Causes of death in female patients with bladder cancer after local tumor excision and radical cystectomy: a contemporary, US population-based analysis

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Abstract
Surgery is one of the most important treatments for bladder cancer, including local tumor excision and radical cystectomy. At present, studies on the causes of death for contemporary survivors, especially women, who have received different surgical treatments are limited. Therefore, the study used a population-based cohort study in the United States from 2000 to 2017 to analyze causes of death for women who underwent local tumor excision or radical cystectomy stratified by demographics and tumor stage. Standardized mortality ratios (SMRs) were calculated based on general population data. In total, 24,040 female patients who underwent surgical treatments were assessed. Of those 20,780 patients undergoing local tumor excision, 36.6% died of bladder cancer, while 63.4% died of other causes. The risk of death from all causes increased in comparison with the general population (SMR 1.85; 95% CI 1.82–1.87), and the most common non-tumor cause of death was from heart diseases (16.2%; SMR 1.13; 95% CI 1.09–1.16). Among women who receive radical cystectomy, 82.3% of deaths occurred within 5 years after surgery. 66.9% deaths resulted from bladder cancer, and the risk of death from all causes significantly higher than that in the general people (SMR 4.67; 95% CI 4.51–4.84). Moreover, the risk of death from non-bladder cancer causes also increased, in particular, such as septicemia (SMR 3.09; 95% CI 2.13–4.34). Causes of death during bladder cancer survivorship after surgery vary by patient and tumor characteristics, and these data provide information regarding primary care for women during postoperative cancer survivorship.

Keywords: Bladder cancer, Women, Population-based, Local tumor excision, Radical cystectomy, Prognosis

Introduction
Bladder cancer is one of the most common malignant tumors and the incidence increases steadily worldwide. More than 500,000 new cases have been confirmed, which accounts for about 3% of all new cancer diagnoses each year, and 200,000 deaths worldwide [1]. Previous study has suggested a positive association between the bladder cancer incidence and human development index and gross domestic product [2]. Metabolic syndrome (MS), a non-negligible public health problem, is characterized by lipid disorders, abnormal glucose tolerance, high blood pressure, and a high mortality rate. The disorder has been reported to be associated with the development and the risk of death of bladder cancer. A retrospective study [3] that involved 169 patients suggested that patients with MS had a higher histological grade of bladder cancer, as well as the low high-density lipoprotein levels. The high body mass index (BMI) has also been considered to be associated with the risk of bladder cancer [4]. In the American population, more
than 80,000 new cases are diagnosed each year, representing 4.6% of all cancer diagnoses, which is greater than global average. Statistics showed that about 17,900 US patients died of bladder cancer in 2019 [5]. Across the world, the number of men diagnosed with bladder cancer is about four times that of women, and the mortality rate is similar [6]. However, studies have shown that for patients with the same stage of bladder cancer, the prognosis of women is worse than that of men [7]. The occurrence of bladder cancer is a complex, multifactorial and multi-step pathological process, which is affected by both internal genetic factors and external environmental factors. Hence, bladder cancer contains of various pathological types and complex treatment modalities. However, for the majority of patients, surgery is still the main means of treatment, including transurethral resection of bladder tumor, partial cystectomy and radical cystectomy etc. [8]. Different surgical methods should be rigorously determined according to the pathological results and the grading and staging of the disease, because of significant differences of the quality of life and prognosis of patients. Hence, understanding the actual causes of death in contemporary bladder cancer cases undergoing different surgical methods can help with a more rigorous surgical plan and proper health care during survivorship.

Several previous studies have illustrated the causes of bladder cancer-specific mortality [9–11], however, the information about causes of death in patients with bladder cancer after local tumor excision and radical cystectomy are limited. Simultaneously, most studies concentrate on patients of all genders, and few studies pay attention to specific gender, especially female patients. Factors such as hormone level, lifestyle, occupational exposure vary widely in male and female population, which may result in differences on causes of death. Hence, understanding the information could guiding the long-term follow-up and therapeutic strategies, and we evaluated contemporary, female population-based data for causes of death during bladder cancer after local tumor excision or radical cystectomy survivorship in the United States using SEER database.

Materials and methods

Data source

The data were acquired from Surveillance, Epidemiology, and End Results (SEER) program which is conducted by National Cancer Institute covering approximately 48% of the US population, and the database SEER 18 registries were accessed from 2000 to 2017 using the SEER*Stat software 8.3.8. The data used are publicly available and our study did not require a declaration or approval of local ethics.

Study population

We included all female patients with a diagnosis of bladder cancer between January 1, 2000, and December 31, 2017 in US, and only first malignant neoplasm was selected. Simultaneously, we excluded data without surgical treatment. We also exclude patients diagnosed only through death certificate and autopsy, patients with unknown follow-up time, survival status, and reasons of death, and patients without general information including age and race.

SMR

The number of deaths in different variables was measured for patients with bladder cancer from the SEER database. Patients were mainly assessed by different surgical methods including local tumor excision and radical cystectomy, and then, stratified by age, year of diagnosis, race, tumor differentiation, and pathological type. All causes of deaths were considered in our study, we divided the causes into malignant cancer group, non-tumor group. Under diseases of the malignant cancer, we included the most common malignant diseases of digestive system, respiratory system, female genital system, urinary system, and lymphatic system. In the non-tumor group, simultaneously, we included virus systematic disorders, such as septicemia, other Infectious and Parasitic Diseases including HIV, diabetes mellitus, Alzheimer’s, diseases of heart, hypertension without heart disease, cerebrovascular diseases, other diseases of arteries, arterioles, capillaries, pneumonia and Influenza, and chronic obstructive pulmonary disease and allied cond. We counted the numbers of deaths in different subgroups at each follow-up stage, and calculated SMR, the ratio of observed-to-expected, with 95% confidence intervals for each cause of death after bladder cancer diagnosis undergoing different surgical treatments. From 2000 to 2016, female patients diagnosed with bladder cancer and underwent surgical treatment. We also exclude patients diagnosed only through death certificate and autopsy, patients with unknown follow-up time, survival status, and reasons of death, and patients without general information including age and race.

Statistical analysis

We calculated SMRs with 95% confidence intervals using the SEER*Stat software 8.3.8 (https://seer.cancer.gov/seerstat/software/). The higher number of deaths with bladder cancer than the expected number in the general population was regarded as a significantly increased risk. p-value<0.05 was considered to be statistically significant.
Results
Baseline characteristics
24,040 female patients with bladder cancer undergoing surgical treatments were collected in our study, in which 20,780 patients received local tumor excision, and 3260 underwent radical cystectomy. Table 1 details the number and SMR with 95% CI of patients by age, year of diagnosis, race, tumor differentiation, pathological type and time period for all deaths by each grouping. The total excess risk of local tumor excision group was 353.65 per 10,000, while 1137.11 in the radical cystectomy group.

Causes of death for female patients undergoing local tumor excision
The majority of deaths for women undergoing local tumor excision occurred in 12 to 59 months after surgery (n=8096 [39%]), Table 1. In this group, as shown in Table 2 and Fig. 1, deaths from bladder cancer accounted for 36.6% of the all deaths (n=20,780), which maintained a relative stable over the different follow-up periods. Deaths from other malignant cancers and non-tumor factors were 2933 and 10,239, respectively. In this study, the most common non tumor cause of death was diseases of heart, and the number of which was 3359, accounting 16.2% of all deaths, while in the malignant cancer group, cancers of lung and bronchus composed the majority, and the number was 1102, which accounted 5.3% of all deaths. Although the risk of death significantly decreased after 2–11 month follow-up (SMR 4.18; 95% CI 4.07–4.29), the risk was higher than that of general population over the follow-up months (SMR 1.77; 95% CI 1.73–1.81 over 12–59 months, SMR 1.35; 95% CI 1.31–1.39 over 12–59 months and SMR 1.34; 95% CI 1.28–1.39 over 60 months).

Data in Table 1 showed subgroup information of female patients undergoing local tumor excision. Most of the deaths were aged 75–84 years, however, compared with the general population, the risk of death was the lowest (SMR 1.53; 95% CI 1.49–1.56). With the decrease of age, the risk level gradually increased, and in the age group of 15–54 years, the risk level was the highest (SMR 3.85; 95% CI 3.58–4.13). White patients compose the majority of deaths, and the risk of death was relatively lower with respect to that of the other three races (n=18,245, SMR 1.77; 95% CI 1.74–1.8). Simultaneously, compared with general population, poorly differentiated and undifferentiated types increased the risk of death by 2.6 and 3.04 times, respectively. The most common pathological types were papillary transitional cell carcinoma and Transitional cell carcinoma (NOS), however, the types that were higher contribution to the risk of death were adenocarcinoma (NOS), small cell carcinoma (NOS), and squamous cell carcinoma (keratinizing, NOS). All year of diagnosis increased the death risk.

Causes of death for female patients undergoing radical cystectomy
Most deaths for female patients underwent radical cystectomy occurred either 2–11 months (n=1152) or 12–59 months (n=1522) after surgery. Deaths from bladder cancer in this group accounted for 66.9% of all deaths, which composed the majority, while other cancer and non-tumor disease accounted for 10% and 23.1%, respectively (Table 3, Fig. 1). In comparison with the general population, the risk of death in female patients undergoing radical cystectomy significantly increased by 4.67 times over all follow-up months (SMR 4.67; 95% CI 4.51–4.84), which was approximately 2.5 times higher compared with local tumor excision group. Over all follow-up months, the risk of death from bladder cancer was the highest (SMR 832.50; 95% CI 797.86–868.26), and was about 4.4 times higher than that of the local tumor excision group. Simultaneously, several other causes of death were elevated in comparison with the general population, including both other malignant cancers and non-tumor causes. Of all the non-tumor deaths, the most common cause was diseases of heart (n=195), which account for 25.9% of all non-tumor deaths. The non-tumor cause of death with the highest increased risk of death was septicemia (SMR 3.09; 95% CI 2.13–4.34), and the lowest was Alzheimer’s (SMR 0.64; 95% CI 0.42–0.94).

Data for subgroups of female patients undergoing radical cystectomy can be found in Table 1. The most common death was the 65–74 age group (n=1089), while compared with the general population, the highest risk of death was the 15–54 age group (SMR 19.11; 95% CI 17.22–21.15). Simultaneously, the risk of death obviously increased in all races, and notably, the risk was most elevated in the American Indian/Alaska native group (SMR 19.42; 95% CI 9.69–34.74). The risk of death was similar among different differentiation groups in comparison with the general population, and in different pathological type groups, the transitional cell carcinoma (NOS) composed the majority (n=1813), however, the highest risk was transitional cell carcinoma (spindle cell) (SMR 10.05; 95% CI 7.8–12.74).

Discussion
In United States, more than 80,500 cases were diagnosed as bladder cancer in 2019 year, which accounted for 4.6% of all cancer diagnoses [12]. Simultaneously, although women are at lower risk of bladder cancer than men, they should be taken seriously. At present, most studies focus on the overall prognosis after diagnosis of bladder cancer, however, reports on the prognosis and
Table 1  Baseline characteristics of patients with bladder cancer after local tumor excision and radical cystectomy

| Variables                      | 2–11 months | 12–59 months | 60–119 months | 120+ months |
|--------------------------------|-------------|--------------|---------------|-------------|
|                                | Observed    | Persons      | Excess Risk   | SMR (95%CI) |
|                                | Observed    | Persons      | Excess Risk   | SMR (95%CI) |
|                                | Observed    | Persons      | Excess Risk   | SMR (95%CI) |
|                                | Observed    | Persons      | Excess Risk   | SMR (95%CI) |
|                                | Observed    | Persons      | Excess Risk   | SMR (95%CI) |
|                                | Observed    | Persons      | Excess Risk   | SMR (95%CI) |
|                                | Observed    | Persons      | Excess Risk   | SMR (95%CI) |
|                                | Observed    | Persons      | Excess Risk   | SMR (95%CI) |
| Local tumor excision           | All         | 20,780       | 45,655        | 353.65      | 1.85 (1.82–1.87) |
| Age, year                      | 15–54 years | 782          | 4997          | 133.31      | 3.85 (3.58–4.13) |
|                                | 55–64 years | 1987         | 8405          | 198.84      | 2.66 (2.54–2.77) |
|                                | 65–74 years | 4684         | 12,338        | 289.68      | 1.95 (1.89–2) |
|                                | 75–84 years | 8018         | 13,035        | 427.11      | 1.53 (1.49–1.56) |
|                                | 85+ years   | 5306         | 6806          | 1332.18     | 2.00 (1.95–2.06) |
| Year of diagnosis              | 2000–2007   | 11,960       | 19,150        | 288.4       | 1.67 (1.64–1.7) |
|                                | 2008–2012   | 5426         | 12,194        | 367.15      | 1.92 (1.87–1.97) |
|                                | 2013-2017   | 3233         | 12,273        | 628.45      | 2.66 (2.56–2.75) |
| Race                           | White       | 18,245       | 40,410        | 325.72      | 1.74 (1.74–1.8) |
|                                | Black       | 1810         | 3254          | 792.24      | 2.83 (2.72–2.96) |
|                                | American    | 48           | 107           | 710.02      | 4.71 (3.47–6.25) |


| Variables                           | Total  | 2–11 months | 12–59 months | 60–119 months | 120+ months |
|------------------------------------|--------|-------------|--------------|---------------|-------------|
|                                   | Obser ved Persons | Excess Risk | SMR (95% CI) | Observed Persons | Excess Risk | SMR (95% CI) | Observed Persons | Excess Risk | SMR (95% CI) | Observed Persons | Excess Risk | SMR (95% CI) |
| Asian or Pacific Islander          | 677    | 1884        | 367.07 (2.26) | 178            | 1884        | 995.92 (4.89) | 279            | 1576        | 335.5 (2.24)   | 144          | 833         | 187.63 (1.61) |
| Observed Persons Excess Risk       |        |             | SMR (95% CI) |                |             |                |                |             |                |             |             |
| SMR (95% CI)                      |        |             |                |                |             |                |                |             |                |             |             |
| Differentiation                    | 2425   | 6461        | 75.08 (1.20)  | 214            | 6461        | 91.32 (1.29)  | 864            | 6205        | 54.71 (1.16)   | 801          | 4596        | 74.27 (1.19) |
| Well-differentiated               | 5288   | 13,790      | 117.98 (1.30) | 639            | 13,790      | 248.61 (1.76) | 1850           | 13,009      | 81.56 (1.23)   | 1695         | 8245        | 105.66 (1.25) |
| Moderately differentiated          | 4902   | 7,892       | 26.00 (1.69)  | 1693           | 7,892       | 2836.00 (6.96) | 1882           | 5479        | 691.45 (2.46)  | 878          | 3119        | 285.37 (1.57) |
| Poorly differentiated              | 5682   | 10,018      | 1,003.81 (3.04) | 2216          | 10,018      | 2634.29 (6.64) | 2465           | 7717        | 824.37 (2.74)  | 745          | 2857        | 307.42 (1.59) |
| Undifferentiated                   | 2322   | 6,190       | 263.09 (1.69) | 530            | 6,190       | 740.43 (3.11)  | 1035           | 5614        | 216.31 (1.59)  | 575          | 3462        | 149.68 (1.36) |
| Unknown                            | 2322   | 6,190       | 263.09 (1.69) | 530            | 6,190       | 740.43 (3.11)  | 1035           | 5614        | 216.31 (1.59)  | 575          | 3462        | 149.68 (1.36) |
| Pathological type                  |        |             | SMR (95% CI) |                |             |                |                |             |                |             |             |
| 8130/3: papillary transitional cell carcinoma | 8130/3: papillary transitional cell carcinoma, NOS | 13,058 | 34,058 | 171.44 (1.42) | 1888 | 34,058 | 161.19 (1.42) | 5254 | 30,448 | 127.75 (1.30) |
| 8120/3: transitional cell carcinoma, NOS | 4089 | 9599.88 | 3.51 (3.42-3.6) | 2660 | 9599.88 | 3.51 (3.42-3.6) | 2328 | 6243 | 960.35 (3.17) | 775 | 2870 | 301.13 (1.60) |
| 8070/3: squamous cell carcinoma, NOS | 421 | 475 | 5377.79 (1.33) | 296 | 475 | 13,208.44 (7.56) | 100 | 168 | 2778.97 (7.56) | 21 | 47 | 1160.00 (4.02) |
| 8010/3: carcinoma, NOS             | 166 | 262 | 959.88 | 3.13 (2.68-3.65) | 78 | 262 | 4175.02 (2.73) | 55 | 172 | 700.93 (2.73) | 23 | 96 | 128.36 (1.26) |
| 8140/3: adenocarcinoma, NOS        | 162 | 250 | 1436.30 | 6.02 (5.13-7.02) | 74 | 250 | 3645.14 (12.89) | 15 | 73 | 321.54 (2.07) | 8 | 27 | 369.81 (2.07) |
Table 1 (continued)

| Variables                              | Total  | 2–11 months | 12–59 months | 60–119 months | 120+ months |
|----------------------------------------|--------|-------------|--------------|---------------|-------------|
|                                        | Observed Persons | Excess Risk | SMR (95%CI)  | Observed Persons | Excess Risk | SMR (95%CI)  | Observed Persons | Excess Risk | SMR (95%CI)  | Observed Persons | Excess Risk | SMR (95%CI)  |
| 8041/3: small cell carcinoma, NOS      | 124    | 2688.94     | 6.60f (5.49–7.87) | 74             | 169          | 7167.6/ (12.99–20.77) | 40           | 84           | 1758.03    | 4.96f (3.55–6.76) | 7           | 29           | 236.32     | 1.44f (0.59–2.97) |
| 8071/3: squamous cell carcinoma, keratinizing, NOS | 117    | 6735.71     | 15.67f (12.96–18.78) | 94             | 129          | 17566.75 (28.71–43.47) | 16           | 33           | 206.21f    | 5.26f (3–8.53)   | 6           | 12           | 139.84     | 3.91f (1.44–8.52)  |
| 8051/3: papillary carcinoma, NOS       | 106    | 214         | 1.48f (1.21–1.79)   | 20             | 214          | 8186.66 (1.97–4.99)  | 36           | 194          | 192.87f    | 1.53f (1.07–2.11) | 26           | 133          | 59.45      | 1.14f (0.75–1.68)  |
| Radical cystectomy                     | 3260   | 5385        | 1137.11 (4.52–4.84) | 1155           | 5385         | 2777.1 (1.32–1.84)   | 1526         | 3957         | 1259.28    | 5.68f (5.4–5.97)  | 376          | 1730         | 264.95     | 1.75f (1.56–1.91)  |
| Age, year                              | 375    | 766         | 854.88 (17.2–21.15) | 125            | 766          | 2152.25 (59.39–85.01) | 201          | 605          | 1196.48    | 23.69f (29.19–38.68) | 34           | 305          | 231.88     | 5.55f (3.85–7.76)  |
| 55–64 years                            | 669    | 1,281       | 1009.47 (9.19–10.71) | 216            | 1,281        | 2232.86 (26.82–35.18) | 352          | 994          | 1282.28    | 15.40f (13.84–17.1) | 66           | 457          | 271.16     | 3.14f (2.43–3.99)  |
| 65–74 years                            | 1089   | 1,801       | 1215.98 (9.43–9.56)  | 372            | 1,801        | 2695.54 (14.75–18.12) | 523          | 1328         | 1395.16    | 7.56f (6.95–8.24)  | 116          | 549          | 304.66     | 1.95f (1.61–2.34)  |
| 75–84 years                            | 965    | 1,337       | 1337.07 (2.67–3.03)  | 365            | 1,337        | 3544.89 (8.81–9.87)  | 389          | 913          | 1103.31    | 2.80f (2.52–3.09)  | 144          | 384          | 221.93     | 1.22f (1.03–1.44)  |
| 85+ years                              | 160    | 196         | 2044.26 (2.16–2.97)  | 77             | 196          | 5197.02 (3.82–6.05)   | 59           | 113          | 1152.30    | 1.80f (1.42–2.4)   | 16           | 34           | 315.24     | 1.24f (0.71–2.02)  |
| Year of diagnosis                      | 1758   | 2275        | 985.27 (3.62–4.03)   | 543            | 2275         | 3056.31 (12.15–14.46) | 748          | 1727         | 1261.04    | 5.39f (4.97–5.74)  | 266          | 965          | 272.26     | 1.72f (1.52–1.94)  |
| 2008–2012                              | 887    | 1434        | 1200.85 (5.06–5.77)  | 328            | 1434         | 2905.97 (12.54–15.62) | 453          | 1098         | 1211.21    | 5.79f (5.25–6.31)  | 104          | 627          | 237.05     | 1.72f (1.41–2.08)  |
| Variables                        | Total | 2–11 months | 12–59 months | 60–119 months | 120+ months |
|---------------------------------|-------|-------------|--------------|---------------|-------------|
|                                 | Observed | Persons | Excess Risk | SMR (95%CI)  | Observed | Persons | Excess Risk | SMR (95%CI)  | Observed | Persons | Excess Risk | SMR (95%CI)  | Observed | Persons | Excess Risk | SMR (95%CI)  |
| 2013–2017                       | 596    | 1424       | 1631.79 (7.37–8.67) | 265      | 1124       | 2293.54 (10.46–13.36) | 3.25     | 1132       | 1326.86 (5.81–7.24) | 6       | 138       | 591.62 (1.04–6.14) | 2.82       | 0        | 0        | 0 (0–0)     |
| Race                            |        |            |              |            |            |            |            |            |            |            |            |            |            |            |            |            |
| White                           | 2750   | 4541       | 1108.75 (4.26–4.6)  | 956      | 4541       | 2707.18 (11.6–13.18) | 1282     | 3361       | 1222.55 (5.08–5.68) | 330     | 1481      | 261.54 (1.04–6.14) | 168       | 658      | 316.37 (1.04–6.14) | 182       | 71       | 150.01 (0.78–2.29) | 1.39       |
| Black                           | 365    | 557        | 1464.79 (5.75–7.08) | 139      | 557        | 3365.11 (13.64–19.16) | 178      | 389        | 1724.63 (6.83–9.22) | 33      | 155       | 331.37 (1.04–6.14) | 2.14       | 71       | 150.01 (0.78–2.29) | 1.39       |
| American Indian/Alaska Native   | 11     | 21         | 1554.96 (9.69–34.74) | 7        | 21         | 4314.66 (16.59–83.01) | 3        | 14         | 718.68 (1.60–10.62) | 0       | 5         | -81.03 (0–34.78) | 0         | 0        | 1 (0–34.78) | 150.01    |
| Asian or Pacific Islander       | 134    | 266        | 989.52 (6.08–8.59)  | 53       | 266        | 2665.39 (16.83–29.4) | 63       | 193        | 1089.87 (6.33–10.54) | 13      | 89        | 223.1 (1.17–3.76)  | 2.20       | 43       | 160.87 (0.63–4.56) | 1.95       |
| Differentiation                 |        |            |              |            |            |            |            |            |            |            |            |            |            |            |            |            |
| Well-differentiated             | 39     | 58         | 9.30.35 (2.94–5.65) | 12       | 58         | 2578.68 (8.62–23.06) | 1.5      | 46         | 822.44 (2.33–8.64)  | 11      | 27        | 786.27 (1.17–3.76) | 3.21       | 9        | -125.31 (0.02–3.72) | 0.67       |
| Moderately differentiated       | 245    | 382        | 1095.83 (4.67–6.02) | 87       | 382        | 2963.45 (13.2–20.32) | 111      | 294        | 1183.86 (6.16–7.63) | 33      | 145       | 375.09 (1.60–10.62) | 2.34       | 74       | 194.28 (0.63–2.55) | 1.52       |
| Poorly differentiated           | 1245   | 1731       | 1235.17 (4.55–5.09) | 445      | 1731       | 3367.21 (13.72–16.55) | 565      | 1275       | 1446.01 (5.64–6.67) | 143     | 607       | 275.36 (1.48–2.06)  | 1.75       | 318      | 291.88 (1.34–2.04) | 1.66       |
| Undifferentiated                | 1560   | 2692       | 1088.28 (4.2–6.64)  | 540      | 2692       | 2467.14 (10.47–12.41) | 764      | 2126       | 1192.41 (4.97–7.54) | 172     | 851       | 220.4 (1.34–1.82)   | 1.54       | 84       | 289.44 (1.26–1.95) | 1.58       |
| Unknown                         | 152    | 270        | 988.55 (4.59–6.34)  | 52       | 270        | 2425.40 (13.81–18.11) | 71       | 216        | 1012.22 (4.38–7.08) | 17      | 100       | 255.57 (1.18–3.24)  | 2.03       | 43       | 677.04 (1.89–6.4)  | 3.67       |
| Pathological type               | 8120/3 transitional cell carcinoma, NOS | 2906 | 1222.50 (4.52–4.96) | 637      | 2906       | 2846.27 (11.9–13.92) | 873      | 2127       | 1393.34 (5.36–6.35) | 195     | 885       | 249.03 (1.42–1.89) | 1.64       | 398      | 296.68 (1.32–1.94) | 1.90       |
| Variables | Total | 2–11 months | 12–59 months | 60–119 months | 120+ months |
|-----------|-------|-------------|--------------|--------------|-------------|
|           | Observed Persons Excess Risk SMR (95%CI) | Observed Persons Excess Risk SMR (95%CI) | Observed Persons Excess Risk SMR (95%CI) | Observed Persons Excess Risk SMR (95%CI) | Observed Persons Excess Risk SMR (95%CI) |
| 8130/3: papillary transitional cell carcinoma | 767 1449 | 780.42 3.45# (3.21–3.7) | 212 1449 | 172.86 8.35# (7.26–9.53) | 369 1154 | 903.2 4.27# (3.84–4.73) | 122 561 | 268.95 1.73# (1.44–2.06) | 64 246 | 277.35 1.60# (1.23–2.05) |
| 8070/3: squamous cell carcinoma, NOS | 219 324 | 1475.83 6.55# (5.7–7.53) | 116 324 | 5319.09 7.79# (3.04–33.44) | 74 200 | 1186.43 5.96# (4.68–7.48) | 17 98 | 182.44 1.59 (0.93–2.53) | 12 45 | 330.84 2.01# (1.04–3.51) |
| 8071/3: squamous cell carcinoma, keratinizing, NOS | 73 118 | 1335.20 5.65# (4.4–7.12) | 42 118 | 5275.67 24.35# (17.55–32.91) | 22 72 | 869.1 4.19# (2.63–6.35) | 5 37 | 119.05 1.41 (0.46–3.29) | 4 14 | 274.06 1.68 (0.46–4.31) |
| 8122/3: transitional cell carcinoma, spindle cell | 68 104 | 2379.77 10.05# (7.8–12.74) | 43 104 | 6400.21 32.04# (23.19–43.16) | 19 53 | 1383.53 6.40# (3.9–10.12) | 5 19 | 464.74 2.5 (0.81–1.584) | 6 4 | 440.6 2.02 (0.05–11.27) |
| 8140/3: Adenocarcinoma, NOS | 61 89 | 1301.96 7.40# (5.66–9.5) | 17 89 | 2396.29 15.22# (8.87–24.37) | 30 65 | 1526.49 10.34# (6.98–14.76) | 8 29 | 543.81 3.72# (1.61–7.34) | 6 16 | 728.82 2.88# (1.06–6.27) |

SMR: standardized mortality ratio, CI: confidence interval, NOS: not otherwise specified

Excess risk is per 10,000

# Statistical significance with $P < 0.05$
|                     | Total          | 2–11 months | 12–59 months | 60–119 months | 120 + months |
|---------------------|----------------|-------------|--------------|---------------|--------------|
|                     | Observed       | Expected    | SMR (95%CI)  | Observed       | Expected    | SMR (95%CI)  | Observed       | Expected    | SMR (95%CI)  | Observed       | Expected    | SMR (95%CI)  |
| **All causes of death** | 20,780         | 11,255.35   | 1.85#(1.82–1.87) | 5453          | 1305.87     | 1.85#(1.82–1.87) | 8096          | 4569.39     | 1.77#(1.73–1.81) | 4694          | 3479.86     | 1.35#(1.31–1.39) |
| **All malignant cancers** | 10,541         | 1953.59     | 5.40#(5.29–5.5) | 4031          | 238.49      | 4.18#(4.07–4.29) | 4311          | 822.82      | 5.24#(5.08–5.4)  | 1540          | 589.96      | 2.61#(2.48–2.74) |
| **Digestive system** | 473            | 478.56      | 0.99(0.9–1.08) | 59            | 58.4        | 1.01(0.77–1.3)  | 164           | 200.81      | 0.82#(0.7–0.95)  | 160           | 144.63      | 1.11(0.94–1.29) |
| **Stomach**         | 42             | 32.58       | 1.29(0.93–1.74) | 8             | 4.21        | 1.9(0.82–3.74)  | 16            | 14.03       | 1.14(0.65–1.85)  | 11            | 9.63        | 1.14(0.57–2.04) |
| **Colon and rectum** | 141            | 195.19      | 0.72#(0.61–0.85) | 12            | 24.6        | 0.49#(0.25–0.85) | 49            | 83.18       | 0.59#(0.44–0.78)  | 47            | 58.29       | 0.81(0.59–1.07) |
| **Liver and intrahepatic bile duct** | 55            | 50.64       | 1.09(0.82–1.41) | 9             | 5.85        | 1.54(0.7–2.92)  | 19            | 20.67       | 0.92(0.55–1.44)  | 15            | 15.6        | 0.96(0.54–1.59) |
| **Liver**           | 36             | 32.91       | 1.09(0.77–1.51) | 9             | 3.86        | 2.33#(1.07–4.43) | 11            | 13.35       | 0.81(0.41–1.46)  | 9             | 10.09       | 0.89(0.41–1.69) |
| **Pancreas**        | 167            | 143.47      | 1.16(0.99–1.35) | 22            | 16.92       | 1.3(0.81–1.97)  | 60            | 59.31       | 1.01(0.77–1.3)  | 63            | 43.95       | 1.43#(1.1–1.83) |
| **Respiratory system** | 1010           | 500.79      | 2.02#(1.89–2.15) | 62            | 61.7        | 1.0(0.77–1.29)  | 443           | 213.38      | 2.08#(1.89–2.28) | 332           | 150.75      | 2.20#(1.97–2.45) |
| **Lung and bronchus** | 1002           | 493.47      | 2.03#(1.91–2.16) | 60            | 60.79       | 0.99(0.75–1.27) | 438           | 210.25      | 2.08#(1.89–2.29) | 332           | 148.57      | 2.23#(2–2.49) |
| **Breast**          | 130            | 251.34      | 0.52#(0.43–0.61) | 10            | 31.04       | 0.32#(0.15–0.59) | 37            | 106.3       | 0.35#(0.25–0.48)  | 52            | 75.44       | 0.69#(0.51–0.89) |
| **Female genital system** | 188           | 181.49      | 1.04(0.89–1.2)  | 31            | 22.31       | 1.39(0.94–1.97) | 66            | 76.83       | 0.86(0.66–1.09)  | 59            | 54.57       | 1.08(0.82–1.39) |
| **Ovary**           | 103            | 94.25       | 1.09(0.89–1.33) | 15            | 11.82       | 1.27(0.71–2.09) | 35            | 40.51       | 0.86(0.6–1.2)   | 34            | 28.16       | 1.21(0.84–1.69) |
|                     |                |             |              |               |             |              |               |             |              |               |             |              |
Table 2 (continued)

|                        | Total          | Observed | Expected | SMR (95%CI) | 2–11 months | Observed | Expected | SMR (95%CI) | 12–59 months | Observed | Expected | SMR (95%CI) | 60–119 months | Observed | Expected | SMR (95%CI) | 120+ months | Observed | Expected | SMR (95%CI) |
|------------------------|----------------|----------|----------|-------------|-------------|----------|----------|-------------|--------------|----------|----------|-------------|--------------|----------|----------|-------------|-------------|----------|----------|-------------|
|                        |                |          |          |             |             |          |          |             |              |          |          |             |              |          |          |             |             |          |          |             |
| Urinary system         | 7876           | 79.66    | 98.87a   | (96.7–101.08) | 3663        | 9.36     | 391.55a  | (378.97–404.44) | 3253        | 32.77    | 90.26a   | (95.88–102.73) | 730      | 24.47    | 29.84a      | (27.71–32.08) | 230     | 13.07    | 17.60a      | (15.4–20.03) |
| Urinary bladder        | 7608           | 40.22    | 189.17a  | (184.94–193.47) | 3578        | 4.64     | 770.87a  | (745.81–796.55) | 3138        | 16.35    | 191.98a  | (185.32–198.81) | 683      | 12.44    | 54.89a      | (50.85–59.16) | 209     | 6.79     | 30.80a      | (26.76–35.27) |
| Kidney and renal pelvis| 153            | 36.45    | 4.20a    | (3.56–4.92)  | 42          | 4.37     | 961.6    | (9.92–1298)   | 60          | 15.21    | 3.94a    | (3.01–5.08)  | 37       | 11.09    | 3.34a        | (2.35–4.6)   | 14      | 5.77     | 24.2a        | (1.33–40.7)  |
| Ureter                 | 37             | 1.6      | 23.09a   | (16.26–31.82) | 12         | 0.18     | 6630.6   | (34.26–115.81) | 21          | 0.65     | 32.34a   | (20.02–49.44) | 3        | 0.5      | 6.02a        | (1.24–17.58) | 1       | 0.27     | 366 (0.09–20.37) |
| Other urinary organs   | 78             | 1.39     | 56.04a   | (44.3–69.94) | 31         | 0.16     | 193.65a  | (131.58–274.87) | 34          | 0.57     | 6.00a    | (4.15–83.84) | 7        | 0.43     | 16.24a       | (6.53–33.47)  | 6       | 0.23     | 25.62a       | (9.4–55.76)  |
| Lymphoma               | 56             | 81.42    | 0.69a    | (0.52–0.89)  | 5          | 9.96     | 0.5      | (0.16–1.17)   | 20          | 34.26    | 0.58a    | (0.36–0.9)   | 21       | 24.58    | 0.85         | (0.53–1.31)  | 10      | 12.62    | 0.79 (0.38–1.46) |
| Non-Hodgkin lymphoma   | 55             | 78.42    | 0.70a    | (0.53–0.91)  | 5          | 9.58     | 0.52     | (0.17–122)    | 20          | 32.98    | 0.61a    | (0.37–0.94)  | 20       | 23.69    | 0.84         | (0.52–1.3)   | 10      | 12.17    | 0.82 (0.39–1.51) |
| Leukemia               | 75             | 76.48    | 0.98     | (0.77–1.23)  | 3          | 9.06     | 0.33a    | (0.07–0.97)   | 30          | 31.64    | 0.95     | (0.64–1.35)  | 28       | 23.45    | 1.19         | (0.79–1.73)  | 14      | 12.34    | 1.13 (0.62–1.9) |
| Miscellaneous malignant cancer | 592 | 153.5    | 3.86a   | (3.55–4.18) | 180        | 18.71    | 962.6    | (8.27–1113)   | 258         | 64.33    | 4.01a    | (3.54–4.53)  | 106      | 46.35    | 2.29a        | (1.87–2.77)  | 48      | 24.11    | 199a (1.47–264) |

Non-tumor deaths

Septicemia               | 231            | 162.89   | 1.42a   | (1.24–1.61)  | 48         | 19.34    | 248.4    | (1.83–3.29)   | 73          | 67.06    | 1.09     | (0.85–1.37)  | 74       | 49.92    | 1.48a        | (1.16–1.86)  | 36      | 26.57    | 136 (0.95–188) |

Other infectious and parasitic diseases including HIV | 119 | 74.41   | 1.60a   | (1.32–1.91) | 30         | 8.37     | 358.6    | (2.42–511)    | 50          | 30.43    | 1.64a    | (1.22–2.17)  | 29       | 23.59    | 1.22         | (0.82–1.77)  | 10      | 12.02    | 0.83 (0.14–1.53) |
Table 2 (continued)

| Category                                      | Total          | Expected | SMR (95%CI) | 2–11 months | Expected | SMR (95%CI) | 12–59 months | Expected | SMR (95%CI) | 60–119 months | Expected | SMR (95%CI) | 120+ months | Expected | SMR (95%CI) |
|-----------------------------------------------|----------------|----------|-------------|-------------|----------|-------------|--------------|----------|-------------|---------------|----------|-------------|-------------|----------|-------------|
| Diabetes mellitus                            | 307            | 280.55   | 1.09 (0.98–1.22) | 59          | 35.03    | 1.68 (1.28–2.17) | 104         | 118.62   | 0.88 (0.72–1.06) | 85       | 84.16       | 1.01 (0.81–1.25) | 59       | 42.75       | 1.38 (1.05–1.78) |
| Alzheimer’s                                   | 598            | 754.66   | 0.79* (0.73–0.86) | 40          | 76.55    | 0.52* (0.37–0.71) | 167         | 284.08   | 0.59 (0.5–0.68) | 204      | 242.72      | 0.84 (0.73–0.96) | 187      | 151.31      | 1.24 (1.07–1.43) |
| Diseases of heart                            | 3359           | 2984.53  | 1.13 (1.09–1.16) | 529         | 360.23   | 1.47 (1.35–1.6) | 1289        | 1231.38  | 1.05 (0.99–1.11) | 995      | 909.16      | 1.09 (1.03–1.16) | 546      | 483.77      | 1.13 (1.04–1.23) |
| Hypertension without heart disease           | 189            | 166.51   | 1.14 (0.98–1.31) | 29          | 18.19    | 1.59 (1.07–2.29) | 63          | 65.34    | 0.96 (0.74–1.23) | 59       | 52.87       | 1.12 (0.85–1.44) | 38       | 30.12       | 1.26 (0.89–1.73) |
| Cerebrovascular diseases                      | 796            | 824.92   | 0.96 (0.9–1.03)  | 114         | 99.72    | 1.14 (0.94–1.37) | 318         | 338.98   | 0.94 (0.84–1.05) | 235      | 249.67      | 0.94 (0.82–1.07) | 129      | 136.56      | 0.94 (0.79–1.12) |
| Other diseases of arteries, arterioles, capillaries | 71            | 48.48    | 1.46 (1.14–1.85) | 6           | 5.85     | 1.03 (0.38–2.23) | 34          | 20.01    | 1.70 (1.18–2.37) | 20       | 14.76       | 1.35 (0.83–2.09) | 11       | 7.85        | 1.4 (0.7–2.51) |
| Pneumonia and influenza                       | 290            | 297.66   | 0.97 (0.87–1.09) | 39          | 36.46    | 1.07 (0.76–1.46) | 122         | 123.74   | 0.99 (0.82–1.18) | 76       | 90.15       | 0.84 (0.66–1.06) | 53       | 47.31       | 1.12 (0.84–1.47) |
| Chronic obstructive pulmonary disease and allied Cond | 1360          | 689.95   | 1.97 (1.87–2.08) | 157         | 78.38    | 2.00 (1.7–2.34) | 549         | 279.31   | 1.97 (1.8–2.14) | 426      | 214.41      | 1.99 (1.8–2.18) | 228      | 117.85      | 1.93 (1.69–2.22) |
| Nephritis, nephrotic syndrome and nephrosis   | 268            | 213.48   | 1.26 (1.11–1.42) | 40          | 24.9     | 1.61 (1.15–2.19) | 93          | 87.41    | 1.06 (0.86–1.3)  | 88       | 66.26       | 1.33 (1.07–1.64) | 47       | 34.9        | 1.35 (0.99–1.79) |
|                          | Total                     | 2–11 months | 12–59 months | 60–119 months | 120+ months |
|--------------------------|---------------------------|-------------|--------------|---------------|-------------|
|                          | Observed | Expected | SMR (95%CI) | Observed | Expected | SMR (95%CI) | Observed | Expected | SMR (95%CI) | Observed | Expected | SMR (95%CI) |
| Symp-toms, signs and ill-defined conditions | 176 | 174.85 | 1.01 (0.86–1.17) | 26 | 19.13 | 1.36 (0.89–1.99) | 62 | 69.68 | 0.89 (0.68–1.14) | 60 | 56.92 | 1.05 (0.8–1.36) |
| Accidents and adverse effects | 275 | 263.02 | 1.05 (0.93–1.18) | 32 | 28.7 | 1.11 (0.76–1.57) | 89 | 103.48 | 0.86 (0.69–1.06) | 97 | 82.89 | 1.17 (0.95–1.43) |
| Suicide and self-inflicted injury | 12 | 15.04 | 0.8 (0.41–1.39) | 4 | 1.88 | 2.13 (0.58–5.44) | 7 | 6.48 | 1.08 (0.43–2.23) | 0 | 4.45 | 0.00 (0–0.83) |
| Other cause of death | 1879 | 2111.31 | 0.89 (0.85–0.93) | 216 | 224.53 | 0.96 (0.84–1.1) | 644 | 819.02 | 0.79 (0.73–0.85) | 620 | 676.59 | 0.92 (0.85–0.99) |

SMR: standardized mortality ratio, CI: confidence interval

* Statistical significance with \( P < 0.05 \)
cause of death of patients who have undergone different surgical treatment were limited. There are significant differences between radical cystectomy and local tumor excision, including operative area and operative procedures [13]. For radical cystectomy, three options are available, including open radical cystectomy, traditional and robotic laparoscopy. Open radical cystectomy is considered to be the gold standard because of
Table 3  Main causes of death for patients with bladder cancer after radical cystectomy

| Cause                              | Total          | 2–11 months | 12–59 months | 60–119 months | 120 + months |
|------------------------------------|----------------|-------------|--------------|---------------|--------------|
|                                    | Observed       | Expected    | SMR (95%CI)  | Observed       | Expected    | SMR (95%CI)  | Observed       | Expected    | SMR (95%CI)  | Observed       | Expected    | SMR (95%CI)  |
| All causes of death                | 3250           | 695.3       | 4.67# (4.51/4.84) | 1152           | 88.18       | 13.06# (12.32/13.84) | 1522           | 268.25       | 5.67# (5.39/5.97) | 375          | 216.59       | 1.73# (1.56/1.92) | 201          | 122.27       | 1.64# (1.42/1.89) |
| All malignant cancers              | 2498           | 142.64      | 17.51# (16.83/18.21) | 973            | 21.56       | 45.12# (42.33/48.05) | 1291           | 59.89        | 21.56# (20.4/22.77) | 172          | 40.77        | 4.22# (3.61/4.9)  | 62            | 20.41        | 3.04# (2.33/3.81)  |
| Digestive system                   | 38             | 3.9         | 1.12 (0.78/1.54) | 1              | 4.97        | 0.2 (0.01/1.12) | 25             | 14.04        | 1.78# (1.15/2.63)  | 8            | 9.85         | 0.81 (0.35/1.6)  | 4             | 5.05         | 0.79 (0.22/2.03)  |
| Colon and rectum                   | 16             | 13.31       | 1.2 (0.69/1.95) | 1              | 1.97        | 0.51 (0.01/2.83) | 7              | 5.54         | 1.26 (0.51/2.6)   | 5            | 3.86         | 1.3 (0.42/3.02)  | 3             | 1.94         | 1.55 (0.32/4.52)  |
| Respiratory system                 | 71             | 38.46       | 1.85# (1.44/2.33) | 4              | 6.08        | 0.66 (0.18/1.68) | 30             | 16.55        | 1.81# (1.22/2.59) | 15           | 10.73        | 1.4 (0.78/2.31)  | 22           | 5.09         | 4.32# (2.71/6.54) |
| Lung and bronchus                  | 70             | 37.9        | 1.85# (1.44/2.33) | 4              | 5.99        | 0.67 (0.18/1.71) | 29             | 16.31        | 1.78# (1.19/2.55) | 15           | 10.58        | 1.42 (0.79/2.34) | 22           | 5.02         | 4.39# (2.75/6.64) |
| Urinary system                     | 2208           | 5.4         | 408.57# (391.7/425.97) | 902            | 0.75        | 1200.55# (1123.4/1281.5) | 1157           | 2.18         | 5.30.82# (500.6/562.3) | 125          | 1.61         | 77.5# (64.54/92.3) | 24           | 0.86         | 27.8# (17.86/41.47) |
| Urinary bladder                    | 2173           | 2.61        | 832.50# (797.86/968.26) | 887            | 0.34        | 2594.47# (2426.5/2770.94) | 1143           | 1.02         | 1.116.02# (1052.2/1182.6) | 119          | 0.8          | 148.70# (123.18/177.94) | 24           | 0.44         | 54.07# (34.64/80.45) |
| Kidney and renal pelvis            | 15             | 2.59        | 5.79# (3.24/9.54) | 7              | 0.38        | 18.30# (7.36/37.71) | 4              | 1.08         | 3.72# (1.01/9.52)  | 4            | 0.75         | 5.33# (1.45/13.64) | 0             | 0.38         | 0.09 (0.61) |
| Miscellaneous malignant cancer     | 138            | 10.67       | 12.93# (10.86/15.28) | 59             | 1.56        | 37.73# (28.72/48.67) | 62             | 4.41         | 14.07# (10.79/18.04) | 12           | 3.1          | 3.87# (2.56/7.6)   | 5             | 1.6          | 3.12# (1.01/7.29)  |
| Non-tumor deaths                   |                |             |               |                |             |               |                |             |               |                |             |               |                |             |             |
| Septicemia                         | 33             | 10.69       | 3.09# (2.13/4.34) | 18             | 1.43        | 12.60# (7.47/19.92) | 7              | 4.23         | 1.65 (0.66/3.41)   | 4            | 3.24         | 1.23 (0.34/3.16)  | 4             | 1.78         | 2.24 (0.61/5.74)  |
| Diabetes mellitus                  | 20             | 19.37       | 1.03 (0.63/1.59) | 9              | 2.83        | 3.18# (1.46/6.04) | 3              | 7.97         | 0.38 (0.08/1.1)    | 5            | 5.64         | 0.89 (0.29/2.07)  | 3             | 2.94         | 10.2 (0.21/2.99)  |
| Alzheimer's                        | 26             | 40.33       | 0.64# (0.42/0.94) | 3              | 3.68        | 0.81 (0.17/2.38) | 7              | 13.37        | 0.52 (0.21/1.08)   | 8            | 13.85        | 0.58 (0.25/1.14)  | 8             | 9.41         | 0.85 (0.37/1.68)  |
| Diseases of heart                  | 195            | 173.52      | 1.12 (0.97/1.29) | 39             | 21.6        | 1.81# (1.28/2.47) | 70             | 66.59        | 1.05 (0.82/1.33)   | 49           | 54.56        | 0.9 (0.66/1.19)   | 37            | 30.77        | 1.2 (0.85/1.66)  |
| Cerebrovascular diseases           | 44             | 48.14       | 0.91 (0.66/1.23) | 11             | 5.97        | 1.84 (0.92/3.3)  | 10             | 18.38        | 0.54 (0.26/1)      | 18           | 15.06        | 1.2 (0.71/1.89)   | 5             | 8.72         | 0.57 (0.19/3.34)  |
| Pneumonia and influenza            | 25             | 16.82       | 1.49 (0.96/2.19) | 7              | 2.04        | 3.43# (1.38/7.06) | 8              | 6.47         | 1.24 (0.53/2.44)   | 6            | 5.35         | 1.12 (0.41/2.44)  | 4             | 2.96         | 1.35 (0.37/3.46)  |
### Table 3 (continued)

| Condition/Condition | Total | 2–11 months | 12–59 months | 60–119 months | 120+ months |
|---------------------|-------|-------------|--------------|---------------|-------------|
|                     | Observed | Expected | SMR (95%CI) | Observed | Expected | SMR (95%CI) | Observed | Expected | SMR (95%CI) | Observed | Expected | SMR (95%CI) |
| Chronic obstructive pulmonary disease and allied Cond | 77 | 45.98 | 1.67# (1.32/2.09) | 5 | 6.15 | 0.81 (0.26/1.9) | 28 | 18.26 | 1.53# (1.02/2.22) | 28 | 13.98 | 2.00# (1.33/2.9) |
| Nephritis, nephrotic syndrome and nephrosis | 27 | 13.57 | 1.99# (1.31/2.89) | 4 | 1.73 | 2.31 (0.63/5.92) | 9 | 5.28 | 1.71 (0.78/3.24) | 8 | 4.22 | 1.9 (0.82/3.74) |
| Symptoms, signs and ill-defined conditions | 18 | 9.52 | 1.89# (1.12/2.99) | 4 | 1 | 4.02# (1.1/10.29) | 4 | 3.43 | 1.17 (0.32/2.98) | 6 | 3.3 | 1.82 (0.67/3.96) |
| Accidents and adverse effects | 23 | 16.29 | 1.41 (0.92/2.12) | 5 | 1.99 | 2.51 (0.82/5.87) | 8 | 6.13 | 1.3 (0.56/2.57) | 3 | 5.15 | 0.58 (0.12/1.7) |
| Other cause of death | 188 | 123.69 | 1.52# (1.31/1.75) | 49 | 13.57 | 3.56# (2.67/4.77) | 55 | 44.51 | 1.24 (0.93/1.61) | 46 | 40.86 | 1.13 (0.82/1.5) |

SMR: standardized mortality ratio, CI: confidence interval

* Statistical significance with $P < 0.05$
the stably long-term oncological outcomes, however, the characteristics of long time consuming, more blood loss, greater trauma, slow postoperative recovery and high complication rate make people strive for a more minimally invasive surgical method. Traditional laparoscopy can effectively decrease these perioperative risks because of minimally invasive approaches, nevertheless, four degrees of freedom of movement and poor ergonomics caused problems for surgeons. Compared with traditional laparoscopy, robotic surgery is characterized by the wider and clearer vision and more accurate and flexible control capability, but the high surgical cost and long learning curve make it controversial. The long-term oncological outcomes of the minimally invasive surgical methods are still under study [14–17]. A previous study [16] that involved 60 patients suggested that minimally invasive approaches could reach similar oncological outcomes to the open radical cystectomy by comparing the five-year recurrence-free survival, cancer-specific survival and overall survival of patients with bladder cancer who underwent different surgical methods. Moreover, the pathological types of bladder cancer are complex. These factors directly affect the economic burden, spiritual stress, quality of life and prognosis of patients. Hence, this emphasizes the requirements to optimize the selection of surgical methods and health management during survivorship. In our study, we assessed the cause of death after two surgical treatments of bladder cancer stratified by patient and tumor characteristics using representative population-based data from the United States. In female patients undergoing local tumor excision, approximately 50% death from non-tumor causes and 13.8% death from other malignant cancers, however, these women were overall less likely to die of most non-bladder cancer causes in comparison with the general population. In women undergoing radical cystectomy, nearly 82.2% of deaths occurred in 5 years after surgery, and compared with general population, the death of risk caused by non-bladder cancer significantly increased.

Patients with cancer usually have various comorbidities, and the status can directly affect the treatment decision-making, prognosis, and survival outcomes. It is reported that the severity of comorbidity status has a strong impact on the survival of patients in a dose-dependent fashion independent of cancer stage. Coexisting diseases can significantly increase the risk of the mortality of bladder cancer, and the influence degree of individual comorbidities and combined comorbidity is different. Simultaneously, the frequency and severity of perioperative complications increase with comorbidity rates increasing [18–20]. In our study, although the risk of death from heart diseases in all female patients who underwent surgery was slightly higher than that in the general population, it was the most common cause of death. Simultaneously, the ratio of cardiac death was continuously higher than the general population over all follow-up years after the surgery. According to the National Vital Statistics System statistics, 23.4% of the total United States population died of heart diseases in 2015 [21]. Considering these results, death caused by cardiovascular events should be concerned and relative risk factors should be monitored early, such as hyperlipidemia, cigarette smoking, and diabetes mellitus [22]. In patients who underwent radical cystectomy, the risk of death from septicemia was significantly increased in comparison with general population over all follow-up years. Nearly 2/3 of patients occur complications within 90 days after radical cystectomy, and the mortality rate ranges between 1.5% and 2% at 30 days postoperatively [20, 23]. Approximately 25% of the complications are infection, and obstruction caused by ureteral mesenteric anastomosis stenosis and urinary retention can lead to hydronephrosis, renal insufficiency and recurrent urinary tract infection [20]. Therefore, in the management of patients undergoing cystectomy, many long-term sequelae of urinary diversion should be considered, and the nursing of fistula, electrolyte balance and vitamin B12 should be monitored regularly [13]. The choice of the type of urinary diversion is crucial to the quality of life and prognosis of patients undergoing radical cystectomy. Failure of the urinary diversion may lead to the above-mentioned multiple complications and ultimately threaten the life of patients. The ideal urinary diversion should optimally maintain renal function, control urinary outflow, and minimize the incidence rate of patients. Among three types of urinary diversion, including orthotopic neobladders, cutaneous diversions and Ileal conduits, ileal conduits are considered to be the fastest, easiest, least complication-prone urinary diversion [24].

For patients with bladder cancer, age is considered to be an important prognostic factor. Compared with young patients, the mortality rate of elderly patients is higher because of poor histologies, higher recurrence rate, long-term accumulation of the molecular and genetic aberrations, accompanied by comorbidities and decreased immunity [25]. However, for patients undergoing radical cystectomy, it is reported that age is an important prognostic factor but is not irreplaceable, and tumor stage, grade and comorbidity status play decisive roles [26]. Our study showed that the risk of postoperative death in the 15–54 and 55–64 age groups, especially in the 15–54 age group, was significantly higher than that both in the other age groups and in the general population. This result seems different from previous studies, which believe that in contrast to those that occur in older patients, individuals under the age of 40 tend to express
smoking, which has been proved to be a risk factor for bladder cancer prognosis [34]. In addition, this study was based on the classification of surgical methods, which enables us to understand the role of surgical modality in the long-term survival of bladder cancer. However, the non-surgical treatment of bladder cancer is also important for the prognosis of patients. Moreover, different surgeons may have respective treatment strategies for bladder tumors of the same grade. The option of treatment and follow-up methods based on the surgeon’s judgment of the final results and the choice of the type of technique proposed will directly affect the prognosis of patients. Finally, the retrospective nature of the SEER database used in the study may have, to an extent, weaken the conclusion.

In summary, this study provides contemporary and comprehensive evaluation of causes of death for female patients of bladder cancer who have undergone radical cystectomy or local tumor excision. We found that the overall risk of death significantly increased for female patients undergoing radical cystectomy or local tumor excision in comparison to the general population, and especially in patients undergoing radical cystectomy. Simultaneously, bladder cancer remains the leading cause of death after surgery, but the death caused by heart diseases could not be ignored, and for patients undergoing radical cystectomy, the death of risk caused by non-bladder cancer significantly increased compared with patients undergoing local tumor excision, such as sepsisemia. These data highlight the need for general primary care for these female patients during postoperative cancer survivorship.

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The authors declare that they have no actual or potential competing interests.
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