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Costs of medical care after open or minimally invasive prostate cancer surgery: A population-based analysis

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Abstract

Background—Evidence suggests that minimally-invasive radical prostatectomy (MRP) and open radical prostatectomy (ORP) have similar short-term clinical and functional outcomes. MRP with robotic assistance is generally more expensive than ORP, but it is not clear whether subsequent costs of care vary by approach.

Methods—In the linked SEER-Medicare database we identified men age 66 or older who received MRP or ORP in 2003-2006 for prostate cancer. Total cost of care was estimated as the sum of Medicare payments from all claims for hospital care, outpatient care, physician services, home health and hospice care, and durable medical equipment in the first year from date of surgical admission. We estimated the impact of surgical approach on costs controlling for patient and disease characteristics.

Results—Of 5,445 surgically-treated prostate cancer patients, 4,454 (82%) had ORP and 991 (18%) had MRP. Mean total first-year costs were more than \$1,200 greater for MRP compared with ORP (\$16,919 vs. \$15,692, $p=0.08$). Controlling for patient and disease characteristics, MRP was associated with 2% greater mean total payments, but this difference was not statistically significant. First-year costs were greater for men who were older, black, lived in the Northeast, had lymph node involvement, more advanced tumor stage or greater comorbidity.

Conclusions—In this population-based cohort of older men, MRP and ORP had similar economic outcomes. From a payer's perspective, any benefits associated with MRP may not translate to net savings compared with ORP in the first year after surgery.

Keywords

prostate; prostatic neoplasms; prostatectomy; minimally invasive surgical procedures; laparoscopy

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BACKGROUND

Each year in the US more than 200,000 men receive a new diagnosis of prostate cancer, and about one-third of these men receive surgical treatment.¹ The use of minimally invasive approaches to prostate cancer surgery, including robot-assisted procedures, has increased dramatically in the past decade.² The rapid uptake of minimally-invasive radical prostatectomy (MRP) has occurred in the absence of randomized trial evidence of its clinical equivalence/superiority to traditional open radical prostatectomy (ORP). Observational studies support claims of lower blood loss and a shorter hospital stay with MRP, but there is limited evidence that short-term functional and oncologic outcomes vary by approach.^{3, 4} Even with the robot-assisted procedure, a substantial proportion of men will experience temporary or permanent urinary and erectile dysfunction and some will require additional cancer therapy.⁵

In addition to its morbidity and mortality burden, prostate cancer has a tremendous economic impact. In 2010 the \$12 billion spent on prostate cancer care accounted for almost 10% of spending on all cancers in the US, and this fraction is expected to exceed 10% by 2020.⁶ Radical prostatectomy accounts for about half of all prostate cancer expenditures.⁷ Thus, widespread changes in surgical approach can substantially influence overall spending for prostate cancer care. Prior studies comparing the costs of MRP and ORP have primarily addressed only the costs of the procedure and initial hospitalization, excluding most or all costs associated with surgical complications, side effects and cancer recurrence.⁸⁻¹² Moreover, these studies were typically performed from a provider perspective, ignoring additional costs to payers and patients. Our objective was to compare direct medical costs in the year following MRP or ORP in a population-based cohort of older men with prostate cancer.

METHODS

Data Source

We used Surveillance Epidemiology and End Results (SEER) cancer registry data linked with Medicare claims. SEER, sponsored by the National Cancer Institute (NCI), is a consortium of population-based cancer registries in selected states and metropolitan areas, covering more than 25% of the US population.¹³ The SEER registries collect data regarding site and extent of disease, first course of cancer-directed therapy, and socio-demographic characteristics, with active follow-up for date and cause of death. Medicare is the primary health insurer for 97% of Americans age 65 years and older, covering inpatient hospital care (Part A), and outpatient care and physician services (Part B). Ninety-four percent of individuals age 65 and older in SEER have been linked to Medicare enrollment records. The SEER-Medicare files were used in accordance with a data-use agreement from NCI, and the study was approved by the Institutional Review Board at Memorial Sloan-Kettering Cancer Center.

Cohort

We identified Medicare beneficiaries age 66 years or older who were diagnosed with prostate cancer between January 1, 2003 and December 31, 2005 and had MRP or ORP between January 1, 2003 and December 31, 2006. Men diagnosed only at death, with a prior malignancy, who were enrolled in a managed care plan, or who lacked Part A or B of Medicare were excluded. Surgical procedures were identified by Healthcare Common Procedural Coding System (HCPCS) codes (55866 - MRP; 55840, 55842, 55845 - ORP) in physician claims. MRP included robotic laparoscopic prostatectomies as well as

laparoscopic procedures without robotic assistance. The HCPCS code for laparoscopic RP (55866) was introduced in 2003.

Defining Costs

Consistent with similar studies, we defined cost as the amount reimbursed by Medicare.¹⁴⁻¹⁶ Unlike provider charges, Medicare payments are derived from reimbursement formulas that are designed to reflect average resource utilization, and thus serve as a closer approximation of the opportunity cost of a good or service.^{17, 18}

We examined costs for all health care reimbursed by Medicare in the year following prostate cancer surgery, from the day of hospital admission for MRP or ORP through the next 365 days. Total cost of care was estimated as the sum of Medicare payments for all claims during the year for hospital care, outpatient care, physician services, home health and hospice care and durable medical equipment. In addition to total cost, we examined costs within specific categories. The cost of surgery included Medicare payments for the radical prostatectomy admission and for any physician services paid by Medicare during that hospital stay. Costs of other cancer therapy included Medicare payments for radiation therapy, chemotherapy, androgen deprivation therapy and bisphosphonates. Inpatient care costs included Medicare payments for all hospitalizations following the initial surgical stay. Other costs included payments for all other services reimbursed by Medicare, including but not limited to home health, durable medical equipment, and hospice care during the 365 days after admission for MRP or ORP.

All costs are reported in 2006 US dollars. We used the Hospital Wage Index¹⁹ and the Medicare Economic Index²⁰ to adjust payments for inpatient and outpatient services, respectively, for inflation. We also adjusted for geographic variability in costs using the Acute Inpatient Prospective Payment System Wage Index^{21, 22} for inpatient services and the Medicare Geographic Practice Cost Index²³ for outpatient services.

Covariates

Demographic covariates included patient age, race, geographic location, and marital status. Median income in the census tract of residence was used as a marker of socioeconomic status. Clinical covariates included tumor stage, lymph node involvement, preoperative PSA, Gleason score, and diagnosis year. Because SEER did not record numeric PSA values until 2004, we used preoperative PSA categorized as elevated, borderline, normal, or unknown. Comorbidity was estimated using the Charlson comorbidity score, based on inpatient claims in the 365 days prior to prostate cancer diagnosis.^{24, 25}

Statistical Analysis

We estimated the mean and standard deviation of total costs and costs within each category by type of surgery. Costs in the two groups (MRP and ORP) were compared using t-tests for the difference in means of log-transformed costs. We also assessed the frequency of any cost within each category, and compared mean costs between groups in an analysis limited to patients with positive costs within a category. The adjusted impact of procedure type on total cost was estimated using multivariable linear regression, controlling for patient and tumor characteristics. The dependent variable was modeled using a natural log transformation, and therefore coefficients can be interpreted as an approximation of the percent difference in costs. All statistical analyses were performed in SAS version 9.2 (SAS Institute, Cary, NC).

RESULTS

Characteristics of the Cohort

We identified 5,445 patients with a prostate cancer diagnosis between 2003 and 2005 and radical prostatectomy, of whom 4,454 (82%) had ORP and 991 (18%) had MRP. There was no difference between the groups with respect to age, preoperative PSA, Gleason score, clinical tumor stage or comorbidity (Table 1). Differences in the distributions of race, census tract median income, region, and nodal involvement were statistically significant but small. Pathologic tumor stage was slightly more favorable in the MRP group, with 81% stage T2 or lower compared with 75% in the ORP group ($p<0.001$). The proportion of MRPs increased over time ($p<0.0001$).

Health Care Costs

Mean total Medicare payments from the date of prostate cancer surgery through 365 days following surgery was \$16,919 (SD \$20,510) for men who had MRP and \$15,692 (SD \$12,720) for those who had ORP (Table 2). While total first-year costs were more than \$1,200 greater, on average, among men who had MRP, a t-test of the log-transformed mean suggested that this difference was not statistically significant ($p=0.08$). However, mean costs differed between groups within specific categories. MRP patients had greater mean costs for surgery (\$10,968 vs. \$10,217, $p=0.02$) while ORP patients had greater mean costs for other cancer therapies (\$702 vs. \$406, $p<0.01$). Costs of inpatient care were similar, and costs of other care were greater in the MRP group (\$2,887 vs \$2,632, $p<0.01$).

The difference between groups in the cost of other cancer therapies may be mostly attributable to a difference in the cost of chemotherapy and bisphosphonates, which were used by 5% and 7% of MRP and ORP patients, respectively. Limiting the analysis to men who had any payment for chemotherapy or bisphosphonates, mean costs in this category were approximately \$1,000 greater in the ORP group ($p=0.01$, Table 3). While mean inpatient care costs were similar on average between the two groups, a slightly greater proportion of ORP patients had any inpatient costs (15% vs. 13%). However, among those with any inpatient care after the initial surgical hospitalization, (mean cost in this category was \$6,000 greater in the MRP group ($p=0.03$)). Use of Medicare-reimbursed home health care was almost twice as great in the MRP group (27% vs. 13%), but among users, the mean cost of home health care was more than \$800 greater in the ORP group ($p<0.0001$).

Controlling for demographic and disease characteristics, MRP was associated with 2% greater mean total cost compared with ORP, but this difference was not statistically significant (Table 4, $p=0.37$). In adjusted analysis, costs were greater among men who were older, black, lived in the Northeast, had lymph node involvement, a higher staged tumor or more comorbidity. Region and comorbidity appeared to exert the greatest impact on total cost. For example, mean costs were 47% lower among men in the South compared with their peers in the Northeast, and men with a Charlson comorbidity score of 2 or greater had 36% higher costs than those with a Charlson score of 0. Preoperative PSA, Gleason score and census tract median income had no impact on first-year cost, controlling for other factors. Mean total Medicare payments in the first year after radical prostatectomy decreased over time, by almost 2% per year.

DISCUSSION

The national movement for comparative effectiveness research recognizes the necessity of information to help providers choose the best treatment for each patient, and comparative studies of prostate cancer treatment options are a high priority on the agenda.²⁶ Mounting evidence from observational studies suggests that for men with early-stage prostate cancer,

MRP and ORP are more similar than different with respect to surgical complications, functional impairment and oncologic outcomes.^{3-5, 27} Results of our population-based analysis suggest that the two procedures also have similar economic outcomes, at least in the first year following surgery.

Estimates of health care costs associated with different interventions can be strongly influenced by both the perspective and time horizon of analysis. Prior comparative studies of costs associated with MRP and ORP have primarily focused on the perioperative period and assumed a hospital or surgeon perspective. Most of these studies found that the robotic cases cost more than the open ones, and differences between the two procedures were primarily attributable to the high fixed costs associated with purchasing and maintaining the robot.^{9, 10, 12, 28} The da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA, USA) costs between \$1 million and \$2.5 million with a maintenance fee of \$120,000 per year after the first year, and the average cost of disposable supplies is approximately \$1,500 per case. The purchase and maintenance costs of the robot are estimated to add almost \$2,700 per patient to the cost of a prostatectomy,⁹ although this incremental cost would be expected to decline with increasing case volume.¹² A recent review of several different robotic procedures found that use of the robot increased costs from as little as \$400 to as much as \$4,800 per case.⁸ Considering amortized equipment costs, utilization of the robot increased total procedure costs by more than \$3,000 per case, compared with the open version of a procedure.⁸

We assessed cost from the perspective of the payer, rather than a hospital or provider, using Medicare payment as an approximation of cost. For radical prostatectomy, hospital reimbursement formulas within the Medicare prospective payment system do not vary by surgical approach, while the professional fees billed by surgeons and reimbursed under the resource-based relative value scale methodology do vary. Without pelvic lymphadenectomy, the difference in average physician reimbursement is about \$100, favoring MRP; with lymphadenectomy the difference is closer to \$1,000.²⁹ Although we saw a difference in Medicare payments associated with all care received during the initial surgical stay, this difference was less than \$1,000 – smaller than the differences of \$1,726 to \$2,698 estimated from a hospital or provider perspective.^{9, 10}

In addition to examining costs associated with the initial surgical procedure, we also estimated costs in the first year following surgery. If there were a true difference in clinical outcomes between MRP and ORP, we might expect to see differences in the use and cost of health care services beyond the perioperative period. We found that in the first year, mean total costs of care did not differ, but costs within specific categories did. For example, average costs associated with surgery, inpatient care after the initial surgical hospitalization and other medical care were greater in the MRP group, while the average cost of other cancer therapy was greater in the ORP group. However, average costs are a function of both service utilization and cost per service. While a slightly greater proportion of ORP patients had any inpatient care costs after the initial hospitalization, the average cost of inpatient care among users was more than \$6,000 greater for those who had MRP. Conversely, while a substantially greater proportion of MRP patients had any home health care costs, the average cost of home health care among users was more than \$800 greater in the ORP group.

Trends in the use and cost of prostate cancer surgery are likely to influence the overall cost of treating this disease. Between 1991 and 2002, the initial costs of prostate cancer treatment declined, largely due to a decrease in the proportion of men receiving surgery.¹⁶ Since then, however, aggressive marketing by hospitals and the robot manufacturer, combined with Americans' appetite for new technology, has fueled a dramatic increase in the number of MRPs performed annually in the US. Intuitive Surgical, manufacturer of the da Vinci

robotic surgical system, reports that in 2009 approximately 90,000 robotic radical prostatectomies were performed in the US compared to just under 20,000 in 2005.³⁰ The number of da Vinci robotic systems purchased by US hospitals has increased from approximately 300 in 2005 to over 1,150 in 2010.³⁰ From 2005 to 2008, hospital discharges for radical prostatectomy increased 60% in the US, largely because of the increase in robotic procedures,⁸ and analysis of hospital discharges in six states found that acquisition of a robot was associated with an increase in the total number of prostatectomies, at both the hospital and regional levels.³¹ Whether or not increased use of MRP represents overtreatment (i.e., surgeries that would not have been performed or indicated in the absence of the robot), the popularity of robotic surgery has likely driven up the overall cost of prostate cancer care. Technological advances in other treatment modalities, such as the use of intensity-modulated radiation therapy instead of three-dimensional conformal radiation therapy may be increasing prostate cancer treatment costs as well.³²

Some advantages of robotic surgery may not be evident from standard economic and clinical endpoints. Robotic surgery may improve visualization and dexterity, reducing the technical complexity of the procedure compared with traditional laparoscopic prostatectomy. However, there is little evidence that these benefits have influenced clinical and economic outcomes, other than reductions in blood loss and length of stay with MRP. From the payer's perspective over a one-year period, these benefits did not translate to net savings in our analysis, compared with ORP.

Several limitations of our analysis should be noted. Our findings are generalizable to the US population of older prostate cancer patients covered by Medicare, but costs associated with prostate cancer surgery and health service utilization after surgery may differ in younger men, due to both their age and insurance coverage. Although we were able to control for numerous important demographic and clinical characteristics, other unmeasured factors, such as the patient's functional status or his surgeon's experience, could potentially confound the relationship between surgical approach and costs. Because all laparoscopic prostatectomies shared a single HCPCS code (55866) during the study period, we could not distinguish procedures performed with and without robotic assistance. However, information regarding the uptake and use of the da Vinci surgical system suggests that the majority of MRPs in our analysis were robot-assisted. Finally, the use of a payer perspective ignores fixed costs borne by hospitals (e.g. purchase and maintenance costs of robot and disposable instrument costs) and out-of-pocket costs borne by patients and their families, although it is not clear whether those out-of-pocket costs would vary by surgical procedure, particularly if clinical outcomes are similar.

As the population ages and the incidence of early-stage prostate cancer rises with continued use of prostate-specific antigen (PSA) screening, total expenditures for prostate cancer, and the portion associated with surgery, will grow as well. If cancer control and functional recovery are similar between MRP and ORP, then cost considerations become even more important for payers, providers, and patients choosing between open and robotic surgical approaches. Our findings, in a population-based cohort of older men, suggest that there is no obvious cost advantage to either approach in the first year following surgery.

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Table 1

Characteristics of cohort by type of surgery

Characteristic	MRP N = 991		ORP N = 4,454		p
	N	%	N	%	
Age at diagnosis (years)					
66-69	551	56%	2569	58%	0.39
70-74	364	37%	1554	35%	
75-79	-	<10%	298	7%	
80+	-	<1%	33	<1%	
Race					
White	834	84%	3807	85%	<.0001
Black	57	6%	334	8%	
Other	100	10%	313	7%	
Census tract median income					
1 st quartile	107	11%	905	20%	<.0001
2 nd quartile	210	21%	1188	27%	
3 rd quartile	252	25%	1165	26%	
4 th quartile	422	43%	1196	27%	
Region					
West	660	67%	2829	64%	<.0001
Midwest	121	12%	528	12%	
South	70	7%	649	15%	
Northeast	140	14%	448	10%	
Preoperative PSA					
Elevated	831	84%	3819	86%	0.092
Normal	97	10%	342	8%	
Borderline	63	6%	293	7%	
Gleason score					
2-4	--	<1%	34	1%	0.27
5-7	--	<50%	2110	47%	
8-10	536	54%	2310	52%	

Characteristic	MRP N = 991		ORP N = 4,454		p
	N	%	N	%	
Nodal involvement					
No	--	99%	4346	98%	0.0006
Yes	--	<1%	108	2%	
Clinical stage					
T2 or less	976	99%	4357	98%	0.41
T3 or greater	--	<1%	78	2%	
Missing	--	<1%	19	<1%	
Pathological stage					
T2 or lower	800	81%	3360	75%	0.0004
T3 or greater	191	19%	1094	25%	
Charlson comorbidity score					
0	776	78%	3420	77%	0.61
1	167	17%	801	18%	
2+	48	5%	233	5%	
Year of surgery					
2003	102	10%	1423	32%	<.0001
2004	286	29%	1499	34%	
2005	450	45%	1302	29%	
2006	153	15%	230	5%	

* Cells with counts 11 and relevant adjacent cells are not shown, in adherence with SEER-Medicare Data Use Agreement

P-values for chi-square tests of association between each characteristic and type of surgery

MRP: minimally invasive radical prostatectomy

ORP: open radical prostatectomy

PSA: prostate-specific antigen

Table 2

Medicare payments in first year after prostate cancer surgery, all patients

Cost category	MRP (N=991)		ORP (N=4454)		Difference		p
	Mean	(SD)	Mean	(SD)	Mean	(SD)	
Total	\$16,919	\$20,510	\$15,692	\$12,720	\$1,227	\$14,452	0.084
Surgery	\$10,968	\$13,647	\$10,217	\$5,944	\$751	\$7,923	0.023
Other cancer therapy	\$406	\$2,545	\$702	\$3,412	-\$296	\$3,272	0.001
Inpatient care	\$2,657	\$11,673	\$2,141	\$7,908	\$516	\$8,715	0.19
Other	\$2,887	\$3,653	\$2,632	\$3,201	\$255	\$3,287	0.0001

Notes: All costs in 2006 US dollars, adjusted for inflation and geographic variability.

P-values for tests of difference in mean of natural log of costs.

Natural log imputed to 0 when cost=\$0.

MRP: minimally invasive radical prostatectomy

ORP: open radical prostatectomy

Table 3

Medicare payments in first year after prostate cancer surgery, patients with positive costs*

Category	MRP (N=991)			ORP (N=4,454)			Difference	
	n	Mean	(SD)	n	Mean	(SD)	Mean	p
Total	991	\$16,919	\$20,510	4454	\$15,692	\$12,720	\$1,227	\$14,452 0.08
Surgery	991	\$10,968	\$13,647	4454	\$10,217	\$5,944	\$751	\$7,923 0.02
Other cancer therapy								
Chemotherapy/bisphosphonates	52	\$1,870	\$3,231	327	\$2,813	\$3,872	-\$943	\$3,792 0.01
Radiotherapy	65	\$4,690	\$8,170	373	\$5,822	\$8,713	-\$1,132	\$8,635 0.18
Androgen deprivation therapy	-	\$410	----	26	\$1,406	\$1,239	-\$996	\$1,239 ----
Inpatient care	129	\$20,415	\$26,238	664	\$14,361	\$15,631	\$6,054	\$17,782 0.03
Other								
Home health care	269	\$1,097	\$1,829	586	\$1,945	\$1,750	-\$848	\$1,776 <0001
Other	986	\$2,602	\$3,112	4433	\$2,387	\$2,884	\$215	\$2,927 0.67

* Notes: Mean for each category based on observations with costs greater than \$0 within category.

Cells with counts 11 and relevant adjacent cells are not shown, in adherence with SEER-Medicare Data Use Agreement

All costs in 2006 US dollars, adjusted for inflation and geographic variability.

P-values for tests of difference in mean of natural log of costs.

MRP: minimally invasive radical prostatectomy

ORP: open radical prostatectomy

Table 4

Predictors of medical care costs in first year after prostate cancer surgery

Characteristic	Coefficient (95% CI)	p
Surgery		
ORP	Reference	0.37
MRP	0.020 (−0.026, 0.065)	
Age at diagnosis (years)		
66-69	Reference	0.0017
70-74	0.037 (0.007, 0.066)	
75-79	0.119 (0.062, 0.176)	
80+	0.283 (0.077, 0.488)	
Race		
White	Reference	0.027
Black	0.092 (0.024, 0.160)	
Other	0.012 (−0.034, 0.058)	
Census tract median income		
1 st quartile	Reference	0.80
2 nd quartile	−0.006 (−0.048, 0.036)	
3 rd quartile	−0.005 (−0.050, 0.040)	
4 th quartile	0.010 (−0.035, 0.055)	
Region		
Northeast	Reference	<0.0001
Midwest	−0.328 (−0.414, −0.242)	
South	−0.468 (−0.544, −0.393)	
West	−0.062 (−0.127, −0.002)	
Preoperative PSA		
Normal	Reference	0.32
Borderline	−0.055 (−0.126, 0.016)	
Elevated	−0.022 (−0.064, 0.021)	
Gleason score		
2-4	Reference	0.097
5-7	−0.060 (−0.173, 0.053)	
8-10	−0.033 (−0.147, 0.081)	
Nodal involvement		
No	Reference	0.0002
Yes	0.157 (0.081, 0.233)	
Pathologic stage		
T2 or less	Reference	<.0001
T3 or greater	0.131 (0.091, 0.172)	
Charlson comorbidity score		
0	Reference	<.0001
1	0.093 (0.060, 0.127)	

Characteristic	Coefficient (95% CI)	p
2+	0.357 (0.272, 0.441)	
Year of surgery	−0.018 (−0.036, −0.001)	0.057

Notes: Coefficients from multivariable linear regression of log-transformed total costs Year of surgery modeled as continuous variable from 2003

MRP: minimally invasive radical prostatectomy

ORP: open radical prostatectomy

PSA: prostate-specific antigen