

## Research Paper

# Marital Status and Survival in Patients with Penile Cancer

Weipu Mao<sup>1,\*</sup>, Ziwei Zhang<sup>1,\*</sup>, Xin Huang<sup>1</sup>, Jie Fan<sup>2,✉</sup>, Jiang Geng<sup>1,✉</sup>

1. Department of Urology, Shanghai Tenth People's Hospital, Tongji University, Shanghai, 200072, China

2. Department of Pathology, Huashan Hospital, Fudan University, Shanghai, 200040, China

\* First author

✉ Corresponding authors: Professor Jiang Geng, Shanghai Tenth People's Hospital, Tongji University, 301 Middle Yanchang Road, Shanghai, 200072, China. Tel: 86-021-66307508; Fax: 86-021-66307508; E-mail: gengjiangsn@sina.com and Jie Fan, Department of Pathology, Huashan Hospital, Fudan University, Shanghai, 200040, China, E-mail: fanfanj369@sina.com

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## Abstract

**Purpose:** We aimed to reveal the effects of marital status on survival outcomes in patients with penile cancer.

**Methods:** Patients with penile cancer who were diagnosed between 2004 and 2015 were identified by using the Surveillance, Epidemiology and End Results (SEER) database. Kaplan-Meier and Cox regressions were used to analyse the effects of marital status on overall survival (OS) and cancer-specific survival (CSS).

**Results:** Among 3,195 eligible patients with penile cancer, 1,951 (61.1%) patients were married, 365 (11.4%) were divorced or separated, 327 (10.2%) were widowed and 552 (17.3%) were single. The widowed patients had the worst OS median survival time (22 months) and CSS median survival time (23.5 months). Marital status was an independent prognostic factor for OS and CSS of penile cancer patients. The multivariate Cox regression showed that widowed patients exhibited the poorest OS (hazard ratio [HR]: 1.73; 95% confidence interval [CI]: 1.48–2.03,  $p < 0.001$ ) and the poorest CSS (HR: 1.64; 95% CI: 1.144–1.279,  $p < 0.001$ ) compared with married patients. Similar results were observed in our centre database and the subgroup analyses based on the SEER stage and grade.

**Conclusions:** In our study, we found that marital status was an independent prognostic factor for survival in patients with penile cancer. Additionally, widowed patients had the lowest OS and CSS compared with married patients.

Key words: penile cancer; marital status; cancer survival; SEER

## Introduction

Penile cancer is a rare malignant tumour in the genitourinary system and mostly occurs in middle-aged men aged 50-70 years [1]. The incidence of penile cancer varies from region to region, due to different countries, nationalities, religions and hygienic habits [2]. Penile cancer accounts for 0.4%-0.6% of all male malignancies in Europe and the United States, but it accounts for as much as 10% of malignancies in economically underdeveloped parts of Asia, Africa and South America [3-5].

Phimosis and prepuce are the more recognized risk factors for penile cancer, which then leads to the prepuce and penile head in the chronic stimulation

environment, with a long-term, local inflammatory response [6]. Multiple sexual partners, genital warts or other sexually transmitted diseases are also risk factors for penile cancer [3].

Previous studies have shown that marital status is an independent prognostic factor for the survival of multiple cancers, including colorectal cancer [7], breast cancer [8], stomach cancer [9] and pancreatic cancer [10]. In this study, our purpose was to investigate the impact of marital status on the survival of penile cancer patients, based on a large amount of population data that was gathered using the

Surveillance, Epidemiology, and End Results (SEER) database.

## Patients and Methods

### Data source and patients

Via the National Cancer Institute's SEER\*Stat software (version 8.3.5; SEER 18 Regs Custom Data [with an additional treatment field], November 2017 Sub [1973-2015 varying] database), we identified 3,983 penile cancer patients with known marital statuses between January 1, 2004, and December 31, 2015. The SEER database covers approximately 28% of the US population and collects information on cancer patients, including demographic information, primary tumour locations, cancer stages, treatment modalities and survival times [11].

The exclusion criteria in our study were as follows: (a) an unknown marital status; (b) an unknown survival time; (c) an unknown AJCC stage; (d) an unknown T/N/M stage; (e) patients who were under 18 years of age and (f) patients who were diagnosed at autopsy. Finally, we identified 3,195 eligible patients who were diagnosed with penile cancer.

A total of 69 patients had diagnoses of penile cancer at the Shanghai Tenth People's Hospital of Tongji University (Shanghai, China) between January 1, 2013, and December 31, 2017. Patients received follow-ups until December 31, 2018. This study was approved by the Ethics Committee of Shanghai Tenth People's Hospital of Tongji University, and written informed consent was obtained from all the patients or their relatives.

### Study variables

The study variables in our study included the age of diagnosis, race, urban-rural residence, tumour primary site, tumour grade, histologic type, SEER stage, AJCC stage, TNM stage and surgical information. According to the marital status, we divided patients into four groups: married, divorced or separated, widowed, and single. The clinicopathological characteristics included age at diagnosis ( $\leq 60$  and  $> 60$ ), race (white, black, and other) and urban-rural residence (metropolitan and nonmetropolitan). The tumour variables included the tumour primary site (prepuce, glans penis, body of penis, overlapping lesion, and penis NOS), histological type (squamous cell carcinoma, verrucous carcinoma, and others), SEER stage (localized, regional, distant, and unknown), AJCC stage (0, I, II, III, and IV), T-stage (Ta, T1, T2, T3, and T4), N-stage (N0, N1, N2, and N3), M-stage (M0 and M1), and treatment (surgery and no surgery). Tumour grades I-IV represented well differentiated, moderately

differentiated, poorly differentiated, and undifferentiated tumours, respectively. Overall survival (OS) and cancer-specific survival (CSS) were the primary study end points in this study.

### Statistical analysis

The chi-square test was used to analyse the factors related to marital status. Kaplan-Meier analyses, with log-rank tests, were used to analyse the OS and CSS rates of patients with different marital statuses and other variables. A multivariable Cox regression was used to determine the factors associated with OS and CSS. Statistical Package for the Social Sciences software (version 20.0; SPSS Inc, Chicago, IL, USA) was used for all the statistical analyses. A  $p$  value  $\leq 0.05$  was considered to be statistically significant.

## Results

### Demographic and clinical characteristics of the penile cancer

A total of 3,195 eligible penile cancer patients were included in our study cohort through the SEER database from 2004 to 2015. Among them, 1,951 (61.1%) patients were married, 365 (11.4%) were divorced or separated, 327 (10.2%) were widowed, and 552 (17.3%) were single. **Table 1** shows the clinical characteristics and the chi-square test results for the comparison of penile cancer with different marital statuses. The Chi-square test exhibited significant differences between the different marital statuses in several variables, including the age at diagnosis ( $p < 0.001$ ), race ( $p < 0.001$ ), tumour primary site ( $p = 0.014$ ), tumour grade ( $p = 0.023$ ), T-stage ( $p = 0.031$ ), N-stage ( $p = 0.044$ ) and surgical treatment ( $p = 0.011$ ). White patients accounted for the majorities of each of the groups, but the proportion of black patients was higher in the single group than in the other groups. The widowed patients were more likely to be over 60 years (95.4%), while most of the single patients were under 60 years (51.3%). In addition, the primary site of penile cancer in the widowed patients is less common in the body of the penis.

### Effects of different variables on OS and CSS in patients with penile cancer

In our study, Kaplan-Meier curves were used to analyse the influences of related factors on the OS and CSS of patients with penile cancer (**Table 2**). The median OS time of the married group was 33 months, while the median OS times of the divorced/separated, widowed and single groups were 28 months, 22 months and 26 months, respectively. The survival times of the four marital subgroups were significantly different ( $p < 0.001$ ) (**Fig. 1a**). In addition, the median

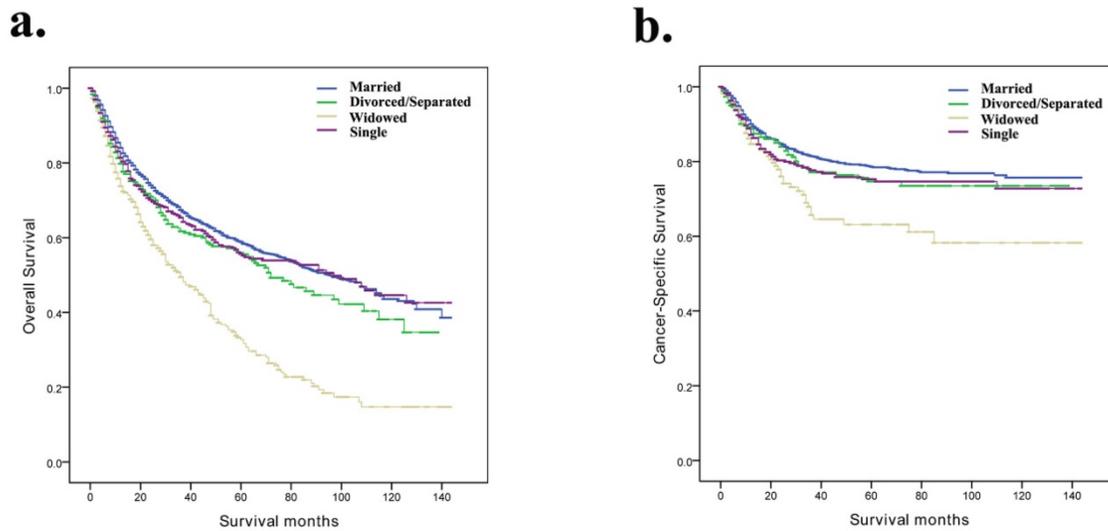
CSS time of the married group was 38 months, while the median OS times of the divorced/separated, widowed and single groups were 34 months, 23.5 months and 29 months, respectively ( $p < 0.001$ ) (Fig. 1b). The widowed patients had the worst OS and CSS.

In addition, the Kaplan-Meier analysis showed that the age at diagnosis, histological type, SEER stage, tumour grade, AJCC stage, TNM stage and surgical therapy were also significantly correlated with OS and CSS.

**Table 1.** Characteristics for penile cancer patients stratified by marital status.

Characteristic	Total No. (%)	Married No. (%)	Divorced/Separated No. (%)	Widowed No. (%)	Single No. (%)	P value
Total	3195	1951 (61.1)	365 (11.4)	327 (10.2)	552 (17.3)	
Age at diagnosis						<0.001
<60	938 (29.4)	534 (27.4)	106 (29.0)	15 (4.6)	283 (51.3)	
≥60	2257 (70.6)	1417 (72.6)	259 (71.0)	312 (95.4)	269 (48.7)	
Race						<0.001
White	2678 (83.8)	1675 (85.9)	311 (85.2)	279 (85.3)	413 (74.8)	
Black	328 (10.3)	144 (7.4)	47 (12.9)	34 (10.4)	103 (18.7)	
Other	189 (5.9)	132 (6.8)	7 (1.9)	14 (4.3)	36 (6.5)	
Urban-rural residence						0.056
Metropolitan	2654 (83.1)	1626 (83.3)	286 (78.4)	280 (85.6)	462 (83.7)	
Nonmetropolitan	541 (16.9)	325 (16.7)	79 (21.6)	47 (14.4)	90 (16.3)	
Primary site						0.014
Prepuce	382 (12.0)	253 (13.0)	39 (10.7)	38 (11.6)	52 (9.4)	
Glans penis	1070 (33.5)	684 (35.1)	107 (29.3)	107 (32.7)	172 (31.2)	
Body of penis	175 (5.5)	103 (5.3)	29 (7.9)	10 (3.1)	33 (6.0)	
Overlapping lesion	139 (4.4)	85 (4.4)	13 (3.6)	13 (4.0)	28 (5.1)	
Penis, NOS	1429 (44.7)	826 (42.3)	177 (48.5)	159 (48.6)	267 (48.4)	
Histological Type						0.071
Squamous cell carcinoma	2879 (90.1)	1738 (89.1)	332 (91.0)	299 (91.4)	510 (92.4)	
Verrucous carcinoma	173 (5.4)	116 (5.9)	17 (4.7)	11 (3.4)	29 (5.3)	
Others	143 (4.5)	97 (5.0)	16 (4.4)	17 (5.2)	13 (2.4)	
SEER stage						0.248
Localized	1978 (61.9)	1233 (63.2)	218 (59.7)	210 (64.2)	317 (57.4)	
Regional	1028 (32.2)	606 (31.1)	123 (33.7)	102 (31.2)	197 (35.7)	
Distant	187 (5.9)	111 (5.7)	23 (6.3)	15 (4.6)	38 (6.9)	
Unstaged	2 (0.1)	1 (0.1)	1 (0.3)	0 (0.0)	0 (0.0)	
Grade						0.023
Grade I/Grade II	2030 (63.5)	1240 (63.6)	212 (58.1)	202 (61.8)	376 (68.1)	
Grade III/Grade IV	612 (19.2)	359 (18.4)	83 (22.7)	65 (19.9)	105 (19.0)	
Unknown	553 (17.3)	352 (18.0)	70 (19.2)	60 (18.3)	71 (12.9)	
AJCC stage						0.123
0	25 (0.8)	16 (0.8)	2 (0.5)	2 (0.6)	5 (0.9)	
I	1708 (53.5)	1064 (54.5)	194 (53.2)	179 (54.7)	271 (49.1)	
II	661 (20.7)	407 (20.9)	65 (17.8)	75 (22.9)	114 (20.7)	
III	519 (16.2)	311 (15.9)	69 (18.9)	42 (12.8)	97 (17.6)	
IV	282 (8.8)	153 (7.8)	35 (9.6)	29 (8.9)	65 (11.8)	
T-stage						0.031
Ta	25 (0.8)	16 (0.8)	2 (0.5)	2 (0.6)	5 (0.9)	
T1	1869 (58.5)	1162 (59.6)	213 (58.4)	190 (58.1)	304 (55.1)	
T2	728 (22.8)	451 (23.1)	74 (20.3)	80 (24.5)	123 (22.3)	
T3	487 (15.2)	281 (14.4)	69 (18.9)	42 (12.8)	95 (17.2)	
T4	86 (2.7)	41 (2.1)	7 (1.9)	13 (4.0)	25 (4.5)	
N-stage						0.034
N0	2620 (82.0)	1619 (83.0)	285 (78.1)	278 (85.0)	438 (79.3)	
N1	193 (6.0)	104 (5.3)	31 (8.5)	22 (6.7)	36 (6.5)	
N2	214 (6.7)	129 (6.6)	31 (8.5)	10 (3.1)	44 (8.0)	
N3	168 (5.3)	99 (5.1)	18 (4.9)	17 (5.2)	34 (6.2)	
M-stage						0.093
M0	3097 (96.9)	1902 (97.5)	350 (95.9)	317 (96.9)	528 (95.7)	
M1	98 (3.1)	49 (2.5)	15 (4.1)	10 (3.1)	24 (4.3)	
Surgical therapy						0.011
No	200 (6.3)	101 (5.2)	33 (9.0)	25 (7.6)	41 (7.4)	
Yes	1995 (93.7)	1850 (94.8)	332 (91.0)	302 (92.4)	511 (92.6)	

Abbreviations: SEER, Surveillance, Epidemiology and End Results; Grade I, Well differentiated; Grade II, Moderately differentiated; Grade III, Poorly differentiated; Grade IV, Undifferentiated; AJCC, American Joint Committee on Cancer; percentages may not total 100 because of rounding.



**Figure 1.** Kaplan-Meier survival curves according to marital status (married, divorced/separated, widowed, and single) in patients with penile cancer. **a.** Overall survival; **b.** cancer-specific survival.

**Table 2.** Kaplan–Meier analysis overall survival and cancer-specific survival for penile cancer patients.

Characteristic	OS MST (months)	Kaplan-Meier		CSS MST (months)	Kaplan-Meier	
		Log Rank $\chi^2$ test	P value		Log Rank $\chi^2$ test	P value
Age at diagnosis		114.547	<0.001		18.655	<0.001
<60	38			42		
≥60	27			31		
Marital status		82.663	<0.001		14.738	0.002
Married	33			38		
Divorced/Separated	28			34		
Widowed	22			23.5		
Single	26			29		
Histological Type		30.477	<0.001		32.174	<0.001
Squamous cell carcinoma	28			33		
Verrucous carcinoma	48			54		
Others	35			49		
SEER stage		347.495	<0.001		468.526	<0.001
Localized	38			44		
Regional	23			25		
Distant	8			9		
Grade		83.892	<0.001		84.244	<0.001
Grade I/Grade II	31			36		
Grade III/Grade IV	20			20		
Unknown	42			48		
AJCC stage		293.283	<0.001		398.246	<0.001
0	42					
I	39			48.5		
II	29			45		
III	22			31		
IV	9.5			24.5		
T-stage		111.027	<0.001		158.953	<0.001
Ta	42			48.5		
T1	36			42		
T2	26			28		
T3	20			23		
T4	13			17.5		
N-stage		261.080	<0.001		438.318	<0.001
N0	35			41		
N1	17			18		
N2	14.5			14.5		
N3	10			10.5		
M-stage		205.009	<0.001		221.247	<0.001
M0	31			36		
M1	7			8		

Characteristic	OS MST (months)	Kaplan-Meier		CSS MST (months)	Kaplan-Meier	
		Log Rank $\chi^2$ test	P value		Log Rank $\chi^2$ test	P value
Surgical therapy		77.741	<0.001		42.611	<0.001
No	13			16		
Yes	31			36		

Abbreviations: MST, median survival time; OS, overall survival; CSS, cause-specific survival; SEER, Surveillance, Epidemiology and End Results; Grade I, Well differentiated; Grade II, Moderately differentiated; Grade III, Poorly differentiated; Grade IV, Undifferentiated; AJCC, American Joint Committee on Cancer

### Identification of prognostic factors for patients with penile cancer

Univariate and multivariate cox regressions were used to analyse the factors associated with OS and CSS. As shown in **Table 3**, the age at diagnosis, marital status, histological type, tumour grade, SEER stage, N stage, M stage, and surgical therapy were factors that affected OS and CSS (all  $p < 0.05$ ). According to the multivariate Cox regression, divorced/separated subjects (vs married; HR=1.11, 95% CI: 0.93-1.32,  $p = 0.238$ ), widowed subjects (vs married; HR=1.73, 95% CI: 1.48-2.03,  $p < 0.001$ ) and single subjects (vs married; HR=1.20, 95% CI: 1.02-1.40,  $p = 0.026$ ) were associated with significantly greater odds of OS. In terms of CSS, the multivariate Cox regression analysis also indicated that marriage was a significant protective factor for penile cancer patients (separated/divorced: HR, 0.95; 95% CI, 0.70-1.28;  $p = 0.743$ ; widowed: HR, 1.64; 95% CI, 1.19-2.25;  $p = 0.002$ ; single: HR, 1.24; 95% CI, 0.97-1.60;  $p = 0.092$ ).

### Subgroup analysis for evaluating the effect of marital status on OS and CSS based on SEER stage and grade

Based on the SEER stage and grade, we further discussed the difference between marital status and

prognosis among the subgroups of the penile cancer patients (Table 4). We observed that, for OS and CSS, marital status was still an independent prognostic factor for localized and Grade I/Grade II subgroups (Fig. 2a, b and Fig. 3a, b). However, for the distant and Grade III/Grade IV subgroup patients, the effect of marital status on OS and CSS was not significant (Fig. 2e, f and Fig. 3c, d).

**Table 3.** Risk factors for survival: outcome is overall survival and penis cancer-specific survival.

Characteristic	OS		CSS	
	Hazard Ratio (95% CI)	P value	Hazard Ratio (95% CI)	P value
Age at diagnosis				
<60	Reference		Reference	
≥60	2.04 (1.77-2.36)	<0.001	1.69 (1.35-2.10)	<0.001
Marital status				
Married	Reference		Reference	
Divorced/Separated	1.11 (0.93-1.32)	0.238	0.95 (0.70-1.28)	0.743
Widowed	1.73 (1.48-2.03)	<0.001	1.64 (1.19-2.25)	0.002
Single	1.20 (1.02-1.40)	0.026	1.24 (0.97-1.60)	0.092
Histological Type				
Squamous cell carcinoma	Reference		Reference	
Verrucous carcinoma	0.59 (0.43-0.81)	0.001	0.26 (0.10-0.66)	0.005
Others	1.10 (0.83-1.45)	0.512	0.58 (0.27-1.28)	0.179
SEER stage				
Localized	Reference		Reference	
Regional	1.39 (1.21-1.60)	<0.001	1.20 (0.79-1.82)	0.467
Distant	2.46 (1.66-3.64)	<0.001	1.98 (1.02-3.84)	0.044
Grade				
Grade I/Grade II	Reference		Reference	
Grade III/Grade IV	1.21 (1.06-1.39)	0.005	1.32 (1.06-1.64)	0.012
Unknown	0.84 (0.71-0.99)	0.042	0.81 (0.58-1.13)	0.210
AJCC stage				
0	Reference		Reference	
I	NA	0.113	0.54 (0.07-4.26)	0.555
II	NA	0.735	1.05 (0.13-8.50)	0.967
III	NA	0.632	1.14 (0.14-9.47)	0.907
IV	NA	0.227	1.30 (0.15-11.27)	0.812
T-stage				
Ta	Reference		Reference	
T1	NA	0.095	NA	0.360
T2	NA	0.796	NA	0.773
T3	NA	0.294	NA	0.718
T4	NA	0.027	NA	0.069
N-stage				
N0	Reference		Reference	
N1	1.35 (1.08-1.69)	0.008	2.10 (1.49-2.97)	<0.001
N2	1.54 (1.24-1.92)	<0.001	2.23 (1.59-3.140)	<0.001
N3	1.65 (1.21-2.24)	0.001	2.17 (1.32-3.58)	0.002
M-stage				
M0	Reference		Reference	
M1	1.56 (1.07-2.29)	0.021	1.94 (1.18-3.19)	0.009
Surgical therapy				
No	Reference		Reference	
Yes	0.56 (0.46-0.68)	<0.001	0.52 (0.38-0.72)	<0.001

Abbreviations: OS, overall survival; CSS, cause-specific survival; SEER, Surveillance, Epidemiology and End Results; Grade I, Well differentiated; Grade II, Moderately differentiated; Grade III, Poorly differentiated; Grade IV, Undifferentiated; AJCC, American Joint Committee on Cancer; NA, not applicable

## Discussion

Our study explored the effect of marital status on OS and CSS in penile cancer patients and found that marital status was an independent prognostic factor

for the prognosis of penile cancer. Marital status has a protective effect on the survival outcome of penile cancer, which was consistent with previous studies on other types of cancer [12-14].

**Table 4.** Median survival months and survival months of penile cancer patients.

Characteristic	OS MST (months)	Kaplan-Meier		CSS MST (months)	Kaplan-Meier	
		Log Rank $\chi^2$ test	P value		Log Rank $\chi^2$ test	P value
Localized		95.335	<0.001		12.127	0.007
Married	40.0			54.0		
Divorced/Separated	40.0			49.5		
Widowed	25.0			36.0		
Single	39.0			45.0		
Regional		11.060	0.011		5.024	0.170
Married	25.0			42.0		
Divorced/Separated	19.0			30.5		
Widowed	21.0			32.0		
Single	20.0			32.0		
Distant		4.864	0.182		2.212	0.530
Married	9.0			19.0		
Divorced/Separated	8.0			13.5		
Widowed	5.0			5.0		
Single	8.5			25.0		
Grade I/Grade II		54.129	<0.001		12.052	0.007
Married	35.0			49.0		
Divorced/Separated	28.0			43.0		
Widowed	23.0			31.0		
Single	28.0			39.0		
Grade III/Grade IV		4.431	0.219		5.499	0.139
Married	20.0			32.0		
Divorced/Separated	19.0			37.0		
Widowed	20.0			31.0		
Single	15.0			33.0		

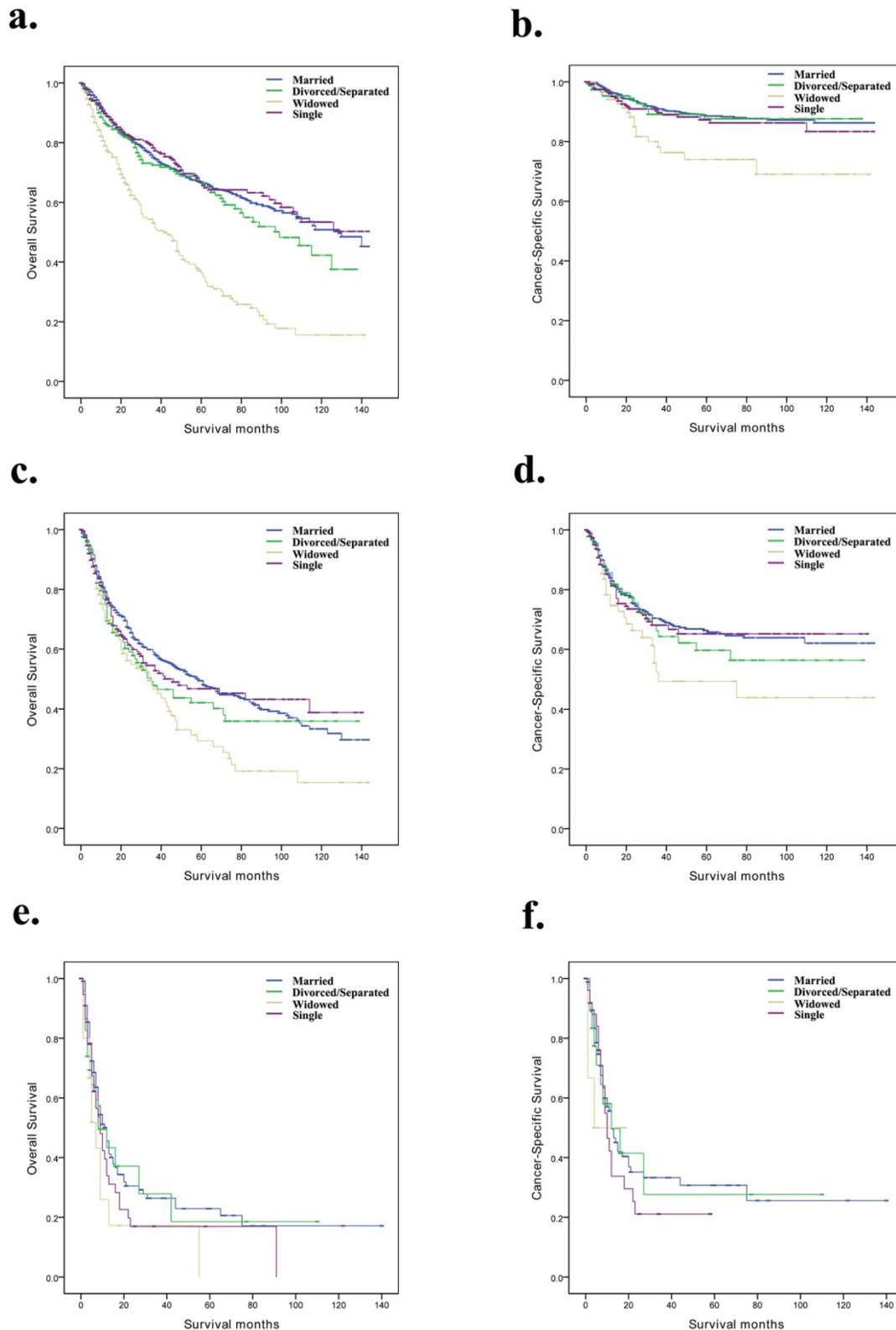
Abbreviations: OS, overall survival; CSS, cause-specific survival; Grade I, Well differentiated; Grade II, Moderately differentiated; Grade III, Poorly differentiated; Grade IV, Undifferentiated; NA, not applicable

Our study showed that the OS and CSS times of the married patients were significantly better than the unmarried patients, including the divorced/separated, the widowed and the single patients. In addition, the widowed patients had the lowest OS and CSS times (22 months and 23.5 months, respectively) compared with the other groups. After adjusting for the age at diagnosis, histological type, tumour grade, SEER stage, AJCC stage, TNM stage and surgical therapy, the multivariable Cox regression analysis showed that married patients had the highest OS and CSS times, and the widowed patients had the worst OS and CSS times. The stratified analysis showed that the married patients had better survival outcomes of the localized and Grade I/Grade II subgroup patients, while the widowed patients had worse survival outcomes.

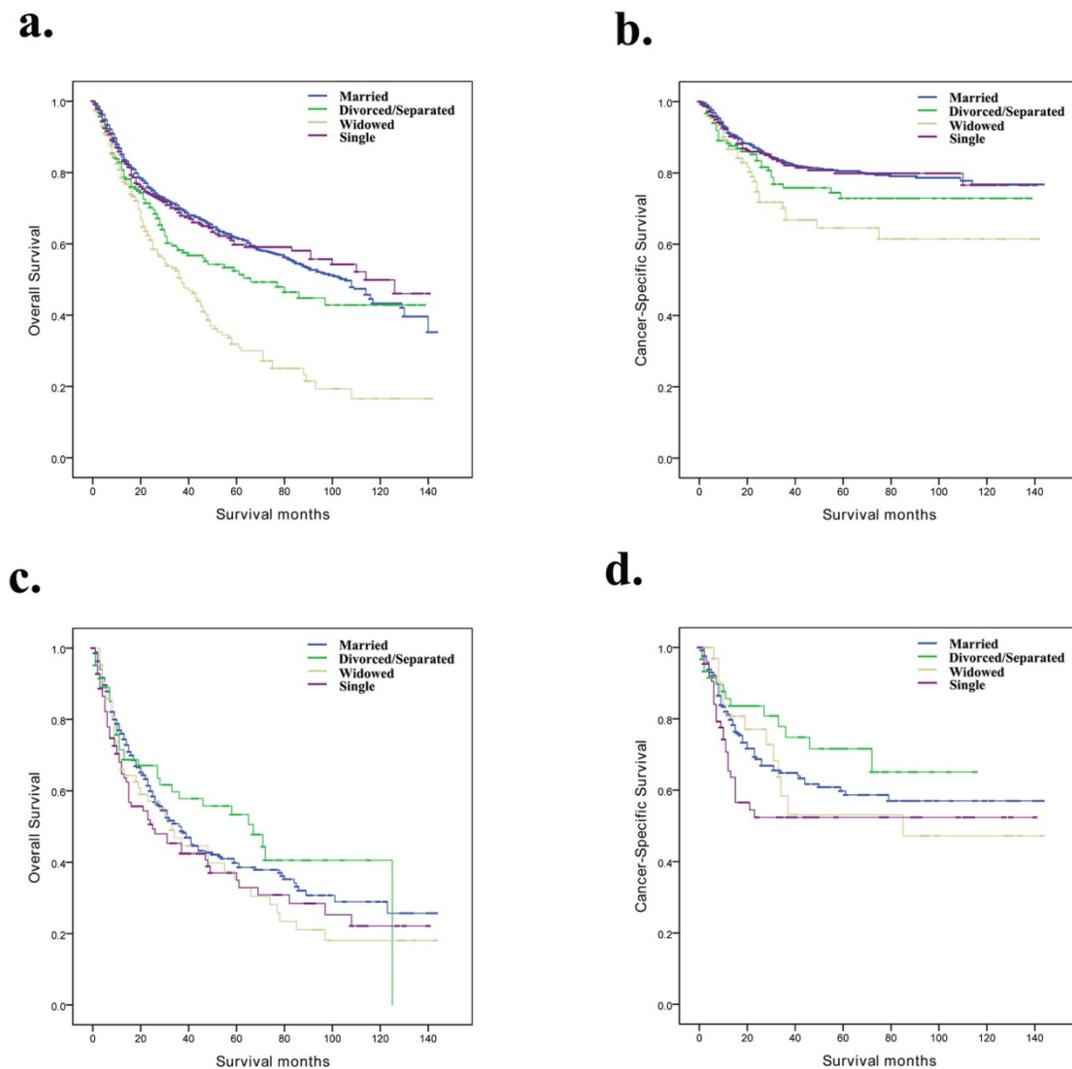
We suspect that the fact that the widowed patients with the worst OS and CSS times may be related to the following factors. First, married patients are in better health than other groups, which may be related to their better family and higher incomes [15, 16]. Second, widowed patients may have more complicated mental and psychological factors, and

mental pressure is more likely to cause depression [17, 18]. In addition, widowed patients may receive less care after being diagnosed with cancer, thus increasing their mortality [19, 20]. Finally, widowed

patients may not focus on their own health conditions, which makes it more likely that they will develop penile infections and increase the risk of illness [21].



**Figure 2.** Overall survival and cancer-specific survival curves of penile cancer patients according to marital status in different SEER stages. **a** and **b**, Overall survival and cancer-specific survival times in localized patients. **c** and **d**, Overall survival and cancer-specific survival times in regional patients. **e** and **f**, Overall survival and cancer-specific survival times in distant patients.



**Figure 3.** Overall survival and cancer-specific survival curves of penile cancer patients according to marital status in different grades. **a** and **b**, Overall survival and cancer-specific survival times in Grade I/Grade II patients. **c** and **d**, Overall survival and cancer-specific survival times in Grade III/Grade IV patients.

Previous studies have examined the relationship between marital status and the survival of patients with squamous cell carcinoma of the penis (SCCP). Thuret et al.[22] analysed 1,884 SCCP patients between 1988 and 2006 and found that unmarried men tend to present with less favourable disease stages when they have penile squamous cell carcinoma, and marital status had no effect on cancer-specific mortality. Ulf-Moller et al.[23] analysed the relationship between invasive penile squamous cell carcinoma and the marital statuses of 1,428 Danish patients and found that the divorced patients had the highest risk (HR: 1.49; 95% CI: 1.24–1.79) compared with married men. However, our study focused on more types of penile cancer patients, including patients with penile squamous cell carcinoma and verrucous carcinoma. According to the marital status, we divided patients into four groups: married, divorced or separated, widowed, and single. In addition, we found that marital status was an

independent prognostic factor for OS and CSS in patients with penile cancer. Moreover, the widowed patients showed the poorest OS (HR: 1.73; 95% CI: 1.48–2.03,  $p < 0.001$ ) and the poorest CSS (HR: 1.64; 95% CI: 1.144–1.279,  $p < 0.001$ ) compared with married patients.

We analysed 69 patients who were diagnosed with penile cancer in our hospital between January 1, 2013, and December 31, 2017, and found that 50 (72.5%) patients were married, 1 (1.5%) was divorced, 16 (23.2%) were widowed, and 2 (2.9%) were single. The Kaplan-Meier curves showed that the widowed patients have the worst survival times (**Supplementary Figure S1**). In addition, we found that, unlike the American population, our hospital had a higher proportion of widowed patients (23.2% vs 10.2%) but a lower proportion of divorced and single patients.

Furthermore, the lower survival times of widowed patients may be related to the following

factors. First, widowed patients are more likely to be over 60 years old. Second, the immunity of the elderly population is low [24], thus resulting in the reduction of the OS of widowed patients. Finally, age affects the choice of treatment [25]. Older patients tend to choose more conservative treatments.

In addition, we found several interesting findings. For distant and Grade III/Grade IV subgroup patients, the effect of marital status on OS and CSS was not significant. This may be due to the higher degree of cancer risk in the distant and Grade III/Grade IV subgroup patients and to their poor physical conditions.

There were several limitations to our research. First, the SEER database is a retrospective dataset with its own retrospective study limitations. Second, the SEER database records the marital status of each patient at the time of diagnosis and lacks data on the subsequent changes in marital status. Third, the patient's physical condition was unclear, and patients with more comorbidities may pursue more conservative treatments. In addition, due to the small amount of data in our hospital, divorced and widowed patients were still alive at the end of the follow-up period. Therefore, further prospective clinical trials are necessary.

## Conclusions

In our study, we found that marital status is an independent prognostic factor for survival in patients with penile cancer. Marital status has a protective effect on the OS and CSS of penile cancer. Unmarried penile cancer patients, especially widowed patients, are at greater risk for OS and CSS compared with married patients. Therefore, more health care should be provided for widowed patients.

## Supplementary Material

Supplementary figure.

<http://www.jcancer.org/v10p2661s1.pdf>

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## Authors' Contributions

WM, JF, JG were involved in the study conception and design. WM collected and assembled

data. WM, JF and JG were involved in data analysis and interpretation. WM, ZZ wrote the manuscript.

## Competing Interests

The authors have declared that no competing interest exists.

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