Real-World Impact of Minimally Invasive Versus Open Radical Cystectomy on Perioperative Outcomes and Spending

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OBJECTIVE To evaluate the effect of the minimally invasive approach on spending and perioperative outcomes for patients undergoing radical cystectomy for bladder cancer. In a randomized control trial conducted at high-volume centers, robotic, and open cystectomy were shown to have similar outcomes. However, because the majority of cystectomies are performed in low-volume centers, it is unknown whether these findings are broadly generalizable.

MATERIALS AND METHODS We identified Medicare patients who underwent radical cystectomy for bladder cancer between 2008 and 2015. We examined the length of stay, readmission rate, and 90-day spending after minimally invasive or open cystectomy. We used multiple regressions to estimate the association between minimally invasive surgery and the outcomes, accounting for patient, hospital, and surgeon factors that may influence these outcomes.

RESULTS Of 4760 patients, 693 (14.6%) underwent minimally invasive cystectomy and 4067 (85.4%) had an open approach. Minimally invasive cystectomy was associated with shorter length of stay (10.1 days vs 11.9 days, P <.001), but no difference in readmission rate (27.4% vs 26.8%, P = .77). Minimally invasive cystectomy was associated with lower adjusted 90-day episode spending ($34,369 vs $38,071, P <.001).

CONCLUSION In patients across diverse institutions in the United States, minimally invasive cystectomy was associated with a shorter length of stay than open cystectomy and reduced 90-day episode spending, but with no significant difference in readmission rate. UROLOGY 125: 86−91, 2019. © 2018 Elsevier Inc.

Radical cystectomy with pelvic lymph node dissection is the standard treatment for invasive bladder cancer and is a complex and morbid procedure. Complications and readmissions occur in more than a quarter of patients undergoing cystectomy, contributing to its high cost.[1-3] Recently, minimally invasive approaches have been rapidly adopted and have the potential to improve these outcomes. However, small trials have not shown a significant benefit.[4-7] The recently published multicenter, randomized open vs robotic cystectomy (RAZOR) trial demonstrated that both approaches had similar oncologic outcomes, complication rates, and quality of life outcomes.[8] However, robotic cystectomy was noted to result in less blood loss and a shorter length of stay than open cystectomy.[8]

One significant limitation of the RAZOR trial was that it included 15 high-volume, specialized centers and surgeons who performed at least 10 radical cystectomy procedures per year. In contrast, more than two-thirds of cystectomies in the United States are performed by surgeons who do fewer than 10 such cases yearly[9] and 60% are performed at centers with fewer than 20 cases yearly.[9,10] As a result, it is not clear how well the results of this trial conducted at high-volume centers with expert surgeons and highly selected subjects can be generalized to patients undergoing radical cystectomy across the United States.

We build on existing studies using National Medicare data to determine the impact of minimally invasive technology on length of stay, readmission, and 90-day episode spending following radical cystectomy for bladder cancer. By virtue of the nationally representative population-

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based sample, we can derive a more robust understanding of the impact of minimally invasive technology on contemporary radical cystectomy outcomes across diverse settings.

METHODS

Data Source and Study population

We used a 20% sample of National Medicare claims to identify patients who underwent radical cystectomy from January 1, 2008 to September 30, 2015. These patients were identified using International Classification of Disease, ninth revision, clinical modification (ICD-9-CM) codes (57.7, 57.71, 57.79). We included only those patients with a diagnosis of bladder cancer (ICD-9-CM code 188.X) and a claim from an urologist for radical cystectomy (Healthcare Common Procedure Coding System code 51570, 51575, 51580, 51585, 51590, 51595, 51596, 51597, or 51999). To measure baseline health status, we included patients with at least 1 year of complete claims prior to surgery. To accurately estimate outcomes, we included patients with at least 90 days of follow-up and continuous Medicare Parts A and B coverage during the entire time period. Beneficiaries with Medicare Advantage plans were excluded to ensure availability of complete claims data.

Exposure

The exposure of interest was minimally invasive cystectomy, identified using a laparoscopic or robotic ICD-9-CM code (17.4, 17.41, 17.42, 17.49, 54.21, or 54.51) concurrent with a radical cystectomy code. Those without a minimally invasive code were considered to have undergone open cystectomy.

Outcomes and Covariates

The outcomes of interest were length of hospital stay during the cystectomy hospitalization, hospital readmission within 30 days of discharge, and total Medicare payments within 90 days of surgery (90-day episode payments). We used 90-day episode payments as a comprehensive measure of all spending, including the initial hospitalization, physician services, postacute care, and readmissions. All payments were inflation-adjusted and price standardized to control for differences in payments related to geography and facility characteristics (eg, disproportionate share and graduate medical education adjustments). For analyses of readmission, beneficiaries who died during the index admission (n = 104) were excluded.

To account for differences between patients who underwent open and minimally invasive cystectomy, we adjusted for patient demographic characteristics, comorbidities, and procedure year. All models were adjusted for patient age, race, sex, socioeconomic status at the zip code level, and area of residence. We also adjusted all models for the receipt of neoadjuvant chemotherapy, defined as any chemotherapy received in the 6 months prior to surgery (Supplemental Appendix 1). Pre-existing conditions were measured using the Center for Medicare and Medicaid Services Hierarchical Condition Categories score. This comorbidity score is used to risk-adjust payments to Medicare Advantage plans and uses differentially weighted diagnosis codes from the year prior to the index surgery. This score has been shown to perform better than other measures in predicting surgical outcomes for Medicare beneficiaries.[11]

Because hospital and surgeon volume may also impact the outcomes associated with radical cystectomy, we also adjusted for hospital characteristics including number of beds, cystectomy volume, and teaching status. Finally, we adjusted for surgeon volume using all claims for radical cystectomy from each performing surgeon.

Statistical Analysis

Baseline characteristics were analyzed according to surgical approach. Pearson's chi-squared test was used for categorical variables and the Wilcoxon rank-sum test (2 groups) or Kruskal-Wallis test (more than 2 groups) was used for continuous variables. Adjusted analyses used negative binomial regression models for length of stay and episode payment and logistic regression models for readmission. All models estimated robust standard errors to account for hospital level clustering. Predicted values were obtained using the *margins* postestimation command in Stata 15.

We performed several sensitivity analyses to test the robustness of our findings. First, to exclude findings driven by large outliers, models for length of stay and spending were repeated with extreme observations truncated at the 5th and 95th percentile. Second, because patients who die during the index hospitalization could have a shorter length of stay and lower total episode spending, we repeated those models after excluding patients who died during the index hospitalization. Third, to ensure that our results were not driven by cases performed in the earliest years of the study period, we analyzed all outcomes for procedures performed in 2014-2015 only. Finally, because hospital volume has been shown to predict outcomes for radical cystectomy,[9] we evaluated patients in our sample who were treated at the hospitals in the highest quartile of cystectomy volume.

All statistical tests were performed using SAS version 9.4 (Cary, NC) and Stata 15 (College Station, TX). All tests were two-tailed and a P value of less than .05 was considered significant. This study was exempted from Institutional Review Board review.

RESULTS

We identified 4760 Medicare beneficiaries who underwent cystectomy for bladder cancer at 952 hospitals. Of these, 693 (14.6%) underwent a minimally invasive cystectomy, while 4067 (85.4%) underwent open cystectomy. The use of minimally invasive cystectomy increased from 3% of cases in 2008 to 24.3% in 2015 (Figure 1). Patients who underwent minimally invasive cystectomy were more often male, more likely to have received neoadjuvant chemotherapy, and more likely to live in a metropolitan and higher socioeconomic status area (Table 1). On average, patients who underwent minimally invasive cystectomy were treated at higher-volume hospitals and by higher-volume surgeons.

Length of Stay

The unadjusted median length of stay was 9 days for open cystectomy (Interquartile range [IQR]: 8-14) and 8 days for minimally invasive cystectomy (IQR 7-10). After adjusting for measured patient, hospital, and surgeon characteristics, minimally invasive cystectomy was associated with a shorter length of stay than open radical cystectomy (10.1 days [95% confidence interval {CI} 9.6-10.5] vs 11.9 days [95% CI 11.6-12.2], P <.001).

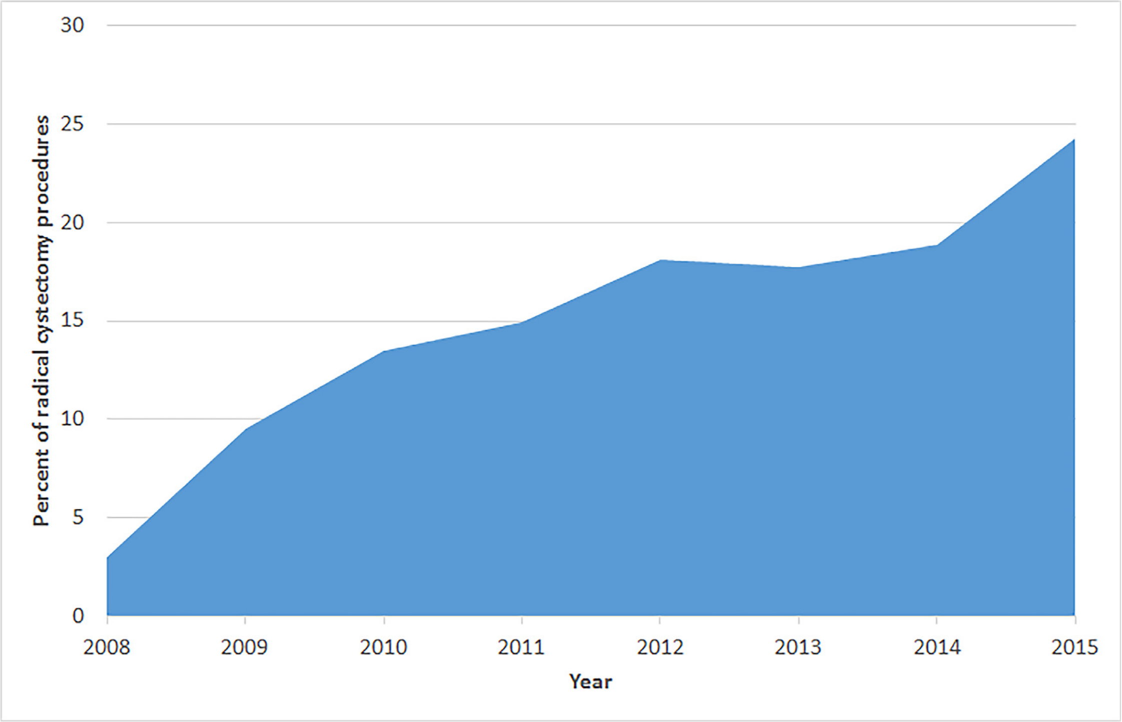

Figure 1. Use of minimally invasive approach among Medicare beneficiaries with bladder cancer undergoing radical cystectomy from 2008 to 2015.

Table 1. Patient characteristics stratified by surgical approach. As hospital and surgeon volume are derived from 20% sample of national Medicare patients, these variables represent only 20% of the total volume.

		Open (n = 4067)	Minimally Invasive (n = 693)	P Value
Age, median (IQR)		75.4 (71.1-80.0)	74.8 (70.6-79.8)	.05
Race	White	3,773 (92.8%)	642 (92.6%)	.69
	Black	180 (4.4%)	28 (4.0%)	
	Other	114 (2.8%)	23 (3.3%)	
Sex	Male	3,228 (79.4%)	597 (86.1%)	<.001
	Female	839 (20.6%)	96 (13.9%)	
Socioeconomic score (tertile)	Lowest	1,356 (34.3%)	195 (28.7%)	.002
	Middle	1,307 (33.0%)	220 (32.4%)	
	Highest	1,293 (32.7%)	264 (38.9%)	
Residential area	Residential area, n (%):	1,794 (44.2%)	337 (48.7%)	.12
	≥1 million metropolitan county	1,360 (33.5%)	208 (30.1%)	
	<1 million metropolitan county	788 (19.4%)	131 (18.9%)	
	Urban county	121 (3.0%)	16 (2.3%)	
Comorbidity score, median (IQR)		1.8 (1.1-3.0)	1.7 (1.1-2.8)	.04
Received neoadjuvant chemotherapy		874 (21.5%)	183 (26.4%)	.004
Year of surgery	2008	637 (15.7%)	20 (2.9%)	<.001
	2009	567 (13.9%)	60 (8.7%)	
	2010	527 (13.0%)	82 (11.8%)	
	2011	508 (12.5%)	89 (12.8%)	
	2012	498 (12.2%)	110 (15.9%)	
	2013	509 (12.5%)	110 (15.9%)	
	2014	472 (11.6%)	110 (15.9%)	
	2015	349 (8.6%)	112 (16.2%)	
Hospital volume, median (IQR)		16 (6-44)	22 (9-42)	<.001
Surgeon volume, median (IQR)		7 (3-18)	9 (4-17)	<.001
Hospital bed size	≤250	724 (17.8%)	114 (16.5%)	.18
	251-500	1,036 (25.5%)	199 (28.7%)	
	>500	2,307 (56.7%)	380 (54.8%)	
Teaching hospital		2,217 (54.5%)	427 (61.6%)	<0.001

IQR, interquartile range.

Table 2. Predicted outcomes from multiple regression models. All models adjusted for: year of surgery; patient age, race, sex, comorbidity score, receipt of neoadjuvant chemotherapy, socioeconomic status, and urban-rural place of residence; surgeon volume; and hospital volume, bed-size, and teaching status.

	Open Cystectomy	Minimally Invasive Cystectomy	Difference	*P* Value
Length of stay, days (95% CI)	11.9 (11.6-12.2)	10.1 (9.6-10.5)	1.8 (1.3-2.3)	<.001
Readmission rate, % (95% CI)	26.8% (25.4%-28.3%)	27.4% (24.0%-30.8%)	−0.8% (−4.3% to 2.7%)	.77
90-day episode spending, $ (95% CI)	$38,071 ($37,084-39,058)	$34,369 ($32,726-36,012)	$3,702 ($1955-5449)	<.001

Additionally, receipt of neoadjuvant chemotherapy, younger age, non-black race, lower comorbidity score, and treatment at a larger hospital were predictive of shorter length of stay (Supplementary Table 1). While the association between treatment at a higher volume hospital and a shorter length of stay was statistically significant, the effect size was small and unlikely to be clinically meaningful.

Readmission

The unadjusted rate of readmission was 26.3% after open cystectomy and 26.8% after minimally invasive cystectomy. In adjusted multiple regression analysis, no association between surgical approach and readmission was noted (open 26.8% [95% CI 25.4-28.3] vs minimally invasive 27.4% [95% CI 24.0-30.8], *P* = .77). Higher comorbidity score, rural residence, and treatment at a teaching hospital predicted higher odds of readmission (Supplementary Table 1).

Episode Spending

The unadjusted mean 90-day episode spending was $32,386 for open and $28,813 for minimally invasive cystectomy. In adjusted multiple regression analysis (Table 2), 90-day episode spending was significantly higher for open cystectomy than minimally invasive cystectomy (open $38,071 [95% CI 37,084-39,058] vs $34,369 [95% CI 32,726-36,012] *P* <.001). Additional predictors of higher spending included older patient age, black race, higher comorbidity score, and treatment at a lower volume hospital (Supplementary Table 1).

Sensitivity Analyses

These results were robust, without significant changes to the direction or magnitude of effects noted in sensitivity analyses which truncated extreme observations, excluded patients who died during the index hospitalization, excluded patients treated prior to 2014, and excluded patients treated in lower volume hospitals (Supplementary Tables 2-5).

DISCUSSION

In this national study of patients who underwent radical cystectomy for bladder cancer between 2008 and 2015, we evaluated the relationship between minimally invasive techniques and perioperative outcomes. After adjustment for patient and hospital factors as well as surgeon and hospital volume, minimally invasive radical cystectomy was associated with a 1.8-day shorter length of hospital stay and approximately $3700 reduced 90-day episode spending than open radical cystectomy. However, there was no difference in adjusted 30-day readmission rates.

It is well established that the use of robotic-assisted radical cystectomy has increased in the United States, and our finding that rates of minimally invasive cystectomy continued to rise through 2015 are consistent with earlier reports of robotic radical cystectomy adoption in the United States.[1,2,12] This likely reflects the increasing availability of robotic technology and of urologists comfortable with minimally invasive techniques.[13] However, the impacts of this adoption of minimally invasive technology on current outcomes are not well understood.

Single center randomized trials found no significant difference in the length of stay after open or robotic cystectomy.[4,5,7] However, previous observational studies and the recent RAZOR trial demonstrated that robotic cystectomy was associated with a 1-day shorter hospital stay.[2,8] Our study confirmed this finding in contemporary Medicare patients undergoing cystectomy for bladder cancer. However, it is important to note that the development of enhanced recovery after surgery (ERAS) programs has occurred concurrently with the adoption of minimally invasive cystectomy.[14,15] RAZOR did not require any particular postoperative management and observational studies have not been able to account for the potential for preferential use of ERAS protocols in robotic cystectomy patients. While we could not account for ERAS use directly, we attempted to control for hospital and surgeon characteristics (eg, volume, teaching status, bed size) which likely coincide with the adoption of ERAS protocols. We found that the shorter length of stay associated with minimally invasive cystectomy was robust to sensitivity analyses that restricted the population to high-volume hospitals and more recent procedures.

Another potential benefit of minimally invasive cystectomy is a reduction in readmissions. Radical cystectomy for bladder cancer is historically associated with a very high readmission rate, approaching 30%.[3,16] It is believed that this high rate of readmissions is the result of a complex surgery, older patient population with significant medical illnesses, and a high rate of postoperative complications.[3] Minimally invasive cystectomy may reduce readmissions by reducing blood loss and requiring smaller incisions, potentially leading to fewer complications. However, in Medicare patients undergoing radical cystectomy, we did not observe any significant difference in 30-day readmissions attributable to surgical approach. This is consistent with earlier studies in privately insured patients,[17,18] the SEER-Medicare database,[2] and an all-payer database from New York state.[12] Our findings are further supported by evidence that readmissions for open and minimally invasive cystectomy are driven by similar types of complications and occur at similar time periods.[17]

The cost of minimally invasive modalities, especially robotic surgery, is of increasing concern to payers and policymakers.[19] For hospitals, robotic cystectomy is more expensive than open cystectomy due to equipment costs and operative time.[20,21] However, from a payer's perspective, minimally invasive cystectomy may generate savings by reducing the use of additional services (eg, complications, postacute care, readmissions). Indeed, such savings have been demonstrated for minimally invasive colectomy.[22] The RAZOR trial, which aimed to investigate hospital costs for open vs robotic cystectomy, was unable to analyze cost data due to unreliable and incomplete information.[8] Our finding that minimally invasive cystectomy was associated with approximately $3700 less spending per 90-day episode is novel and contrasts with that of Hu et al, who found that robotic cystectomy was associated with increased postacute care and higher 30- and 90-day episode spending.[2] In part, the difference in these results may be due to the earlier time period of the previous analysis (2002-2012). Procedures performed earlier in the adoption of minimally invasive technology for radical cystectomy may indeed have led to higher spending due to relative inexperience with the procedure or more conservative postoperative management and disposition. However, in this contemporary cohort, we found that minimally invasive cystectomy was associated with considerable savings to Medicare.

These findings must be considered in the context of several limitations. First, our data is limited to patients aged 66 and older and may not be generalizable to all patients undergoing radical cystectomy for bladder cancer. However, bladder cancer is a disease of the elderly and the majority of patients diagnosed with bladder cancer are older than 65.[23] Second, our approach does not allow us to consider some clinical factors, such as tumor histology, tumor stage, and the type of urinary diversion employed. This limits the scope of our findings as we did not specifically investigate minimally invasive cystectomy performed with an intracorporeal urinary diversion, which may have additional benefits when compared to open cystectomy. Finally, our analyses of the financial implications of minimally invasive cystectomy are from Medicare's perspective as a payer. This analysis does not, therefore, consider the "costs" of robotic cystectomy, which are not inconsequential.[20,21,24,25]

Notwithstanding these limitations, nationally representative population-based data offers excellent generalizability as an adjunct to randomized controlled trials at high-volume, specialized centers. This analysis uses more recent data than previous studies, capturing minimally invasive surgery beyond the early-adoption phase. The findings of a shorter length of stay, reduced 90-day episode spending and no significant difference in readmissions support the conclusion that minimally invasive cystectomy has some benefits relative to open radical cystectomy and should be available to appropriately selected patients with bladder cancer.

In conclusion, minimally invasive cystectomy is increasingly used among Medicare beneficiaries with bladder cancer. In a contemporary cohort, minimally invasive cystectomy is associated with a shorter length of stay, reduced spending, but no significant difference in readmission rate. Future studies of cystectomy approach should examine patient-centered outcomes and the impact of intracorporeal urinary diversion to identify the best approach for each individual patient.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.urology.2018.10.022.

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