Impact of Obesity on Perioperative Outcomes at Robotic-assisted and Open Radical Prostatectomy: Results From the National Inpatient Sample

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OBJECTIVE To test the effect of obesity (body mass index ≥30 kg/m^2) on perioperative outcomes and total hospital charges at robot-assisted vs open radical prostatectomy (RARP vs ORP).

METHODS Within the National Inpatient Sample database (2008-2015), we identified obese vs nonobese RARP and ORP patients. Estimated annual percent changes, multivariable logistic regression and linear regression models were used. All models were adjusted for clustering and weighted.

RESULTS Of all, 53,626 (60%) underwent RARP vs 35,757 (40%) underwent ORP. At RARP, 8.6% were obese vs 6.9% at ORP. RARP rate increased significantly over time (12.5%-81.5%). Obesity rate increased significantly over time at both, RARP (5.1%-10.5%) and ORP (5.4%-10.7%). In multivariable logistic regression models, obesity predicted 5 of 11 unfavourable perioperative complications at RARP (odds ratio: 1.6-1.8) and 9 of 11 at ORP (odds ratio: 1.3-2.8). In linear regression models, obesity significantly added to total hospital charges at RARP (740$) and ORP (312$).

CONCLUSION Obesity may predispose to higher rates of adverse outcomes at RP. Its effect varies according to surgical approach. UROLOGY 133: 135−144, 2019.

Radical prostatectomy (RP) represents the reference standard for treatment of clinically localized prostate cancer (CaP) and is mainly performed via open retropubic RP (ORP) or robot-assisted approach (RARP). Regardless of the surgical technique, obese patients may be predisposed to more frequent adverse perioperative outcomes, such as higher complication rates, longer length of stay (LOS) and higher total hospital charges (THC). This relationship has been explored in contemporary large-scale analyses. However, some of these reports failed to include a control-group of nonobese patients.[1] Others relied on population-based data repositories, that nonetheless were limited in sample size and generalizability of their findings.[2,3] Finally, others focused on specific complications, or analysed RARP without comparison to ORP or vice versa.[4-7] In consequence, there is an unmet need for a comprehensive, contemporary, and highly generalizable analysis of the effect of obesity on several perioperative and early postoperative outcomes, with specific focus on comparisons between RARP and ORP. We address these objectives in the current study and hypothesized that potentially more favourable outcomes are observed in obese patients when RARP is used instead of ORP.

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PATIENTS AND METHODS

Data Source

We relied on the National Inpatient Sample (NIS) database (2008-2015). The NIS is a set of longitudinal hospital inpatient databases included in the Healthcare Cost and Utilization Project family, created by the Agency for Healthcare Research and Quality through a Federal-state partnership.[8] The database includes 20% of United States inpatient hospitalizations, with discharge abstracts from 8 million hospital stays.

Study Population

We relied on the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) to identify patients with a primary diagnosis of CaP (code 185), aged ≥18 years. Primary procedure codes identified RP (code 60.5)

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and secondary procedure codes stratified according to robotic or open approach (modifier codes 17.4 and 17.42).[9] Secondary procedure codes (modifier codes 40.3 and 40.5) determined lymph node dissection status at RP. Patients with a secondary diagnosis of metastatic disease (code 197.x and 198.x) were excluded.

Definition of Obesity

Obesity was defined as a body mass index (BMI) ≥30 kg/m^2, according to the World Health Organization (WHO) definition.[10] Diagnostic codes 278.00 (obesity, unspecified), 278.01 (morbid obesity), V85.30-V85.39 (Obesity, BMI 30-39) and V85.41-V85.45 (Obesity, BMI >40) were used to identify obese patients.[11]

Outcomes of Interest

We focused on 4 categories of perioperative and early postoperative outcomes, that consisted of complications, in-hospital mortality, LOS, and THC. The first outcome of interest was complications, which were defined using secondary International Classification of Diseases, Ninth Revision, Clinical Modification diagnostic codes.[12,13] Within complications, we focused on overall, intraoperative, and postoperative (cardiac, respiratory, vascular, operative wound, genitourinary, infectious, blood transfusions, miscellaneous medical, and miscellaneous surgical) complications.[9]

In-hospital mortality represented the second outcome of interest (defined by NIS coding). LOS represented the third outcome of interest (defined by NIS coding).[14] Finally, inflation-adjusted THC represented the fourth outcome of interest (defined by NIS coding).

Additional Variables

For purpose of multivariable adjustment, we relied on patient and hospital characteristics. These included patient age, year of surgery, race/ethnicity (Caucasian, African American, and others), Charlson comorbidity index (CCI), income, and insurance status (private insurance, Medicare, Medicaid, and other [self-pay]).[14,15] Additional variables defined the institution type, where RP were performed, namely hospital region (Northeast, Midwest, South, West), hospital bed size (small, medium and large) and hospital teaching vs nonteaching status.[8] Finally, annual hospital volume tertiles (low, medium, and high), representing the number of RPs performed at each participating institution during each study calendar year, was calculated.

Statistical Analyses

Descriptive statistics included medians and interquartile ranges, as well as frequencies and proportions for continuous and categorical variables, respectively. The statistical significance of differences in medians and proportions was evaluated with the Kruskal-Wallis and chi-square tests. Annual rates were examined with estimated annual percent change (EAPC) methodology.

Univariable and multivariable logistic regression models were used to test the relationship between obesity and the first 3 outcomes of interest, namely complications, in-hospital mortality and LOS. The relationship between obesity and the fourth outcome of interest, namely THC, was tested in linear regression models.

All multivariable models were adjusted for additional variables, as well as lymph node dissection status. Multivariable logistic regression models predicting LOS were additionally adjusted for all complications. Multivariable linear regression models predicting THC were additionally adjusted for all complications and LOS. All multivariable models relied on generalized estimating equations to further adjust for clustering.[16] Subsequently, data distribution was adjusted according to the provided NIS population weights to render estimates more accurate nationally.

For all statistical analyses R software environment for statistical computing and graphics (version 3.4.3) was used. All tests were 2 sided with a level of significance set at P <.05.

RESULTS

Obesity Rates and Annual Trends

Of all 89,383 RP patients within the NIS (2008-2015), 7.9% were obese. Of all, 53,626 (60.0%) underwent RARP and 35,757 (40.0%) underwent ORP (Table 1). At RARP, 8.6% were obese vs 6.9% at ORP (P <.001).

Analyses according to annual rates (2008-2015) showed an increase in obesity rates (6.3%-10.1%, EAPC: 8.1%, P <.001). Virtually the same results were recorded in RARP (5.8%-10.8%, EAPC: 8.2%, P <0.001), as well as in in ORP patients (5.9%-10.7%, EAPC: 8.2%, P <.001, Fig. 1). Additionally, analyses according to annual rates (2008-2015) showed an increase in RARP rate (12.5%-81.5%, EAPC: 10.9%, P = .03) and a decrease in ORP rate (87.5%-18.5%, EAPC: −23.6%, P = .002).

Patients' and Hospitals' Characteristics

At RARP, obese patients were younger (60.9 vs 61.7 years in nonobese, P <.001), were more frequently African American (13.3 vs 10.7% in nonobese, P <.001), more frequently harboured CCI ≥2 (7.6 vs 3.1% in nonobese, respectively, P <.001), were more frequently within the first and lowest income quartile (18.6 vs 20.4% in nonobese, P <.001), and were more frequently treated in low and medium volume hospitals (69.3 vs 66.6% in nonobese, P <.001, Table 1).

At ORP, obese patients were younger (61.2 vs 61.6 years in nonobese, P <.001), were more frequently African American (13.3 vs 11.3% in nonobese, P <.001), more frequently harboured CCI ≥2 (7.9 vs 3.3% in nonobese, respectively, P <.001), were more frequently within the first and lowest income quartile (22.0 vs 20.7% in nonobese, P <.001), and were more frequently treated in low and medium volume hospitals (71.9 vs 65.9% in nonobese, P <.001, Table 1).

Overall and Specific Complications

Overall complications were recorded in 13.1 vs 7.9% of obese vs nonobese RARP and 17.4 vs 11.3% of obese vs nonobese ORP (both P <.001, Table 2). Miscellaneous medical complications were recorded in 7.7 vs 4.4% of obese vs nonobese RARP and in 8.3 vs 5.6% of obese vs nonobese ORP (both P <.001). Cardiac complications were recorded in 1.8 vs 0.8% of obese vs nonobese RARP and in 2.6 vs 1.2% of obese vs nonobese ORP (both P <.001). Respiratory complications were recorded in 7.7 vs 4.4% of obese vs nonobese RARP and in 2.9 vs 1.7% of obese vs nonobese ORP (both P <.001). Genitourinary complications were recorded in 1.4 vs 0.8% of obese vs nonobese RARP and in 1.9 vs 1.0% of obese vs nonobese ORP (both P <.001). Blood transfusions were recorded in 1.9 vs 1.5% of obese vs nonobese RARP (P = .03) and in 10.6 vs 8.8% of obese vs nonobese ORP (P <.01). No differences were recorded in wound, infectious, and vascular complications in obese vs nonobese RARP and obese vs nonobese ORP, respectively.

Table 1. Descriptive characteristics of 89,383 radical prostatectomy patients (unweighted population), within the National Inpatient Sample (2008-2015), stratified according to surgical approach (robotic-assisted radical prostatectomy [RARP] vs open radical prostatectomy [ORP]) and obesity (nonobese [BMI <30 kg/m^2] vs obese [BMI ≥30 kg/m^2]).

	RARP (*n* = 53,626, 60%)		ORP (*n* = 35,757, 40%)	
Variables Overall *n* = 89,383	Obese (4589, 8.5%)	Nonobese (49,037, 92.5%)	Obese (2499, 6.9%)	Nonobese (33,258, 93.1%)
Age at surgery, years[+,*,†]				
Mean (STE)	60.9 (0.102)	61.7 (0.032)	61.2 (0.139)	61.6 (0.04)
Median (IQR)	61 (57-66)	62 (57-67)	62 (57-66)	62 (57-67)
Year of surgery, n (%)[+,*,†]				
2008-2011	2079 (45.3)	25,281 (51.6)	1811 (72.5)	26,420 (79.4)
2012-2015	2510 (54.7)	23,756 (48.4)	688 (27.5)	6838 (20.6)
Race, *n* (%)[+,*,†]				
Caucasian	3082 (67.2)	33,803 (68.9)	1,649 (66)	21,361 (64.2)
African American	610 (13.3)	5239 (10.7)	333 (13.3)	3770 (11.3)
Other/Unknown	897 (19.5)	9995 (20.4)	517 (20.7)	8127 (24.4)
Length of stay, days[+,*,†]				
Mean (STE)	1.8 (0.031)	1.6 (0.007)	2.7 (0.043)	2.4 (0.012)
Median (IQR)	1 (1-2)	1 (1-2)	2 (1-3)	2 (1-3)
CCI, *n* (%)[+,*,†]				
0	2889 (63.0)	38,581 (78.7)	1535 (61.4)	25,743 (77.4)
1	1351 (29.4)	8945 (18.2)	766 (30.7)	6412 (19.3)
>=2	349 (7.6)	1511 (3.1)	198 (7.9)	1103 (3.3)
Insurance status, *n* (%)[+,*,†]				
Medicare	1406 (30.6)	16,128 (32.9)	792 (31.7)	10,749 (32.3)
Medicaid	100 (2.2)	1026 (2.1)	69 (2.8)	846 (2.5)
Private	2897 (63.1)	29,906 (61.0)	1534 (61.4)	19,799 (59.5)
Other	186 (4.1)	1977 (4)	104 (4.2)	1864 (5.6)
Income, *n* (%)[+,*,†]				
First quartile	938 (20.4)	9142 (18.6)	551 (22.0)	6874 (20.7)
Second quartile	1101 (24.0)	11,093 (22.6)	644 (25.8)	8095 (24.3)
Third quartile	1261 (27.5)	12,725 (25.9)	644 (25.8)	8452 (25.4)
Fourth quartile	1206 (26.3)	14,891 (30.4)	594 (23.8)	8922 (26.8)
Unknown	83 (1.8)	1186 (2.4)	66 (2.6)	915 (2.8)
LND, *n* (%)[+,†]				
Not performed	2746 (59.8)	30784 (62.8)	1288 (51.5)	17,058 (51.3)
Performed	1843 (40.2)	18,253 (37.2)	1211 (48.5)	16,200 (48.7)
Annual hospital volume, *n* (%)[+,*,†]				
Low	1536 (33.5)	15,846 (32.3)	809 (32.4)	10,753 (32.3)
Medium	1644 (35.8)	16,801 (34.3)	988 (39.5)	11,162 (33.6)
High	1409 (30.7)	16,390 (33.4)	702 (28.1)	11,343 (34.1)
Teaching status, *n* (%)[+]				
Nonteaching	1167 (25.4)	12,993 (26.5)	12,841 (38.6)	13,771 (38.5)
Teaching	3422 (74.6)	36,044 (73.5)	20,417 (61.4)	21,986 (61.5)
THC, in $[+,*,†]				
Mean (STE)	15,288 (113.17)	13,663 (30.89)	13,085 (174.37)	12,274 (46.16)
Median	13,667.80	12,135.70	11,217.20	10,677
IQR	10,592.80-17,902.20	9491.50-15,884.30	8483.60-15,266.10	7932.80-14,462.90

BMI, body mass index; CCI, Charlson comorbidity index; IQR= interquartile range; LND, lymph node dissection; STE, standard error; THC, total hospital charges.
[+] Statistically significant difference between nonobese and obese patients within overall cohort.
[†] Statistically significant difference between nonobese and obese patients within RARP cohort.
* Statistically significant difference between nonobese and obese patients within ORP cohort

In-hospital Mortality, Length of Stay and Total Hospital Charges

Further, 36 cases of in-hospital mortality were recorded, of which 2 vs 12 occurred in obese vs nonobese RARP (P = .4) and 4 vs 18 in obese vs nonobese ORP (P = .7). LOS was ≥3 days in 15.4 vs 11.0% of obese vs nonobese RARP patients and 39.5 vs 32.5% of obese vs nonobese ORP patients (both P <.001). The median THC were $13,668 vs $12,136 in obese vs nonobese RARP patients and $11,217 vs $10,677 in obese vs nonobese ORP patients (both P <.001).

Multivariable Analyses (MVA)

In individual MVA predicting complications, obesity reached independent predictor status (IPS) for 5 complication definitions at both RARP and ORP, namely overall (odds ratio [OR]: RARP 1.7, ORP 1.5), miscellaneous medical (OR: RARP 1.7, ORP 1.4), cardiac (OR: RARP 1.8, ORP 1.8), respiratory (OR: RARP 1.6, ORP 1.5), and genitourinary complications (OR: RARP 1.7, ORP 1.8) (Table 3). Obesity reached IPS for 4 additional complication definitions exclusively at ORP, namely blood transfusions (OR: ORP 1.3), wound (OR: ORP 2.8),

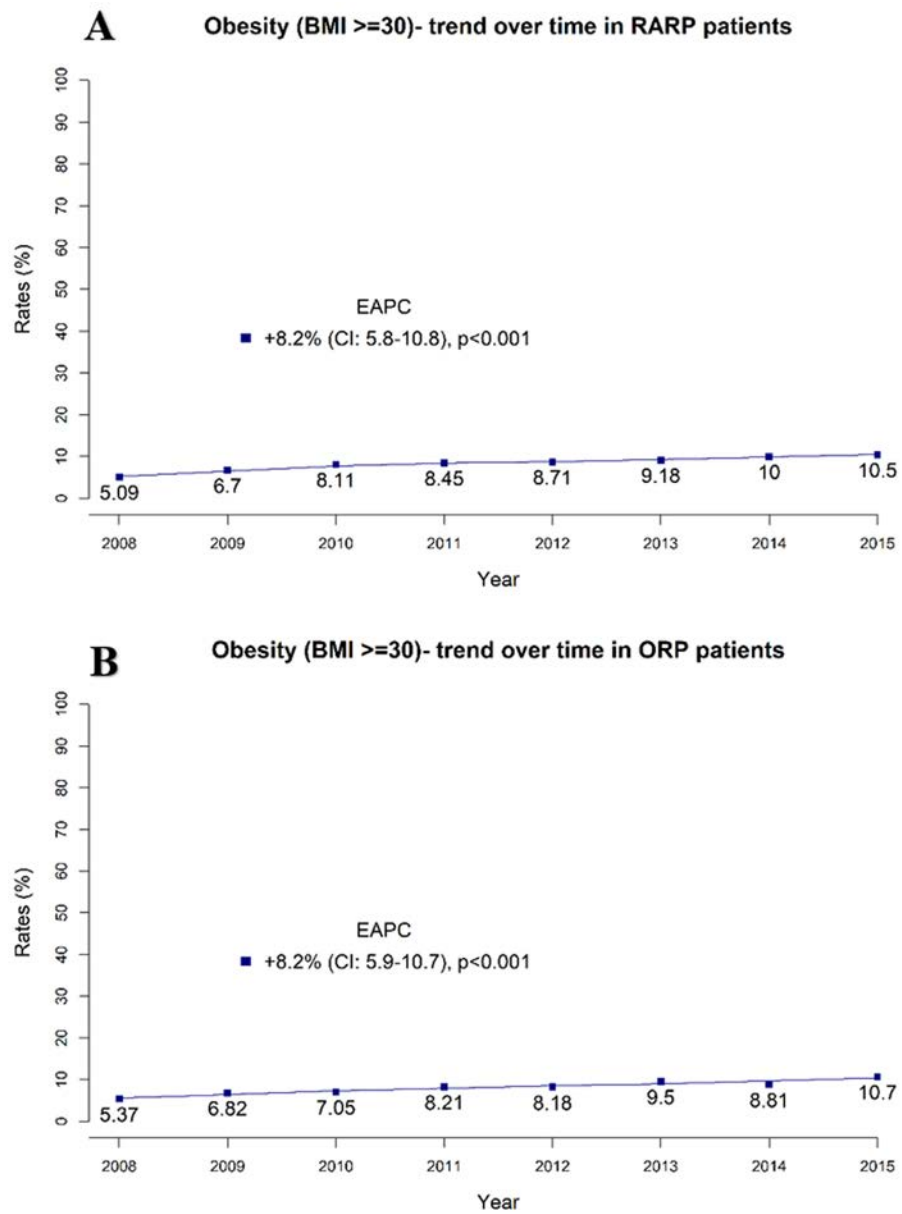

Figure 1. A and B: graphical presentation of temporal trends for obesity in 89,383 prostate cancer patients who underwent radical prostatectomy (RP) within the National Inpatient Sample database from 2008 to 2015, stratified according to surgical approach (A: robotic-assisted RP [RARP] vs B: open RP [ORP]). CI, 95% confidence interval; EAPC, estimated annual percentage changes. (Color version available online.)

infectious (OR: ORP 2.4), and vascular complications (OR: ORP 1.7). Finally, obesity did not reach IPS for intraoperative and miscellaneous surgical complications at either RARP or ORP.

In MVA predicting in-hospital mortality, obesity was not an independent predictor at either RARP (OR: 2.4, *P* = .4) or ORP (OR: 1.3, *P* = .7). In MVA predicting LOS ≥3 days, obesity reached IPS at RARP (OR: 1.3) and ORP (OR: 1.3). In MVA predicting THC, obesity was associated with higher THC at RARP (relative linear increase: $740.86, *P* <.001), as well as at ORP (relative linear increase: $311.57, *P* <.001).

DISCUSSION

Obesity is a growing public health issue worldwide and in the United States, and is generally defined as BMI ≥30 kg/m^2.[10] Nonetheless, several other obesity definitions such as waist circumference ≥102 cm or waist-hip ratio >1.0 can be used.[17] However, BMI represents the most frequently used anthropometric in clinical studies regarding CaP.[18] In general, obese patients are predisposed to higher rates of adverse peri- and postoperative outcomes.[18,19] In context of RP, several institutional analyses

Table 2. Complications rates of 89,383 radical prostatectomy patients, within the National Inpatient Sample (2008-2015), stratified according to surgical approach (robotic-assisted radical prostatectomy [RARP] vs open radical prostatectomy [ORP] and obesity (nonobese [body mass index (BMI) <30 kg/m^2] vs obese [BMI ≥30 kg/m^2]). Each cell denotes the absolute number followed by percentage of total. Absolute differences between obese vs nonobese for each complication category or other outcome (length of stay [LOS], total hospital charges [THC]) are expressed as percentages. Relative differences between obese vs nonobese are expressed as odds ratios (OR).

	RARP *n* = 53,626, 60%			ORP *n* = 35,757, 40%		
Variables	Obese *n* = 4589, 8.6%	Nonobese *n* = 49,037, 91.4%	Absolute difference (%)/relative difference (OR)	Obese *n* = 2499, 6.9%	Nonobese *n* = 33,258, 93.1%	Absolute difference (%)/relative difference (OR)
Overall complications						
No	3989 (86.9)	45,181 (92.1)		2065 (82.6)	29,485 (88.7)	
Yes	600 (13.1)	3856 (7.9)	5.2/1.7†	434 (17.4)	3773 (11.3)	6.1/1.5*
Miscellaneous medical complications						
No	4236 (92.3)	46,902 (95.6)		2292 (91.7)	31,407 (94.4)	
Yes	353 (7.7)	2135 (4.4)	3.3/1.8†	207 (8.3)	1851 (5.6)	2.7/1.5*
Cardiac complications						
No	4507 (98.2)	48,644 (99.2)		2434 (97.4)	32,851 (98.8)	
Yes	82 (1.8)	393 (0.8)	1.0/2.3†	65 (2.6)	407 (1.2)	1.4/2.2*
Respiratory complications						
No	4520 (98.5)	48,626 (99.2)		2427 (97.1)	32,689 (98.3)	
Yes	69 (1.5)	411 (0.8)	0.7/1.9†	72 (2.9)	569 (1.7)	1.2/1.7*
Genitourinary complications						
No	4527 (98.6)	48,646 (99.2)		2451 (98.1)	32,910 (99.0)	
Yes	62 (1.4)	391 (0.8)	0.6/1.8†	48 (1.9)	348 (1.0)	0.9/1.9*
Blood transfusion						
No	4502 (98.1)	48,313 (98.5)		2233 (89.4)	30,334 (91.2)	
Yes	87 (1.9)	724 (1.5)	0.4/1.3†	266 (10.6)	2924 (8.8)	1.8/1.2*
Wound complications						
No	4578 (99.8)	48,968 (99.9)		2480 (99.2)	33,174 (99.7)	
Yes	11 (0.2)	69 (0.1)	0.1/2.0	19 (0.8)	84 (0.3)	0.5/2.7*
Infectious complications						
No	4579 (99.8)	48,971 (99.9)		2483 (99.4)	33,177 (99.8)	
Yes	10 (0.2)	66 (0.1)	0.1/2.0	16 (0.6)	81 (0.2)	0.4/3.0*
Vascular complications						
No	4570 (99.6)	48,864 (99.6)		2479 (99.2)	33,112 (99.6)	
Yes	19 (0.4)	173 (0.4)	0.0/0.0	20 (0.8)	146 (0.4)	0.4/2.0*
Miscellaneous surgical complications						
No	4522 (98.5)	48,326 (98.6)		2440 (97.6)	32,415 (97.5)	
Yes	67 (1.5)	711 (1.4)	0.1/1.1	59 (2.4)	843 (2.5)	0.1/0.9
Intraoperative complications						
No	4562 (99.4)	48,768 (99.5)		2,478 (99.2)	32,891 (98.9)	
Yes	27 (0.6)	269 (0.5)	0.1/1.2	21 (0.8)	367 (1.1)	0.3/0.7
In-hospital mortality						
No	4,587 (100)	49,025 (100)		2495 (99.8)	33,240 (99.9)	
Yes	2 (0)	12 (0)	0.0/0.0	4 (0.2)	18 (0.1)	0.1/2.0

Continued

Table 2. Continued

Variables	RARP n = 53,626, 60% Obese n = 4589, 8.6%	Nonobese n = 49,037, 91.4%	Absolute difference (%)/relative difference (OR)	ORP n = 35,757, 40% Obese n = 2499, 6.9%	Nonobese n = 33,258, 93.1%	Absolute difference (%)/relative difference (OR)
Length of stay, ≥3 days, n (%)						
<3 days	3883 (84.6)	43,658 (89.0)		1512 (60.5)	22,436 (67.5)	
≥3 days	706 (15.4)	5379 (11.0)	4.4/1.4†	987 (39.5)	10,822 (32.5)	7.0/1.2*
Total hospital charges, in $						
Mean (STE)	15,288.50 (113.17)	13,663 (30.89)		13,085.40 (174.37)	12,274 (46.16)	
Median	13,667.80	12,135.70	+$1532.10†	11,217.20	10,677	+$540.20*
IQR	10,592.80-17,902.20	9491.50-15,884.30		8483.60-15,266.10	7932.80-14,462.90	

† Statistically significant difference between obese and nonobese patients within RARP cohort.
* Statistically significant difference between obese and nonobese patients within ORP cohort.

examined the relationship between obesity and outcomes showing generally worse outcomes in obese patients.[4-7,20] Additionally, 3 North-American populations-based studies examined this relationship.[1-3] Specifically, Ellimoottil et al relied on 2009-2010 NIS data and described 9108 obese patients (weighted population) regarding complications and LOS.[1] Unfortunately, no nonobese control-group was neither defined nor interpreted. Monn et al relied on 2011-2012 National Surgical Quality Improvement Program (NSQIP) data and described 12,454 RP patients regarding wound complications.[3] However, their analysis focused only on 1 specific complication without accounting for other complications, as well as for in-hospital mortality and LOS. Finally, Johnson et al relied on 2008-2013 NSQIP data, and described 22,367 patients focusing on overall, as well as several specific complications in their comprehensive study.[2] The authors performed 3 separate analyses that focused on BMI 30-35, BMI 35-40, and BMI >40. However, this approach resulted in limited and relatively small sample size within the subgroups. Taken together, evidence originating from single-institutional studies, as well as the 3 population-based studies is limited with respect to risk variable definition and outcome definition, in addition to relying on smaller sample size.

Based on these considerations, we decided to examine the relationship between obesity and perioperative, as well as early postoperative outcomes. We relied on the WHO definition of obesity (BMI $\geq$30 kg/m^2) and stratified our analyses according to RP surgical approach. We hypothesized that potentially more favourable outcomes are observed in obese patients, when RARP is used instead of ORP. Our analyses demonstrated several noteworthy observations.

First, within the overall population, 7.9% were obese according to WHO definition and the rate was higher at RARP than at ORP (8.6 vs 6.9%, P <.001). These rates are in disagreement with the literature, where obesity ranged from 12.0% to 36.0% at either RARP or ORP.[2-7] Moreover, within the general US population, the prevalence of obesity within male adults aged 60 and older was 38.5% in 2015.[21] These observations suggest a potential selection bias within the small-scale institutional studies, as well as the 22,367 patient NSQIP population (obesity rate: 34.3%) relative to the 89,383 patient cohort examined here.[2] The discrepancy between the current large-scale database and that of NSQIP is striking even when the same definition of obesity is used. However, none of the previous publications reported results from the NIS. Moreover, the obesity rates within the current study are consistent with obesity rates reported in previous NIS analyses that focused on other types of urologic patients; that is, patients treated with percutaneous nephrolithotomy (obesity rate: 10.3%).[11] Taken together, our data as well as other institutional data indicate that a larger proportion of obese patients are treated with RARP.

Second, we identified significant associations between obesity and patient characteristics, as well as hospital

Table 3. Fourteen multivariable regression models, predicting risk of perioperative complications (models 1-11), in-hospital mortality (model 12), length of stay (model 13) and total hospital charges (model 14) according to the presence of obesity (BMI ≥30 kg/m^2) for robotic-assisted radical prostatectomy (RARP) vs open radical prostatectomy (ORP) within the National Inpatient Sample (2008-2015).

	RARP		ORP	
Outcome of Interest	OR (CI)	*P* Value	OR (CI)	*P* Value
Overall complications	1.7 (1.5-1.8)	<0.001	1.5 (1.4-1.7)	<0.001
Miscellaneous medical complications	1.7 (1.5-1.9)	<0.001	1.4 (1.2-1.6)	<0.001
Cardiac complications	1.8 (1.4-2.3)	<0.001	1.8 (1.4-2.3)	<0.001
Respiratory complications	1.6 (1.3-2.2)	<0.001	1.5 (1.2-2.0)	<0.001
Genitourinary complications	1.7 (1.3-2.2)	<0.001	1.8 (1.3-2.5)	0.002
Blood transfusion	1.2 (1.0-1.5)	0.1	1.3 (1.1-1.4)	<0.001
Wound complications	1.5 (0.8-2.9)	0.2	2.8 (1.7-4.8)	<0.001
Infectious complications	1.5 (0.7-2.9)	0.3	2.4 (1.4-4.3)	0.002
Vascular complications	1.0 (0.6-1.7)	0.9	1.7 (1.1-2.9)	0.03
Miscellaneous surgical complications	1.0 (0.8-1.3)	0.9	0.9 (0.7-1.2)	0.5
Intraoperative complications	1.1 (0.8-1.7)	0.5	0.7 (0.5-1.2)	0.2
In-hospital mortality*	2.4 (0.4-16.2)	0.4	1.3 (0.3-5.8)	0.7
Length of stay ≥3 days*	1.3 (1.2-1.5)	<0.001	1.3 (1.2-1.4)	<0.001
Total Hospital Charges (Linear Regression Model)+	$ 740.86++ (615.35- 866.36)	<0.001	$ 311.57++ (87.38-535.76)	<0.001

CI, 95% confidence interval; BMI, body mass index; OR, odds ratio.
All models adjusted for: BMI, age, year of surgery, Charlson comorbidity index, insurance status, race, teaching status, lymph node dissection, hospital volume, region, hospital bed size and income. All models clustered and weighted.
* Model additionally adjusted for all complications.
+ Model additionally adjusted for all complications and length of stay.
++ Reported as relative linear increase.

characteristics. Specifically, obese patients were younger, more frequently African American, were more frequently within the first and lowest income quartile and were more frequently treated in low- and medium-volume hospitals. The association of obesity with unemployment, African American populations, and percent ≤65 years has been described in general.[22,23] However, to the best of our knowledge, we are the first to report on the association between obesity and these sociodemographic and hospital characteristics in localized CaP. Our findings indicate that obese patients are not only worse surgical candidates because of elevated BMI, but additionally are more frequently within more unfavourable income group and insurance status.

Third, the rate of overall complications was significantly higher in obese vs nonobese RARP (5.2% absolute difference) and in obese vs nonobese ORP (6.1% absolute difference). Moreover, significantly higher complication rates were recorded in 6 out of 11 complication categories in obese vs nonobese RARP, and in 9 out of 11 complication categories in obese vs nonobese ORP. Taken together, obesity has a more unfavourable effect at ORP, even though a larger proportion of RARP patients were obese. This is consistent with previous reports, which reported on higher transfusion rates, higher wound complications and infection rates in obese ORP patients.[3,5-7] In the NSQIP study of Monn et al, the rate of wound and renal complications was higher in both, obese RARP and obese ORP patients. In contrast to our results, in this study thromboembolic and infectious complications were higher only in obese RARP patients, while no difference was observed in cardiac and respiratory complications in both ORP and RARP.[2]

Fourth, despite the observed differences in the effect of obesity on complications according to RP type, no significant difference in mortality was observed. In contrast, a meaningful and significant difference in LOS was observed. Finally, RARP performed in obese patients resulted in highest THC that exceeded THC of ORP performed in obese patients. To the best of our knowledge, we are the first to report on a comprehensive analysis of THC of obesity in RARP vs ORP. Our analyses suggest that a premium in THC is associated with use of RARP relative to ORP in obese patients, as well as in nonobese patients.

In the final section of our analyses, we relied on MVA to examine the relationship of obesity and complications, in-hospital mortality, LOS, and THC. In those analyses, obesity independently predicted 5 out of 11 complication categories at RARP, and 9 out of 11 at ORP. The clinical implication of these multivariable observations confirms our univariable observations, where obesity predisposes to fewer complications at RARP than ORP. However, the MVA focusing on complication rates need to be interpreted in the light of MVA predicting THC. Here, obesity predicted higher THC at RARP than ORP. In consequence, the complication benefit of RARP in obese patients is offset by higher price of RARP in obese patients, relative to ORP in obese patients. From a practical perspective, the cost increment of $741 associated with RARP in obese patients only represents a 6.0% increase relative to the median cost of RARP in the current database ($741/$12.273×100 = 6.0%). In consequence, the added cost is clearly warranted in individual patients. These results are mainly consistent with the literature.[3,5-7,20] However, to the best of our knowledge, we are the first to report on higher cardiac, respiratory, and miscellaneous medical complications in obese RP patients, as well as we are the first to report a comprehensive analysis examining the effect of obesity on THC for RP patients. Our findings add to the existing body of evidence of increased THC in obese patients that until now originates from outside of urologic oncology.[11,24,25]

Our study has several strengths that distinguish it from previous reports. It relies on the most contemporary patient population that reflects modern diagnostics, staging, and therapeutics. In consequence, it is the most generalizable study to illustrate contemporary management of CaP patients. Moreover, it relies on the largest patient cohort with most stringent adjustment for potential selection biases that could distinguish obese from nonobese patients.

Several limitations of our study need to be mentioned. First, our study is based on a retrospective analysis with all of its inherent limitations. Nonetheless, all previous studies that reported on obese RP patients have also been based on retrospective designs. Additionally, the current database only allows assessment of BMI. However, other anthropometric measures such as waist circumference or waist-hip ratio are not available in NIS and could therefore not be analyzed to further proof the validity of our hypothesis. Furthermore, the definition of complications relies on retrospective assessment of ICD-9 codes. Ideally, within a prospective study design, Clavien-Dindo complication definition would be used.[26] This limitation is shared with all previous studies, except for 1 population-based study of Johnson et al and 1 institutional study of Beyer et al.[2,20] Additionally, our study suffers of several other limitations that are inherent to population-based analyses. For example, we were unable to adjust for further patients' characteristics, such as performance status, American Society of Anesthesiology status, differences in laboratory values and opioid use, as well as neoadjuvant androgen deprivation and preoperative radiotherapy, which may affect complications, LOS, and THC. However, this mainly applies to previous reports of population-based data repositories as well.[2,3] Last but not least, our analyses focused on perioperative outcomes that occurred during admission. Unfortunately, adverse outcomes that occurred after discharge such as readmission rates could not be assessed.

CONCLUSION

Obesity at RARP translates into fewer adverse perioperative outcomes compared to obesity at ORP. However, THC associated with RARP appear to be higher than those associated with ORP in obese patients. Thus, the resulting trade-off between higher cost but more favorable complication profile of RARP in obese patients suggests primarily considering RARP in these patients.

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EDITORIAL COMMENT

This study focuses on the impact of obesity on perioperative outcomes at robotic-assisted and open radical prostatectomy.[1] Putting aside the fact that a much lower percentage of this population was obese when compared to the general population, obesity clearly increased both the risks and the costs of surgery.

The comparison of robotic assisted vs open radical prostatectomy is less relevant in countries who have already adopted robotic surgery, as the vast majority of cases are done robotic assisted, despite prior studies showing no significant difference in functional outcomes between the 2 approaches.[2,3] As others have observed, it is almost certainly the case that the individual skill of the surgeon is a more important factor that the surgical approach employed.[3]

Obesity increases the risks regardless of the method of surgery, and as the authors suggest, it is clearly a growing public health issue. The obese patient is more likely to be black, poor, and treated at a low or medium volume hospital.[1]

The gold standard for prostate cancer remains a radical prostatectomy. African Americans are at higher risk of prostate cancer, and yet there is compelling evidence that they are less likely to receive definitive treatment and experience a significantly poorer quality of care overall.[4,5] A renewed emphasis should be placed on addressing health care disparities in prostate cancer care.

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AUTHOR REPLY

Prostate cancer (CaP) patients treated with radical prostatectomy (RP) may have a longer life expectancy than the age-matched general population.[1] At first glance, this might be a counter-intuitive observation. However, it is based on a heavy selection bias in the diagnostic and treatment decision-making process prior to RP. This might be 1 explanation why obesity is under-represented in a surgically treated cohort compared to the general population as correctly pointed out in this editorial.

Beyond the differences in surgical complication rates between open and robotic-assisted RP (ORP and RARP) in obese men, the accompanying commentary complements our findings and emphasizes important racial and socioeconomic disparities in treatment outcomes of CaP patients. Accordingly, it was shown that wealthier patients are more likely to receive RARP than ORP.[2] The commentator states that "The obese patient is more likely to be black, poor, and treated at a low or medium volume hospital" and calls for a renewal in addressing health care disparities in CaP treatment. We completely agree with this claim and endorse that outcome differences based on the surgical approach for RP probably have a lower impact compared to outcome differences that are based on social, racial, and even geographical disparities.[3,4] Nevertheless, in centers or regions in which both surgical approaches are available, our study supports the current evidence that obese patients can expect fewer complications if treated robotically-assisted.

Last but not least, another patient group should not be forgotten in the debate addressing outcome inequalities in CaP treatment: the old patient. Several recent studies demonstrated the underutilization of local treatment options in chronologically older men with a long life expectancy.[5] Besides the above-mentioned sources for disparities, this growing group of patients deserves careful attention since recent data argue against a strong inherent effect of age on risk of CaP death and indicate that in current clinical practice, old men with CaP receive insufficient diagnostic workup and subsequent curative treatment.[6]

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