Association Between Urologists' Caseload Volume and In-hospital Mortality for Transurethral Resection of Prostate: A Nationwide Population-based Study

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OBJECTIVES To examine the relationship between the urologist case volume for transurethral resection of the prostate (TURP) and in-hospital mortality using a Taiwan nationwide population-based data set.

METHODS This study used data from the 2003 Taiwan National Health Insurance Research Database. The sample of 9539 patients who had undergone TURP was divided into three urologist caseload volume groups: fewer than 27 cases annually (low volume), 27-55 cases annually (medium volume), and more than 55 cases annually (high volume). Multivariate logistic regression analysis using generalized estimating equations was conducted to assess the adjusted association of urologist TURP caseload volume and patient in-hospital mortality to account for the urologist, patient, and hospital characteristics and the clustered nature of the study sample.

RESULTS The in-hospital mortality rate decreased with an increasing TURP caseload volume. The in-hospital mortality rate was 2.37%, 1.97%, and 1.16% for patients treated in the low, medium, and high-volume urologist group, respectively. After adjusting for others factors, the likelihood of in-hospital mortality for patients treated by urologists with a low and medium TURP caseload volume was 1.835 (95% confidence interval 1.198-2.812, $P < .01$) and 1.606 (95% confidence interval 1.052-2.452, $P < .05$) respectively, compared with that for patients treated at high-volume hospitals.

CONCLUSIONS The results of our study have shown that, after adjusting for patient, urologist, and hospital characteristics, high-volume urologists are associated with superior treatment outcomes for patients undergoing TURP. UROLOGY 72: 329–335, 2008.

Benign prostatic hyperplasia (BPH) is a major problem for men worldwide. The indications for surgical treatment of BPH have been agreed on, with surgery reserved for cases of complicated BPH and after failed medical treatment for moderately to severely disabling lower urinary tract symptoms. Transurethral resection of the prostate (TURP) was developed in the United States in the 1920s and 1930s. As a treatment modality for obstructive BPH, TURP has gained widespread acceptance worldwide over the years. New techniques of minimally invasive resection are now being developed as alternatives to TURP. However, the results must be confirmed in the long term before these methods can be considered as valid alternatives to TURP. Currently, TURP remains the reference standard for surgical management of BPH.

The past quarter of a century has seen the publication of a substantial number of studies aimed at explaining the association between the volume of patients treated for a particular procedure by surgeons or particular hospitals and the subsequent patient outcomes.[1,2] A large body of research has consistently documented better health outcomes for patients at hospitals with larger procedure volumes, suggesting that many surgical deaths could be prevented if the surgeries were performed at hospitals or by physicians with adequate experience in the respective surgical procedure.[3-6] Although a gradual reduction in the immediate postoperative mortality rate associated with TURP has occurred during the past decades,[7,8] to the best of our knowledge, no published study has yet reported on the relationship between surgical TURP volume and patient outcome.

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This study presents a broad-based assessment of the relationship between urologists' TURP volume and in-hospital mortality using a Taiwan nationwide population-based data set. The main reason for selecting the urologist case volume rather than the hospital case volume was that many previous studies have consistently reported that the physician volume is a much more significant factor than the hospital volume with regard to predicting patient outcomes.[9,10] We hypothesized that urologists with a high caseload volume would be associated with superior treatment outcomes for patients undergoing TURP.

MATERIAL AND METHODS

Database

This study used data from the National Health Insurance Research Database (NHIRD), which is provided by the Bureau of National Health Insurance, Taiwan Department of Health and managed by the Taiwan National Health Research Institutes. Taiwan launched its national health insurance program, which covers almost all Taiwanese citizens, in 1995. Unlike healthcare delivery systems in some countries or regions that use a gatekeeper system to limit patients' choice of healthcare providers, patients in Taiwan have the choice of access to any provider at their will. The NHIRD provides a unique opportunity to examine the volume–outcome relationship for TURP.

The NHIRD includes a registry of contracted medical facilities, a registry of board-certified physicians, a monthly claims summary for in-patient claims, and details of in-patient orders. It also provides principal operational procedures, along with one principal diagnosis code and up to four secondary diagnosis codes for each patient, using the "International Classification of Disease, Ninth Revision, Clinical Modification" (ICD-9-CM).

Study Sample

The study sample was identified from the database by the principal procedure ICD-9-CM code 602 (transurethral prostatectomy) from January to December 2003. We limited our study sample to patients undergoing TURP for the first time. In addition, we excluded patients whose conditions were complicated by any type of neoplasm (ICD-9-CM codes 140-239). Ultimately, our study sample comprised 9539 patients treated by 546 urologists at 200 hospitals.

Urologist TURP Caseload Volume Groups

Unique urologist identifiers are available for each medical claim submitted to the Bureau of National Health Insurance, and this enabled us to identify particular urologists performing TURP during our study period. Thereafter, urologists were sorted in ascending order by their total TURP volume, with the volume category cutoff points (high, medium, and low) determined by sorting the sample into three approximately equal groups, in accordance with standard practice.[11,12] The volume cutoff points were determined so that each group would have an approximately equal number of patients. The sample of 9539 patients was thus divided into three urologist caseload volume groups: fewer than 27 cases annually (low volume), 27-55 cases annually (medium volume), and more than 55 cases annually (high volume).

Key Variables of Interest

The key independent variable of interest was the urologist caseload volume. The key dependent variable of interest was in-hospital mortality. Because home death is generally regarded as a good death in traditional Taiwan culture, patients are often brought home in the terminal stage of an illness, rather than dying in the hospital. The mean length of stay for TURP in this study was 5.44 days, and the overwhelming majority of in-hospital mortality should have already been included in the 7-day mortality data. Therefore, we defined in-hospital mortality as the death of a patient at any time after admission, if the patient had not left the hospital or had died within 7 days of discharge, to better reflect the actual situation in Taiwanese communities. We linked the data from the NHIRD with the government cause of death data to obtain the in-hospital mortality rate as our outcome measure.

The variables adjusted for in the regression model included the urologist, hospital, and patient characteristics. The urologist characteristics included the urologists' age (as a surrogate for practice experience) and sex.

The hospital characteristics included hospital ownership, hospital level, and geographic location. Hospital ownership was recorded as one of three types: public, private not-for-profit, or private for-profit. Hospital level indicated whether each hospital was a medical center (with a minimum of 500 beds), a regional hospital (minimum of 250 beds), or a district hospital (minimum of 20 beds). The hospital level could therefore be used as a proxy for both hospital size and clinical service capabilities. Hospital teaching status was not included within the regression analyses, because all medical centers and regional hospitals in Taiwan are teaching hospitals.

The patient characteristics included age, sex, and comorbidities. Because no illness severity index for TURP is currently available in Taiwan, we used the Elixhauser Comorbidity Index to adjust for patient comorbidites. The Elixhauser Comorbidity Index was created in 1997 and has been widely used for risk adjustment in administrative data sets. The Elixhauser method of comorbidity measurement uses 30 binary (1 = present and 0 = absent) comorbidity measures to account for in-patient morbidity and mortality.

Statistical Analysis

The Statistical Analysis Systems statistical package for Windows, version 8.2 (SAS Institute, Cary, NC) was used to perform statistical analyses of the data. Global χ^2 analyses were conducted to examine the relationship between urologist TURP caseload volume and the distribution of the patient and urologist characteristics. In addition, relationships between in-hospital mortality and comorbidity were examined. Then, a multivariate logistic regression analysis using generalized estimating equations was conducted to assess the association between urologist TURP caseload volume and patient in-hospital mortality after accounting for urologist, patient, and hospital characteristics and the clustered nature of the study sample. Only those covariates that had significant relationships with in-hospital mortality were entered into the regression model. Two-sided $P \leq .05$ was considered statistically significant.

RESULTS

In-hospital mortality decreased with increasing urologist TURP caseload volume. The in-hospital mortality rate

Table 1. In-hospital mortality rate and patient and urologist characteristics stratified by TURP caseload volume (n = 9539)

Variable	All	Urologist TURP Volume			*P* Value
		Low (<27)	Medium (27–55)	High (≥56)	
In-hospital mortality rate (%)	1.83	2.37	1.97	1.16	0.001
Patient characteristics					
Overall (n)	9539	3203 (33.6)	3141 (32.9)	3195 (33.5)	
Age (n)					0.959
<65 y	1672 (17.5)	571 (17.8)	542 (17.3)	559 (17.5)	
65–74	3975 (41.7)	1319 (41.2)	1320 (42.0)	1336 (41.8)	
>74	3892 (40.8)	1313 (41.0)	1279 (40.7)	1300 (40.7)	
Urologist characteristics					
Overall (n)	546	413 (75.6)	91 (16.9)	41 (7.5)	
Mean annual case volume	19.1 ± 24.3	8.4 ± 7.5	37.9 ± 7.4	85.3 ± 29.8	<0.001
Age (n)					
<40 y	193 (35.4)	169 (40.9)	22 (23.9)	2 (4.9)	
40–49 y	250 (45.8)	181 (43.8)	45 (48.9)	24 (58.5)	
>49 y	103 (18.8)	63 (15.3)	25 (27.2)	15 (36.6)	
Sex (n)					
Male	539 (98.7)	406 (98.3)	92 (100)	41 (100)	
Female	7 (1.3)	7 (1.7)	—	—	

TURP = transurethral resection of prostate.
Data in parentheses are percentages.

was 2.37%, 1.97%, and 1.16% for patients treated in the low, medium, and high-volume urologist group, respectively. Table 1 lists the distribution of urologist and patient characteristics stratified by urologist TURP caseload volume group. No significant relationship was observed between patient age and urologist TURP caseload volume group ($P = .959$). However, the urologists in the high-volume caseload group were more likely to be older ($P < .001$). No female urologists were in the medium or high-volume caseload volume groups.

Table 2 lists the distribution of in-hospital mortality by patient characteristics and comorbidities. As expected, patients older than 74 years had a greater in-hospital mortality rate than did patients in other age groups ($P = .048$). The χ^2 analyses showed that in-hospital mortality was significantly related to whether a patient's condition was complicated by peripheral vascular disorders ($P < .001$), neurologic disorders ($P = .009$), renal failure ($P = .001$), or deficiency anemia ($P = .039$).

Table 3 lists the crude and adjusted odds of in-hospital mortality by urologist TURP caseload volume. These data showed that that the likelihood of in-hospital mortality for patients treated by low and medium-volume urologists was 2.074 (95% confidence interval [CI] 1.396-3.082, $P < .001$) and 1.719 (95% CI 1.140-2.590, $P < .01$) greater than that of patients treated by high-volume urologists, respectively. After adjusting for patient, urologist, and hospital characteristics, the odds ratio of in-hospital mortality declined with increasing urologist caseload volume, with the odds of in-hospital mortality for patients treated by low and medium-volume urologists 1.835 (95% CI 1.198-2.812, $P < .01$) and 1.606 (95% CI 1.052-2.452, $P < .05$) greater, respectively, than the odds for patients treated by high-volume urologists.

COMMENT

This was the first study to investigate the surgical volume–outcome relationships for TURP using a nationwide population-based database. The findings of our study were based on 9539 patients who had undergone TURP in Taiwan in 2003. Our results have demonstrated that patients treated by urologists performing a greater volume of procedures had lower in-hospital mortality than their counterparts treated by medium or lower TURP caseload-volume urologists, after adjusting for other factors. Our findings thus support the hypothesis that high caseload-volume urologists are associated with superior treatment outcomes for patients undergoing TURP.

Two major hypotheses can explain the inverse volume–outcome relationship.[13] "Practice makes perfect" is the first of these and assumes that a larger volume of patients allows providers to develop better skill and expertise in surgical or treatment procedures. Therefore, high caseload-volume providers are more likely to achieve better clinical performance because of their greater skill and experience. If specific urologists, moving from low through medium to high volumes, show a declining mortality rate on average, this would strongly favor the "practice makes perfect" hypothesis. Although, our cross-sectional study could not provide evidence in support of such a hypothesis, one study by Furuya et al.[14] retrospectively examined the improvement in surgeons' skill at performing TURP by evaluating the outcomes for 4031 patients who had undergone TURP performed by a single surgeon from May 1979 to December 2003. They found that as the number of TURP procedures increased, the surgeon's skill level improved. We, therefore, believe that at least part of the volume–outcome relationship for

Table 2. Distribution of in-hospital mortality after TURP stratified by patient characteristics and comorbidities (n = 9539)

Variable	In-hospital Mortality		*P* Value
	Yes	No	
Overall	175 (1.83)	9364 (98.17)	
Age (y)			.048
<65	24 (1.44)	1648 (98.56)	
65–74	64 (1.61)	3911 (98.39)	
>74	87 (2.24)	3805 (97.76)	
Cardiac arrhythmia			.245
Yes	4 (3.23)	120 (96.77)	
No	171 (1.82)	9244 (98.18)	
Congestive heart failure			.819
Yes	2 (2.15)	91 (97.85)	
No	173 (1.83)	9273 (98.17)	
Valvular disease			.343
Yes	1 (4.65)	21 (95.45)	
No	174 (1.83)	9343 (98.17)	
Pulmonary circulation disorders			
Yes	0	4 (100.00)	
No	175 (1.84)	9360 (98.16)	
Peripheral vascular disorders			<.001
Yes	1 (25.00)	3 (75.00)	
No	174 (1.82)	9361 (98.18)	
Hypertension			.301
Yes	27 (1.54)	1731 (98.46)	
No	148 (1.90)	7633 (98.10)	
Paralysis			.176
Yes	3 (3.90)	74 (96.10)	
No	172 (1.82)	9290 (98.18)	
Coagulopathy			—
Yes	0	42 (100.00)	
No	175 (1.85)	9324 (98.15)	
Other neurologic disorders			.009
Yes	4 (6.15)	61 (93.85)	
No	171 (1.80)	9303 (98.20)	
Chronic pulmonary disease			0.398
Yes	6 (1.32)	450 (98.68)	
No	169 (1.86)	8914 (98.14)	
Diabetes, uncomplicated			0.283
Yes	10 (1.33)	742 (98.67)	
No	165 (1.88)	8622 (98.12)	
Diabetes, complicated			0.812
Yes	4 (2.06)	190 (97.94)	
No	171 (1.83)	9174 (98.17)	
Hypothyroidism			—
Yes	0	43 (100.00)	
No	175 (1.84)	9321 (98.16)	
Renal failure			0.001
Yes	5 (6.94)	67 (93.06)	
No	170 (1.80)	9272 (98.20)	
Liver disease			0.481
Yes	2 (2.99)	65 (97.01)	
No	173 (1.83)	9299 (98.17)	
Peptic ulcer disease excluding bleeding			0.383
Yes	3 (3.00)	97 (97.00)	
No	172 (1.82)	9267 (98.18)	
Solid tumor without metastasis			0.387
Yes	4 (2.8)	139 (97.20)	
No	171 (1.82)	9225 (98.18)	
Rheumatoid arthritis			—
Yes	0	12 (100.00)	
No	175 (1.84)	9352 (98.16)	
Fluid and electrolyte disorders	.		—
Yes	0	71 (100.00)	
No	175 (1.85)	9293 (98.15)	

Table 2. *Continued*

Variable	In-hospital Mortality Yes	No	*P* Value
Deficiency anemias			0.039
Yes	6 (4.11)	140 (95.89)	
No	169 (1.80)	9224 (98.20)	
	30-d Mortality		
Alcohol abuse			
Yes	0	0	
No	175 (1.83)	9364 (98.17)	—
Psychoses			—
Yes	0	14 (100.00)	
No	175 (1.84)	9350 (98.16)	
Depression			—
Yes	0	15 (100.00)	
No	174 (1.84)	98.16	
AIDS			—
Yes	0	0	
No	175 (1.83)	9364 (98.17)	
Lymphoma			—
Yes	0	6 (100.00)	
No	175 (1.84)	9358 (98.16)	
Metastatic cancer			—
Yes	0	20 (100.00)	
No	175 (1.84)	9344 (98.16)	
Obesity			—
Yes	0	0	
No	175 (1.83)	9364 (98.17)	
Weight loss			—
Yes	0	1 (100.00)	
No	175 (1.83)	9363 (98.17)	
Drug abuse			—
Yes	0	0	
No	175 (1.83)	9364 (98.17)	
Blood loss anemia			—
Yes	0	12 (100.00)	
No	175 (1.84)	9352 (98.16)	

TURP = transurethral resection of prostate; AIDS = acquired immunodeficiency syndrome.
Data presented as number of patients, with percentages per row in parentheses.

TURP found in our study can be attributable to the "practice makes perfect" hypothesis.

Another hypothesis often proposed to explain the volume–outcome relationship is that of "selective referral." This hypothesis suggests that selective referral by physicians or patients leads more patient to providers who achieve superior outcomes and who consequently perform a high volume of procedures. Selective referral could also have been a factor contributing to the inverse volume–outcome relationship observed in our study, because Taiwanese consumers choose their providers freely owing to the lack of a gatekeeper or referral system.[15] However, TURP is a well-established procedure, the mortality rate is very low, and the variation in mortality by disease is too low to influence patient choice.[16,17] Furthermore, to date, performance information on individual physicians is not released to the public in Taiwan; thus, patients have no means of obtaining such information as a basis for physician selection. Therefore, although it is difficult to refute the role that "selective referral" might play in the Taiwan's system of healthcare delivery, we believe that this hypothesis is less likely to account for the volume–outcome relationship for TURP.

Our study also showed that in-hospital mortality significantly increased with renal failure, although myocardial infarction and sepsis[18] were the most commonly reported causes of death after TURP. Acute renal failure, known to be a clinical presentation of some TURP syndromes, has been less discussed. Tarrass et al.[19] proposed hemolysis as the mechanism by which renal failure most likely develops. Other factors, such as hemodynamic alterations, hypotension, and rhabdomyolysis, could also be related to renal failure after TURP.

The strengths of our study consisted of its large nationwide population-based sample and the adjustment for comorbidities and other potential confounding factors. However, one caveat should be noted: very few female urologists were included in this study and some had only very small TURP caseloads. Such small caseloads prohibited meaningful statistical comparisons between male and female urologists.

Table 3. Crude and adjusted odds ratios for in-hospital mortality by urologists TURP caseload volumes in 2003

Variable	Odds Ratio (95% CI) Crude	Odds Ratio (95% CI) Adjusted
Urologist caseload volume		
<27	2.074 (1.396–3.082)*	1.835 (1.198–2.812)†
27–55	1.719 (1.140–2.590)†	1.606 (1.052–2.452)‡
≥56 (reference group)	1.000	1.000
Patient characteristic		
Patient age (y)		
<65 (reference group)		1.000
65–74		1.101 (0.685–1.770)
>74		1.499 (0.945–2.378)
Other neurologic disorders		3.133 (1.118–8.782)‡
Renal failure		3.862 (1.510–9.876)†
Deficiency anemias		1.993 (0.856–4.639)
Urologist characteristic		
Age (y)		
<40		1.440 (0.998–2.079)
40–49 (reference group)		1.000
>49		1.055 (0.715–1.555)
Hospital characteristic		
Hospital level		
Medical center		1.197 (0.734–1.952)
Regional hospital		0.961 (0.621–1.488)
District hospital (reference group)		1.000
Hospital ownership		
Public hospital		1.053 (0.650–1.706)
Private not-for-profit		0.954 (0.590–1.543)
Private for-profit (reference group)		1.000
Geographic region		
Northern (reference group)		1.000
Central		1.074 (0.734–1.571)
Southern		0.954 (0.648–1.404)
Eastern		0.894 (0.350–2.284)

TURP = transurethral resection of prostate; CI = confidence interval.
* $P < .001$.
† $P < .01$.
‡ $P < .05$.

CONCLUSIONS

Our finding that, after adjusting for patient, urologist, and hospital characteristics, a volume–outcome relationship does exist for patients undergoing TURP in Taiwan can help increase the awareness of the volume–outcome issue for TURP among policy makers and urologists in Taiwan and elsewhere. Our study results should prove useful in terms of facilitating cross-country comparisons. Although a low volume must be used with considerable caution as an overall indicator of poor quality, investigations can be done to identify differences in clinical approach and techniques between high-volume urologists with superior outcomes and low-volume urologists with poor outcomes to help decrease the mortality rate for patients undergoing TURP.

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