Robot-assisted versus open radical prostatectomy utilization in hospitals offering robotics

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YANAMADALA S, CHUNG BI, HERNANDEZ-BOUSSARD TM. Robot-assisted versus open radical prostatectomy utilization in hospitals offering robotics. *Can J Urol* 2016;23(3):8279-8284.

Introduction: *Prostate cancer is an extremely prevalent cause of morbidity and mortality among American men. Several different treatments exist, but differences in utilization between these treatments are not well understood.*

Materials and methods: *We performed an observational study using administrative datasets linked to hospital survey data, which included non-metastatic prostate cancer patients receiving robot-assisted radical prostatectomy (RARP) or open radical prostatectomy (ORP) in California, Florida, or New York from 2009-2011. We developed two hierarchical regression models with fixed effect accounting for hospital clustering and physician clustering to determine factors associated with utilization of RARP versus ORP at hospitals offering robotic surgery.*

Results: *A total of 36,694 patients were identified, with 77.13% receiving RARP and 22.87% receiving ORP. African American patients had lower RARP rates than White patients (OR = 0.80, p < 0.001). Patients using Medicare (OR = 0.91, p = 0.028), Medicaid (OR = 0.68, p < 0.001), or self-pay (OR = 0.72, p = 0.046) had lower RARP rates than patients using private insurance. Patients in Florida had lower RARP rates than patients in California (OR = 0.48, p = 0.010). Patients treated at teaching hospitals had lower RARP rates than patients treated at non-teaching hospitals (OR = 0.50, p = 0.006). The average cost of RARP was $13,614.83, and the average cost of ORP was $12,167.44 (p < 0.001).*

Conclusions: *This population based study suggests that both patient and hospital characteristics are associated with utilization of RARP versus ORP in hospitals where robotic surgery is offered.*

Key Words: prostatectomy, prostatic neoplasms, robotics, utilization

Introduction

Prostate cancer is the second highest cancer-related cause of mortality among men in the United States. In 2015, approximately 221,000 men in the United States were diagnosed with prostate cancer, and approximately 30,000 American men died of this disease.[1] Several treatment options exist, ranging from radical prostatectomy to radiation therapy and watchful waiting, yet no single approach can be recommended as the preferred treatment for localized prostate cancer due to gaps in evidence and the large role individual patient preferences play in treatment selection.[2-4]

Multiple studies have shown that delivery of care varies across different subpopulations of prostate cancer patients. An association between race and treatment rates has been demonstrated, with White patients having significantly higher rates of radical prostatectomy and radiotherapy than African

Accepted for publication February 2016

Acknowledgements
This study was funded by the Stanford University School of Medicine Medical Scholars Research Program and the Agency for Healthcare Research and Quality. Dr. Hernandez-Boussard was supported by grant number K01HS018558 from the Agency for Healthcare Research and Quality.

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American patients, after adjusting for other patient characteristics and stage.[5] Moreover, recent studies analyzing radical prostatectomy rates have suggested that race, hospital type, and hospital volume are associated with utilization of robot-assisted radical prostatectomy (RARP).[6,7]

While these differences in utilization have been documented, to the best of our knowledge, studies have not used an all-capture dataset to analyze factors associated with utilization of RARP versus open radical prostatectomy (ORP) within hospitals offering robotic surgery. We hypothesized that there would be differential RARP utilization observed even within these hospitals. Therefore, we sought to identify patient and hospital characteristics associated with the utilization of RARP versus ORP in hospitals where robotic surgery is offered.

Materials and methods

Data source

Discharge data from the State Inpatient Databases (SID) and State Ambulatory Surgery Databases (SASD), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality from California, Florida, and New York were used in this study.[8,9] These are all-capture state databases that contain patient characteristics, primary and secondary diagnoses, procedures, and the ability to link patients over time. Discharge records were linked to the 2008 and 2011 American Hospital Association (AHA) annual survey database, which contains information on the availability of robotic surgery at different hospitals.[10,11] HCUP cost-to-charge ratio files were used to derive procedure costs from total charges.[12] The CoinNews US inflation calculator was used to calculate all costs in 2011 dollars.[13]

Study population

We identified prostate cancer patients from 2009-2011 using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD9-CM) diagnostic code 185. Patients receiving RARP and ORP were identified using ICD9-CM procedure codes and Current Procedural Terminology (CPT) codes. The ICD9-CM code 605 with 1742 or 1749 and the CPT code 55866 were used to identify patients receiving RARP. The CPT codes 55801, 55810, 55812, 55815, 55821, 55831, 55840, 55842, and 55845 and the ICD9-CM codes 605 (without 5421, 1742, or 1749) and 6062 were used to identify patients receiving ORP. Patients receiving both procedures and patients who did not visit a hospital offering robotic surgery were not included in the analysis. Patients with metastatic cancer were excluded from the study using the Elixhauser comorbidity index with the ICD-9-CM codes 196, 197, 198, and 199.[14] Comorbidities were identified using the Elixhauser comorbidity index.[14] We followed each patient's treatment over the 3 year period, and the variable visitlink was used to uniquely identify patients. This study was exempt from IRB approval.

Outcome of interest

Our main outcome of interest was treatment received. A variable was created to describe whether patients received RARP or ORP.

Statistical analysis

Descriptive statistics were performed using univariate regression analysis and Kruskal-Wallis, as appropriate. We developed a hierarchical regression model with fixed effect accounting for hospital clustering to identify patient and hospital characteristics associated with treatment received. All patients with the prostate cancer diagnosis without metastasis who visited a hospital offering robotic surgery and received one of the two procedures were included in the model. The dependent variable was whether RARP or ORP was received, and the independent variables were race, primary payer, age group, comorbidities, hospital volume, hospital state, teaching status, proximity in time of robot acquisition, and year. A sensitivity analysis was conducted by developing a second hierarchical regression model with fixed effect accounting for physician clustering; only Florida and New York were included in the sensitivity analysis due to a lack of available data for California. All statistical analyses were performed using STATA version 13.0.[15]

Results

Patient characteristics are described in Table 1. A total of 36,694 patients were identified, with 77.13% undergoing RARP and 22.87% undergoing ORP. A larger proportion of White patients received RARP over ORP (71.01% versus 66.71%) compared to African American (8.64% versus 12.62%, $p < 0.001$) and Hispanic (9.06% versus 10.15%, $p < 0.001$) patients. A larger proportion of patients using private insurance (62.84% versus 55.31%) received RARP over ORP than patients using Medicare (32.14% versus 37.59%, $p < 0.001$), Medicaid (2.49% versus 3.54%, $p < 0.001$) and self-pay (0.67% versus 0.93%, $p = 0.001$). A larger proportion of patients at high volume hospitals (87.13% versus 70.28%, $p < 0.001$) received RARP over ORP compared to patients at medium (11.87% versus 25.31%, $p < 0.001$) and low (1.00% versus 4.41%) volume hospitals. Among patients treated in California, 83.22% received RARP, while 72.71% of patients in Florida ($p < 0.001$) and 73.75% of patients in New York ($p < 0.001$) received

TABLE 1. **Patient characteristics**

	RARP	ORP	Total	OR	95% CI	p value
Total	28,301 (77.13)	8,393 (22.87)	36,694 (100)			
Age (y)						
<= 50	2,234 (7.89)	615 (7.33)	2,849 (7.76)	Ref.		
51-60	9,844 (34.78)	2,501 (29.80)	12,345 (33.64)	1.01	1.00-1.03	0.127
61-70	13,118 (46.35)	3,837 (45.72)	16,955 (46.21)	0.99	0.97-1.01	0.218
> 70	3,105 (10.97)	1,440 (17.16)	4,545 (12.39)	0.90	0.89-0.92	< 0.001
Race						
White	20,097 (71.01)	5,599 (66.71)	25,696 (70.03)	Ref.		
African American	2,445 (8.64)	1,059 (12.62)	3,504 (9.55)	0.92	0.91-0.93	< 0.001
Hispanic	2,565 (9.06)	852 (10.15)	3,417 (9.31)	0.97	0.95-0.98	< 0.001
Other	3,194 (11.29)	883 (10.52)	4,077 (11.11)	1.00	0.99-1.02	0.853
Primary payer						
Private insurance	17,783 (62.84)	4,642 (55.31)	22,425 (61.11)	Ref.		
Self-pay	189 (0.67)	78 (0.93)	267 (0.73)	0.92	0.87-0.97	0.001
Medicare	9,097 (32.14)	3,155 (37.59)	12,252 (33.39)	0.95	0.94-0.96	< 0.001
Medicaid	706 (2.49)	297 (3.54)	1,003 (2.73)	0.91	0.89-0.94	< 0.001
Other	526 (1.86)	221 (2.63)	747 (2.04)	0.91	0.89-0.94	< 0.001
Comorbidities, mean [sd]	0.95 [1.02]	1.08 [1.11]	0.98 [1.04]	0.98	0.98-0.98	< 0.001
Hospital volume tercile						
1st tercile	284 (1.00)	370 (4.41)	654 (1.78)	Ref.		
2nd tercile	3,358 (11.87)	2,124 (25.31)	5,482 (14.94)	1.20	1.16-1.24	< 0.001
3rd tercile	24,659 (87.13)	5,899 (70.28)	30,558 (83.28)	1.45	1.41-1.50	< 0.001
Hospital state						
California	11,847 (83.22)	2,388 (16.78)	14,235 (38.79)	Ref.		
Florida	7,655 (72.71)	2,873 (27.29)	10,528 (28.69)	0.90	0.89-0.91	< 0.001
New York	8,799 (73.75)	3,132 (26.25)	11,931 (32.51)	0.91	0.90-0.92	< 0.001
Teaching hospital						
No	8,183 (28.91)	2,063 (24.58)	10,246 (27.92)	Ref.		
Yes	20,118 (71.09)	6,330 (75.42)	26,448 (72.08)	0.96	0.95-0.97	< 0.001
Cost, mean [sd]	13,614.83 [7,526.84]	12,167.44 [9,063.22]	13,284.18 [7,927.35]			< 0.001

RARP = robot-assisted radical prostatectomy; ORP = open radical prostatectomy; OR = operating room; CI = confidence interval

RARP. A lower proportion of patients received RARP over ORP at teaching hospitals (71.09% versus 75.42%, $p < 0.001$) than non-teaching hospitals (28.91% versus 24.58%). The mean cost of RARP was 13,614.83 dollars, and the mean cost of ORP was 12,167.44, in 2011 dollars ($p < 0.001$), Table 1. The percentage of patients receiving RARP among patients receiving either RARP or ORP increased by 11.54% from 2009 to 2011. While the percentage of patients receiving RARP differed by patient race and payer, the magnitude of the difference between the White-African American, White-Hispanic, private insurance-Medicare, private insurance-Medicaid, and private insurance-self-pay groups decreased over the 3 year period, Figures 1 and 2.

A total of 181 hospitals were included in the analysis, with 39.23% in California, 33.70% in Florida, and 27.07% in New York. Of these hospitals, 43.65% were teaching hospitals, and 69.06% had a surgical robot in 2008. They all acquired a robot by 2011.

Factors associated with the odds of receiving RARP versus ORP at a hospital offering robotic surgery are shown in Table 2. African American patients had lower RARP rates than White patients (OR = 0.80, $p < 0.001$). Patients using Medicare (OR = 0.91, $p = 0.028$), Medicaid (OR = 0.68, $p < 0.001$), or self-pay (OR = 0.72, $p = 0.046$) were less likely to receive RARP than patients using private insurance. Patients treated at mid procedure volume hospitals (OR = 2.18, $p = 0.010$)

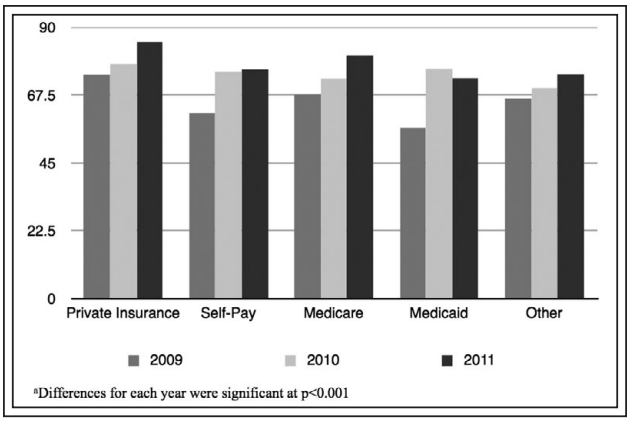

Figure 1. Percentage of patients receiving robot-assisted radical prostatectomy over open radical prostatectomy at hospitals offering robotic surgery, stratified by payer.[a]

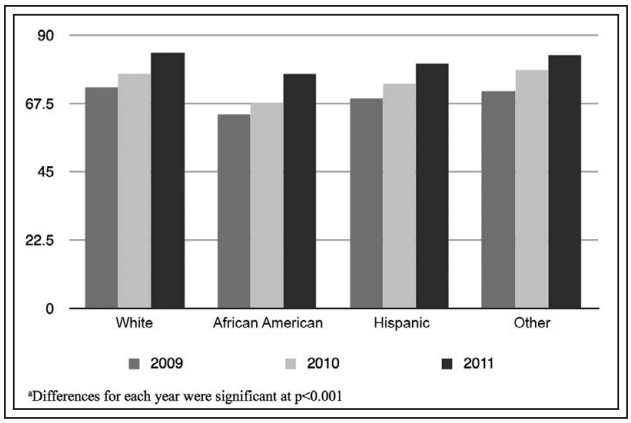

Figure 2. Percentage of patients receiving robot-assisted radical prostatectomy over open radical prostatectomy at hospitals offering robotic surgery, stratified by race.[a]

TABLE 2. **Factors associated with treatment utilization**

	OR	95% CI	p value
Race (White)			
African American	0.80	0.72-0.89	< 0.001
Hispanic	1.20	1.07-1.34	0.002
Other	0.94	0.85-1.04	0.260
Primary Payer (private insurance)			
Self-pay	0.72	0.52-0.99	0.046
Medicare	0.91	0.84-0.99	0.028
Medicaid	0.68	0.57-0.81	< 0.001
Other	0.76	0.61-0.94	0.011
Age (<=50)			
51-60	1.08	0.95-1.21	0.232
61-70	0.89	0.78-1.00	0.051
> 70	0.52	0.45-0.61	< 0.001
Comorbidities	0.93	0.91-0.96	< 0.001
Hospital volume (1st tercile)			
2nd tercile	2.18	1.21-3.95	0.010
3rd tercile	8.76	4.67-16.46	< 0.001
State (California)			
Florida	0.48	0.28-0.84	0.010
New York	1.18	0.65-2.14	0.588
Teaching hospital (No)			
Yes	0.50	0.31-0.82	0.006
Newly acquired robot (before 2008)			
2008 or after	0.70	0.41-1.18	0.182
Year (2009)			
2010	1.40	1.30-1.50	< 0.001
2011	2.24	2.07-2.41	< 0.001

OR = operating room; CI = confidence interval

or high procedure volume hospitals (OR = 8.76, p < 0.001) were more likely to receive RARP than patients treated at low procedure volume hospitals. Patients treated at hospitals in Florida had lower RARP rates than patients treated at hospitals in California (OR = 0.48, p = 0.010). Patients treated at a teaching hospital were less likely to receive RARP than patients not treated at a teaching hospital (OR = 0.50, p = 0.006). Patients in the > 70 age group were less likely to receive RARP than patients in the 51-60 age group (OR = 0.52, p < 0.001). Patients with more comorbidities were less likely to receive RARP (OR = 0.93, p < 0.001), Table 2.

Our sensitivity analysis for Florida and New York revealed that, with a fixed effect for physician clustering, Medicaid patients were less likely to receive RARP over ORP than private insurance patients (OR = 0.74, p = 0.027), and African American patients were less likely to receive RARP over ORP than White patients (OR = 0.82, p = 0.020).

Discussion

In this study of prostate cancer treatment across three large and diverse US states, we evaluated factors associated with utilization of RARP versus ORP among patients receiving treatment at hospitals offering robotic surgery from 2009 to 2011. Although all patients in the study visited a hospital offering robotic surgery, patient characteristics, including race, payer, age, and comorbidities, were associated with utilization of RARP rather than ORP. Additionally, hospital characteristics, including state and teaching status, were associated with utilization of RARP rather than ORP. Our study is particularly unique in that it provides insight into utilization of RARP versus ORP at hospitals which have a robotic system using 100% all-capture state databases, while other studies that have looked at differences in treatment utilization among prostate cancer patients have used nationwide sample data, which captures approximately 20% of inpatient data.

Our data indicate that there is a significant association between utilization of RARP and patient race within hospitals offering robotic surgery. African American patients had lower utilization of RARP over ORP than White patients, even after controlling for other patient and hospital characteristics. These results are consistent with previous studies that have demonstrated that race is associated with differential treatment.[5-7,16] In particular, some have demonstrated that African American patients are less likely to visit a hospital offering robotic surgery than White patients and that non-White patients have a lower likelihood of receiving RARP or laparoscopic radical prostatectomy (LRP) over ORP compared to White patients.[6,7] Even in our sensitivity analysis in which we took into account physician clustering, African American patients were still significantly less likely to receive RARP over ORP than White patients, suggesting that factors outside of the control of the physician, such as patient preferences, may play a role in differential utilization of treatments between the two groups. This may be partially attributable to differential exposure to robotic surgical marketing efforts, which could lead to differing levels of patient awareness about robotic surgery.[17] Additionally, although African American patients were less likely to receive RARP than White patients, interestingly, Hispanics had higher odds of receiving RARP than White patients. The increased odds of Hispanic patients undergoing RARP is a unique finding, and the reasons for it are unclear. Additional research is necessary to fully understand the reasons for this finding. Our data also indicate that differences in RARP rates decreased over the 3 year period, suggesting that, while differences in utilization patterns between different racial groups do exist, they are becoming less pronounced over time.

In our study, primary payer was significantly associated with utilization of RARP rather than ORP within hospitals offering robotic surgery despite a modest difference in cost between the two procedures. A higher proportion of patients with private insurance received RARP over ORP when compared to patients with all other payers. These associations persisted even after controlling for important confounding factors, such as race, age group, comorbidities, and hospital characteristics. Even in our sensitivity analysis, when we accounted for physician clustering, private insurance patients were still significantly more likely to receive RARP over ORP than Medicaid patients. Previous literature has demonstrated an association between insurance status and prostate cancer treatment. For example, it has been shown that patients using Medicaid are less likely to visit hospitals offering robotic surgery.[7] Our data expand on these results by providing evidence that suggests that, even when visiting hospitals offering robotic surgery, insurance status is associated with whether a patient receives RARP versus ORP. However, our data also suggest that differences in RARP rates between different payers decreased over the 3 year period, suggesting that overall trends are moving towards more similar utilization patterns amongst patients using different payers. Additional research can help further characterize the relationship between primary payer and RARP utilization.

Of note, older age and increased number of comorbidities were also associated with lower utilization of RARP versus ORP. This may reflect a combination

of physician and patient preferences for treatment, and warrants further investigation.

We also observed variations in utilization of RARP based on hospital characteristics, including state and teaching hospital status. Patients in California were more likely to receive RARP over ORP than patients in Florida, even after adjusting for population-age differences. This may be related to disproportionate rates of technology diffusion. Acquiring more surgical robots in low RARP regions may lead to more similar utilization patterns in different states. In fact, acquisition of surgical robots has been shown to be associated with higher radical prostatectomy rates.[18] Additionally, we found that patients treated at teaching hospitals were less likely to receive RARP over ORP than patients treated at non-teaching hospitals. This finding is quite different than what we would have expected based on previous literature.[7] Further research is warranted to understand the underlying causes of this finding.

Our study has several limitations. First, this study only provides a 3 year overview of each patient's care pathway and does not account for treatments received before or after the three year window. Second, this study uses administrative data which is based on billing claims data. These data lack important clinical details, including cancer stage, and cannot identify patient preferences.[19] Although these limitations exist, we were still able to exclude patients with metastatic cancer and control for other comorbidities. Third, as we used all-capture state databases, it is possible that the results of our analysis may not be generalizable to the nation as a whole. Finally, we used CPT code 55866 to represent RARP, although in some instances this code could also represent LRP. However, due to the very low overall percentage of LRP performance in the United States, this code is well accepted to represent RARP in similar analyses. Additionally, the same code may in some instances represent RARP performed for benign conditions, although RARP rarely is used as a treatment modality for benign prostatic disease.

Our study represents a large population-based observational study in prostate cancer that suggests significant differences in utilization of RARP versus ORP based on both patient and hospital characteristics within hospitals where robotic surgery is offered using a unique all-capture state database. These differences in utilization persisted despite a small difference in average cost between the two procedures and even when accounting for physician clustering, suggesting that factors outside of cost and physician preference may play a role in differential utilization patterns. Further research can help identify the underlying cause for these differences in treatment utilization and improve delivery of care for prostate cancer patients. □

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