# *Impact of hospital volume on perioperative outcomes and costs of radical cystectomy: analysis of the Maryland Health Services Cost Review Commission database*

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***Introduction:*** *The objective of this study was to evaluate the impact of hospital case volume on perioperative outcomes and costs of radical cystectomy (RC) after controlling for differences in patient case mix.*

***Materials and methods:*** *The Maryland Health Services Cost Review Commission database was queried for patients who underwent an open RC between 2000 and 2011. Patients were divided into tertiles based on hospital case volume. Groups were compared for differences in length of intensive care unit (ICU) stay, length of total hospital stay, rate of in-hospital deaths and procedure-related costs.*

***Results:*** *In total, 1620 patients underwent a RC during the study period. Of these patients, 457 (28.2%) underwent surgery at 37 low volume centers, 465 (28.7%) at six mid volume centers and 698 (43.1%) at a single high volume center. The mean case volume of each group was 1.1, 7.0 and 63.5 RC/center/year, respectively. After controlling for marked differences in patient case mix, having surgery at the single high-volume center was independently associated with a decrease in length of ICU stay (coefficient = -0.41 days, 95% CI -0.78–-0.05, p = 0.03), in-hospital mortality (OR 0.18, 95% CI 0.04-0.80, p = 0.02) and total medical costs (coefficient = -2.91k USD, 95% CI -4.15–-1.67, p < 0.001). Decreased total costs were driven by reductions in charges associated with the operating room, drugs, radiology tests, labs, supplies and physical/occupational therapy (all p < 0.001).*

***Conclusions:*** *Undergoing RC at a high volume medical center was associated with improved outcomes and reduced costs. These data support the centralization of RC to high volume centers.*

**Key Words:** bladder cancer, cost analysis, outcomes, radical cystectomy, surgical volume

## Introduction

Radical cystectomy (RC) represents the standard of care for patients with muscle invasive bladder cancer as well as those with high grade non-invasive disease refractory to intravesical therapy.[1,2] Despite significant advances over the last several decades in the care of these patients, contemporary population-based data suggests a perioperative complication rate as high as 28% with an associated in-hospital death rate of nearly 3%.[3] These data have lead to an increased focus on ways to minimize the morbidity and mortality following RC.

Across surgical specialties, growing evidence suggests that increased hospital volume is associated with improved outcomes and decreased costs for

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various complex surgical procedures.[4-7] Within the field of urology, a number of studies have shown that RC is safest and most cost-effective when performed at high volume (HV) centers.[8-16] This appears to be independent of surgeon volume and has been attributed to differences in the quality of perioperative care, access to advanced diagnostic tests and availability of ancillary services.[9,15]

Lacking from many of the studies aimed at evaluating the volume-outcome relationship is rigorous adjustment for inherent differences in the case mix of patients seen at treating centers. A recent study of the Nationwide Inpatient Sample highlights the importance of this as there appears to be marked variation in the demographics and medical complexity of patients treated at high versus low volume (LV) centers.[17] In light of these observations, the objective of this study was to utilize a robust, statewide database to evaluate the impact of hospital case volume on perioperative outcomes and costs of RC after controlling for difference in patient case mix at treating centers.

## Materials and methods

The Health Services Cost Review Commission (HSCRC) was established in the 1970's to regulate hospital rates in the State of Maryland (http://www.hscrc.state.md.us).[18] This office prospectively collects clinical, demographic, and billing data on inpatient discharges from 51 non-federated hospitals in Maryland. De-identified data from the HSCR database is made publically available and has previously been used in a number of studies evaluating surgical outcomes.[19-22]

After obtaining institutional review board approval, the HSCRC database was queried for patients who underwent an open RC (ICD-9 procedure code 57.7, 57.71 or 57.79) between the years 2000 and 2011 for a diagnosis of bladder cancer (ICD-9 diagnosis code 188.0-188.9, 233.7, 236.7 or 239.4). Following grouping by treating hospital identifier and then ordering by case volume, the study cohort was divided into tertiles.

TABLE 1. **Comparison of patient characteristics, outcomes and costs**

| Variable | Low volume n = 457 | Mid volume n = 465 | High volume n = 698 | p value |
|---|---|---|---|---|
| Age (years) | 69.1 ± 10.2 | 68.4 ± 10.6 | 65.2 ± 10.5 | < 0.001 |
| Sex | | | | < 0.001 |
| Male | 327 (71.6) | 382 (82.2) | 605 (86.7) | |
| Female | 130 (28.4) | 83 (17.8) | 93 (13.3) | |
| Race | | | | < 0.001 |
| White | 356 (77.9) | 400 (86.0) | 630 (90.3) | |
| Black | 87 (19.0) | 49 (10.5) | 40 (5.7) | |
| Other | 14 (3.1) | 14 (3.0) | 28 (4.0) | |
| Severity of illness | | | | < 0.001 |
| Low | 0 (0) | 0 (0) | 0 (0) | |
| Mild | 51 (11.2) | 57 (12.3) | 159 (22.8) | |
| Moderate | 311 (68.1) | 319 (68.6) | 489 (70.1) | |
| High | 95 (20.8) | 89 (19.1) | 50 (7.2) | |
| Mortality risk | | | | < 0.001 |
| Low | 110 (24.1) | 114 (24.5) | 254 (36.4) | |
| Mild | 151 (33.0) | 182 (39.1) | 310 (44.4) | |
| Moderate | 116 (25.4) | 114 (24.5) | 101 (14.5) | |
| High | 80 (17.5) | 55 (11.8) | 33 (4.7) | |
| Length of ICU stay (days) | 1.3 ± 3.6 | 2.4 ± 5.7 | 0.7 ± 1.5 | < 0.001 |
| Total length of stay (days) | 12.1 ± 9.8 | 11.1 ± 10.0 | 9.5 ± 6.0 | < 0.001 |
| In-hospital deaths | 27 (5.9) | 8 (1.7) | 2 (0.3) | < 0.001 |
| Total charges (per 1000 USD) | 39.2 ± 34.5 | 42.0 ± 38.6 | 30.8 ± 19.1 | < 0.001 |

Continuous variables are presented as mean ± standard deviation and categorical variables as n (%).
ICU = intensive care unit, USD = United States dollars

Patients in each group were compared for differences in demographic data including patient age, sex, race, and severity of illness/mortality risk as defined by the validated stratification method of All Patient Refined Diagnosis Related Groups (APR-DRG, 3M Company, St. Paul, MN, USA).[23-26] Further, groups were compared for differences in the outcomes of length of intensive care unit (ICU) stay, length of total hospital stay, rate of in-hospital deaths, and total hospital charges. All cost data are presented in thousands of United States dollars (USD) and were adjusted for inflation using data made available by the Bureau of Labor and Statistics (http://www.bls.gov/data/inflation_calculator.htm).

For our initial analysis, continuous and categorical variables were compared between groups with the univariate Kruskal-Wallis and $\chi^2$ tests, respectively. Multivariate linear and logistic regression analyses of outcomes were then performed controlling for year of surgery, patient demographics, medical complexity or mortality risk and high versus low to mid center volume. Of note, the analysis of cost additionally controlled for length of total hospital and ICU stay.

All statistical analyses were performed in SPSS 20.0 (IBM Corporation, Armonk, NY, USA). A p value of $< 0.05$ was defined as statistically significant and all univariate comparisons were two-sided. In text, continuous variables are represented as mean ± standard deviation and categorical variables as n (%).

## Results

In total, 1620 patients underwent a RC in the state of Maryland between 2000 and 2011. Of these patients, 457 (28.2%) underwent surgery at 37 LV centers, 465 (28.7%) at six mid volume (MV) centers and 698 (43.1%) at a single HV center (Johns Hopkins Hospital). The mean case volume of each group was 1.1, 7.0 and 63.5 RC/center/year, respectively. Table 1 details differences between the three tertiles. Notably, there were marked differences in the case mix between groups. More specifically, patients treated at LV centers were older, more likely to be female, of non-white race and classified as having a higher severity of illness and/or risk of mortality risk (p value for all comparisons $< 0.001$).

On univariate analysis, Table 1, increasing procedure volume was associated with reductions in length of ICU stay (LV: 1.3 ± 3.6, MV: 2.4 ± 5.7, HV: 0.7 ± 1.5 days, $p < 0.001$), length of total hospital stay (LV: 12.1 ± 9.8, MV: 11.1 ± 10.0, HV: 9.5 ± 6.0 days, $p < 0.001$), rate of in-hospital mortality (LV: 5.9%, MV: 1.7%, HV: 0.3%, $p < 0.001$) and total inflation-adjusted hospital charges (LV: 39.2 ± 34.5, MV: 42.0 ± 38.6, HV: 30.8 ± 19.1 thousands of USD, $p < 0.001$). On multivariate analysis, having surgery at the single HV center was independently associated with a decrease in length of ICU stay (Table 2, coefficient = -0.41 days, 95% CI -0.78–-0.05, p = 0.03) but not total length of hospital stay (coefficient = -0.07 days, 95% CI -0.84-0.70, p = 0.86).

TABLE 2. **Multivariate linear regression analysis of length of length of intensive care unit (ICU) and total hospital stay**

| | Length of ICU stay (days) | | Total length of stay (days) | |
|---|---|---|---|---|
| **Covariate** | **Coefficient (95% CI)** | **p value** | **Coefficient (95% CI)** | **p value** |
| Age | 0.02 (-0.00-0.03) | 0.08 | 0.06 (0.03-0.10) | 0.001 |
| Sex | | | | |
| Female | --- | --- | --- | --- |
| Male | 0.12 (-0.33-0.56) | 0.61 | 0.77 (-0.17-1.70) | 0.11 |
| Race | | | | |
| White | --- | --- | --- | --- |
| Non-white | -0.14 (-0.64-0.36) | 0.59 | 1.01 (-0.05-2.06) | 0.06 |
| Severity of illness | | | | |
| Mild | --- | --- | --- | --- |
| Moderate | 0.24 (-0.24-0.72) | 0.32 | 1.90 (0.89-2.91) | < 0.001 |
| High | 4.32 (3.68-4.97) | < 0.001 | 12.98 (11.6-14.3) | < 0.001 |
| Center volume | | | | |
| Low to mid | --- | --- | --- | --- |
| High | -0.41 (-0.78–-0.05) | 0.03 | -0.07 (-0.84–0.70) | 0.86 |
| Year of procedure | -0.12 (-0.17–-0.07) | < 0.001 | -0.20 (-0.30–-0.09) | < 0.001 |

TABLE 3. **Multivariate logistic regression analysis of in-hospital death**

| | In-hospital death | |
|---|---|---|
| **Covariate** | **OR (95% CI)** | **p value** |
| Age | 1.01 (0.97-1.06) | 0.53 |
| Sex | | |
| Female | --- | --- |
| Male | 1.08 (0.46-2.49) | 0.86 |
| Race | | |
| White | --- | --- |
| Non-white | 1.44 (0.56-3.71) | 0.45 |
| Mortality risk | | |
| Low | --- | --- |
| Mild | 1.49 (0.13-16.77) | 0.75 |
| Moderate | 5.44 (0.61-48.48) | 0.13 |
| High | 72.30 (9.20-568.48) | < 0.001 |
| Center volume | | |
| Low to mid | --- | --- |
| High | 0.18 (0.04-0.80) | 0.02 |
| Year of procedure | 0.90 (0.80-1.00) | 0.05 |

TABLE 4. **Multivariate linear regression analysis of total hospital charges**

| | Total cost (per 1000 USD) | |
|---|---|---|
| **Covariate** | **Coefficient (95% CI)** | **p value** |
| Age | -0.15 (-0.20–-0.09) | < 0.001 |
| Sex | | |
| Female | --- | --- |
| Male | -1.08 (-2.58-0.42) | 0.16 |
| Race | | |
| White | --- | --- |
| Non-white | 0.79 (-0.91-2.48) | 0.36 |
| Severity of illness | | |
| Mild | --- | --- |
| Moderate | 0.21 (-1.41-1.83) | 0.80 |
| High | 6.38 (3.96-8.80) | < 0.001 |
| Length of ICU stay | 1.57 (1.39-1.76) | < 0.001 |
| Length of total stay | 2.73 (2.64-2.82) | < 0.001 |
| Center volume | | |
| Low to mid | --- | --- |
| High | -2.91 (-4.15–-1.67) | < 0.001 |
| Year of procedure | 1.13 (0.95-1.30) | < 0.001 |

ICU = intensive care unit

For both length of ICU and total hospital stay, severity of illness was the strongest predictor of these outcomes.

In terms of in-hospital mortality, having surgery at a HV center was independently associated with a decreased risk of death (Table 3, OR 0.18, 95% CI 0.04-0.80, p = 0.02). In contrast, a high mortality risk as determined by APR-DRG was predictive of in-hospital death (OR 72.30, 95% CI 9.20-568.48, p < 0.001).

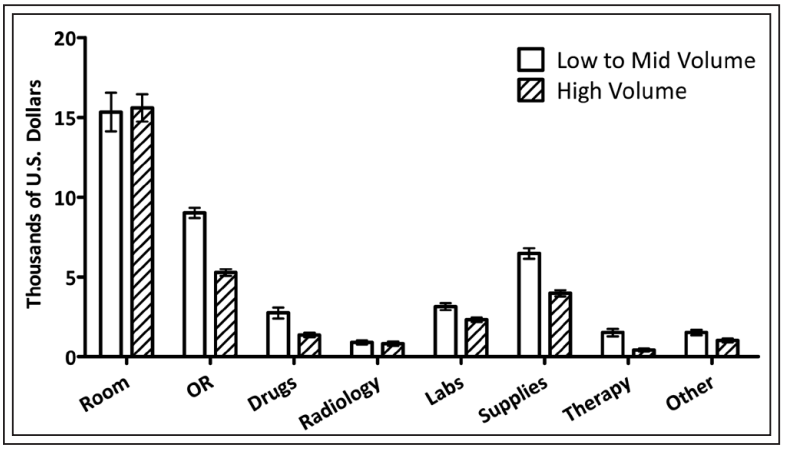


**Figure 1.** Breakdown of hospital charges by center volume. Means are presented with 95% confidence intervals. With the exception of room charges, all other charge categories were significantly lower at the HV center (all p ≤ 0.001 by the Mann-Whitney U Test).

Lastly, high hospital volume was independently associated with decreased total medical costs (Table 4, coefficient = -2.91k USD, 95% CI -4.15–-1.67, p < 0.001). Not surprisingly, high severity of illness was associated with increased medical costs (coefficient = 6.38k USD, 95% CI 3.96-8.80, p < 0.001). Comparing HV to LV and MV centers, decreased total costs were driven by reductions in charges associated with the operating room, drugs, radiology tests, labs, supplies and physical/occupational therapy, Figure 1.

## Discussion

To date, a number of studies have demonstrated that higher-hospital volume is associated with improved outcomes of RC.[8-16] These outcomes include shorter hospital stays, decreased risk of perioperative mortality and decreased hospital costs. Consistent with these reports, our analysis revealed that having surgery at a single HV center in the state of Maryland was independently associated with shorter ICU stays and a decreased risk

of in-hospital death. In addition, we found that these differences translated to decreased inflation-adjusted hospital charges.

Unique to our study, we employed multivariate statistical methods to account for differences in treating hospital case mix based on APR-DRG derived severity of illness and mortality risk groups. The use of APR-DRG data has previously been shown to be highly predictive of differences in medical complexity as well as mortality risk.[23-26] These studies have even shown a higher sensitivity for discernment when compared to other well established comorbidity indices. As evident from the data in Table 1, this was a crucial component of our analysis as we observed marked differences in the demographics of patients treated in each volume tertile. These data are consistent with previous observations from the Nationwide Inpatient Sample which have demonstrated disparities in access to care for complex urologic oncology procedures.[17] More specifically, analysis of this dataset revealed that older, sicker and socioeconomically disadvantaged patients were less likely to be treated at HV hospitals. To our knowledge, our study is the first of its kind to evaluate both perioperative outcomes and costs of RC after accounting for such differences in patient case mix. In contrast, a number of previous studies did not correct for differences in patient demographics, while others simply used number of medical comorbidities as a surrogate for medical complexity.[8-11,16] Still others employed a comorbidity index, however, these studies did not comprehensively evaluate both perioperative outcomes and costs, as was the case in the present study utilizing the Maryland HSCRC.[12,14,15]

In light of our findings, we feel that patients in need of a RC should be considered for referral to a HV center of excellence. This view is shared by others in the field of urologic oncology and has led to the centralized performance of complex urologic procedures in the United Kingdom.[27-29] It is important to note, however, that in practice this is a difficult recommendation to make as no study to date has been able to precisely define "high volume." In a 2011 meta-analysis, Goossens-Laan et al found that higher hospital volume was associated with a decreased risk of postoperative mortality following RC (OR 0.55, 95% CI 0.44-0.69, $p < 0.001$).[13] Despite data from seven large studies, the authors were unable to identify a cutoff point at which patients had improved surgical outcomes. This has been attributed to the marked variation between studies in the definition of a HV center. More specifically, this definition ranged from 4 to 24 cases per year. Therefore, what defined HV in one study, may have defined MV or LV in another (or vice versa). This was a direct consequence of reports defining case volume using arbitrary cutoffs such as tertiles or quartiles. Therefore, future studies should aim to evaluate center volume as a continuous variable. Unfortunately, individual State datasets such as the HSCRC lack the number of centers with differing case volumes to perform such an analysis. Thus, we look to future work with meta-data or large national datasets to better define HV or center of excellence. As we demonstrated the importance of here, these analyses should also include correction for differences in patient case mix.

The potential mechanisms which underlie the observation that surgery at HV center is associated improved outcomes of RC is not fully understood. Once identified, it may be possible for lower-volume centers to adapt these practices in an attempt to improve safety and cost-effectiveness. This is of particular relevance, as referral to a tertiary center is not always practical given geographic isolation and other financial constraints. To better evaluate this question, Hollenbeck and coworkers analyzed the Nationwide Inpatient Sample database for mediators of the effect of hospital volume on postoperative death following RC.[9] Notably, the authors found that compared to patients who underwent surgery at LV centers, those who had surgery at a HV center had greater access to advanced ancillary tests and services such as magnetic resonance imaging, an ICU, interventional radiology, hemodialysis, chemotherapy and radiation oncology. When differences in these factors were controlled for in a multivariate model, the effect of hospital volume was attenuated by up to 59%. This finding implies that by introducing select additional services to lower volume hospitals, it may be possible to improve perioperative outcomes for those unable to seek care at a HV center. An additional step towards this goal would be to adopt clinical pathways developed by HV centers aimed at streamlining the care of RC patients. The use of such pathways is purported to be associated with fewer ICU admissions, shorter LOS and decreased medical costs.[30-33]

While the results of our study suggest improved outcomes and decreased cost when RC is performed at a HV center, several important limitations of this study should be noted. First, our analysis only included a single center in the highest volume group. Therefore, it is difficult to know if the observed trends are truly reflective of other HV centers or just this single center. Notably, however, this hospital is an academic tertiary center with operative volume similar to that of other HV centers in the above-cited reports. A second limitation is that the analysis only included patients treated in the state of Maryland. Given this, our results may not be generalizable to the rest of the United States. A third limitation of our study is that the HSCR database does

not include data on hospital readmissions or oncologic outcomes. Thus, it is not known how patients faired with regard to these important endpoints following hospital discharge. One last limitation of our study is the fact that cost data were based on hospital charges and not actual payments. Therefore, observed differences in costs may be biased by differences in charges as determined locally by the treating hospital. However, we believe this effect was minimal, as the HSCRC works within the state of Maryland to standardize costs.

## Conclusions

After controlling for severity of illness and mortality risk, we found that undergoing a RC at a HV medical center was associated with shorter ICU stays, a decreased risk of death in the perioperative period and reduced procedure-related costs. In light of these data, patients requiring a RC for the treatment of bladder cancer should be considered for referral to a HV center of excellence. Future work, however, must aim to more precisely define HV as well as evaluate ways to improve outcomes at lower volume centers. □

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