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Sedation as an alternative anesthetic technique for frail patients in transurethral resection of the prostate

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Abstract

Background: Transurethral resection of the prostate (TURP) under Monitored Anesthesia Care MAC/Sedation (macTURP), as compared with TURP under general (genTURP) or spinal (spTURP) anesthesia, is a safer and infrequently used technique reserved for high-risk patients.

Objectives: The aim of this study is to compare 30-day postoperative outcomes of TURP using the three types of anesthesia techniques.

Design and methods: The American College of Surgeons National Surgical Quality Improvement Program database was queried for patients who underwent TURP between 2008 and 2019. Demographics, lab values, medical history, and 30-day outcomes were compared. Univariate and multivariate regression models for postoperative complications were constructed. A propensity score–matched analysis was then performed for genTURP and macTURP and for spTURP and macTURP as a sensitivity analysis.

Results: A total of 53,182 patients underwent TURP. Older patients (>80) with diabetes requiring insulin (7.9%), leukocytosis (7.4%), history of chronic obstructive pulmonary disease (COPD) (7.8%), dyspnea (7.2%), and of ASA > 2 (58.8%) were more likely to undergo macTURP as compared with genTURP ($p < 0.013$). SpTURP showed lower rates of urinary tract infection (UTI) [odds ratio (OR) = 0.869] as compared with genTURP ($p = 0.049$), whereas macTURP showed higher rates of major adverse cardiovascular events (OR = 2.179) as compared with genTURP ($p = 0.005$). All other postoperative complications showed similar rates between the three procedures. The propensity-matched cohorts demonstrated that no differences in postoperative complication rates were noted between macTURP and genTURP and between macTURP and spTURP.

Conclusion: MacTURP was found to be feasible with a good safety profile as compared with genTURP and spTURP. MacTURP could be used in elderly, frail, and co-morbid patients with a similar safety profile as compared with more invasive anesthetic techniques.

Keywords: anesthesia, benign prostatic hyperplasia, endourology, prostate

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Introduction

Transurethral resection of the prostate (TURP) is considered the gold standard for benign prostatic hyperplasia (BPH) treatment.[1,2] Prostatic resection could be performed using various modalities of anesthesia such as general (genTURP), neuraxial (spTURP), and, less frequently, sedation/MAC (monitored anesthesia care) (macTURP).[2] Due to age-related factors, BPH shows a greater incidence in older individuals reaching an incidence of 60% at age of 60 and 80% at age of 80.[2,3] This elderly population presents with comorbidities and risk factors making BPH treatment and anesthesia challenging. GenTURP is associated

with several intraoperative and postoperative complications such as cardiorespiratory depression, postoperative pneumonia, post-op ventilator dependence, post-op nausea, and vomiting.[4,5] Therefore, spTURP has been considered a safe alternative and has allowed the detection of early TURP syndrome.[6] SpTURP also allows the detection of intraoperative complications such as capsular tears and bladder perforation.[4,7] As a result, spTURP in some cases is preferred over genTURP. On the contrary, macTURP is a less frequently used procedure utilizing sedoanalgesia, the combination of sedation and locally injected analgesia to perform surgery.[8] MacTURP has not been widely adopted as a preferred method of anesthesia and is usually left for high-risk patient who cannot tolerate general nor spinal anesthesia. The sedoanalgesic substances used and modes of administration in macTURP differ between different studies.[8–11] Nevertheless, early uses of this technique showed promising results and macTURP was found to have excellent pain control and few intraoperative/postoperative complications.[9,12–15] Hence, the aim of this study is to compare 30-day postoperative outcomes of TURP using the three types of anesthesia techniques (general, spinal, and mac/sedation) from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database.

Materials and methods

Study design and data retrieval

The ACS-NSQIP dataset was used to collect data on patients who underwent TURP between the years 2008 and 2019. The corresponding Current Procedural Terminology (CPT) code 52601 for TURP was used. The ACS-NSQIP database is a nationally validated, risk-adjusted, outcomes-based program. It encompasses 963 centers and more than 65 collaboratives both inside and outside the United States. All centers receive intensive training and follow-up support for their trained Surgical Clinical Reviewers (SCRs). The ACS-NSQIP dataset contains de-identified information only; hence, IRB (Institutional Review Board) approval was not needed.

Patient and covariates

Patient baseline demographics, lab values, and medical history variables were collected. Patient demographics included age, body mass index (BMI), American Society of Anesthesiology (ASA) class, smoking status, and race. Laboratory values included abnormal creatinine defined as creatinine $\geq$1.5 mg/dL, leukocytosis defined as white blood cell (WBC) count $>$11,000 per mm^3, thrombocytopenia defined as platelet count $<150 \times 10^3$, and anemia defined as hematocrit level $<$41%. Medical history variables included diabetes mellitus, diabetes mellitus requiring insulin, hypertension requiring medication, acute renal failure, history of chronic obstructive pulmonary disease (COPD), dyspnea, presence of bleeding disorders, congestive heart failure (CHF), steroid use, and disseminated cancer.

Outcomes of interest

Postoperative complications were compared between the different anesthesia techniques that included return to operative room, urinary tract infection, occurrence of pneumonia, sepsis, bleeding transfusion, pulmonary embolism and deep vein thrombosis (PE/DVT), renal failure, septic shock, reintubation defined as any incidence of unplanned intubation intraoperatively or postoperatively that was not intended or planned that could include, but is not limited to, unplanned intubations for refractory hypotension, cardiac arrest, or inability to protect airway, failure to wean defined as ventilator-assisted respirations for more than 48 h after surgery, and major adverse cardiovascular event (MACE) defined as the occurrence of stroke, cardiac arrest, or death.[16] Re-intubation does not include the following cases: patients returned to the operative room for an unplanned reintervention, patients undergoing time off the ventilator during weaning trials and fail the trial and placed back on ventilator, intraoperative conversion from local or monitored anesthesia care (MAC) to general anesthesia, in the absence of an emergency, secondary to a patient not tolerating local or MAC anesthesia, and patient self-extubation requiring reintubation.[17] Furthermore, surgical characteristics were compared between the different anesthesia techniques that included operative time, time from anesthesia start to surgery start, and time from surgery stop to anesthesia stop.

Statistical analysis

Patient demographics, preoperative labs, medical history, and 30-day postoperative outcomes were compared between individuals undergoing genTURP, spTURP, and macTURP. Categorical

variables were compared using chi-square test and presented as counts and percentages while continuous variables were compared using one-way analysis of variance (ANOVA) and presented as mean and standard error of the mean (SEM).

Univariate and multivariate logistics regressions were performed for categorical variables and linear regressions were performed for continuous variables adjusting for age, race, BMI, history of severe COPD, dyspnea, bleeding disorder, insulin-dependent diabetes, leukocytosis, disseminated cancer, and ASA score.

Propensity score matching

As a sensitivity analysis, a 1:1 propensity score matching was performed for genTURP and macTURP and a second propensity match was also performed for spTURP and macTURP. Patients were matched on all preoperative demographics, lab values, and medical history variables. Postoperative complications were then compared between the two groups post-propensity score matching.

For all aforementioned tests, two-sided statistical significance was set as p value < 0.05. All analyses were conducted using the statistical analysis software platform (IBM SPSS) version 28.0.0.0 (190).

Results

Patient demographics, medical history, and preoperative labs

The dataset was managed and yielded a total of 53,182 patients who underwent TURP between the years 2008 and 2019. Of those, 40,160 (75.5%) underwent genTURP, 11,547 (21.7%) underwent spTURP, and 1475 (2.8%) underwent macTURP. GenTURP patients were found to be younger, have a higher BMI, and have bleeding disorders as compared with spTURP and macTURP ($p < 0.001$). Furthermore, patients undergoing macTURP were found to be older, have a higher ASA class, leukocytosis, and diabetes requiring insulin as compared with genTURP ($p < 0.001$). SpTURP and macTURP patients were also shown to have higher rates of COPD and dyspnea as compared with genTURP ($p < 0.001$). As for smoking status, anemia, thrombocytopenia, abnormal creatinine, diabetes, hypertension requiring medication, acute renal failure, congestive heart failure, steroid use, and history of myocardial infarction, no differences were seen between the three groups. Further baseline demographics, lab values, and medical history variables for the three groups could be seen in Table 1.

Thirty-day postoperative outcomes before propensity score matching

At the univariate level, macTURP was found to have a higher risk of MACE (1.6%) and reintubation (0.3%) and lower rates of sepsis (0.8%) as compared with genTURP (0.8%, 0.2%, and 1% respectively) ($p < 0.04$), whereas with respect to return to operating room, urinary tract infection, pneumonia, bleeding transfusion, PE/DVT, failure to wean of ventilator, and renal failure, no difference in risk was shown between macTURP, spTURP, and genTURP (Table 2).

After adjusting for covariates, spTURP showed lower odds of urinary tract infection [0.896 (0.756, 0.99)] as compared with genTURP ($p = 0.049$), whereas macTURP still showed higher odds of MACE [2.179 (1.273, 3.729)] as compared with genTURP ($p = 0.005$). As for all other outcomes, no difference was recorded when comparing the three procedures (Table 4).

Thirty-day postoperative outcomes for genTURP and macTURP after propensity score matching

Propensity score matching yielded a matched cohort of 1596 patients, 798 in macTURP and 798 in genTURP **(S1)**. All preoperative variables were matched and similar between macTURP and genTURP **(S1)**. This match was used as a sensitivity analysis to focus on comparing macTURP and genTURP in postoperative complications (Table 3). The matched analysis showed that macTURP and genTURP did not differ significantly in any postoperative complication or characteristic (Table 4).

Thirty-day postoperative outcomes for spTURP and macTURP after propensity score matching

Propensity score matching yielded a matched cohort of 1686 patients, 834 in macTURP and 834 in spTURP **(S2)**. Similar to the previous propensity score matching, all preoperative variables were matched and similar between macTURP and spTURP **(S2)**. This match was used as a

Table 1. Patient baseline demographic, lab values, and medical history compared between the three TURP techniques between the years 2008 and 2019.

***N* = 53,182**		**TURP type**			***p***
		GenTURP, *N* = 40,160	**SpTURP, *N* = 11,547**	**MacTURP, *N* = 1475**	
		***n* (%)**	***n* (%)**	***n* (%)**	
Demographics[a]					
Age	<50	622 (1.5)	49 (0.4)	18 (1.2)	<0.001*
	50–59	4040 (10.1)	694 (6)	99 (6.7)	
	60–69	12,813 (31.9)	3129 (27.1)	470 (31.9)	
	70–79	14,760 (36.8)	4453 (38.6)	521 (35.3)	
	⩾80	7925 (19.7)	3222 (27.9)	367 (24.9)	
BMI	Normal	10,418 (25.9)	3504 (30.3)	432 (29.3)	<0.001*
	Overweight	16,777 (41.8)	4818 (41.7)	573 (38.8)	
	Class I	8804 (21.9)	2231 (19.3)	335 (22.7)	
	Class II	2961 (7.4)	709 (6.1)	92 (6.2)	
	Class III	1200 (3)	285 (2.5)	43 (2.9)	
ASA class	⩽2	18,156 (45.2)	5243 (45.4)	608 (41.2)	0.008*
	>2	22,004 (54.8)	6304 (54.6)	867 (58.8)	
Smoker		4456 (11.1)	1229 (10.6)	181 (12.3)	0.119
Race	Black	2952 (9)	285 (5.5)	65 (7.4)	<0.001*
	White	28,178 (86.2)	4549 (87.1)	775 (88.8)	
	Others	1544 (4.7)	390 (7.5)	33 (3.8)	
Lab values[a]					
Anemia		16,506 (41.1)	4837 (41.9)	595 (40.3)	0.244
Thrombocytopenia		3582 (8.9)	983 (8.5)	117 (7.9)	0.194
Leukocytosis		2673 (6.7)	690 (6)	109 (7.4)	0.013*
Abnormal creatinine		4728 (11.8)	1318 (11.4)	161 (10.9)	0.375
Medical history[a]					
Diabetes		8679 (21.6)	2580 (22.3)	326 (22.1)	0.233
Diabetes requiring insulin		2680 (6.7)	667 (5.8)	117 (7.9)	<0.001*
Hypertension		24,306 (60.5)	6870 (59.5)	906 (61.4)	0.095
Acute renal failure		174 (0.4)	46 (0.4)	6 (0.4)	0.874
COPD		2299 (5.7)	929 (8)	115 (7.8)	<0.001*
Dyspnea		2482 (6.2)	850 (7.4)	106 (7.2)	<0.001*

(Continued)

Table 1. (Continued)

***N* = 53,182**	**TURP type**			***p***
	GenTURP, *N* = 40,160	**SpTURP, *N* = 11,547**	**MacTURP, *N* = 1475**	
	***n* (%)**	***n* (%)**	***n* (%)**	
Bleeding disorders	1379 (3.4)	202 (1.7)	36 (2.4)	<0.001*
Congestive heart failure	407 (1)	114 (1)	21 (1.4)	0.283
Steroid use	1101 (2.7)	282 (2.4)	42 (2.8)	0.197
Disseminated cancer	775 (1.9)	182 (1.6)	20 (1.4)	0.017*

ASA, American Society of Anesthesiology; BMI, body mass index in kg/m^2; GenTURP, TURP under general; MacTURP, TURP under monitored anesthesia care MAC/sedation; SpTURP, TURP under spinal anesthesia; TURP, transurethral resection of the prostate; WBC, white blood cell.
Normal (<25), overweight (25–29.9), class 1 (30–34.9), class 2 (35–39.9), class 3 (≥40); smoker is a current smoker within 1 year; anemia is defined as hematocrit < 41%; thrombocytopenia is platelet count < 150 × 10^3; abnormal creatinine is serum creatinine ≥ 1.5 mg/dL; leukocytosis is defined as WBC count > 11,000 /mm^3; hypertension indicates hypertension requiring medication; COPD indicates chronic obstructive pulmonary disease.
[a]Chi-square test.
*Significance $p < 0.05$.

Table 2. Patient 30-day postoperative outcomes in different TURP techniques.

***N* = 53,182**	**TURP type**			***p***
	GenTURP, *N* = 40,160	**SpTURP, *N* = 11,547**	**MacTURP, *N* = 1475**	
	***n* (%)**	***n* (%)**	***n* (%)**	
Complications[a]				
Return to operative room	889 (2.2)	225 (1.9)	29 (2)	0.198
UTI	2065 (5.1)	554 (4.8)	60 (4.1)	0.074
Pneumonia	140 (0.3)	49 (0.4)	7 (0.5)	0.393
Sepsis	386 (1)	82 (0.7)	12 (0.8)	0.04*
Bleeding transfusion	664 (1.7)	207 (1.8)	21 (1.4)	0.439
PE/DVT	158 (0.4)	47 (0.4)	4 (0.3)	0.734
Renal failure	152 (0.4)	30 (0.3)	4 (0.3)	0.143
Septic shock	102 (0.3)	23 (0.2)	4 (0.3)	0.559
Reintubation	89 (0.2)	12 (0.1)	4 (0.3)	0.035*
Failure to wean of ventilator	45 (0.1)	6 (0.1)	0 (0)	0.089
MACE	318 (0.8)	116 (1)	24 (1.6)	<0.001*
Dead	193 (0.5)	65 (0.6)	15 (1)	0.013*
Myocardial infarction	98 (0.2)	44 (0.4)	11 (0.7)	<0.001*
Stroke	48 (0.1)	16 (0.1)	1 (0.1)	0.728

(Continued)

Table 2. (Continued)

***N* = 53,182**	**TURP type**			
	GenTURP, *N* = 40,160	**SpTURP, *N* = 11,547**	**MacTURP, *N* = 1475**	***p***
	***n* (%)**	***n* (%)**	***n* (%)**	
Characteristics[b]				
Operative time (min)	58.2 ± 38.7	48.3 ± 32.9	48.84 ± 31.8	<0.001*
Time from anesthesia start to surgery start (min)	37.5 ± 100	26.4 ± 41.4	23.4 ± 12	<0.001*
Time from surgery stop to anesthesia stop (min)	14 ± 9	10.8 ± 17.1	9.72 ± 5.1	<0.001*

DVT, deep vein thrombosis; genTURP, TURP under general anesthesia; MACE, major adverse cardiovascular event a composite outcome of myocardial infarction, stroke or death; macTURP, TURP under MAC/sedation; PE, pulmonary embolism; spTURP, TURP under spinal anesthesia; TURP, transurethral resection of the prostate; UTI, urinary tract infection.
[a]Chi-square test.
[b]One-way analysis of variance.
*Significance $p < 0.05$.

Table 3. Univariable and multivariable analysis of postoperative complications.

Variable (General as Ref.)	**Univariable regression**				**Multivariate regression**			
	SpTURP[a]	***p***	**MacTURP[a]**	***p***	**SpTURP[b]**	***p***	**MacTURP[b]**	***p***
Complications								
Return to operating room	0.878 [0.757, 1.018]	0.084	0.886 [0.610, 1.287]	0.525	0.839 [0.677, 1.040]	0.109	0.966 [0.609, 1.533]	0.884
Bleeding transfusion	1.086 [0.928, 1.271]	0.305	0.859 [0.555, 1.331]	0.496	0.815 [0.631, 1.052]	0.116	0.671 [0.356, 1.266]	0.671
UTI	0.930 [0.844, 1.024]	0.137	0.782 [0.602, 1.017]	0.066	0.869 [0.756, 0.999]	0.049*	0.801 [0.574, 1.117]	0.191
Pneumonia	1.218 [0.879, 1.688]	0.235	1.363 [0.637, 2.917]	0.425	1.024 [0.630, 1.664]	0.925	1.251 [0.457, 3.425]	0.663
Sepsis	0.737 [0.58, 0.936]	0.012*	0.845 [0.475, 1.505]	0.568	0.781 [0.555, 1.098]	0.155	0.465 [0.173, 1.252]	0.130
Septic shock	0.784 [0.498, 1.233]	0.292	1.068 [0.393, 2.904]	0.898	0.634 [0.304, 1.323]	0.224	0.899 [0.220, 3.685]	0.883
MACE	1.271 [1.027, 1.574]	0.028*	2.072 [1.364, 3.148]	<0.001*	1.144 [0.830, 1.575]	0.411	2.179 [1.273, 3.729]	0.005*
PE/DVT	1.035 [0.747, 1.434]	0.838	0.688 [0.255, 1.860]	0.462	0.839 [0.512, 1.376]	0.487	0.829 [0.263, 2.610]	0.749
Renal failure/ insufficiency	0.686 [0.463, 1.015]	0.059	0.716 [0.265, 1.934]	0.510	0.906 [0.534, 1.538]	0.714	0.926 [0.293, 2.930]	0.896
Reintubation	0.468 [0.256, 0.856]	0.014	1.224 [0.449, 3.338]	0.693	0.568 [0.260, 1.241]	0.156	0.945 [0.23, 3.88]	0.945
Failure to wean of ventilator	0.463 [0.198, 1.087]	0.077	0	0.99	0.497 [0.152, 1.631]	0.497	0	0.991
Characteristics								
Operative time (min)	−9.91 [−10.69, −9.14]	<0.001*	−9.36 [−11.3, −7.42]	<0.001*	0.25 [−0.86, 1.35]	0.66	−3.39 [−5.92, −0.86]	0.009*

(Continued)

Table 3. (Continued)

Variable (General as Ref.)	Univariable regression				Multivariate regression			
	SpTURP[a]	*p*	MacTURP[a]	*p*	SpTURP[b]	*p*	MacTURP[b]	*p*
Time from anesthesia start to surgery start (min)	**−11.09** [−16.42, −5.78]	<**0.001***	−14.15 [−36.73, 8.44]	0.219	**−9.14** [−16.72, −1.57]	**0.018***	−14.59 [−51.35, 22.16]	0.436
Time from surgery stop to anesthesia stop (min)	**−3.22** [−3.97, −2.47]	<**0.001***	**−4.31** [−7.45, −1.16]	**0.007***	**−1.62** [−2.65, −0.58]	**0.002***	−3.22 [−8.20, 1.76]	0.205

ASA, American Society of Anesthesiology; BMI, body mass index; COPD, chronic obstructive pulmonary disease; DVT, deep vein thrombosis; GenTURP, TURP under general anesthesia; MACE, major adverse cardiovascular event a composite outcome of myocardial infarction, stroke or death; macTURP, TURP under MAC/sedation; PE, pulmonary embolism; spTURP, TURP under spinal anesthesia; TURP, transurethral resection of the prostate; UTI, urinary tract infection.
[a]Univariate logistic or linear regression model.
[b]Multivariate logistic or linear regression model adjusted for age, race, BMI, history of severe COPD, bleeding disorder, insulin-dependent diabetes, dyspnea, leukocytosis, disseminated cancer, and ASA score.
*Significance $p < 0.05$.

Table 4. Patient 30-day postoperative outcomes for genTURP and macTURP post-propensity score matching.

***N* = 1596**	**TURP type**			**Propensity matched**	
	GenTURP, *N* = 798	**MacTURP, *N* = 798**	***p***	**MacTURP[a]**	***p***
	***N* (%)**	***N* (%)**		**OR [CI]**	
Complications[b]					
Return to OR	19 (2.4)	16 (2)	0.608	0.839 [0.428, 1.643]	0.609
UTI	32 (4)	33 (4.1)	0.899	1.033 [0.629, −1.696]	0.899
Pneumonia	3 (0.4)	3 (0.4)	0.99	1.000 [0.201, −4.97]	0.99
Sepsis	5 (0.6)	3 (0.4)	0.726	0.598 [0.143, 2.513]	0.483
Bleeding transfusion	9 (1.1)	9 (1.1)	0.99	1.000 [0.395, −2.532]	0.99
PE/DVT	3 (0.4)	2 (0.3)	0.99	0.666 [0.111, 3.996]	0.656
Renal failure/insufficiency	3 (0.4)	3 (0.4)	0.99	1.000 [0.201, −4.97]	0.99
Septic shock	4 (0.5)	1 (0.1)	0.374	0.249 [0.028, 2.233]	0.214
Reintubation	3 (0.4)	2 (0.3)	0.65	0.666 [0.111, 3.996]	0.656
Failure to wean of ventilator	0 (0)	0 (0)	–	–	–
MACE	6 (0.8)	10 (1.3)	0.315	1.675 [0.606, 4.631]	0.32
Dead	5 (0.6)	6 (0.8)	0.762	1.20 [0.37, 3.95]	0.763
Myocardial infarction	1 (0.1)	5 (0.6)	0.218	5.03 [0.59, 43.1]	0.141
Stroke	1 (0.1)	1 (0.1)	0.99	0.99 [0.06, 16.01]	0.99
Characteristics[c]					
Operative time (min)	60.3 ± 35.2	58.3 ± 33.7	0.243	−2.02 [−5.4, 1.37]	0.243
Time from anesthesia start to surgery start (min)	30 ± 72	25.5 ± 11.7	0.768	−4.6 [−35, 25.9]	0.768
Time from surgery stop to anesthesia stop (min)	14.4 ± 10	10.9 ± 4.23	0.104	−3.52 [−7.75, 0.72]	0.104

CI, confidence interval; DVT, deep vein thrombosis; GenTURP, TURP under general anesthesia; MACE, major adverse cardiovascular event a composite outcome of myocardial infarction, stroke or death; macTURP, TURP under MAC/sedation; OR, odds ratio; PE, pulmonary embolism; spTURP, TURP under spinal anesthesia; TURP, transurethral resection of the prostate; UTI, urinary tract infection.
Significance $p < 0.05$.
[a]GenTURP as reference.
[b]Chi-square test and univariate logistics regression.
[c]One-way analysis of variance and uni variate linear regression.

further sensitivity analysis to focus on comparing macTURP and spTURP in postoperative complications (Table 3). MacTURP showed longer operative times (by 2.5 min) and shorter time from anesthesia start to surgery start (by 5.68 min) as compared with spTURP ($p < 0.001$). MacTURP and spTURP, however, did not differ significantly in any postoperative complication or event (Table 5).

Discussion

In this study, we aimed to demonstrate that macTURP is feasible and is comparable in outcomes with genTURP and spTURP in a selected group of patients. To the best of our knowledge, this is the first retrospective cohort utilizing the NSQIP dataset aimed at performing a large population comparative study between sedation, general, and spinal anesthesia in TURP. Our study showed that macTURP when used in a select group of patients of old age, high ASA class, diabetics, and COPD showed similar postoperative complication rates when compared with genTURP and spTURP.

MacTURP was first introduced by Moffat *et al.*[9] in 1977 through a perineal and penoscrotal approach in 18 patients. Patients tolerated the procedure well and no major complications were noted although the measure of patient tolerance was not clearly defined.[9] Sedoanalgesia then gained further interest in urological surgical procedures, including transurethral incision of prostate,[12] resection of bladder tumors,[8,12] ureteroscopy and calculi removal,[18] transurethral balloon dilations,[19] and laser-assisted prostatectomies.[14] These attempts demonstrated the feasibility of sedation in urological procedures and yielded good patient tolerances and promising outcomes. A large pilot study using macTURP was performed by Sinha *et al.*[10] in 100 patients. His study showed excellent pain control (87% good or excellent tolerance) and 98% of patients agreed that they would perform the procedure again. Another large pilot study was performed by Birch *et al.*[8] in which the authors performed various urological procedures using sedoanalgesia, of which 38 were macTURP. They found that macTURP was a safe alternative to genTURP. In addition, the authors postulated that patients preferred a technique in which they remained conscious and had protective reflexes rather than techniques in which they were unconscious.

MacTURP is considered a less invasive and complex technique as compared with genTURP. This allows procedures to be performed rapidly with fast induction times and fast recovery times. Several sedoanalgesia techniques and approaches have been discussed in the literature.[8–11] Details on the efficacy of each technique and the use of different sedoanalgesic agents are not within the scope of our study as the NSQIP dataset does not describe the aforementioned details.

Patients who undergo general anesthesia have an increased risk of postoperative pneumonia, prolonged ventilator dependence, and unplanned intubation.[5] Therefore, frail patients with comorbidities such as CHF, COPD, and a high ASA class are not well suited for general anesthesia.[20] For these reasons, alternatives such as neuraxial and sedoanalgesia have been attempted in frail patients to circumvent genTURP complications. In fact, our study demonstrated that older individuals with an ASA class > 2 were more likely to undergo macTURP as compared with genTURP. Similarly, macTURP patients in several studies were shown to be above the age of 70 and of an ASA class of III or greater.[8,21]

Spinal anesthesia, although regarded as advantageous in endourologic procedures, entails risks and complications that sedoanalgesia could possibly circumvent. Spinal anesthesia has been notorious for causing hypotension, bradycardia, and asystole.[22–24] These complications were pronounced in elderly, overweight, and frail patients.[22,25] Spinal anesthesia has also been shown to increase the risk of cardiorespiratory arrest in several studies.[26–28] In one study, spinal anesthesia was accompanied with an increased risk of cardiac arrest as compared with peripheral nerve blocks and intravenous regional anesthesia.[29] A direct comparison of cardiorespiratory complications between sedoanalgesia and spinal anesthesia has not been performed. Nevertheless, a study comparing patient outcomes between spinal anesthesia and sedoanalgesia during endourologic procedures demonstrated that 12.5% of patients undergoing spinal anesthesia experienced hypotension *versus* an absence of hypotension in patients undergoing sedoanalgesia; however, no statistical significance was reported due to the small sample size.[30] The proposed mechanism of cardiorespiratory depression during spinal anesthesia is not well understood; however, possible explanations include blockade of sympathetic

Table 5. Patient 30-day postoperative outcomes for spTURP and macTURP post-propensity score matching.

***N* = 1686**	**TURP type**			**Propensity matched**	
	SpTURP, *N* = 834	**MacTURP, *p* = 834**	***p***	**MacTURP[a]**	***p***
	***n* (%)**	***n* (%)**		**OR [CI]**	
Complications[b]					
Return to OR	13 (1.5)	18 (2.1)	0.795	1.39 [0.68, 2.86]	0.367
UTI	31 (3.7)	37 (4.4)	0.458	1.20 [0.74, 1.96]	0.458
Pneumonia	1 (0.1)	4 (0.5)	0.374	4.01 [0.45, 36]	0.214
Sepsis	5 (0.6)	3 (0.4)	0.726	0.60 [0.14, 2.51]	0.483
Bleeding transfusion	7 (0.8)	10 (1.2)	0.465	1.43 [0.54, 3.78]	0.467
PE/DVT	4 (0.5)	3 (0.4)	0.99	0.75 [0.17, 3.36]	0.706
Renal failure/insufficiency	1 (0.1)	3 (0.4)	0.625	3.01 [0.31, 29]	0.341
Septic shock	1 (0.1)	2 (0.2)	0.99	2 [0.18, 22.12]	0.571
Reintubation	1 (0.1)	2 (0.2)	0.99	2.02 [0.18, 22.1]	0.571
Failure to wean of ventilator	1 (0.1)	0 (0)	–	–	–
MACE	7 (0.8)	14 (1.7)	0.124	2.01 [0.81, 5.02]	0.132
Dead	4 (0.5)	9 (1.1)	0.164	2.26 [0.69, 7.38]	0.175
Myocardial infarction	1 (0.1)	7 (0.8)	0.07	7.05 [0.87, 57.4]	0.068
Stroke	2 (0.2)	1 (0.1)	0.99	0.50 [0.05, 5.52]	0.571
Characteristics[c]					
Operative time (min)	55.7 ± 31	58.2 ± 34	0.112	2.51 [–0.59, 5.6]	<0.001*
Time from anesthesia start to surgery start (min)	29.5 ± 47.7	23.8 ± 12.05	0.552	–5.68 [–24.5, 13.1]	<0.001*
Time from surgery stop to anesthesia stop (min)	12.4 ± 6.78	11.32 ± 4.4	0.430	–1.08 [–3.77, 1.61]	0.430

CI, confidence interval; DVT, deep vein thrombosis; GenTURP, TURP under general anesthesia; MACE, major adverse cardiovascular event a composite outcome of myocardial infarction, stroke or death; macTURP, TURP under MAC/sedation; OR, odds ratio; PE, pulmonary embolism; spTURP, TURP under spinal anesthesia, TURP, transurethral resection of the prostate; UTI, urinary tract infection.
[a]SpTURP as reference.
[b]Chi-square test and univariate logistics regression.
[c]One-way analysis of variance and univariate linear regression.
*Significance $p < 0.05$.

efferent fibers, decrease in preload, and vagal-induced bradycardia, all of which are circumventable with local sedation and analgesia.[31] In our cohort, spTURP and macTURP had similar postoperative cardiorespiratory complications; however, intraoperative hypotension and bradycardia were not recorded. In theory, the minimal invasiveness of sedoanalgesia could circumvent the cardiorespiratory depression that is induced by spinal anesthesia, but this should be explored in further studies.

Our analysis showed that patients with comorbidities, including insulin-dependent diabetes,

history of COPD, and dyspnea, were more likely to undergo macTURP and spTURP as compared with genTURP. This was also evident in a study by Sood *et al.*[32] in which he compared TURP with photoselective vaporization under sedoanalgesia. From the 78 patients who participated in the study, all of them had some form of comorbidity such as COPD, diabetes, and hypertension. Furthermore, macTURP and spTURP carry the advantage of early detection of TUR syndrome as the patient remains conscious in both procedures and can report symptoms if they occur. In fact, TUR syndrome incidence can range from 1% to 8% and entails significant morbidity and mortality.[33,34] Detection of TUR syndrome in macTURP or spTURP has not been previously documented and the occurrence of TUR syndrome is not recorded within NSQIP datasets; hence, no direct comparison could be made.

Waiting times for TURP have increased over the years. One study showed that patients having to wait >150 days for TURP increased from 2% to 45% between the years 2009 and 2015.[35] To expedite essential medical treatments, day care procedures have gained importance in every day clinical settings. MacTURP and other procedures under sedation aided in increasing day care treatments from 25% to 60%.[11] Sedation procedures such as macTURP have the ability to increase efficiency in day care situations, improve operative dynamics, and allow for short delays between cases with less recovery times.[11] In our study, macTURP showed short operative times, time from anesthesia start to surgery start, and time from surgery stop to anesthesia stop. These shorter times allow for macTURP to be performed quicker in day care settings. This was also demonstrated when macTURP and Photovaporization of the Prostate (PVP) under sedoanalgesia were feasible in selected patients with excellent treatment outcomes, short hospital stays, and excellent patient satisfaction.[32] Sedation procedures were also described as cost-effective and safe alternatives to general anesthesia.[36] It was shown that procedures under sedation helped in decreasing staff-related costs, anesthetic equipment costs, and operative time.[37]

Prostate size and tissue resection are not recorded within the NSQIP dataset; nevertheless, it is worth mentioning that most studies performed macTURP on prostates less than 30 g in size.[21,38] Others have declared that macTURP is best suited for prostates <40 g in size, whereby dealing with larger glands came with limitations such as patient comfort and positioning.[11] Therefore, further studies are required to investigate the possibility of macTURP in prostates >40 g in size.

Limitations

Our study comes with various limitations. The NSQIP dataset lacks data on specific anesthetic factors such as the agent type, agent doses, and the technique used: perineal *versus* intraurethral. In addition, as the NSQIP dataset is a multi-institutional dataset, there exists variability between institutions in terms of surgical techniques when it comes to TURP (monopolar *versus* bipolar). In addition, the NSQIP dataset does not reflect on complications happening outside the NSQIP participating institutions. This study was limited to 30-day outcomes, and hence studies with longer durations of follow-ups and randomized control trials should be used to support our findings. Prostate size, estimated blood loss, amount of tissue removed, International Prostate Symptom Score (IPSS) score, and postoperative urological outcomes are not reported within the NSQIP dataset. Furthermore, the NSQIP does not report on the occurrence of TUR syndrome and a comparison of its ease of detection between macTURP and spTURP could not be performed. To further compare these procedures and assess their feasibility, further studies with more extensive data variables are required.

Conclusion

MacTURP can be performed safely and effectively in selected group of patients ⩾80 years, BMI ⩾40, ASA class >2, diabetic on insulin, COPD, and history of dyspnea. MacTURP patients demonstrated similar rates of postoperative outcomes when compared with genTURP indicating its noninferiority to the aforementioned technique and its use as an alternative in select patients. Nevertheless, further studies and trials are required to assess the efficiency of macTURP with further literature on the subject.

Declarations

Ethics approval and consent to participate

The de-identified database (ACS-NSQIP) does not constitute human subject research; therefore institutional review board (IRB) approval and consent were not required.

Consent for publication
Not applicable.

Author contributions
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Availability of data and materials
The ACS-NSQIP data are subject to a data use agreement. To access the dataset, a request to the ACS-NSQIP participant use form should be placed at the following link (https://www.facs.org/quality-programs/acs-nsqip/participant-use). The American University of Beirut Medical Center is enrolled in ACS-NSQIP as a participating center. As such, the data were made available by the ACS-NSQIP center and the AUBMC Department of Surgery after signing the data use agreement.

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Supplemental material
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