

Impact of Robotic Technique and Surgical Volume on the Cost of Radical Prostatectomy

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Abstract

Background and Purpose: Our present understanding of the effect of robotic surgery and surgical volume on the cost of radical prostatectomy (RP) is limited. Given the increasing pressures placed on healthcare resource utilization, such determinations of healthcare value are becoming increasingly important. Therefore, we performed a study to define the effect of robotic technology and surgical volume on the cost of RP.

Methods: The state of Maryland mandates that all acute-care hospitals report encounter-level and hospital discharge data to the Health Service Cost Review Commission (HSCRC). The HSCRC was queried for men undergoing RP between 2008 and 2011 (the period during which robot-assisted laparoscopic radical prostatectomy [RALRP] was coded separately). High-volume hospitals were defined as >60 cases per year, and high-volume surgeons were defined as >40 cases per year. Multivariate regression analysis was performed to evaluate whether robotic technique and high surgical volume impacted the cost of RP.

Results: There were 1499 patients who underwent RALRP and 2565 who underwent radical retropubic prostatectomy (RRP) during the study period. The total cost for RALRP was higher than for RRP (\$14,000 *vs* 10,100; $P < 0.001$) based primarily on operating room charges and supply charges. Multivariate regression demonstrated that RALRP was associated with a significantly higher cost (β coeff 4.1; $P < 0.001$), even within high-volume hospitals (β coeff 3.3; $P < 0.001$). High-volume surgeons and high-volume hospitals, however, were associated with a significantly lower cost for RP overall. High surgeon volume was associated with lower cost for RALRP and RRP, while high institutional volume was associated with lower cost for RALRP only.

Conclusions: High surgical volume was associated with lower cost of RP. Even at high surgical volume, however, the cost of RALRP still exceeded that of RRP. As robotic surgery has come to dominate the healthcare marketplace, strategies to increase the role of high-volume providers may be needed to improve the cost-effectiveness of prostate cancer surgical therapy.

Introduction

ROBOT-ASSISTED LAPAROSCOPIC RADICAL PROSTATECTOMY (RALRP) has risen in popularity in the last decade and has supplanted open surgery as the dominant surgical approach to prostate cancer in the United States.^{1,2} This transition has occurred despite the higher cost^{2–4} and unclear clinical benefits of robotic surgery.^{5,6} While there has been no level-one evidence comparing open and RALRP, there have been large observational studies that have yielded mixed results. RALRP has been shown to be associated with decreased blood loss, fewer perioperative complications, and shorter length of stay,^{5–9} but has also been associated with higher rates of salvage therapy and worse functional outcomes.⁹ Ultimately, there is no rigorous evidence supporting one

procedure over the other⁷; rather, there is growing sentiment that high-volume surgeons produce excellent results by either approach.^{5,10}

Multiple studies of open surgery have demonstrated that increased surgeon volume is associated with superior oncologic results,^{11,12} decreased length of stay, and fewer perioperative complications.^{10,13–15} Hospital volume has also been found to be associated with decreased length of stay and postoperative complication rates.^{13,15,16} There has been limited work performed, however, on the association between robotic surgical volume and both clinical outcomes and healthcare costs. It may be that a high surgical volume of RALRP will be associated with overall decreased costs, because of greater progression through the learning curve and streamlined clinical pathways.

To evaluate this hypothesis, we performed a study to evaluate the effect of robotic surgery and surgical volume on the cost of radical prostatectomy (RP) using a prospectively collected, statewide administrative database.

Methods

The state of Maryland mandates that all acute-care hospitals report encounter-level and hospital discharge data to the Health Service Cost Review Commission (HSCRC). This discharge database includes clinical, demographic, and billing data on all inpatient discharges from 51 nonfederal hospitals (94% of hospitals in Maryland). The HSCRC was queried for men undergoing RP between 2008 and 2011 (the period during which RALRP was coded separately). Patients were categorized as undergoing radical retropubic prostatectomy (RRP) or RALRP. High-volume hospitals were defined as >60 cases per year, while High-volume surgeons were defined as those performing >40 cases per year. These parameters have been used in previous analyses of the volume-outcomes relationship for RP.¹³ Multivariate linear regression was performed to evaluate whether robotic technique, surgeon volume, and hospital volume impacted the cost of RP.

No patients were excluded. All monetary values were adjusted to 2011 dollars, and all values were presented as 1000s of dollars. STATA software (College Station, TX) was used for basic statistical and linear regression analysis.

Results

During the study period, 1499 patients underwent RALRP and 2565 underwent RRP (Table 1 for demographic and outcomes data for the two groups). No demographic or disease-specific data were available within the HSCRC database.

Overall, the cost of care for RALRP was higher than for RRP (\$14,000 vs \$10,100; $P < 0.001$). This was based primarily on operating room charges and supply charges (Table 2). Multivariate linear regression demonstrated that RALRP was associated with a significantly higher cost overall compared

with RRP (β coeff 4.1; $P < 0.001$), even at high-volume hospitals (β coeff 3.3; $P < 0.001$) and at the highest volume hospital in Maryland (β coeff 3.5; $P < 0.001$).

High-volume surgeons and high-volume hospitals were associated with a significantly lower cost for RP overall ($P < 0.001$) (Table 3). Importantly, high surgeon volume was associated with decreased cost at High-volume hospitals (β coeff -1.2 ; $P < 0.001$), as well as at the highest volume hospital (β coeff -0.6 ; $P = 0.009$). Thus, high surgeon volume was an independent predictor of lower cost of RP. For RRP specifically, high surgeon volume was associated with decreased cost (β coeff -1.59 ; $P < 0.001$), but high institutional volume was not (β coeff 0.06; $P = 0.81$) (Table 4). For RALRP specifically, both high surgeon (β coeff -0.54 ; $P = 0.009$) and high institutional volume (β coeff -4.12 ; $P < 0.001$) were associated with decreased cost (Table 5).

Discussion

Our data demonstrate that (1) high surgeon and institutional volume are associated with decreased hospitalization costs for RP overall; (2) for RRP, high surgeon volume was associated with decreased cost (institutional volume was not); (3) for RALRP, both high surgeon and high institutional volume were associated with decreased cost; and (4) even at hospitals with the highest surgical volume, RALRP is still associated with higher cost than RRP.

The relationship between high surgical volume and decreased costs is unsurprising, given the known association between volume and clinical outcomes. A high-volume surgeon is likely to have progressed through his/her learning curve with associated improvements in operative times, blood loss, and reduction in technical complications—eg, urine leak. Literature clearly supports the relationship between high surgeon volume and improved perioperative outcomes, including lower risk of transfusion, fewer postoperative complications, and decreased length of stay.^{11–13,16,17} This relationship has been noted for minimally invasive techniques

TABLE 1. DEMOGRAPHIC AND OUTCOME DATA FOR PATIENTS UNDERGOING RADICAL PROSTATECTOMY IN MARYLAND FROM 2008 TO 2011 STRATIFIED BY OPERATIVE APPROACH

Variable	Patients undergoing RALRP N = 1499	Patients undergoing RRP N = 2565	Comparison (P value)
Age	59.3 (38–76)	59.2 (38–80)	0.57
Race			0.10
Caucasian	76.2% (1141)	78.8% (2022)	
African-American	18.9% (284)	16.4% (419)	
Other	4.9% (74)	4.8% (124)	
Patient complexity level			0.06
1	59.5% (892)	60.2% (1545)	
2	37.4% (560)	37.9% (972)	
3	2.9% (43)	1.6% (41)	
4	0.2% (4)	0.2% (7)	
LOS (days)	1.7 (1–17)	1.9 (1–23)	<0.001
ICU stay	1.3% (19)	1.6% (42)	0.35
% High-volume surgeon	50.6% (759)	71.2% (1826)	<0.001
% High-volume hospital	74.8% (1122)	83.3% (2136)	<0.001
% Medicare/Medicaid	19.7% (296)	20.3% (540)	0.32

RALRP=robot-assisted laparoscopic radical prostatectomy; RRP=radical retropubic prostatectomy; LOS=length of stay; ICU=intensive care unit.

TABLE 2. HOSPITAL CHARGES TO PATIENTS UNDERGOING ROBOT-ASSISTED LAPAROSCOPIC RADICAL PROSTATECTOMY AND RADICAL RETROPUBIC PROSTATECTOMY IN MARYLAND FROM THE FOURTH QUARTER OF 2008 TO THE FIRST QUARTER OF 2011*

Variable	Patients undergoing RALRP N=1499	Patients undergoing RRP N=3947	Comparison (P value)
Total charge	14.0	10.1	<0.001
Operating room charge	6.8	4.3	<0.001
Room and board charge	2.6	3.2	<0.001
Radiology charge	0.04	0.04	0.75
Drug charge	0.15	0.17	0.003
Laboratory charge	0.7	0.9	<0.001
Supply charge	3.5	1.4	<0.001
Therapy charge	0.03	0.02	0.14
Other charges	0.05	0.03	<0.001

*Charges presented in 1000s, 2011 U.S. dollar increments.

RALP=robot-assisted laparoscopic radical prostatectomy; RRP=radical retropubic prostatectomy.

as well as for open surgery.¹⁰ It is intuitive that these improved outcomes would be associated with decreased costs.

We found that institutional volume was also associated with decreased cost of RP. Because institutions have their own “learning curve” for treating patients and managing convalescence, high-volume hospitals may have more refined postoperative pathways—eg, encouraging prompt ambulation, transitioning patients from intravenous to oral pain medication, etc. Indeed, “pathway” driven care has been

shown to reduce length of stay without compromising outcomes in other surgical settings.¹⁸ An association between hospital RRP volume and decreased length of stay has been shown in previous studies.^{16,19} Conversely, one study did show that hospital volume was not a significant predictor of length of stay after RRP when adjusting for physician volume.¹³ Because our data demonstrate that hospital volume was not independently associated with lower cost of RRP but rather for RALRP only, it may be that greater institutional

TABLE 3. UNIVARIATE AND MULTIVARIATE REGRESSION MODELS PREDICTING TOTAL COST PER RADICAL PROSTATECTOMY IN MARYLAND HOSPITALS FROM 2008 TO 2011

Variable	Univariate	P value	Multivariate	P value
Age	0.02 (−0.01–0.04)	0.20	−0.02 (−0.04–0.002)	0.08
Race				
Caucasian	Ref	Ref	Ref	Ref
African-American	1.92 (1.48–2.35)	<0.001	0.18 (−0.11–0.47)	0.23
Other	0.76 (−0.0002–1.52)	0.05	0.14 (−0.36–0.64)	0.58
Patient complexity				
1	Ref	Ref	Ref	Ref
2	1.27 (0.96–1.58)	<0.001	0.39 (0.17–0.62)	0.001
3	7.81 (6.76–8.87)	<0.001	1.0 (0.21–1.82)	0.01
4	37.16 (34.30–40.03)	<0.001	8.2 (5.79–10.66)	<0.001
LOS	2.68 (2.56–2.79)	<0.001	2.3 (2.18–2.40)	<0.001
ICU	13.23 (11.94–14.51)	<0.001	4.3 (3.37–5.31)	<0.001
Robotic Approach	3.95 (3.63–4.27)	<0.001	4.1 (3.84–4.30)	<0.001
High-volume hospital	−4.56 (−4.94–−4.17)	<0.001	−2.0 (−2.37–−1.67)	<0.001
High-volume surgeon	−3.67 (−4.0–−3.35)	<0.001	−1.0 (−1.30–−0.70)	<0.001
Medicare/Medicaid	0.60 (0.20–1.01)	0.004	0.23 (−0.08–0.54)	0.14

LOS=length of stay; ICU=intensive care unit.

TABLE 4. UNIVARIATE AND MULTIVARIATE REGRESSION MODELS PREDICTING TOTAL COST OF RADICAL RETROPUBIC PROSTATECTOMY IN MARYLAND HOSPITALS FROM 2008 TO 2011

<i>Variable</i>	<i>Univariate</i>	<i>P value</i>	<i>Multivariate</i>	<i>P value</i>
Age	-0.0004 (-0.03-0.03)	0.98	-0.03 (-0.05- -0.002)	0.03
Race				
Caucasian	Ref	Ref	Ref	Ref
African-American	1.6 (1.07-2.13)	<0.001	0.08 (-0.30-0.46)	0.68
Other	0.45 (-0.46-1.36)	0.34	0.17 (-0.47-0.81)	0.60
Patient complexity				
1	Ref	Ref	Ref	ref
2	1.24 (0.87-1.60)	<0.001	0.27 (-0.01-0.56)	0.06
3	8.34 (6.92-9.77)	<0.001	1.31 (0.16-2.46)	0.03
4	36.56 (33.17-39.95)	<0.001	6.09 (3.04-9.13)	<0.001
LOS	3.01 (2.89-3.13)	<0.001	2.48 (2.33 0 2.62)	<0.001
ICU	15.10 (13.67-16.53)	<0.001	4.96 (3.75-6.17)	<0.001
High-volume hospital	-3.61 (-4.12- -3.10)	<0.001	0.06 (-0.44-0.57)	0.81
High-volume surgeon	-3.52 (-3.3- -3.11)	<0.001	-1.59 (-2.0-1.17)	<0.001
Medicare/Medicaid	0.40 (-0.08-0.88)	0.10	0.31 (-0.09-0.70)	0.13

LOS=length of stay; ICU=intensive care unit.

TABLE 5. UNIVARIATE AND MULTIVARIATE REGRESSION MODELS PREDICTING TOTAL COST OF ROBOT-ASSISTED LAPAROSCOPIC RADICAL PROSTATECTOMY IN MARYLAND HOSPITALS FROM 2008 TO 2011

<i>Variable</i>	<i>Univariate</i>	<i>P value</i>	<i>Multivariate</i>	<i>P value</i>
Age	0.04 (0.002-0.07)	0.04	0.003 (-0.03-0.03)	0.82
Race				
Caucasian	Ref	Ref	Ref	Ref
African-American	1.98 (1.36-2.60)	<0.001	0.45 (0.01-0.88)	0.04
Other	1.14 (0.02-2.26)	0.05	0.25 (-0.51-1.00)	0.52
Patient complexity				
1	Ref	Ref	Ref	ref
2	1.34 (0.88-1.79)	<0.001	0.53 (0.19-0.88)	0.002
3	6.21 (4.90-7.52)	<0.001	0.67 (-0.40-1.74)	0.22
4	38.24 (34.04-42.43)	<0.001	10.63 (6.73-14.53)	<0.001
LOS	2.53 (2.37-2.7)	<0.001	2.16 (1.98-2.33)	<0.001
ICU	9.84 (7.71-11.97)	<0.001	2.57 (1.0-4.14)	0.001
High-volume hospital	-4.74 (-5.25- -4.23)	<0.001	-4.12 (-4.58- -3.65)	<0.001
High-volume surgeon	-2.23 (-2.71- -1.76)	<0.001	-0.54 (-0.95- -0.13)	0.009
Medicare/Medicaid	1.17 (0.56-1.78)	<0.001	0.13 (-0.25-0.60)	0.59

LOS=length of stay; ICU=intensive care unit.

familiarity with RRP contributed to less fluctuation of cost with changes in volume at the institutional level.

There has been limited direct study of the relationship between surgical volume and the cost of RP. Budaus and colleagues²⁰ retrospectively evaluated total hospital charges for minimally invasive RP (MIRP), including both robotic and laparoscopic procedures, as a function of surgeon experience using a statewide database in Florida between 2002 and 2008. Multivariate analysis determined that high surgeon experience reduced the likelihood of charges above the median by 68%. The same group studied the impact of surgeon caseload on total hospital charges for MIRP *vs* RRP for Florida patients in 2008.²¹ These authors found that while higher surgeon volume decreased hospital charges for both procedures, hospital charges for MIRP were more sensitive to a caseload effect (ie, high surgeon volume had a greater effect on hospital charges compared with open surgery). The authors concluded that this was likely because of the greater complexity of MIRP, as well as a more long-standing experience with the open approach, as discussed above.

We corroborate previous studies demonstrating that RALRP is clearly associated with higher cost compared with RRP. The primary drivers of increased cost have been the purchase and maintenance fees of robotic systems. In comparing costs of open and MIRP, Lotan and associates²² determined that a significant decrease in purchase and maintenance fees would be necessary for RALRP to become cost equivalent to alternative approaches. We were not able to capture these costs within the HSCRC database; thus, the cost differential between open and RALRP is likely greater than we report.

Because RALRP has become installed as the surgical approach of choice at many centers in the United States, what strategies can be adopted to optimize cost-effectiveness? Because high-volume surgeons have been shown to be associated with improved outcomes and lower cost, it may be that increased referral to high-volume providers is warranted. Indeed, studies have shown that most MIRP surgeons are still low-volume providers.¹⁷ Shifting volume to high-volume providers would also allow for maximizing the full "cost potential" of each robotic system.²³ Indeed, high robotic surgical volume may decrease the "variable" cost of robotic surgery by disseminating the capital costs among a larger denominator of cases.^{1,24} For providers desiring tertiary level practices in RP, there should be a clearer certification process, more stringent credentialing within hospitals, and to some degree monitoring of outcomes. Indeed, previous studies have shown that even high-volume surgeons can have wide variation in outcomes¹³; thus, even experienced surgeons can benefit from analysis of their methods and results. High-volume institutions should evaluate and refine postoperative pathways to ensure that patients are discharged with maximal efficiency and safety.

Our study relied on a statewide administrative database that possesses certain strengths and limitations. Strengths include prospective data collection, as well as use of actual hospital costs. In addition, using updated coding, we were able to identify RALRP precisely rather than a general category of MIRP. Limitations of our dataset included a lack of granular clinical details; thus, we could not ascertain whether there were significant differences in case mix between surgeons and providers that might bias the results. Finally, our data only encompassed hospitalization costs and could not

capture long-term costs related to prostate cancer and sequelae of treatment. Indeed, salvage therapy and treatment of functional deficits after RP may differentially impact the cost of the two procedures. The costs of long-term care for prostate cancer patients after different types of surgical therapy warrant further investigation.

Conclusion

We found that high surgeon volume was associated with lower costs for both RRP and RALRP, while high hospital volume was associated with lower costs for RALRP only. Even at high surgical volume, RALRP was still associated with greater cost than RRP. Because RALRP has been installed as the surgical approach of choice for prostate cancer at most hospitals, it may be that cost controls can be best accomplished with regionalization of care to high-volume providers. Further efforts are needed to better define the validity of this conjecture.

Disclosure Statement

No competing financial interests exist.

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Abbreviations Used

HSCRC = Health Service Cost Review Commission

MIRP = minimally invasive radical prostatectomy

RALRP = robot-assisted laparoscopic radical prostatectomy

RP = radical prostatectomy

RRP = radical retropubic prostatectomy