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High Radical Prostatectomy Surgical Volume is Related to Lower Radical Prostatectomy Total Hospital Charges

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Abstract

Objective: To test the hypothesis that individual surgical volume (SV) is an independent predictor of radical prostatectomy (RP) total charges.
Methods: We used the Florida State Inpatient Data File. ICD-9 codes 60.5 (RP) and 185 (prostate cancer) identified all men treated with RP for prostate cancer between January 1 and December 31, 1998. Among 1,923,085 records, 3167 RPs were selected. SV represented the predictor. Total RP charges represented the outcome. Age, race, and comorbidity represented covariates. Univariate and multivariate linear regression models were used.
Results: All 3167 RPs were performed by 81 surgeons. SV ranged from 2 to 162 (mean, 68). Charges were \$4755 to \$140,201 (mean, \$18,200). In the multivariate model, each SV increment corresponding to one RP reduced hospital charges by \$25 ($p \leq 0.001$).
Conclusions: Redistribution of RPs from low to high SV users could result in significant savings. For example, \$4 million could be saved if 1000 RPs were redistributed from surgeons with an SV of 18 to surgeons with an SV of 200.

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1. Introduction

Several studies addressed the relationship between surgical volume (SV) and health indicators in an attempt to support the ''practice makes perfect'' hypothesis [1–6]. Birkmeyer et al. [1] found that mortality decreased as hospital volume increased for 14 types of procedures, including cystectomy and

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nephrectomy. The premise stating that higher patient volume will lead to greater expertise and that greater expertise may translate into better outcomes was confirmed in several analyses. These focused on major surgical procedures, such as esophagectomy, pancreaticoduodenectomy, craniotomy for cerebrovascular aneurysms, and pelvic exenteration [2]. However, when less complex procedures, such as cholecystectomy or arthroplasty, were analysed, the relationship between volume and outcome could no longer be shown. In addition to health outcomes, several studies focused on the relationship between patient volume and variables defining hospital charges and length of stay (LOS) associated with medical and surgical interventions [4–6]. Their findings suggest that high patient volume may reduce charges and LOS. However, radical prostatectomy (RP) total charges received less attention and only one study addressed the relationship between RP hospital volume and total charges [5]. We hypothesized that low RP surgical volume is a significant determinant of high RP total charges, after accounting for the confounding effects of age, race, and comorbidity. To test this hypothesis, we assessed the effect of individual surgeon volume on total RP charges, using the 1998 State of Florida Inpatient Data File.

2. Methods

We used the January 1 to December 31, 1998 State of Florida Inpatient Discharge Information Data File. The database contains information abstracted from patient medical records after discharge. Exceptions include free-standing psychiatric, rehabilitation, Veterans Administration, Bureau of Indian Affairs, and state-operated hospitals. Data collection in the participating institutions represents a mandatory process and is performed by trained professional coders. Prior to being made available to interested parties, data are audited for errors.

Elements of the data file that were made available to us consisted of patient identifiers, diagnosis and procedure identifiers, and an encrypted surgeon identifier. Diagnosis and procedure identifiers consisted of the principal diagnosis codes and the principal procedure codes. Patient identifiers consisted of age at admission, race, and comorbidity. Age was defined in years. Race was defined as white or other. Comorbidity was defined according nine secondary ICD-9 diagnostic codes. These were converted to the Charlson comorbidity index using the D'Hoore method, which was specifically developed for use with ICD-9 diagnostic codes found in administrative data [7].

The ICD-9 diagnostic and procedure code, respectively, identified 3167 patients treated with RP (ICD-9 60.5) for prostate cancer (ICD-9 185). The encrypted surgeon identifier allowed us to determine the SV for each urologic surgeon who performed at least one RP. SV represented the predictor variable. Total charges in dollars for the procedure and hospitalisation, which were made available in the database, represented the outcome variable. Covariates consisted of age, race and comorbidity. Because the predictor and outcome variables represent continuously coded data, we used univariate and multivariate linear regression models to test the relationship between the predictor and the outcome. All data were modeled without transformations, because all distributions approximated the normal distribution, with the exception of hospital charges where a slight right-sided tail was noted. To comply with methodology used in similar analyses and based on the robustness of the normal theory, we relied on linear regression without data transformation [4]. All statistical tests were performed using the Statistical Package for Social Sciences version 10 (SPSS, Chicago, IL) and a two-sided statistical significance level of 0.05 was used.

3. Results

Between January 1 and December 31 1998, 3167 RPs were performed in participating Florida hospitals. Individual SV ranged from 2 to 162 RPs (mean, 68 with standard deviation [SD] 41) and is shown in Table 1. Average patient age was 63.5 yr (range, 38–83 yr). The majority (77.3%) of patients were white. Of all diagnostic codes used to define the Charlson comorbidity score, three code groups predominated. Hypertension and secondary hypertension were recorded in, respectively, 56.0% and 21.5% of patients. Unspecified effects of radiation, which include sunburns, were recorded in 8.6%. Other diagnostic codes were found in ≤5% of the population. Hospital charges ranged from $4755 to $140,201 (mean, $18,200; median, $16,600). The univariate

Table 1 – Descriptive statistics

Variable	
Individual surgeon surgical volume	
Mean (SD)	68 (41)
Range	2–162
Age, yr	
Mean (SD)	63 (7)
Range	38–83
Race	
White, %	77.3
Hospital charges (US $)	
Mean (SD)	18,200 (8100)
Range	4755–140,201
ICD-9 comorbidity codes, %	
Hypertensive renal disease (403)	56
Secondary hypertension (405.3, 405.9)	21.5
Hypertensive heart disease (402.9)	5.1
Rheumatic fever (390, 391)	4.2
Hepatitis (573.2)	2.8
Hearing loss (389.3, 389.0)	2.0
Others	<1

Table 2 – Univariate and multivariate linear regression models of the association between surgical volume and total hospital charges

Predictors	Univariate[a]		Multivariate[b]	
	Regression coefficient	*p* value	Regression coefficient	*p* value
Surgical volume	**−26.5**	**≤0.001**	**−25.0**	**≤0.001**
Age	−0.0001	0.8	0.0003	0.4
Race	0.06	≤0.001	0.06	≤0.001
Comorbidity	−0.008	0.08	−0.005	0.2

[a] In univariate linear regression analysis surgical volume represents a predictor of radical prostatectomy hospital charges ($p < 0.001$). For each increment in surgical volume corresponding to one radical prostatectomy hospital charges are expected to decrease by $26.50.
[b] In multivariate linear regression analysis, surgical volume also represents a predictor of radical prostatectomy hospital charges ($p < 0.001$), after adjusting for age, race, and comorbidity. For each increment in surgical volume corresponding to one radical prostatectomy hospital charges are expected to decrease by $25.00.

relationship between SV and hospital charges is shown in Fig. 1. Table 2 shows the univariate linear regression models, where SV was inversely related to hospital charges. The negative regression coefficient (−26.5) indicates that a 1-unit increase in the predictor variable (one RP increase on the SV scale) is associated with a 26.5-unit decrease on the outcome scale ($26.50 decrease in total charges). In the multivariate model, the relationship between SV and hospital charges was adjusted for age, race, and comorbidity, coded according to the Charlson index. The multivariate regression coefficient indicates that a SV increase corresponding to one RP is associated with a $25 decrease in hospital charges.

We explored the impact of varying SV on total charges in a hypothetical cohort of 1000 RP patients. According to the multivariate regression coefficient, the difference in hospital charges for one patient operated by a surgeon performing 50 RPs annually versus one performing 10 RPs is $1000, or 40 times

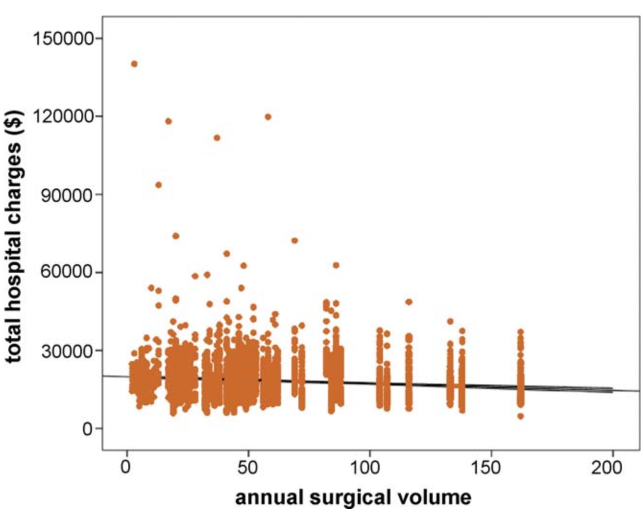

Fig. 1 – Distribution of total hospital charges, in United States dollars ($), according to annual surgical radical prostatectomy volume in the State of Florida.

$25. This corresponds to a saving of $1,000,000, if the individual amount is applied to 1000 patients. In 1997, 18 RPs represented the national average [8]. If 1000 RPs were performed by 10 surgeons with an SV of 100, instead of surgeons with an SV of 18, a saving of $2,050,000 could be expected. If the same 1000 RPs were performed by surgeons with an annual SV of 200 RPs, instead of surgeons with an SV of 18, a saving of $4,550,000 could be expected. The least important saving would correspond to an SV difference of one RP, or $25, which would result in an economy of $25,000, if applied to 1000 patients.

Table 2 also demonstrates the effect of other variables on total charges. Age was not statistically associated with total charges in either univariate ($p = 0.8$) or multivariate models ($p = 0.4$). Although, RP in nonwhite patients was associated with higher total charges ($0.06, $p \leq 0.001$), in univariate and multivariate analyses, the magnitude of this effect was not practically meaningful. Finally, the rare occurrence of comorbidities, except for frequent presence of hypertension diagnostic codes, resulted in a nonsignificant effect of comorbidity on total charges in univariate ($p = 0.08$) and multivariate analysis ($p = 0.2$). Taken together these findings indicate that of all variables examined in the multivariate model, SV clearly represents the only important determinant of total charges.

4. Discussion

Prostate cancer is the most frequent male malignancy and the second leading cause of male cancer-related deaths [9]. United States data for 2005 indicate 232,090 new cases and 30,350 prostate cancer deaths [10]. These incidence and prevalence figures translate into important economic implications, as evidenced by cumulative annual charges of $1,720 billion for RPs performed in the United States, based on average charges of $20,000 [11]. In the context of increasing health care budgetary constraints, health care cost control should represent a public health priority.

We addressed the relationship between SV and RP total charges in the State of Florida. Our results demonstrated that an increase in annual SV corresponding to one RP was related to a $25 decrease in total RP charges. This rate was statistically significant after adjusting for age, race, and comorbidity ($p \leq 0.001$).

Although, savings related to an increase in SV corresponding to one RP are small ($25), the relation between SV and total charges is very significant if it is applied to a large pool of RP users. To further explore this hypothesis, we calculated the projected savings for a hypothetical cohort of 1000 RPs and made comparisons with the 1997 United States SV RP average, which consisted of 18 RPs [8]. If all 1000 surgeries were performed by surgeons with an SV of 100 RPs versus 18 RPs, a saving of over $2 million could be expected. If all RPs were redistributed to surgeons with an SV of 200 RPs, a saving of $4.5 million could be expected. The least savings could be realized if surgeries were relegated to surgeons with an annual SV of 19 RPs, an SV increase corresponding to one RP, under which condition only $25,000 could be saved. These estimates are realistic, because the United States annual SV average corresponds to 18 RPs and many RPs could be readily redistributed to higher SV users [8].

Our findings add to the existing body of evidence, which addresses the relationship between SV and various outcome indicators. Several previous studies addressed the ''practice makes perfect'' hypothesis, and several confirmed that high SV and surgical expertise lead to superior results [12–16]. Based on these SV versus outcome considerations, procedures of greater complexity, such as coronary bypass grafts, have been redistributed to high-volume centres [17]. However, recent findings suggested that third variables may confound or contribute to the relation between SV and outcomes. These may include surgical learning curve, ongoing improvements in surgical training, and ongoing technical advances [17]. Thus, future studies need to account for these possible confounders. Moreover, future studies need to explore the most significant variables that underlie and explain the relation between SV and various health outcomes.

The limitations of our study pertain to a possible selection bias of our patient sample. All patients were treated by urologic surgeons from a geographic area with high RP volume, which exceeds the national average [8]. This may have enabled us to confirm the presence of an important and clinically significant relationship between RP SV and total charges. We believe that this relationship may be more difficult to demonstrate in patient samples, where SV range is narrower, and where economic outcomes differences may not be as pronounced. It is also important to notice that our findings are most applicable to large patient cohorts, because our original findings are derived from a population of patients treated within an entire state.

Moreover, our findings may not apply to geographic areas where charges differ from costs in the United States. For example, in Canada surgical fees and charges related to hospital stay are lower. Within the United States, important differences in charges may relate to individual agreements between health care providers and payers. Moreover, charges in the State of Florida may differ from those in other states. Additionally, the calculation of total charges may differ between geographic areas as well as between individual hospitals. This variability may have affected our results. If so, it is, however, impossible to know what was the direction of its effect.

Finally, we have not been able to address the effect of hospital volume because this variable was not available in the database. It could be postulated that inclusion of hospital volume in our analyses could confirm previous analyses, where surgeries performed in high-volume centres were associated with lower cost [18]. Moreover, an interaction may exist between surgeon volume and hospital volume. High-volume surgeons may have a stronger effect on reduction of total charges, if surgeries are performed in high-volume hospitals, where cost containment is coordinated at several levels.

Although our findings confirm that high SV is associated with better outcomes, it needs to be stressed that any statistical model only represents an approximation of the reality. Moreover, the trends reported in statistical analyses represent central tendencies and do not invariably perfectly fit all observations. Lack of fit may apply to some low volume surgeons, whose surgeries were associated with low total charges. Conversely, some RPs performed by high-volume surgeons were associated with high total charges. Finally, in real life projected savings are not always realised and projected savings do not always accrue in a linear fashion.

Our findings suggest that RPs should be redistributed to high-volume users. However, such practice may not always be possible. For example, in rural areas practicing urologists may be compelled to perform a large variety of surgical procedures, instead of focusing on one or few surgeries. Similarly, surgeons with capacity for becoming high RP volume surgeons may not always have the capacity or the motivation to increase their RP surgical volume. For example, logistic limitations related to operating room availability may not allow increases in SV. Therefore, despite best intentions redistribution of patients from low-volume to high-volume RP users may not always be possible.

5. Conclusion

Our data demonstrate that high RP SV is related to lower charges. Redistribution of RPs from low- to high-volume users could result in significant savings of health dollars.

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Editorial Comment

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Will volume-based referral strategies reduce costs or just save lives?

For many elective high-risk surgical procedures, high-volume hospitals have been shown to have much lower operative morbidity and mortality rates than low-volume centers. This volume-outcome relationship has been remarkably consistent over time and across studies. A recent literature review revealed that 96% of studies encompassing over 40 different surgical procedures found lower mortality rates at high-volume hospitals [1]. These findings have led to consumer-oriented volume-based referral strategies. In the United States, for example, both the media and several large advocacy groups are emphasizing the importance of volume with different procedures and providing patients with information about volume at nearby hospitals [2,3]. The non-profit Leapfrog Group, a coalition of more than 100 Fortune 500 employers and public-sector purchasers, is emphasizing volume standards for coronary artery bypass graft surgery, coronary angioplasty, carotid endarterectomy, abdominal aortic aneurysm repair, and esophagectomy (www.leapfroggroup.org). In addition to being patient-based, volume based referral strategies can also be regulatory in nature. For example, individual states are mandating incorporation of volume standards in certificate-of-need applications for new surgical centers. Although these efforts may reduce surgical mortality, the economic implications of volume-based referral strategies have not been fully considered.

The limited healthcare resources in every country and rising costs of health care require better utilization of volume resources. I want to congratulate Karakiewicz and colleagues for assessing the effect of radical prostatectomy volume on total cost at hospital discharge. The authors demonstrate that the cost of this procedure decreases with increasing individual surgical volume. This article is an important and timely source of information that can guide decisions made by prostate cancer researchers, physicians, patients, and other clinical decision-makers. However, like all other volume–outcome studies, this study does not use risk adjustment. A frequent argument against the validity of the volume–outcome relationship is that low-volume hospitals tend to treat sicker patients who are socially disadvantaged and have more co-morbidities.

Although the hospital volume and outcome relationship has been established, the underlying causes that produce the association between volume and outcome are still largely unknown. Volume is most likely a surrogate measure for higher quality of care. Important structural components at the physician level include experienced surgeons and health care professionals who implement standardized selection criteria, operative management and postoperative care. Surgeons at high-volume facilities have the ability to refine surgical techniques and thereby improve outcomes, representing the ''the more you do, the better you are at it'' hypothesis, and by extension are ''less likely to make a mistake.'' The presence of an experienced surgical team improves the patient selection process and peri-operative clinical decision-making, which results in a lower rate of medical errors and thereby lowers morbidity, mortality, and cost.

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