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Perioperative outcomes of open vs. robotic radical cystectomy: a nationwide comparative analysis (2008–2014)

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Introduction Radical cystectomy (RC) is a complex procedure with high perioperative morbidity. In an effort to reduce complications, robotic-assisted RC (RARC) has been adopted as a minimally invasive alternative to the open approach (ORC). Herein, we examine post-operative outcomes of the two surgical approaches in the United States (US) using a large all-payer database.

Material and methods Using International Classification of Disease, ninth revision (ICD-9) codes, patient who underwent RC were captured from National Inpatient Sample (2008–2014). ICD-9 diagnosis and procedure codes were used to identify post-operative complications. Trends in the utilization of RARC were analyzed. Logistic and log-linear regression accounting for hospital sample weights and sampling years were performed to analyze outcomes after adjustment of pertinent covariates.

Results Of 11,189 patients, 14% underwent RARC. RARC was performed in more teaching hospitals, male patients, those with private insurance, and lower comorbidity score. Performance of RARC steadily increased over the study period ($p < 0.01$). In the last year of the study, 22.8% of cases performed robotically. The weighted average length-of-stay were 10.4 and 8.79 days for ORC and RARC, respectively ($p < 0.01$). In multivariable analyses, RARC was associated with decreased blood transfusion, parenteral nutrition, pneumonia, surgical-site infection, wound and respiratory complications (all, $p < 0.05$). No significant differences were found for in-hospital mortality, cardiac, genitourinary, and vascular complications.

Conclusions Performance of RARC has significantly increased in recent years. RARC appears safe and feasible for select patients. Earlier discharge and lower complications were noted for those undergoing RARC across different hospital systems nationwide.

Key Words: bladder cancer ‹› robotic cystectomy ‹› national inpatient sample

INTRODUCTION

More than 80,000 cases of bladder cancer were diagnosed in 2017, and currently there are an estimated 540,000 bladder cancer survivors living in the United States (US) [1, 2, 3]. Most cases are diagnosed as non-muscle invasive disease and are amenable to less radical interventions. Unfortunately, 15% to 20% of patients progress to invasive disease requiring more aggressive treatment such as radical cystectomy (RC) [4, 5].

Despite improvements in surgical techniques and perioperative care, RC remains associated with significant patient morbidity [6]. In an effort to improve outcomes, robot-assisted RC (RARC) has been adopted as an alternative to the open approach (ORC) particularly by academic, referral centers [7, 8]. Few prospective studies at high, volume

centers have demonstrated similar perioperative outcomes between the two approaches [9, 10, 11]. To date, the adoption of RARC remains controversial as it has been criticized regarding the cost, lack of tactile feedback, and concern for inferior oncologic outcome. In this study, we sought to evaluate trends of RARC over the study period and to compare perioperative outcomes for RARC and ORC using a large, all-payer nationwide database.

MATERIAL AND METHODS

Data and study source

We utilized discharge data from the National Inpatient Sample (NIS) which is available through the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality [12]. The NIS is the largest all-payer inpatient care database, comprising 20% of all inpatient hospitalizations in the US [13]. Using International Classification of Disease, ninth revision (ICD-9) codes, patient who underwent RC for malignant neoplasm of the bladder (ICD-9-CM code 188.0–188.6, 188.8, 188.9) were captured from the years 2008 to 2014. Patients with metastatic disease or pure laparoscopy were excluded from analysis (i.e. ICD-9 197.0–197.8).

Outcome and variables

Patient characteristics included age, gender, race, urinary diversion, and insurance payer. Comorbidity was calculated using the Elixhauser comorbidity score [14]. Hospital characteristics included hospital status and teaching status. ICD-9 diagnosis and procedure codes were used to identify post-operative complications [15]. In-hospital infections were grouped into 4 major groups for analytical purposes: urinary tract infection, surgical site infection (SSI), pneumonia, and sepsis. Inpatient complications were assessed as previously described and grouped into 5 major groups: cardiac, respiratory, genitourinary, wound, and vascular complications [16].

Statistical analyses

Demographic factors and clinical variables were compared between ORC and RARC. Comparisons were performed using the two-sample t test or Fisher's exact test for categorical variables, as appropriate. Continuous variables were compared using Mann-Whitney tests. The Cochran-Armitage trend test was used to assess utilization of each approach over time. Logistic and log-linear regression accounting for hospital sample weights and sampling years were performed to analyze the outcomes. Adjustment for age, gender, race, comorbidity, teaching status, hospital volume, insurance status, and urinary diversion was performed. All statistical analyses were performed using SAS 9.3 (SAS Institute, Cary, NC, USA).

RESULTS

Study cohort

Of 11,189 patients, 14% underwent RARC. There were no differences in age or race between the two groups. RARC was performed in more teaching hospitals, male patients, those with private insurance, and lower comorbidity score (all, $p \leq 0.01$). RARC was also associated with higher rate of ileal conduit urinary diversion ($p < 0.01$) (Table 1).

Trends in surgical approach

Performance of RARC steadily increased over the study period. A significant increase was noted after 2011 with RARC being performed in 18.8% of cases versus 12.2% in the prior years ($p < 0.01$) (Figure 1). The largest proportion was seen in 2014 with 22.8% of cases performed robotically. Length of stay (LOS),

Table 1. *Summary of patient and hospital characteristics*

Variable	Patients, n (%)		p-value[b]
	Open (n = 9630)	Robotic (n = 1565)	
Age, mean (SD)[a]	68.40 ±0.13[a]	68.01 ±0.27	0.16
Female	1495 (15.49)	196 (12.51)	**<0.01**
Race	n = 8,619	n = 1,358	0.71
White	7534 (87.39)	1187 (87.30)	
Black	434 (5.04)	74 (5.44)	
Others	651 (7.58)	97 (7.25)	
Ileal conduit diversion	8186 (85.12)	1377 (87.95)	**<0.01**
Elixhauser comorbidity scores			**<0.01**
<0	1992 (20.68)	404 (25.87)	
=0	1173 (12.22)	169 (10.84)	
1~4	830 (8.59)	130 (8.37)	
≥5	5635 (58.51)	862 (54.92)	
Insurance			0.01
Medicare/Medicaid	6407 (66.58)	1004 (64.19)	
Private	2783 (28.95)	504 (32.29)	
Others	428 (4.46)	56 (3.52)	
Teaching hospital	7564 (79.63)	1360 (87.10)	**<0.01**
Bed size			**<0.01**
Small	923 (9.26)	267 (16.87)	
Medium	1602 (17.16)	244 (15.88)	
Large	6985 (73.57)	1052 (67.26)	

[a]mean±standard error based on the hospital sampling weight; [b]derived from two-sample t test for age and Fisher's exact test for categorical variables
Bold values indicate statistical significance

in-hospital mortality, and complication rate did not significantly change over time for each approach (not shown).

Outcomes

The weighted average LOS were 10.4 and 8.79 days for ORC and RARC, respectively (p <0.01). In the adjusted regression models, RARC was associated with decreased blood transfusion, parenteral nutrition, wound and respiratory complications (all, p ≤0.02). RARC was also associated with decreased risk of pneumonia and surgical site infection (SSI) (all, p ≤0.01). No significant differences were found for in-hospital mortality, cardiac, genitourinary, and vascular complications (Table 2).

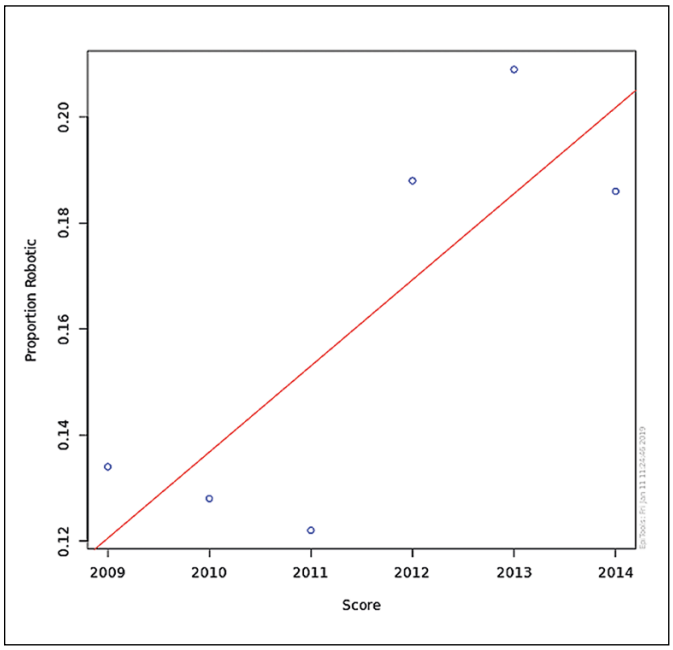

Figure 1. *Proportion of robotic procedures over study period.*

DISCUSSION

Because of its complexity, RC has been performed in an open approach for decades. In an attempt to improve perioperative outcomes, RARC has been increasingly performed over time thanks to efforts from academic centers demonstrating the minimally-invasive feasibility of this procedure. Recently, a multicenter study showed no differences in perioperative complications among high-volume academic programs [17]. Our current study shows the steady increased adoption of the robotic platform in community hospitals for a complex urological procedure as well its association with acceptable perioperative outcomes.

Our findings add generalizable, contemporary data on the rise and robotic feasibility of a major urologic surgery across several hospital settings in the US. A previous study by Leow et al. showed performance of RARC had increased from 0.6% in 2004 to 12.8% in 2010 [18]. Our findings corroborate this upward trend with the proportion of RARC increasing to a remarkable 22.8% in 2014. This is the highest reported rate of RARC nationwide and highlights

Table 2. *Comparison in peri-operative outcomes of open and robotic cystectomy from 2008 to 2014*

Outcomes	Patients, n (%)		OR[c] (95% CI; p-value)	
	Open (n = 9624)	Robotic (n = 1565)	Unadjusted	Adjusted[d]
Length of stay, mean (SD)[a]	10.40 ±0.12	8.79 ±0.18	0.85 (0.81, 0.89); p <0.0001	**0.86 (0.82, 0.91); p <0.01**
In-hospital mortality	170 (1.77[b])	16 (1.02)	0.58 (0.34, 0.98); p = 0.04	0.70 (0.40, 1.23); p = 0.21
Blood transfusion	3359 (34.79)	314 (19.98)	0.47 (0.39, 0.57); p <0.0001	**0.46 (0.37, 0.57); p <0.01**
Parental nutrition	982 (10.23)	115 (7.34)	0.70 (0.56, 0.86); p = 0.001	**0.77 (0.62, 0.97); p = 0.02**
Complications				
Surgical site infection	575 (5.97)	68 (4.38)	0.72 (0.56, 0.93); p = 0.01	0.79 (0.60, 1.03); p = 0.08
Pneumonia	449 (4.66)	46 (2.95)	0.62 (0.46, 0.84); p <0.01	**0.61 (0.44, 0.86); p <0.01**
Sepsis	446 (4.64)	46 (2.90)	0.61 (0.45, 0.83); p <0.01	**0.66 (0.47, 0.92); p = 0.01**
Cardiac	513 (5.33)	58 (3.72)	0.69 (0.52, 0.91); p <0.01	0.75 (0.57, 1.01); p >0.05
Respiratory	770 (8.03)	113 (7.22)	0.89 (0.73, 1.09); p = 0.27	0.97 (0.77, 1.22); p = 0.78
Genitourinary	1390 (14.49)	157 (9.96)	0.65 (0.55, 0.78); p <0.0001	**0.69 (0.57, 0.83); p <0.01**
Wound	1744 (18.14)	255 (16.26)	0.88 (0.75, 1.02); p = 0.09	0.90 (0.76, 1.06); p = 0.22
Vascular	671 (6.97)	76 (4.83)	0.69 (0.53, 0.87); p <0.01	**0.68 (0.51, 0.90); p <0.01**
	182 (1.89)	25 (1.62)	0.85 (0.54, 1.33); p = 0.48	0.97 (0.60, 1.55); p = 0.89

[a]weighted average based on the hospital sampling weights; [b]weighted percentage based on the hospital sampling weights; [c]derived from logistic regression for binary outcomes and from log-normal regression for length of stay after accounting for hospital sample weights and sampling years; [d]adjusted for age, gender, race, Elixhauser comorbidity score, teaching status, insurance status, hospital size, and urinary diversion
Bold values indicate statistical significance

the increased investment with robotic technologies for a traditionally-morbid operation.

RC has long been associated with considerable post-operative morbidity, including major and minor complications ranging from 13 to 67% [19, 20, 21]. Bochner et al. performed a single institution, prospective study comparing ORC and RARC. The study was closed when an interim analysis showed no difference in the Clavien grade 2 to 5 complications [9]. In terms of oncologic outcomes, the recent RAZOR trial showed equivalent 2-year progression-free survival between robotic and open RC (71.6 versus 72.3%, respectively) [17]. However, these outcomes could be more a reflection of skill and experience of high-volume surgical team and hospital care rather than the technology itself.

Examining nationwide perioperative outcomes, RARC was associated with decreased select complications. Although difficult to compare retrospective registries due to variance in patient population as well as collection and interpretation of data, our adjusted analysis did show RARC associated with lower respiratory and wound complications as well as a decreased risk of infections such as pneumonia and SSI. In addition, RARC patients had less transfusions, parenteral nutrition rates, and decreased LOS. The results are important in regards to health-system costs, as well as a potential benefit of decreased patient convalescence which could be associated with an earlier return to work.

Although we were unable to compare high vs. low-grade complications, our results showed equivalent in-hospital mortality regardless of approach and speaks to the complexity of the procedure and the need for comprehensive care for these patients. Although this is a large, contemporary analysis of RARC versus ORC, there are limitations that cannot be overcome. Since this is a retrospective registry-derived study, there is no direct insight into patients' or physicians' preferences in decision-making regarding approach. Also, we were unable to compare pathological characteristics for either procedures which is an inherent limitation of this dataset. However, our study uses a large, inpatient database which makes our results generalizable with real-life experience on the increased utilization of the robotic platform for a major urological procedure.

CONCLUSIONS

Performance of RARC has continued to increase over time. RARC appears safe and feasible for select patients. Earlier discharge and lower complications were noted for those undergoing RARC across different hospital systems nationwide.

Clinical practice points

- There has been a significant increase in robotic-assisted radical cystectomy (RARC) across community hospitals in the United States
- Shorter length-of-stay and fewer complications were noted with RARC
- More studies are needed to evaluate the effect of RARC on improving perioperative morbidity

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

References

1. United States Census data, 2010: www.census.gov/main/popclock.html. Accessed 07/18/2018
2. National Cancer Institute, Surveillance Epidemiology and End Results Program Cancer Statistics, 2018: http://seer.cancer.gov/statfacts/html/urinb.html. Accessed 07/18/2018.
3. Siegel RL, Miller KD, Jemal A: Cancer statistics, 2018. CA Cancer J Clin. 2018; 68: 7-30.
4. Cheng L, Neumann RM, Weaver AL, Spotts BE, Bostwick DG. Predicting cancer progression in patients with stage T1 bladder carcinoma. J Clin Oncol. 1999; 17: 3182-3187.
5. Millan-Rodriguez F, Chechile-Toniolo G, Salvador-Bayarri J, Palou J, Algaba F, Vicente-Rodríguez J. Primary superficial bladder cancer risk groups according to progression, mortality and recurrence. J Urol. 2000; 164: 680-684.
6. Chang SS, Cookson MS, Baumgartner RG, NWells N, Smith JA Jr. Analysis of early complications after radical cystectomy: results of a collaborative care pathway. J Urol. 2020; 167: 2012-2016.
7. Sathianathen NJ, Kalapara A, Frydenberg M, Lawrentschuk N, Weight CJ, Parekh D, Konety BR. Robotic-assisted radical cystectomy vs open radical cystectomy: systematic review and meta-analysis. J Urol. 2019; 201: 715-720.
8. Lau CS, Blackwell RH, Quek ML: Radical cystectomy: open vs robotic approach. J Urol. 2015; 193: 400-402.
9. Bochner BH, Sjoberg DD, Laudone VP. A randomized trial of robot-assisted laparoscopic radical cystectomy. N Engl J Med. 2014; 371: 389-390.
10. Nix J, Smith A, Kurpad R, Nielsen ME, Wallen EM, Pruthi RS. Prospective randomized controlled trial of robotic versus open radical cystectomy for bladder cancer: perioperative and pathologic results. Eur Urol. 2010; 57: 196-201.
11. Parekh DJ, Messer J, Fitzgerald J, Ercole B, Svatek R. Perioperative outcomes and oncologic efficacy from a pilot prospective

randomized clinical trial of open versus robotic assisted radical cystectomy. J Urol. 2013; 189: 474-479.

12. The Healthcare Cost and Utilization Project (HCUP): https://www.hcup-us.ahrq.gov/nisoverview.jsp. Accessed 08/15/2018.

13. Khera R, Angraal S, Couch T, et al. Adherence to Methodological Standards in Research Using the National Inpatient Sample. Jama. 2017; 318: 2011-2018.

14. Elixhauser A, Steiner C, Harris DR, et al: Comorbidity measures for use with administrative data. Med Care. 1998; 36: 8-27.

15. Yu H-y, Hevelone ND, Lipsitz SR, Coffey RM. Comparative Analysis of Outcomes and Costs Following Open Radical Cystectomy Versus Robot-Assisted Laparoscopic Radical Cystectomy: Results From the US Nationwide Inpatient Sample. Eur Urol. 2012; 61: 1239-1244.

16. Yu HY, Hevelone ND, Lipsitz SR, et al. Comparative analysis of outcomes and costs following open radical cystectomy versus robot-assisted laparoscopic radical cystectomy: results from the US Nationwide Inpatient Sample. Eur Urol. 2012; 61:1 239-1244.

17. Parekh DJ, Reis IM, Castle EP, et al. Robot-assisted radical cystectomy versus open radical cystectomy in patients with bladder cancer (RAZOR): an open-label, randomised, phase 3, non-inferiority trial. Lancet. 2018; 391: 2525-2536.

18. Leow JJ, Reese SW, Jiang W, et al. Propensity-matched comparison of morbidity and costs of open and robot-assisted radical cystectomies: a contemporary population-based analysis in the United States. Eur Urol. 2014; 66: 569-576.

19. Wijburg CJ, Michels CTJ, Oddens JR, Grutters JPC,Witjes JA,Rovers MM. Robot assisted radical cystectomy versus open radical cystectomy in bladder cancer (RACE): study protocol of a non-randomized comparative effectiveness study. BMC Cancer. 2018; 18: 861.

20. Cookson MS, Chang SS, Wells N, Parekh DJ, Smith JA Jr. Complications of radical cystectomy for nonmuscle invasive disease: comparison with muscle invasive disease. J Urol. 2003; 169: 101-104.

21. Shabsigh A, Korets R, Vora KC, et al. Defining early morbidity of radical cystectomy for patients with bladder cancer using a standardized reporting methodology. Eur Urol. 2009; 55: 164-174. ■