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ORIGINAL REPORT

Utilization and Outcomes of Minimally Invasive Radical Prostatectomy

Jim C. Hu, Qin Wang, Chris L. Pashos, Stuart R. Lipsitz, and Nancy L. Keating

From the Division of Urologic Surgery; Center for Surgery and Public Health; Division of General Internal Medicine, Brigham and Women's Hospital; Department of Health Care Policy, Harvard Medical School, Boston, MA; and the Abt Associate Clinical Trials, Bethesda, MD.

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Corresponding author: Jim C. Hu, MD, MPH, Division of Urologic Surgery, Brigham and Women's Hospital, Boston, MA 02115; e-mail: jhu2@partners.org.

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ABSTRACT

Purpose
Demand for minimally invasive radical prostatectomy (MIRP) to treat prostate cancer is increasing; however, outcomes remain unclear. We assessed utilization, complications, lengths of stay, and salvage therapy rates for MIRP versus open radical prostatectomy assessed whether MIRP surgeon volume is associated with better outcomes.

Methods
We identified 2,702 men undergoing MIRP and open radical prostatectomy during 2003 to 2005 from a national 5% sample of Medicare beneficiaries. We assessed the association between surgical approach and outcomes, adjusting for surgeon volume, age, race, comorbidity, and geographic region.

Results
MIRP utilization increased from 12.2% in 2003 to 31.4% in 2005. Men undergoing MIRP versus open radical prostatectomy had fewer perioperative complications (29.8% *v* 36.4%; $P = .002$) and shorter lengths of stay (1.4 *v* 4.4 days; $P < .001$); however, they were more likely to receive salvage therapy (27.8% *v* 9.1%, $P < .001$). In adjusted analyses, MIRP versus open radical prostatectomy was associated with fewer perioperative complications (odds ratio [OR], 0.73; 95% CI, 0.60 to 0.90), shorter lengths of stay (parameter estimate, −2.99; 95% CI, −3.45 to −2.53) but more anastomotic strictures (OR, 1.40; 95% CI, 1.04 to 1.87) and higher rates of salvage therapy (OR, 3.67; 95% CI, 2.81 to 4.81). Patients of high-volume MIRP experienced fewer anastomotic strictures (OR, 0.93; 95% CI, 0.87 to 0.99) and less salvage therapy (OR, 0.92; 95% CI, 0.88 to 0.98).

Conclusion
Men undergoing MIRP versus open radical prostatectomy have lower risk for perioperative complications and shorter lengths of stay, but are at higher risk for salvage therapy and anastomotic strictures. However, risk for these unfavorable outcomes decreases with increasing MIRP surgical volume.

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INTRODUCTION

One in six men in the United States will develop prostate cancer in his lifetime, and prostate cancer is the second leading cause of cancer mortality in men.[1] Radical prostatectomy remains the most common treatment choice in the United States,[2,3] accounting for one half of the $1.7 billion spent annually on prostate cancer.[4] Presently, men opting for surgery must choose between open and minimally invasive radical prostatectomy with limited data demonstrating differences in outcomes.

Although the use of minimally invasive radical prostatectomy has increased in recent years, few data are available about utilization and outcomes compared with open radical prostatectomy. Moreover, while increased surgeon volume is associated with better outcomes for open radical prostatectomy,[5,6] there is an absence of data regarding whether volume-outcome effects exist for minimally invasive radical prostatectomy. This is particularly relevant given descriptions of steep learning curves[7,8] and increased complications associated with rapid adoption of minimally invasive surgical approaches for other procedures.[9,10]

To explore utilization and outcomes of minimally invasive radical prostatectomy, we performed a population-based study of Medicare beneficiaries undergoing radical prostatectomy during 2003 to 2005. In particular, we examined whether complications, lengths of stay, and need for salvage therapy were comparable after minimally invasive versus open radical prostatectomy. Furthermore, among men undergoing minimally invasive radical prostatectomy, we assessed whether surgeon volume was associated with better outcomes.

METHODS

Study Population

We identified men ≥ 65 years old undergoing radical prostatectomy from a 5% national, random sample of Medicare beneficiaries using administrative data from the Center for Medicare and Medicaid Services (CMS). We excluded men enrolled in health maintenance organizations because their medial claims are not reliably captured by CMS. Men who underwent open (ie, perineal and retropubic radical prostatectomy) and minimally invasive radical prostatectomy from 2003 to 2005 (n = 2,818) were identified from inpatient, outpatient, and carrier component files (formerly Physician/Provider B) based on the presence Physicians Current Procedural Terminology Coding System (fourth edition, [CPT-4]): codes 55810, 55812, 55815 for perineal radical prostatectomy; 55840, 55842, 55845 for retropubic radical prostatectomy; and 55866 for minimally invasive radical prostatectomy.

Dependent Variables

Perioperative complications, hospital length of stay, anastomotic strictures, and initiation of salvage therapies were identified using inpatient, outpatient, and carrier file International Classification of Diseases, ninth revision or CPT-4 codes for relevant procedures and diagnosis (online-only Appendix Table A1).[5,6] Perioperative complications were ascertained in the 90 days after surgery and included potentially life-threatening cardiac, respiratory, or vascular events; need for re-operation; bleeding; and other events, such as renal failure and shock. Anastomotic strictures were identified up to 9 months after surgery; they typically present within 6 months of surgery.[11] Hospital length of stay was defined as the number of days from admission to discharge. Salvage therapy in the form of radiation or injectable hormone therapy was identified up to 6 months after surgery.[12] Because only three men underwent orchiectomy, this modality was excluded from our analysis of salvage therapy.

Independent Variables

Information on patient age (65 to 69, 70 to 75, > 75 years) and race (white, black, and other) was obtained from the Medicare denominator file. Comorbidity was assessed using the Charlson index based on inpatient, outpatient, and carrier claims during the year before surgery.[13] Geographic region was classified according to US Census Bureau regions (northeast, midwest, south, and west).

To measure surgeon volume, we determined the number of minimally invasive radical prostatectomies each surgeon had performed during 2003 to 2005 based on our data, which reflects 5% of all procedures performed on Medicare beneficiaries.

Statistical Analysis

Utilization rates for perineal, retropubic, and minimally invasive radical prostatectomy were derived for the 3-year study period. Due to the small number of perineal radical prostatectomies, we restricted the remaining analysis to minimally invasive and retropubic (open) radical prostatectomy. We first compared patient characteristics by surgical approach using the χ^2 test. Next, we compared the outcomes of interest among men undergoing minimally invasive and open radical prostatectomy, and we assessed the association of surgeon volume with each outcome using the χ^2 statistic with an α level of .05 for perioperative complications, anastomotic strictures, and salvage therapies and one-way analysis of variance for length of stay.

Multivariate models were constructed to determine the effect of surgical approach, minimally invasive versus open radical prostatectomy, on outcomes of interest while adjusting for age, race, comorbidity, and geographic region. In separate analyses, we also adjusted for open and minimally invasive surgeon volume, which yielded similar results and did not confound the relationship between surgical approach and outcomes (data not shown). Logistic regression was used for perioperative complications, anastomotic strictures, and salvage therapies. The distribution of the length of stay data was unimodal and symmetric with a slight tail. Thus, since the data were approximately symmetric, we estimated a linear regression model using ordinary least squares, a technique robust for estimating linear regression models with symmetric errors, even if the errors are not normally distributed. A second set of multivariate models restricted to minimally invasive radical prostatectomy were constructed to determine the effect of minimally invasive surgeon volume on outcomes while adjusting for age, race, comorbidity, and geographic region. In sensitivity analyses, we repeated analyses after categorizing surgeon volume in tertiles. Results were similar and are not reported. R^2 and C (rank correlation index) statistics are reported to provide overall model predictive value for the linear and logistic models, respectively. Because the outcomes of interest from radical prostatectomies performed by the same surgeon may be similar (ie, correlated), we used a robust SE estimate[14] for all regression models.

Because both age and comorbidity were associated with type of prostatectomy and outcomes, we assessed whether including this interaction in the models influenced the associations between type of prostatectomy and outcomes or between volume of minimally invasive surgeries and outcomes. Inclusion of the interaction terms did not influence any of the relationships of interest; therefore, we present the main effects models only.

RESULTS

Minimally invasive radical prostatectomy increased from 12.2% of all radical prostatectomies in 2003 to 31.4% in 2005 (Fig 1) while retropubic radical prostatectomy decreased from 82.0% to 66.1%, and perineal radical prostatectomy decreased from 5.8% to 2.6% ($P < .001$). There were no racial or geographic variations in utilization of open versus radical prostatectomy (Table 1); however, men undergoing minimally invasive radical prostatectomy were older ($P < .001$) and more likely to have multiple comorbid conditions ($P = .01$).

The unadjusted overall perioperative complication rate for minimally invasive versus open radical prostatectomy was 29.8% versus

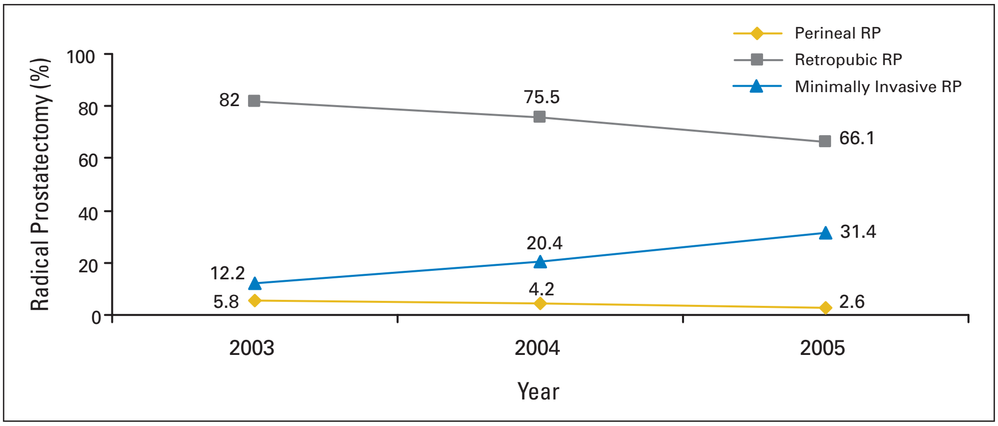

Fig 1. Rates of different radical prostatectomy surgical approaches over time. $P < .001$ using the Mantel-Hanszel χ^2 test assessing changes over time. RP, radical prostatectomy.

Table 1. Patient Characteristics From 2003 to 2005					
	Minimally Invasive Radical Prostatectomy (n = 608)		Open Radical Prostatectomy (n = 2,094)		
Characteristic	No.	%	No.	%	*P*
Age, years					
65-69	315	51.8	1,135	54.2	< .001
70-75	168	27.6	718	34.3	
> 75	125	20.5	241	11.5	
Race					
White	520	85.5	1,837	87.7	.09
Black	49	8.1	173	8.3	
Other	39	6.4	84	4.0	
Region					
Midwest	167	27.5	580	27.7	.70
North	84	13.8	285	13.6	
South	220	36.2	799	38.2	
West	137	22.5	430	20.5	
Charlson index					
0	361	59.4	1,130	54.0	.01
1-2	196	32.2	710	33.9	
≥ 3	51	8.4	254	2.1	

36.4% (P = .002), and men undergoing minimally invasive versus open radical prostatectomy had fewer cardiac, respiratory, wound/bleeding, genitourinary, and miscellaneous medical complications (all $P < .05$; Table 2). Mean length of stay was approximately 3 days shorter for minimally invasive versus open radical prostatectomy ($P < .001$). Conversely, the rate of anastomotic stricture was 3% higher after minimally invasive versus open radical prostatectomy, although this difference did not reach statistical significance ($P = .11$).

In adjusted analysis (Table 3), men undergoing minimally invasive versus open radical prostatectomy were less likely to develop perioperative complications (OR, 0.73; 95% CI, 0.60 to 0.90), and experienced shorter lengths of stay (parameter estimate, −2.99; 95% CI, −3.45 to −2.53). However, minimally invasive radical prostatectomy was associated with more anastomotic strictures (OR, 1.40; 95% CI, 1.04 to 1.87) and more salvage therapies within 6 months of surgery (OR, 3.67; 95% CI, 2.81 to 4.81). Multiple comorbidities and older age were significantly associated with perioperative complications, anastomotic strictures, longer lengths of stay, and a greater likelihood of salvage therapy.

In unadjusted analyses among men who underwent minimally invasive radical prostatectomy, we found no association between minimally invasive surgeon volume and perioperative complications ($P = .41$), lengths of stay ($P = .14$), or anastomotic strictures ($P = .42$). However, overall rates of salvage therapy ranged from 40.4% for low volume surgeons to 32.3% for medium and 18.9% for high volume surgeons. Adjusted analysis (Table 4) demonstrated that higher minimally invasive surgeon volume was associated with less salvage therapy (0.92; 95% CI, 0.88 to 0.98) and fewer anastomotic strictures (OR, 0.93; 95% CI, 0.87 to 0.99). The OR for volume can be interpreted as the odds associated with performing 20 more surgeries among Medicare beneficiaries.

DISCUSSION

For many disease processes, minimally invasive surgery offers distinct, consistently reproducible advantages over open approaches, including shorter hospital stays, fewer inpatient procedures, and lower costs. However, open radical prostatectomy is performed through a relatively small incision that is infrequently associated with significant pain, and relatively short lengths of stay, averaging 1 to 3 days at high volume referral centers.[15-18] Nevertheless, many patients intuitively perceive minimally invasive approaches to reduce complications compared with conventional open operations and prefer them due to smaller incisions requiring less analgesics and shorter hospital stays,

Table 2. Unadjusted Rates of Complications, Length of Stay, and Anastomotic Strictures for Patients Undergoing Minimally Invasive Versus Open Radical Prostatectomy					
	Minimally Invasive Radical Prostatectomy (n = 608)		Open Radical Prostatectomy (n = 2,094)		
Parameter	No.	%	No.	%	*P*
Perioperative complication					
Overall	181	29.8	763	36.4	.002
Cardiac	26	4.3	139	6.6	.03
Respiratory	41	6.7	244	11.7	< .001
Vascular	32	5.3	137	6.5	.25
Wound or bleeding	10	1.6	75	3.6	.02
Genitourinary	27	4.4	168	8.0	.003
Miscellaneous medical	67	11.0	342	16.3	.001
Miscellaneous surgical	40	6.6	167	8.0	.25
Length of stay, days					
Mean	1.42		4.35		
Standard deviation	2.04		5.84		< .001
Anastomotic stricture	52	15.2	205	12.0	.111
No.	343		1,704		
Salvage therapy	148	27.8	177	9.1	< .001
No.	533		1,943		

Table 3. Adjusted Analyses of Complications, Length of Stay, and Anastomotic Strictures for Patients Undergoing Minimally Invasive Versus Open Radical Prostatectomy

	Perioperative Complication		Stricture		Length of Stay		Salvage Therapy Within 6 Months	
Parameter	OR	95% CI	OR	95% CI	Parameter Estimate*	95% CI	OR	95% CI
Minimally invasive (*v* open radical prostatectomy)	0.73†	0.60 to 0.90	1.40†	1.04 to 1.87	−2.99†	−3.45 to −2.53	3.67†	2.81 to 4.81
Race (*v* white)								
Black	1.05	0.78 to 1.41	1.09	0.70 to 1.72	0.18	−0.52 to 0.88	1.18	0.73 to 1.90
Other (*v* white)	1.04	0.70 to 1.54	0.78	0.39 to 1.53	−0.002	−0.93 to 0.92	0.90	0.49 to 1.66
Age (*v* 65-69)								
70-74	1.22†	1.02 to 1.46	0.99	0.75 to 1.32	0.58†	0.16 to 1.01	1.77†	1.32 to 2.37
75+	1.79†	1.41 to 2.29	1.46†	1.03 to 2.06	2.59†	2.00 to 3.18	2.73†	1.94 to 3.83
Charlson (*v* 0)								
1 or 2	1.92†	1.61 to 2.29	1.10	0.84 to 1.46	0.50†	0.08 to 0.91	1.22	0.91 to 1.62
≥ 3 (*v* 0)	2.76†	2.13 to 3.57	1.74†	1.21 to 2.50	3.31†	2.68 to 3.94	2.25†	1.56 to 3.24
Region (*v* south)								
West	0.86	0.68 to 1.08	0.76	0.53 to 1.09	−0.52	−1.05 to 0.005	1.25	0.88 to 1.76
Midwest	1.01	0.83 to 1.24	1.10	0.81 to 1.50	0.07	−0.40 to 0.55	1.10	0.77 to 1.48
North	1.17	0.91 to 1.51	1.21	0.83 to 1.75	0.77*	0.17 to 1.37	0.97	0.64 to 1.46
Model fit	C = 0.63		C = 0.60		R^2 = 0.13		C = 0.70	

Abbreviation: OR, odds ratio.
*Parameter estimate denotes difference in mean length of stay for covariate versus referent value.
†Denotes $P < .05$.

even at greater cost.[19] Some studies suggest that minimally invasive versus open radical prostatectomy results in significantly less blood loss, lower transfusion rates, less use of postoperative analgesics, and quicker convalescence.[16,20-22] However, distinguishing hype from reality may be difficult for novel procedures such as minimally invasive radical prostatectomy,[22] and the absence of randomized, controlled trials limits the ability to discern differences in open and minimally invasive radical prostatectomy outcomes.

Our study has several important findings. First, minimally invasive radical prostatectomy has been rapidly adopted since the initial suggestion of potential advantages over open radical prostatectomy in 2000.[23] In contrast to the late 1980s and 1990s when significant geographic variation in open radical prostatectomy utilization and outcomes existed,[24,25] minimally invasive radical prostatectomy was adopted uniformly throughout all regions of the United States over our 3-year study period. The trend in diffusion of minimally invasive radical prostatectomy is faster than laparoscopic nephrectomy for donation or cancer control, which comprised less than 10% of all cases 5 years after initial description.[26] However, it is slightly less pervasive than laparoscopic cholecystectomy, which accounted for at least 40%

Table 4. Adjusted Association of Surgeon Volume With Complications, Length of Stay, and Anastomotic Strictures for Patients Undergoing Minimally Invasive Radical Prostatectomy

	Perioperative Complications		Stricture		Length of Stay		Salvage Therapy Within 6 Months	
Parameter	OR	95% CI	OR	95% CI	Parameter Estimate	95% CI	OR	95% CI
Surgeon volume (continuous)	0.98	0.95 to 1.02	0.93*	0.87 to 0.99	0.006	−0.03 to 0.04	0.92*	0.88 to 0.98
Race (*v* white)								
Black	0.96	0.50 to 1.86	0.49	0.16 to 1.47	−0.53†	−1.13 to 0.06	1.35	0.58 to 3.15
Other	0.92	0.44 to 1.90	0.60	0.17 to 2.12	0.20	−0.47 to 0.87	1.61	0.65 to 4.01
Age (*v* 65-69)								
70-74	0.89	0.59 to 1.35	0.76	0.41 to 1.43	−0.39*	−0.77 to −0.02	3.23*	1.86 to 5.61
75+	0.69	0.43 to 1.12	0.96	0.51 to 1.81	−0.83*	−1.25 to −0.40	6.04*	3.44 to 10.60
Charlson (*v* 0)								
1 or 2	1.48†	1.00 to 2.19	1.26	0.71 to 2.23	0.06	−0.29 to 0.42	1.37	0.83 to 2.29
≥ 3	3.05*	1.63 to 5.68	2.19†	0.92 to 5.23	0.88*	0.28 to 1.49	1.61	0.76 to 3.41
Region (*v* south)								
Midwest	0.88	0.56 to 1.38	0.97	0.53 to 1.79	−0.39†	−0.80 to 0.02	1.44	0.80 to 2.59
North	1.74	0.41 to 1.33	0.82	0.37 to 1.83	−0.46†	−0.98 to 0.05	1.12	0.52 to 2.43
West	1.11	0.68 to 1.82	0.33*	0.14 to 0.78	−0.28	−0.73 to 0.18	2.91*	1.55 to 5.48
Model fit	C = 0.60		C = 0.66		R^2 = 0.05		C = 0.75	

Abbreviation: OR, odds ratio.
*Denotes $P < .05$.
†Denotes $P = .05$ to .10.

of all cases 5 years after initial description.[26] Nevertheless, minimally invasive radical prostatectomy is in widespread and rapidly expanding use.

Minimally invasive radical prostatectomy was associated with lower perioperative complication rates than open radical prostatectomy. This is noteworthy considering that a greater proportion of men with multiple comorbid conditions and older age underwent minimally invasive versus open radical prostatectomy, and older age and multiple comorbid conditions influence perioperative complications.[6,25] Other studies have suggested similar rates of perioperative complications after radical prostatectomy[27-29]; however, these retrospective, self-reported complications by high volume surgeons primarily focus on genitourinary and surgical complications rather than respiratory and miscellaneous medical complications, which were the leading contributors to overall perioperative complications in our study. Furthermore, comparison of outcomes between reported radical prostatectomy series and different health settings is imprecise due to differences in patient selection and methods of data collection and reporting.[22] The use of administrative data may offset these potential biases.

The lower perioperative complication rates we observed for minimally invasive radical prostatectomy may be related to procedural blood loss and transfusion rates, which are consistently lower for the minimally invasive versus open surgical approach due in part to the carbon dioxide insufflation pressures used during laparoscopy.[16,20-22] Less blood loss lowers the risk of cardiac ischemia and resultant cardiovascular complications, renal insufficiency, and also lessens the risk of respiratory complications that may result from aggressive, compensatory volume expansion. Similarly, intraoperative blood loss is a strong predictor of major complications and death after general and vascular surgeries.[30]

Men undergoing minimally invasive versus open radical prostatectomy had more than 3 times the odds of receiving salvage therapy (ie, hormone therapy or external-beam radiotherapy) within 6 months of surgery. From 1985 to 1991, 15% of Medicare beneficiaries underwent salvage therapy within 6 months of radical prostatectomy,[12] a rate higher than the 9% of men who underwent open radical prostatectomy during 2003 to 2005 in our study, and stage migration may contribute to this difference. According to national guidelines, salvage radiotherapy or hormone therapy should be administered after surgery if prostate specific antigen (PSA) levels fail to reach undetectable levels and or for men with adverse pathologic features and/or positive surgical margins.[31] Thus, salvage therapy is a surrogate end point for cancer control.

Men undergoing minimally invasive versus open radical prostatectomy were more likely to develop anastomotic strictures, one of the most common complications of open radical prostatectomy, with reported rates ranging from 4% to 32%.[11,27,32-34] Strictures negatively impact continence[11] and require additional surgery to dilate or incise the scar tissue under general anesthesia, followed by urethral catheterization. In addition, most anastomotic strictures recur and require additional procedures[31] that may result in incontinence, requiring placement of artificial urinary sphincter in severe cases.[11,17]

For minimally invasive radical prostatectomy, the urethrovesical anastomosis is the most technically demanding step for surgeons early in their experience.[35] This may explain the lower stricture rate of high volume minimally invasive surgeons in our study. Furthermore, the higher rates of anastomotic stricture and salvage therapy for minimally invasive versus open radical prostatectomy may be due in part to inadequate training and credentialing of practicing surgeons in new minimally invasive techniques.[9,10] Similarly, the rapid adoption of laparoscopic cholecystectomy in the United States resulted in the hidden risk of major bile duct injury.[9,36]

Patients of higher volume minimally invasive surgeons were less likely to experience anastomotic strictures or undergo salvage therapies within 6 months of surgery. A prior case series reported fewer anastomotic strictures associated with greater minimally invasive radical prostatectomy experience.[20] Similarly, a retrospective multicenter study demonstrated that greater open surgeon experience was associated with fewer PSA recurrences, presumably due to better open radical prostatectomy surgical technique.[37] Authors have described significant learning curves, suggesting that 40 to 150 minimally invasive radical prostatectomies are required to achieve proficiency and outcomes comparable to open radical prostatectomy[7,38]; yet, a recent survey of urologists found that 37% reported doing fewer than 11 radical prostatectomies per year, while 84% reported doing fewer than 31 per year.[39] Consequently, the learning curve may be extended for years.[38] Paradoxically, there is no formal certification process and considerable variation exists among hospitals for attaining minimally invasive radical prostatectomy privileges; surgeons may perform the procedure after completing brief courses lasting 2 days or less.[35,38] Additional research is needed to assess the impact of minimally invasive radical prostatectomy experience on preservation of urinary and sexual function, for which surgical technique is important.[40]

Finally, length of stay was approximately 3 days shorter with minimally invasive versus open radical prostatectomy. The duration of the hospital stay is the primary determinant of hospital costs associated with radical prostatectomy,[15] and the shorter lengths of stay in addition to lower transfusion rates of minimally invasive versus open radical prostatectomy[16,20] may result in cost advantages despite higher intraoperative costs from using disposables and longer operative times.[15] However, these minimally invasive cost advantages may only be realized with high surgeon volume,[40] shorter operative times,[15,17] lower complication rates, and lower rates of salvage therapy.

Limitations

Our use of Medicare claims data has certain limitations. First, claims files are designed primarily to provide billing information, not detailed clinical information. More comprehensive clinical data on severity of illness and comorbidity might have influenced the associations we identified. Nevertheless, the older age and higher comorbidity burden of the men undergoing minimally invasive radical prostatectomy suggests that our findings of fewer perioperative complications and shorter lengths of stay are not driven by better health status among men undergoing this procedure. In addition, we could not adjust for tumor characteristics, such as tumor grade or stage; however, differences in tumor characteristics are unlikely to influence perioperative complications, anastomotic strictures, or lengths of stay. Because tumor characteristics may influence the need for salvage therapy, the significantly higher rate of salvage therapy for minimally invasive radical prostatectomy could be due to either poor patient selection (ie, offering minimally invasive surgery to men with aggressive tumor characteristics) and/or poor surgical technique resulting in incomplete resection. However, it is unlikely that differences in tumor characteristics alone account for such wide variation in utilization of salvage therapies between minimally invasive versus open radical prostatectomy, as more than 90% men diagnosed with prostate cancer present with localized disease,[42] and only 15% present with high-risk features.[43] In our study, the association of higher minimally invasive surgeon volume with fewer salvage therapies supports the latter explanation that higher failure rates result from differences in surgical technique, consistent with the findings by Vicker et al.[37] However, the increased risk of salvage therapies may reflect variations in physician practice patterns and thresholds for initiating salvage therapy for positive surgical margins or detectable PSA.

Our measures of procedure volume were based on volume within the 5% random sample of Medicare beneficiaries that we studied, and may be measured with some error. Nevertheless, radical prostatectomy surgeon volume for older men enrolled in Medicare, correlates strongly with overall radical prostatectomy surgeon volume.[5] We did not examine rates of impotence and incontinence because these are poorly ascertained with administrative data. Moreover, recovery of urinary and sexual function plateau at 18 to 24 months postprostatectomy,[44] limiting our ability to detect significant differences over our 3-year study period.

Finally, minimally invasive radical prostatectomy included procedures performed with and without robotic assistance because both share a common CPT code. We were therefore unable to distinguish whether the robot was used for assistance during laparoscopy; however, the intraoperative strategy is similar and the prostatic anatomy is by definition identical.[45] Several reports suggest that robotic assistance may shorten the learning curve for minimally invasive radical prostatectomy,[38,42] but additional research is necessary to determine whether differences in outcomes exist between minimally invasive radical prostatectomy with and without robotic assistance.

Summary

Minimally invasive radical prostatectomy diffused rapidly over the study period, and is associated with a lower risk of perioperative complications and shorter lengths of stay, but an increased risk for anastomotic strictures and early cancer recurrence compared with open radical prostatectomy. Nevertheless, among men who underwent minimally invasive radical prostatectomy, higher minimally invasive surgeon volumes was associated with a lower risk of anastomotic strictures and salvage therapy, suggesting better cancer control. Given the rapid adoption, increased patient demand, steep learning curves, and low radical prostatectomy volumes for the majority of practicing urologists, additional research is needed to delineate long-term outcomes such as urinary and sexual function to guide men considering minimally invasive radical prostatectomy. These studies may characterize minimally invasive surgeon experience thresholds and redefine current certification practices for obtaining minimally invasive radical prostatectomy privileges to optimize outcomes.

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

The author(s) indicated no potential conflicts of interest.

AUTHOR CONTRIBUTIONS

Conception and design: Jim C. Hu, Nancy L. Keating
Financial support: Jim C. Hu
Administrative support: Jim C. Hu, Chris L. Pashos
Collection and assembly of data: Qin Wang, Chris L. Pashos, Nancy L. Keating
Data analysis and interpretation: Qin Wang, Chris L. Pashos, Stuart R. Lipsitz, Nancy L. Keating
Manuscript writing: Jim C. Hu, Stuart R. Lipsitz, Nancy L. Keating
Final approval of manuscript: Stuart R. Lipsitz, Nancy L. Keating

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Appendix

The Appendix is included in the full-text version of this article, available online at www.jco.org. It is not included in the PDF version (via Adobe® Reader®).

