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ORIGINAL ARTICLE

Perioperative outcomes and hospital reimbursement by type of radical prostatectomy: results from a privately insured patient population

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BACKGROUND: With the increasing use of robotic surgery in the United States, the comparative effectiveness and differences in reimbursement of minimally invasive radical prostatectomy (MIRP) and open prostatectomy (ORP) in privately insured patients are unknown. Therefore, we sought to assess the differences in perioperative outcomes and hospital reimbursement in a privately insured patient population who were surgically treated for prostate cancer.

METHODS: Using a large private insurance database, we identified 17 610 prostate cancer patients who underwent either MIRP or ORP from 2003 to 2010. The primary outcomes were length of stay (LOS), perioperative complications, 90-day readmissions rates and hospital reimbursement. Multivariable regression analyses were used to evaluate for differences in primary outcomes across surgical approaches.

RESULTS: Overall, 8981 (51.0%) and 8629 (49.0%) surgically treated prostate cancer patients underwent MIRP and ORP, respectively. The proportion of patients undergoing MIRP markedly rose from 11.9% in 2003 to 72.5% in 2010 ($P < 0.001$ for trend). Relative to ORP, MIRP was associated with a shorter median LOS (1.0 day vs 3.0 days; $P < 0.001$) and lower adjusted odds ratio of perioperative complications (OR: 0.82; $P < 0.001$). However, the 90-day readmission rates of MIRP and ORP were similar (OR: 0.99; $P = 0.76$). MIRP provided higher adjusted mean hospital reimbursement compared with ORP (US$19 292 vs US$17 347; $P < 0.001$).

CONCLUSIONS: Among privately insured patients diagnosed with prostate cancer, robotic surgery rapidly disseminated with over 70% of patients undergoing MIRP by 2009–2010. Although MIRP was associated with shorter LOS and modestly better perioperative outcomes, hospitals received higher reimbursement for MIRP compared with ORP.

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INTRODUCTION

Prostate cancer is the most commonly diagnosed non-cutaneous malignancy among men in the United States with ~241 000 incident cases in 2013.[1] Over the past decade, health technology innovation has markedly changed the national trends in the surgical management of abdominal and pelvic malignancies. One such poignant example of health technology innovation and dissemination is robotic surgery, where this minimally invasive approach has been rapidly adopted by surgeons for gynecologic, colorectal and genitourinary diseases.[2,3] Minimally invasive robotic-assisted radical prostatectomy (MIRP) represents one of the first applications of robotic surgery and has subsequently become the predominant surgical approach for localized prostate cancer in the absence of any clinical trials demonstrating improved patient-reported and oncologic outcomes.[4–11]

Several reasons have been postulated to explain the dissemination of robotic surgery. For example, the primary advantages of robotic surgery often put forward involve smaller incisions and increased magnification with the goal of reducing postoperative pain, complications and reducing the length of stay (LOS). In the case of prostate cancer, the benefits of greater magnification in improving the cancer control and functional outcomes from MIRP have been directly advertised to patients.[12] Indeed, several studies support some of these benefits in robotic-assisted surgery, such as shorter LOS and lower risks of perioperative complications.[2,13,14] Other studies have suggested that robotic surgery may be used to increase the market share, as has been previously reported with MIRP in a hospital referral region.[15,16] Yet, MIRP has been shown to have higher hospitalization costs compared with open radical prostatectomy (ORP).[5,13] Another plausible factor responsible contributing to the dissemination of robotic surgery may be an economic incentive, in particular among privately insured patients as reimbursement for both surgical approaches are nearly identical from the Centers for Medicare and Medicaid Services.[5]

To date, little is known about the differences in reimbursement for MIRP and ORP among privately insured and younger patients with prostate cancer. Examining whether private insurance plans provide higher reimbursement for advanced treatment technology, such as MIRP, is an important health policy question that may elucidate some reasons behind the rapid dissemination

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of robotic surgery in the United States In addition, most population-based studies examining the comparative effectiveness of MIRP and ORP have largely focused on Medicare beneficiaries.[4,17,18] Therefore, we aimed to assess the comparative effectiveness of MIRP and ORP on LOS, perioperative complications, readmissions and hospital reimbursement in a privately insured population of patients surgically treated for prostate cancer from 2003 to 2010 in the United States

MATERIALS AND METHODS

Data

Data for all patients diagnosed with prostate cancer and who underwent radical prostatectomy were abstracted from the IMS LifeLink Health Plan Claims Database, which was provided by IMS Health.[19] The database covers ~55 million privately insured patients and 80 health plans in the United States. It includes all claims and encounters from outpatient office visits, in-patient/hospitalization services, ambulatory services, emergency room visits and home health services. In addition, the IMS database provides the specific reimbursement for each outpatient and in-patient episode of care.

Study population

To identify our analytic cohort, we adopted a similar methodology from hospital claims using International Classification of Disease Modification, 9th Edition (ICD-9) and Current Procedural Terminology-4 codes described previously.[4] From January 2003 through December 2010, we identified all male patients between 40–64 years of age diagnosed with prostate cancer based on the presence of an ICD-9 code (185). Next, the presence of Current Procedural Terminology-4 codes from surgical claims determined receipt of ORP (55840, 55842 or 55845) or MIRP (55866). ICD-9 codes from 1 year before radical prostatectomy were used to define an Elixhauser comorbidity index.[20]

Outcomes

The primary outcomes of this study were LOS, perioperative complications, 90-day readmission rates and total hospital reimbursement for either ORP or RARP. We defined perioperative complications similar to previous studies examining the comparative effectiveness of MIRP versus ORP.[4,13,14] Using ICD-9 codes from secondary diagnoses, we designated perioperative complications that occurred during hospitalization into the following categories: cardiac, respiratory, genitourinary, wound, vascular and miscellaneous medical- or surgical-related complications. We further categorized surgical complications as presence of any miscellaneous surgical or wound complications, and medical complications as presence of one or more of the remaining complications. Hospital readmissions were defined as all admissions within 90 days of the radical prostatectomy following discharge from the claims data. IMS LifeLink Health Plan Claims Database provides information on the specific amount of hospital charges (amount charged) and reimbursement (amount allowed) for each specific hospitalization and surgical procedures from private health insurance plans. For the purposes of our study, we used the total hospital reimbursement for each surgery, and this was adjusted to 2010 US dollars (US$) using the National Income and Product Accounts table of gross domestic product price index.[21]

Statistical analysis

Bivariate associations of patient and hospital variables with ORP and MIRP were tested by Pearson's χ^2 test. We constructed multivariable logistic regression models to assess for differences in perioperative complications and 90-day readmissions across surgical procedures controlling for patient covariates and clustering of patients to the surgeon level. Differences in median hospital reimbursement and LOS and temporal trends of MIRP and ORP were tested by the Wilcoxon's rank-sum and Cochran–Armitage trend tests, respectively. We then fit generalized estimating equation models to assess whether MIRP or ORP were associated with higher hospital reimbursement, adjusting for patient covariates and year of surgery, and used repeated-measures analysis to account for clustering at the surgeon level. To account for the skewed distribution of costs, we specified a gamma distribution and log link in the generalized estimating equation models and determined adjusted reimbursement for ORP and MIRP.[22] Nonparametric bootstrapping was used to estimate the 95% confidence intervals for hospital reimbursement.[23]

RESULTS

From the IMS LifeLink data, we identified 17 610 patients who underwent radical prostatectomy for prostate cancer by 4092 surgeons from 2003 to 2010 in the United States. The mean age was 57.6 years (s.d.: 4.8). Overall, 8981 (51.0%) and 8629 (49.0%) of surgically treated prostate cancer patients underwent MIRP and ORP, respectively. Table 1 describes the clinical characteristics of the population-based cohort among privately insured patients by surgical approach. Patients who underwent MIRP and ORP had similar distributions regarding age and Elixhauser comorbidity index.

Table 2 provides the differences in LOS, perioperative complications and hospital reimbursement by type of radical prostatectomy. Overall, the median LOS was significantly less for MIRP compared with ORP (1.0 days vs 3.0 days; $P < 0.001$). In comparison with ORP, MIRP was also associated with a statistically significant lower percentage of patients having respiratory (0.7% vs 1.1%; $P = 0.005$), genitourinary (1.2% vs 1.7%; $P = 0.007$) and overall (2.1% vs 3.0%; $P < 0.001$) complications. However, the 90-day readmission rates for MIRP and ORP were similar (5.2% vs 5.3%; $P = 0.85$). MIRP was also associated with a higher median hospital reimbursement compared with ORP (US$16 661 vs US $14 784; $P < 0.001$). During the study interval, MIRP rapidly supplanted ORP as the primary surgical approach for prostate cancer each year (Figure 1; $P < 0.001$ for trend). While approximately a tenth of patients received MIRP in 2003–2004, this increased to 72.5% by 2009–2010.

After adjusting for patient covariates, MIRP was associated with lower ORs of perioperative complications compared with ORP (Table 3). For instance, prostate cancer patients undergoing MIRP had lower adjusted odds ratios (ORs) for overall (OR: 0.82; $P < 0.001$) and genitourinary (OR: 0.76; $P < 0.001$) complications compared with ORP during the hospitalization on multivariable analysis. All other covariates were not associated with significant differences for the remaining perioperative complications. Furthermore, there were minimal differences in the adjusted OR for 90-day readmission for ORP and MIRP (OR: 0.99; 95% CI: 0.92–1.06). Elixhauser comorbidity index, year of surgery and surgical approach were associated with higher reimbursement on multivariable analysis (Table 4). More specifically, the adjusted mean hospital reimbursement was US$1945 more per case for MIRP

Table 1. Patient characeristics ($n = 17\,610$)

Feature	*MIRP* (n = *8981*)	*ORP* (n = *8629*)	P-*value*
	%	%	
Patient age			0.09
40–49	617 (6.9)	529 (6.1)	
50–59	4696 (52.3)	4490 (52.0)	
60–64	3668 (40.8)	3610 (41.8)	
Elixhauser comorbidity			0.62
1	2003 (22.3)	1872 (21.7)	
2	3002 (33.4)	2899 (33.6)	
⩾3	3976 (44.3)	3858 (44.7)	
Geographic region			< 0.0001
East	2218 (24.7)	1408 (16.3)	
Midwest	2624 (29.2)	3122 (36.2)	
South	2857 (31.8)	2448 (28.4)	
West	1282 (14.3)	1651 (19.1)	

Abbreviations: MIRP, minimally invasive radical prostatectomy; ORP, open prostatectomy.

compared with ORP (US$19 292; 95% CI: US$19 243–19 341 vs US$17 347; 95% CI: US$17 299–17 395; $P < 0.001$).

DISCUSSION

In this study, we assessed the comparative effectiveness of MIRP and ORP by critically evaluating differences in-hospital reimbursement and in-hospital outcomes from a privately insured patient population with prostate cancer. To the best of the authors' knowledge, ours is the first study to examine specifically the differences in-hospital reimbursement exlusively among younger, privately insured patients. Our findings build upon prior work in several important ways. First, we present novel results about the differential in-hospital reimbursement for MIRP and ORP. Specifically, hospitals received ~US$2000 more per case for MIRP compared with ORP. Therefore, ~US$126.4 million in additional reimbursement was provided to hospitals for robotic surgery from 2003 to 2010.

It is also essential to recognize that our study characterizes the actual reimbursement for MIRP and ORP among privately insured patients and, as a result, contextualize a possible economic incentive for increasing utilization of robotic surgery for across surgical specialties.[2–4,13] Indeed, greater transparency of the hospital reimbursement is essential to understanding the rapid adoption of health technology innovation. Previous studies have relied on data that may not accurately capture health-care costs nor have examined reimbursement, at a time when prostate cancer consumes US$12 billion each year in the United States.[24]

Table 2. LOS, perioperative complications, 90-day readmission rates and hospital reimbursement for patients diagnosed with prostate cancer and surgically treated with MIRP and ORP[a]

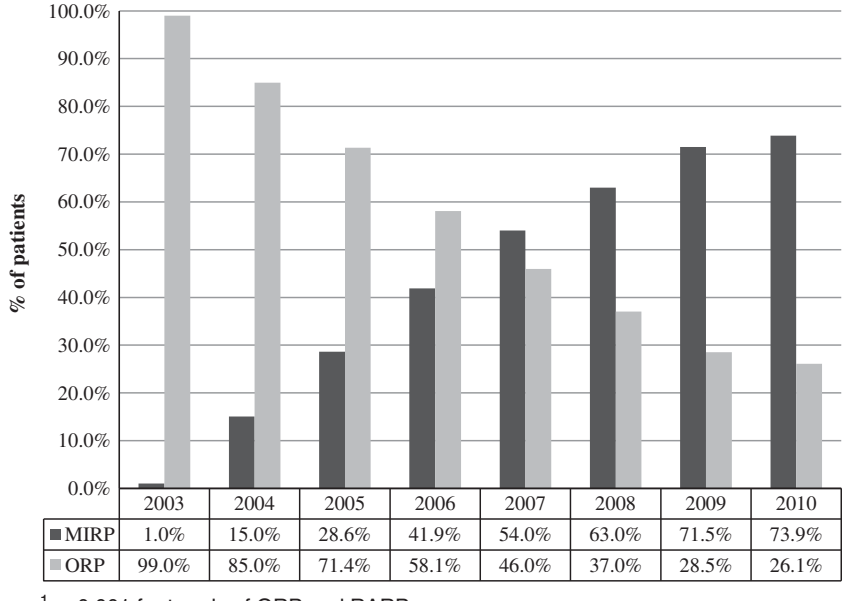
Outcome	*MIRP*	*ORP*	P-*value*
	Median (IQR)	*Median (IQR)*	
LOS (days)	1.0 (1.0,2.0)	3.0 (2.0,3.0)	< 0.0001
	n *(%)*	n *(%)*	
Complications			
Respiratory	64 (0.7)	96 (1.1)	0.005
Genitourinary	109 (1.2)	147 (1.7)	0.007
Wound	2 (0.02)	4 (0.05)	0.39
Vascular	10 (0.11)	11 (0.13)	0.76
Medical	20 (0.22)	14 (0.16)	0.36
Overall	190 (2.1)	257 (3.0)	< 0.001
90-Day readmission rates	5.2%	5.3%	0.85
	Median (IQR)	*Median (IQR)*	
Hospital reimbursement[b]	US$16 661 (US$11 495, US$22 255)	US$14 784 (US$11 424, US$19 463)	< 0.0001

Abbreviations: IQR, interquartile range; LOS, length of stay; MIRP, minimally invasive radical prostatectomy; ORP, open prostatectomy. [a]IQR. [b]Adjusted to 2010 US$.

Table 3. Odds ratios of in-hospital complications for MIRP and ORP[a,b]

Feature	*Unadjusted OR (95% CI)*	P-*value*	*Adjusted OR (95% CI)*	P-*value*
Overall	0.84 (0.76, 0.92)	< 0.001	0.82 (0.74, 0.91)	< 0.001
Respiratory	0.80 (0.68, 0.94)	0.006	0.85 (0.71, 1.02)	0.07
Genitourinary	0.84 (0.74, 0.95)	0.007	0.76 (0.67, 0.87)	< 0.001
Wound	0.69 (0.30, 1.62)	0.40	0.79 (0.32, 1.96)	0.61
Vascular	0.93 (0.61, 1.43)	0.76	1.24 (0.78, 1.98)	0.36
Medical	1.17 (0.83, 1.65)	0.36	1.07 (0.73, 1.56)	0.74

Abbreviations: CI, confidence interval; MIRP, minimally invasive radical prostatectomy; OR, odds ratio; ORP, open prostatectomy. [a]Reference: ORP. [b]Adjusted for patient age, number of comorbidities, region and year of surgery.



	2003	2004	2005	2006	2007	2008	2009	2010
MIRP	1.0%	15.0%	28.6%	41.9%	54.0%	63.0%	71.5%	73.9%
ORP	99.0%	85.0%	71.4%	58.1%	46.0%	37.0%	28.5%	26.1%

[1] p<0.001 for trends of ORP and RARP

Figure 1. Proportion of patients surgically treated by MIRP and ORP by year[1]. MIRP, minimally invasive radical prostatectomy; ORP, open prostatectomy.

Table 4. Multivariable analysis of hospital reimbursement by patient and hospital characteristics

Feature (reference)	*Coefficient (95% CI)*	P-*value*
Age (40–49) (years)		
50–59	−0.014 (−0.062, 0.033)	0.56
60–64	0.024 (−0.029, 0.078)	0.37
Elixhauser comorbidity (1)		
2	0.023 (−0.002, 0.048)	0.07
⩾3	0.082 (0.054, 0.110)	<0.001
Geographic region (East)		
Midwest	−0.038 (−0.140, 0.065)	0.47
South	−0.247 (−0.341, −0.154)	<0.001
West	0.044 (−0.049, 0.137)	0.36
Year (2003)		
2004	0.175 (0.070, 0.281)	<0.001
2005	0.209 (0.104, 0.313)	<0.001
2006	0.266 (0.162, 0.370)	<0.001
2007	0.271 (0.163, 0.378)	<0.001
2008	0.322 (0.207, 0.437)	<0.001
2009	0.357 (0.242, 0.472)	<0.001
2010	0.385 (0.274, 0.497)	<0.001
MIRP (ORP)	0.051 (0.002, 0.101)	0.04

Abbreviations: CI, confidence interval; MIRP, minimally invasive radical prostatectomy; ORP, open prostatectomy.

More specifically, Nguyen *et al*.[5] described minimal differences in Medicare costs between ORP and MIRP (US$293 per case), although this finding is not surprising since Centers for Medicare and Medicaid Services reimburses hospitals at the same rate regardless of surgical approach. Other studies have relied on the cost-to-charge ratio from the Nationwide In-patient Sample, which reflects provider costs for each of the procedures. In our previous study, we found that MIRP cost ~US$2500 more than conventional open surgery per case (US$12 193 vs US$10 051; $P < 0.001$).[13] In a recent systematic review, Bolenz *et al*.[25] also found large variations in health-care costs attributable to ORP and MIRP. To date, however, reimbursement from private insurance by type of radical prostatectomy remains poorly described. One possible inference is that the higher hospital reimbursement for MIRP may be construed as a financial incentive to offer MIRP to newly diagnosed prostate cancer patients considering surgery.

Second, another key finding highlights the perioperative outcomes in a younger, privately insured patient population. Although the privately insured patients in this study had similar low rates of 90-day readmissions, MIRP was associated with better postoperative outcomes regarding LOS and specific complications. In a SEER-Medicare study, Hu *et al*.[4] demonstrated that MIRP was associated with lower risks of respiratory, medical and surgical complications, but a higher risk of genitourinary complications in comparison with ORP.[4] Moreover, some long-term outcomes appeared worse among patients surgically treated with MIRP, in particular for erectile dysfunction and urinary incontinence, compared with those undergoing ORP. Trinh *et al*.[26] used the Nationwide In-patient Sample to demonstrate MIRP similarly reduced LOS, along with the lower rates of cardiac, respiratory, vascular and intraoperative complications. We found that patients undergoing surgery were younger and healthier than previous studies, thereby accounting for some of the difference observed compared with previous studies. Furthermore, the findings presented here also demonstrate that more comorbidities were associated with higher reimbursement from private health insurance plans. Taken together, our results further support previous studies demonstrating shorter LOS and lower risks of perioperative complications as a clinical advantage of MIRP over ORP for prostate cancer patients.

We acknowledge several limitations in our study. First, we recognize that the IMS LifeLink claims data are primarily used for billing and thereby contain limited clinical information about stage and preoperative quality of life. Second, it is plausible that surgeons and patients prefer MIRP, or perceive this minimally invasive approach as a operation with a more expeditious convalescence and better functional outcomes and cancer control. Indeed, patients may be increasingly requesting robotic surgery because of direct marketing to patients.[12] Third, this large privately insured database has limited information about hospital and surgeon characteristics and the different private health insurance plans that may have affected the relationship between the radical prostatectomy and hospital outcomes and reimbursement. For example, it has been well documented that a volume–outcome relationship exists among patients undergoing radical prostatectomy in that less complications are associated with high volume surgeons.[8,10,27,28] Fourth, although higher hospital reimbursement for MIRP explains some of the greater utilization of robotic surgery in United States, other reasons likely contribute to this phenomenon, especially considering we did not survey patients and providers about treatment preferences regarding ORP and RARP. Fifth, we also recognize that event rate of postoperative complications was relatively low and, as a result, it was difficult to investigate the relationship of postoperative complications and hospital reimbursement by surgical approach. Moreover, it is also necessary to acknowledge that although several studies have made use of a similar methodology to ascertain postoperative complications, these definitions of complications have yet to be validated. Last, the primary outcomes only focused on short-term, hospitalization outcomes regarding LOS, complications and hospital reimbursement. We acknowledge that our study did not evaluate differences in long-term outcomes, survival and quality of life as these data were not available. Therefore, any inferences regarding a comprehensive evaluation of the comparative effectiveness of MIRP and ORP are somewhat limited.

Our findings have health-care policy implications for the rapid dissemination of robotic surgery in prostate cancer. We believe we are the first to present information on hospitalization outcomes and reimbursement in a population-based cohort of privately insured patients. Our results suggest that MIRP was used to a greater extent than previously reported among privately insured patients with prostate cancer. In addition, MIRP conferred better outcomes during the hospitalization with shorter LOS and less perioperative adverse events, in particular for genitourinary complications. However, the clinical benefits do come at a price in that hospitals are receiving ~US$2000 more per case for MIRP than ORP.

A multitude of factors are responsible for the dissemination of robotic surgery in the United States. In addition to higher reimbursement and better in-hospital outcomes with MIRP, hospitals and urologic surgeons also face market pressure to purchase robotic surgical systems to either maintain or gain market share of prostate cancer patients. Indeed, hospitals may in fact have greater profitability with robotic surgery because of the greater reimbursement from private payers and shorter LOS and lower risks of complications attributable to RARP. Yet, the type of health insurance will also influence the profitability of purchasing a robotic surgical system. For example, Lotan *et al*.[29] previously demonstrated that patients insured by Medicare would in fact cost the hospital US$4000 more per case for MIRP as Centers for Medicare and Medicaid Services dispense the similar reimbursement regardless of surgical approach for radical prostatectomy.

In the future, robotic surgery may face greater scrutiny around reimbursement given the limited high-quality evidence to suggest that it improves better long-term functional and oncologic

outcomes, and the estimated US$1 billion annually more in health-care costs attributable to the advances in robotic surgery.[30] Furthermore, previous studies have demonstrated that uninsured patients and minority patients face limited access to hospitals with robotic surgery availability as well as treatment with MIRP among prostate cancer patients who are least likely to benefit because of limited life expectancy or the indolent nature of low-risk disease.[11,31] Careful attention is needed to better understand the relationship of greater reimbursement and receipt of radical prostatectomy at a time when there are also growing concerns about the overtreatment of prostate cancer.[32]

In summary, MIRP is associated with shorter LOS and fewer complications as well as greater reimbursement compared to ORP from 2003 to 2010. During this rapid expansion of robotic surgery for localized prostate cancer, hospitals received ~US$2000 more per case for MIRP compared with ORP. Further research is needed to examine critically the hospital and payer characteristics that explain why robotic surgery has become dominant in the US market share of patients surgically treated for prostate cancer.

CONFLICT OF INTEREST

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