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Optimizing Prostate Cancer Diagnostic Work-Up Through Micro-Ultrasound: Minimizing Unnecessary Procedures and Reducing Overdiagnoses

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ABSTRACT

Introduction: We aim to critically assess Microultrasound (mUS) clinical performance in an outpatient setting, focusing on its ability to reduce unnecessary diagnostic procedures, potentially reshape prostate cancer (PCa) diagnostic protocols, and increase the ability to rule out clinically significant (Gleason Score $\geq 3+4$) PCa (csPCa).

Materials and Methods: Between November 2018 and April 2022, we conducted a prospective study involving men who underwent mUS examination due to clinical symptoms, PSA elevation, or opportunistic early detection of PCa. Experienced urologists performed mUS assessments in an outpatient setting using the prostate risk identification using micro-ultrasound (PRI-MUS) protocol to identify lesions suspicious of csPCa (PRI-MUS score ≥ 3). Men with negative mUS results were followed through consistent phone follow-up calls and visits until October 2023 to assess their diagnostic and therapeutic pathways. Using Cox regression models adjusted for PSA levels, DRE results, age, and previous biopsy history, we calculated the hazard ratio (HR) for biopsy-free (BFS), defined as the time from mUS to biopsy or last follow-up, cancer-free survival (CFS), and clinically significant cancer-free survival (csCFS) within the cohort based on mUS results.

Results: Overall, 425 men were enrolled. The median (IQR) age was 66 (59–72) years, PSA levels were 5.7 (4.0–7.9) ng/mL, prostate volume was 44 (31.5–62.1) mL, and the median follow-up was 39 months (27–53). mUS identified lesions suggesting csPCa in 201/425 (47.3%) men. Overall, mUS resulted negative in 224/425 (52.7%) men, of whom 207/224 (92.4%) did not undergo subsequent mpMRI, while 22/224 (9.8%) proceeded with mpMRI according to the referring physician's decision. The latter detected suspicious lesions in 12/22 cases (54.5%), but only 2/12 (16.7%) were confirmed by biopsy as csPCa. Among those with negative mUS results, 192/224 (85.7%) men avoided additional biopsies during follow-up. Men with negative mUS results exhibited superior BFS (aHR: 0.17; $p < 0.001$), CFS (aHR:0.12; $p < 0.001$), and csCFS (aHR:0.09; $p < 0.001$) survival rates compared to their mUS-positive counterparts.

Beatrici Edoardo and De Carne Fabio. contributed equally to this work.

Conclusions: Our findings suggest that mUS can potentially refine patient stratification and transform PCa screening and diagnostic protocols. Pending validation by other studies, a wider implementation of mUS could optimize resource allocation, minimize wastage, and reserve additional costly tests.

1 | Introduction

Prostate cancer (PCa) is the fourth most common cancer worldwide and the second most prevalent in men [1]. The adoption of prostate-specific antigen (PSA) has significantly increased cancer incidence while reducing PCa mortality [2]. However, it also raises concerns about overdiagnosis and overtreatment [3]. Population screening involving PSA and digital rectal examination (DRE) is recommended by guidelines such as the National Comprehensive Cancer Network and the European Association of Urology (EAU) [4, 5].

However, PSA, DRE, and systematic biopsy alone are suboptimal for detecting clinically significant prostate cancer (csPCa) [6, 7]. The advent of multiparametric magnetic resonance imaging (mpMRI) has improved csPCa detection and reduced overdiagnosis of clinically insignificant PCa (GS 3 + 3) (ciPCa), leading to its widespread use before the prostatic biopsy [8–10]. Despite this, challenges like limited access to high-quality imaging and medical contraindications persist, such as implanted devices, claustrophobia, or renal impairment [9, 11–13].

Micro-ultrasound (mUS), with its advanced 29 MHz frequency—far exceeding the 8–12 MHz typical of traditional ultrasound—represents an innovative and useful imaging technique for PCa diagnosis. Indeed, this superior frequency enhances the detection of glandular alterations in the prostate, thereby improving the accuracy in identifying or excluding areas suspected of PCa [14, 15]. Numerous studies have validated mUS effectiveness in detecting csPCa, underscoring its diagnostic precision [16, 17]. Given these advantages, we hypothesize that mUS can reduce the number of unnecessary invasive procedures by reliably identifying patients at low risk of csPCa, resulting in improved biopsy-free and cancer-free survival. Furthermore, a renewed interest in PCa diagnosis has emerged, highlighting the challenge of creating a balanced protocol that minimizes overdiagnosis while controlling costs. While mUS shows promise, it has yet to be extensively evaluated in broader contexts. Our study aims to critically assess mUS clinical performance in an outpatient setting by investigating its effectiveness in a large, though still selected, population of men with clinical suspicion of PCa, focusing on its ability to reduce unnecessary diagnostic procedures, potentially reshape PCa diagnostic protocols, and increase the ability to rule out csPCa.

2 | Materials and Methods

2.1 | Data Source

In the present study, we collected and archived data from patients subjected to microUS examination in an outpatient clinical setting. This data collection was prospectively executed and stored within an internal database, employing the resources of our healthcare facility solely.

2.2 | Study Design and Population

This prospective observational, longitudinal study enrolled male participants aged 18 years and older who were referred from November 2018 through April 2022 to our institution's outpatient clinic by their referring physicians for further evaluation due to clinical symptoms, PSA elevation, suspicious findings at DRE for PCa, or opportunistic early detection of PCa in patients with family history. All participants underwent a urological examination, including DRE and had a PSA evaluation. Two expert urologists (G.L. and M.L.) with extensive experience (performing mUS since 2017) conducted the examinations utilizing the mUS technology. Men with a history of previously positive prostate biopsy for PCa and/or individuals currently under active surveillance for PCa were excluded from the study.

2.2.1 | Diagnostic Pathway

Participants demonstrating positive mUS findings, characterized by a prostate risk identification using micro-ultrasound (PRI-MUS) score of 3 or higher, were advised to consider a prostate biopsy for further evaluation. Conversely, individuals with negative mUS results underwent systematic follow-up via outpatient visits and telephone calls through August 2023, enabling ongoing assessment of their diagnostic and therapeutic journeys. In both scenarios, the contemplation of additional imaging modalities, including mpMRI, was guided by a collaborative decision-making approach. This process integrated the expertize of urologists with patient-specific factors—such as familial history, clinical examination outcomes (including PSA levels and DRE findings), and mUS results—to tailor the subsequent diagnostic pathway. In case of a positive microUS and/or mpMRI finding, both targeted (> = 2 cores for each lesion) and systematic biopsies (> = 12 cores) were performed.

2.3 | Main Outcome Variable

Our analysis centered on evaluating mUS impact on biopsy-free survival (BFS), cancer-free (CFS) and clinically significant-cancer-free survival (csCFS) among participants. BFS was calculated by stratifying patients based on the mUS findings (negative mUS vs. positive mUS) from the date of the mUS examination to the date of the following prostate biopsy for men who underwent prostate biopsy, while censoring those who did not undergo biopsy at the time of the last follow-up visit. This evaluation aimed to assess the potential of mUS to reduce unnecessary biopsies by identifying patients at lower risk of

csPCa. CFS and csCFS were determined by stratifying men based on mUS findings (negative mUS vs. positive mUS) from the mUS examination date until the diagnosis of PCa and csPCa or the last follow-up for individuals without such a diagnosis (censored population), evaluating mUS's effectiveness in early detection of PCa and csPCa and its influence on further diagnostic and therapeutic pathways.

2.4 | Main Predictor Variable

The primary predictor variable in this study was the outcome of the mUS exam, classified by the PRI-MUS score. A PRI-MUS score ≥ 3, indicating suspicion of csPCa, prompted further diagnostic evaluations like prostate biopsies or mpMRI. In contrast, a PRI-MUS score < 3 suggested a lower csPCa risk, guiding against immediate further invasive diagnostics. This binary classification of mUS outcomes facilitated a detailed assessment of its predictive accuracy for csPCa risk, thereby informing subsequent clinical decision-making processes.

2.5 | Statistical Analysis

We summarized continuous variables using median values and interquartile ranges (IQRs). The association between mUS results and the avoidance of additional diagnostic procedures, including mpMRI and prostate biopsy, was initially explored through descriptive statistics, quantifying frequencies, and proportions for categorical outcomes. Categorical variables were compared using Chi-square tests, and continuous variables were compared using Mann-Whitney U tests. Complete-case Cox regression models were employed to assess the impact of mUS on BFS, CFS and csCFS within the cohort. These models were adjusted for key variables, including PSA levels, DRE findings, patients' age, and the history of previous biopsies, providing a risk-adjusted perspective on the outcomes of interest. Hazard ratios (HRs) were calculated to quantify the risk of undergoing a biopsy or receiving a cancer diagnosis based on the mUS findings. Kaplan-Meier survival curves were generated to visually depict trends in BFS, CFS, and csCFS, enabling an intuitive understanding of the duration until patients underwent prostate biopsy or were diagnosed with cancer. The log-rank test was employed to evaluate the statistical significance of differences between the survival curves.

Statistical analyses were conducted using Stata software (18.0, SE-Standard Edition, Copyright 1985–2023 StataCorp LLC), with all tests being two-sided and a significance level set at $p < 0.05$.

3 | Results

3.1 | Baseline Characteristics

A total of 425 patients with a clinical suspicion of PCa were included in our study. The median age of our population was 66 years (IQR: 59–72), PSA levels were 5.7 ng/mL (IQR: 4.0–7.9), and prostate volume was 44 mL (IQR: 31.5–62.1). Overall, all 425 (100%) patients underwent DRE, of whom 51 (12%) resulted to be positive. Among our population, 294 (69.2%) men were biopsy-naïve, while the remaining 131 (30.8%) were subjected to a previous prostate biopsy with a negative finding before the mUS investigation. The median time from mUS evaluation to last follow-up was 39 months (IQR: 27–53). Further population baseline characteristics categorized according to the mUS findings are listed in Table 1.

3.2 | Microultrasound Results

Overall, mUS identified lesions suggestive of csPCa (PRI-MUS ≥ 3) in 201/425 (47.3%) men. Among these men, a total of 147/201 (73.1%) underwent prostate biopsy with a result of 47/147 (32%) csPCa and 34/147 (23.1%) ciPCa at the level of the lesion identified during mUS examination, while the remainder had a negative biopsy result.

Of the men diagnosed with csPCa, 18/47 (38.3%) were finally treated with radiotherapy (RT), 19/47 (40.4%) with robotic-assisted radical prostatectomy (RARP), 3/47 (6.4%) with focal therapy (High-Intensity Focal Ultrasound [HIFU]), 4/47 (8.5%) with hormone therapy when indicated.

When considering the 224/425 (52.7%) men with negative results at mUS, 207/224 (92.4%) were suggested to be monitored through PSA measuring and periodic urological evaluation, initially avoiding any further investigation. Overall, 192/224 (85.7%) men with negative mUS avoided additional biopsies during follow-up. Conversely, 22/224 (9.8%) of patients were referred for additional investigation, specifically mp-MRI, by urologists other than those who had performed the initial mUS examination. Among these 22 men, 10/22 (45,5%) tested negative, while 12/22 (54.5%) had at least one suspected lesion PIRADS ≥ 3 at the following mp-MRI, requiring a prostate biopsy. Nevertheless, after undergoing prostate biopsy, only 2/12 (16.7%) csPCa were detected.

Finally, DRE was positive 41/201 patients (20.4%) with positive mUS results and in 10/224 patients (4.5%) with negative mUS results (Table 1).

3.3 | Biopsy-Free, Cancer-Free and Clinically Significant Cancer-Free Survival Time

In the multivariable Cox regression model, men with a negative mUS result demonstrated significantly lower risk of undergoing prostate biopsy (aHR:0.17; 95%CI:0.11–0.27; $p < 0.001$) compared to those with positive mUS findings (Table 2a). Figure 1 presents the Kaplan-Meier survival curves, illustrating the difference in BFS between the groups based on mUS results.

Similarly, men with negative mUS findings demonstrated a significantly lower risk of being detected with PCa (aHR: 0.12; 95% CI: 0.06–0.24; $p < 0.001$) compared to those with positive mUS results (Table 2b). Figure 2 presents the Kaplan-Meier survival curves, illustrating the difference in CFS between the groups based on mUS results.

TABLE 1 | Population baseline characteristics categorized according to the mUS findings.

	mUS negative $N = 224$	mUS positive $N = 201$	Total $N = 425$	p value
Age	65.5 (59.0–71.0)	67.0 (59.5–73.0)	66.0 (59.0–72.0)	0.10
Total PSA	5.2 (3.9–7.2)	6.1 (4.2–8.5)	5.7 (4.0–7.9)	0.017
PSA ratio	20.0 (14.0–27.0)	16.0 (11.0–21.0)	17.5 (13.0–24.0)	0.003
Prostate volume (mL)	51.0 (35.0–75.0)	38.0 (30.0–55.0)	44.0 (31.5–62.1)	< 0.001
DRE				< 0.001
Negative	214 (95.5%)	160 (79.6%)	374 (88.0%)	
Positive	10 (4.5%)	41 (20.4%)	51 (12.0%)	
Previous biopsies				0.52
No	158 (70.5%)	136 (67.7%)	294 (69.2%)	
Yes	66 (29.5%)	65 (32.3%)	131 (30.8%)	
Previous mpMRI				0.96
No	151 (67.4%)	136 (67.7%)	287 (67.5%)	
Yes	73 (32.6%)	65 (32.3%)	138 (32.5%)	
Findings at previous mpMRI				0.50
PIRADS 3	20 (8.9%)	16 (8.0%)	36 (8.5%)	
PIRADS 4	6 (2.7%)	6 (3.0%)	12 (2.8%)	
PIRADS 5	0 (0.0%)	2 (1.0%)	2 (0.5%)	
Negative mpMRI	47 (21.0%)	41 (20.4%)	88 (20.7%)	
No previous mpMRI	151 (67.4%)	136 (67.6%)	287 (67.5%)	
Number of mUS lesions				< 0.001
0 Lesions	224 (100.0%)	0 (0.0%)	224 (52.7%)	
1 Lesion	0 (0.0%)	180 (89.6%)	180 (42.4%)	
2 Lesions	0 (0.0%)	20 (10.0%)	20 (4.7%)	
3 Lesions	0 (0.0%)	1 (0.5%)	1 (0.2%)	
Findings at mUS				< 0.001
PRIMUS 3	0 (0.0%)	31 (15.4%)	31 (7.3%)	
PRIMUS 4	0 (0.0%)	125 (62.2%)	125 (29.4%)	
PRIMUS 5	0 (0.0%)	45 (22.4%)	45 (10.6%)	
Negative mUS	224 (100.0%)	0 (0%)	224 (52.7%)	
Follow-up (months)	37.0 (27.0–53.0)	40.0 (27.0–53.0)	39.0 (27.0–53.0)	0.52

Note: Data are presented as median (IQR) for continuous measures, and n (%) for categorical measures.
Abbreviations: DRE, digital rectal examination; mpMRI, multiparametric magnetic resonance imaging; mUS, microUltraSound; PIRADS, prostate imaging - reporting and data system; PSA, prostate-specific antigen.

Finally, men with negative mUS findings demonstrated a significantly lower risk of being detected with csPCa (aHR: 0.09; 95% CI: 0.03–0.26; $p < 0.001$) compared to those with positive mUS results (Table 2c). Figure 3 presents the Kaplan-Meier survival curves, illustrating the difference in csCFS between the groups based on mUS results.

4 | Discussion

Our study suggests that mUS could represent a pivotal development in addressing the limitations of current PCa diagnostic methodologies, which often lead to overdiagnosis and consequent overtreatment of indolent PCa. The results from our investigation demonstrate that mUS substantially enhances the detection accuracy for csPCa, thereby providing a strategic advantage in minimizing unnecessary diagnostic interventions. Specifically, our data reveal that negative mUS findings are associated with markedly and significantly reduced risks of undergoing prostate biopsies, with adjusted hazard ratios indicating a lower likelihood of biopsy, PCa detection, and csPCa detection. Additionally, we observed strong adherence to clinical recommendations based on mUS findings, emphasizing its reliability, patient acceptance, and accuracy over time.

As highlighted by the Lancet Commission on Prostate Cancer, the expected surge in PCa incidence—projected at 3 million new cases by 2040—urgently calls for a reevaluation of our

TABLE 2 | Multivariable Cox regression model reporting the risk of: (a) undergoing prostate biopsy, (b) identifying prostate cancer, (c) identifying clinically significant prostate cancer according to microultrasound findings, and adjusting the models for PSA values, digital rectal examination findings, patients' age at the time of microultrasound assessment, and history of previous prostate biopsies.

	a. Risk of undergoing prostate biopsy			b. Risk of identifying prostate cancer			c. Risk of identifying clinically significant prostate cancer		
	Hazard ratio	*p* value	95% confidence interval	Hazard ratio	*p* value	95% confidence interval	Hazard ratio	*p* value	95% confidence interval
mUS									
Positive	Ref.	—	—	1 (base)	—	—	1 (base)	—	—
Negative	0.17	< 0.001	0.11–0.27	0.12	< 0.001	0.06–0.24	0.09	< 0.001	0.03–0.25
PSA value	1.01	0.58	0.97–1.06	1.01	0.67	0.95–1.08	1.05	0.19	0.98–1.12
DRE									
Negative	1 (base)	—	—	1 (base)	—	—	1 (base)	—	—
Positive	1.08	0.75	0.66–1.78	1.25	0.49	0.67–2.33	1.67	0.19	0.78–3.59
Age	1.01	0.92	0.99–1.03	1.02	0.15	0.99–1.05	1.04	0.04	1.00–1.09
History of previous prostate biopsies	1.05	0.82	0.71–1.55	0.98	0.94	0.57–1.68	0.95	0.88	0.46–1.93

Abbreviations: DRE, digital rectal examination; mUS, microUltraSound; PSA, prostate-specific antigen.

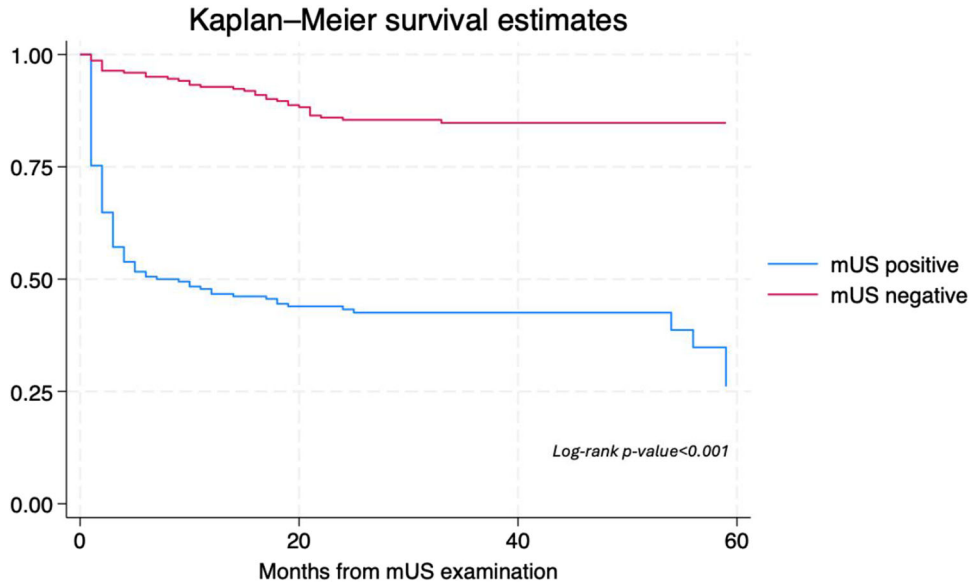

FIGURE 1 | Kaplan-Meier survival curves, illustrating the difference in biopsy-free survival between the groups based on mUS results. [Color figure can be viewed at wileyonlinelibrary.com]

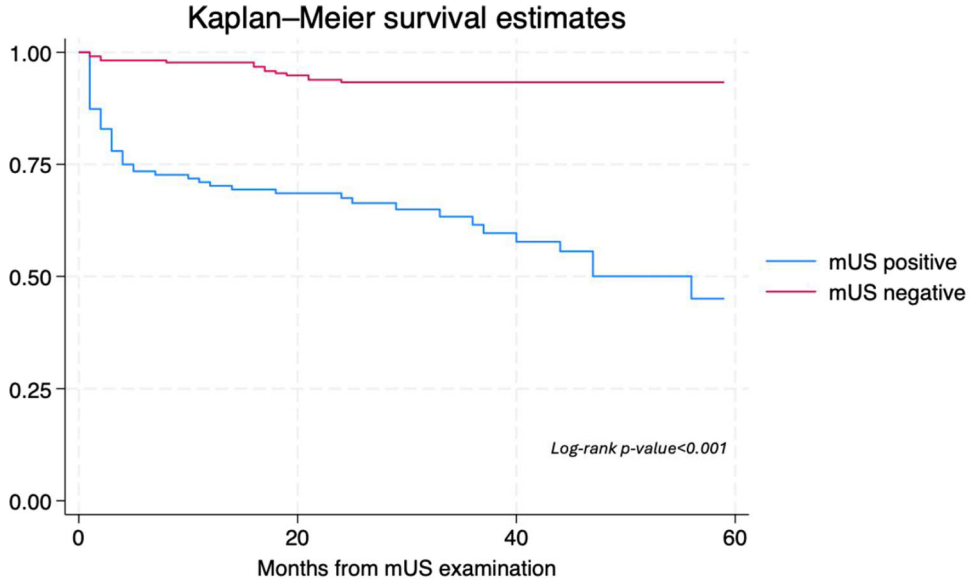

FIGURE 2 | Kaplan-Meier survival curves, illustrating the difference in cancer-free survival between the groups based on mUS results. [Color figure can be viewed at wileyonlinelibrary.com]

diagnostic pathways [18]. This imperative arises from the prevalent issues of overdiagnosis and the resultant overtreatment of indolent disease forms, and the loss of csPCa cases worthy of immediate diagnosis and treatment [3].

As we navigate the shifting terrain of PCa management, the necessity to refine our screening and diagnostic practices becomes increasingly apparent [19, 20]. On one hand, considerable ambiguity persists concerning the routine use of PSA testing as the primary screening modality for men at risk of PCa, based on age [21, 22]. Recent findings from Martin et al. revealed that a singular invitation to undergo a PSA screening in men aged 50–69 years, modestly decreased PCa mortality over a median follow-up of 15 years. However, the reduction in absolute mortality rates compared to those who received no invitation was minimal, highlighting the nuanced benefits and limitations of widespread PSA screening [23]. The integration of PSA with secondary diagnostic tools like the Kallikrein panel, the prostate health index, and mpMRI aims to refine risk stratification and develop tiered diagnostic pathways [24]. These pathways progress from less invasive and cost-effective tests to more advanced, costly, and invasive procedures. Nonetheless, recent findings by Auvine et al. indicate that the overall benefit of such an approach may be constrained [25].

In this context, there is a pressing need to elevate public consciousness about the disease and its genetic predispositions, particularly for individuals with familial risk [18, 26]. The current underappreciation of genetic risk factors underscores the urgent clinical imperative to develop personalized health promotion and

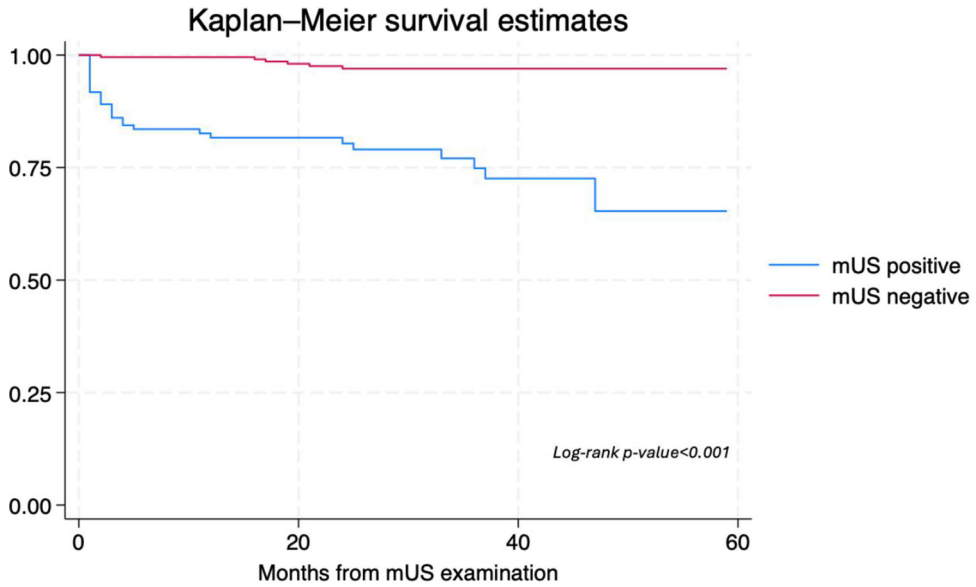

FIGURE 3 | Kaplan-Meier survival curves, illustrating the difference in clinically significant-cancer-free survival between the groups based on mUS results. [Color figure can be viewed at wileyonlinelibrary.com]

targeted screening strategies [24, 27, 28]. Following precision medicine principles, the scientific community supports incorporating genetic testing into PCa diagnostics to enhance risk stratification and establish tailored pathways, ensuring timely and appropriate interventions for those at greatest risk.

In addition to developing specific PCa screening and diagnostic pathways based on risk stratification and molecular as well as genetic testing, the integration of novel imaging technologies can further refine these processes. Incorporating mUS into PCa screening and diagnostic pathways may represent a significant advancement. In this regard, mUS not only streamlines the diagnostic process but also enhances the precision in identifying patients who eventually require more invasive diagnostic or radiological investigations [29, 30]. This technique not only saves time and resources but also enhances the role of urologists, who can perform mUS assessments repeatedly at short intervals. This capability allows for immediate adjustments based on any new uncertainties or changes in a patient's condition, ensuring a more efficient and responsive approach to PCa management [14]. Given this consideration, although our study lacks a control group, the potential to utilize this urologist-friendly tool in an opportunistic screening setting or within a randomized study is highly appealing. The ongoing OPTIMUM trial partially addresses this approach, underscoring the attractiveness of mUS as a versatile and effective diagnostic tool [31].

Moreover, the adoption of cutting-edge diagnostic tools like mUS is critical for differentiating between csPCa and less aggressive forms. This differentiation is crucial in averting unnecessary and more expensive medical procedures, thereby enhancing the efficiency of patient care. Evidence of mUS's effectiveness in our cohort is demonstrated by high patient adherence rates to recommendations and follow-up indications after positive (75%) or negative (> 80%) mUS findings.

The high negative predictive value of mUS highlights its efficacy as a practical diagnostic tool, minimizing the necessity for additional invasive procedures in patients unlikely to harbor csPCa. Conversely, the use of mpMRI in screening and diagnostics settings is hampered by significant drawbacks, including high costs, limited availability, and operational complexity, which impede its adoption on a broad scale [9, 12]. In response, bpMRI serves as a more accessible alternative, offering reductions in both scanning time and cost [32, 33]. Despite these improvements, bpMRI still requires substantial infrastructure and expertize, which can limit its practicality for quick assessments and routine follow-ups. Hence, while bpMRI presents advantages over mpMRI, mUS might emerge as a superior alternative within PCa screening and diagnostic paradigms. Its capabilities for immediate, precise diagnostics significantly streamline the management of PCa, offering a robust, efficient pathway for early detection and treatment within an evolving clinical landscape. This integration not only conserves resources but also substantively enhances patient care, adhering closely to the principles of precision medicine and the contemporary demands of urological practice.

This study provides valuable insights into the integration of mUS in PCa diagnostic pathway, yet several limitations warrant consideration. First, the findings are derived from a single institution, which may limit their generalizability across different demographics and healthcare settings. Second, the study population consisted of men attending the urological consultation referred by general practitioners due to elevated PSA levels, suspicious DRE, or opportunistic early detection of PCa. This variation might introduce selection bias, potentially affecting the extrapolation of the results to a general or asymptomatic population. This limitation highlights the necessity for future research to assess the efficacy of mUS within a population-based screening framework. Additionally, the interpretation of mUS results relied on a limited number of experienced urologists, which could introduce variability in diagnostic accuracy depending on the examiner's expertize with mUS technology. Moreover, the follow-up duration may not be long enough to fully evaluate the long-term outcomes

associated with mUS diagnostic pathway, such as cancer progression and survival, necessitating extended observational periods. A comprehensive cost-effectiveness analysis was not performed, which is crucial for assessing the economic viability of integrating mUS into routine PCa screening. Furthermore, while the study discusses reducing reliance on mpMRI through mUS, direct comparison between these modalities was not the primary focus. Future research should directly compare the diagnostic performance, patient outcomes, and cost-effectiveness of mUS and mpMRI to solidify mUS's role in the diagnostic pathway. Addressing these limitations in subsequent research is vital to ensure robust and comprehensive evidence supports the use of mUS in clinical practice. Lastly, the limited availability of mUS technology, currently produced by a single manufacturer and implemented in few institutions, poses a potential challenge due to the risk of monopolization. This proprietary nature may limit access, increase costs, and restrict competition, complicating efforts to integrate mUS into PCa screening and diagnostic guidelines. Ensuring broader availability and preventing monopolistic practices will be crucial for equitable adoption and widespread implementation.

Despite the aforementioned limitations, our data strongly suggest that mUS could significantly reduce the reliance on mpMRI in PCa diagnostic protocols. If widely adopted, mUS could serve as a primary imaging modality, particularly for patients with mildly elevated PSA levels or a family history of PCa. Therefore, we propose a tiered diagnostic strategy where mUS serves as the primary imaging modality for initial patient evaluation, with mpMRI employed selectively as a second-line tool in cases where mUS findings indicate higher risk or diagnostic ambiguity that requires further clarification. This approach prioritizes referral to biopsy based on a combination of mUS results and clinical evaluation. Such a strategic realignment in the diagnostic pathway could optimize resource utilization and streamline patient management, ensuring that advancements in screening and diagnostic technology translate into more efficient and effective patient care.

5 | Conclusions

Our findings suggest that mUS can effectively refine patient stratification and potentially transform PCa screening and diagnostic protocols to emphasize precision medicine. By adopting a tiered diagnostic pathway, where mUS is used as the first-line imaging modality and mpMRI is reserved for cases requiring further clarification, healthcare providers could enhance the accuracy of PCa diagnosis while minimizing unnecessary interventions. Broader implementation could enhance resource allocation, minimize wastage, and reserve more invasive, costly examinations like mpMRI for selectively identified cases requiring further investigation.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data supporting this study's findings are confidential and cannot be shared publicly. Further inquiries may be directed to the corresponding author.

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