

Volume-Based Trends in Thyroid Surgery

Christine G. Gourin, MD; Ralph P. Tufano, MD; Arlene A. Forastiere, MD;
Wayne M. Koch, MD; Timothy M. Pawlik, MD, MPH; Robert E. Bristow, MD

Objective: To characterize contemporary patterns of thyroid surgical care and variables associated with access to high-volume care.

Design: Cross-sectional analysis.

Setting: Maryland Health Service Cost Review Commission database.

Patients: Adults who underwent surgery for thyroid disease in Maryland between January 1, 1990, and July 1, 2009.

Results: Overall, 21 270 thyroid surgical procedures were performed by 1034 surgeons at 51 hospitals. Procedures performed by high-volume surgeons increased from 15.7% in 1990-1999 to 30.9% in 2000-2009 (odds ratio [OR], 3.69; $P < .001$), while procedures performed at high-volume hospitals increased from 11.9% to 22.7% (3.46; $P < .001$). High-volume surgeons were more likely to perform total thyroidectomy (OR, 2.50; $P < .001$) and neck dissection (1.86; $P < .001$), had a shorter length of hos-

pitalization (0.44; $P < .001$), and had a lower incidence of recurrent laryngeal nerve injury (0.46; $P = .002$), hypocalcemia (0.62; $P < .001$), and thyroid cancer surgery (0.89; $P = .01$). After controlling for other variables, thyroid surgery in 2000-2009 was associated with high-volume surgeons (OR, 1.76; $P < .001$), high-volume hospitals (2.93; $P < .001$), total thyroidectomy (2.67; $P < .001$), and neck dissection (1.28; $P = .02$) but was less likely to be performed for cancer (0.83; $P < .001$).

Conclusions: The proportion of thyroid surgical procedures performed by high-volume surgeons and in high-volume hospitals increased significantly from 1990-1999 to 2000-2009, with an increase in total thyroidectomy and neck dissection. Surgeon volume was significantly associated with complication rates. Thyroid cancer surgery was less likely to be performed by high-volume surgeons and in 2000-2009 despite an increase in surgical cases. Further investigation is needed to identify factors contributing to this trend.

Arch Otolaryngol Head Neck Surg. 2010;136(12):1191-1198

Author Affiliations:

Department of Otolaryngology-Head and Neck Surgery (Drs Gourin, Tufano, and Koch), Department of Oncology, Sidney Kimmel Comprehensive Cancer Center (Dr Forastiere), and Department of Surgery (Dr Pawlik), The Johns Hopkins Medical Institutions, and Kelly Gynecologic Oncology Service, Department of Gynecology and Obstetrics (Dr Bristow), Baltimore, Maryland.

POSITIVE VOLUME-OUTCOME relationships exist for diseases treated with technically complex surgery. Most studies¹⁻⁴ investigating volume-outcome relationships have focused on the relationship between hospital volume and operative mortality from cardiovascular, intrathoracic, and intra-abdominal procedures and demonstrate lower short- and long-term mortality rates for procedures performed at high-volume hospitals. Although less widely studied, similar observations for volume and outcome have been reported for surgeon-based care, with lower surgical mortality rates for patients treated by high-volume surgeons, and surgeon volume accounts for a large proportion of the effect of hospital outcome on surgical mortality.⁵ These observations served as the basis for the controversial adoption of hospital volume standards as a surrogate marker for quality by commercial in-

surer industry coalitions, such as the Leapfrog Group, which requires nonrural hospitals to meet volume standards for selected surgical procedures to be eligible for beneficiary referral.^{6,7}

There is a relative scarcity of literature regarding the relationship between volume and outcome in head and neck surgery. However, similar observations regarding the positive effect of hospital⁸⁻¹² and surgeon^{5,13-16} volume on outcome have been reported for surgical treatment of parotid, larynx, pharynx, and thyroid disease and cervical metastases. The oldest documented relationship between volume and outcome is in the field of thyroid surgery. As cited by Becker,¹⁷ Theodor Kocher reported operative mortality of 13% for his first 100 thyroid procedures but by 1917 had performed 5000 thyroidectomies with operative mortality of only 0.5%, demonstrating a strong correlation between surgical experience and clinical outcome. Despite this recogni-

tion, limited data exist regarding volume-outcome relationships in thyroid surgery, and most thyroid surgery in the United States is performed by low-volume (≤ 3 cases per year) thyroid surgeons.^{15,18} In light of the increasing emphasis on positive volume-outcome relationships as a proxy for quality of care, and the potential impact of this relationship on referral and practice patterns, we undertook the present study to characterize contemporary patterns of thyroid surgical care through an analysis of statewide data according to hospital and surgeon volume, and to investigate temporal changes as well as variables associated with access to high-volume care.

METHODS

A cross-sectional analysis of patients with a diagnosis of thyroid disease was performed using hospital discharge data from nonfederal acute care hospitals in Maryland collected by the Maryland Health Service Cost Review Commission (HSCRC). The HSCRC database provides information regarding the index hospital admission (surgery) and is limited to 30 days of follow-up. Adult patients (≥ 18 years) who underwent an ablative procedure for benign or malignant thyroid disease in Maryland between January 1, 1990, and July 1, 2009, comprised the study population. *International Classification of Disease, Ninth Revision (ICD-9)* codes for benign diseases (ICD-9 codes 241.0, 241.1, 241.9, 242.00, 242.01, 242.10, 242.11, 242.20, 242.21, 242.30, 242.31, 226, 237.4, 239.7, 240.9, 242.4, 246, 246.1, 246.2, 246.9, 648.1, and 874.2) and malignant diseases (ICD-9 code 193) of the thyroid were used for sorting. All cell types were included. Surgical procedures included in this analysis were limited to ablative procedures: excision of lesion (ICD-9 code 06.31), isthmusectomy or partial thyroidectomy (ICD-9 code 06.39), unilateral lobectomy (ICD-9 code 06.2), complete thyroidectomy (ICD-9 code 06.4), other (unspecified) operations on thyroid glands (ICD-9 code 06.98), substernal thyroidectomy (ICD-9 code 06.5) (including partial [ICD-9 code 06.51] or complete [ICD-9 code 06.52] substernal thyroidectomy), and neck dissection (ICD-9 codes 40.40, 40.41, 40.42, and 40.3). Postoperative surgical complications were derived from codes assigned at the time of hospital discharge for recurrent laryngeal nerve injury (ICD-9 codes 478.3, 478.30, 478.31, 478.32, 478.33, 478.34, and 951.8), hypoparathyroidism (ICD-9 code 252.1), and hypocalcemia (ICD-9 codes 275.4, 275.40, 275.49, 264.40, 275.41, and 275.49).

Individual surgeon and individual hospital annual thyroid surgery case volumes were the primary independent variables in this study. Surgeons and hospitals were included in the analysis if they were involved with at least 1 thyroid surgery during the entire study period. Surgeon and hospital volumes were modeled as categorical variables. Annual volumes were divided into quartiles, with high volume defined as those above the 75th percentile. Univariate logistic regression was performed to evaluate patterns of care among the remaining quartiles.¹⁹ Based on analysis results, cutoff values for annual case volume of 3 or less, 4 to 24, and greater than 24 were used to classify surgeons by low, intermediate, and high volume, respectively, and cutoff values of 22 or less, 23 to 100, and greater than 100 were used to classify hospitals by low, intermediate, and high volume. These numbers were similar to the results seen when volume cutoff points were determined by division into tertiles and parallel those reported by other researchers^{14,18} studying thyroid surgery volumes in the Nationwide Inpatient Sample. Total surgeon and hospital volumes of more than 100 and more than 150 cases, respectively, have previously been suggested as a cutoff values for high volume.^{10-13,20,21} In this series, annual volumes correlated with total volume: all surgeons

in the high-volume quartile performed more than 100 cases, and all hospitals in the high-volume quartile performed more than 150 cases per year.

Secondary independent variables included were age, sex, race, APR-DRG (All Patient Refined Diagnosis Related Groups) case complexity score (1-4), APR-DRG mortality risk score (1-4), length of stay, intensive care unit days, other specialty unit care days, payer source (commercial, health maintenance organization [HMO], Medicare or Medicaid, or self-pay), nature of admission (emergent/urgent or other), readmission, inpatient death, hospital type (university, community teaching, or community), procedure, and a diagnosis of thyroid cancer. A community teaching hospital was defined as a nonuniversity hospital with a residency program in general surgery or otolaryngology-head and neck surgery. Thyroid surgery-specific complications of recurrent laryngeal nerve injury and hypocalcemia were included as secondary independent variables but were also analyzed separately as primary independent variables to determine factors associated with an increased risk of these complications. For statistical analysis of temporal trends, the study period was divided into 2 time intervals: 1990-1999 and 2000-2009. American Joint Commission on Cancer tumor stage, tumor grade, histologic subtype, and outcome beyond 30 days were not available from the HSCRC database.

Data were analyzed using a statistical software program (STATA 10; StataCorp LP, College Station, Texas). Standard statistical analysis, including unpaired *t* tests and analysis of variance for continuous data and χ^2 tests for categorical data, were used to evaluate factors associated with volume category. Bivariate logistic regression analysis was used to determine variables that were significantly associated with the outcome of interest. Multiple logistic regression analysis was used to identify factors associated with high-volume surgical care, with surgeon or hospital volume as the outcome variable of interest; factors associated with complications, with recurrent laryngeal nerve injury or hypocalcemia as the outcome variable of interest; and factors associated with temporal trends, with time interval as the outcome variable of interest. Collinearity was checked by performing a multiple regression analysis and by calculating the variance inflation factors and removing variables with a variance inflation factor greater than 10.0, which suggests collinearity. Variables that were hypothesized to have predictive value and those that were significant in bivariate analysis were entered into the regression models. Models were sequentially built to identify variables that were significantly associated with high-volume surgeons or hospitals. A second approach used stepwise backward variable selection to determine which subset of variables was predictive of the outcome of interest. The Akaike information criterion was used to select models by goodness of fit. Odds ratios (ORs) are expressed relative to a reference baseline category. This protocol was reviewed and approved by The Johns Hopkins Medical Institutions institutional review board.

RESULTS

A total of 21 270 cases met the study criteria (**Table 1**). The mean patient age was 49.7 years (age range, 18-95 years). The mean number of annual thyroid cases treated surgically was 1064, with an annual mean of 943 cases treated surgically during 1990-1999 and 1184 during 2000-2009. The majority of patients were women, were white, had commercial or HMO insurance, received their care at a community hospital, and underwent surgery for benign thyroid disease. Partial thyroidectomy was the most

Table 1. Demographic Characteristics

Characteristic	All (N=21 270)	1990-1999 (n=9430)	2000-2009 (n=11 840)	P Value
Race				
White	14 746 (69.3)	6738 (71.5)	8008 (67.6)	<.001
Black	5043 (23.7)	2191 (23.2)	2852 (24.1)	
Asian	570 (2.7)	231 (2.4)	339 (2.9)	
American Indian	33 (0.2)	8 (0.1)	25 (0.2)	
Other	806 (3.8)	237 (2.5)	569 (4.8)	
Unknown	6 (0.03)	0	6 (0.1)	
Biracial	66 (0.3)	25 (0.3)	41 (0.3)	
Sex				
Male	4182 (19.7)	1842 (19.5)	2340 (19.8)	.68
Female	17 088 (80.3)	7588 (80.5)	9500 (80.2)	
Hospital type				
Community	14 937 (70.2)	7116 (75.4)	7821 (66.0)	<.001
Community teaching	1829 (8.6)	814 (8.6)	1015 (8.6)	
University	4504 (21.2)	1500 (16.0)	3004 (25.4)	
Payer status				
Commercial	9756 (45.9)	4516 (47.9)	5240 (44.2)	<.001
Health maintenance organization	6283 (29.5)	2640 (28.0)	3643 (30.8)	
Medicare or Medicaid	4629 (21.8)	1962 (20.8)	2667 (22.5)	
Self-pay	602 (2.8)	312 (3.3)	290 (2.5)	
Case complexity score ^a				
1	14 932 (71.7)	6981 (77.7)	7951 (67.1)	<.001
2	5203 (25.0)	1735 (19.3)	3468 (29.3)	
3	571 (2.7)	212 (2.4)	359 (3.0)	
4	117 (0.6)	55 (0.6)	62 (0.6)	
Mortality risk score ^a				
1	14 773 (86.8)	4467 (86.3)	10 306 (87.0)	.12
2	1867 (11.0)	584 (11.3)	1283 (10.9)	
3	282 (1.7)	101 (2.0)	181 (1.5)	
4	94 (0.5)	24 (0.4)	70 (0.6)	
Hospital admission type				
Emergent/urgent	2064 (9.7)	1022 (10.8)	1042 (8.8)	<.001
Other	19 206 (90.3)	8408 (89.2)	10 798 (91.2)	
Readmission within 30 d ^a				
Yes	852 (4.7)	418 (6.8)	434 (3.7)	<.001
No	17 133 (95.3)	5727 (93.2)	11 406 (96.3)	
30-d Mortality				
Alive	21 260 (99.9)	9424 (99.9)	11 836 (99.9)	.32
Death	10 (0.1)	6 (0.1)	4 (0.1)	
Pathology				
Benign thyroid disease	14 704 (69.1)	6936 (73.5)	7768 (65.6)	<.001
Thyroid cancer	6566 (30.9)	2494 (26.5)	4072 (34.4)	

^aStatus was not known for all patients.

common surgical procedure and was performed in 60.4% of all patients (**Figure 1**). The incidence of recurrent laryngeal nerve injury was 1.0% and was greater for patients undergoing surgery for thyroid cancer (2.0%) compared with benign disease (0.5%, $P < .001$). Similarly, the incidence of hypocalcemia after total thyroidectomy was 10.0% and was greater for patients treated for thyroid cancer (10.8%) compared with those treated for benign disease (9.3%; $P = .02$). The distribution of thyroid surgical procedures differed between 1990-1999 and 2000-2009, with a significant decrease in partial thyroidectomy and a significant increase in total thyroidectomy in 2000-2009 compared with 1990-1999 ($P < .001$). The number of thyroid surgical procedures performed for an initial diagnosis of thyroid cancer was higher in 2000-2009 (34.4%) compared with 1990-1999 (26.5%; $P < .001$).

Overall, 1034 surgeons performed thyroid surgery, although not all surgeons performed surgery in every year of the study. The mean annual number of thyroid surgical procedures performed by an individual surgeon per year of surgical activity was obtained by calculating the mean of the number of procedures performed each year for each individual surgeon for the years in which that surgeon performed at least 1 thyroid surgery. Only 8 surgeons were categorized as high-volume surgeons (0.8%), while 888 surgeons (85.9%) performed 3 or fewer thyroid surgery procedures per year on average. Fifty-one hospitals cared for patients undergoing thyroid surgery, with only 1 hospital (2.0%) categorized as high volume, which was a university hospital; 36 hospitals (70.6%) performed 22 thyroid surgical procedures or fewer per year on average. The mean annual number of thyroid surgery procedures performed in an individual hospital per

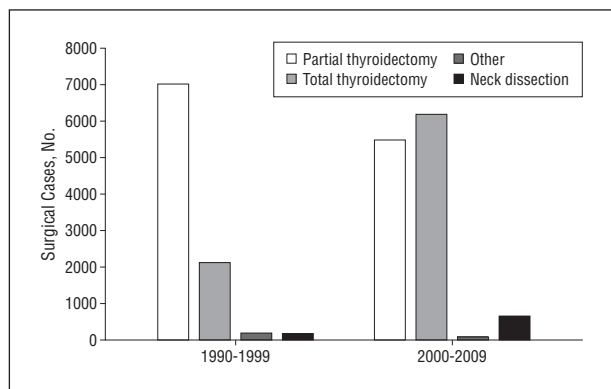


Figure 1. Temporal trends in thyroid surgical procedures between 1990-1999 and 2000-2009 ($P < .001$).

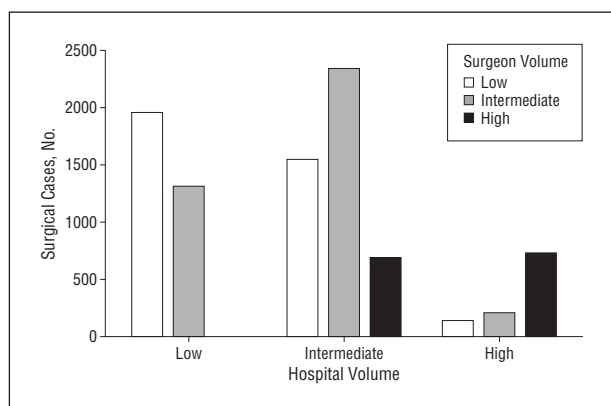


Figure 2. Distribution of annual thyroid surgical case volume by hospital and surgeon in the time interval of 1990-1999 ($P < .001$).

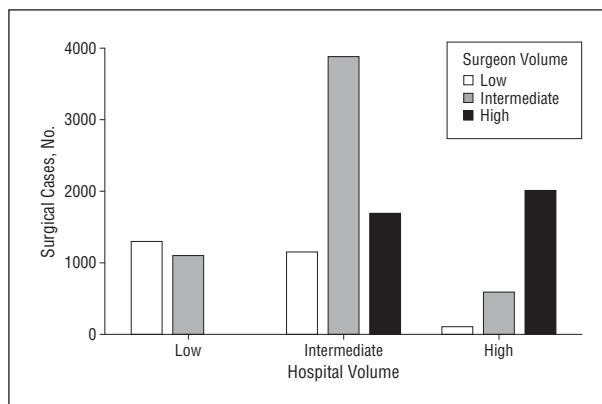


Figure 3. Distribution of annual thyroid surgical case volume by hospital and surgeon in the time interval of 2000-2009 ($P < .001$).

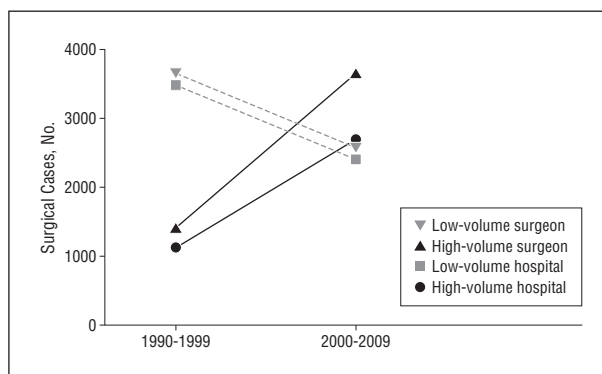


Figure 4. Temporal trends in thyroid surgical case volume between 1990-1999 and 2000-2009 for high-volume surgeons, low-volume surgeons, high-volume hospitals, and low-volume hospitals.

year of surgical activity was obtained by calculating the mean of the number of cases performed each year for each individual hospital for the years in which the hospital performed at least 1 thyroid surgery.

The distribution and number of surgeons and hospitals providing thyroid surgical care varied by time interval. Compared with 1990-1999, in 2000-2009, the number of high-volume surgeons increased from 5 to 8 and the number of intermediate-volume surgeons increased from 91 to 117, while the number of low-volume surgeons decreased from 601 to 528. The number of low-volume hospitals decreased from 36 in 1990-1999 to 31 in 2000-2009, while the number of intermediate-volume ($n=14$) and high-volume ($n=1$) hospitals remained constant.

Similarly, the distribution of thyroid surgical cases by hospital and surgeon volume differed by time interval. In 1990-1999, the largest combined category was that of intermediate-volume surgeons operating at intermediate-volume hospitals, which accounted for 26.2% of all cases, followed by low-volume surgeons operating at low-volume hospitals, which comprised 21.9% of cases, while the proportion of cases performed by high-volume surgeons at high-volume hospitals was 8.0% (**Figure 2**). Low-volume surgeons performed 40.9% of all thyroid surgical procedures in 1990-1999, and surgeons at low-volume hospitals performed 36.7% of cases. High-volume surgeons performed 15.7% of cases in 1990-

1999, and surgeons at high-volume hospitals performed 12.1% of cases. In 2000-2009, the proportion of cases performed by high-volume surgeons and hospitals increased, while the proportion of cases performed by low-volume surgeons and hospitals decreased. The largest combined category in 2000-2009 was still intermediate-volume surgeons operating at intermediate-volume hospitals, which accounted for 32.9% of all procedures, while the proportion of procedures performed by high-volume surgeons operating at high-volume hospitals increased to 16.8% (**Figure 3**). Low-volume surgeons performed 21.8% of all thyroid surgery in 2000-2009, and surgeons at low-volume hospitals performed 20.4% of procedures. High-volume surgeons performed 31.0% of procedures in 2000-2009, and surgeons at high-volume hospitals performed 22.7% of procedures.

Comparison of data from 2000-2009 with 1990-1999 revealed statistically significant trends of improved access to high-volume surgeons and high-volume hospitals (**Figure 4**). There was a significant increase in the proportion of procedures performed by high-volume surgeons from 15.7% in 1990-1999 to 30.9% in 2000-2009 (OR, 3.69; 95% confidence interval [CI] = 3.41-3.99; $P < .001$), while the proportion of procedures performed by low-volume surgeons decreased from 40.9% to 21.8%. The proportion of procedures performed at high-volume hospitals increased from 11.9% in 1990-1999 to 22.7% in 2000-2009 (OR, 3.46; 95% CI,

Table 2. Variables Associated With High-Volume Thyroid Surgery

Variable	Odds Ratio (95% CI)	P Value
High-volume surgeon		
Community teaching hospital	2.09 (1.84-2.39)	<.001
University hospital	17.40 (15.80-19.17)	<.001
Total thyroidectomy	2.50 (2.29-2.73)	<.001
Neck dissection	1.86 (1.52-2.27)	<.001
Intensive care unit stay	2.03 (1.77-2.33)	<.001
Advanced case complexity score	1.16 (1.06-1.27)	.001
Length of hospitalization	0.44 (0.41-0.47)	<.001
Urgent or emergent admission	0.49 (0.42-0.58)	<.001
Medicare or Medicaid	0.59 (0.53-0.66)	<.001
Self-pay	0.41 (0.32-0.53)	<.001
Recurrent laryngeal nerve injury	0.46 (0.28-0.75)	.002
Hypocalcemia	0.62 (0.50-0.66)	<.001
Cancer diagnosis	0.89 (0.81-0.98)	.01
High-volume hospital		
High-volume surgeon	15.87 (14.50-17.37)	<.001
Total thyroidectomy	1.62 (1.48-1.78)	<.001
Other unspecified procedure	1.48 (1.07-2.04)	.02
Neck dissection	1.73 (1.43-2.09)	<.001
Advanced case complexity score	1.40 (1.30-1.52)	<.001
Urgent or emergent admission	1.56 (1.34-1.81)	<.001
Health maintenance organization	0.65 (0.59-0.72)	<.001
Medicare or Medicaid	0.86 (0.76-0.96)	.01
Self-pay	2.15 (1.70-2.72)	<.001
Cancer diagnosis	1.78 (1.61-1.96)	<.001

Abbreviation: CI, confidence interval.

3.17-3.77; $P < .001$), while the proportion of procedures performed at low-volume hospitals decreased from 37.0% to 20.4%.

Thyroid cancer surgical cases accounted for 30.9% of all thyroid surgical cases (Table 1). The incidence of thyroid cancer increased from 26.5% in 1990-1999 to 34.4% in 2000-2009. High-volume surgeons performed 20.9% of thyroid cancer surgical procedures in 1990-1999 and 36.8% in 2000-2009 ($P < .001$). For benign thyroid disease, high-volume surgeons performed 13.9% of procedures in 1990-1999 and 28.0% in 2000-2009 ($P < .001$). High-volume hospitals cared for 19.4% of thyroid cancer surgical cases in 1990-1999 and for 33.3% in 2000-2009 ($P < .001$). Surgery for benign thyroid disease was performed at high-volume hospitals in 9.2% of cases in 1990-1999 and in 17.1% in 2000-2009 ($P < .001$).

Multiple logistic regression analysis of variables associated with high-volume care showed that high-volume surgeons were significantly associated with teaching and university hospitals (Table 2). Compared with intermediate- and low-volume surgeons, high-volume surgeons were significantly more likely to perform total thyroidectomy procedures and neck dissection. High-volume surgeons were associated with increased case complexity scores, reflecting the presence of advanced comorbid disease, intensive care unit utilization, and decreased length of hospitalization. Self-pay and Medicare or Medicaid patients were less likely to undergo surgery by high-volume surgeons, and high-volume surgeons were less likely to operate on patients admitted urgently or emergently. The incidences of thyroid surgery-specific

Table 3. Variables Associated With Thyroid Surgery-Specific Complications

Variable	Odds Ratio (95% CI)	P Value
Recurrent laryngeal nerve injury		
Cancer diagnosis	2.90 (2.14-3.94)	<.001
High-volume surgeon	0.46 (0.32-0.69)	.001
Neck dissection	1.91 (1.24-2.94)	.003
Urgent or emergent admission	1.52 (1.02-2.26)	.04
Hypocalcemia		
Cancer diagnosis	1.28 (1.12-1.47)	.001
High-volume surgeon	0.49 (0.41-0.57)	<.001
Total thyroidectomy	4.32 (3.70-5.05)	<.001
Other unspecified procedure	2.58 (1.70-3.91)	<.001
Neck dissection	1.54 (1.23-1.93)	<.001

Abbreviation: CI, confidence interval.

complications of recurrent laryngeal nerve injury and postoperative hypocalcemia were significantly lower for high-volume surgeons. High-volume surgeons were less likely to perform surgery with an initial diagnosis of thyroid cancer compared with intermediate- and low-volume surgeons. High-volume hospitals were significantly associated with high-volume surgeons, urgent or emergent admissions, and an initial diagnosis of thyroid cancer. Compared with intermediate- and low-volume hospitals, high-volume hospitals were associated with increased case complexity scores, total thyroidectomy, other unspecified thyroid procedures, and neck dissections. Patients with HMO and Medicare or Medicaid insurance were less likely to be treated at a high-volume hospital, while self-pay patients were more likely to receive care at a high-volume hospital.

Multiple logistic regression analysis of variables associated with thyroid surgery-specific complications revealed an association with surgeon volume. Recurrent laryngeal nerve injury was significantly more likely for a diagnosis of thyroid cancer, neck dissection, and urgent or emergent admission but was significantly less likely for high-volume surgeons after controlling for all other variables (Table 3). Postoperative hypocalcemia was significantly more likely for a diagnosis of thyroid cancer, total thyroidectomy or other unspecified operations on the thyroid gland, and neck dissection but was significantly less likely for high-volume surgeons. Hospital volume was not significantly associated with either complication.

Multiple logistic regression analysis of 2000-2009 compared with the reference group of 1990-1999 showed that surgery was significantly more likely to be performed by high-volume surgeons and at high-volume hospitals in 2000-2009 (Table 4). Patients were less likely to undergo surgery at a university hospital. There was a significant increase in the odds of total thyroidectomy and neck dissection and a decrease in the odds of other unspecified thyroid procedures. Compared with 1990-1999, thyroid surgery in 2001-2009 was more likely to be performed in nonwhite patients and was associated with increased case complexity scores and decreased length of hospitalization. Thyroid surgery in 2000-2009 was more likely to be performed in patients with HMO

Table 4. Variables Associated With Significant Differences in Thyroid Surgery in 2000-2009 Compared With 1990-1999 (Reference Population)

Variable	Odds Ratio (95% CI)	P Value
High-volume surgeon	1.76 (1.61-1.92)	<.001
High-volume hospital	2.93 (2.40-3.58)	<.001
Total thyroidectomy	2.67 (2.49-2.87)	<.001
Other unspecified procedure	0.63 (0.50-0.79)	<.001
Neck dissection	1.28 (1.04-1.56)	.02
Length of hospitalization	0.78 (0.76-0.79)	<.001
Advanced case complexity score	1.37 (1.28-1.47)	<.001
Health maintenance organization	1.07 (1.00-1.15)	.049
Medicare or Medicaid	1.35 (1.24-1.46)	<.001
Self-pay	0.82 (0.68-0.99)	.03
Nonwhite race	1.12 (1.08-1.16)	<.001
Cancer diagnosis	0.83 (0.77-0.89)	<.001

Abbreviation: CI, confidence interval.

and Medicare or Medicaid insurance and was less likely to be performed in self-pay patients. Surgery was less likely to be performed for an initial diagnosis of thyroid cancer in 2000-2009 after controlling for other variables.

COMMENT

The results of this analysis suggest that surgeon volume is a significant predictor of thyroid surgery outcomes. High-volume surgeons were more likely to perform more extensive surgery for thyroid disease, including neck dissection, were more likely to care for privately insured patients, and had lower incidences of recurrent laryngeal nerve injury and postoperative hypocalcemia and a reduced length of stay.¹³⁻¹⁵ However, high-volume surgeons were less likely to operate on patients with a diagnosis of thyroid cancer and on patients admitted urgently. In contrast, high-volume hospitals, although significantly associated with high-volume surgeons, were more likely to treat patients admitted urgently, without insurance, and with cancer. These findings may reflect differences in volume-based referral patterns and limitations to the use of hospital discharge data.

Birkmeyer et al⁵ reported that much of the favorable effect of hospital volume on outcome is actually explained by surgeon volume, and the association varies according to procedure, with technical skill and intraoperative processes assuming greater importance in procedures that required a shorter stay and less dependence on hospital-based resources. Thyroid surgery may be the best example of such a procedure, in which the effect of surgeon experience on outcomes has been recognized for nearly a century and is less dependent on hospital-based services.¹⁷ Although the relationship between volume and outcome seems intuitive, it is difficult to determine the direction of the causal relationship: whether "practice makes perfect" or whether referral patterns result in a subset of providers with better outcomes selectively attracting more patients.^{7,13,22} High-volume surgeons receive a disproportionate volume of referrals from endocrinologists who have identified these surgeons as subspecialists. We found that high-volume surgeons were more

likely to perform total thyroidectomy, had a lower incidence of postoperative complications, had a shorter length of hospitalization, and were more likely to operate on privately insured patients. However, in contrast to previous studies,^{13,15} we found that high-volume surgeons were less likely to operate for an initial diagnosis of thyroid cancer. One possible explanation is that high-volume surgeons who receive the bulk of their referrals from endocrinologists perform a greater proportion of surgery for benign disease compared with surgeons who have not made endocrine surgery the focus of their practice.

The effect of hospital volume on thyroid surgery outcomes has produced varying results in the literature, with some researchers reporting a decreased incidence of complications^{10,11} and an increase in case complexity,¹¹ total thyroidectomy,¹⁰⁻¹² and cancer¹¹ at high-volume hospitals, whereas others have reported that hospital volume has a negligible effect on outcomes.^{13,15} In this study, high-volume hospitals were associated with an increased incidence of total thyroidectomy, case complexity, and cancer diagnoses but were not associated with thyroid surgery-specific complications, which were directly associated with the extent of surgery and a diagnosis of cancer and were inversely related to surgeon volume. Urgent admissions and self-pay patients were more common for high-volume hospitals, in contrast to high-volume surgeons, and this variable likely reflects differences in referral pathways by which patients arrive at surgery.²

There are several limitations to the use of hospital discharge data that may affect these findings. Although case complexity and mortality risk scores were used for risk adjustment, the ability to adequately control for case mix is limited when discharge diagnoses from administrative databases are used, which is the case in almost all studies investigating volume and outcome associations to date, including the present study.^{1,2,6,22-24} The Maryland HSCRC database provides no follow-up data beyond the index admission and is limited to a 30-day postoperative window and contains no information on stage of disease, grade, subtype, or previous treatment. As a result, the effect of treatment on survival cannot be estimated. There may be differences in the type of patient or disease cared for at high-volume hospitals that are not adequately captured. A diagnosis of thyroid cancer may not be apparent at the time of discharge, and, as a result, the incidence of thyroid cancer may be underestimated. Similarly, the incidence of complications may be underreported because complications pertaining to recurrent laryngeal nerve injury and hypoparathyroidism may not be evident until after discharge,^{13-15,18} particularly because many surgeons do not routinely evaluate vocal cord function with laryngoscopy²⁵ and many routinely send patients home with prophylactic calcium supplementation.²⁶ The prevalence of these practices cannot be determined from the HSCRC database. Finally, an increasing proportion of thyroid surgery is performed on an outpatient basis, which is not captured in this inpatient database limited to hospital admissions, which may result in underreporting of cases and complications.¹⁵

Nevertheless, these data show a significant relationship between surgeon volume and surgical morbidity and demonstrate a favorable trend of increased market share

by high-volume surgeons and hospitals in the past decade, suggesting a trend toward greater centralization of thyroid surgical care. Despite this trend, the majority of thyroid surgery in Maryland is not performed by high-volume providers. Although the number of high-volume surgeons has increased, high-volume thyroid surgeons represent only 1% of all surgeons who perform thyroid surgery in Maryland. In addition, while the incidence of thyroid cancer has increased, the overall number of thyroid surgical procedures being performed has also increased, possibly as a result of improved imaging resulting in earlier detection of thyroid abnormalities, variations in fine-needle aspiration cytologic diagnostic criteria for suspicious lesions, or increased sensitivity to the possibility of a missed cancer diagnosis. As a result, thyroid surgery in 2000-2009 was associated with a decreased likelihood of a cancer diagnosis. These findings have important implications for the future of our specialty and for efforts to improve quality and quality measurements.

It has been argued that volume is an unvalidated and poor proxy measure of quality.^{24,27-29} The late Avedis Donabedian³⁰ defined quality care as consisting of 3 components: structure, including the adequacy of facilities, administration, staff, and volume; process; and outcome. In the absence of valid comparative quality measurement systems, volume-based standards are used as a surrogate of quality by the Leapfrog Group, a coalition of large employers, including General Motors, General Electric, Verizon, and other Fortune 500 companies, and the federal government, as one of several health care purchasing standards aimed at promoting safety, quality, and value.⁷ In actuality, surgical outcomes are more likely a result of the processes of care that providers adopt, including patient selection, preoperative evaluation and preparation, the use of evidence-based medicine, surgical judgment and skill, and postoperative care.^{14,29} The American College of Surgeons recognizes that surgeons need to provide quality outcomes data and that commitment and investment of resources is required to improve systemic efforts to measure quality and generate defensible data.²⁷ Volume serves as a crude measure of quality because it is a structural characteristic that is easy to calculate, but volume-based initiatives are limited in their potential to improve patient outcomes by emphasizing structure over process and do not predict performance for individual hospitals or surgeons. On a practical level, volume-based initiatives will never result in concentration of all care at high-volume centers because of patient preferences, geography, and provider incentives, and strategies for improving care by all providers, including low-volume providers, are needed.²

These data suggest that given the observed relationship between volume and outcome, the temporal trend of fewer surgical procedures performed by low-volume providers seems appropriate. However, a significant proportion of surgical procedures are still performed at low-volume facilities and by low-volume surgeons, and, thus, increased efforts by professional societies to export the surgical excellence of high-volume surgeons through educational efforts and adoption of best practices may improve outcomes for low-volume providers.^{14,31} It has been reported that the success of New York State in reducing

mortality rates for coronary artery bypass graft surgery was not because a greater proportion of procedures were performed by high-volume surgeons but rather because the gap in outcomes between high- and low-volume surgeons narrowed, and mortality rates for both groups decreased substantially.²⁹ Finally, the increase in thyroid surgery numbers has not been matched by a parallel increase in surgical procedures performed by graduating chief residents,^{18,32,33} lending credence to the call for increased training of endocrine surgery specialists either through enhanced exposure during training or through an increased number of fellowships in endocrine surgery to minimize the number of low-volume surgeons engaged in the performance of thyroid surgery in the future.

Submitted for Publication: April 11, 2009; final revision received July 22, 2010; accepted September 7, 2010.
Correspondence: Christine G. Gourin, MD, Department of Otolaryngology-Head and Neck Surgery, The Johns Hopkins University, 601 N Caroline St, Ste 6260, Baltimore, MD 21287 (cgourin1@jhmi.edu).

Author Contributions: Dr Gourin had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Gourin, Forastiere, Pawlik, and Bristow.
Acquisition of data: Gourin.
Analysis and interpretation of data: Gourin, Tufano, Forastiere, Pawlik, and Bristow.
Drafting of the manuscript: Gourin.
Critical revision of the manuscript for important intellectual content: Gourin, Tufano, Forastiere, Koch, Pawlik, and Bristow.
Statistical analysis: Gourin, Forastiere, and Bristow.
Administrative, technical, and material support: Gourin.
Study supervision: Gourin, Forastiere, and Bristow.

Financial Disclosure: None reported.

Previous Presentation: This study was presented at the annual meeting of the American Head and Neck Society; April 29, 2010; Las Vegas, Nevada.

REFERENCES

1. Birkmeyer JD, Siewers AE, Finlayson EV, et al. Hospital volume and surgical mortality in the United States. *N Engl J Med*. 2002;346(15):1128-1137.
2. Birkmeyer JD, Sun Y, Wong SL, Stukel TA. Hospital volume and late survival after cancer surgery. *Ann Surg*. 2007;245(5):777-783.
3. Finlayson EV, Goodney PP, Birkmeyer JD. Hospital volume and operative mortality in cancer surgery: a national study. *Arch Surg*. 2003;138(7):721-726.
4. Cheung MC, Hamilton K, Sherman R, et al. Impact of teaching facility status and high-volume centers on outcomes for lung cancer resection: an examination of 13,469 surgical patients. *Ann Surg Oncol*. 2009;16(1):3-13.
5. Birkmeyer JD, Stukel TA, Siewers AE, Goodney PP, Wennberg DE, Lucas FL. Surgeon volume and operative mortality in the United States. *N Engl J Med*. 2003;349(22):2117-2127.
6. Birkmeyer JD, Finlayson EV, Birkmeyer CM. Volume standards for high-risk surgical procedures: potential benefits of the Leapfrog initiative. *Surgery*. 2001;130(3):415-422.
7. Dudley RA, Johansen KL. Invited commentary: physician responses to purchaser quality initiatives for surgical procedures. *Surgery*. 2001;130(3):425-428.
8. Chen AY, Pavluck A, Halpern M, Ward E. Impact of treating facilities' volume on survival for early-stage laryngeal cancer. *Head Neck*. 2009;31(9):1137-1143.
9. Cheung MC, Koniaris LG, Perez EA, Molina MA, Goodwin WJ, Salloum RM. Impact of hospital volume on surgical outcome for head and neck cancer. *Ann Surg Oncol*. 2009;16(4):1001-1009.
10. Thomusch O, Machens A, Sekulla C, et al. Multivariate analysis of risk factors for postoperative complications in benign goiter surgery: prospective multicenter study in Germany. *World J Surg*. 2000;24(11):1335-1341.

11. Pieracci FM, Fahey TJ III. Effect of hospital volume of thyroidectomies on outcomes following substernal thyroidectomy. *World J Surg.* 2008;32(5):740-746.
12. Lifante JC, Duclos A, Couray-Targe S, Colin C, Peix JL, Schott AM. Hospital volume influences the choice of operation for thyroid cancer. *Br J Surg.* 2009;96(11):1284-1288.
13. Sosa JA, Bowman HM, Tielsch JM, Powe NR, Gordon TA, Udelsman R. The importance of surgeon experience for clinical and economic outcomes from thyroidectomy. *Ann Surg.* 1998;228(3):320-330.
14. Boudourakis LD, Wang TS, Roman SA, Desai R, Sosa JA. Evolution of the surgeon-volume, patient-outcome relationship. *Ann Surg.* 2009;250(1):159-165.
15. Stavrakis AI, Ituarte PH, Ko CY, Yeh MW. Surgeon volume as a predictor of outcomes in inpatient and outpatient endocrine surgery. *Surgery.* 2007;142(6):887-899.
16. Morton RP, Gray L, Tandon DA, Izzard M, Mclvor NP. Efficacy of neck dissection: are surgical volumes important? *Laryngoscope.* 2009;119(6):1147-1152.
17. Becker WF. Presidential address: pioneers in thyroid surgery. *Ann Surg.* 1977;185(5):493-504.
18. Saunders BD, Wainess RM, Dimick JB, Doherty GM, Upchurch GR, Gauger PG. Who performs endocrine operations in the United States? *Surgery.* 2003;134(6):924-931.
19. Bristow RE, Puri I, Diaz-Montes TP, Giuntoli RL, Armstrong DK. Analysis of contemporary trends in access to high-volume ovarian cancer surgical care. *Ann Surg Oncol.* 2009;16(12):3422-3430.
20. McHenry CR. Patient volumes and complications in thyroid surgery. *Br J Surg.* 2002;89(7):821-823.
21. Zambudio AR, Rodríguez J, Riquelme J, Soria T, Canteras M, Parrilla P. Prospective study of postoperative complications after total thyroidectomy for multinodular goiters by surgeons with experience in endocrine surgery. *Ann Surg.* 2004;240(1):18-25.
22. Hillner BE, Smith TJ, Desch CE. Hospital and physician volume or specialization and outcomes in cancer treatment: importance in quality of cancer care. *J Clin Oncol.* 2000;18(11):2327-2340.
23. Birkmeyer NJ, Goodney PP, Stukel TA, Hillner BE, Birkmeyer JD. Do cancer centers designated by the National Cancer Institute have better surgical outcomes? *Cancer.* 2005;103(3):435-441.
24. Berger DH, Ko CY, Spain DA. Society of University Surgeons position statement on the volume-outcome relationship for surgical procedures. *Surgery.* 2003;134(1):34-40.
25. Schlosser K, Zeuner M, Wagner M, et al. Laryngoscopy in thyroid surgery: essential standard or unnecessary routine? *Surgery.* 2007;142(6):858-864, e1-e2.
26. Roh JL, Park CI. Routine oral calcium and vitamin D supplements for prevention of hypocalcemia after total thyroidectomy. *Am J Surg.* 2006;192(5):675-678.
27. Russell TR. Invited commentary: volume standards for high-risk operations: an American College of Surgeons' view. *Surgery.* 2001;130(3):423-424.
28. Khuri SF. Invited commentary: surgeons, not General Motors, should set standards for surgical care. *Surgery.* 2001;130(3):429-431.
29. Epstein AM. Volume and outcome: it is time to move ahead. *N Engl J Med.* 2002;346(15):1161-1164.
30. Donabedian A. Evaluating the quality of medical care: 1966. *Milbank Q.* 2005;83(4):691-729.
31. Birkmeyer JD, Sun Y, Goldfaden A, Birkmeyer NJ, Stukel TA. Volume and process of care in high-risk cancer surgery. *Cancer.* 2006;106(11):2476-2481.
32. Terris DJ, Seybt MW, Siupsinskiene N, Gourin CG, Chin E. Thyroid surgery: changing patterns of practice. *Laryngoscope.* 2006;116(6):911-915.
33. Harness JK, van Heerden JA, Lennquist S, et al. Future of thyroid surgery and training surgeons to meet the expectations of 2000 and beyond. *World J Surg.* 2000;24(8):976-982.