Correlation between Annual Volume of Cystectomy, Professional Staffing, and Outcomes

A Statewide, Population-Based Study

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BACKGROUND. The association between high procedure volume and lower perioperative mortality is well established among cancer patients who undergo cystectomy. However, to the authors' knowledge, the association between volume and perioperative complications has not been studied to date and hospital characteristics contributing to the volume-outcome correlation are unknown. In the current study, the authors studied these associations, emphasizing hospital factors that contribute to the volume-outcome correlation.

METHODS. Multiple-variable models of inpatient mortality and complications were developed among all 1302 bladder carcinoma patients who underwent cystectomy between January 1, 1999 and December 31, 2001 in all Texas hospitals. General estimating equations were used to adjust for clustering within the 133 hospitals. Data were obtained from hospital claims, the 2000 U.S. Census, and databases from the Center for Medicare and Medicaid Services and the American Hospital Association.

RESULTS. Complications were reported to occur in 12% of patients, 2.2% of whom died. Mortality was higher in low-volume hospitals compared with high-volume hospitals (3.1% vs. 0.7%; $P < 0.001$); mortality in moderate-volume hospitals was reported to be intermediate (2.9%). After adjustment for advanced age and comorbid conditions, treatment in high-volume hospitals was associated with lower risks of mortality (odds ratio [OR] = 0.35; $P = 0.02$) and complications (OR = 0.53; $P = 0.01$). Hospitals with a high registered nurse-to-patient ratio also had a lower mortality risk (OR = 0.43; $P = 0.04$).

CONCLUSIONS. Mortality after cystectomy was found to be significantly lower in high-volume hospitals, regardless of patient age. Referral to a hospital performing greater than 10 cystectomies annually is indicated for all patients. However, patients with poor access to a high-volume hospital may derive similar benefit from treatment at a hospital with a high-registered nurse-to-patient ratio. This finding requires further confirmation. ***Cancer*** **2005;104:975–84.**

KEYWORDS: outcomes, volume-outcome correlation, cancer surgery, nurse staffing.

High procedure volume has been associated with lower operative mortality after high-risk cancer surgeries (pancreatectomy, esophagectomy, etc.) in numerous studies.[1–8] The consistency of these findings has led to recommendations that patients who require these high-risk procedures should be referred to high-volume centers.[9–13] A modest benefit also has been shown for moderate-risk cancer surgeries (colectomy, lobectomy, etc.).[14–21] To our knowledge, there is less agreement regarding the value of referral in this setting,[5,17] although alternative means of improving outcomes are lack-

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ing. That is unfortunate because moderate-risk procedures are far more common than high-risk procedures.

We conducted a population-based study of the association between inpatient mortality and complications and the annual volume of cystectomies performed for bladder carcinoma, a procedure associated with a moderate risk of mortality. We believe the current study is unique in two respects. First, we extended previous research regarding volume-outcome correlations in cystectomy[8,22] by examining a second outcome, postoperative complications, in addition to mortality. Second, we explored hospital factors that explain the volume-outcome correlation. The identification of such factors could lead to quality improvement interventions other than referral to high-volume centers.

MATERIALS AND METHODS

All 1302 patients with bladder carcinoma (International Classification of Diseases, 9th revision [ICD-9] codes 188.0–188.9 and 236.7) who underwent total cystectomy (ICD-9 codes 57.7, 57.71, 57.79, and 68.8) between January 1, 1999 and December 31, 2001 were identified from a statewide claims database. Patients with carcinoma in situ and those who underwent partial cystectomy were excluded.

Data Sources

Patients were identified from the Texas Hospital Discharge Public Use Data File, which includes claims from all hospitals in Texas except Veterans Administration and military hospitals. Clinical, demographic, and economic data obtained from these claims were linked to socioeconomic data from the 2000 U.S. Census (by patients' postal code) and to hospital ownership, facility, and staffing information from the Center for Medicare and Medicaid Services' (CMS) Hospital Cost Report Information System, Provider of Services files, and the American Hospital Association Survey (AHA) (by hospital provider number).[23–25]

Definitions

Two outcomes, inpatient mortality and postoperative complications, were evaluated. Inpatient mortality was identified by discharge status coding from each claim. Complications were identified by searching the 10 diagnosis fields in each claim for ICD-9 codes corresponding with algorithms developed by Iezzoni et al. for use with administrative data sets.[26] The complications evaluated (and their respective ICD-9 codes) included bacteremia (038.xx and 790.7), wound infection (998.59 and 998.51), pulmonary compromise (514, 518.4, 518.5, 518.81, 518.82, 799.0, and 799.1), pneumonia (481, 482.00–482.99, 483, 485, and 486), deep venous thrombosis (451.11, 451.19, 451.2, 451,81, and 453.8), pulmonary embolus (415.1), reoperation (procedures: 54.12 and 54.61), postoperative coma or shock (780, 780.03, 780.03, and 998), acute myocardial infarction (410.00–410.91), arrhythmia (426, 427.41, 427.42, and 429.4), and cardiac arrest or shock (37.91, 427.5, and 799.1). Preexisting conditions were excluded by excluding conditions coded in either the primary or admitting diagnosis fields. Preexisting conditions also were excluded logically because of the elective nature of the timing of radical cystectomy. Because cystectomy is very rarely an emergency, it typically would not be attempted if conditions such as bacteremia, pneumonia, or myocardial infarction were present. The specific complications were chosen because of their correlation with the quality of perioperative care and because of their high sensitivity and specificity in comparisons of claims for surgical procedures with medical records.[27,28] Although claims data were reported to have a low sensitivity for medical complications in previous studies (35%), the sensitivity exceeded 60% for surgical complications. We included only those with a sensitivity ≥ 60%. Failure to rescue was defined as inpatient mortality after 1 of the 10 complications occurred.[29]

Patient-level factors included age, gender, race (white, African American, Asian, and others), Hispanic ethnicity, and distance from the closest high-volume hospital, which was computed between the center point of each patient's ZIP code of residence and the center point of the ZIP code of the closest high-volume hospital. Comorbid conditions were coded using the Dartmouth Manitoba adaptation of the Charlson comorbidity score.[30,31] The six procedure fields from each claim were searched for lymph node dissections and urinary diversion procedures. Patient-level socioeconomic information included payor (commercial, Medicare, Medicaid, self, and others) and type of health plan (health maintenance organization [HMO], preferred provider organization [PPO], or fee for service). Patients' educational level, income, and primary language were not available. However, the percentages of high school graduates and English speakers and the median family income corresponding to each patient's ZIP code were obtained from the 2000 U.S. census. These factors have been shown to be valid indicators of socioeconomic status.[32,33] For analysis, these factors were dichotomized based on the U.S. median value from the 2000 U.S. census (80.4% of U.S. residents were high school graduates, 82.1% spoke English, and had a median income of $41,994).

Characteristics of the hospitals were obtained from the CMS Hospital Cost Report Information System and Provider of Services files, and from the AHA

TABLE 1
Characteristics of Patients

Characteristic	Low volume (n = 455) value (95% CI)	Moderate volume (n = 381) value (95% CI)	High volume (n = 466) value (95% CI)	P value
% male	74 (70–78)	76 (71–80)	78 (74–82)	0.43
% age > 75 yrs	28 (24–32)	30 (25–35)	25 (21–29)	0.33
% Non-Hispanic white	74 (69–78)	85 (81–88)	85 (81–88)	<0.001
% African American	7 (4–9)	4 (3–7)	5 (3–8)	0.38
% Hispanic	16 (13–20)	7 (5–10)	7 (5–10)	<0.001
% Charlson cormorbity score > 1	35 (31–40)	33 (28–38)	23 (20–28)	<0.001
ZIP mean % HS graduate	75 (74–76)	77 (76–78)	77 (76–78)	0.07
ZIP mean % English speakers	73 (71–75)	76 (74–48)	76 (75–78)	0.01
ZIP % below U.S. median income	65 (60–69)	67 (62–72)	65 (60–69)	0.64
ZIP median family income	$40,208 ($38,850–$41,565)	$41,273 ($39,760–42,783)	$43,923 ($42,369–45,477)	0.001
% living within 100 miles of a high-volume hospital	49 (44–54)	49 (44–54)	54 (49–58)	0.27

95% CI: 95% confidence interval; ZIP: data specific to ZIP code of patient's residence from U.S. census. Not individual patient data.

Database, by matching based on hospital provider numbers and verifying the name and address of the provider. All 133 hospitals were matched to the CMS and AHA sources. Hospital ownership, for-profit and teaching status, number of beds and critical care beds, occupancy, and annual number of surgical procedures performed were studied. Staffing-to-occupied bed ratios were constructed based on the number of professional staff (registered nurses, licensed practical nurses, and respiratory therapists) and the mean annual number of occupied bed days.[34,35] Surgeon identifiers were not reported by the majority of Texas hospitals; therefore, analysis of surgeon volume was not possible.

Statistical Analysis

Many previous authors have categorized volume of procedures[2–4,6] whereas others have advocated analysis of volume as a continuous variable.[1,5,17,18] We categorized volume to facilitate decision-making by identifying a threshold above or below which action is appropriate. The cohort was divided into 3, approximately equal groups, such that each group contained at least 25% of patients and at least 5 hospitals, and hospitals with the same volume were in the same group. After this procedure, there were 105 low-volume hospitals (≤ 3 cystectomies performed annually), 23 moderate-volume hospitals (4–10 cystectomies performed annually), and 5 high-volume hospitals (> 10 cystectomies performed annually). This method resulted in the same thresholds used for the presentation of data in prior studies of cystectomy.[22]

Differences with regard to patient and hospital factors among the volume groups were tested univariately using the Pearson chi-square test for categoric variables and the Student t test for continuous variables. The impact of these factors on mortality and complication rates was examined using generalized estimating equations (GEE), with a compound symmetric working correlation matrix, to adjust for the clustering of multiple patients within hospitals. Because many patient and hospital factors are correlated, multiple-variable GEE models (with logit links) were developed to estimate the unique contribution of each factor to inpatient mortality and to the development of complications. Two sets of models were developed. The first model replicated previous analyses of volume-outcome correlations in cancer surgeries. Patient factors with a P value of less than 0.10 on univariate analysis and one hospital factor (annual volume of cystectomies) were examined using GEE to adjust for within-hospital correlation. In the second model, hospital factors with a P value less than 0.10 on univariate analysis were added. Finally, we developed a multiple-variable GEE model of failure to rescue using all patient and hospital factors. All multiple-variable models were adjusted for advanced age and comorbidities; all P values were two-sided.

RESULTS

During the 3-year study period, 1302 patients underwent cystectomy in 133 hospitals. As would be expected based on the epidemiology of bladder carcinoma, the majority of patients were males and nearly one- third were older than 75 years (Table 1). Most procedures were accompanied by lymph node dissection (70%). The majority of claims were coded for either ileal conduit (89%) or a continent form of bladder reconstruction (2%). However, in 120 cases, no urinary diversion procedure was coded. In all but

TABLE 2
Characteristics of Hospitals

Characteristic	Low volume (n = 105) value (95% CI)	Moderate volume (n = 23) value (95% CI)	High volume (n = 5) value (95% CI)	P value
% teaching hospital	37 (28–47)	74 (52–90)	100 (48–100)	< 0.001
Mean no. of beds (not critical care)	272 (224–320)	553 (425–682)	588 (217–959)	< 0.001
Mean % occupancy (not critical care)	57 (54–59)	59 (54–64)	69 (67–72)	0.08
Mean annual occupied bed days	56,328 (45,189–67,468)	116,960 (87,814–146,108)	149,656 (52,464–246,848)	< 0.001
Mean annual Medicare bed days	20,861 (16,935–24,788)	40,761 (29,671–51,851)	54,164 (14,350–93,979)	< 0.001
Mean no. of critical care beds	30 (24–35)	51 (37–65)	89 (20–158)	< 0.001
Mean % occupancy–critical care	65	72	74	0.16
Mean no. of RNs	261 (208–315)	543 (414–673)	912 (379–1445)	< 0.001
Mean no. of LPNs	83 (65–101)	153 (92–214)	89 (0–191)	0.01
RT-to-occupied bed ratio	0.14 (0.12–0.15)	0.14 (0.11–0.17)	0.10 (0–0.22)	0.57
RN-to-occupied bed ratio	1.6 (1.5–1.8)	1.7 (1.4–2.1)	2.3 (1.8–3.1)	0.04
LPN-to-occupied bed ratio	0.6 (0.5–0.7)	0.5 (0.3–0.7)	0.2 (0–0.5)	< 0.001
Mean annual surgical procedures	6,975 (o6,055–7,895)	17,348 (14,065–20,632)	28,260 (9,402–47,118)	< 0.001
% sole community hospital	3 (< 1–8)	0 (0–15)	0 (0–52)	0.66
% rural primary care hospital	10 (5–17)	0 (0–5)	0 (0–52)	0.24

95% CI: 95% confidence interval; RN: registered nurse; LPN: licensed practical nurse; RT: respiratory therapist.
Source of Data: Center for Medicare and Medicaid Services' Hospital Cost Report Information System. Provider of Services Files and the American Hospital Association Survey.

three of these cases, all six procedure fields were coded with other procedures, suggesting that urinary diversion procedures, particularly continent diversions, were underreported due to the number of procedures allowed in the data set. This limitation of the data also may apply to lymph node dissections.

Overall, 36% of patients were treated in 1 of the 5 high-volume hospitals, all of which are located in either Houston or Dallas, in the eastern portion of the state. High-volume hospitals typically treat more patients with advanced malignancies compared with community centers. However, the physical and financial ability to travel is often a condition of treatment in a high-volume center, particularly in a large state such as Texas (e.g., patients residing in west Texas are more than 600 miles from a high-volume center.) Therefore, it comes as no surprise that patients treated in high-volume hospitals were found to have fewer comorbidities ($P < 0.001$) than those treated at low-volume or moderate-volume hospitals (Table 1). Significantly more non-Hispanic whites were treated in high-volume hospitals compared with lower-volume hospitals, whereas Hispanic patients were treated more often in low-volume hospitals ($P < 0.001$). Approximately 49% of patients treated at low-volume hospitals lived within 100 miles of a high-volume hospital compared with 54% of patients treated at high-volume hospitals. The similarity of these findings suggests that factors other than geographic proximity may influence access to high-volume providers. Patients treated at moderate-volume hospitals were very similar to those treated at low-volume hospitals.

All the high-volume hospitals were teaching hospitals compared with 74% of the moderate-volume hospitals and only 37% of the low-volume hospitals ($P < 0.001$) (Table 2). On average, high-volume hospitals had more total beds and critical care beds than low-volume and moderate-volume hospitals. High-volume hospitals had 2.3 registered nurses per occupied bed compared with only 1.7 and 1.6 registered nurses per bed, respectively, in moderate-volume and low-volume hospitals ($P = 0.03$). Approximately 10% of low-volume hospitals were designated by the CMS as rural primary care hospitals and 3% as sole community providers. None of the moderate-volume or high-volume hospitals were found to have such designations.

Outcomes of Cystectomy

Twenty-eight patients (2.2%) died perioperatively. Inpatient mortality was significantly more frequent in low-volume hospitals compared with high-volume hospitals, whereas mortality in moderate-volume hospitals was intermediate (3.1% vs. 2.9% vs. 0.7%; $P = 0.04$). Only 3 of the 28 deaths occurred within 2 days of surgery; 68% occurred more than 1 week after surgery. Unlike high-risk cancer surgeries (i.e., esophagectomy), for which intraoperative mortality plays a major role, the majority of deaths after cystectomy were the result of failure to rescue after the development of postoperative complications.

One hundred ninety-five such complications were reported to have occurred in 155 patients (12%). Postoperative infections (bacteremia in 24 patients, wound infection in 25 patients, and pneumonia in 30 patients) were most common (41%). Thirteen patients required reopening of the surgical site. Twenty-six cardiovascular complications occurred (shock in 2 patients, cardiac arrest in 8 patients, myocardial infarction in 12 patients, and arrhythmias in 4 patients). Sixty-six patients developed pulmonary complications, primarily atelectasis. Eleven episodes of deep venous thrombosis were reported. Thirty-four patients had more than 1 complication. Among those who developed at least 1 complication, failure to rescue after complications was more common among patients in low-volume and moderate-volume hospitals compared with those in high-volume hospitals (13% vs. 6%), although this difference did not reach statistical significance after adjustment for clustering within hospitals ($P = 0.22$).

The mean length of hospitalization was significantly longer in low-volume and moderate-volume hospitals compared with high-volume hospitals (13 days, 13 days, and 11 days, respectively; $P = 0.009$). Transfer from high-volume hospitals most likely was not the cause of the shorter hospital stays because such patients were slightly less likely to be discharged to other hospitals (3.0%) than those in moderate-volume (4.5%) and low-volume (6.4%) hospitals ($P = 0.10$). More patients in high-volume (28.7%) and moderate-volume (24.5%) hospitals received home health care services after discharge compared with those treated in low-volume hospitals (20.5%), although this difference did not reach statistical significance ($P = 0.34$). Because these services may not have been available in communities with low-volume hospitals, longer hospitalizations may have been required. It is also possible that skilled nursing or intermediate-care facilities were used in such communities as an alternative to home healthcare services. Because the patients, mortality, complication rates, and length of stay were so similar between the low-volume and moderate-volume hospitals, those groups were combined for the remainder of the analysis.

TABLE 3
Correlation between Patient Factors and Risk of Mortality or Complications

Patient factors	No. of patients	Mortality		Complications	
		%[a]	P value	%[a]	P value
Male	992	2.4	0.34	13.5	0.27
Female	310	3.3		16.0	
NH white	1054	2.5	0.59	13.4	0.18
African American	71	2.7		14.9	
Hispanic	132	3.1		16.6	
Asian and others	45	3.4		18.5	
Age < 65 yrs	460	1.0	0.005	11.0	0.02
65–75 yrs	486	2.5		14.3	
> 75 yrs	356	4.5		16.9	
Comorbidity	395	3.5	0.14	18.4	0.001
No comorbidity	907	2.1		11.7	
Lymph node dissection	907	2.7	0.71	14.0	0.58
No lymph node dissection	395	2.5		14.6	
ZIP low income	853	2.9	0.51	13.8	0.65
ZIP high income	449	2.2		14.7	
ZIP low no. of English speakers	774	2.9	0.48	13.6	0.58
ZIP high no. of English speakers	528	2.2		14.7	
ZIP low level of education	797	2.7	0.70	13.4	0.39
ZIP high level of education	505	2.4		15.1	
Payor–commercial	428	2.4	0.60	12.4	0.06
Payor–Medicare	741	2.7		14.7	
Payor–Medicaid	25	3.0		17.3	
Payor–self	57	2.2		10.4	
Payor–others	51	3.4		20.2	
Plan–HMO	233	1.5	0.09	13.2	0.42
Plan–PPO	91	0.7		12.0	
Plan–fee-for-service	978	3.1		14.6	
Year–1999	428	3.2	0.30	14.1	0.99
Year–2000	418	2.6		14.1	
Year–2001	456	2.1		14.1	

NH: non-Hispanic; HMO: health maintenance organization; PPO: preferred provider organization.
[a] Adjusted for clustering within hospitals.
(Factors with a P value <0.10 were considered in subsequent multiple-variable models.)

Factors Associated with Mortality and Complications

Overall, mortality was significantly more common among the elderly ($P = 0.005$) (Table 3). This association was reflected in higher mortality rates for patients with Medicare and those with fee-for-service insurance plans. There was a nonsignificant trend toward higher mortality among patients with comorbid conditions. The risk profile for complications was similar to that for mortality, except that the presence of comorbidities was associated with a significantly higher risk of developing complications (18% vs. 12%; $P = 0.001$).

Both complications and mortality were more common in low-volume hospitals, particularly among for-profit hospitals (Table 4). The volume-outcome correlation observed among patients age > 65 years (mortality rate of 3.8% vs. 0.9%; $P = 0.03$) also applied to younger patients (mortality rate of 1.3% vs. 0.3%, $P = 0.02$, data not shown). It is interesting to note that although the absolute differences in mortality between high-volume and low-volume hospitals were found to vary by age, the relative differences, as measured by the odds ratio (OR), were identical (4.2 for both). The number of beds and annual occupancy did not appear to influence mortality and complication rates, but mortality rates were found to be significantly higher in hospitals with low registered nurse-to-occupied bed ratios. A similar pattern was observed for complication rates.

We developed two sets of multiple variable mod-

TABLE 4
Correlation between Hospital Factors and Risk of Mortality or Complications

Hospital factors	No. of hospitals	Mortality		Complications	
		%[a]	*P* value	%[a]	*P* value
Non-profit	43	0.4	0.13	6.3	0.04
For profit	90	2.6		13.4	
Teaching	61	2.1	0.24	13.4	0.57
Nonteaching	72	3.5		15.0	
High volume	5	0.7	0.04	9.0	0.01
Moderate volume	23	2.9		12.1	
Low volume	105	3.1		15.9	
Sole community provider	3	10.8	0.18	20.9	0.60
Not sole community provider	130	2.5		14.0	
Rural	10	2.6	0.84	14.0	0.78
Urban	123	3.2		16.0	
Many beds	29	3.0	0.60	12.0	0.11
Few beds	104	2.4		15.4	
Many critical care beds	42	2.7	0.96	13.0	0.51
Few critical care beds	91	2.6		14.8	
High occupancy	64	2.8	0.98	13.2	0.8
Low occupancy	69	2.6		15.0	
Many RNs per occupied bed	75	1.6	0.008	12.6	0.17
Few RNs per occupied bed	58	4.4		16.2	
Many LPNs per occupied bed	75	3.1	0.45	14.0	0.94
Few LPNs per occupied bed	58	2.3		14.2	
Many RTs per occupied bed	59	1.7	0.12	15.3	0.50
Few RTs per occupied bed	74	3.3		13.5	

RN = registered nurse; LPN = licensed practical nurse; RT = respiratory therapist.
[a] Adjusted for clustering within hospitals.
(Factors with a *P* value < 0.10 were considered in subsequent multiple-variable models.)

TABLE 5
Factors Associated with Inpatient Mortality–Multiple Variable Models, Adjusted for Advanced Age, Comorbidity, and Clustering within Hospitals

Factor	Risk of mortality		
	ORs	95% CI	*P* value
Patient factors and hospital volume tested			
Patient age ≥ 75 yrs	3.48	1.62–7.46	0.001
High-volume hospital	0.24	0.07–0.80	0.02
Comorbid conditions	1.73	0.80–3.70	0.16
Patient factors and all hospital factors tested			
Patient age ≥ 75 yrs	3.56	1.66–7.66	0.001
High-volume hospital	0.35	0.10–1.27	0.11
High RN-to-occupied bed ratio	0.43	0.19–0.97	0.04
Comorbid conditions	1.72	0.80–3.69	0.16

OR: odds ratio; 95% CI: 95% confidence interval; RN: registered nurse.

els using variables with P values < 0.10 on univariate analysis. Replicating previous volume-outcome studies, we tested patient factors (age, comorbidity, and payor) and one hospital factor (annual volume of cystectomies performed) in the first set of models. These analyses revealed that the risk of inpatient mortality was nearly 3-fold higher among elderly patients ($P = 0.001$) (Table 5). After accounting for the influence of age and comorbidity, patients who underwent cystectomy at high-volume hospitals were 76% less likely to die ($P = 0.02$).

In the second set of models, we tested patient factors, annual volume of cystectomies performed, and previously untested hospital factors. Again, elderly patients' risk of inpatient mortality were found to be significantly higher than that of younger patients ($P = 0.001$). High registered nurse-to-bed ratios were found to confer protective effects, reducing the mortality rate by greater than 50% ($P = 0.04$) and replacing the high annual volume of procedures in this model. All high-volume hospitals were found to have high nurse-to-patient ratios, but several lower-volume hospitals also had high nurse-to-patient ratios. Mortality among patients treated in well staffed, lower-volume hospitals was found to be significantly lower than that observed in lower-volume, poorly staffed hospitals (1.9% vs. 4.5%; $P = 0.04$), although not as low as that observed in high-volume hospitals (1.9% vs. 0.7%; $P = 0.07$). Although 37% of the patients in the current study lived more than 250 miles from a high-volume hospital, all patients lived within 250 miles of a hospital with a high nurse-to-patient ratio.

A similar analytic approach was used for complications. First, patient factors (age, comorbidity, and payor) were tested with the annual volume of cystectomies performed. That analysis revealed that the risk of developing a complication was significantly higher among patients with comorbid conditions (OR = 1.75; 95% confidence interval [95% CI], 1.2–2.5 [$P = 0.001$]) and was 47% lower among patients treated in high-volume hospitals (OR = 0.53; 95% CI, 0.3–0.8 [$P = 0.01$]). The addition of hospital-level factors did not improve the model.

Previous authors have argued that failure to rescue (death after a complication) is a better measure of quality of care than all-cause inpatient mortality, which may reflect a differing case mix. We developed a multiple-variable model of failure to rescue using both patient and hospital factors. In this analysis, a high registered nurse-to-bed ratio was associated with a 60% lower risk of failure to rescue (OR = 0.39; 95% CI, 0.1–0.8 [P = 0.03]). Treatment in a high-volume hospital (OR = 0.48; 95% CI, 0.08–2.97 [$P = 0.42$]), advanced age (OR = 2.01; 95% CI, 0.81–5.0 [$P = 0.13$]), and comorbid conditions (OR = 1.23; 95% CI, 0.48–3.1 [$P = 0.67$]) failed to achieve statistical significance in this analysis

DISCUSSION

More than 50,000 new cases of bladder carcinoma are diagnosed annually in the U.S. Approximately 20% of these tumors invade the muscle at the time of diagnosis. Among the remaining patients with superficial disease, 10–30% develop disease recurrence with muscle-invasive disease after initial therapy.[36,37] Cystectomy, the standard of care for patients with invasive bladder carcinoma, has been associated with a perioperative mortality rate of approximately 2%. Our population-based rate of 2.2% is consistent with published rates, and illustrates the moderate mortality risk of this procedure.[38,39]

Volume, Outcomes, and Staffing

Although the perioperative mortality risk is not high after cystectomy, the results of the current study suggest that a reduction in these mortality rates still may be possible. Clearly, patients treated at some hospitals enjoyed particularly good outcomes that can not be explained entirely by clinical and socioeconomic patient-level factors. A high annual volume of procedures performed is one characteristic of the hospitals with superior outcomes and, in this respect, the current study findings are consistent with previous studies of cystectomy and other cancer surgeries.[1–10,14–22,40] Based on the analysis of hospital volume, routine referral to high-volume centers appears appropriate. In fact, recent commentators have challenged that the volume-outcome association is so well established that a policy of referral to high-volume centers is justified for major cancer procedures.[9–11,13,41] Furthermore, recent reports suggest that regionalization of procedures has the potential to save many lives[42] and, when regionalization is implemented, it results in decreased mortality.[43] The results of the current study add to the growing body of literature suggesting that referral to a high-volume center is a prudent approach for patients who live locally. However, we argue that this most likely is neither feasible nor desirable for the large number of patients who are far removed from specialty centers. In many parts of the U.S., high-volume hospitals are too few and too far away to make widespread referral practical.

Our position echoes that voiced by other authors. Schrag et al. have suggested that although there is a modest benefit to colectomy performed in high-volume centers, the economic disadvantages of referral may be substantial.[17] Bach et al. pointed to the potentially negative effect of widespread referral on outcomes in high-volume centers, which could suffer due to overcrowding.[5] Previous authors also have stressed that referral of the most profitable procedures (including cancer procedures) to large centers could reduce general surgical capacity (which is subsidized by specialty surgical procedures) in rural areas.[44] In sum, there is mounting agreement that referral of all moderate-risk cancer surgeries most likely is logistically and financially impractical, despite its expected benefit. Referral outside the community also may be undesirable, posing both social and psychologic burdens for patients undergoing major surgery. Previous research has suggested that patients prefer to undergo surgery at local facilities, even if traveling to a regional center would confer a modest survival benefit.[45] These previous authors have joined the National Cancer Policy Board[12] in calling for research into the underlying explanations for the volume-outcome correlation. In addressing this issue, we believe the results of the current study provide intriguing hints of ways to improve cancer surgery outcomes in those cases in which referral to high-volume centers is impractical or undesirable.

We studied hospital factors and professional staffing levels and found that after adjustment for age and comorbidities, a high registered nurse-to-bed ratio was associated with a significantly lower mortality rate, particularly among patients who developed complications. Although to our knowledge this has not been studied previously in volume-outcome research, the conclusion is not unique to our research. Increased registered nurse staffing has been associated with lower postoperative complications,[34,46,47] a lower incidence of adverse events,[35] lower rates of failure to rescue after complications, and lower nosocomial infection rates.[48] These observations may be a direct result of nursing care, or increased registered nurse staffing may be a marker for other, unmeasured factors. However, based on the consistency of these findings, it appears that performing moderate-risk procedures in hospitals with high nurse-to-patient ratios could have a positive effect on perioperative mortality.

Implications for Quality Improvement

How might this observation be used to improve the quality of care? One method for ensuring that moderate-risk procedures are performed in well staffed hospitals involves referral to regional centers. Referral to the appropriate site of care is a strategy to improve the quality of care that can be implemented at the physician or health plan level. As previously noted, referral to high-quality centers often is neither feasible nor desirable. In fact, referral to high-quality centers has been difficult to achieve even when quality information is made public.[49–51] (The analysis of changes in market share after reports of cardiac surgery mortality

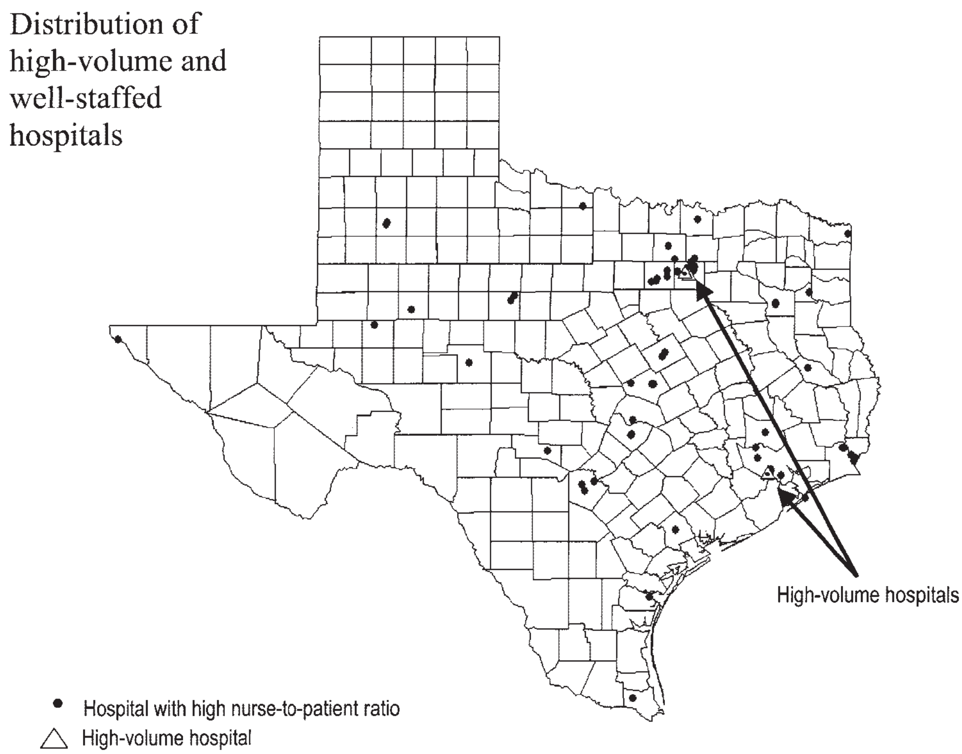

FIGURE 1. Geographic distribution of high-volume hospitals and hospitals with high nurse-to-patient ratios in Texas.

rates reported in 1998 by Mukamel and Mushlin is a notable exception.[52]) However, it is important to note that referral to *well staffed* hospitals may prove to be more feasible than referral to *high volume* hospitals. In the current study, although high-volume hospitals were confined to only two large metropolitan areas, there were well staffed hospitals throughout the state (Fig. 1). If this finding applies to other parts of the country, the referral of patients undergoing moderate-risk procedures to well staffed, lower-volume hospitals may provide a viable alternative to referral to the relatively few high-volume hospitals in the U.S.

The current study findings also point to measures for improvement in the quality of care at the hospital level. If confirmed in further studies of cystectomy and other moderate-risk cancer procedures, the association between high registered nurse staffing and low perioperative mortality suggests the importance of recruiting and retaining an adequate number of registered nurses in hospitals in which moderate-risk cancer procedures are performed. In an ideal world, all hospitals performing such procedures should meet or exceed the staffing levels of the well-staffed hospitals. However, given the recent shortage of registered nurses, increasing staffing will likely continue to be a challenge in the near term, particularly in rural hospitals. Although recent reports have suggested that employment growth has been strong among registered nurses employed in hospitals, the shortage persists.[53]

Limitations

We believe the current study differs from most previous volume-outcome studies in that we chose to use a statewide claims database rather than Medicare claims or the linked Surveillance, Epidemiology, and End Results (SEER)–Medicare files. This choice permitted us to study patients younger than 65 years, but limited our ability to study some questions (i.e., readmission, longer-term survival) because longitudinal data were unavailable. This lack of longitudinal data also may have limited our ability to identify chronic comorbid conditions. Previous research has indicated that the sensitivity of claims data for comorbid conditions is improved by using multiple inpatient and outpatient claims. Because we were unable to use multiple claims, it is possible that comorbid conditions were underreported in the current study. However, concern about this possibility is reduced by the similarity of the prevalence of comorbid conditions reported in the current study (30%) to prevalence rates reported in previous studies of cystectomy based on multiple Medicare claims (approximately 34–40%).[22]

Claims also are imperfect sources of data regarding complications, a primary endpoint in the current analysis. Although the complications reported herein were chosen for their high sensitivity and specificity in comparisons with surgical procedures listed on Medicare claims from general hospitals, to our knowledge they have not been validated among claims for cancer surgeries in Texas. Inaccuracies in these claims could invalidate the findings of the current study with respect to the complication outcome.

Surgeon identifiers were unavailable in this data set. Based on reports by Birkmeyer et al., in which surgeon volume accounted for approximately 39% of the volume-outcome correlation noted among Medicare recipients undergoing cystectomy, this could be a significant limitation.[22] In previous studies addressing both surgeon and hospital volume, the correlation between surgeon volume and hospital volume was high. If surgeon volume positively influences outcomes and is correlated with a high hospital volume and/or high nurse-to-patient ratios, our failure to examine this factor would result in an overestimation of the significance of these factors. Based on previous studies, the likelihood of this bias is high in the case of hospital volume, but less clear in the case of high nurse-to-patient ratios, which occurred frequently among lower-volume hospitals, in which high-volume surgeons are less likely to practice.

Conclusions

Treatment at a high-volume hospital appears to confer a modest, but statistically significant, survival benefit for patients who undergo cystectomy for bladder carcinoma. Referral to a hospital performing more than 10 cystectomies annually is indicated for patients who have access to high-volume centers, which also may provide long-term survival benefits from the multidisciplinary planning and treatment available at such centers. Among patients who do not have access to high-volume hospitals, treatment in a local hospital with a high nurse-to-patient ratio may confer a similar benefit. However, further study is required to confirm these findings.

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