# Nanosensors for early stage detection of Circulating Tumour Cell biomarkers in Prostate Cancer Diagnosis: : A Systematic Review of Published Evidence

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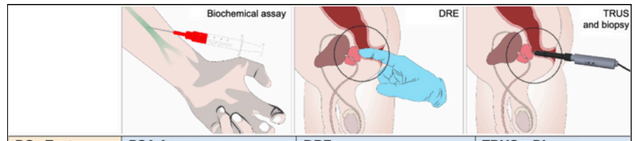
## Background

- Prostate Cancer: Most common cause of cancer-associated mortality in men.
- Stage IV Metastatic Prostate Cancer: 5-year survival rate of **27%.**
- Tissue-specific and cancer-specific biomarkers: **PSA.**

## Current Diagnostic Flow




| PCa Test | PSA Assay | DRE | TRUS + Biopsy |
|---|---|---|---|
| **Disadvantages** | High percentage of: **False Positives** (67%) **False Negatives** (15%) Main cause of redundant biopsies (2/3rd) | Unpleasant procedure Variation of examiners Biased diagnosis leads to inaccuracies | Non-Patient-Friendly Exhaustive Unwanted side effects (Infections, Erectile dysfunction) |

**Liquid biopsies:** Circulating Tumour Cells (CTC's) Prognostic biomarker for metastatic assessment

Current **Challenges** with PCa Diagnosis

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Need for **Modern Technology**
- Non- invasive
- Patient-friendly
- High sensitivity and specificity
- Safe

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Application for **Nanosensors in CTC Diagnosis**

## Nanoparticals

**Gold (AuNPs)**

**Quantum Dots (QD)**

**Magnetic (MNP's)**

**Graphene**

## Methodology

Systematic Search: Filters: Last 10 years (2014-2024), Language: English, Titles and Abstracts, Relevant Keywords

Pubmed Search Criteria

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((Prostate Cancer) AND (CTC) AND (Biomarkers))

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((Prostate Cancer) AND (CTC) AND (Biomarkers) AND (Nanosenor))

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((Prostate Cancer) AND (CTC) AND (Biomarkers) AND (Nanosenor) AND (Nanotechnology) AND Early Diagnosis))

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Primary Research papers n= 4

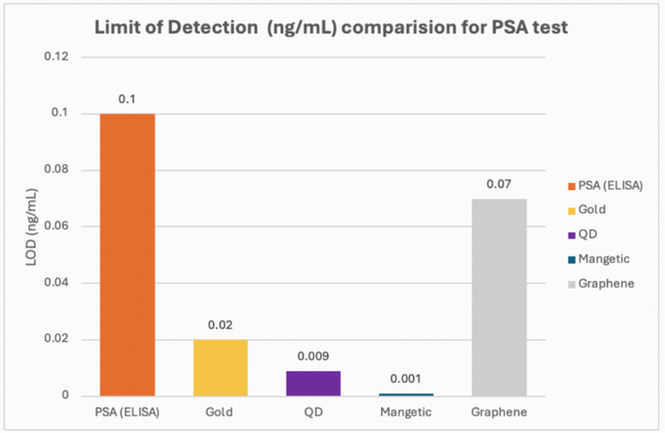
Systematic Review n= 10

## Hypothesis

Nanosensors will **enhance** the detection of CTC biomarkers in prostate cancer, leading to increased early diagnosis and metastatic risk assessment **compared** to existing technologies

## Results

| Nano sensor | Biomarker | Detection Method | Feature | LOD (ng/mL) | Efficacy % |
|---|---|---|---|---|---|
| Standard PSA (ELISA) test | PSA | Blood Serum | Standard Assay | 0.1 | 70–90 |
| Gold (AuNPs) | PSA | Serum of healthy prostate | Linear range: 0-0.8 ug/L | 0.02 | Not reported (–) |
| Quantum Dot | f-PSA and c-PSA | Two human serum | Assay time: 60 minutes; detects f-PSA and c-PSA | 0.009 | 86, 70-80 |
| Magnetic (MNP's) | PSA | Human Plasma | Linear range 0.001-1 ug/L | 0.001 (1 nG/L) | >94, >75, 90 |
| Graphene | PSA | Blood | Not reported (–) | 0.2 (total PSA) 0.07 (free PSA) | 73 |
| Carbon Nanotube | miR-21 | Human serum | miR-21 (0.01 fmol/L to 1 µmol/L) | 0.01 fmol/L Not applicable for PSA | >40 |




**Lower LOD aligned with higher sensitivity to clinically relevant concentrations**

**Magnetic nanoparticles showed the strongest performance; LOD = 0.001 ng/mL**

## Conclusion

| Nanosensor | LOD (ng/mL) | Interpretation | Advantages | Disadvantages |
|---|---|---|---|---|
| Gold (AuNPs) | 0.02 | Moderate sensitivity | Simple synthesis Ease of surface modification Unique spectral properties Biocompatibility | Signal to noise ratio High Cost Toxicity Poor Stability and reproducibility |
| Quantum Dot | 0.009 | High sensitivity, but less compared to MNPs. Detects both f-PSA and c-PSA within short assay time | Inherent fluorescence Controllable size Long fluorescence lifetime Tunable emission wavelengths | Cytotoxicity Non- Biodegradable Photochemical disturbances Synthesis complexity |
| Magnetic (MNP's) | 0.001 (1 nG/L) | Most sensitive amongst all. Detects extremely low concentrations of PSA. | Ease of surface modification Controllable size Superparamagnetic High stability of surface chemistry Biocompatibility | Toxicity Non-specific binding to WBC's Aggregation in biological fluid Rapid clearance by immune system with no surface modification. |
| Graphene | 0.2 (total PSA) 0.07 (free PSA) | Good sensitivity | High SA:Vol ratio Ease of surface modification Miniaturisation Wide detection range Biocompatibility | Scalability Signal-to-Noise Ratio Poor Stability and Durability High Cost |

## Future Work

- Integrating biomaterials
- Reducing cytotoxicity
- Surface Modification
- Enhanced sensitivity
- Processing and durability

## References

Scan Here

International Urology Cancer Summit