The LACE Score as a Tool to Identify Radical Cystectomy Patients at Increased Risk of 90-Day Readmission and Mortality

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Original Paper

Introduction: Radical cystectomy for bladder cancer is associated with high rates of readmission. We investigated the LACE score, a validated prediction tool for readmission and mortality, in the radical cystectomy population. Materials & Methods: Patients who underwent radical cystectomy for bladder cancer were identified by ICD-9 codes from the Healthcare Cost and Utilization Project State Inpatient Database for California years 2007–2010. The LACE score was calculated as previously described, with components of L: length of stay, A: acuity of admission, C: comorbidity, and E: number of emergency department visits within 6 months preceding surgery. Results: Of 3,470 radical cystectomy patients, 638 (18.4%) experienced 90-day readmission, and 160 (4.6%) 90-day mortality. At a previously validated “high-risk” LACE score ≥ 10, patients experienced an increased risk of 90-day readmission (22.8 vs. 17.7%, p = 0.002) and mortality (9.1 vs. 3.5%, p < 0.001). On adjusted multivariable analysis, “high risk” patients by LACE score had increased 90-day odds of readmission (adjusted OR = 1.24, 95% CI: 0.99–1.54, p = 0.050) and mortality (adjusted OR = 2.09, 95% CI: 1.47–2.99, p < 0.001). Conclusion: The LACE score reasonably identifies patients at risk for 90-day mortality following radical cystectomy, but only poorly predicts readmission. Providers may use the LACE score to target high-risk patients for closer follow-up or intervention.

Key Words
Cystectomy • Urologic surgical procedures • Outcomes assessment

Abstract

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To our knowledge, the utility of the LACE index has not yet been investigated specifically in urologic surgery patients. Thus, the aim of our study is to investigate the utility of the LACE index in predicting the risk of readmission and mortality in patients undergoing radical cystectomy.

### Materials and Methods

We performed a retrospective review of patients who underwent radical cystectomy for bladder cancer 2007–2010 in the state of California. The data source was Health Care Utilization Project State Inpatient Database (HCUP SID) for the state of California. The HCUP SID includes de-identified inpatient discharge records from all non-federal hospitals within the state, including patient demographic, clinical diagnoses and procedures during the associated admission. Beginning in 2007 a present on admission indicator was instituted, allowing for the differentiation between medical diagnoses that were truly present on admission, and those that developed over the course of the admission. Further, the HCUP SID includes a unique linkage variable assigned to each individual patient, which while de-identified, allows for longitudinal patient follow-up after the index surgical hospitalization. This allows for the assessment of readmission and mortality. This study was approved by our institutional review board and deemed to be low risk for patient identification given the use of a large, de-identified, administrative dataset.

Patients were identified for inclusion in the study using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD9-CM) procedure and diagnosis codes. Patients were included who were ≥ 18 years of age and underwent a radical cystectomy or pelvic exenteration (ICD9-CM: 57.7, 57.71, 57.79, 68.8) for bladder cancer (ICD9-CM: 188.x), as described in prior study on this patient population [14].

Patient baseline demographic characteristics and medical comorbidities were assessed, including age, gender, race (Caucasian, African American, Hispanic, Asian, unknown/other), primary insurance provider (private insurance, public insurance, self-pay), as well as diagnoses of diabetes mellitus, hypertension, congestive heart failure, coronary artery disease, peripheral vascular disease, chronic renal insufficiency, and chronic lung disease.

**Table 1. LACE score components and scoring**

| LACE Score Components | Score |
|-----------------------|-------|
| L: length of stay (days) |       |
| 1                     | 1     |
| 2                     | 2     |
| 3                     | 3     |
| 4–6                   | 4     |
| 7–13                  | 5     |
| ≥ 14                  | 7     |
| A: acuity of admission |       |
| Elective              | 0     |
| Urgent/emergent       | 3     |
| C: Charlson comorbidity score |       |
| 0                     | 0     |
| 1                     | 1     |
| 2                     | 2     |
| 3                     | 3     |
| ≥ 4                   | 5     |
| E: emergency department visits in the preceding 6 months |       |
| 0                     | 0     |
| 1                     | 1     |
| 2                     | 2     |
| 3                     | 3     |
| ≥ 4                   | 4     |

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the corresponding years was also employed. While the HCUP SID includes all ED visits that result in an inpatient hospitalization, the State Emergency Department Database includes all ED visits within the state. Using the unique linkage variable that is consistent across the SID and State Emergency Department Database, all ED visits experienced by patients who underwent radical cystectomy were able to be identified. The scoring of was performed as previously described: ED = 0, 0 points; ED = 1, 1 point; ED = 2, 2 points; ED = 3, 3 points; ED ≥ 4, 4 points. Following point scoring of the individual components, a composite LACE score was calculated.

The primary outcomes for this study were readmission within 90 days of discharge and death within 90 days following radical cystectomy. The exposure variable, a composite LACE score ≥ 10, was determined for each patient, and descriptive statistics performed. For continuous variable of age, LOS, CCI, and ED visits, values are reported as medians, interquartile range (IQR) given non-normal distribution of the data, and Wilcoxon rank-sum tests performed. For categorical variables chi-squared tests were performed. Multivariable logistic regression models were fit in a non-parsimonious fashion, including all patient demographic and clinical variables regardless of significance, in order to isolate the effect of the exposure variable (LACE score, either as a continuous or categorical variable) on outcomes (either 90-day readmission or mortality). C-statistics [area under the receiver operating characteristic curve (AUC)] were used to assess the discriminatory power of the regression models. For reference, an AUC of 0.5 indicates a regression model that is no better than chance, while a value of 0.7 or higher is considered to significantly identify a difference between groups. Aside from AUC, other statistical tests were considered statistically significant with a p ≤ 0.05. Stata 13 (StataCorp, College Station, TX, USA) was used for statistical analysis.

### Results

In this cohort, 3,470 patients underwent radical cystectomy for bladder cancer. Baseline characteristics of the overall study population are shown in table 2. The median age was 70 years (IQR: 62–77), and the majority of patients were Caucasian (76%) with public insurance (67.5%). The most prevalent comorbidities included hypertension (58.4%), chronic lung disease (19.5%), coronary artery disease (16.8%), and type II diabetes mellitus (16.2%). Table 2 also shows the LACE score broken down by component: median LOS (9 days, IQR: 7–13), admission acuity (all elective cases), median CCI (3, IQR: 2–8), and median ED visits within 6 months preceding surgery (0 visits, range: 0–8). Median composite LACE score was 8 (IQR: 7–9). Patients demonstrated a higher risk of 90-day readmission and mortality with a LACE score ≥ 10 (table 3). No patient had a LACE score of 0 or 1.

With regular- and high-risk patients stratified by a LACE score of < 10 and ≥ 10, respectively, univariate analyses were performed as demonstrated in table 4. High-risk patients composed 24% of the population, and were older (72 vs. 70 years, p = 0.002), less likely to be Caucasian (72.4 vs. 77.1%, p < 0.001), and more likely to carry public insurance (76.3 vs. 64.7%, p < 0.001). High-risk patients demonstrated higher rates of all med-

### Table 2. Baseline patient characteristics

| Characteristics                  | n (%) |
|----------------------------------|-------|
| **Patient demographics**         |       |
| Age (years), median (IQR)        | 70 (62–77) |
| Gender (male)                    | 2,627 (75.8) |
| Race                              |       |
| Caucasian                        | 2,638 (76.0) |
| African American                 | 134 (3.9) |
| Hispanic                         | 305 (8.8) |
| Asian                            | 191 (5.5) |
| Other/unknown                    | 202 (5.8) |
| **Primary insurance provider**   |       |
| Public                           | 2,341 (67.5) |
| Private                          | 1,017 (29.3) |
| Self-pay/uninsured               | 112 (3.2) |
| **Medical comorbidities**        |       |
| Diabetes mellitus, type II       | 561 (16.2) |
| Hypertension                     | 2,027 (58.4) |
| Congestive heart failure         | 172 (5.0) |
| Coronary artery disease          | 583 (16.8) |
| Peripheral vascular disease      | 250 (7.2) |
| Chronic renal insufficiency      | 403 (11.6) |
| Chronic lung disease             | 678 (19.5) |
| **LACE score components**        |       |
| **Length of stay (days), median (IQR)** | 9 (7–13) |
| **Acuity of admission (elective)** | 3,470 (100) |
| Charlson comorbidity index, median (IQR) | 3 (2–8) |
| Emergency department visits,* median (range) | 0 (0–8) |
| Composite LACE score, median (IQR) | 8 (7–9) |

| Outcomes                        |       |
| Readmission within 90 days      | 638 (18.4) |
| Mortality within 90 days        | 160 (4.7) |

*Emergency department visits within 6 months preceding surgery.

### Table 3. LACE score and 90-day readmission and mortality rates

| LACE Score | Readmission | Mortality |
|------------|-------------|-----------|
| 0          | –           | –         |
| 1          | –           | –         |
| 2–3        | 0%          | 0%        |
| 4–6        | 16.5%       | 2.4%      |
| 7–9        | 17.7%       | 3.6%      |
| ≥ 10       | 22.8%       | 9.1%      |
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Table 4. Univariate analysis assessing characteristics of regular- versus high-risk patients, stratified by LACE score

| Characteristics                        | LACE < 10 n (%) | LACE ≥ 10 n (%) | p    |
|----------------------------------------|-----------------|-----------------|------|
| **Patient demographics**               |                 |                 |      |
| Age (years), median (IQR)              | 70 (62–76)      | 72 (62–78)      | 0.002|
| Gender (male)                          | 2,001 (75.6)    | 626 (76.5)      | 0.6  |
| Race                                    |                 |                 |      |
| Caucasian                               | 2,045 (77.1)    | 593 (72.4)      | < 0.001|
| African American                        | 100 (3.8)       | 34 (4.2)        |      |
| Hispanic                                | 196 (7.4)       | 109 (13.3)      |      |
| Asian                                   | 157 (5.9)       | 34 (4.2)        |      |
| Other/unknown                           | 153 (5.8)       | 49 (5.9)        |      |
| **Primary insurance provider**         |                 |                 |      |
| Public                                  | 1,716 (64.7)    | 625 (76.3)      | < 0.001|
| Private                                 | 853 (32.2)      | 164 (20.0)      |      |
| Self-pay/uninsured                     | 82 (3.1)        | 30 (3.7)        |      |
| **Medical comorbidities**              |                 |                 |      |
| Diabetes mellitus, type II             | 397 (15.0)      | 164 (20.0)      | 0.001|
| Hypertension                           | 1,515 (57.2)    | 512 (62.5)      | 0.006|
| Congestive heart failure               | 77 (2.9)        | 95 (11.6)       | < 0.001|
| Coronary artery disease                | 385 (14.5)      | 198 (24.2)      | < 0.001|
| Peripheral vascular disease            | 169 (6.4)       | 81 (9.9)        | 0.001|
| Chronic renal insufficiency            | 187 (7.1)       | 216 (26.4)      | < 0.001|
| Chronic lung disease                   | 447 (16.9)      | 231 (28.2)      | < 0.001|
| **LACE score components**             |                 |                 |      |
| Length of stay (days), median (IQR)    | 9 (7–11)        | 14 (9–20)       | < 0.001|
| Acuity (elective)                      | 2,651 (100)     | 819 (100)       | 0.99 |
| Charlson comorbidity index, median (IQR)| 3 (2–4)       | 8 (4–9)         | < 0.001|
| Emergency department visits,* median (range) | 0 (0–4) | 1 (0–8)    | < 0.001|
| Composite LACE score, median (IQR)     | 8 (7–9)         | 10 (10–11)      | < 0.001|
| **Outcomes**                           |                 |                 |      |
| Readmission within 90 days             | 468 (17.7)      | 170 (22.8)      | 0.002|
| Mortality within 90 days               | 92 (3.5)        | 68 (9.1)        | < 0.001|

*Emergency department visits within 6 months preceding surgery.

Table 5. Univariate analysis assessing characteristics of regular- versus high-risk patients, stratified by LACE score

| Characteristics                        | Unadjusted OR (95% CI) | p       | Adjusted OR* (95% CI) | p     |
|----------------------------------------|------------------------|---------|-----------------------|-------|
| Readmission with 90 days               |                        |         |                       |       |
| LACE ≥ 10 (categorical variable)       | 1.38 (1.13–1.69)       | 0.002   | 1.24 (1.00–1.54)      | 0.050 |
| LACE increase by 1 point (continuous variable) | 1.11 (1.05–1.18) | < 0.001 | 1.07 (1.00–1.15) | 0.037 |
| Mortality within 90 days               |                        |         |                       |       |
| LACE ≥ 10 (categorical variable)       | 2.79 (2.01–3.85)       | < 0.001 | 2.09 (1.47–2.99)      | < 0.001|
| LACE increase by 1 point (continuous variable) | 1.43 (1.30–1.59) | < 0.001 | 1.33 (1.19–1.49) | < 0.001|

*Adjusted for patient medical comorbidities and baseline characteristics.

clinical comorbidities reported, and had a higher CCI (8 vs. 3, p < 0.001) compared to regular-risk patients. High-risk patients by LACE score also had longer inpatient LOS (14 vs. 9 days, p < 0.001), more preceding ED visits [1 (range 0–8) vs. 0 (range 0–4), p < 0.001], and a higher overall composite LACE score [10 (IQR: 10–11) vs. 8 (IQR: 7–9)]. High-risk patients had increased rates of 90-day readmission compared to regular-risk patients (22.8 vs. 17.7%, p = 0.002), as well as increased 90-day mortality rates (9.1 vs. 3.5%, p < 0.001). On univariate analysis, LACE score high-risk patients had an increased odds of 90-day readmission (OR = 1.38, 95% CI: 1.13–1.6, p

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Multivariate models (table 5) adjusted for baseline differences in demographic characteristics and medical comorbidities demonstrate the effect of LACE scores on 90-day readmission and mortality rates. As a continuous variable, a one point increase in LACE score had a 7.3% increased adjusted odds of readmission, as well as a 33.2% increased adjusted odds of mortality. As a categorical variable, high-risk patients with a LACE score ≥ 10 had increased 90-day adjusted odds of readmission (adjusted OR = 1.24, 95% CI: 0.99–1.54, p = 0.050) and mortality (adjusted OR = 2.09, 95% CI: 1.47–2.99, p < 0.001).

Receiver operator characteristic curves for 90-day readmission and mortality are demonstrated in figure 1a–b. C-statistics demonstrate poor prediction for 90-day readmission with an AUC of 0.5812 (95% CI: 0.5561–0.6063) in figure 1a, but reasonable prediction of 90-day mortality (AUC = 0.7181, 95% CI: 0.6789–0.7573) in figure 1b.

**Discussion**

The baseline population undergoing radical cystectomies is highly comorbid and aged, and thus at high risk for perioperative complications, readmission and death. The LACE score identified nearly one-quarter of the radical cystectomy population as high-risk, a group that experienced a markedly greater rate of 90-day mortality as well as inpatient readmission.

In this population 4.6% of patients experienced 90-day mortality, which is consistent with prior reports (3.7–10.6%) [2, 7, 8]. Ninety-day mortality was seen at a significantly higher rate in the LACE high-risk group (9.1 vs. 3.5%, p < 0.001), and the LACE score predicted an adjusted odds of 2.09 for morality with a reasonable predictive value (AUC of 0.7181). The overall 90-day readmission rate was 18.4%, and consistent with reported rates in the literature (16–25%) [2–6]. Higher readmission rates were seen in high-risk patients as identified by LACE score (22.8 vs. 17.7%, p = 0.002), and while univariate analysis demonstrated a strong relationship with high-risk designation and readmission, adjusted multivariate analysis demonstrated only a borderline increase in risk with poor predictive value for 90-day readmission (AUC = 0.5812).

Other radical cystectomy postoperative risk scores exist to identify patients at risk for complications. A recent study by Chappidi et al. [16] used the modified frailty index (mFI) to identify high-risk patients for 30-day complications and mortality. The mFI is an 11 variable score consisting of medical comorbidities, very similar in concept to the CCI, although including different medical conditions as covariates. One addition to the mFI is an assessment of preoperative functional status. While the mFI is able to discern which patients are more likely
to experience Clavien 4 or 5 complications, it is unable to discern post-cystectomy mortality (Clavien 5) independently.

Better identification of high-risk patients offer a targeted intervention to those who may benefit the most. Bronstein et al. [13] utilized the LACE score to identify high-risk hospitalized patients for targeted social work intervention, leading to a reduction in readmissions in this cohort by 22% compared to standard treatment. While Bronstein used a cutoff of LACE ≥ 7 to identify high-risk patients, in our study 95% of patients in our study had a LACE ≥ 7, offering little benefit in discriminating patient populations. With our selected cutoff of LACE ≥ 10, 24% of patients fell within the high-risk category, a group that clearly demonstrated a higher rate of postoperative issues to which a targeted intervention could be employed. Krishnan et al. [17] found that optimizing the timing of follow-up calls and appointments after radical cystectomy allowed for identification of concerning symptoms that may lead to readmission. Using the LACE score to identify patients for hospital-based and ambulatory interventions, as well as increased postoperative follow-up would be a reasonable investigative next-step at the institutional level.

With the LACE score automatically populating into the electronic medical record and being utilized by ancillary providers, it is interesting to observe the utility of this tool in the bladder cancer population. It is possible that given the high baseline readmission rate following radical cystectomy, and the myriad of complications that can occur postoperatively, it is difficult for this fairly simple tool to differentiate high-risk patients for readmission. The strength of the LACE score in this population is in predicting an increased risk of mortality. It is of note that only LOS is not known preoperatively and as such a general sense of a patient’s mortality risk may be inferred even preoperatively based on their level of comorbidity and burden of ED visits preceding surgery.

Limitations in our study, as a retrospective review of administrative data, warrant discussion. As has been discussed in several comparably designed analyses, these results derived from administrated data are dependent on accurate coding and completeness of the database. The results are also limited in that only one state was included in the present analysis. For follow-up purposes, patients who may have been admitted to a hospital in another state would be accurately included in the analysis. Further, due to variability in geographic practice patterns and enhanced recovery protocol utilization, differences in LOS and/or readmission rates may be affected, and as such these results may not be generalizable to the larger cystectomy population. Another limitation is that data only include inpatient and ED visits, which may leave mortality rates underestimated if a patient were to die at home or a nursing facility without transfer to a hospital, leaving this event uncaptured. The mortality rates found in this study were consistent with prior reports, leaving this of minimal concern. Finally, patient-level data including preoperative functional status, marital/family support, etc. are not able to be ascertained from the data, which may alter a patient’s ability to recover at home and their propensity to require readmission.

**Conclusion**

Radical cystectomy is a highly morbid procedure, with a high associated rate of 90-day inpatient readmission and postoperative mortality. The LACE score reasonably identifies patients at risk for 90-day mortality following radical cystectomy, but only poorly predicts readmission. The LACE score is an easy to use, validated tool that can be used to target patients for close postoperative follow-up and possible additional intervention.
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