Research and Reports in Urology

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

The Prognostic Value of Perioperative Factors on Biochemical Recurrence in Patients Undergoing Radical Prostatectomy

Nikolaos Pyrgidis*, Philipp Weinhold*, Gerald Bastian Schulz, Michael Chaloupka, Elena Berg, Thilo Westhofen, Severin Rodler, Patrick Keller, Friedrich Jokisch, Christian G Stief, Julian Marcon, Robert Bischoff

Department of Urology, University Hospital, LMU Munich, Munich, Germany

*These authors contributed equally to this work

Correspondence: Nikolaos Pyrgidis, University Hospital LMU Munich, Department of Urology, Marchioninistraße 15, Munich, 81377, Germany, Tel +0049 152 5484 7591, Fax +49 89 4400 78890, Email Nikolaos.pyrgidis@med.uni-muenchen.de

Introduction: We aimed to assess the role of major perioperative risk factors (age, preoperative PSA values, body mass index, pathologic T-stage, resection status, and ISUP grade) in predicting biochemical recurrence (BCR) and survival after radical prostatectomy (RP) for prostate cancer (PC).

Methods: An analysis of the prospective cohort of patients undergoing RP from 2013 to 2023 at our center was performed. Patients who received neoadjuvant or adjuvant therapies for PC or those with PSA persistence after RP were excluded. A Cox regression analysis was undertaken to evaluate the effect of major perioperative risk factors on the time to BCR. The role of the EAU BCR risk stratification on survival was also assessed. For all analyses, hazard ratios (HRs) with the corresponding 95% confidence intervals (CIs) were estimated.

Results: A total of 1539 patients underwent RP for localized PC. At a median follow-up of 39 months (IQR: 25–60) from RP, 393 (26%) patients developed BCR. Of them, 266 (68%) were classified as EAU BCR high risk and 127 (32%) as EAU BCR low risk. In the multivariate Cox regression analysis, locally advanced PC (HR: 1.5, 95% CI: 1.2–1.9, p<0.001), positive surgical margins (HR: 1.4, 95% CI: 1.1–1.7, p=0.01), as well as ISUP grade 3 (HR: 2.4, 95% CI: 1.5–3.6, p<0.001) and 4 (HR: 2.4, 95% CI: 1.5–3.7, p<0.001) were associated with worse time to BCR. Overall, 16 (1%) patients died. Of them, 13 (81%) were classified as EAU BCR high risk and 3 (19%) as EAU BCR low risk (p<0.001). In the univariate Cox regression analysis, patients with EAU BCR high risk presented worse overall survival (HR: 4.9, 95% CI: 1.4–17, p=0.014).

Conclusion: Locally advanced PC, positive surgical margins, and worse ISUP grade are independent risk factors for BCR. Accordingly, patients at BCR high-risk based on the EAU risk stratification present worse overall survival.

Keywords: prostate cancer, prostatectomy, overall survival, biochemical recurrence

Introduction

Localized prostate cancer (PC) is considered the commonest non-cutaneous malignancy in men and is often treated with radical prostatectomy (RP).[1] Although PC runs, in most cases, a fairly indolent course, biochemical recurrence (BCR) may occur in more than 30% of all patients after RP during follow-up.[2] Nevertheless, only a subgroup of patients with BCR will develop metastatic progression, and only a few of them will die due to PC.[3,4] Thus, it is mandatory to identify patients at a high risk of disease progression or death from PC directly at the time of RP.

A plethora of clinical factors and tumor features have been introduced as independent predictors for BCR or survival after RP.[5] Accordingly, numerous prognostic tools have been launched to predict the risk of BCR for patients treated with RP.[6] Although it is of utmost importance to identify the perioperative risk factors that may lead in the long-term to BCR and to worse prognosis after RP for localized PC, solid recommendations on the matter are lacking.[7] Increased age,

Received: 12 October 2024
Accepted: 30 April 2025
Published: 27 May 2025

higher preoperative PSA or body mass index (BMI), positive surgical margins, and worse T-stage or ISUP grade have been associated in some studies with worse oncological outcomes.[8–11] Nevertheless, it should be noted that, for some of these risk factors, contradictory findings exist.[12]

Based on the previous notion, high-volume cohort studies evaluating the impact of age, preoperative PSA values, BMI, pathologic T-stage, resection status, and ISUP grade on BCR are lacking.[13,14] Within this framework, we aimed to assess the role of major perioperative risk factors in predicting BCR and survival through a large, contemporary, long-term prospective cohort study.

Materials and Methods

Study Design

All patients undergoing open or robot-assisted RP for PC at our tertiary Urology Department are included in a prospective single-center cohort study. This cohort was initially approved by our institutional review board and all participants provided written informed consent prior to RP. The study conforms with the ethical principles of the Declaration of Helsinki and its findings are presented based on the STROBE statement 12. For the present sub-analysis, we included all patients undergoing RP for non-metastatic PC (no lymph node, bone, or other metastases) between 2013 and 2023. Patients who received neoadjuvant or adjuvant therapies (radiotherapy, androgen deprivation therapy, or other treatments) for PC or those with PSA persistence after RP (defined as $\geq$ 0.1 ng/mL) were excluded. Accordingly, we excluded all patients with no follow-up or missing data.

Outcomes

The primary outcome of the present study was to determine the role of major perioperative risk factors in predicting BCR and survival after RP for localized PC. Patients with BCR were further classified based on the EAU BCR risk stratification for RP into BCR low-risk (PSA doubling-time >1 year and ISUP grade after RP <4) and BCR high-risk (PSA doubling-time $\leq$1 year and/or ISUP grade after RP 4–5).[15] Data about the initial diagnosis and perioperative outcomes were retrieved from patients' medical records. Accordingly, follow-up was obtained through regular assessment of all patients based on the recommended protocol for patients with PC undergoing RP. In particular, PSA monitoring after RP was performed every three months during the first year after surgery, every six months until the third year of surgery, and annually thereafter. PSA doubling time was calculated based on the current EAU guideline recommendations using the nomogram provided by Memorial Sloan Kettering Cancer Center. BCR was defined as a rising PSA of $\geq$ 0.2 ng/mL on two consecutive measurements. The time to BCR and the overall survival were registered.

Statistical Analysis

All continuous variables were presented as median with interquartile range (IQR) and were compared with the Mann–Whitney *U*-test. Similarly, all categorical variables were presented as frequencies with proportions and were compared with the chi-squared test. A univariate and multivariate Cox regression analysis was performed to assess the effect of preoperative and perioperative outcomes on the time to BCR. The included risk factors in the regression models comprised age, preoperative PSA values, BMI, pathologic T-stage, resection status, and ISUP grade. All confounders were selected based on clinical importance and no stepwise selection methods were applied. A univariate Cox regression analysis was also performed to assess the effect of preoperative and perioperative outcomes on long-term survival. The included risk factors in the regression models comprised age, preoperative PSA values, BMI, pathologic T-stage, resection status, and EAU BCR risk stratification. For all analyses, hazard ratios (HRs) with the corresponding 95% confidence intervals (CIs) were computed. A two-sided p-value < 0.05 was considered statistically significant for all analyses, which were performed with the R statistical software (version 3.6.3, R Core Team 2020).

Results

Baseline Characteristics

A total of 1,539 patients underwent RP for localized PC at our institution between 2013 and 2023 and fulfilled the selection criteria of the present study. Their median age was 67 years (IQR: 61–72), their median BMI was 26 kg/m^2 (IQR: 24–28), their preoperative PSA values 7.7 ng/mL (IQR: 5.5–11), and their prostate volume 51 mL (IQR: 41–65). A robot-assisted approach was performed in 723 (47%) cases. The median operative time was 114 minutes (IQR: 70–176) and the median blood loss was 200 mL (IQR: 100–300). Overall, 450 (29%) patients had at least a pT3 tumor, and 296 (20%) patients were diagnosed with positive surgical margins based on the pathological findings. The ISUP grade was 1 in 195 (13%) cases, 2 in 720 (47%), 3 in 390 (25%), and above 4 in 234 (15%). The baseline characteristics of all included patients are available in Table 1.

Time to BCR

At a median follow-up time of 39 months (IQR: 25–60) from RP, 393 (26%) patients developed a BCR. Of those, 266 (68%) were classified as EAU BCR high risk and 127 (32%) as EAU BCR low risk ($p < 0.001$). In the univariate Cox regression analysis with respect to the time to BCR, age ($p = 0.003$), locally advanced PC ($p < 0.001$), positive surgical margins ($p < 0.001$), ISUP grade 2 ($p = 0.01$), 3 ($p < 0.001$), and over 4 ($p < 0.001$) were associated with worse outcomes. Subsequently, in the multivariate Cox regression analysis after adjusting for all perioperative risk factors of the

Table 1 Baseline Characteristics of All Included Patients Undergoing Radical Prostatectomy for Localized Prostate Cancer

Characteristic	Overall, n = 1,539
Age (years)	67 (61–72)
Body Mass Index (kg/m^2)	26 (24–28)
Preoperative PSA (ng/mL)	7.7 (5.5–11)
Prostate volume (mL)	51 (41–65)
T after radical prostatectomy	
≤ T2	1,089 (71%)
≥ T3	450 (29%)
Positive surgical margins	296 (20%)
ISUP grade	
1	195 (13%)
2	720 (47%)
3	390 (25%)
4	141 (9%)
5	93 (6%)
Operative time (minutes)	114 (70–176)
Blood loss (mL)	200 (100–300)
Robot-assisted prostatectomy	723 (47%)

Notes: Values are presented as median (interquartile range) or n (%).

https://doi.org/10.2147/RRU.S500506

univariate Cox regression analysis, locally advanced PC (HR: 1.5, 95% CI: 1.2 to 1.9, $p < 0.001$), positive surgical margins (HR: 1.4, 95% CI: 1.1 to 1.7, $p = 0.01$), as well as ISUP grade 3 (HR: 2.4, 95% CI: 1.5 to 3.6, $p < 0.001$) and 4 (HR: 2.4, 95% CI: 1.5 to 3.7, $p < 0.001$) remained statistically significant. The corresponding Kaplan-Meier curves for all significant outcomes are displayed in Figure 1 and the results of the Cox regression analysis for the time to BCR in Table 2.

Overall Survival

At a median follow-up of 39 months (IQR: 25–60) from RP, 16 (1%) patients died. Of them, 13 (81%) were classified as EAU BCR high risk and 3 (19%) as EAU BCR low risk ($p < 0.001$). In the univariate Cox regression analysis regarding the time to death, none of the assessed preoperative and perioperative risk factors were associated with worse prognosis. On the contrary, patients with EAU BCR high risk presented worse overall survival (HR: 4.9, 95% CI: 1.4 to 17, $p = 0.014$). Due to the low number of deaths, we did not perform a multivariate Cox regression analysis for the time to death. The corresponding Kaplan-Meier curve based on the EAU BCR risk groups is depicted in Figure 2 and the univariate Cox regression analysis for the time to death after RP in Table 3.

Discussion

The findings of the present cohort study in patients undergoing RP for localized PC indicate that locally advanced PC, positive surgical margins, and worse ISUP grade are key factors in predicting the time to BCR and the overall survival. In particular, after adjusting for important perioperative risk factors, patients with locally advanced PC had 50% higher HRs, patients with positive surgical margins had 40% higher HRs, and patients with ISUP grade 3 or ≥ 4 had 140% higher HRs for the time to BCR. Importantly, none of the evaluated perioperative risk factors could predict mortality in patients with localized PC undergoing RP. Nevertheless, only the EAU BCR was associated with worse overall survival in the present high-volume, long-term cohort study.

In the present analysis, locally advanced PC, positive surgical margins, and worse ISUP grade were the main drivers for predicting the time to BCR. The latter has already been demonstrated in multiple studies.[16] Interestingly, preoperative PSA was not associated with worse BCR rates in our study, even though it is a recognized independent risk factor for BCR.[17] This might be attributed to the fact that we included patients with localized PC and generally low PSA levels (median of 7.7 ng/mL). Accordingly, patients who receive any adjuvant or neoadjuvant treatments as well as those with PSA persistence were excluded. Indeed, it seems that the first postoperative PSA measurement is the prior determinant for the time to BCR.

It should be noted that our findings are in line with previous studies regarding patients' age. In particular, multiple studies indicate that increased age is not an independent risk factor for worse oncological outcomes after RP for localized PC.[18] On the contrary, increased BMI was not associated with higher risk for the time to BCR in the present cohort study. The latter might be explained by the fact that we included patients that were mostly obese since we reported a median BMI of 26 kg/m^2. Available individual studies show inconsistent results, including positive and negative findings about the association between obesity and BCR.[19] Nevertheless, a growing body of evidence, including high-volume contemporary meta-analyses, suggests that obesity displays a moderate, consistent relationship with BCR after RP.[20]

The present analysis underscores the importance of incorporating perioperative risk factors such as locally advanced disease, positive surgical margins, and higher ISUP grade into clinical decision-making frameworks for the management of PC. These factors not only refine risk stratification for BCR but also provide a robust basis for tailoring patient follow-up protocols. For instance, patients with these high-risk features may benefit from more intensive PSA monitoring schedules or early consideration of adjuvant or salvage therapies to mitigate progression risks. Furthermore, integrating these findings into postoperative management plans could optimize resource allocation, enhance patient outcomes, and reduce unnecessary interventions for those at lower risk. This personalized approach aligns with the movement toward precision medicine in the management of PC. Still, further research is mandatory to assess all perioperative risk factors in a broader, multicenter context.

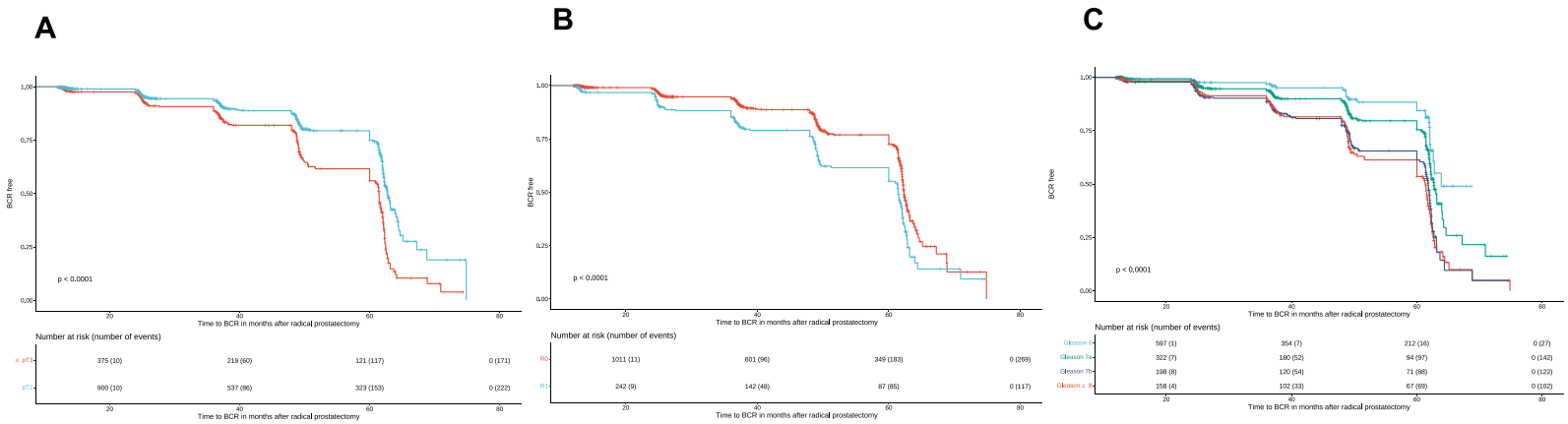

Figure 1 Kaplan-Meier curves for BCR in patients undergoing radical prostatectomy for localized prostate cancer based on the T-stage (**A**), surgical margins (**B**), and ISUP grade (**C**).
Abbreviation: BCR, biochemical recurrence.

Table 2 Univariate and Multivariate Cox Regression Analysis for Time to Biochemical Recurrence in Patients After Radical Prostatectomy

Outcome	Univariate Cox Regression			Multivariate Cox Regression		
	HR	95% CI	p-value	HR	95% CI	p-value
Age	1.02	1.01, 1.03	**0.003**	1.01	0.99, 1.02	0.2
Preoperative PSA	1.01	1.00, 1.02	0.07	1	0.99, 1.01	0.7
Body mass index	1.02	0.99, 1.05	0.2	1.01	0.98, 1.04	0.6
pT						
≤ T2	—	—		—	—	
≥ T3	2	1.6, 2.4	**<0.001**	1.5	1.2, 1.9	**<0.001**
Positive surgical margins	1.7	1.4, 2.1	**<0.001**	1.4	1.1, 1.7	**0.01**
ISUP grade						
1	—	—		—	—	
2	1.7	1.1, 2.6	**0.01**	1.5	0.97, 2.2	0.07
3	3	2, 4.6	**<0.001**	2.4	1.5, 3.6	**<0.001**
≥ 4	3.3	2.2, 5.1	**<0.001**	2.4	1.5, 3.7	**<0.001**

Notes: All values of the univariate regressions were also included in the multivariate model. The risk factors were selected based on clinical relevance. The bold cells indicate statistically significant p-values.
Abbreviations: CI, Confidence Interval; HR, Hazard Ratio.

None of the available perioperative risk factors could predict overall mortality after RP for localized PC. Considering that localized PC runs, in most cases, a fairly indolent course, available literature suggests that the time to death, contrary to the time to BCR, cannot be predicted during RP.[21] However, in patients presenting with BCR after treatment with curative intent for non-metastatic PC, PSA doubling-time and ISUP grade above 4 are the main determinants of overall survival based on a meta-analysis performed by the Guideline Panel of the EAU on PC.[22] The proposed classification system has also been externally validated by high-quality, high-volume studies.[23,24] Therefore, it seems that mortality predictors still rely predominantly on the established risk stratification tools. Still, some recent studies indicated that it may display limited accuracy in predicting death and that the inclusion of other factors could increase its predictive power.[25] Nevertheless, in our setting, despite the low mortality rates, the EAU BCR risk stratification was the only factor to predict mortality, and patients classified as high-risk had a 385% higher HR for mortality.

It should be stressed that the findings of the present analysis were mitigated by some limitations relevant to its single-center design. Moreover, we restricted our analysis to patients with localized PC undergoing RP. Thus, the effect of perioperative risk factors on oncological outcomes in patients requiring neoadjuvant or adjuvant treatments and in those with PSA persistence, as well as the effect of perioperative risk factors in patients receiving other management options with curative intent such as external beam radiation therapy could not be assessed. The latter might have introduced a selection bias in the present analysis. Importantly, we could not assess the role of further risk factors such as lymphovascular invasion, additional patient comorbidities, genetic predispositions, socioeconomic status, preoperative PIRADS, or perioperative complications in predicting long-term oncological outcomes after RP. It should be also acknowledged that the small number of deaths in the present cohort may limit the conclusions drawn from the survival analysis. Finally, given that we included patients who were operated in the last ten years with different surgical techniques, we could not evaluate the role of the evolution of different surgical techniques and perioperative medical care on oncological outcomes. Based on the previous notion, we included patients who were operated both with an open and a robot-assisted approach, which might have affected outcomes. Nevertheless, it should be stressed that it was

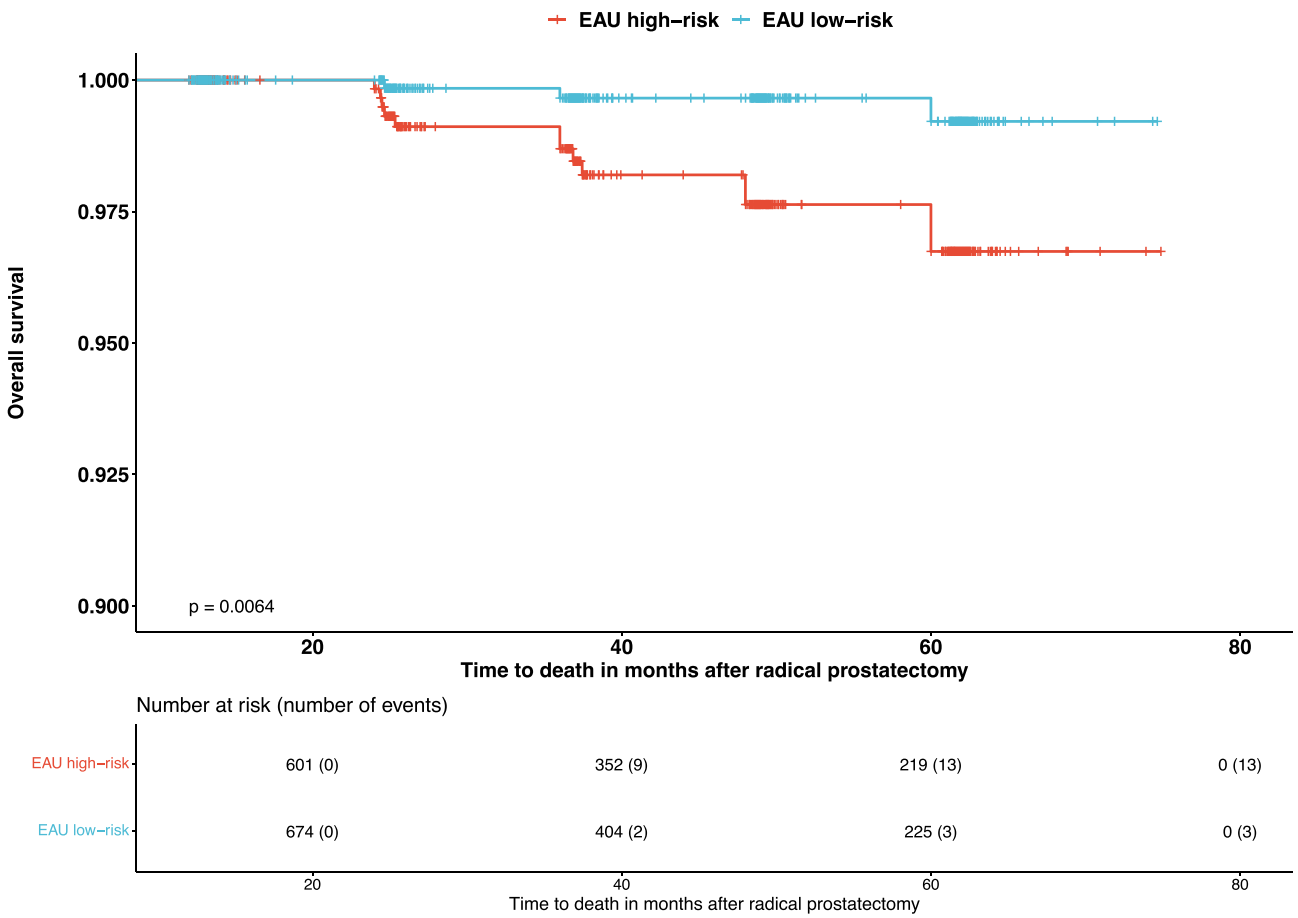

Figure 2 Kaplan-Meier curves for overall survival in patients undergoing radical prostatectomy for localized prostate cancer based on the EAU biochemical recurrence risk stratification.

beyond the scope of the present study to compare open versus robot-assisted RP, given that multiple studies on the matter exist.[26]

Table 3 Univariate Cox Regression Analysis for Overall Survival in Patients Undergoing Radical Prostatectomy

Outcome	Univariate Cox Regression		
	HR	95% CI	p-value
Age	1.05	0.98, 1.1	0.14
Preoperative PSA	1.02	0.99, 1.1	0.2
Body mass index	1.08	0.96, 1.22	0.2
T after radical prostatectomy			
≤ T2	—	—	
≥ T3	0.58	0.16, 2	0.4

(*Continued*)

https://doi.org/10.2147/RRU.S500506

Table 3 (Continued).

Outcome	Univariate Cox Regression		
	HR	**95% CI**	**p-value**
Positive surgical margins	0.96	0.27, 3.4	>0.9
ISUP grade			
1	—	—	
2	1.4	0.17, 12	0.7
3	2.8	0.32, 24	0.4
≥ 4	4.2	0.49, 36	0.2
EAU BCR risk stratification			
Low-Risk	—	—	
High-Risk	4.85	1.38, 17.0	**0.014**

Notes: The risk factors were selected based on clinical relevance. The bold cells indicate statistically significant p-values.
Abbreviations: BCR, biochemical recurrence; CI, Confidence Interval; EAU, European Association of Urology; HR, Hazard Ratio.

Conclusions

The present findings from a prospective, long-term cohort study in a tertiary referral center for PC indicate that locally advanced PC, positive surgical margins, and worse ISUP grade are independent risk factors for BCR among patients with non-metastatic PC. On the contrary, none of the assessed risk factors at the time of RP can predict mortality. Nevertheless, patients at high risk based on the EAU BCR risk stratification were associated with worse overall survival. Overall, further research on the matter is mandatory.

Data Sharing Statement

All data generated or analyzed during this study are included in this article. Further inquiries can be directed to the corresponding author.

Statement of Ethics

This study protocol was reviewed and approved by the Ludwig Maximilian University Ethics Committee. All human subjects provided written informed consent with guarantees of confidentiality. In lieu of an Ethical Review Board, the authors state that this article does not contain any studies with human participants performed by any of the authors. Our research was carried out in accordance with the Declaration of Helsinki of the World Medical Association, and informed consent was obtained from all patients. All data were collected and analyzed anonymously.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work. NP has full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Funding

There is no funding to report.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Siegel RL, Giaquinto AN, Jemal A. Cancer statistics, 2024. *CA Cancer J Clin*. 2024;74:12–49. doi:10.3322/caac.21820
2. Pompe RS, Gild P, Karakiewicz PI, et al. Long-term cancer control outcomes in patients with biochemical recurrence and the impact of time from radical prostatectomy to biochemical recurrence. *Prostate*. 2018;78:676–681. doi:10.1002/pros.23511
3. Boorjian SA, Thompson RH, Tollefson MK, et al. Long-term risk of clinical progression after biochemical recurrence following radical prostatectomy: the impact of time from surgery to recurrence. *Eur Urol*. 2011;59:893–899. doi:10.1016/j.eururo.2011.02.026
4. Pound CR, Partin AW, Eisenberger MA, et al. Natural history of progression after PSA elevation following radical prostatectomy. *JAMA*. 1999;281:1591–1597. doi:10.1001/jama.281.17.1591
5. Van den Broeck T, van den Bergh RCN, Briers E, et al. Biochemical recurrence in prostate cancer: the European Association of Urology prostate cancer guidelines panel recommendations. *Eur Urol Focus*. 2020;6:231–234. doi:10.1016/j.euf.2019.06.004
6. Stephenson AJ, Scardino PT, Eastham JA, et al. Postoperative nomogram predicting the 10-year probability of prostate cancer recurrence after radical prostatectomy. *J Clin Oncol off J Am Soc Clin Oncol*. 2005;23:7005–7012. doi:10.1200/JCO.2005.01.867
7. Mottet N, van den Bergh RCN, Briers E, et al. EAU-EANM-ESTRO-ESUR-SIOG guidelines on prostate cancer-2020 update. Part 1: screening, diagnosis, and local treatment with curative intent. *Eur Urol*. 2021;79:243–262. doi:10.1016/j.eururo.2020.09.042
8. Lughezzani G, Briganti A, Karakiewicz PI, et al. Predictive and prognostic models in radical prostatectomy candidates: a critical analysis of the literature. *Eur Urol*. 2010;58:687–700. doi:10.1016/j.eururo.2010.07.034
9. Polverino F, Di Bello F, Morra S, et al. Predictive factors of hemoglobin drop after robot-assisted radical prostatectomy: a single center prospective study. *J Robot Surg*. 2024;18:337. doi:10.1007/s11701-024-02093-4
10. Di Bello F, Morra S, Fraia A, et al. The prostate-gland asymmetry affects the 3- and 12-month continence recovery after RARP in patients with small prostate glands: a single center study. *J Robot Surg*. 2024;18:319. doi:10.1007/s11701-024-02024-3
11. Di Mauro E, Di Bello F, Califano G, et al. Incidence and predicting factors of histopathological features at robot-assisted radical Prostatectomy in the mpMRI era: results of a single tertiary referral center. *Med Kaunas Lith*. 2023;59:625.
12. Sanda MG, Cadeddu JA, Kirkby E, et al. Clinically localized prostate cancer: AUA/ASTRO/SUO guideline. Part I: risk stratification, shared decision making, and care options. *J Urol*. 2018;199:683–690. doi:10.1016/j.juro.2017.11.095
13. Di Bello F, Baudo A, de Angelis M, et al. Other-cause mortality in incidental prostate cancer. *Prostate*. 2024;84:731–737. doi:10.1002/pros.24689
14. Di Bello F, Jannello LMI, Baudo A, et al. Life expectancy in high-grade incidental prostate cancer patients versus population-based controls according to treatment type. *Prostate*. 2025;85:191–197. doi:10.1002/pros.24816
15. Van den Broeck T, van den Bergh RCN, Arfi N, et al. Prognostic value of biochemical recurrence following treatment with curative intent for prostate cancer: a systematic review. *Eur Urol*. 2019;75:967–987. doi:10.1016/j.eururo.2018.10.011
16. D'Amico AV, Whittington R, Malkowicz SB, et al. The combination of preoperative prostate specific antigen and postoperative pathological findings to predict prostate specific antigen outcome in clinically localized prostate cancer. *J Urol*. 1998;160:2096–2101. doi:10.1016/S0022-5347(01)62251-1
17. Freedland SJ, Terris MK, Csathy GS, et al. Preoperative model for predicting prostate specific antigen recurrence after radical prostatectomy using percent of biopsy tissue with cancer, biopsy ISUP grade and serum prostate specific antigen. *J Urol*. 2004;171:2215–2220. doi:10.1097/01.ju.0000124463.13319.0a
18. da Cruz JAS, Passerotti CC, Dos Reis ST, et al. Is age an independent factor for prostate cancer? A paired analysis. *Curr Urol*. 2017;9:183–187. doi:10.1159/000447138
19. Rivera-Izquierdo M, Pérez de Rojas J, Martínez-Ruiz V, et al. Obesity as a risk factor for prostate cancer mortality: a systematic review and dose-response meta-analysis of 280,199 patients. *Cancers*. 2021;13:4169. doi:10.3390/cancers13164169
20. Rivera-Izquierdo M, Pérez de Rojas J, Martínez-Ruiz V, et al. Obesity and biochemical recurrence in clinically localised prostate cancer: a systematic review and meta-analysis of 86,490 patients. *Prostate Cancer Prostatic Dis*. 2022;25:411–421. doi:10.1038/s41391-021-00481-7
21. Antonarakis ES, Chen Y, Elsamanoudi SI, et al. Long-term overall survival and metastasis-free survival for men with prostate-specific antigen-recurrent prostate cancer after prostatectomy: analysis of the Center for prostate disease research national database. *BJU Int*. 2011;108:378–385. doi:10.1111/j.1464-410X.2010.09878.x
22. Preisser F, Abrams-Pompe RS, Stelwagen PJ, et al. European Association of Urology biochemical recurrence risk classification as a decision tool for salvage radiotherapy–a multicenter study. *Eur Urol*. 2024;85:164–170. doi:10.1016/j.eururo.2023.05.038
23. Tilki D, Preisser F, Graefen M, et al. External validation of the European Association of Urology Biochemical Recurrence Risk Groups to predict metastasis and mortality after radical prostatectomy in a European Cohort. *Eur Urol*. 2019;75:896–900. doi:10.1016/j.eururo.2019.03.016
24. Pak S, Lee D-E, You D, et al. Validation of the European association of urology biochemical recurrence risk groups after radical prostatectomy in an Asian cohort and suggestions for refinement. *Urol Oncol*. 2021;39:298.e1–298.e6. doi:10.1016/j.urolonc.2020.12.023
25. Sopeña Sutil R, Vázquez-Martul D, De Pablos-Rodríguez P, et al. European Association of Urology biochemical recurrence risk groups after radical prostatectomy: external validation and identification of independent risk factors for progression and death. *Actas Urol Esp*. 2023;47:422–429. doi:10.1016/j.acuro.2023.01.001
26. Pyrgidis N, Volz Y, Ebner B, et al. Evolution of robotic urology in clinical practice from the beginning to now: results from the GRAND study register. *Eur Urol Focus*. 2024;S2405–4569(24)00159–7.