Processes of Care and the Impact of Surgical Volumes on Cancer-specific Survival: A Population-based Study in Bladder Cancer

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OBJECTIVE
To describe the relationships between procedure volume and late survival after cystectomy for muscle-invasive bladder cancer (MIBC) and explore variables explaining any effect.

MATERIALS AND METHODS
Electronic records of treatment and surgical pathology reports were linked to a population-based registry to identify patients who underwent cystectomy during 1994-2008 in Ontario, Canada. Explanatory variables included adjuvant chemotherapy, lymph node dissection (LND), and margin status. A Cox proportional hazards regression model was used to explore associations between volume and cancer-specific survival (CSS) as well as overall survival.

RESULTS
The cohort included 2802 MIBC patients treated with cystectomy. High-volume hospitals were more likely to have used adjuvant chemotherapy (25% vs 18%; P < .001), more likely to have performed an LND (83% vs 53%; P < .001), and associated with a lower 90-day mortality (6% vs 10%; P = .032). Low-volume hospitals had a lower 5-year CSS rate of 32% (28%-36%) compared with those of high-volume centers at 38% (33%-42%). Individual surgeon volume was similarly associated with both early- and long-term outcomes. In multivariate analysis, both surgeon and hospital volumes were associated with CSS and overall survival. The surgeon volume effect on long-term outcomes was modestly modified by indicators of the quality of the LND, with little effect of the other explanatory variables.

CONCLUSION
Higher provider volume is associated with higher CSS in patients with MIBC in the general population. The volume effect was modestly mediated by the quality of LND.

The variability in the delivery of care for muscle-invasive bladder cancer (MIBC) in the general population has led to a marked disparity in outcomes compared with those reported in clinical trials or centers of excellence.1-4 In concert with the development of more efficacious treatment strategies, the optimization of care delivery for existing therapies in routine clinical practice is necessary to improve outcomes of patients with MIBC. Initiatives in other disease sites have focused on centralization of specialized services to lower operative morbidity and mortality, and potentially to improve late oncologic outcomes,3-8 grounded in the increasingly strong associations between provider volume and surgical outcomes.9-14

Multiple studies confirm a similar volume-outcome relationship for cystectomy with a significant inverse relationship of volume and postoperative mortality.15-20 However, several investigators have more recently highlighted limitations of the existing data exploring the volume-outcome relationship, including methodological concerns.19,21,22 The Institute of Medicine in the United States had proposed recommendations to improve the quality of volume-outcome studies22; however, the quality of that for cystectomy has been described as modest at best.19 Many available studies report on databases that tend to represent restricted populations and lack
information on important prognostic factors, including stage. Few studies address long-term survival, adjust for the relative effects of both surgeon and hospital volumes, or simultaneously investigate process of care factors underpinning the volume-outcome relationship. We undertook the current population-based cohort study to evaluate the effect of hospital and surgeon volumes on cancer-specific survival (CSS) after cystectomy for MIBC, and to investigate 3 potential surrogates for the processes of care that may explain any volume-cancer outcome relationship.

MATERIALS AND METHODS

Study Design and Population

All incident patients of MIBC who underwent cystectomy in Ontario, Canada between 1994 and 2008 were identified using the Ontario Cancer Registry (OCR). The parent study on which this report is based was focused on the quality of care of patients with MIBC and specifically the utilization and impact of adjuvant chemotherapy. Therefore, patients captured in this cohort included only those that the study team felt a priori would be potential candidates for adjuvant chemotherapy.

The primary objective of this study was to describe the association between hospital and surgeon cystectomy volumes on long-term outcomes, specifically CSS as a surrogate of a Donabedian structure of care indicator. This conceptual framework of surgical quality informed our study design, whereby excellent structures of care lead to improved processes of care and subsequently to optimal outcomes. To identify the potential process of care variables that could explain any volume-outcome relationship on CSS we evaluated the effect of surgical margins, pelvic lymph node dissection (LND), and adjuvant chemotherapy (ACT; Supplementary Fig. 1). These 3 explanatory factors were chosen as they were well detailed in the database and reflect important processes of the entire team, including the individual surgical technique, pathologic expertise and the involvement of medical oncology. These factors chosen a priori to explain any volume-outcome relationship represented a surrogate of numerous other process of care. NeoACT utilization was not evaluated as an explanatory variable as use in the population was low (~4%), and only postoperative staging was available.

Data Sources

The OCR is a passive, population-based cancer registry that captures diagnostic and demographic information on at least 98% of all incident cases of cancer diagnosed and provides the following information: International Classification of Disease site and histology codes, date of diagnosis, date of birth, place of residence at diagnosis, vital status, date of death, and cause of death. Complete information about vital status was available up to December 31, 2010, and cause of death was available up to December 31, 2008. We specifically focused on CSS as the main outcome of interest as it is less prone to unmeasured confounders.

A variety of electronic administrative health databases were linked to the OCR. Records of hospitalization from the Canadian Institute for Health Information provided information about surgical interventions and hospital care. Provincial physician billing records and treatment records from Ontario’s regional cancer centers were used to identify chemotherapy utilization. A team of trained data abstractors reviewed the pathology reports (provided by the OCR) and entered variables according to a predefined study protocol.

Definitions of Exposures

Comorbidity was classified using the Charlson Comorbidity Index modified for administrative data. Indicators of the socioeconomic status of the community in which patients resided at the time of diagnosis were linked to the OCR as described previously. ACT was defined as any chemotherapy administered within 16 weeks after surgery. Pathologic stage was dichotomized as <T3 or T3-4, as the number of pathologic pT1 or pT4 cases was negligible. Number of lymph nodes resected was categorized in quartiles; analyses were also performed using a cut-point of 10 lymph nodes resected and as a continuous variable.

The number of cystectomies performed at the hospital per year was derived using the overall study population. To account for year-to-year variation, a volume level for each hospital was derived, which represented the mean annual number of cystectomies performed over a 5-year study period. Each case was assigned a hospital volume index based on the year of surgery and the hospital where surgery took place. The hospitals were divided into quartiles of annual hospital volume. We used the same approach to derive a surgeon volume index for each patient.

Statistical Analysis

Comparisons of proportions between study groups were made using the chi-square test. Survival was determined from the date of surgery using the Kaplan-Meier technique, and comparisons between groups were made using the log-rank test. The association between patient-, disease-, and treatment-related factors and overall survival (OS) or CSS was evaluated using several Cox proportional hazards regression models. The first models included only hospital volume or surgeon volume. In subsequent models, we included hospital volume and surgeon volume as well as the prespecified process of care variables: margin status, LND, and ACT (Supplementary Fig. 1). In these models we controlled for age, T stage, and comorbidity. We did not originally adjust for lymph node status due to concerns of confounding (ie, nodal sampling differed across volume groups, and therefore, node status would be biased). However, in a series of exploratory analyses the models were subsequently run with lymph node status. Results were considered statistically significant at a P value <.05. All analyses were performed using SAS, version 9.3 (SAS Institute, Cary, NC). This study was approved by the Research Ethics Board at Queen’s University, Kingston, Ontario.

RESULTS

Study Population

During 1994-2008, we identified 2802 patients who had received a cystectomy in Ontario meeting our inclusion criteria. Twenty of the included patients were found to be only stage T1 or carcinoma in situ stage in the final cystectomy specimen but were included into the study group as they were also found to be lymph node positive. Characteristics of the study population are listed in Table 1.

Volume Trends

The lowest quartile hospital volume (Q1) was 4.1 cases/y and the highest (Q4) was >20 cases/y. The lowest
quartile surgeon volume (Q1) was 1.3 cases/y and the highest (Q4) was 6.2 cases/y. Among the 2802 cystectomy cases in the cohort, 1431 had pelvic lymph nodes in specimen, 1143 had an explicit number of nodes, and 619 cases had an explicit number of positive nodes. Patients performed with Q4 hospitals or surgeons were more likely to have had an LND and were associated with a higher nodal count. The mean (median) number of lymph nodes reported for patients at Q1 hospitals was 7.6 (6) compared with 11.1 (10) at Q4 hospitals. Similarly, Q4 surgeon volume was associated with a lower node density (33%) compared with that of Q1 (54%). Case volume was associated with use of ACT: 16% for Q1 surgeons vs 27% for Q4.

### Volume-outcome Relationships

Unadjusted short- and long-term outcomes by volume quartile are listed in Table 2. Length of stay was shorter with Q4 hospitals or surgeons but the readmission rates were higher. Five-year OS and CSS for all cases were 30%...
same Cox model (Table 3). Hospital volume and surgeon volumes on long-term outcomes, both were placed in the CI, 32%-36%). (95% confidence interval [CI], 28%-31%) and 34% (95% CI, 32%-36%).

To determine the relative effect of surgeon and hospital volumes on long-term outcomes, both were placed in the same Cox model (Table 3). Hospital volume and surgeon volume were each associated with outcome in isolation. Q1 hospitals were associated with a lower CSS and OS relative to Q4 hospitals. Similarly, Q1 surgeons were associated with a lower CSS and OS relative to Q4 surgeons. However, when hospital and surgeon volumes were put into the same model the effect of each was attenuated, generally by half. For example, the hazard ratio point estimates of the volume effect for the highest surgeon volume was 1.31 (95% CI, 1.14-1.52), which was modified by adding hospital volume to 1.17 (95% CI, 0.97-1.42), losing statistical significance (P = .93). However, given the consistent results over all the quartiles for both CSS and OS we interpret these results as depicting an association of both provider volumes on outcomes. The lack of statistical significance for an individual cut-point with both volumes in the model is more likely due to adding additional observations and losing some degree of power. To further explore this, we tested for interaction between surgeon and hospital volume within this cohort and found no significant interaction effect for OS (P value for the interaction term = .93) and CSS (P value = .71). Hospital and surgeon clusters were taken into account using cluster-specific random effects. We reran the models with surgeon level clustering using 2 different approaches (robust variance and frailty). The estimates did not significantly change further suggesting that both surgeon and hospital volumes contribute to the effects on long-term survival (Supplementary Tables 1, 2).

To determine if there was any ceiling effect in the survival benefits associated with surgeon volume, we looked at the highest surgeon volume (Q4) and further ranked cases by surgeon volume into tertiles (Supplementary Table 3). There was no significant difference in OS or CSS among tertiles.

### Process of Care Variables and Volume Effect

The hazard ratio point estimates of the volume effect for both CSS and OS were partially modified when LND as a dichotomous variable (yes or no) is put into the model, whereas the other 2 variables (margin status and ACT) did not mitigate the volume effect (data not shown). We then restricted the analysis to only those patients who received an LND (Table 4) and used number of nodes resected to specifically determine any modifying effect of the quality of LND. As shown in Table 5, when adjusting for the number of lymph nodes (categorical <10 vs >10
and continuous) the volume effect is partially attenuated. Because of the potential for confounding of lymph node status with volume and use of LND, the analysis were repeated without controlling for lymph node status, and the findings were unchanged. Because most of the volume effect appears to take place between Q3 and Q4, we dichotomized cases as Q1, Q2, Q3 vs Q4 (Supplementary Table 4) again demonstrating a modest effect of the quality of LND on the volume effect with little effect by the other process of care variables studied.

**COMMENT**

The influence of the volume-outcome relationship is well described, including the effect on early outcomes after cystectomy.\(^{15-20}\) We sought to expand our understanding of this relationship on long-term outcomes in the general population and to identify potential process-related factors that may help explain any effects of higher surgical volume. Our results confirm those of others demonstrating an association with higher volume and superior early outcomes.\(^{15-20}\) For the first time we also demonstrate that cystectomy volume, both at the hospital and surgeon level, are associated with significantly improved CSS.

Although the adequacy of the LND appears to explain some of the effect, other key explanatory factors did not measurably explain the observed volume-outcome relationship.

Provider volumes were associated with the late outcomes of CSS and OS. Low-volume hospitals had a lower 5-year OS at 28% and CSS at 35% compared with high-volume centers at 35% and 38%, respectively. Individual surgeon volume was associated with both early and late outcomes with low-volume surgeons having a lower 5-year OS at 28% and CSS at 31% compared with high-volume surgeons at 36% and 39%, respectively. In multivariate analysis, both surgeon and hospital volumes were associated with CSS and OS. The highest quartile hospital volume in our cohort was >20 cases/y and surgeon volume was >6 case, and we were unable to confirm further benefit when analyzing higher volumes. Although there was a trend to improved OS for very high-volume surgeons, the relatively small number of cases analyzed in Q4 (624) makes definitive conclusions around the role of even higher threshold cut-points of case load problematic.

Using a similar approach by Birkmeyer et al.,\(^{14}\) we subsequently included both surgeon and hospital volumes

<table>
<thead>
<tr>
<th>Volume Quartile</th>
<th>Hospital Volume, HR (95% CI)</th>
<th>Surgeon Volume, HR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hospital Volume</td>
<td>Hospital Volume Controlling for Surgeon Volume</td>
</tr>
<tr>
<td>OS Q1</td>
<td>1.25 (1.10-1.41)</td>
<td>1.14 (0.96-1.34)</td>
</tr>
<tr>
<td>Q2</td>
<td>1.27 (1.12-1.44)</td>
<td>1.15 (0.99-1.34)</td>
</tr>
<tr>
<td>Q3</td>
<td>1.11 (0.98-1.27)</td>
<td>1.04 (0.90-1.20)</td>
</tr>
<tr>
<td>Q4</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td>CSS Q1</td>
<td>1.28 (1.11-1.47)</td>
<td>1.16 (0.96-1.40)</td>
</tr>
<tr>
<td>Q2</td>
<td>1.30 (1.13-1.50)</td>
<td>1.20 (1.00-1.43)</td>
</tr>
<tr>
<td>Q3</td>
<td>1.08 (0.93-1.25)</td>
<td>1.02 (0.86-1.20)</td>
</tr>
<tr>
<td>Q4</td>
<td>Ref</td>
<td>Ref</td>
</tr>
</tbody>
</table>

HR, hazard ratio; Ref, reference; other abbreviations as in Table 2.

* The model controls for age, comorbidity, and T stage.

**Table 4.** Cox model investigating potential explanatory, process-related variables on surgeon volume effect, restricted to patients with lymph node dissection

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Quartile</th>
<th>Variables Added to the Model, HR (±95% CI)</th>
<th>Volume Alone</th>
<th>Volume + Nodes</th>
<th>Volume + ACT</th>
<th>Volume + Margins</th>
<th>Volume + Nodes/ACT/Margins</th>
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</thead>
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<tr>
<td>OS</td>
<td>Q1</td>
<td>1.26 (1.08-1.47)</td>
<td>1.19 (1.02-1.40)</td>
<td>1.21 (1.04-1.41)</td>
<td>1.28 (1.10-1.49)</td>
<td>1.15 (0.98-1.36)</td>
<td></td>
</tr>
<tr>
<td>Q2</td>
<td>1.29 (1.11-1.49)</td>
<td>1.21 (1.04-1.41)</td>
<td>1.26 (1.08-1.46)</td>
<td>1.30 (1.12-1.50)</td>
<td>1.19 (1.02-1.39)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q3</td>
<td>1.30 (1.12-1.51)</td>
<td>1.25 (1.08-1.46)</td>
<td>1.26 (1.08-1.46)</td>
<td>1.33 (1.14-1.54)</td>
<td>1.23 (1.06-1.44)</td>
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<tr>
<td>Q4</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>CSS</td>
<td>Q1</td>
<td>1.29 (1.08-1.53)</td>
<td>1.23 (1.03-1.47)</td>
<td>1.24 (1.04-1.47)</td>
<td>1.31 (1.10-1.56)</td>
<td>1.19 (1.00-1.43)</td>
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</tr>
<tr>
<td>Q2</td>
<td>1.22 (1.03-1.44)</td>
<td>1.16 (0.97-1.38)</td>
<td>1.20 (1.01-1.42)</td>
<td>1.23 (1.04-1.46)</td>
<td>1.15 (0.96-1.37)</td>
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<tr>
<td>Q3</td>
<td>1.26 (1.06-1.50)</td>
<td>1.23 (1.03-1.46)</td>
<td>1.23 (1.03-1.45)</td>
<td>1.30 (1.09-1.54)</td>
<td>1.22 (1.02-1.45)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q4</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
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</tbody>
</table>

Abbreviations as in Tables 1-3.

Analysis of 1931 of 2802 patients with evidence of lymph node dissection.

Analyses controlled for age, T stage, comorbidity, and node status.

Number nodes classified as >10 (570 of 1931), <10 (873 of 1931), and unknown (488 of 1931).

Margin status refers to involvement of any margin (bladder, urethra, or ureteric).
in the same model. The results of this analysis suggest that both provider volumes are independently associated with long-term survival. Testing for interaction between surgeon and hospital volume within this cohort demonstrated no significant interaction effect for OS and CSS. The importance of understanding such interactions between surgeon and hospital volumes cannot be understated as these concepts could help inform potential pathways as well as intraoperative technical proficiency. Hollenbeck et al. demonstrated a number of processes of care factors that may explain some of the volume effect on early mortality in cystectomy cases, although it was estimated that those identified only contributed 23% of the observed effect. The present population-based study substantiates the volume effect on early outcomes, suggesting a true association of higher volume and provider quality after adjusting for case mix. Interestingly, although there was an association of high-volume providers and length of stay as well as 90-day mortality, there was an inverse relationship with readmission rates. This may be explained by the greater use of more complex reconstruction for urinary diversions, although we were unable to capture this in the data set.

We hypothesized a priori that the quality of the LND, use of perioperative chemotherapy and surgical margin status, as surrogates for a number of local and systemic processes of care, would best explain any volume-outcome relationship for long-term survival. We demonstrated that the quality of the LND modestly mitigates the volume effect on CSS and, perhaps, use of ACT although we were unable to capture this in the data set. The processes of care underpinning the surgical volume effect, as proposed in a Donebian model of health care quality, are poorly understood and likely reflect perioperative factors such as patient selection, adherence to care pathways as well as intraoperative technical proficiencies. Hollenbeck et al. demonstrated a number of processes of care factors that may explain some of the volume effect on early mortality in cystectomy cases, although it was estimated that those identified only contributed 23% of the observed effect. The present population-based study substantiates the volume effect on early outcomes, suggesting a true association of higher volume and provider quality after adjusting for case mix. Interestingly, although there was an association of high-volume providers and length of stay as well as 90-day mortality, there was an inverse relationship with readmission rates. This may be explained by the greater use of more complex reconstruction for urinary diversions, although we were unable to capture this in the data set.

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To our knowledge, this is the first study to critically analyze the cystectomy volume effect on CSS in the general population; however, several methodological limitations merit comment. This study does satisfy a number of the methodological quality guidelines for volume-outcome research, including the examination of late outcomes and putative processes of care as well as

### Table 5. Cox model investigating potential explanatory, process-related variables on surgeon volume effect, restricted to patients with lymph node dissection containing an explicit number of nodes documented

<table>
<thead>
<tr>
<th>Quartile</th>
<th>Volume Alone</th>
<th>Volume + Nodes*</th>
<th>Volume + Nodes†</th>
<th>Volume + Nodes*/ACT/Margin</th>
<th>Volume + Nodes*/ACT/Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1</td>
<td>1.28 (1.07-1.53)</td>
<td>1.23 (1.02-1.47)</td>
<td>1.23 (1.02-1.48)</td>
<td>1.21 (1.01-1.45)</td>
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<td>Q2</td>
<td>1.31 (1.10-1.55)</td>
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<td>1.23 (1.03-1.46)</td>
<td>1.23 (1.03-1.47)</td>
</tr>
<tr>
<td>Q3</td>
<td>1.30 (1.10-1.54)</td>
<td>1.26 (1.07-1.50)</td>
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<td>1.26 (1.06-1.50)</td>
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<tr>
<td>Q4</td>
<td>Ref</td>
<td>Ref</td>
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<td>Ref</td>
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<tr>
<td><strong>CSS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1</td>
<td>1.29 (1.06-1.58)</td>
<td>1.25 (1.02-1.54)</td>
<td>1.22 (0.99-1.50)</td>
<td>1.25 (1.01-1.53)</td>
<td>1.22 (0.99-1.50)</td>
</tr>
<tr>
<td>Q2</td>
<td>1.22 (1.01-1.49)</td>
<td>1.18 (0.96-1.45)</td>
<td>1.15 (0.94-1.41)</td>
<td>1.17 (0.96-1.44)</td>
<td>1.15 (0.94-1.41)</td>
</tr>
<tr>
<td>Q3</td>
<td>1.23 (1.02-1.49)</td>
<td>1.21 (0.99-1.47)</td>
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<td>1.22 (1.00-1.48)</td>
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<td>Ref</td>
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</table>

**Abbreviations as in Tables 1-3.**

Analysis of 1443 of 2802 patients with lymph node dissection who have an explicit number of nodes. Analyses controlled for age, T stage, comorbidity, and node status. Margin status refers to involvement of any margin (bladder, urethra, or ureteric). * Number of nodes classified as >10 vs <10 (873 of 1443). † Number of nodes as continuous variable.
the specific identification of individual providers. The data set is limited by the lack of procedure-specific risk adjustment tools and the granularity of the specific processes that our explanatory variables encompass. As an example, lymph node yield represents only a surrogate of the extent of the LND, tissue handling and pathologic reporting. Furthermore, the data sources used in this study describe general aspects of disease, treatment, and outcome for all patients in Ontario, detailed information related to performance status and preoperative imaging results is not available. As well, pathology was not centrally reviewed and during this time, pathologic reporting of cases was not standardized. Despite these limitations, a major strength of the present study is that our study population includes all cases of bladder cancer treated with curative surgery minimizing the referral and selection biases of traditional institution-based observational studies.

CONCLUSION
This study confirms a significant effect of hospital and surgeon volumes on early- and long-term outcomes after radical cystectomy for MIBC. Explorations of process of care in the study suggest that quality of the LND may be at least partially explanatory of the volume-outcomes relationship. Based on our results, and what is already known about the importance of nodal yield and extent of dissection at cystectomy, this may be an appropriate target for quality improvement. However, the majority of factors explaining the volume effect remains elusive and suggests that further detailed investigation of explanatory processes would be needed to optimize outcomes of providers with lower volume case loads.

References
APPENDIX

SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.urology.2014.06.070.

EDITORIAL COMMENT

Over the last decade, volume-outcome analysis has been a constant feature in the quality of care in surgery literature. It has been the platform on which we have continued the fundamental principles of Donabedian who perceived quality of care as the interaction of 3 key elements; structure, process, and outcome. Much of the initial work on assessing the volume-outcome relationship has taken “volume” at face value, that is, a measure of activity and justified the relationship with improved outcomes based on the “practice makes perfect” theory. Although this is true in part, it cannot account for the complex interaction between a health care system, those who work within it, and patients themselves that ultimately determines the quality, including outcome, of a patient’s treatment pathway. Although numerous studies have demonstrated a correlation between volume and outcome, it is not always clear whether the relationship is continuous (linear or nonlinear) or follows a stepwise or cut-off relationship. This “pattern” of relationship is fundamental as our experience and insight of the volume-outcome relationship have improved with the understanding that volume is more plausibly a surrogate marker for the complex interaction that occurs between structural and process factors that determine outcome.

In this article, Siemens et al1 have investigated the confounders of surgical margin status, pelvic lymph node dissection, and adjuvant chemotherapy as markers of team-based processes of care, on the surgeon and institutional volume-outcome relationship using cancer-specific survival (CSS) after radical cystectomy for muscle-invasive bladder cancer as the dependent outcome. One of the most striking results is the decrease in magnitude of effect and loss of statistical significance between CSS and either hospital or surgeon volume once the hierarchical association between surgeon volume and hospital volume was accounted for. This underlines the importance of robust methodology as undertaken by Mayer et al and the interaction between each on patient outcome. With regard to process of care measures, the picture was less clear, although the performance of a lymph node dissection per se and a greater the lymph node yield had some influence on the surgeon volume-outcome relationship. The authors were unable to demonstrate a cut-off point for surgeon volume.

Although one might assume that structural or process hospital factors have their greatest influence on surgeon performance for short-term outcomes such as complication rates, mortality, readmissions, and so forth, this study importantly adds to the evidence that the hospital or surgeon interaction goes deeper and influences long-term outcomes such as overall survival and CSS. It cannot be underestimated how fundamental is the need for us to continue to develop the analytical knowledge by which we can fully understand the interplay between surgeon and hospital processes and structural factors on quality of care for our patients.

Erik Mayer, Ph.D., F.R.C.S., Department of Surgery & Cancer, Imperial College London, London, United Kingdom

REFERENCES


http://dx.doi.org/10.1016/j.urology.2014.06.073

REPLY

We appreciate the positive and insightful thoughts of this editorial comment in review of our article1 that confirms the effect of both hospital and surgeon volumes on early- and long-term cancer outcomes after radical cystectomy. We agree that any such volume-outcome relationship is the summation of complex interactions, including decisions and expertise within the multidisciplinary health care team as well as numerous processes implemented within the institution and medical community as a whole. The editorial specifically points out an important concept within the paper, which is the relative contribution of both the surgeon and hospital volume on long-term survival. In other words, can a low-volume surgeon still attain excellent outcomes in a high-volume institution? Our results demonstrated that both provider volumes were each associated with outcome in isolation. When both were put into the same Cox model, the effect was generally attenuated by half. However, given the consistent trends comparing the volume quartiles on long-term survival, as well as the tests for interaction effects between the 2 provider volumes, we interpret these results to suggest that there is most probably an independent association of both surgeon and hospital volumes on long-term outcomes. Any lack of statistical significance is more likely a result of adding more observations to the models and a subsequent loss of power.

Despite over a decade of numerous publications demonstrating the association of higher case volumes on outcomes of complex surgical procedures, our understanding of the explanatory factors remains limited.2-2 In our study, we explored several processes of care that we presumed would have a significant chance of explaining much of the volume-outcome association on survival. Although we show that the quality of the lymph node dissection somewhat modified the effect, the majority of factors explaining the association of case volume and cancer outcomes remain unidentified. We concur that further investigation is needed to more fully understand these interactions and processes that engender improved outcomes for patients with bladder cancer. We suggest this may be a difficult task without prospectively collected, detailed information on patient care over a large, diverse population. In the meanwhile, perhaps the lack of our ability to fully define and implement such factors of quality...
care suggests that it is time to more strongly advocate for centralization of care for patients with high-risk bladder cancer to dedicated, multidisciplinary teams at high-volume institutions.

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References

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