variables: years since graduation ($n=3$), state of practice ($n=7$), number of bladder cancer patients treated per year ($n=6$), number of cystectomies per year ($n=7$), practice in the public health system ($n=7$), and clinical management scenarios for NMIBC and MIBC ($n=8$ each), corresponding to less than 1% of responses per item. No formal assessment of missing data mechanisms was performed, as no item-level missingness was present. Given the minimal proportion and apparently non-systematic nature of these exclusions, the risk of bias is likely negligible.

Participation in the survey was voluntary, anonymous, and without financial compensation. No personally identifiable information was collected. Because the study involved anonymized physician-reported practice patterns and did not include patient-level data, the risk to participants was considered minimal. The study was conducted in accordance with applicable ethical standards for survey-based research. Under Article 1, sole paragraph, items I and VII, of Brazilian National Health Council Resolution No. 510/2016, this study was exempt from registration and ethical review by the CEP/CONEP system, as it consisted of an anonymous public opinion survey and an analysis of situations derived from professional practice, with no identifiable participant data.

Descriptive statistics were used to summarize respondent characteristics and survey responses. Categorical variables were presented as absolute and relative frequencies (numbers and percentages). Associations between categorical variables were evaluated using the chi-square test or Fisher's exact test, as appropriate according to sample distribution. Subgroup analyses were performed to compare practice patterns according to geographic region and practice-related variables. A significance level of 95% was adopted, and p -values < 0.05 were considered statistically significant. Statistical analyses were performed using Stata version 18.0. Missing data was handled by available-case analysis, and percentages for individual items were calculated based on the number of respondents who completed each specific question.

RESULTS

Demographic aspects

A total of 914 urologists completed the survey, corresponding to 13.6% of the 6,690 urologists practicing in Brazil, with responses obtained from 25 federative units. State-level representativeness ranged from 8.6% to 48.5%. The mean experience with urological practice among respondents was 17.7 ± 8.8 years (range: 0–57 years).

Among respondents, 85.1% reported working in private practice, frequently in association with major insurance providers, while nearly three-quarters also reported working within the public health system (SUS) (72.7%).

Many respondents rated reimbursement for cystoscopy, TURBT and radical cystectomy as poor or very poor, reaching 81.5% for cystoscopy.

Initial diagnosis and management of bladder cancer

Cystoscopy was widely adopted, being routinely performed by nearly all respondents (93.8%), with more than half reporting office-based cystoscopy. However, access to advanced technologies such as flexible cystoscopy and narrow-band imaging remained limited (Table-1).

Office-based cystoscopy was more frequently performed among urologists who reported adequate or good reimbursement compared to those reporting poor reimbursement (72.9% vs. 53.0%). This difference was statistically significant ($p < 0.001$).

Most urologists reported a low annual volume of bladder cancer cases, with 52.1% treating between one and five patients per year. Despite this, hematuria evaluation was nearly universal in clinical practice (99.5%). The diagnostic approach varied, with urinalysis, ultrasound,

Table 1 - Cystoscopy and TURBT practice patterns among Brazilian urologists.

Variable	n (%)
Cystoscopy setting ^a	
Operating room cystoscopy	857 (93.8)
Office-based cystoscopy	508 (55.6)
Flexible cystoscopy	176 (19.3)
Narrow-band imaging	164 (17.9)
TURBT surgical practice	
Most used energy source	
Monopolar	381 (41.7)
Bipolar	513 (56.1)
Laser	18 (2.0)
Preferred technique	
Conventional TURBT	513 (56.1)
En bloc TURBT	105 (11.5)
Both techniques	286 (33.1)
re-TURBT performance	
Always	230 (25.2)
Most cases	631 (69.0)
Rarely	44 (4.8)
Never	9 (1.0)

Note: TURBT = transurethral resection of bladder tumor a Multiple choices were allowed for the cystoscopy setting question.

computed tomography and cystoscopy frequently used, whereas advanced imaging modalities were uncommon.

When imaging suggested bladder tumor, most urologists preferred to combine diagnostic cystoscopy with immediate TURBT (84%). Bipolar resection was the most commonly used technique, whereas conventional TURBT remained the predominant surgical approach (Table-1).

Immediate postoperative intravesical chemotherapy was infrequently used, with most urologists reporting that they never prescribe it (65%). No statistically significant association was observed between the use of postoperative intravesical chemotherapy and geographic region of practice (all $p > 0.05$).

Following NMIBC diagnosis, most urologists continued managing patients themselves (82.9%), with a minority referring patients to clinical oncologists or other specialists.

Continued treatment, more complex NMIBC follow-up and intravesical treatments

Second TURBT was commonly performed, although not universally adopted, with 69% reporting its use in most cases and 25.2% in all cases. Management of intravesical chemotherapy showed substantial variability, with many urologists delegating treatment definition and/or administration to clinical oncologists.

For patients with NMIBC who had previously received treatment, most urologists reported not prescribing BCG and instead referring patients to a clinical oncologist. Conversely, 39.3% prescribed BCG in the majority of cases (Table-2).

BCG use was heterogeneous. Although access was reported by most respondents, consistent availability for all patients was limited, and a considerable proportion reported no access. Among the respondents, the SWOG BCG regimen, consisting of a 6-week induction course followed by maintenance therapy for 1–3 years, was the most frequently adopted protocol (Table-2).

BCG prescription patterns were not significantly associated with the degree of access to BCG ($p = 0.353$), as referral to other specialists remained common even among respondents reporting broad access to the drug. However, significant regional differences were observed regarding BCG prescription patterns. Urologists practicing in the

Northeast ($p = 0.011$), Southeast ($p < 0.001$), and South ($p = 0.012$) were more likely to prescribe BCG directly, whereas referral to another specialist was more frequent in other regions.

In cases of BCG unresponsive disease, the most commonly selected management options were intravesical chemotherapy (43.1%), radical cystectomy (41.5%), repeat TURBT alone (27%), pembrolizumab (25.4%), and repeat BCG (18.6%). Multiple answers were allowed for this question.

In a hypothetically healthy patient diagnosed with NMIBC, BCG remained the preferred first-line therapy (86%), followed by intravesical chemotherapy and, less frequently, pembrolizumab and radical cystectomy. Treatment sequencing analysis confirmed BCG as the most common first-line option (65.4%), with intravesical chemotherapy predominating in second-line settings and systemic or surgical approaches more frequently selected in later lines of treatment (Figure-1).

A substantial proportion of respondents reported not prescribing intravesical chemotherapy (42.9%). Among those who did, referral for administration was common (64.5%). Gemcitabine was the most frequently used agent (44.1%), followed by mitomycin C and combination regimens. Also, 46.0% reported prescribing none of these agents.

Regarding emerging therapies for NMIBC, systemic immunotherapy was perceived as the most promising approach (56.5%), followed by TAR (29.9%), BCG (18.7%), intravesical chemotherapy (18.7%), Adstiladri (12.9%), Anktiva (8.4%), Cretostimogene Grenadenorepvec (5.8%), and Oncotepad (4.2%). However, BCG and intravesical chemotherapy were considered the most clinically relevant therapies in current practice.

MIBC treatment and radical cystectomy practices

Following MIBC diagnosis after TURBT, most urologists continued patient management (65.3%), although referral to specialized urologists or clinical oncologists was also common.

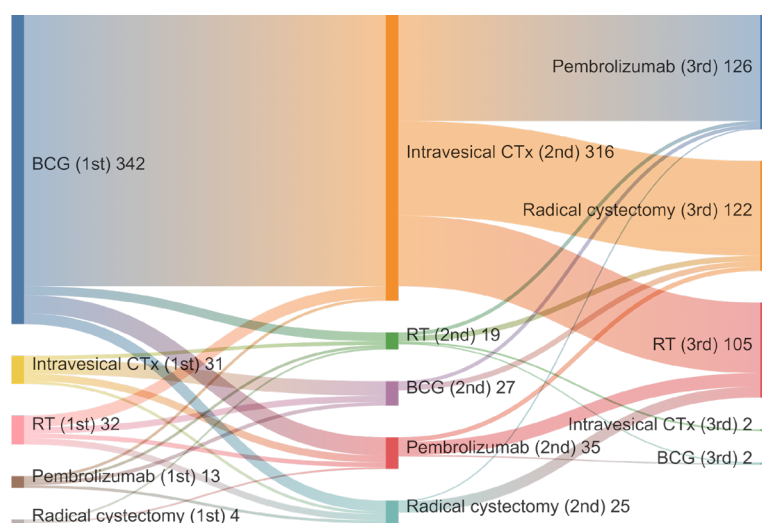
Radical cystectomy was reported to have been performed by 703 respondents. Of these, 91.5% performed the procedure themselves, while 8.5% invited a more experienced surgeon to assist. Referral to specialized centers was reported by 20.1%.

Table 2 - BCG availability and prescribing patterns among Brazilian urologists.

Variable	n (%)
BCG availability	
Available for all	131 (14.3)
Available for the vast majority	324 (35.4)
Available, but just for some	226 (24.7)
Not available	188 (20.6)
Unknown	45 (4.9)
BCG after HR-NMIBC a	
Prescribe BCG	359 (39.3)
Refer the patient to an urologic oncologist for prescription	60 (6.6)
Refer the patient to a clinical oncologist for prescription	495 (54.2)
'BCG protocol	
6-week induction + 3x maintenance (1-3 years) – SWOG b	443 (48.5)
6-week induction + monthly maintenance (1-3 years)	286 (31.3)
Other protocol	13 (1.4)
No regular BCG administration	67 (7.3)
Unknown	105 (11.5)

Note: BCG = Bacillus Calmette-Guérin. a HR-NMIBC = high-risk non-muscle-invasive bladder cancer. b SWOG = Southwest Oncology Group.

Figure 1 - Sankey diagram of the most common sequential treatments of HR-NMIBC according to 914 respondent urologists. The diagram illustrates the flow of treatment preferences across first-, second-, and third-line options, with stream width proportional to the number of respondents.



It shows how initial choices distribute into subsequent treatment options, allowing visualization of the most common therapeutic sequences. Intravesical CTx = Intravesical Chemotherapy; RT = Radiotherapy

RC is annually performed by 65.1% of respondents, however, surgical volume was generally low. Within the last year, 36% did not perform any surgeries, and most urologists reported fewer than five procedures per year (77.7%).

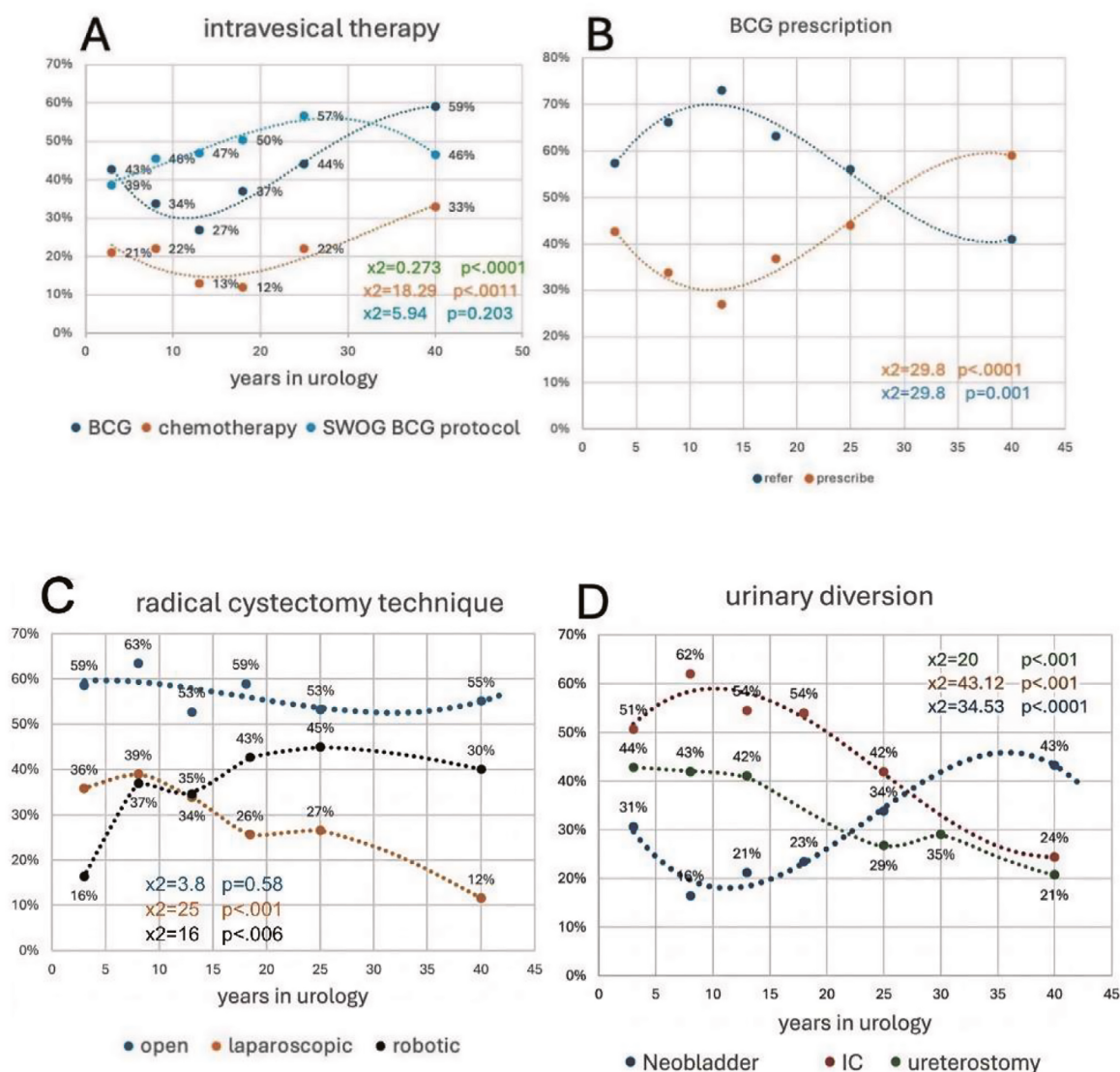
Open surgery was the most performed exclusive approach (28.5%), although minimally invasive and robotic techniques were also reported. Ileal conduit was the most frequently performed urinary diversion (73.0%),

while a notable proportion of respondents reported not performing any type of diversion (21.1%) (Figure-2).

Most urologists referred patients to clinical oncologists for neoadjuvant therapy rather than managing it directly (79.4%).

Finally, bladder-preserving strategies such as radiotherapy or intravesical chemotherapy were generally considered second-line options, typically reserved for selected cases (60.9%).

Figure 2 - Practice patterns according to years of urological experience.



A) Intravesical therapies prescribed and BCG protocol. B) referral or prescription of intravesical BCG. C) radical cystectomy techniques. D) common techniques of urinary diversion.

DISCUSSION

The incidence of bladder cancer in Brazil has risen during the last decade (6). Most procedures to treat bladder cancer are performed by community urologists, and there is a paucity of information on how these patients are treated. In recent years, there have been dramatic changes in technologies and medications available to treat both NMIBC and MIBC. Several factors, such as cultural differences, basic training, structure, and medical knowledge, may play a major role in the heterogeneity of care. Understanding these gaps may help guide educational strategies, resource allocation, and quality improvement initiatives tailored to local needs.

Our findings suggest that cystoscopy is widely incorporated into urological practice in Brazil, reinforcing its role as a fundamental diagnostic tool. However, the pattern of use highlights structural and technological limitations within the healthcare system. The predominance of rigid cystoscopy in office-based settings, along with the limited availability of flexible cystoscopes and enhanced visualization techniques, suggests important limitations in access to contemporary diagnostic technologies (Table-1).

Financial factors appear to play a significant role in shaping this scenario. The overall perception of inadequate reimbursement for cystoscopy, together with its association with lower adoption of office-based procedures, suggests that economic constraints may directly influence clinical decision-making. In this context, suboptimal reimbursement may act as a barrier not only to the incorporation of more efficient technologies, but also to adherence to recommended surveillance strategies in NMIBC patients. These findings likely reflect broader systemic issues, including resource limitations, healthcare organization, and a lower degree of subspecialization and referral compared to higher-income settings. A recent nationwide analysis of bladder cancer procedures within the Brazilian public health system demonstrated significant regional disparities in surgical volume, mortality, and access to care, reinforcing the presence of structural inequalities that may directly impact treatment delivery (7).

Consistent with international trends, bipolar TURBT has gained widespread acceptance (8), and represents the technique mostly used by Brazilian urologists. Additionally, en bloc resection has become more commonly debated in recent years (8). In our survey, we have noticed that almost half of the urologists have been applying this technique. Conventional TURBT, however, remains the most used technique in most cases (Table-1).

Single instillation of an intravesical chemotherapy agent after a conventional low/intermediate-risk TURBT is a recommended practice. However, only 10.1% of Brazilian urologists consistently practice this. For the vast majority, this practice is never performed (Table-3). This is a point that should be addressed through educational initiatives, since this practice is associated with up to 12% decrease in NMIBC recurrence (9). It is important to reinforce, however, that this practice is very difficult to be accepted by health insurance in Brazil, and there are logistical challenges to overcome this current limitation.

These findings are consistent with previous national data. A prior Brazilian survey also demonstrated low adherence to guideline-recommended immediate intravesical chemotherapy in low-risk disease, with substantial variability in clinical practice patterns. Despite the time gap between studies and major advances in NMIBC landscape including bladder-preserving approaches such as gene therapy, immune checkpoint inhibitors, and IL-15 superagonists for BCG-unresponsive disease, adherence to immediate postoperative intravesical chemotherapy in Brazil remains consistently low. Considering that this recommendation has been consistently endorsed by international guidelines for more than a decade, our findings suggest that barriers to guideline implementation remain largely unresolved (10–14).

Another recommended practice for most cases is to repeat a TURBT (Re-TURBT), mostly after a T1 or high-grade disease, if the muscle was not represented. For the vast majority of urologists, Re-TURBT is commonly performed. This is an important good practice, as it is associated with an additional 50% risk of residual NMIBC and an 8% risk of up-staging (15).

Although our manuscript highlights variability in clinical practice, a formal comparison with contemporary international guidelines (EAU, AUA, and NCCN)

Table 3 - Reported Brazilian Practice Patterns Compared with Guideline Recommendations.

Topic	Brazilian Practice	SBU (2010)	AUA (2024)	NCCN (2026)	EAU (2026)
Immediate Intravesical Chemotherapy	65% of urologists report they never prescribe it	Instillation within 6 hours of TURBT	For low-risk and small papillary Ta recurrences (> 1 year after previous TURBT) within 24 hours	Single dose within 24 hours	For low-risk cases within 24 hours
Re-TURBT	69% perform it in most cases; 25.2% perform it in all cases	For incomplete/high-volume tumors, T1, or if muscle is absent from specimen	For incomplete resections, high-grade Ta, or if muscle is absent. Timing: 2–6 weeks	For high-risk, incomplete visually resections, high-grade, or if muscle is absent	Standard practice for T1 high-grade within 6 weeks
BCG for High-Risk NMIBC	86% of specialists choose BCG as initial therapy	Superior to chemotherapy for reducing progression	Full-dose induction followed by maintenance BCG for reducing progression to invasive disease	Selected as first-line BCG for induction and maintenance phases	BCG induction and maintenance phases
BCG Maintenance	Most follow SWOG protocol (6-week induction course followed by maintenance therapy for 1–3 years)	At least one year of maintenance is necessary	Recommended for three years in high-risk patients to prevent recurrence	One year for intermediate-risk and three years for high-risk patients	Ideally one year for intermediate; one to three years for high and very high-risk
Management after BCG Failure	Intravesical chemo (43%), Cystectomy (41.5%), Pembrolizumab (25.4%), Repeat BCG (18.6%)	Early radical cystectomy is recommended for all failure within 6 months	Preferred: Radical Cystectomy. Bladder-sparing: Pembrolizumab, TAR-200, Nadofaragene, or N-803 + BCG	Preferred: Radical Cystectomy. Bladder-sparing: Nadofaragene, N-803+BCG, or Pembrolizumab	Primary: Offer radical cystectomy. Alternatives: Nadofaragene, Gem/Doc, or Pembrolizumab (for CIS)

Source: Elaborated by the authors

provides additional perspective. Adherence appeared heterogeneous across different domains of NMIBC management. High concordance was observed for practices such as repeat TURBT in high-risk disease, whereas substantial gaps were identified in the use of immediate postoperative intravesical chemotherapy and maintenance BCG therapy. These findings suggest that, although several key recommendations have been successfully incorporated into clinical practice, others remain underutilized, particularly in settings affected by logistical, economic, and resource-related constraints

(11–14) (Table-3). This interpretation is supported by recent Latin American multicenter data demonstrating frequent delays in BCG initiation and low adherence to maintenance schedules across the region (16).

Brazilian guidelines for NMIBC, published under the supervision of the Sociedade Brasileira de Urologia (SBU), are largely based on recommendations from the European Association of Urology (EAU) and demonstrate substantial concordance with contemporary quality control/performance indicators (QCI/QPIs) for bladder cancer management (14). Internationally recognized quality

metrics consistently include adequate TURBT with detrusor muscle sampling, appropriate use of repeat TURBT in high-risk disease, immediate postoperative intravesical chemotherapy, and standardized surgical documentation (17, 18). In this context, Brazilian recommendations remain broadly aligned with internationally adopted quality indicators associated with improved staging accuracy, treatment adequacy, and oncological outcomes (17, 19). Although current QCI place increasing emphasis on operative reporting and documentation quality, including tumor characteristics, completeness of resection, and intravesical therapy administration, the overall principles remain consistent with current Brazilian guideline recommendations (14, 19, 20).

As previously mentioned, a relevant finding from the present study is the apparent shift in the management of high-risk NMIBC (HR-NMIBC), with many urologists no longer directly prescribing or administering intravesical BCG despite its well-established role as the standard of care following adequate TURBT (and ReTURBT for most patients) (Table-2). Although BCG has historically been managed within urology practice since the 1980s (13), our data suggest an increasing tendency to refer these patients to medical oncologists or other specialists. Notably, the lack of association between BCG availability and the referral patterns reinforces the hypothesis that factors beyond simple access are involved. Elements such as referral pathways, institutional workflows, increasing subspecialization, and logistical challenges related to BCG administration likely play a central role in shaping care delivery. In addition, the prolonged shortage of BCG in Brazil over the past decade (21) may have contributed to a loss of familiarity or routine among some urologists, further supporting this apparent shift in practice. This is consistent with the observed variation according to years of practice, with higher referral rates among urologists with five to 18 years of practice.

This observed trend raises important concerns regarding care coordination. As medical oncologists do not typically perform cystoscopies, coordinating intravesical instillations and surveillance cystoscopies may introduce logistical challenges, particularly when care is delivered across different providers or institutions. Such

fragmentation may impact adherence to recommended follow-up protocols. On the other hand, this evolving pattern may offer potential advantages in the future. Recent studies have suggested that combining systemic pembrolizumab or sasanlimab with BCG (22, 23) may be advantageous. If approved by regulatory agencies, these regimens might be easier to adopt in Brazil, as many patients already receive BCG from clinical oncologists, who are the usual prescribers of immunotherapies.

Our findings highlight a heterogeneous use of intravesical chemotherapy in Brazil, with a substantial proportion of urologists either not prescribing it or referring patients to medical oncologists. This variability likely reflects differences in drug availability, institutional protocols, and professional familiarity. The predominance of Gemcitabine is consistent with international trends, particularly in most Eastern countries, where it is also the most common drug prescribed (24). In China, gemcitabine currently figures as the second most prescribed drug, after epirubicin (24). Its predominance may also be influenced by the limited availability of Mitomycin C in Brazil in recent years.

Regarding treatment sequencing, BCG remains the cornerstone of first-line therapy for HR-NMIBC, in line with current guidelines. However, the distribution of second-line strategies after BCG failure reveals a balanced preference between intravesical chemotherapy and radical cystectomy, mirroring global patterns. A recent study has demonstrated similar results worldwide, with RC and intravesical chemotherapy competing as the most common second-line treatments for a BCG-unresponsive NMIBC (23, 24). According to the study, RC was mostly performed in Romania (67%), Arab Countries (50%), and the USA (27%). Brazilian urologists would indicate RC for 41.5% of these patients. Intravesical chemotherapy as a second-line treatment was most used in China (64%), the USA (53%), Middle Eastern countries (30%), and Germany (27%) (15, 17). In Brazil, intravesical chemotherapy was the preferred second line, being mentioned in 43.1% of situations (Figure-1).

Pembrolizumab is approved in Brazil for BCG-unresponsive high risk NMIBC (HR-NMIBC) with carcinoma in situ. Long-term results of these therapies are limited (25), which might explain the low adoption of

pembrolizumab for NMIBC worldwide. As reported by Chakra et al., it is fairly adopted, mainly as a third-line option, by 5%-17% of Europeans, 14% of North Americans, 23% of Chinese, and is not adopted in Arab Countries (24). In Brazil, only 5.9% of urologists mentioned pembrolizumab as an eventually prescribed drug for HR-NMIBC. It is interesting, though, that when asked to draw potential sequential treatment lines, a larger proportion of urologists included pembrolizumab in their armamentarium (Figure-1), even when combined with radiotherapy, which is uncommon (26-28).

For Brazilian urologists, the most promising upcoming therapies in the NMIBC scenario are systemic immunotherapy and GEM-IDRS, followed by BCG and intravesical chemotherapy protocols.

Radical cystectomy was mentioned as a routinely indicated practice by most Brazilian urologists. This contrasts with global trends and recommendations (29). RC is a complex procedure, and it is recommended that surgeons perform at least 10 cases per year to achieve acceptable outcomes (30, 31). However, just a few urologists reported referring their patients for RC or to a more experienced surgeon to perform the procedure. It is important to emphasize that not only the surgeon's experience, but also the institution's experience, is crucial for optimal postoperative care following RC (32). Notably, the majority of urologists reported an extremely low procedure volume in the previous year (zero to five procedures). An adequate number of procedures, established at more than 10 per year, was reported by less than 5% of the Brazilian urologists. These findings suggest a possible lack of centralization of complex oncologic procedures in Brazil, which contrast with international recommendations advocating concentration of radical cystectomy in experienced centers. However, it is important to emphasize that our study did not evaluate surgical outcomes such as complications or mortality. Therefore, any potential impact on patient outcomes should be interpreted cautiously and is inferred from previous studies demonstrating the association between higher surgical volume and improved postoperative outcomes (33, 34). Structural barriers, referral pathways and healthcare organizations may contribute to this pattern and warrant further investigation.

This study has several notable strengths. To the best of our knowledge, it is the largest and most comprehensive contemporary study to characterize real-world treatment patterns for both NMIBC and MIBC in Brazil, encompassing a broad national sample and reflecting current clinical practice in the context of recent therapeutic advances. Beyond describing practice patterns, it provides a comprehensive overview of current challenges in bladder cancer care and offers relevant insights for educational initiatives, public health strategies, industry engagement, and the identification of unmet clinical needs. It may also inform the design of future clinical trials by improving understanding of how patients with bladder cancer are managed across the country.

Importantly, the findings highlight substantial variability in clinical practice as well as a concerning mismatch between resource availability and treatment delivery. Despite a response rate of approximately 14%, inherent to survey-based methodologies, the study includes a large absolute sample (n=914) with broad geographic representation across 25 Brazilian federative units. This extensive participation enhances the representativeness of the data and strengthens the validity of the observed patterns. Although respondents were explicitly instructed to base their answers on practice within the supplementary healthcare system, potential contamination from public healthcare (SUS) practices should be acknowledged. Given that many participants work across both systems, some responses may reflect overlapping experiences, potentially influencing the reported patterns of care. In addition, selection bias may be present, as the sample was composed of members of the Brazilian Society of Urology and participants in the Brazilian Congress of Urology, potentially reflecting a more academically engaged population. Furthermore, as with all survey-based studies, the findings are subject to self-report and recall bias. Responses may be affected by memory limitations as well as social desirability bias, potentially leading to overestimation of guideline-adherent practices compared to actual clinical behavior.

Future studies incorporating objective clinical data, registry-based analyses, or observational audits will be important to validate and expand upon these findings.

CONCLUSIONS

The management of NMIBC in Brazil is characterized by considerable variability, despite general alignment with guideline-based recommendations. Our findings highlight important structural and organizational gaps that influence care delivery, including limited access to intravesical BCG, frequent referral to other specialists for its administration, and restricted availability of office-based flexible cystoscopy.

Together, these factors suggest that barriers related to resource distribution, healthcare organization, and workflow integration may impact both treatment implementation and surveillance strategies. Addressing these challenges represents an important opportunity to educational, organizational, and policy-level interventions aimed at improving the quality and consistency of bladder cancer care in Brazil.

ABBREVIATIONS

BCG = Bacillus Calmette-Guérin

SUS = Universal public health care system (Sistema Único de Saúde)

NMIBC = non-muscle invasive bladder cancer

MIBC = Muscle-invasive bladder cancer

TURBT = Transurethral resection of bladder tumors

Re-TURBT = Repeat Transurethral resection of bladder tumors

CFM = Federal Council of Medicine

NBI = Narrow-band imaging

RC = Radical cystectomy

HR-NMIBC = High risk non-muscle invasive bladder cancer

MRI = Magnetic resonance imaging

PET-FDG = Fluorodeoxyglucose-positron emission tomography

EAU = European Association of Urology

AUA = American Urologic Association

NCCN = National Comprehensive Cancer Network

QCI/QPI = Quality Control Indicators / Quality Performance Indicators

SWOG = Southwest Oncology Group

CEP/CONEP = Research Ethics Committee/National Research Ethics Commission (Brazil)

ETHICS APPROVAL

This study was not submitted for review by a Research Ethics Committee, as it falls under the exemptions provided in Article 1, sole paragraph, items I and VII, of Brazilian National Health Council Resolution No. 510/2016. Specifically, it is characterized as an anonymous public opinion survey and as a theoretical analysis of situations arising spontaneously and contingently from professional practice, without disclosure of identifiable participant data. Therefore, under the terms of this regulation, the study did not require registration or review within the CEP/CONEP system.

CONFLICT OF INTEREST

None declared.

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Precise Robotic Y-V Plasty for Vesico-Urethral Anastomotic Stenosis: Avoiding Urinary Incontinence

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ABSTRACT

Objective: The treatment of vesico-urethral anastomotic stenosis (VUAS) is difficult because of the high risk of urinary incontinence. Cystoscopy-guided robotic Y-V plasty is hypothesized to reduce the incidence of urinary incontinence compared to traditional Y-V plasty. The purpose of this study was to evaluate the efficacy of cystoscopy-guided robotic Y-V plasty.

Materials and Methods: All patients diagnosed with VUAS following radical prostatectomy between January 2019 and December 2024 were retrospectively reviewed. Patients with damaged external urethral sphincter or stenosis involving the external sphincter were excluded. Cystoscopy-guided robotic Y-V plasty was performed at least three months after the last failed intervention. After catheter removal, patients were scheduled for re-examination at one, six, twelve and twenty-four months. Uroflowmetry was routinely performed and cystoscopy was performed at six months after surgery. Postoperative changes in patients' erectile function, lower urinary tract symptoms, and urinary continence were followed up using Five-item International Index of Erectile Function (IIEF-5), International Prostate Symptom Score (IPSS), and urinary continence grading.

Results: Twenty-eight patients were enrolled. All patients were followed up for 6–59 (median 30) months after surgery. The final success rate was 96.4% (27/28). Normal continence was achieved in 25 patients (92.6%). Social continence occurred in 2 (7.4%). No patients experienced clinical incontinence. The patients' postoperative IPSS scores achieved significant improvement compared with preoperative.

Conclusion: The surgical strategy cystoscopy-guided robotic Y-V plasty is more precise, direct and efficient in protecting the external urethral sphincter. It ensures a high success rate and simultaneously reduces the occurrence of urinary incontinence.

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INTRODUCTION

Vesico-urethral anastomotic stenosis (VUAS) is a potential complication after radical prostatectomy (1). The reported incidences have significantly decreased since the advent of robotic surgery, largely thanks to higher-quality vesico-urethral anastomosis and greater water tightness (2-4). The actual incidence of VUAS has declined significantly over time, from an initial alarming rate of > 17% to a contemporary lower rate of < 1% (5, 6). Despite its decreasing prevalence, VUAS continues to pose a significant challenge in terms of management for both patients and reconstructive surgeons.

In case of stenosis recurrence after two or more failed endoscopic attempts, it is described as recalcitrant VUAS. This rare yet challenging condition lacks a universally accepted standard treatment approach. The first-line treatment often involves endoscopic procedures (7), with variations in its modalities: dilatation, incision, resection, or application of scar modulators. Surgical reconstruction is typically utilized for intricate cases of recurrent VUAS (8). Several reports advocate a vesico-urethral reanastomosis after failure of endoscopic treatments (9, 10). Nonetheless, the occurrence of new onset incontinence is surprisingly high, reaching up to 31%. This limits its widespread application. In 1950s, Young first described an Y-V plasty of the bladder neck (11). The Y-V plasty offers a high success rate by enabling reconstruction of a wide reanastomosis with a flap of healthy tissue. Although this technology brings new hope for bladder neck contracture after transurethral surgery for benign prostatic hyperplasia (12, 13), it is difficult to effectively treat the VUAS after radical prostatectomy. The primary challenge lies in mitigating the risk of urinary incontinence, given the limited length of the residual functional urethra following radical prostatectomy, which poses a challenge in avoiding damage to the external urethral sphincter. Therefore, avoiding intraoperative injury to the external sphincter is crucial to reduce the occurrence of new onset incontinence.

Robotic bladder neck Y-V plasty under direct vision of the cystoscope can achieve the goal of preserving urinary control function. Here, through this multi-center retrospective study, we aimed to share our

experience and preliminary outcomes of cystoscopy-guided robotic Y-V plasty for the treatment of VUAS following radical prostatectomy.

MATERIALS AND METHODS

Patients and preoperative preparations

This study adheres to the principles outlined in the Declaration of Helsinki and was approved by the institutional review board (LY2025-378-B). Informed consent was obtained from all patients. All patients diagnosed with VUAS following radical prostatectomy between January 2019 and December 2024 were retrospectively reviewed. The surgeries were performed by four surgeons in three institutions. Preoperative evaluation included a medical history, physical examination, urinalysis, urine culture, uroflowmetry, retrograde and voiding cysto-urethrography (RVCUG), cystoscopy and magnetic resonance imaging (MRI). Based on the preoperative MRI (Figure-1A), RVCUG (Figure-1B) and cystoscopy (Figure-1C), patients who had undergone cystoscopy-guided robotic Y-V plasty and whose external urethral sphincter was structurally and functionally intact were included. However, those with damaged external urethral sphincter or stenosis involving the external sphincter were excluded. Patients who underwent radiotherapy after radical prostatectomy were excluded. In addition, patients with incomplete clinical records, missing follow-up data, or lost to follow-up were also excluded. Before surgery, the erectile functions of all patients were evaluated using the Five-item International Index of Erectile Function (IIEF-5). According to the IIEF-5, erectile function can be divided into normal, mild, moderate, and severe erectile dysfunction (ED) (14). The International Prostate Symptom Score (IPSS) was used to assess patients' lower urinary tract symptoms (15). Cystoscopy-guided robotic Y-V plasty was performed at least three months after the last failed intervention.

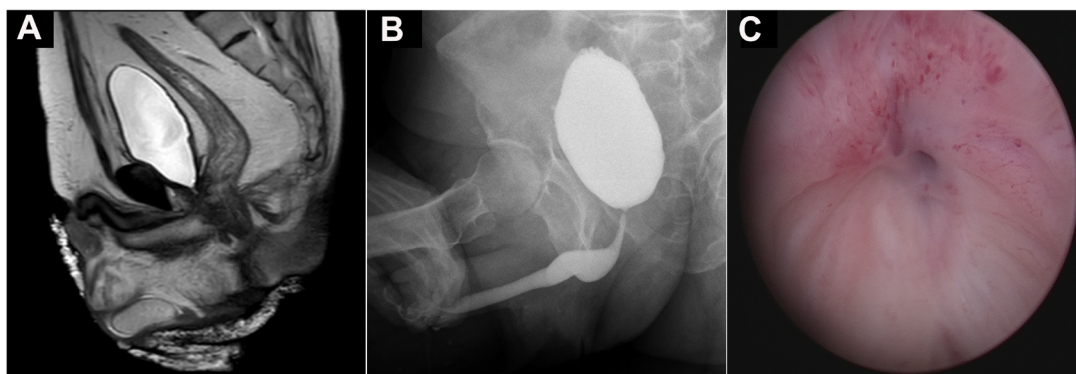
SURGICAL STRATEGY AND TECHNIQUES

The robotic surgery was performed using da Vinci Xi platform. Patients were placed in a low lithotomy

position. The transabdominal robotic technique with five trocars began with entering the abdomen with an approach similar to a radical prostatectomy (16). The surgical procedure begins with the dissection and mobilization of the Retzius space. The bladder is first freed from the overlying peritoneum to identify the obstructed bladder neck under the guidance of cystoscopy performed by an auxiliary surgeon (Figures 2A and E). A cystoscope is

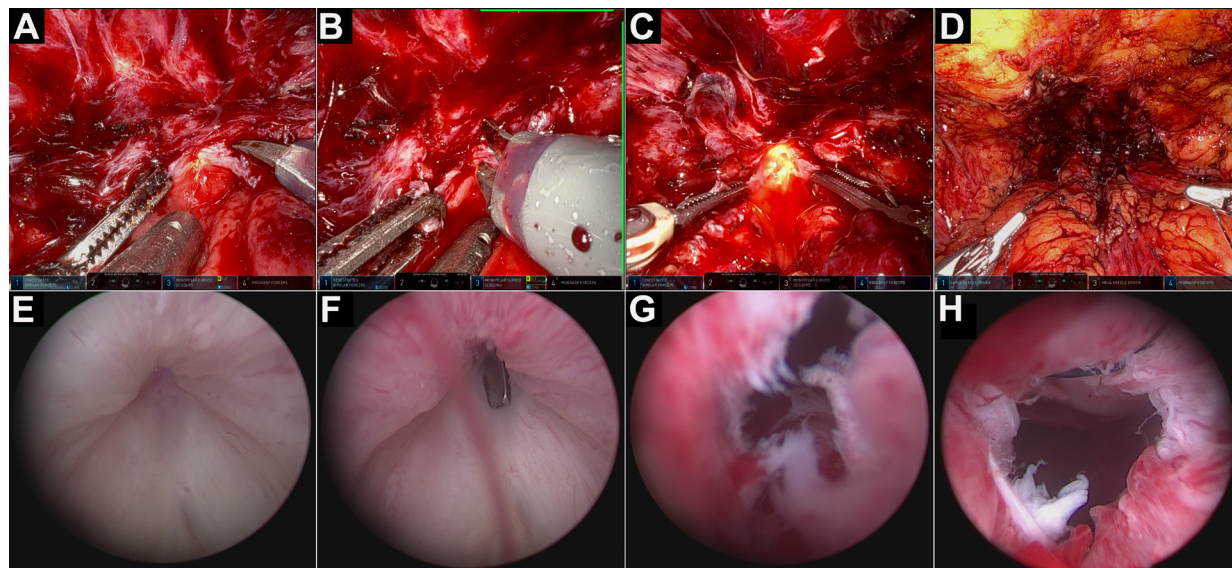
placed at the membranous urethra and crosses the external urethral sphincter to confirm the integrity of external urethral sphincter and observe the incision of narrowed segment performed using monopolar scissors (Figures 2B and F). Then a Y-shaped incision of anterior bladder neck is performed (Figure 2C) under the observation of cystoscopy to avoid any potential injury to the external sphincter (Figure-2G and Supplementary video 1).

Figure 1 - Preoperative evaluation by MRI.



A) RVCUG, B) and cystoscopy, C) of one patient. The distance between the bladder neck and the external sphincter is assessed by MRI; the length and degree of stenosis are assessed by RVCUG; and the distance between the bladder neck and the external sphincter and the degree of stenosis are further confirmed by cystoscopy.

Figure 2 - The surgical procedures.



A) The bladder is first freed from the overlying peritoneum to identify the obstructed bladder neck. B) The obstructed bladder neck was incised by monopolar scissors. C) A Y-shaped incision of the obstructed bladder neck is performed. D) A V-shaped suture is made to reconstruct na enlarged bladder neck. E) The obstructed bladder neck was identified under the guidance of urethroscopy. F) A cystoscope is placed at the membranous urethra to confirm the integrity of external urethral sphincter and observe the bladder neck incision. G: While a Y-shaped incision is performed, a cystoscope was used to observe and avoid potential injury to the external sphincter. H: The V-shaped suture is completed under cystoscopic surveillance.

WATCH THE FULL VIDEO 1

The apex of the V-shaped anterior bladder flap is advanced into the distal aspect of the incision, and a V-shaped suture is made to reconstruct an enlarged bladder neck using 3-0 barbed sutures (Figure-2D). The suturing of the apex is also completed under cystoscopic surveillance (Figure-2H and Supplementary video 2).

WATCH THE FULL VIDEO 2

After control for leak tightness, an F22 silicone catheter is inserted into the urethra to maintain patency.

Postoperative management and follow-up

Urethral catheter was routinely left indwelling for two weeks after surgery. After catheter removal, patients were scheduled for re-examination at one, six, twelve and twenty-four months. After two years, all patients were consistently followed up through outpatient visits, telephone calls, or e-mails. Uroflowmetry was routinely performed. Cystoscopy was performed at six months after surgery (Supplementary video 3).

WATCH THE FULL VIDEO 3

RVCUG was not performed for everyone. However, if the patient complained of urinary obstruction during follow-up, RVCUG became necessary. Success of VUAS after cystoscopy-guided robotic Y-V plasty was defined as restoring a wide bladder neck determined by flexible cystoscopy and no need for further intervention procedures such as dilatation, internal urethrotomy, or reconstructive surgery. The surgery was considered successful if the maximum urine flow rate is greater than 15mL/s and the 17Fr cystoscope can pass smoothly. The Clavien-Dindo Classification system was employed to categorize postoperative complications (17). All patients were followed up on urinary continence, erectile function and IPSS at three and six months postoperatively in the outpatient clinic. Based on symptoms, urinary continence was categorized into three levels: normal continence, social continence defined as a requirement

of 2 pads or less per 24-hour period, and clinical incontinence necessitating more than 2 pads per 24-hour period (18).

RESULTS

Patient characteristics

In total, 31 patients diagnosed with VUAS after radical prostatectomy had undergone cystoscopy-guided robotic Y-V plasty. Three patients were excluded because of incomplete follow-up data. Therefore, 28 patients with a median age of 69 (range 60–85) years were finally enrolled. Table-1 presents the demographics and clinical data, including age, body mass index, diabetes mellitus, previous surgical approach to radical prostatectomy, previous surgical methods to radical prostatectomy, previous pelvic lymph node dissection, history of failed transurethral procedures, suprapubic cystostomy, erectile dysfunction, disease course and VUAS length. The operation time was 50–150 (median 70) min. Intraoperative blood loss was 50–200 (median 80) mL.

Treatment effectiveness

All patients were followed up for 6–59 (median 30) months. After surgery, the final success rate was 96.4% (27/28). Postoperative complications mainly included bladder spasm in six patients, urethral orifice pain in two, wound infection in one, wound bleeding in one and intermuscular vein thrombosis of lower limbs in one. No serious complications related to cystoscopy-guided robotic Y-V plasty occurred. Normal continence was achieved in 25 patients (92.6%). Social continence occurred in 2 patients (7.4%). No patient experienced clinical incontinence. The incidence of ED was similar to that before surgery (Table-1). Among the 27 patients who were successfully treated, the maximum urinary flow rate (Q_{max}) was significantly improved, with preoperative and postoperative Q_{max} of 7.1 ± 1.7 mL/s and 18.1 ± 2.8 mL/s respectively ($p=0.000$). Likewise, the patients' IPSS scores also achieved significant improvement with preoperative and postoperative scores of 19.1 ± 1.8 and 5.9 ± 1.7 respectively ($p=0.000$). The failed patient was successfully cured with transurethral resection of bladder neck.

Table 1 - Patient demographics and clinical records.

Variables	Value
Patients, n	28
Age, median (range) yrs	69 (60 - 85)
BMI (kg/m ²), median (range)	26.4 (19.2 - 32.5)
Diabetes mellitus, n (%)	
Yes	5 (17.9)
No	23 (82.1)
Previous surgical approach to RP, n (%)	
Extraperitoneal	20 (71.4)
Transperitoneal	8 (28.6)
Previous surgical methods of RP, n (%)	
Laparoscopic	17 (60.7)
Robotic	11 (39.3)
Previous pelvic lymph node dissection, n (%)	
Yes	2 (8.1)
No	26 (92.9)
History of failed transurethral procedures, n (%)	
Urethral dilatation	19 (67.9)
DVIU	22 (78.6)
TUR of BN	20 (71.4)
Any two or more procedures	28 (100)
Suprapubic cystostomy, n (%)	
Yes	7 (25.0)
No	21 (75.0)
Erectile function	
Normal	0 (0)
Mild ED	1(3.6)
Moderate ED	2(7.1)
Severe ED	25 (89.3)
Disease course, median (range) months	21 (7 - 47)
Stenosis length, Mean $\pm$ SD (range) mm	5.32 $\pm$ 0.98 (4 - 8)
VUAS recurrence, n (%)	1 (3.6)

continue

Variables	Value
Postoperative complications, Clavien-Dindo, n (%)	
I	8 (28.6)
II	3 (10.7)
II	0
VI	0
V	0
Any grade	11 (39.3)
Erectile function, n (%)	
Normal	0 (0)
Mild ED	1(3.7)
Moderate ED	2(7.4)
Severe ED	24 (88.9)
Total	27 (100)
Urinary continence, n (%)	
Normal continence	24 (92.6)
Social continence	2 (7.4)
Clinical incontinence	0 (0)
Total	27 (100)

BMI = body mass index; BN = bladder neck; DVIU = direct visual internal urethrotomy; ED = erectile dysfunction; RP = radical prostatectomy; TUR = transurethral resection.

DISCUSSION

With the aging of the social population and the increasing detection rate of prostate cancer year by year, especially Asian countries (19, 20), it is urgent to find an effective surgical method to solve the VUAS after radical prostatectomy. In this work, the new surgical strategy of cystoscopy-guided robotic Y-V plasty was preliminarily effective in treating VUAS following radical prostatectomy. It not only ensures a high success rate but also reduces the occurrence of urinary incontinence. This report is the first on the application of cystoscopy-guided robotic Y-V plasty in the surgical treatment of VUAS.

For the treatment of patients with VUAS, while reconstructing a wide bladder neck, it is also necessary to

consider how to ensure urinary control. Since the prostatic urethra is completely resected during radical prostatectomy, and the internal urethral sphincter is also destroyed, the patient's urinary control mainly relies on the external urethral sphincter. Therefore, the focus of reconstructive surgery for patients with VUAS is to protect the external urethral sphincter. According to previous reports (21), the traditional bladder neck Y-V plasty involves incision and reconstruction of the bladder neck under direct vision through a transabdominal or extraperitoneal approach (22). Although this surgery has a high success rate in resolving patients' urinary difficulties, it cannot ensure whether the external sphincter is damaged during the surgery. The incontinence rates were about 18-27% (2). In this regard, based on this surgical procedure, we

made technical improvements aimed at protecting the external sphincter, that is to perform bladder neck Y-V plasty under direct vision of the cystoscope. Two reconstructive urologists operated da Vinci platform and cystoscope simultaneously in a combined antegrade and retrograde manner, to avoid over-incision of the bladder neck and posterior urethra, and to avoid suturing into the external sphincter. This can effectively prevent damage to the external sphincter. In this study, the surgery was performed transperitoneally because the difficulty of establishing surgical cavities and surgical procedures through an extraperitoneal pathway is extremely harder.

In this study, the surgical success rate reached 96.4%. Among the 27 patients who were successfully treated, no patient experienced severe incontinence requiring urinal pads. Only two patients developed occasional incontinence without the need for urinal pad usage. Postoperative cystoscopy showed that the contractile function of the external urethral sphincter in the two patients was not significantly damaged. According to our follow-up results, the urinary leakage symptoms of the two patients were significantly relieved in 6 and 8 months after surgery respectively. On the third to sixth day after surgery, bladder spasm occurred in six patients. At the same time, the amount of drainage in these patients increased significantly, and the creatinine of the drainage fluid also increased. Among these, five patients showed significant relief in bladder spasm symptoms and corresponding reduction in drainage after conservative treatment. However, one case showed no significant improvement after 3 days of conservative treatment, so the catheter was replaced by a 16 Fr nephrostomy balloon catheter on the seventh day after surgery. Subsequently, the patient's bladder spasm symptoms were resolved.

Each surgical technique has its indications. In recent years, bladder neck Y-V plasty has gradually become the gold standard surgical procedure for bladder neck stenosis after prostatic hyperplasia. However, for patients with VUAS after radical prostatectomy, it is necessary to strictly select suitable patients before performing Y-V plasty. Patients whose preoperative cystoscopy indicates that the stenosis involves the external urethral

sphincter are not suitable for Y-V plasty. We believe that the key to ensuring good urinary control is that there should be a certain distance between the distal end of the Y-shaped incision and the external urethral sphincter to ensure that the anastomosis will not affect the external sphincter. In patients with long stenosis zones involving the external sphincter, Y-V plasty combined with an artificial sphincter system may be a more suitable option.

A good therapeutic effect was achieved through the strategy of cystoscopy-guided robotic Y-V plasty; however, this study had some limitations. First, this is a retrospective clinical study, and there may be some bias in the collection of research data. Prospective studies are imperative for validating its effectiveness. Second, definite conclusions cannot be drawn from the small cohort. Therefore, this study only provides some references on how to reduce incontinence after bladder neck reconstruction. Future studies should aim to include a larger pool of patients to ensure greater reliability of the results. Third, the cause of social continence remains unclear. Urodynamic testing should be used to evaluate urethral pressure and bladder detrusor function as well as bladder capacity. Fourth, this study did not include patients with a history of radiotherapy, so the conclusions drawn from this study are not applicable to all VUAS patients.

We believe that the proposal of this precise surgical strategy will further improve the treatment effect of VUAS after radical prostatectomy. At the same time, we hope that researchers will jointly conduct such clinical studies to further clarify the pros and cons of this surgical strategy and improve the details of the surgical procedures.

CONCLUSIONS

This is the first report on cystoscopy-guided robotic Y-V plasty in the surgical treatment of VUAS after radical prostatectomy. This surgical strategy is more precise, direct and efficient in protecting the external urethral sphincter. It ensures a high success rate and simultaneously reduces the occurrence of urinary incontinence. This technology is worth further validation and widespread promotion.

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Lin Wang and Fuhao Ji contributed equally to this article.

CONFLICT OF INTEREST

None declared.

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Could the preoperative urethral curve be used to predict immediate urinary continence following Retzius-sparing robot-assisted radical prostatectomy? A retrospective multicenter study

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ABSTRACT

Purpose: Immediate urinary continence (UC) recovery following Retzius-sparing robot-assisted radical prostatectomy (RS-RARP) remains highly variable, highlighting the need for reliable preoperative prediction. We aimed to develop and validate models to identify patients likely to achieve immediate UC recovery following RS-RARP.

Materials and Methods: A total of 580 prostate cancer patients who underwent RS-RARP from four medical centers were assigned to a training set (n=348), an internal validation set (n=103) and an external validation set (n=129). Independent predictors were identified through univariate analysis and LASSO regression. A nomogram was constructed using multivariate logistic regression. Its performance was evaluated with receiver operating characteristic (ROC) curve, calibration curves, and decision curve analysis.

Results: Immediate UC recovery was observed in 84.5% (294/348) of patients in the training cohort, 80.6% (83/103) in the internal validation cohort, and 81.4% (105/129) in the external validation cohort, respectively. Multivariate analysis identified membranous urethral length (MUL) (OR=1.23, P=0.029) and urethral curvature (OR=2.84, P<0.001) as independent predictors, while prostate volume (PV) (OR=0.84, P<0.001) as a protective factor. The nomogram integrating MUL, PV, and urethral curvature demonstrated superior predictive accuracy,

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with an AUC of 0.87 (95% CI, 0.83-0.91) in the training cohort. The bootstrap-corrected calibration slope was 0.96, and the Brier score was 0.08. Calibration curves and decision curve analysis confirmed the predictive accuracy and clinical utility of the nomogram.

Conclusions: Our study introduces a novel quantitative method for assessing urethral curvature. The mpMRI-based model, integrating urethral curvature and prostate spatial configuration, offers enhanced predictive accuracy for postoperative immediate UC recovery.

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Data Availability

The data presented in the study are included in the article, and further inquiries can be directed to the corresponding authors.

INTRODUCTION

Prostate cancer (PCa) is the second most common malignancy among men globally (1), and its incidence in China has increased rapidly due to expanded screening (2). Radical prostatectomy (RP) is one of the standard treatment options for localized and locally advanced PCa (3-5). However, urinary incontinence, the most common postoperative complication, significantly impacts quality of life (5). Although long-term urinary continence remains an important functional endpoint after radical prostatectomy, immediate UC recovery has attracted increasing attention because it directly reflects the effectiveness of anatomical preservation during surgery and has a substantial impact on early postoperative quality of life and functional recovery (6-8). Therefore, identifying patients who are likely to achieve immediate UC before surgery may facilitate individualized counseling and perioperative management.

Advancements in minimally invasive surgery have made robot-assisted radical prostatectomy (RARP) the predominant approach (9-11). In 2010, Galfano et al. (12) introduced Retzius-sparing RARP (RS-RARP), which offers a posterior approach that preserves the neurovascular bundle (NVB) and improves early urinary continence (UC) outcomes compared to the traditional anterior approach (12, 13). Nevertheless, the incidence of immediate UC recovery after RS-RARP ranges from 38% to 80% (14, 15), with some patients still failing to achieve immediate UC postoperatively. Therefore, identifying reliable preoperative predictors of immediate UC recovery following RS-RARP is clinically critical for risk stratification and surgical planning.

In recent years, preoperative multiparametric magnetic resonance imaging (mpMRI) has gained attention for predicting postoperative UC recovery in PCa surgery (16). Anatomical parameters such as membranous urethral length (MUL) (17), prostate volume (PV) (18), intravesical prostatic protrusion length (IPPL) (17), and prostatic apex morphology (19) have been investigated as potential predictors. Nevertheless, these metrics do not fully capture the functional anatomy that supports urethral closure and continence. The curvature of the male urethra, shaped by spatial relationships between the prostate, pubic bone, and surrounding supportive structures, serves a critical functional role in maintaining urinary continence (19). It enables coordinated action of the rhabdosphincter and puboperinealis muscles, which compress the urethra against the pubic bone under increased intra-abdominal pressure, facilitating urethral closure and preventing urinary leakage. Without this curvature, the urethra would be straight, hindering the generation of sufficient pressure to seal the urethra, thereby compromising the prevention of urine leakage (20). Although the functional importance of urethral curvature is recognized, prior studies have not quantified this parameter or validated its predictive performance for immediate UC after RARP.

We therefore hypothesized that urethral curvature reflects the functional continuity of the urethral support mechanism and may serve as an independent predictor of immediate UC recovery after RS-RARP. In this study, we aimed to introduce a novel mpMRI-based method for quantifying urethral curvature, validate its performance in preoperative assessment of immediate

UC recovery following RS-RARP, and develop a multiparametric predictive nomogram combining urethral curvature with established anatomical predictors for clinical guidance in postoperative UC recovery.

MATERIALS AND METHODS

Study design and patients

This retrospective study was approved by the Ethics Committee of the First Affiliated Hospital University (approval number: MRCTA, ECFAH of FMU [2025] 002), and the study protocol was registered at clinicaltrials.gov (registration number: NCT06850116). Immediate UC was defined as patient-reported use of zero pads or one security liner per day within one week of catheter removal (21). Patients diagnosed with PCa who underwent RS-RARP at our center between January 2022 and January 2026 were included and were assigned to the training and internal validation cohorts according to the admission time. Patients admitted between January 2022, and January 2025 were assigned to the training cohort (n=348), whereas those admitted between February 2025 and January 2026 were assigned to the internal validation cohort (n=103). Patients treated at Nanjing Drum Tower Hospital, Qilu Hospital of Shandong University, and Baoji Central Hospital between February 2025, and January 2026 were assigned to the external validation cohort (n=129) (Figure-1).

The inclusion criteria were as follows: [1] prostate biopsy and postoperative pathology confirmed as prostate cancer; [2] mpMRI with a 3.0 T scanner for prostate or pelvic scans performed within 30 days before the operation; [3] localized tumor defined as cT1, cT2, or cT3aN0M0 in TNM staging, without regional lymph node metastasis or distant metastasis; [4] availability of complete clinicopathological data; [5] complete follow-up data. The exclusion criteria were as follows: [1] history of prior neoadjuvant treatments, including hormone therapy or radiotherapy; [2] history of previous urethral trauma or surgery; [3] severe lower urinary tract symptoms before operation; [4] presence of recurrent or metastatic cancer; [5] incomplete clinical, imaging, or pathological data, or loss to follow-up.

MpMRI examination

The mpMRI imaging was performed using a magnetic resonance scanner (MAGNETOM™ Verio 3.0T, Siemens Healthineers) with a transabdominal external phased-array coil. Patients were positioned in a supine position with a moderately filled bladder during imaging. The following sequences were obtained: [1] axial, coronal, and sagittal T2-weighted imaging (T2WI) sequences; [2] axial T1-weighted imaging (T1WI) scans; [3] diffusion-weighted imaging (DWI); [4] apparent diffusion coefficient (ADC), and [5] dynamic contrast enhancement (DCE). The contrast agent (gadolinium Gd-DTPA) was injected through the cubital vein at a flow rate of 3.0 mL/s, and the contrast injection was simultaneously scanned for 15 cycles. The MRI image acquisition parameters are listed in Table-S1.

MpMRI scanning evaluation

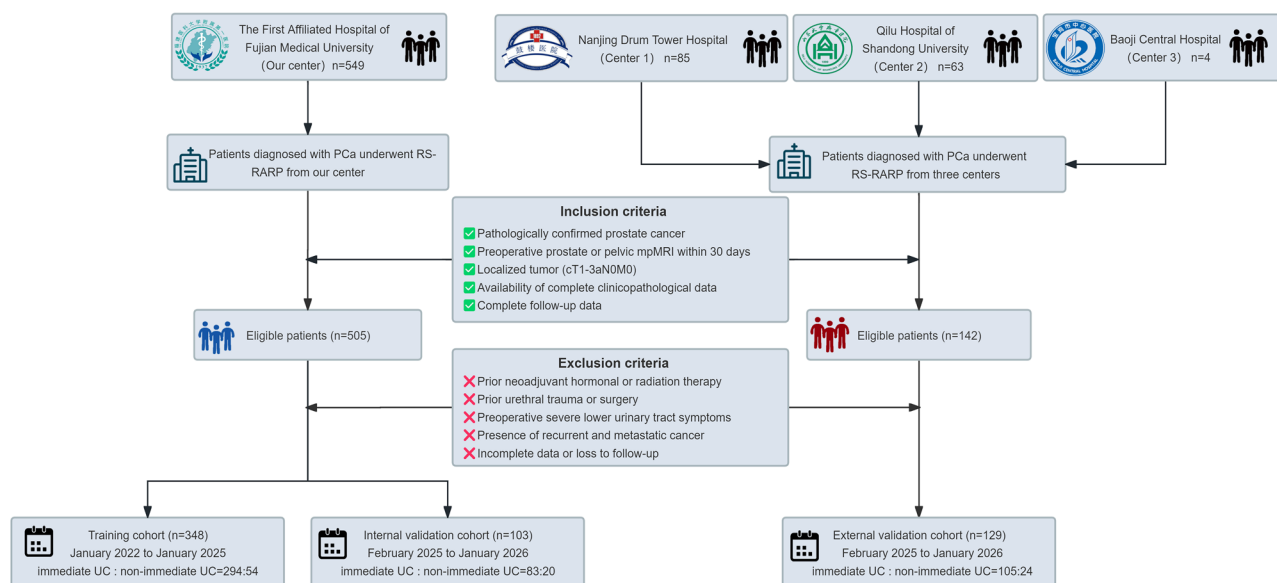
Preoperative anatomical measurements of mpMRI were evaluated with Prostate Imaging Reporting and Data System (PIRADS) version 2 (22). For each variable, measurements were independently conducted by two radiologists with ten (QJX) and eight (SBZ) years of experience, respectively, under the guidance of one experienced urologist (SHC). The measurers were blinded to each other's results, and both were blinded to the clinical information and follow-up outcomes of the patients. Discrepancies were resolved through consensus reading. All images were evaluated on T2WI sequences using the Philips MR workstation (IntelliSpace Portal, ISP). The measured mpMRI parameters were as follows:

MUL: the length of the urethra between the lower border of the prostatic apex and the upper border of the penile root (Figure-2A).

Membranous urethral width (MUW): the maximum diameter of the membranous urethra measured on the axial plane (Figure-2B).

PV: prostate width × length × height × ($\pi/6$) (Figures 2C-E).

IPPL: the vertical distance from the tip of the protruding prostate to the base of the urinary bladder on the midsagittal image (Figure-2F).

Figure 1 - A flow diagram of the patient recruitment and study procedures.**Table S1 - Sequence parameters for mpMRI.**

Parameters	T2WI	T1WI	DWI	DCE
TR/TE, ms	5960/93	573/11	6900/93	5.1/1.7
Flip angle, °	150	150	N/A	15
Echo train length	25	3	N/A	N/A
FOV, mm ²	160×160	320×320	190×260	260×260
Matrix size	256×256	256×192	102×160	138×192
Slice thickness, mm	3.0	5.0	3.0	3.6
Others	b values = 0, 50, 800, 1500 sec/mm ²			Temporal resolution = 9.3 s, total scan time of 3.53 min

mpMRI = multiparametric magnetic resonance imaging; T2WI = T2-weighted imaging; T1WI = T1-weighted imaging; DWI = diffusion-weighted imaging; ADC = apparent diffusion coefficient; DCE = dynamic contrast enhancement; 3D-GRE = three dimensional-gradient echo; TR = repetition time; TE = time echo; FOV = field of view; N/A = not available.

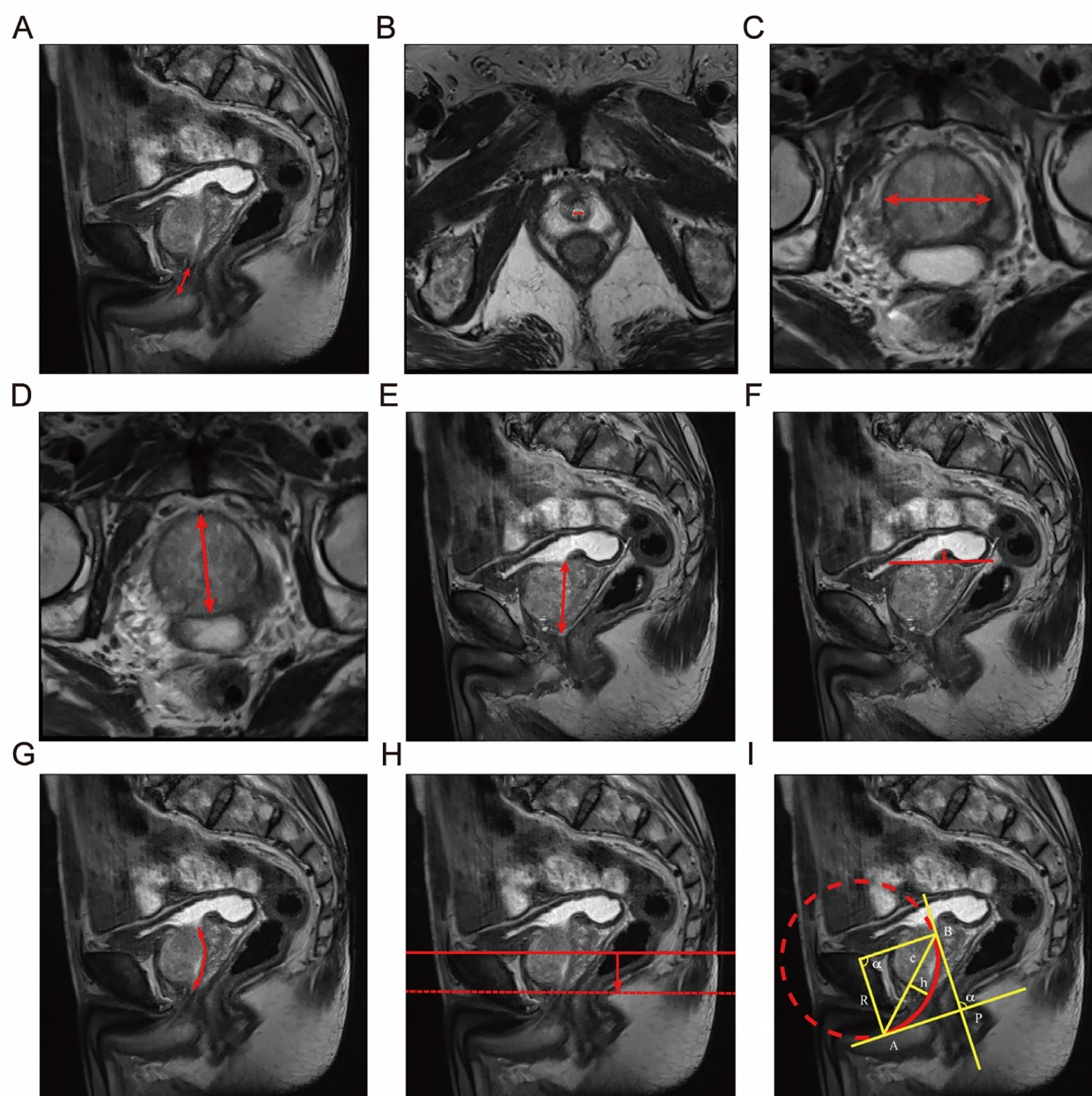
Prostatic urethral length (PUL): the length from the prostatic apex to the entrance of the urethral bulb on the sagittal plane (Figure-2G).

Pubic symphysis-prostate apex length (PAL): the distance between the extension lines of the suprapubic ridge and the prostate apical line on the sagittal MRI (Figure-2H).

Urethral curvature: reciprocal of the urethral curve radius between the bladder neck and the origin of the membranous urethra (Figure-2I). The radius was measured in centimeters (cm).

Specifically, to measure urethral curvature, the sagittal T2-weighted image slice with the clearest visualization of the urethral arc between the bladder neck and the origin of the membranous urethra was selected. The distance between the inflection points on both sides of the dome was considered (denoted as line c in Figure-2I). The distance from the apex of the dome to line c was measured as a perpendicular line (denoted as h in Figure-2I). The radius (R) of the hypothetical circle defined by its chord c and height h was then calculated.

Figure 2 - Prostate MRI parameters.



A) Membranous urethral length; B) Membranous urethral width; C) Prostate width; D) Prostate length; E) Prostate height; F) Intravesical prostatic protrusion length; G) Prostatic urethral length; H) Pubic symphysis-prostate apex length; I) Measurement of urethral curvature (solid red line). The chord length (c) was defined as the line connecting the bladder neck and the origin of the membranous urethra, whereas the height (h) was the perpendicular distance from the chord to the urethral curve margin. The radius (R) of the fitted circle (dashed red line) is shown in yellow, and curvature was calculated as $1/R$.

The geometric formula used to determine R is as follows:

$$R = \frac{h}{2} + \frac{c^2}{8h}$$

The mean curvature K of the urethral curve segment is defined as the ratio of the total tangent turning angle α (in radians) to the arc length $\cap$ AB (s); For an arbitrary arc $\cap$ AB on the circle (Figure-2I), the tangent turning angle α equals the central angle subtended by the arc. By the circular arc length formula $s=R\alpha$, substituting into the mean curvature definition directly yields:

$$K = \frac{\alpha}{s} = \frac{1}{R} = \frac{1}{R}$$

The pointwise curvature K at any point on the circle is the limit of as the arc length approaches zero:

$$K = \lim_{s \rightarrow 0} \frac{1}{R} = \frac{1}{R}$$

Lee-type (19): A) The prostate apex covers the anterior and posterior parts of the membranous urethra (Figure-3A); B) the prostate apex covers the anterior part of the membranous urethra (Figure-3B); C) the prostate apex covers the posterior part of the membranous urethra (Figure-3C); D) the prostate apex does not cover the membranous urethra (Figure-3D).

SURGICAL TECHNIQUES

All procedures were performed by experienced surgeons with more than 5 years of experience in RS-RARP, each of whom performed more than 100 RS-RARP procedures annually. The procedure was performed using the Da Vinci Xi™ surgical system. The RS-RARP surgical approach was based on the techniques described by Lim et al. (23), bladder neck preservation method was based on the techniques described by Galfano et al. (12), the neurovascular bundle preservation method was based on the techniques described by Kowalczyk et al. (24), and the urethral length preservation method was based on the techniques described by Hamada et al. (25).

Data collection

Demographic and clinical features: age, body mass index (BMI), presence of hypertension, diabetes, and prostate surgery history, D'Amico risk classification, PIRADS score, international prostate symptom score (IPSS), and clinical TNM staging (NCCN guideline 2022.4).

Perioperative outcomes and pathological characteristics: preoperative prostate-specific antigen (PSA) level, operative time (from skin incision to closure), estimated blood loss, blood transfusion status, neurovascular bundle preservation, postoperative drainage volume, postoperative drain and catheter removal times, length of hospital stay, status of surgical margin and nerve invasion, and Gleason score of prostate biopsy.

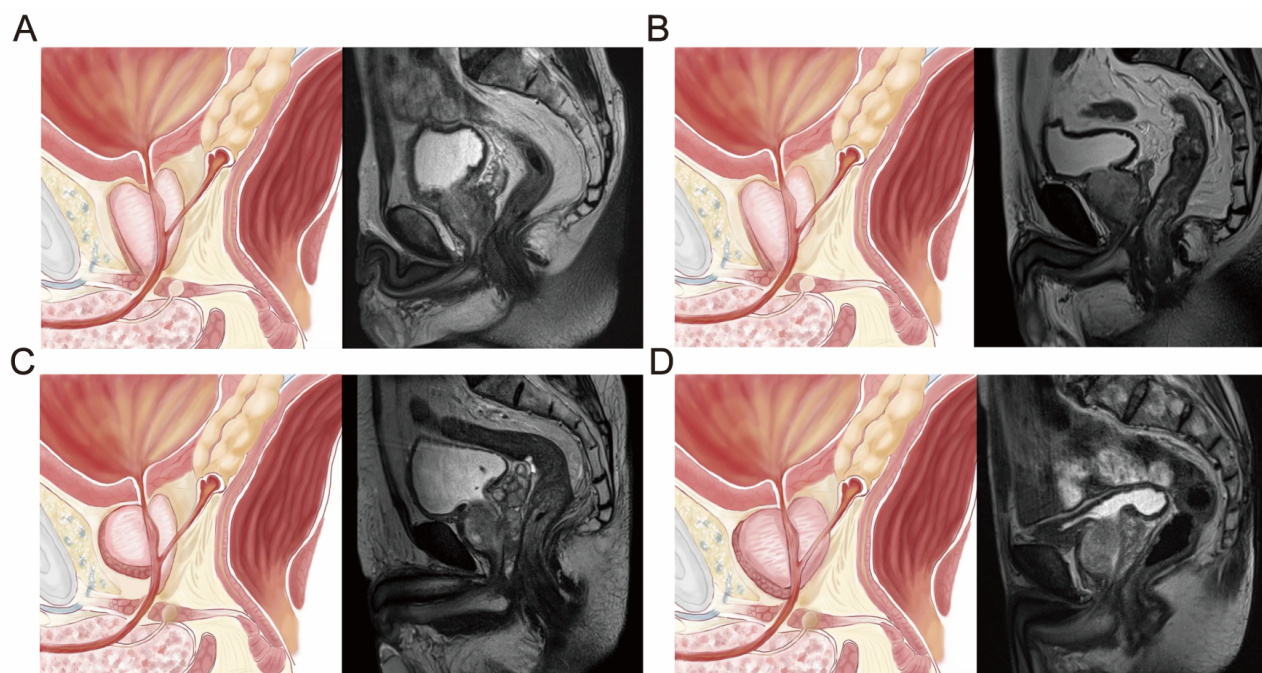
MpMRI imaging measurements: including MUL, MUW, PV, urethral curvature, IPPL, PUL, PAL, and Lee-type.

Statistical Analyses

Statistical analyses were performed using SPSS version 26.0 (IBM Corp, Armonk, NY, USA). Inter-observer agreement was assessed using weighted Cohen's kappa (26) for categorical variables and intraclass correlation coefficients (ICCs) (27) for continuous variables. Kappa values were interpreted as: poor (less than 0.20), fair (0.21-0.40), moderate (0.41-0.60), substantial (0.61-0.80) or almost perfect agreement (0.81-1.00). ICCs were interpreted as: poor (less than 0.40), fair (0.40-0.59), good (0.60-0.74), and excellent (0.75-1.00). Normally distributed data were expressed as mean $\pm$ standard deviation (SD) and analyzed using Student's t-test for comparisons between two groups or one-way ANOVA for comparisons among three or more groups. Non-normally distributed data were expressed as median and interquartile range (IQR) and analyzed using the Mann-Whitney U test for two-group comparisons or the Kruskal-Wallis test for three or more groups. Categorical variables were expressed as counts and percentages and analyzed using the chi-square or Fisher's exact test.

Univariate analysis and least absolute shrinkage and selection operator (LASSO) regression were used to screen for the best predictors. The selected predictors were then included in multivariate logistic regression analysis. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to identify predictors of

Figure 3 - A schema illustrating the four types of prostatic apex.



A) Lee-type A: the prostate apex covers the anterior and posterior parts of the membranous urethra; B) Lee-type B: the prostate apex covers the anterior part of the membranous urethra; C) Lee-type C: the prostate apex covers the posterior part of the membranous urethra; D) Lee-type D: the prostate apex does not cover the membranous urethra

immediate UC after RS-RARP. The multivariate logistic regression results were presented as a nomogram, constructed using R software (R Foundation for Statistical Computing, Vienna, Austria, version 4.1.0). The models were internally validated using 1,000 bootstrap resampling iterations. Nomogram performance was evaluated using the AUC to assess discriminative ability. Calibration was assessed using bootstrap-corrected calibration curves with 1,000 bootstrap resamples, Brier scores, and mean squared error (MSE) to evaluate the agreement between predicted and observed probabilities. Bootstrap resampling was performed to reduce model optimism (28). Decision curve analysis was conducted to compare the clinical utility of the nomogram with individual parameters across the full range of risk thresholds (0–1). Pearson's coefficient and Variance Inflation Factor (VIF) were used to evaluate the correlation and the co-linearity of the final predictors (29). The predictive performance of the nomogram was assessed using ROC curve analysis with MedCalc version 15.2 (Ostend, Belgium), determining the optimal cutoff values, sensi-

tivity, and specificity based on the maximum Youden index. The predictive performance of various parameters for immediate UC recovery following RS-RARP was assessed using positive predictive value (PPV) and negative predictive value (NPV). The area under the ROC curve (AUC) and the 95% CIs were calculated. The DeLong test was applied to compare the AUCs of different variables (30). A two-sided p-value < 0.05 was considered statistically significant.

RESULTS

Demographic, perioperative clinicopathological features and mpMRI imaging characteristics

A total of 580 patients with PCa who underwent RS-RARP were included in this study, comprising 451 cases from our center and 129 cases from external institutions, including Nanjing Drum Tower Hospital (n=78), Qilu Hospital of Shandong University (n=47), and Baoji Central Hospital (n=4). Among the 451 patients from our center, 348 were allocated to the training cohort and 103

to the internal validation cohort. The 129 patients from external institutions were assigned to the external validation cohort (Figure-1). Their demographic and clinical data are shown in Table-1. The median age was 68 years (range 62-74), and the median BMI was 24.09 kg/m² (range 22.43-25.50). The clinical TNM staging revealed that 30.7% of patients were classified as T1, 62.2% as T2, and 7.1% as T3. Preoperative Gleason scores were 30.2% for 6, 48.6% for 7, and 21.2% for ≥ 8 . The median preoperative PSA level was 11.12 ng/mL (range 7.49-18.68). Immediate UC recovery was observed in 83.1% (482/580) of all patients, which was 84.5% (294/348) in the training cohort, 81.4% (105/129) in the external validation cohort, and 80.6% (83/103) in the internal validation cohort.

Comparison of the variables between the groups in the training cohort

The inter-observer reliability analysis demonstrated a strong correlation between the two observers for mpMRI imaging measurements, with ICCs ranging from 0.86 to 0.98 (Table-S2). Univariate analysis was performed to compare the variables between the immediate and non-immediate UC groups in the training cohort. The non-immediate UC group had a higher BMI (25.08 vs. 23.84 kg/m², $P = 0.005$), larger PV (58.64 vs. 49.34 mL, $P < 0.001$), and a higher proportion of T3 stages (13.0% vs. 4.4%, $P = 0.046$).

Bilateral NVB preservation, a key factor in preserving postoperative UC function, was significantly higher in the immediate UC group (41.8% vs. 20.4%, $P < 0.001$). Anatomical measurements showed significant differences between the groups. The immediate UC group had a longer MUL (16.00 vs. 12.83 mm, $P < 0.001$), shorter IPPL (4.27 vs. 4.96 mm, $P = 0.028$), shorter PAL (26.12 vs. 27.53 mm, $P = 0.030$), larger urethral curvature (0.321 vs. 0.285 cm-1, $P < 0.001$), and a larger proportion of Lee-type D (59.2% vs. 9.3%, $P < 0.001$) (Table-2).

Logistic regression analysis identifying independent predictors of immediate urinary continence recovery after RS-RARP

Since the results of the univariate analysis could be influenced by confounding factors, the statistically significant indicators in Table-2 were selected as indepen-

dent variables, and LASSO regression was performed to further screen variables with non-zero coefficients from the univariate logistic regression. The best predictors of immediate UC recovery following RS-RARP were NVB preservation, Lee-type D, clinical T stage, MUL, PV, and urethral curvature (Figures 4A and 4B).

In further analyses, these six potential factors, along with clinically relevant parameters (including operative time) (31), were incorporated as confounders into the multivariable logistic regression model to identify reliable preoperative predictors of immediate UC recovery. The results demonstrated that MUL (OR=1.23, $P=0.029$) and urethral curvature (OR=2.84, $P<0.001$) were identified as independent predictors for immediate urinary continence recovery, while PV (OR=0.84, $P<0.001$) was identified as a protective factor (Table-3).

Construction and validation of a nomogram for predicting immediate urinary continence recovery following RS-RARP

In the training cohort, a nomogram was developed based on multivariate regression, incorporating MUL, PV, and urethral curvature, to predict immediate postoperative UC recovery after RS-RARP (Figure-5A). Pearson's coefficients were -0.13 between urethral curvature and PV, and 0.17 between urethral curvature and MUL. The VIF for both predictors was 1.014, indicating no multicollinearity between PV, MUL, and urethral curvature. ROC analysis showed that the AUC values for MUL, PV, and urethral curvature were 0.74, 0.75, and 0.76 respectively (Table-3 and Figure-5B). To improve clinical applicability, a multivariate prediction model was developed using a combination of the three parameters through permutation testing. The AUC values for the two-parameter combined tests (MUL+PV), (MUL+urethral curvature), and (PV+urethral curvature) were 0.83 (95% CI, 0.79-0.87), 0.82 (95% CI, 0.78-0.86), and 0.83 (95% CI, 0.79-0.87), respectively.

The nomogram model demonstrated robust discriminative performance, with an AUC of 0.87 (95% CI, 0.83-0.91; bootstrap-corrected, 0.87) in the training cohort (Figure-5B), surpassing those of the individual parameters and the two-parameter combined model, including MUL (DeLong test $z = 4.05$, $P < 0.001$), PV (z

Table 1 - Baseline characteristics of patients.

	All patients (n=580)	Training cohort (n=348)	External validation cohort (n=129)	Internal validation cohort (n=103)
Median age, (y)	68.00 (62.00, 74.00)	67.00 (62.00, 74.00)	68.00 (63.00, 74.00)	69.00 (64.00, 76.00)
BMI, (kg/m ²)	24.09 (22.43, 25.50)	24.08 (22.47, 25.27)	24.22 (22.29, 26.18)	24.08 (22.47, 25.13)
Hypertension, (%)				
No	314 (54.1%)	200 (57.5%)	58 (45.0%)	56 (54.4%)
Yes	266 (45.9%)	148 (42.5%)	71 (55.0%)	47 (45.6%)
Diabetes, (%)				
No	347 (59.8%)	202 (58.0%)	85 (65.9%)	60 (58.3%)
Yes	233 (40.2%)	146 (42.0%)	44 (34.1%)	43 (41.7%)
D'Amico risk classification, (%)				
Low	42 (7.2%)	30 (8.6%)	5 (3.8%)	7 (6.8%)
Intermediate	400 (69.0%)	246 (70.7%)	82 (63.6%)	72 (69.9%)
High	138 (23.8%)	72 (20.7%)	42 (32.6%)	24 (23.3%)
PIRADS score, (%)				
≤3	156 (26.9%)	89 (25.6%)	40 (31.0%)	27 (26.2%)
>3	424 (73.1%)	259 (74.4%)	89 (69.0%)	76 (73.8%)
IPSS score	13.50 (7.00, 19.00)	13.00 (6.00, 19.00)	14.00 (10.00, 19.00)	14.00 (8.00, 20.00)
Preoperative PSA, (ng/mL)	11.12 (7.49, 18.68)	11.03 (7.49, 18.95)	9.79 (7.27, 16.14)	13.30 (8.39, 19.30)
Clinical T stage, (%)				
T1	178 (30.7%)	111 (31.9%)	35 (27.1%)	32 (31.1%)
T2	361 (62.2%)	217 (62.3%)	86 (66.7%)	58 (56.3%)
T3	41 (7.1%)	20 (5.8%)	8 (6.2%)	13 (12.6%)
Operative time, (min)	115.28 (105.00,130.12)	116.60 (106.44, 130.80)	120.00 (100.00,130.00)	111.00 (106.00, 127.00)
Estimated blood loss, (mL)	60.00 (40.00, 80.00)	60.00 (50.00, 80.00)	80.00 (30.00, 90.00)	60.00 (30.00, 95.00)
Postoperative average drainage volume, (mL)	56.86 (30.28, 83.00)	57.36 (30.18, 82.00)	50.00 (25.00, 100.00)	62.00 (45.50, 79.00)
Postoperative drain removal time, (d)	3.00 (2.00, 4.00)	3.00 (2.00, 4.00)	3.00(2.00, 3.00)	3.00(2.00, 4.00)
Postoperative catheter removal time, (d)	15.00 (13.00, 20.00)	15.00 (13.00, 20.00)	15.00 (13.00, 18.00)	16.00 (14.00, 19.50)
Postoperative hospitalization duration, (d)	6.50 (5.00, 8.00)	7.00 (5.00, 8.00)	6.00 (5.00, 7.00)	7.00 (5.50, 8.00)
NVB preservation, (%)				
No	317 (54.7%)	195 (56.0%)	70 (54.3%)	52 (50.5%)
Unilateral	40 (6.9%)	19 (5.5%)	12 (9.3%)	9 (8.7%)
Bilateral	223 (38.4%)	134 (38.5%)	47 (36.4%)	42 (40.8%)

continue

	All patients (n=580)	Training cohort (n=348)	External validation cohort (n=129)	Internal validation cohort (n=103)
Intraoperative transfusion, (%)				
No	572 (98.6%)	345 (99.1%)	127 (98.5%)	100 (97.1%)
Yes	8 (1.4%)	3 (0.9%)	2 (1.5%)	3 (2.9%)
Surgical margin, (%)				
Negative	448 (77.2%)	260 (74.7%)	105 (81.4%)	83 (80.6%)
Positive	132 (22.8%)	88 (25.3%)	24 (18.6%)	20 (19.4%)
Gleason score of prostate biopsy, (%)				
6	175 (30.2%)	111 (31.9%)	32 (24.8%)	32 (31.1%)
7	282 (48.6%)	163 (46.8%)	71 (55.0%)	48 (46.6%)
≥8	123 (21.2%)	74 (21.3%)	26 (20.2%)	23 (22.3%)
Nerve invasion, (%)				
No	358 (61.7%)	226 (64.9%)	68 (52.7%)	64 (62.1%)
Yes	222 (38.3%)	122 (35.1%)	61 (47.3%)	39 (37.9%)
MUL, (mm)	15.61 (12.99, 18.06)	15.55 (12.96, 18.29)	15.44 (12.44, 17.95)	16.31 (13.63, 17.86)
MUW, (mm)	10.93 (9.55, 12.29)	10.82 (9.54, 12.20)	11.04 (9.84, 12.32)	11.19 (9.52, 12.51)
PV, (mL)	50.86 (44.87, 56.95)	50.56 (44.48, 56.39)	52.61 (46.67, 59.57)	50.09 (44.59, 56.14)
Urethral curvature, (cm-1)	0.316 (0.283, 0.348)	0.312 (0.286, 0.344)	0.322 (0.288, 0.352)	0.307 (0.271, 0.343)
Lee-type, (%)				
A	133 (22.9%)	73 (21.0%)	38 (29.4%)	22 (21.4%)
B	110 (19.0%)	66 (19.0%)	25 (19.4%)	19 (18.4%)
C	45 (7.8%)	30 (8.6%)	5 (3.9%)	10 (9.7%)
D	292 (50.3%)	179 (51.4%)	61 (47.3%)	52 (50.5%)
PUL, (mm)	37.25 ± 4.95	37.65 ± 5.04	36.50 ± 4.67	36.87 ± 4.92
IPPL, (mm)	4.35 (3.16, 5.45)	4.37 (3.10, 5.52)	4.64 (3.25, 5.52)	4.00 (3.12, 4.98)
PAL, (mm)	26.56 (24.47, 29.09)	26.39 (24.03, 29.10)	27.31 (25.44, 29.35)	26.02 (24.71, 28.87)
Immediate UC, (%)				
No	98 (16.9%)	54 (15.5%)	24 (18.6%)	20 (19.4%)
Yes	482 (83.1%)	294 (84.5%)	105 (81.4%)	83 (80.6%)

BMI = body mass index; PIRADS = prostate imaging reporting and data system; IPSS = international prostate symptom score; PSA = prostate specific antigen; NVB = neurovascular bundle; MUL = membranous urethral length; MUW = membranous urethral width; PV = prostate volume; PUL = prostatic urethral length; IPPL = Intravesical prostatic protrusion length; PAL = pubic symphysis-prostate apex length; UC = urinary continence.

Table 2 - Baseline characteristics and perioperative outcomes of patients with immediate vs non-immediate urinary continence in the training cohort.

	immediate urinary continence (n=294)	non-immediate urinary continence (n=54)	P value
Median age, (y)	66.00 (61.25, 74.00)	69.00 (62.25, 75.00)	0.076a
BMI, (kg/m ²)	23.84 (22.31, 25.03)	25.08 (23.10, 25.86)	0.005a
Hypertension, (%)			0.374b
No	166 (56.5%)	34 (63.0%)	
Yes	128 (43.5%)	20 (37.0%)	
Diabetes, (%)			0.090b
No	165 (56.1%)	37 (68.5%)	
Yes	129 (43.9%)	17 (31.5%)	
D'Amico risk classification, (%)			0.651b
Low	26 (8.9%)	4 (7.4%)	
Intermediate	205 (69.7%)	41 (75.9%)	
High	63 (21.4%)	9 (16.7%)	
PIRADS score, (%)			0.457b
≤3	73 (24.8%)	16 (29.6%)	
>3	221 (75.2%)	38 (70.4%)	
IPSS score	13.00 (6.00, 19.75)	13.00 (3.00, 18.00)	0.194a
Preoperative PSA, (ng/mL)	10.48 (7.28, 18.70)	12.09 (8.87, 21.09)	0.113a
Clinical T stage, (%)			0.046b
T1	95 (32.3%)	16 (29.6%)	
T2	186 (63.3%)	31 (57.4%)	
T3	13 (4.4%)	7 (13.0%)	
Operative time, (min)	116.37 (106.49, 129.91)	121.37 (105.19, 137.72)	0.158a
Estimated blood loss, (mL)	60.00 (50.00, 80.00)	60.00 (30.00, 70.00)	0.113a
Postoperative average drainage volume, (mL)	56.14 (28.00, 83.75)	63.24 (47.06, 79.16)	0.236a
Postoperative drain removal time, (d)	3.00 (2.00, 4.00)	3.00 (2.00, 4.00)	0.771a
Postoperative catheter removal time, (d)	15.00 (13.00, 20.00)	15.00 (12.00, 20.00)	0.919a
Postoperative hospitalization duration, (d)	7.00 (5.00, 8.00)	7.00 (5.00, 8.75)	0.273a
NVB preservation, (%)			<0.001b
No	165 (56.1%)	30 (55.5%)	
Unilateral	6 (2.1%)	13 (24.1%)	
Bilateral	123 (41.8%)	11 (20.4%)	

continue

	immediate urinary continence (n=294)	non-immediate urinary continence (n=54)	P value
Intraoperative transfusion, (%)			0.398b
No	292 (99.3%)	53 (98.1%)	
Yes	2 (0.7%)	1 (1.9%)	
Surgical margin, (%)			0.823b
Negative	219 (74.5%)	41 (75.9%)	
Positive	75 (25.5%)	13 (24.1%)	
Gleason score of prostate biopsy, (%)			0.620b
6	94 (32.0%)	17 (31.5%)	
7	137 (46.6%)	26 (48.1%)	
≥8	63(21.4%)	11 (20.4%)	
Nerve invasion, (%)			0.116b
No	196 (66.7%)	30 (55.6%)	
Yes	98 (33.3%)	24 (44.4%)	
MUL, (mm)	16.00 (13.63, 18.51)	12.83 (11.26, 14.89)	<0.001a
MUW, (mm)	10.95 (9.66, 12.23)	10.33 (9.04, 11.53)	0.122a
PV, (mL)	49.34 (43.74, 53.89)	58.64 (51.10, 69.69)	<0.001a
Urethral curvature, (cm-1)	0.321 ± 0.044	0.285 ± 0.027	<0.001c
Lee-type, (%)			<0.001b
A	59 (20.1%)	14 (25.9%)	
B	38 (12.9%)	28 (51.8%)	
C	23 (7.8%)	7 (13.0%)	
D	174 (59.2%)	5 (9.3%)	
PUL, (mm)	37.55 ± 4.84	38.19 ± 6.02	0.392c
IPPL, (mm)	4.27 (3.08, 5.46)	4.96 (3.61, 6.25)	0.028a
PAL, (mm)	26.12 (23.84, 28.92)	27.53 (25.93, 29.87)	0.030a

a P values were calculated with Mann-Whitney U test; b P values were calculated with the chi-square test or Fisher's exact test; c P values were calculated with Student's t test.

BMI = body mass index; PIRADS = prostate imaging reporting and data system; IPSS = international prostate symptom score; PSA = prostate specific antigen; NVB = neurovascular bundle; MUL = membranous urethral length; MUW = membranous urethral width; PV = prostate volume; PUL = prostatic urethral length; IPPL = Intravesical prostatic protrusion length; PAL = pubic symphysis-prostate apex length.

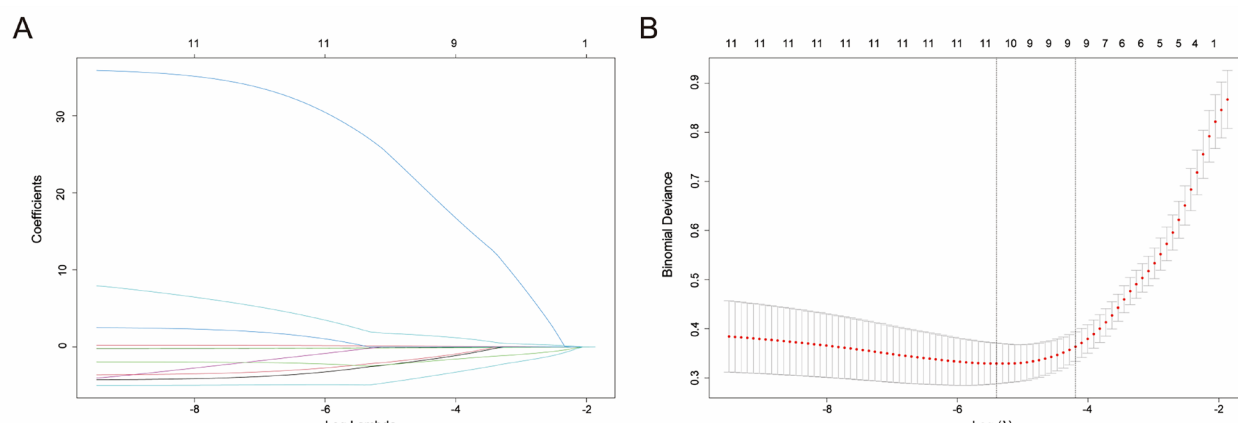
Table S2 - Inter-observer agreement in mpMRI parameter measurements for individual radiologists.

mpMRI imaging measurements	ICCa or Cohen's kappa		
	All patients (n=580)	immediate urinary continence (n=482)	non-immediate urinary continence (n=98)
MUL	0.97(0.96-0.98)	0.96(0.95-0.97)	0.98(0.97-0.99)
MUW	0.97(0.96-0.98)	0.97(0.96-0.98)	0.98(0.91-0.99)
PV	0.96(0.93-0.97)	0.95(0.92-0.97)	0.95(0.87-0.98)
Urethral curvature	0.89(0.78-0.94)	0.88(0.75-0.93)	0.86(0.74-0.92)
PUL	0.95(0.94-0.96)	0.95(0.94-0.96)	0.96(0.91-0.98)
IPPL	0.96(0.95-0.97)	0.96(0.94-0.97)	0.98(0.96-0.99)
PAL	0.90(0.88-0.91)	0.90(0.88-0.91)	0.90(0.86-0.93)
Lee-type	0.84(0.80-0.88)	0.82(0.77-0.86)	0.80(0.70-0.90)

aICC was used for continuous variables (e.g., MUL, MUW, PV, urethral curvature, PUL, IPPL, PAL).

bCohen's kappa was used for categorical variables (e.g., Lee-type).

ICC = Intraclass correlation coefficient; mpMRI = multiparametric magnetic resonance imaging; MUL = membranous urethral length; MUW = membranous urethral width; PV = prostate volume; PUL = prostatic urethral length; IPPL = Intravesical prostatic protrusion length; PAL = pubic symphysis-prostate apex length.

Figure 4 - Selection of predictive factors using LASSO logistic regression algorithm.

A) LASSO coefficient profiles for the 9 candidate variables; B) The optimal value was determined by the two dashed vertical lines, which were drawn based on the minimum mean square error criterion (left dashed line) and the standard error criterion (right dashed line). In this study, six predictors were selected according to the standard error criterion ($\lambda = 0.015$). LASSO, least absolute shrinkage and selection operator.

= 4.50, $P < 0.001$), urethral curvature ($z = 3.96$, $P < 0.001$), (MUL+PV) ($z = 2.96$, $P = 0.003$), (MUL+urethral curvature) ($z = 2.01$, $P = 0.044$), and (PV+urethral curvature) ($z = 2.78$, $P = 0.005$) (Table-S3). The nomogram demonstrated satisfactory discriminative performance, with an AUC of 0.93 (95% CI, 0.86-0.97; bootstrap-corrected, 0.92) in the internal validation cohort (Figure-5C) and an AUC

of 0.93 (95% CI, 0.88-0.97; bootstrap-corrected, 0.92) in the external validation cohort (Figure-5D). The calibration curves demonstrated good agreement between the predicted probabilities and the observed immediate UC recovery rates. The bootstrap-corrected calibration slopes were 0.96, 0.84, and 0.89 for the training, internal validation, and external validation cohorts, respectively. The

corresponding Brier scores were 0.08, 0.07, and 0.09, respectively. The corresponding mean squared error (MSE) values were 0.00078, 0.00433, and 0.00240, respectively, indicating good calibration in all three cohorts (Figures 5E-G). As illustrated in Figures 5H-J, decision curve analy-

sis indicated that the nomogram provided a higher net benefit than the individual parameters across a broad range of reasonable threshold probabilities, demonstrating superior clinical utility for guiding decision-making.

DISCUSSION

Table 3 - Multivariate logistic regression analysis identifying independent predictors of immediate urinary continence recovery after RS-RARP and receiver operating characteristic analysis of their predictive performance.

Variable	Multivariate logistic regression analysis						Receiver operating characteristic analysis					
	B	Standard Error	P value	OR	95% CI		AUC	95% CI		Cutoff value	Sensitivity	Specificity
					Lower limit	Upper limit		Lower limit	Upper limit			
NVB preservation	-0.12	0.36	0.737	0.89	0.44	1.80						
Lee-type D	2.54	1.77	0.152	2.84	1.57	5.16						
MUL	0.20	0.09	0.029	1.23	1.02	1.47	0.74	0.69	0.79	14.98	0.80	0.64
PV	-0.18	0.04	<0.001	0.84	0.77	0.91	0.75	0.70	0.80	54.99	0.65	0.80
Urethral curvature	1.04	0.30	<0.001	2.84	1.57	5.16	0.76	0.71	0.80	0.323	1.00	0.48
Clinical T3 stage	-0.34	0.18	0.059	0.71	0.50	1.01						
Operative time	-0.06	0.22	0.775	0.94	0.61	1.45						

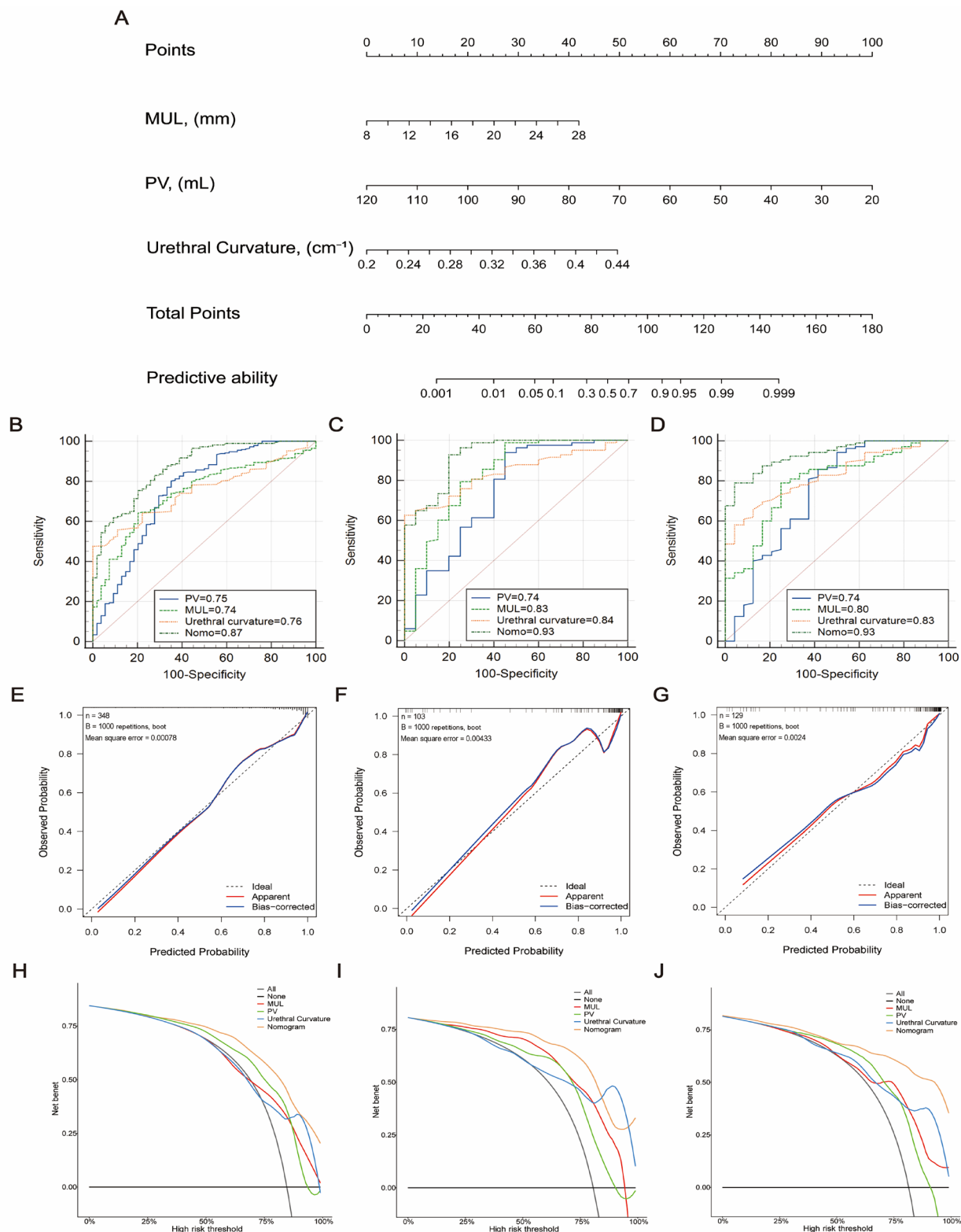
RS-RARP = Retzius-sparing robot-assisted radical prostatectomy; OR = odds ratio; CI = confidence interval; NVB = neurovascular bundle; MUL = membranous urethral length; PV = prostate volume; AUC = the area under the ROC curve.

Table S3 - Delong test comparing different ROC curves in the training cohort.

Comparison	AUC difference	Standard Error	Z value	P value	95% CI	
					Lower limit	Upper limit
MUL~nomogram	0.13	0.03	4.05	<0.001	0.07	0.19
PV~nomogram	0.12	0.03	4.50	<0.001	0.07	0.17
Urethral curvature~nomogram	0.11	0.03	3.96	<0.001	0.06	0.18
MUL+PV~nomogram	0.04	0.01	2.96	0.003	0.01	0.07
MUL+Urethral curvature~nomogram	0.05	0.02	2.01	0.044	0.01	0.10
PV+Urethral curvature~nomogram	0.04	0.01	2.78	0.005	0.01	0.07

ROC, = receiver operating characteristic; AUC = the area under the ROC curve; CI = confidence interval; MUL = membranous urethral length; PV = prostate volume.

Figure 5 - Construction and validation of a nomogram.



To our knowledge, this is the first multicenter study exploring the role of male physiological urethral curvature in urinary continence following RARP, including 580 patients (training cohort: $n=348$; internal validation cohort: $n=103$; external validation cohort: $n=129$). We present an innovative quantitative method for assessing urethral curvature and validate its reliability in predicting immediate UC recovery after RS-RARP using multicenter data (AUC of 0.76, 0.84, and 0.83 in the training, internal validation, and external validation cohorts, respectively). Furthermore, an mpMRI-based predictive model incorporating MUL, PV, and urethral curvature demonstrated excellent accuracy (AUC of 0.87, 0.93, and 0.93 in the training, internal validation, and external validation cohorts, respectively), outperforming individual parameters and dual-marker combinations ($P < 0.05$ for all DeLong tests). The bootstrap-corrected calibration curves and low MSE values confirmed the predictive accuracy of the nomogram. The excellent agreement between the predicted and observed probabilities following bootstrap resampling further supported the robustness of the proposed model. In addition, decision curve analysis demonstrated significantly improved net benefits across a range of threshold probabilities. This model offers a precise tool for assessing postoperative urinary incontinence risk and provides insights for developing individualized treatment strategies.

Preoperative mpMRI is crucial in diagnosing PCa and providing valuable anatomical data for both intraoperative and postoperative settings (32, 33). Chierigo et al. (34) highlighted that MRI-derived anatomical characteristics, particularly MUL, bladder neck position, and pelvic floor-related anatomical preservation, may be closely associated with early functional recovery after RS-RARP. MUL, the length of the urethra between the prostatic apex and the penile root, includes both smooth and striated muscle. During RARP, significant portions of striated muscle fibers surrounding the prostate are excised. Studies have shown that patients with a longer preoperative MUL tend to have a relatively longer membranous urethra postoperatively, which may facilitate earlier recovery of UC (35). Consistent with these observations, MUL was identified as an independent predictor in our cohort. Fonseca et al. (36) found that PV was linked to urinary incontinence at 3 and

6 months after RS-RARP, but not at 12 months, suggesting minimal impact on long-term UC recovery. However, our study identified smaller prostates (<53.94 mL) were associated with earlier recovery, likely due to larger prostates causing a larger bladder neck post-surgery, which increases surgical difficulty during bladder neck anastomosis. Prostatic enlargement may also lead to short-term bladder decompensation, contributing to postoperative urinary incontinence (18). Notably, our study demonstrated that preoperative urethral curvature was also independently associated with immediate UC recovery. This finding suggests that the preoperative geometric configuration of the urethra may provide additional prognostic information for individualized risk stratification.

The intra-abdominal curvature of the male urethra is crucial for maintaining urinary continence by increasing urethral pressure and enhancing sphincter function (37). Zhang et al. (38) demonstrated that an appropriately curved urethra increases urethral pressure, aiding continence. Furthermore, this curvature modifies urine flow dynamics and enhances sphincter control, which is crucial under increased abdominal pressure, thereby reducing the risk of incontinence. Wang et al. (39) used computational fluid dynamics simulations to demonstrate that urethral curvature enhances the urethra's adaptability to pressure changes, thereby reinforcing continence. These findings highlight the critical role of urethral curvature in preventing incontinence by optimizing pressure distribution and flow dynamics. In light of this, surgical procedures such as RS-RARP with a posterior approach aim to preserve the natural urethral curvature by maintaining urethral support structures, including the pubovesical ligaments and bladder neck, ensuring optimal curvature through anastomosis between the bladder neck and urethral stump. In contrast, conventional RARP with an anterior approach may disrupt these structures, potentially leading to urethral elongation or straightening, which can negatively impact continence (40). This likely explains the difference in immediate urinary continence rates between RS-RARP and conventional RARP (41). To quantify this physiological urethral curvature, we introduce urethral curvature, the reciprocal of the urethral curve radius between the bladder neck and the origin of the mem-

branous urethra. It provides an objective and repeatable measure to urethral curve and offers new insights into urethral morphology. Our findings suggest that the urethral curvature is associated with the immediate UC recovery following RS-RARP, with an optimal cutoff value of 0.323 cm-1 in the training cohort.

Furthermore, previous studies have suggested that the shape of the prostate apex influences immediate urinary continence recovery after RS-RARP (42). In this study, we classified prostate apex shape according to the Lee et al. classification (19). Our results showed that patients with Lee-type D had higher rates of immediate urinary continence, consistent with findings by Wenzel et al. (42) and Lacovelli et al. (43). This may be attributed to the higher position of the prostate apex, which spares the membranous urethra, facilitating better preservation of its integrity and function during surgery, thereby minimizing urethral trauma and enhancing urinary continence recovery. Beyond anatomical predictors, patient-related clinical characteristics may also contribute to UC recovery after RS-RARP. Dell'Oglio et al. (44) reported that the probability of immediate and 12-month UC recovery progressively declined with increasing age at surgery. Although age was not identified as an independent predictor in our cohort, this discrepancy may be related to differences in patient characteristics, sample size, and model construction. Further studies are warranted to clarify the combined contributions of anatomical and clinical factors to UC recovery.

From a clinical practice perspective, the measurement of urethral curvature and the construction of the predictive nomogram show excellent feasibility. All parameters are derived from standard preoperative 3.0 T mpMRI (T2WI sequences) without requiring additional imaging sequences or prolonged scan time. Furthermore, the reliance on standard anatomical landmarks and simple geometric calculations facilitates straightforward implementation in routine radiological practice with minimal additional training, while the inter-observer agreement (ICC: 0.86-0.98) confirms its high reproducibility. With ongoing advances in artificial intelligence-assisted image segmentation and quantitative image analysis, automated or semi-automated measurement tools may further improve measurement efficiency and reproduc-

ibility, thereby facilitating broader clinical implementation (45). The nomogram provides a clear, visual, and instantaneous risk stratification tool that can be used during preoperative counseling and surgical planning without complex computational support. Consequently, this method can be easily integrated into routine clinical pathways for patients undergoing RS-RARP.

Despite these noteworthy findings, our study has several limitations. First, the retrospective design may introduce potential selection bias. In addition, the exclusion of patients with severe preoperative LUTS may limit the generalizability of our findings. Further prospective studies are needed to verify the conclusions. Second, although mpMRI was analyzed by experienced urological imaging specialists under the supervision of an experienced urologist, interobserver variability cannot be completely excluded. Finally, due to the short follow-up period, long-term urinary continence rates and their influencing factors were not analyzed. Further studies with longer follow-up are warranted to validate the predictive value of this model for long-term continence recovery.

CONCLUSION

Our study proposes a novel quantitative method for assessing urethral curvature and validates its reliability in predicting immediate UC recovery following RS-RARP. This method is simple, reproducible, and highly feasible for implementation in routine clinical practice. Additionally, by utilizing mpMRI-based indicators, a nomogram was constructed and validated in both internal and external cohorts, demonstrating superior predictive accuracy, good calibration, and favorable clinical utility. This model provides a valuable quantitative tool for preoperative risk stratification and personalized surgical planning.

ABBREVIATIONS

RS-RARP = Retzius-Sparing Robot-Assisted Radical Prostatectomy

RARP = Robot-Assisted Radical Prostatectomy

RP = Radical Prostatectomy

PCa = Prostate Cancer

mpMRI = Multiparametric Magnetic Resonance Imaging

T2WI = T2-Weighted Imaging

T1WI = T1-Weighted Imaging

DWI = Diffusion-Weighted Imaging

PIRADS = Prostate Imaging Reporting and Data System

UC = Urinary Continence

MUL = Membranous Urethral Length

MUW = Membranous Urethral Width

PV = Prostate Volume

IPPL = Intravesical Prostatic Protrusion Length

PUL = Prostatic Urethral Length

PAL = Pubic Symphysis-Prostate Apex Length

ROC = Receiver Operating Characteristic

AUC = Area Under the ROC Curve

CI = Confidence Interval

OR = Odds Ratio

LASSO = Least Absolute Shrinkage and Selection Operator

MSE = Mean Squared Errors

VIF = Variance Inflation Factor

BMI = Body Mass Index

PSA = Prostate-Specific Antigen

IPSS = International Prostate Symptom Score

NVB = Neurovascular Bundle

ICC = Intraclass Correlation Coefficient

PPV = Positive Predictive Value

NPV = Negative Predictive Value

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This was approved by the Ethics Committee of the First Affiliated Hospital of Fujian Medical University (approval number: MRCTA, ECFAH of FMU [2025] 002). Informed consent was waived due to the retrospective nature of this study

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CONFLICT OF INTEREST

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Editorial Comment: Multiparametric Magnetic Resonance Imaging and Vesical Imaging-Reporting and Data System (VI-RADS) for Bladder Cancer Diagnosis and Staging: A Guide for Clinicians from the American College of Radiology VI-RADS Steering Committee

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COMMENT

Bladder cancer is one of the most common urologic cancers. This cancer has a high potential for aggression and about 1/3 of patients will be presented with muscle invasive disease, which is associated with a higher risk for metastatic disease. Treatment of the bladder cancer following transurethral resection will depend on the staging of the disease. Superficial tumors can be treated with intravesical therapy, whereas muscle-invasive tumors have conventional or robotic radical surgery as the treatment of choice (1-4).

The Vesical Imaging Reporting and Data System (VI-RADS), a scoring system emphasizing a standardized approach to multiparametric Magnetic Resonance Imaging (mpMRI) acquisition, has the purpose of to improve the diagnosis, staging and surveillance of patients with bladder cancer. mpMRI has been useful in the assessment of complete response after neoadjuvant chemotherapy and the response to immunotherapy (1).

In the paper of Panebianco (5), the authors show in a very interesting narrative review the importance of VI-RADS to bladder cancer diagnostic and therapeutic pathway. The authors show that mpMRI with VI-RADS improves the accuracy of preoperative staging, helps in

avoiding repeat transurethral resection of bladder tumor in selected non muscular invasive bladder cancer cases, and supports decision-making in muscle invasive bladder cancer in MRI-based pathways. The authors concluded that mpMRI, VI-RADS and nacVI-RADS represent essential tools for enhancing risk stratification and personalizing bladder cancer management in clinical urology practice. I congratulate the authors on the importance of this paper.

CONFLICT OF INTEREST

None declared.

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Safety and Efficacy of the SHURUI Single-Port Robot-Assisted System via Transmesenteric Approach for Pyeloplasty in Upper Ureteral Stricture: A Single-Center Prospective Cohort Study

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ABSTRACT

Purpose: Pyeloplasty is an established procedure for proximal ureteral strictures, with proven feasibility and favorable outcomes (1). The single-port robotic system offers potential advantages such as reduced invasiveness and improved cosmesis (2, 3), while the transmesenteric approach provides direct retroperitoneal access with minimal colonic mobilization (4, 5). However, the combination of single-port robotic platform with transmesenteric approach for pyeloplasty remains scarcely reported. This study aims to evaluate the safety and efficacy of this combined technique using the SHURUI single-port robotic surgical system.

Materials and methods: From June 2024 to March 2025, 8 patients with upper ureteral stricture underwent robotic pyeloplasty via transmesenteric approach using the SHURUI single-port system. Demographic, perioperative, and follow-up data were prospectively collected. Clinical success was defined as symptom-free with no radiographic evidence of obstruction.

Results: All surgeries were successfully completed without any conversion to laparoscopic or open procedures. The median docking time and console time were 4 (IQR: 2–8) min and 125 (IQR: 113–157) min, respectively. The median estimated blood loss was 10 (IQR: 10–10) ml, and none of the patients required intraoperative transfusion. The median postoperative stay was 4 (IQR: 3–6) days, with no complications occurring. With a median follow-up of 15 (IQR: 11–17) months, all patients achieved clinical success.

Conclusions: The SHURUI single-port robotic system is safe and effective for pyeloplasty in upper ureteral stricture via transmesenteric approach. Further validation through multi-center studies with larger cohorts and longer-term follow-up is recommended.

CONFLICT OF INTEREST

None declared.

ETHICAL APPROVAL

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Conversion of Total Intracorporeal Ileal Conduit to Studer Orthotopic Ileal Neobladder Using the Kangduo 2000 Robotic System

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ABSTRACT

Purpose: Ureteroileal anastomotic stricture (UAS) is a challenging complication after radical cystectomy and urinary diversion, with an incidence of approximately 15% (1, 2). Secondary surgical repair remains technically demanding due to postoperative anatomical distortion, tissue adhesions, and anastomotic scarring (3). Robotic surgery has demonstrated favorable safety and efficacy (4-6). This study aimed to report the preliminary outcomes of converting a totally intracorporeal ileal conduit to a Studer orthotopic ileal neobladder using the Kangduo 2000 Robotic System.

Materials and Methods: A 67-year-old male patient had previously undergone robot-assisted radical cystectomy with ileal conduit urinary diversion three years prior. Bilateral hydronephrosis and UAS were detected one year postoperatively. Surgical procedures included adhesiolysis of the ileal conduit, dissection of bilateral ureteroileal anastomoses, resection of stenotic ureteral segments, dissection and reconstruction of the proximal urethral orifice, as well as harvesting of ileal segments and construction of a Studer orthotopic neobladder.

Results: The operation was completed successfully without open conversion. The operative time was 583 minutes, and the estimated blood loss was 100 mL. The patient was discharged on postoperative day 15. Double-J stents and nephrostomy tubes were removed at two months postoperatively. At four months of follow-up, renal function was significantly improved, and satisfactory daytime and nighttime continence were achieved. The patient was able to void smoothly in the standing position with a good urinary stream, without urinary dribbling or incontinence.

Conclusions: Total intracorporeal conversion from ileal conduit to Studer orthotopic ileal neobladder using the Kangduo 2000 Robotic System is feasible, safe, and effective. Further studies with longer follow-up periods and larger cohorts are warranted to validate these findings.

CONFLICT OF INTEREST

None declared.

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Robotic Flexible Ureteroscopy: A Step-by-Step Guide to the ILY® Platform

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ABSTRACT

Introduction: Robotic flexible ureteroscopy (rfURS) is emerging as an alternative to manual flexible ureteroscopy for the treatment of upper urinary tract stones. Contemporary guidelines and reviews describe its potential ergonomic and radiation-related advantages, as well as comparable surgical outcomes (1–5). Initial clinical and simulation studies with the ILY® platform have demonstrated feasibility, safety, and a short learning curve, although standardized implementation remains limited (6–10). This video presents a step-by-step workflow for the safe and efficient use of the ILY® platform.

Materials and Methods: A 43-year-old woman with a previous right double-J stent placed for obstructive pyelonephritis underwent rfURS for a 13-mm renal pelvic stone (1,497 HU; volume 1,214 mm³). The video demonstrates operating-room setup, robot calibration and sterile draping, robot positioning and fixation, docking to the ureteral access sheath and ureteroscope assembly, console-controlled navigation, laser lithotripsy, systematic renal inspection, and standardized undocking. A flexible suction sheath was used throughout the procedure.

Results: Draping and docking times were 167 and 645 seconds, respectively. Robotic console time was 115 minutes, including 52 minutes of laser lithotripsy at 8 Hz and 1.2 J. Basket extraction was not required. Undocking was completed in 74 seconds, and total operative time was 130 minutes. No intraoperative complications or troubleshooting events occurred. Postoperative day-1 computed tomography confirmed stone-free status. The patient was discharged at 36 hours postoperatively without complications, as graded by the Clavien-Dindo classification (11). Surgeon satisfaction was rated 8 out of 10.

Conclusion: rfURS using the ILY® platform was feasible, safe, and effective. A standardized step-by-step workflow may facilitate adoption, improve procedural consistency, and enhance surgeon ergonomics (12). rfURS represents a meaningful step toward autonomous surgery (13).

CONFLICT OF INTEREST

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Digital Rectal Examination in the Imaging Era: Not Abandoned, but Repositioned

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To the editor,

We read with great interest the expert opinion by Reis, entitled "Repositioning the Digital Rectal Examination in the Era of Risk-Adapted Prostate Cancer Diagnostics: Right Tool to the Right Patient at the Right Time," published in the July–August 2026 issue of the International Brazilian Journal of Urology. The author provides a timely and balanced perspective on the evolving role of digital rectal examination (DRE) in contemporary prostate cancer diagnostics (1).

We fully agree with the central message of the article: DRE should no longer be regarded as a frontline population-based screening tool, but it should not be considered obsolete. Rather, its current value lies in selected clinical scenarios, particularly when interpreted within a risk-adapted and multimodal diagnostic pathway. As highlighted by the author, DRE has important limitations, including low sensitivity, operator dependence, and limited ability to detect anterior or small-volume tumors. These limitations have become even more apparent with the expanding role of mpMRI, which improves the detection of clinically significant prostate cancer and the prediction of pathological grade. Accordingly, DRE has increasingly been relegated to a secondary role in contemporary diagnostic pathways (2). Nevertheless, a clearly suspicious DRE may still provide meaningful clinical information, especially when imaging findings are equivocal or discordant with clinical suspicion (3).

In line with this perspective, recent studies have increasingly explored the relationship between DRE findings and modern imaging parameters, including mpMRI-derived PI-RADS scores, lesion size, and PSMA PET/CT uptake (4, 5). Our recent clinical data also support this concept. In a cohort of 164 patients with prostate cancer, suspicious DRE findings were associated with higher PI-RADS scores, larger mpMRI lesion size, elevated PSMA PET/CT SUVmax, clinically significant prostate cancer, and advanced pathological stage. Notably, each one-point increase in PI-RADS score was associated with a 2.14-fold increase in the likelihood of suspicious DRE findings. We also identified clinically relevant thresholds for DRE positivity, including an mpMRI lesion size of 13.5 mm and a PSMA PET/CT SUVmax of 15.1. These observations suggest that DRE positivity may reflect not only anatomical palpability, but also tumor burden and biological aggressiveness (5).

Therefore, the contemporary role of DRE should be defined more precisely. It is not a replacement for PSA, mpMRI, or PSMA PET/CT, nor should it be used as a stand-alone screening tool. However, when abnormal, DRE may serve as a simple, low-cost, and immediately available clinical marker that strengthens suspicion for high-volume or advanced disease. It should be acknowledged that the intimate nature and manner of performing DRE may cause

additional stress, while investigation for possible cancer and the prospect of a cancer diagnosis may themselves provoke anxiety and depression. Therefore, the examination should be conducted within a patient-centered framework, with clear communication about its purpose, benefits, and limitations (6).

CONFLICT OF INTEREST

None declared.

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The rising cost of litigation for urological tumors in the Brazilian Public Health System: an analysis of e-NatJus technical notes (2020–2026)

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To the editor,

Health litigation has become one of the major threats to the sustainability of the Brazilian Public Health System (SUS), and urological tumors occupy a prominent place in this phenomenon. We analyzed the technical notes issued by the Judiciary's Technical Support Centers (NatJus), made available through the National Council of Justice (CNJ) e-NatJus system, concerning malignant neoplasms of the genitourinary tract (ICD-10 C60–C68). Our aim was to assess the volume of demands, the most requested technologies, the rate of favorable opinions, and the evolution of the associated costs.

A total of 11,239 technical notes were identified for the C60–C68 group. The distribution is markedly concentrated: prostate cancer (C61) accounts for 6,218 notes (55.3%), followed by kidney cancer (C64) with 4,312 notes (38.4%) and bladder cancer (C67) with 567 notes (5.0%); the remaining topographies (C60, C62, C63, C65, C66, and C68) together represent less than 1.5% of the total. Prostate cancer is therefore the urological malignancy generating the greatest number of legal demands — a finding consistent with recent evidence that androgen receptor pathway inhibitors constitute an urgent public health problem in Brazil (1).

Using the Maximum Sale Price to the Government (MSGP) as a reference for the cost of the demanded technologies, a marked increase was observed over the study period. The aggregate value rose from BRL 450.9 thousand in 2020 to BRL 24.4 million in 2025 — an approximately 54-fold increase. The first half of 2026 alone already totals BRL 11.8 million, which, when projected to the full year, signals a level comparable to 2025 (approximately BRL 23.7 million). This growth is driven by two simultaneous vectors: the expansion in the number of demands (a 6.1-fold increase in notes between 2020 and 2025) and the rising unit cost of the requested technologies (the mean MSGP per priced note nearly doubled, from approximately BRL 8.8 thousand to BRL 18.5 thousand). Table-1 summarizes this evolution.

The profile of the requested technologies reflects the recent incorporation of high-cost drugs into oncological practice (1-3). In prostate cancer (C61), androgen receptor pathway inhibitors predominate — abiraterone (the most frequently demanded technology), enzalutamide, apalutamide, and darolutamide — along with radioligand therapies (lutetium-177 PSMA and radium-223) and olaparib; among procedures, robot-assisted radical prostatectomy, PSMA PET-CT, and radiotherapy stand out. In kidney cancer (C64), demands are concentrated on tyrosine kinase inhibitors (pazopanib, sunitinib, cabozantinib, axitinib, and lenvatinib) and immune checkpoint inhibitors (nivolumab, pembrolizumab, and ipilimumab). In bladder cancer (C67), immunotherapy (pembrolizumab, maintenance avelumab, atezolizumab, nivolumab, and durvalumab), the antibody-drug conjugate enfortumab vedotin, erdafitinib, and intravesical BCG are prominent (4).

Table 1 - e-NatJus technical notes for urological tumors (ICD C60-C68), aggregate cost by MSGP, and rate of favorable opinions, 2020-2026.

Year	Technical notes	Aggregate MSGP (BRL)*	Mean MSGP/note (BRL)	Favorable (%)
2020	392	450,854	8,840	74.2
2021	1,118	1,490,755	9,495	61.7
2022	1,529	1,430,066	9,408	60.3
2023	2,004	1,376,691	23,736	60.9
2024	2,353	5,297,857	16,504	50.4
2025	2,386	24,383,002	17,342	36.8
2026**	1,168	11,844,047	18,506	35.2

*MSGP summed only over notes with a registered price (a proxy for unit cost, not for the total cost of treatment).

**First half of 2026 only.

MSGP = Maximum Sale Price to the Government.

Regarding technical merit, the C60-C68 group showed an overall rate of 50.7% favorable opinions. Notably, this rate declined over time: from 74.2% in 2020 to 36.8% in 2025 and 35.2% in the first half of 2026. In other words, as the volume and cost of demands grow, an increasing proportion of requests pertains to technologies that lack robust evidence or have not yet been incorporated into the SUS, thereby raising the proportion of unfavorable opinions.

These data align directly with the national urological literature. Korkes et al. estimated that litigation for prostate cancer alone may represent an annual burden of approximately BRL 783 million to the SUS, with a 30-fold increase in demands over four years and a concentration on androgen receptor pathway inhibitors, especially abiraterone (1). Similarly, this Journal has previously highlighted the rising costs of bladder cancer management in the public system and the need for structured public policies (2, 3). Our findings, drawn from an independent source (the e-NatJus repository of technical notes), reinforce and broaden this diagnosis for urological tumors as a whole.

We acknowledge several limitations: the MSGP is a reference unit price and underestimates the total cost of treatment, which depends on dose, duration, and line of therapy; furthermore, price capture within the notes improved throughout the period, making the absolute values conservative. Even so, the direction and magnitude (5) of the phenomenon are unequivocal.

In conclusion, litigation for urological tumors — led by prostate cancer and driven by high-cost oncology drugs — imposes a growing and potentially unsustainable financial burden on the SUS. The declining rate of favorable opinions suggests a progressive mismatch between judicial demand and the available scientific evidence. Coordinated action among health managers, the scientific community, the Judiciary, and patient advocacy groups is urgently needed, including the strengthening of health technology assessment processes and of the NatJus networks themselves, to ensure equitable, rational, and financially sustainable access to cancer treatment in Brazil.

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CONFLICT OF INTEREST

None declared.

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The requirements for authorship and the general rules for preparation of manuscripts submitted to the **International Braz J Urol** are in accordance with the Uniform Requirements for Manuscripts Submitted to Biomedical Journals (International Committee of Medical Journal Editors. Uniform Requirements for Manuscripts Submitted to Biomedical Journals. *Ann Intern Med*, 126: 36-47, 1997). An electronic version of the Uniform Requirements is available on various websites, including the International Committee of Medical Journal Editors web site: **www.icmje.org**.

In response to the concerns of the editors of scientific medical journals with ethics, quality and seriousness of published articles, a Committee on Publication Ethics (COPE) was established in 1997 and a guideline document was published. The International Braz J Urol signed, approved, and follows the COPE guidelines. The Editor strongly encourages the authors to carefully read these guidelines before submitting a manuscript (**www.publicationethics.org.uk/guidelines** or **www.brazjurol.com.br**, vol. 26 (1): 4-10, 2000).

Peer Review – All submissions are subject to editorial review. Typically, each manuscript is anonymously forwarded by the Editor to 4 Reviewers (at least 2). If the Editor receives conflicting or inconclusive revisions, the manuscript is always sent to 1 or 2 additional Reviewers before the Editor's decision. If considered necessary by the Editor or by the Reviewers, statistical procedures included in the manuscript will be analyzed by a statistician.

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Page and Video Section. The articles should be written in Portuguese or English official orthography.

Abbreviations should be avoided, and when necessary must be specified when first time mentioned. Unusual expressions may not be used. A list of abbreviations must be provided at the end of the manuscript.

Every manuscript submitted to publication should have a cover page containing the title, short title (up to 50 characters), authors and institution. Up to six key words should be provided. These words should be identical to the medical subject headings (MeSH) that appear in the Index Medicus of the National Library of Medicine (<http://www.nlm.nih.gov/mesh/meshhome.html>). One of the authors should be designated as correspondent and the complete correspondence address, telephone and fax numbers and E-mail should be provided.

If any financial support has been provided, the name of the institution should be mentioned.

Original Article: Original articles should contain a Cover Page, Abstract, Introduction, Materials and Methods, Results, Discussion, Conclusions, References, Tables and Legends, each section beginning in a separate page and numbered consecutively. Original articles should cover contemporary aspects of Urology or experimental studies on Basic Sciences applied to urology. The manuscript text should contain no more than 2500 words, excluding the Abstract. The number of authors is limited to five. References should contain no more than 30 citations, including the most important articles on the subject. Articles not related to the subject must be excluded.

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Structure of the articles

Abstract (maximum 200 words) and should contain

- **Main findings:** Report case(s) relevant aspects
- **Case(s) hypothesis:** Proposed premise substantiating case(s) description
- **Promising future implications:** Briefly delineates what might it add? Lines of research that could be addressed

Full text (maximum 2000 words):

- **Scenario:** Description of case(s) relevant preceding and existing aspects;
- **Case(s) hypothesis and rational:** precepts, clinical and basic reasoning supporting the case(s) hypothesis and the raised scenario. Why is it important and is being reported?
- **Discussion and future perspectives:** what might it add and how does it relate to the current literature. 'Take-home message' - lessons learnt;
- **Table and/or Figure limits:** 2 (plates aggregating multiple images are encouraged) each exceeding table or figure will decrease 250 words of the full text;
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Video Section: The material must be submitted in the appropriate local, in the Journal's site, whe-



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- 2) Check that each figure is cited in the text.
- 3) The legends must be sent in a separate page.
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Papers published in periodicals:

- Paterson RF, Lifshitz DA, Kuo RL, Siqueira Jr TM, Lingeman JE: Shock wave lithotripsy monotherapy for renal calculi. *Int Braz J Urol.* 2002; 28:291-301.



- Holm NR, Horn T, Smedts F, Nordling J, de la Rossette J: Does ultrastructural morphology of human detrusor smooth muscle cell characterize acute urinary retention? J Urol. 2002; 167:1705-9.

Books:

- Sabiston DC: Textbook of Surgery. Philadelphia, WB Saunders. 1986; vol. 1, p. 25.

Chapters in Books:

- Penn I: Neoplasias in the Allograft Recipient. In: Milford EL (ed.), Renal Transplantation. New York, Churchill Livingstone. 1989; pp. 181-95.

The Int Braz J Urol has the right of reject inappropriate manuscripts (presentation, number of copies, subjects, etc.) as well as proposes modifications in the original text, according to the Referees' and Editorial Board opinion.

THE EDITORS SUGGEST THE AUTHORS TO OBSERVE THE FOLLOWING GUIDELINES WHEN SUBMITTING A MANUSCRIPT:

The **Ideal Manuscript** may not exceed 2500 words.

The **Title** must be motivating, trying to focus on the objectives and content of the manuscript.

Introduction must exclude unnecessary information. It should briefly describe the reasons and objective of the paper.

Materials and Methods should describe how the work has been done. It must contain sufficient information to make the study reproducible. The statistical methods have to be specified.

The **Results** should be presented using Tables and Figures whenever possible. Excessive Tables and Figures must be avoided. The tables should not be repeated on the text.

The **Discussion** must comment only the results of the study, considering the recent literature.

Conclusions must be strictly based on the study findings.

References should contain no more than 30 citations, including the most important articles on the subject. Articles not related to the subject must be excluded.

The Abstract must contain up to 250 words and must conform to the following style: Purpose, Materials and Methods, Results and Conclusions. Each section of the manuscript must be synthesized in short sentences, focusing on the most important aspects of the manuscript. **The authors must remember that the public firstly read only the Abstract, reading the article only when they find it interesting.**

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- The sequence of manuscript arrangement is according to the Information for Authors.
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- Generic names are used for all drugs. Trade names are avoided.
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- The staining technique and the final magnification were provided for all histological illustrations. The histological illustrations are supplied in color.
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- An Abstract was provided for all type of articles. The length of the Abstract is about 250 words.
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- Conflict of Interest – Any conflict of interest, mainly financial agreement with companies whose products are alluded to in the paper, is clearly disclosed in the manuscript.
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- The photographs are supplied as TIFF or JPG files and saved at a resolution of 300 dpi (dots per inch) at final size.
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