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# Diagnosis accuracy of PCA3 level in patients with prostate cancer: a systematic review with meta-analysis

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## ABSTRACT

*Background:* The diagnostic value and suitability of prostate cancer antigen 3 (PCA3) for the detection of prostate cancer (PCa) have been inconsistent in previous studies. Thus, the aim of the present meta-analysis was performed to systematically evaluate the diagnostic value of PCA3 for PCa.

*Materials and Methods:* A meta-analysis was performed to search relevant studies using online databases EMBASE, PubMed and Web of Science published until February 1st, 2019. Ultimately, 65 studies met the inclusion criteria for this meta-analysis with 8.139 cases and 14.116 controls. The sensitivity, specificity, positive likelihood ratios (LR+), negative likelihood ratios (LR–), and other measures of PCA3 were pooled and determined to evaluate the diagnostic rate of PCa by the random-effect model.

*Results:* With PCA3, the pooled overall diagnostic sensitivity, specificity, LR+, LR–, and 95% confidence intervals (CIs) for predicting significant PCa were 0.68 (0.64-0.72), 0.72 (0.68-0.75), 2.41 (2.16-2.69), 0.44 (0.40-0.49), respectively. Besides, the summary diagnostic odds ratio (DOR) and 95% CIs for PCA3 was 5.44 (4.53-6.53). In addition, the area under summary receiver operating characteristic (sROC) curves and 95% CIs was 0.76 (0.72-0.79). The major design deficiencies of included studies were differential verification bias, and a lack of clear inclusion and exclusion criteria.

*Conclusions:* The results of this meta-analysis suggested that PCA3 was a non-invasive method with the acceptable sensitivity and specificity in the diagnosis of PCa, to distinguish between patients and healthy individuals. To validate the potential applicability of PCA3 in the diagnosis of PCa, more rigorous studies were needed to confirm these conclusions.

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## INTRODUCTION

Prostate cancer (PCa) is a worldwide diagnosed malignant neoplasm, which has become the second mortality rate of tumors in elderly men (1-3). The clinic symptoms of PCa are mostly similar to benign prostatic hyperplasia (BPH), which makes a difficulty for clinician to accurately distinguish PCa from BPH (4). Due to lack of effective and timely diagnostic methods, the prognosis of PCa was generally poor (4). It is quiet important for clinicians to the detection of PCa at an early stage, in order to reduce the mortality of PCa, improve the survival rate and

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increase the opportunity of effective medical interventions (5-7).

Nowadays, serum prostate-specific antigen (PSA) is still widely used for PCa screening (5, 8). Serum PSA level has been widely used to detect PCa, which is an organ-specific antigen, but not a cancer-specific antigen (9). Several diseases, including BPH, prostatitis and PCa, might be associated with an elevated PSA level (5, 9). Though a high level of PSA is likely to be associated with PCa, the low specificity of PSA limits its use as a screening test and unnecessary biopsies (10). As a noninvasive diagnostic urine test, prostate cancer gene 3 (PCA3) is more accurate than PSA and can reduce the likelihood of false-positive results (11). Up to present, numerous individual studies have been performed to explore the diagnostic value of urine PCA3 in the management of PCa (12-18). However, these studies on the diagnostic performance of PCA3 have reported unclear or even conflicting results.

Based on a systematic review with meta-analysis, the objective of this study was to systematically collect the databases search results and perform an updated meta-analysis to assess the efficacy of diagnostic tests of PCA3 for the early detection of PCa.

## MATERIALS AND METHODS

### Literature search strategy

Studies were searched in the electronic databases EMBASE, PubMed and Web of Science up to February 1st, 2019. Available publications were identified using the following keywords or text words: 'Differential Display clone 3' or 'DD3' or 'prostate cancer antigen 3' or 'PCA3', 'prostate cancer' or 'prostate neoplasms' or 'prostate carcinoma' or 'prostatic cancer' or 'prostatic neoplasm' or 'prostatic carcinoma' or 'cancer of prostate' or 'neoplasms of prostate' or 'carcinoma of prostate', and 'sensitivity' or 'specificity' or 'false negative' or 'false positive' or 'diagnosis' or 'detection' or 'accuracy'. For assessing all relevant studies, the most eligible literatures were retrieved. Moreover, relevant articles from reference lists of selected articles were searched to identify more relevant publications and avoid relevant information missing. No language restriction was applied.

There is no registered protocol for this systematic review. This systematic review and meta-analysis was conducted in accordance with the PRISMA guidelines, which compile guidelines for the reporting of meta-analysis of observational studies. The relevant studies included in this meta-analysis are previously published, and therefore, ethical approval and informed consent are not required.

### Criteria for inclusion and exclusion of published studies

The included studies must meet the inclusion criteria: (1) A case-control, nested case-control, or cohort randomized prospective or retrospective study, (2) Evaluate the diagnostic value of PCA3 in patients with PCa, (3) Available data for extraction to calculate sensitivity, specificity and other measures, (4) When duplications or the same patients used in several publications existed, the most recent or complete study was chosen in this meta-analysis. Additionally, the major exclusion criteria were as follows: (1) No available data; (2) Non-case-control studies, case reports, letters, reviewed editorial articles, (3) Duplicated publications with previous studies.

### Data extraction

The extracted appropriate information and data with a standard protocol were inspected by two researchers independently, to ensure the reliability and accuracy of the results. Moreover, the controversies were reviewed and settled through discussion by a third investigator, until all problems were finally resolved. The following information from each study were extracted: name of first author, publication date, country, ethnicity, mean age, PSA value (ng/mL), assay type, sample source, sample size, cut-off value, controls value (ng/mL), PCa/non-PCa case, and raw data including true positive (TP), true negative (TN), false positive (FP), and false negative (FN) results.

In addition, the quality of each reference was also evaluated by two investigators independently, according to the revised QUADAS tools (19). Each domain contains seven questions, whi-

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ch can be answered by "yes", "no" or "not clear" that assess the quality of included studies. An answer of "yes" means a low risk of bias, whereas "no" or "not clear" means a higher risk of bias in terms of the loss of some information from each literature.

### Statistical analysis

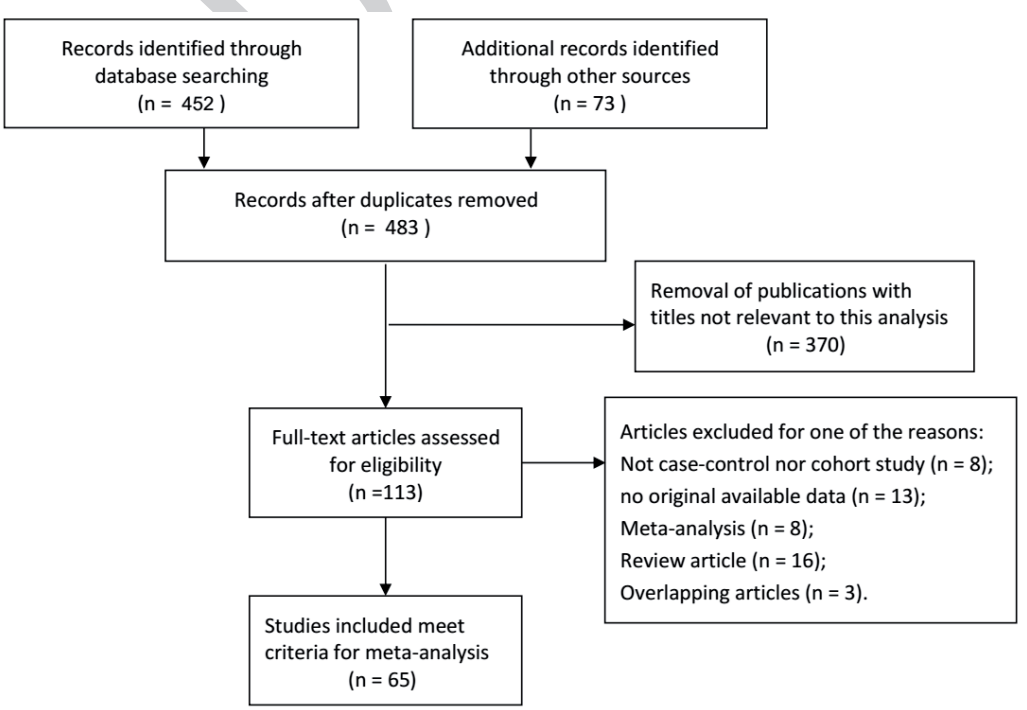
The statistical software STATA version 12.0 (StataCorp LP, College Station, TX) was performed to conduct all statistical data in this meta-analysis, and the Spearman test was used to analyze the threshold effect or the non-threshold effect. All of the statistical tests were two-sided, and P <0.05 was considered statistically significant. The pooled sensitivity, specificity, positive likelihood ratios (LR+), negative likelihood ratios (LR–), and the diagnostic odds ratio (DOR) as well as their corresponding 95% CIs were summarized to assess the diagnostic value of PCA3 in patients with PCa. Data were visualized as forest plots and receiver operating characteristic curves (ROC). The between-study heterogeneity was evaluated by Q test and I2 statistic, and P <0.05 was deemed statistically significant. As a quantitative measurement of inconsistency across different studies, I2-square value, ranged from 0 (no observed heterogeneity) to 100% (maximal heterogeneity), was also calculated. If the heterogeneity across studies was not identified, the fixed-effects model was used. Otherwise, the random-effects model was used in the meta-analysis. In addition, the summary receiver operating characteristic (sROC) curve was generated and the area under sROC curves (AUC) was calculated both overall and the subgroup analysis. Additionally, publication bias was investigated using Deek's funnel plot asymmetry test. When the P value of the Egger test was <0.05, the statistical significance was defined. Then, we replicated the funnel plot with its "missing" counterparts around the adjusted summary estimate.

## RESULTS

### Studies characteristics

As shown in Figure-1, 483 records were retrieved. After screening titles and abstracts of

**Figure 1 - Flowchart of literature search and selection process.**

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relevant articles, 418 articles were excluded because these were not related to the inclusion criteria. Finally, 65 case-control studies published between 2003 and 2018 were included in the meta-analysis (11-18, 20-76). All of these studies were retrospective in design.

The present meta-analysis included 8.139 cases and 14.116 controls from a total of 65 case--control studies about evaluating the diagnostic value of PCA3 in patients with PCa, and the detailed data of each study are listed in Table-1. Based on the studies described above, we retrieved data from 22.255 patients with PCA3 test and 5.065 patients with diagnosed PCa. All the studies presented the sensitivity, specificity, LR+, LR– and cut-off points. In these studies, these assay types, such as enzyme-linked immunosorbent assay (ELISA) and reverse transcription-polymerase chain reaction (RT-PCR), were applied to detect the expression level of PCA3. Besides, fifty studies were performed on Caucasian population, ten studies were conducted on Asian population, one study was carried out on African population, and the remaining studies involved more than one race.

**Quantitative synthesis results**

In this meta-analysis, the random-effects model was selected to calculate the sensitivity, specificity, LR+, and LR– with corresponding 95% CIs, because of the obvious between-study heterogeneity among those studies ($P < 0.05$). The meta--analytic results showed that the pooled overall diagnostic sensitivity, specificity, LR+, LR– and 95% CIs about PCA3 for predicting significant PCa were 0.68 (0.64-0.72), 0.72 (0.68-0.75), 2.41 (2.16-2.69), 0.44 (0.40-0.49), respectively (Figure-2). Moreover, the summary diagnostic odds ratio (DOR) and 95% CIs for the diagnostic value of PCA3 in PCa patients was 5.44 (4.53-6.53) (Figure-3). In addition, AUC and 95% CI was 0.76 (0.72-0.79) (Figure-4).

**Test of heterogeneity**

The I2-square of sensitivity, specificity, LR+, LR– and DOR in this meta-analysis were as follows: 88.86%, 92.08%, 82.17%, 81.70% and 100%, which proved that the heterogeneity between eligible studies was significant. As a result, the random effects model was chosen to synthesize the relevant data mentioned above.

**Publication bias**

The potential publication bias of the included studies was evaluated through the Deek's funnel plot asymmetry test. The data of the slope coefficient of the regression line were symmetric, which suggested that the meta-analysis did not have a likelihood of publication bias (Figure-5).

## DISCUSSION

Though PCa presents a slow progress, it has become a big threat to the health of men (4). Thus, the intervention at the early staging of PCa improves clinical prognosis. Serum PSA, DRE and transrectal ultrasound are still served as the screening of PCa in many countries and areas, which provides clinicians a low positive rate in the diagnosis of PCa (8). Among them, PSA is a serum marker widely used for screening of PCa in past years (4, 7). However, the proportion of positive biopsy is less than 50% in men with elevated serum PSA (10, 77). Therefore, the false-positive of PSA results may lead to unnecessary prostate biopsies and cause the complications of prostate biopsy (78). For these reasons, the searching for novel specific biomarkers of PCa has been attempted all the time.

In recent years, several serologic and pathologic biomarkers, with higher specificity than serum PSA, have been found to reduce unnecessary biopsy and inform the treatment (79, 80). Among them, PCA3 is one of the most valuable biomarkers in the detection of PCa (80). There are different expression of PCA3 gene in PCa tissue and other noncancerous tissue, which provides a great help for clinician to distinguish PCa from other prostatic diseases (80, 81). PCA3 gene is located on the long arm of chromosome 9 with 23kb long of nucleic acid and four exons and it cannot be translated into protein in normal cells (11, 82). In addition, it is a specific biomarker, over-expressed in more than 95% of PCa cells, so it can help to distinguish benign from cancerous prostate cells with an accuracy approaching 100% (83). Besides, PCA3 is also not affected by age, prostate volume or other prostatic diseases (81). In clinic, it is normally extracted

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**Table 1 - Characteristics and methodology assessment of individual studies included in the meta-analysis.**

| Year | First author | Country | Ethnicity | T Mean age (years) | T Mean PSA (ng/mL) | Assay type | Sample source | Cut-off value | Case | Control | TP | FP | FN | TN | QUADA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2018 | Li | China/Asian | Asian | NR | NR | PCR | Urine | 33.9 | 24 | 53 | 21 | 9 | 3 | 42 | 12 |
| 2017 | Sanda MG | US | Caucasian / Asian/African | 62 (33-85) | 4.8 *(0.3-460.4) | PCR | Urine | 20 | 264 | 262 | 104 | 18 | 160 | 244 | 10 |
| 2017 | Zhou | China/Asian | Asian | 65.3±7.8 | 7.1±1.77 | PCR | Urine | 23.5 | 33 | 89 | 27 | 48 | 6 | 41 | 11 |
| 2017 | Rubio-Briones | Spain | Caucasian | 61.7±6.12 | 4.49±1.99 | PCR | Urine | 35 | 161 | 396 | 115 | 186 | 46 | 210 | 11 |
| 2017 | Bernardeau S | France | Caucasian | 66.5 | 5.6 | PCR | Urine | 24 | 47 | 78 | 34 | 34 | 13 | 44 | 10 |
| 2017 | Cao | US | Caucasian / African | 63* (59–68) | NR | PCR | Urine | 35 | 77 | 195 | 50 | 55 | 27 | 140 | 12 |
| 2017 | Wang | China/Asian | Asian | 45-92 | NR | PCR | Urine | 40.38 | 169 | 425 | 112 | 81 | 57 | 344 | 12 |
| 2016 | Abdellaoui Maane I | Morocco | Caucasian | 52-73 | 6.16-15.9 | PCR | Tissue | cutoff 1.035 | 64 | 41 | 48 | 7 | 16 | 34 | 11 |
| 2016 | Tan | China/Asian | Asian | 71 (60-89) | 32.4 (2.5-199.7) | LAMP | Serum | NR | 89 | 101 | 76 | 8 | 13 | 93 | 10 |
| 2016 | Nygård Y | Norway | Caucasian | 64.0 (65.1*; 62.9-65.2a) | 9.1 (7.2*;8.3-9.9a) | PCR | Urine | 35 | 70 | 54 | 45 | 12 | 25 | 42 | 10 |
| 2015 | Merola R | Italy | Caucasian | NR | NR | PCR | Urine | 51 | 195 | 212 | 185 | 85 | 10 | 127 | 11 |
| 2015 | Kaufmann | Germany | Caucasian | 65 ± 5.6 (52–79) | 10 ± 4.4 (4.0–25.0) | PCR | Urine | 35 | 22 | 27 | 16 | 10 | 6 | 17 | 12 |
| 2015 | Rubio-Briones | Spain | Caucasian | 64(58-69) | 5.2(4.3-7.2) | PCR | Urine | 35 | 318 | 374 | 190 | 90 | 128 | 284 | 11 |
| 2015 | Vlaeminck-Guillem V | France | Caucasian | 64 ± 7(64*,59—69) | 6.2 ± 4.3(6.6*,5—9.4) | PCR | Urine | 35 | 480 | 535 | 326 | 155 | 154 | 380 | 10 |
| 2015 | Coelho FF | Brasil | Caucasian | 65.8±7.35 | NR | PCR | Urine | cutoff 0.2219 | 22 | 37 | 14 | 9 | 8 | 28 | 12 |
| 2015 | Huang | China/Asian | Asian | 70*(51-88) | 13.67(7.98–29.02)b | PCR | Urine | 35 | 112 | 24 | 90 | 9 | 22 | 15 | 11 |
| 2014 | Ruffion | France | Caucasian | 63(58-67)b | 5.9(4.7-7.9)b | PCR | Urine | 35 | 274 | 321 | 173 | 90 | 101 | 231 | 11 |
| 2014 | Nygård Y | Norway | Caucasian | 54.0 ± 6.4; 65.1* | 9.1 ± 4.7; 7.2* | PCR | Urine | 35 | 59 | 65 | 42 | 18 | 17 | 47 | 10 |
| 2014 | Wei | US | Caucasian / Asian/African | 62±8 | 8±14 | PCR | Urine | 35 | 331 | 528 | 205 | 122 | 126 | 406 | 13 |
| 2014 | Porpiglia | Italy | Caucasian | 65 (60-70)b | 6.9 (5.2-9.8)b | PCR | Urine | 32.5 | 52 | 118 | 34 | 29 | 18 | 89 | 10 |
| 2014 | Chevli | US | Caucasian | 64.8± 9.2 | 6.4±23.3c | PCR | Urine | 35 | 902 | 2171 | 478 | 543 | 424 | 1628 | 12 |
| 2013 | Busetto | Italy/Rome | Caucasian | 66.4 ± 5.3 | 6.8± 1.6 | PCR | Urine | 35 | 68 | 95 | 46 | 48 | 22 | 47 | 11 |
| 2013 | Rubio-Briones | Spain | Caucasian | 57.5±6.2 (57*,40-74) | 4.63±2.25 (4.04*,0.37-19.5) | PCR | Urine | 35 | 105 | 216 | 82 | 93 | 23 | 123 | 10 |
| 2013 | Salagierski | Poland/ Europe | Caucasian | 66.2±6.8 | 7.5±1.9 | PCR | Urine | 35 | 24 | 56 | 18 | 24 | 6 | 32 | 11 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | Ochiai | Japan | Asian | 69*(42–89) | 7.6 *(1.4–1908) | PCR | Urine | 35 | 264 | 369 | 176 | 105 | 88 | 264 | 11 |
| 2013 | Goode | US | Caucasian | 66*(41–90 ) | 4.8*(0.1–54.2) | PCR | Urine | 35 | 95 | 361 | 48 | 116 | 47 | 245 | 11 |
| 2013 | Stephan | Germany/ Europe | Caucasian | 65 *(41–81) | 6.05 (0.50–19.77) | PCR | Urine | 28 | 110 | 136 | 94 | 90 | 16 | 46 | 12 |
| 2012 | Perdona | Italy/Europe | Caucasian | 64.91±7.37 | 6.13 *(4.46–7.93)[b] | PCR | Urine | 32.5 | 47 | 113 | 24 | 19 | 23 | 94 | 10 |
| 2012 | Ng CF | China/Asian | Asian | 71 (56-86) | 20 / 10* (2-127) | PCR | Urine | 35 | 17 | 24 | 12 | 2 | 5 | 22 | 12 |
| 2012 | Crawford | US | Caucasian | 64.4±8.6 | 8.0±20.0 | PCR | Urine | 35 | 802 | 1111 | 389 | 249 | 413 | 862 | 12 |
| 2012 | Babera | Italy/Europe | Caucasian | 64* | 9.5*(3.7-28) | PCR | Urine | 35 | 110 | 67 | 36 | 13 | 74 | 54 | 10 |
| 2012 | Pepe | Italy/Europe | Caucasian | 64*(48-74) | 8.9*(4.5-10) | PCR | Urine | 35 | 27 | 47 | 19 | 27 | 8 | 20 | 11 |
| 2012 | Pepe | Italy/Europe | Caucasian | 62.5*(48-72) | 8.5 * (3.7-24) | PCR | Urine | 35 | 32 | 86 | 23 | 50 | 9 | 36 | 11 |
| 2012 | Sciarra | Italy/Europe | Caucasian | 63.7±7.24 | 6.98±2.86 | PCR | Urine | 35 | 55 | 113 | 41 | 30 | 14 | 83 | 10 |
| 2012 | Wu | US | Caucasian | 63.5±7.4 | 11.0±8.5 | PCR | Urine | 35 | 46 | 57 | 18 | 13 | 28 | 44 | 11 |
| 2011 | Vlaeminck-Guillem V | France | Caucasian | 63 ± 7 | 6.2 ± 4.3 | PCR | Urine | 35 | 126 | 114 | 76 | 37 | 50 | 77 | 11 |
| 2011 | Ochiai | Japan | Asian | 66*(44-87) | 7.2*(3.3-720.6) | PCR | Urine | 35 | 35 | 67 | 26 | 17 | 9 | 50 | 11 |
| 2011 | De La Taille A | France/ Germany/ Europe | Caucasian | 63.0± 7.6 | 5.9 ± 2.1 | PCR | Urine | 35 | 207 | 309 | 133 | 74 | 74 | 235 | 12 |
| 2011 | Adam | South Africa | African | 67(35–89) | NR | PCR | Urine | 35 | 44 | 61 | 34 | 30 | 10 | 31 | 11 |
| 2010 | Cao | China/Asian | Asian | NR | NR | PCR | Urine | AUC:0.73 | 86 | 45 | 82 | 24 | 4 | 21 | 10 |
| 2010 | Roobol | Netherlands/ Europe | Caucasian | 70.07(63.7–74.0) | 2.74 (0.2–23.0) | PCR | Urine | 35 | 122 | 599 | 83 | 265 | 39 | 334 | 11 |
| 2010 | Rigau | Spain/ Europe | Caucasian | 65.7 (44–85) | 11.86 (1.5–189) | PCR | Urine | 35 | 73 | 142 | 50 | 58 | 23 | 84 | 12 |
| 2010 | Auprich | France/ Germany/ Europe | Caucasian | 63(35–90) | 7.3(1–82.7) | PCR | Urine | 35 | 255 | 366 | 164 | 110 | 91 | 256 | 12 |
| 2010 | Ouyang | US | Caucasian | NR | NR | PCR | Urine | 19 | 43 | 49 | 31 | 20 | 12 | 29 | 10 |
| 2010 | Henderson | England/The Netherlands | Caucasian | 69.9 | 10.1(3.03-44.2) | PCR | Urine | 35 | 6 | 44 | 5 | 18 | 1 | 26 | 11 |
| 2010 | Aubin | US | Caucasian | NR | (0.30-33.9) | PCR | Urine | 35 | 190 | 882 | 92 | 189 | 98 | 693 | 12 |
| 2010 | Morote | Spain | Caucasian | 64* (39–85) | 6.4*(1.5–189) | PCR | Urine | NR | 83 | 161 | 75 | 34 | 8 | 127 | 11 |
| 2010 | Nyberg | Sweden/ Europe | Caucasian | 63 *(57–70) b | 7.9 *(5.1–12.8)b | PCR | Urine | 35 | 18 | 44 | 12 | 24 | 6 | 20 | 10 |
| 2010 | Shen | China/Asian | Asian | 70.3(51–86) | NR | PCR | Urine | cutoff 0.107 | 35 | 64 | 22 | 6 | 13 | 58 | 10 |
| 2010 | Schilling | Germany/ Europe | Caucasian | NR | 7.7*(2.0–46.9) | ELISA | Urine | 35 | 18 | 14 | 17 | 9 | 1 | 5 | 10 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | Shappell | US | Caucasian | NR | NR | PCR | Urine | 35 | 11 | 19 | 8 | 3 | 3 | 16 | 11 |
| 2009 | Wang | US | Caucasian | 62 ±8.3(44-86) | 8.7±12.4 | PCR | Urine | 35 | 87 | 100 | 46 | 20 | 41 | 80 | 10 |
| 2009 | Mearini | Italy/Europe | Caucasian | 69.1(53–83) | 1.08- 172.0 | PCR | Urine | AUC: 0.814 | 70 | 26 | 42 | 0 | 28 | 26 | 10 |
| 2008 | Haese | Europe | Caucasian | 64.4±6.6 | 8.9 ± 7.6 | PCR | Urine | 35 | 128 | 335 | 60 | 94 | 68 | 241 | 11 |
| 2008 | Deras | US/ Canada | Caucasian | 64 (32–89) | 7.8 (0.3–484) | PCR | Urine | 35 | 206 | 357 | 111 | 93 | 95 | 264 | 12 |
| 2008 | Nakanishi | US | Caucasian / African | 60 (45–70) | 5.7 (1.0–27.0) | PCR | Urine | 25 | 40 | 102 | 25 | 19 | 15 | 83 | 12 |
| 2008 | Laxman | US | Caucasian | NR | NR | PCR | Urine | AUC:0.66 | 138 | 96 | 91 | 23 | 47 | 73 | 11 |
| 2007 | Marks | US/Canada | Caucasian | 64 ± 7(64*45-83) | 7.4 ± 4.3(6.1*2.5-31.1) | PCR | Urine | 35 | 60 | 166 | 35 | 46 | 25 | 120 | 11 |
| 2007 | Van Gils MPMQ | Netherlands/ Europe | Caucasian | 64.3±7.2 | 7.49 ± 2.93 | PCR | Urine | 58 | 174 | 360 | 113 | 122 | 61 | 238 | 12 |
| 2007 | Van Gils MPMQ | Netherlands/ Europe | Caucasian | 64±7.2 | 8.73± 6.61 | PCR | Urine | 43 | 23 | 44 | 14 | 9 | 9 | 35 | 10 |
| 2007 | Van Gils MPMQ | Netherlands/ Europe | Caucasian | NR | NR | PCR | Urine | 66 | 23 | 44 | 15 | 8 | 8 | 36 | 10 |
| 2006 | Groskopf | US | Caucasian | 67±11 (45-93) | 7.7±14.1(0.4-101.7) | PCR | Urine | cutoff 0.05 | 16 | 52 | 11 | 11 | 5 | 41 | 12 |
| 2004 | Tinzl | Austria/ Europe | Caucasian | 64.7 (41-89) | 0.59 -1486 | PCR | Urine | cutoff 0.5 | 79 | 122 | 65 | 29 | 14 | 93 | 13 |
| 2004 | Fradet | Canada | Caucasian | 64* (40-87) | 0.1-144 | PCR | Urine | cutoff 0.5 | 152 | 291 | 100 | 32 | 52 | 259 | 12 |
| 2003 | Hessels | Netherlands/ Europe | Caucasian | NR | NR | PCR | Urine | cutoff 0.2 | 24 | 84 | 16 | 14 | 8 | 70 | 11 |

*: median; **a:** 95%CI; **b:** IQR (interquartile range); **c:** missing; **d:** SEM; **AUC:** area under curve; PCA3/PSA

**NA:** data are not available; mean median (ranges); cutoff values were not provided because these studies found serum PCA3 has no correlation with PCa.

in urine samples collected after DRE (11). And PROGENSA PCA3 assay has been already widely used to measure the level of urinary PCA3, and it can also been measured in serum and tissue samples (20, 23, 84).

Over the past years, many studies have increased to evaluate the value of PCA3 in the detection of PCa. In order to elucidate the expression differences of PCA3, meta-analysis has been updated to comprehensively and systematically investigate the diagnosis accuracy of PCA3 level in PCa patients. However, the outcomes of these studies remained inconsistent and controversial. There were several variables in these studies, such as the different ethnicities, the small sample size of individual study, the possible limited effect of individual patient data, among other factors, which could have caused the limited statistical power in the published studies. Compared with previous review and meta-analysis (85-87), this meta-analysis contains more studies for the sake of the sufficient evidence of our results. Furthermore, the publication of the previous meta-analysis might generate great influence on the results. All these factors made contributions to the development of the current meta-analysis.

Compared to a single study, meta-analysis would provide more sufficient results. Thus, we suggested that there existed stronger advantages

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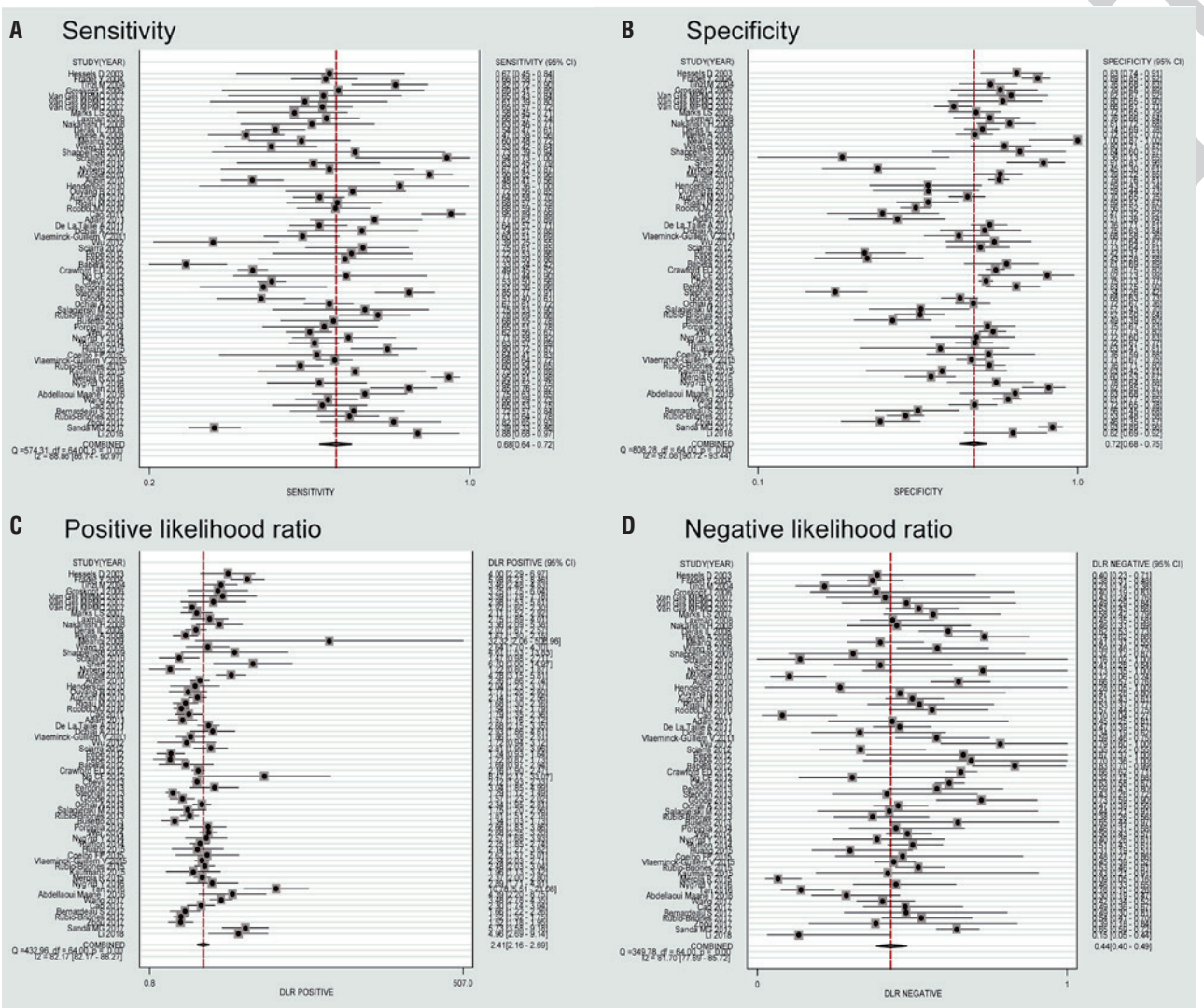
**Figure 1 - Flowchart of literature search and selection process.**




to prove the relevance between the level of PCA3 and the diagnosis of PCa. Though it was deemed that PCA3 might be a valuable diagnostic biomarker of PCa in the previous studies, correlation between PCA3 level and the diagnosis of PCa remains unclear. Therefore, we need a better method for further analysis and elaboration about the diagnostic value of PCA3 for PCa. In the present meta-analysis, the summary DOR and 95% CIs for PCA3 was 5.44 (4.53-6.53), and AUC and 95% CIs was 0.76 (0.72-0.79). Thus, the above results revealed that PCA3 could be acceptable as a valuable biomarker to distinguish PCa patients from healthy individuals.

Overall, the sufficient statistical evidences including the large sample size were used to estimate the diagnostic value of PCA3 in the detection of PCa. However, several limitations were involved in this meta-analysis. First of all, the ethnicities involved in these studies were mainly Caucasians, However, Asian and African populations were included in relatively few studies. Thus, more attention should be paid to the influence of ethnicity. Secondly, there was a threshold effect and obvious heterogeneity in this meta-analysis, probably due to the large difference in reagent resource, patient characteristics, the assay type and

**Figure 3 - Forest plots of summary diagnostic odds ratio of by PCA3 as a diagnostic marker for PCa in this meta-analysis. Each solid circle represents an eligible study. The size of solid circle reflects the sample size of each eligible study. Error bars represent 95% CIs.**

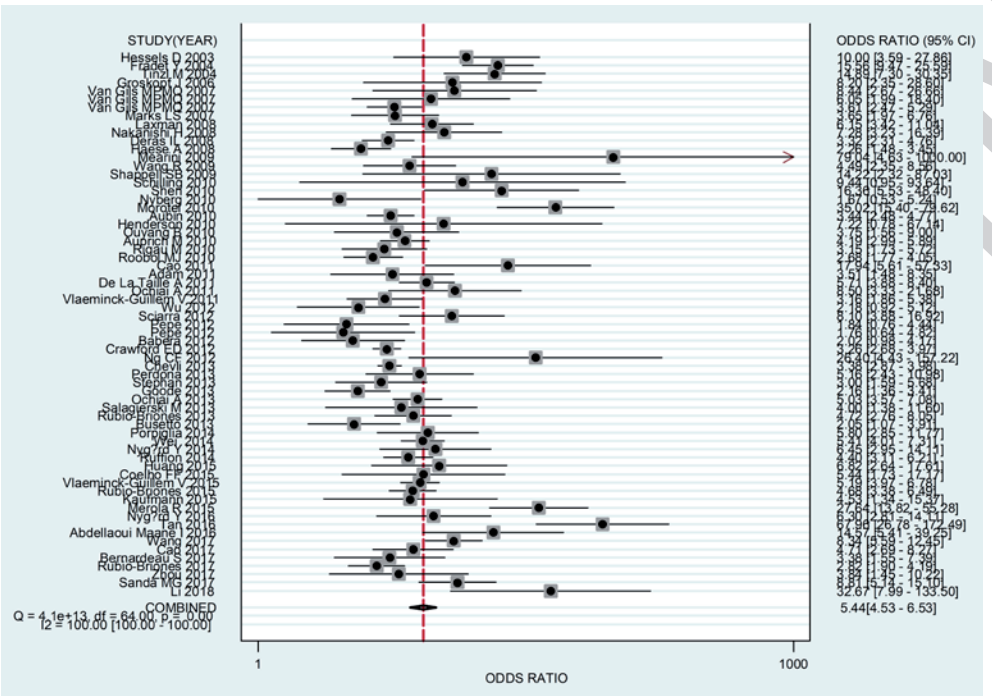



**Figure 4 - Summary receiver operating characteristic curves of PCA3 for the diagnosis of PCa. Each solid circle represents an eligible study. The size of solid circle represents the sample size of each eligible study. The overall diagnostic efficiency is summarized by the regression curve.**

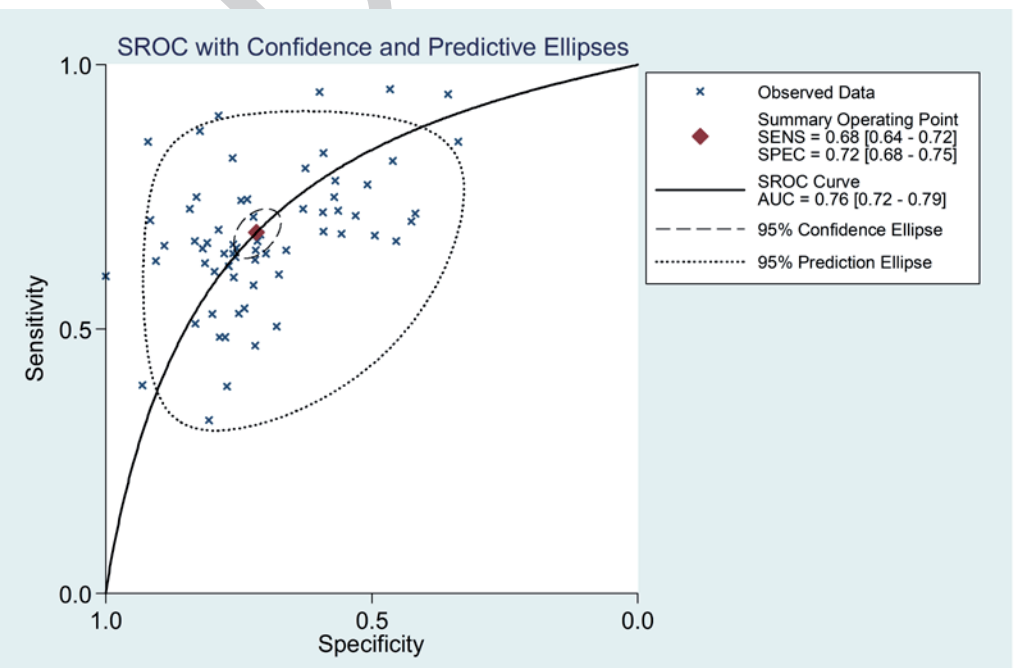
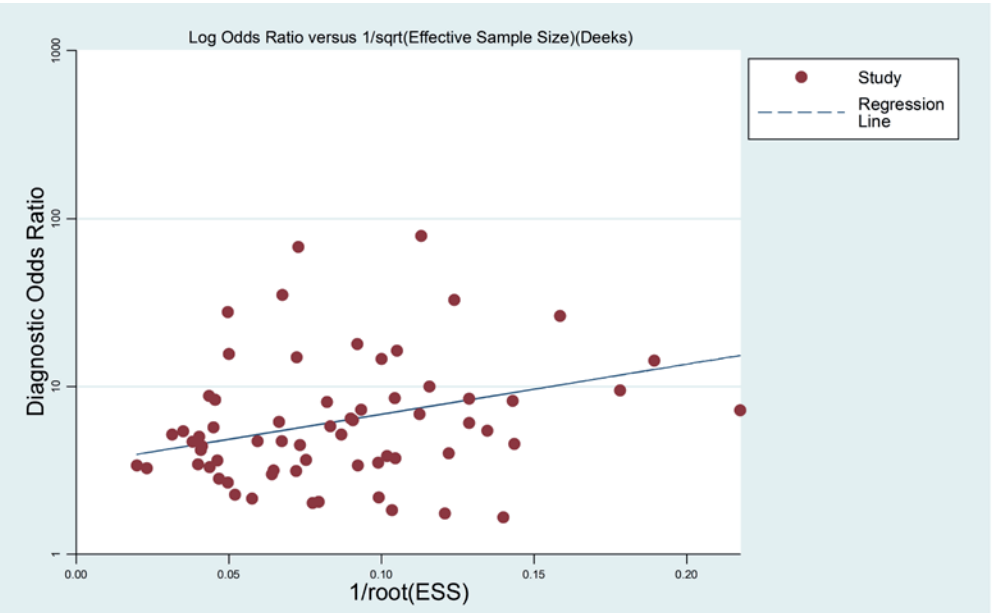


**Figure 5 - Linear regression test of funnel plot asymmetry. The statistically non-significant P value of the slop coefficient indicates symmetry of the data and a low likelihood of publication bias.**




the cut-off value. Moreover, the lack of sufficient data, the internal references and cut-off values were not considered in meta-regression analysis. Hence, it might reduce the reliability of our meta-analysis. In addition, more attention should be paid in further researches to the comparison of PCA3, PSA, and other biomarkers in the diagnosis of PCa. To improve reliability of the meta-analysis, well-designed studies with large sample size should be continued to evaluate the effectiveness of PCA3 in the detection of PCa in the subsequent years.

## CONCLUSIONS

This meta-analysis suggested that PCA3 is acceptable as a valuable diagnostic biomarker in the management of PCa, which is a non-invasive method with the acceptable sensitivity and specificity in the diagnosis of PCa to distinguish patients from healthy individuals. To further evaluate the diagnostic value of PCA3 in patients with PCa, more well-designed studies with large sample sizes are needed to validate the effectiveness of PCA3 to differentially diagnose PCa.

## ABBREVIATIONS

PCA3 = prostate cancer antigen 3;
PCa = prostate cancer;
LR+ = positive likelihood ratios;
LR– = negative likelihood ratios;
CIs = confidence intervals;
sROCs = ummary receiver operating characteristic;
AUC = area under sROC curves;
BPH = benign prostatic hyperplasia;
PSA = prostate-specific antigen;
TP = true positive;
TN = true negative;
FP = false positive;
FN = false negative;
DOR = diagnostic odds ratio;
ELISA = enzyme-linked immunosorbent assay;
RT-PCR = reverse transcription-polymerase chain reaction.

## CONFLICT OF INTEREST

None declared.

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