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Pediatric Thyroidectomy: Hospital Course and Perioperative Complications

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Abstract

Objectives/Hypothesis. To evaluate hospital course and associated complications among pediatric patients undergoing thyroidectomy.

Study Design and Setting. Retrospective database review of the Kids' Inpatient Database (2009, 2012).

Methods. The Kids' Inpatient Database was evaluated for thyroidectomy patients for the years 2009 and 2012. Surgical procedure, patient demographics, length of stay, hospital charges (in US dollars), and surgical complications were evaluated.

Results. Of an estimated 1099 nationwide partial thyroidectomies and 1654 total thyroidectomies, females accounted for 73.5% and 79.1% of patients, respectively. Children <1 year of age had significantly longer hospital courses ($P <$ .0001), and patients 1 to 5 years of age had a significantly greater length of stay than individuals 6 to 20 years of age (7.8 vs 2.1 days, $P <$ .001). The most common complications overall included hypocalcemia, respiratory complications, vocal cord paresis/paralysis, postoperative infection, and bleeding. Vocal cord paralysis was noted in 1.7% of pediatric thyroidectomy patients. The presence of these complications among total thyroidectomy patients significantly increased one's length of stay and hospital charges. A neck dissection was reported in 22.9% of malignant thyroidectomy patients.

Conclusion. Nearly 20% of children who underwent total thyroidectomy experienced postoperative hypocalcemia, positing a need for the development of postoperative calcium replacement algorithms to minimize the sequelae of hypocalcemia. A greater incidence of respiratory and infectious complications among younger patients (<6 years) suggests a need for closer monitoring, possibly encompassing routine postoperative intensive care unit utilization, in an attempt to minimize these sequelae.

Keywords

thyroidectomy, pediatric thyroidectomy, pediatric thyroid cancer, Kids' Inpatient Database

The surgical management of pediatric thyroid disease has evolved considerably in recent years. Although a wealth of literature describes intrainstitutional experience and patient management strategies for adults, historically fewer analyses have targeted pediatric patients. Al-Qurayshi et al recently reported, in agreement with prior analyses,[1,2] that children with thyroid cancer, though rare, more commonly present with metastatic and advanced disease and frequently require cervical lymph node dissections.[3] Perhaps as a response to this recognized difference, among others in pediatric thyroid disease presentation, the American Thyroid Association (ATA) recently released management guidelines for children with thyroid nodules and differentiated cancers.[4] These guidelines harbor the potential to influence practitioners whose treatment practices and surgical recommendations previously employed a more conservative approach to pediatric thyroid disease. Prior to these guidelines, some practitioners largely relied on adult guidelines and anecdotal experience. In addition to undefined thyroid nodules as well as malignancies, Graves' disease is an important clinical issue among the pediatric population. Although radioactive iodine and medical management have roles, concerns exist regarding the safety of these approaches for children, and a significant

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proportion of patients fail these modalities, ultimately requiring surgery.[5-7]

Despite numerous analyses composed of single-institution retrospective reviews and other patient series, there has been limited population-based inquiry evaluating pediatric thyroidectomy. Approaching a clinical issue from a population-based perspective allows for greater generalizability of results (ie, external validity) and may allow for greater sample sizes facilitating adequate statistical power to detect differences. To the best of our knowledge, our analysis represents the only current report of inpatient hospitalizations in pediatric patients following thyroidectomy for benign and malignant pathology. Our objective was to employ a widely used and validated nationwide database, the Kids' Inpatient Database (KID), to evaluate characteristics of inpatient hospitalization following pediatric thyroidectomy and to explore the relationship of surgical approach and patient demographics with complications and outcomes.

Methods

To characterize current surgical incidence and outcomes in pediatric patients undergoing thyroidectomy, we analyzed the 2 most recent versions of the KID (2009 and 2012) from the Healthcare Cost and Utilization Project (HCUP). The KID incorporates inpatient hospital stay data collected from discharge paperwork detailing *International Classification of Diseases, Ninth Revision* (*ICD-9*) and procedural data from 5118 hospitals spanning 44 of the 50 states. Data for the 2 years under review totaled 6,602,928 cases; or, an estimated 14,045,425 national cases extrapolated by HCUP provided and validated estimation formulas and patient sample weights. The KID is the only national data set detailing pediatric inpatient stay information from rural and urban teaching and nonteaching facilities with hospital identification and characteristic data linkable to the American Hospital Association Annual Survey Database. As such, our analysis utilized the HCUP-provided cross reference data file to identify teaching hospitals and characteristic data. The HCUP and American Hospital Association Annual Survey Database classify a hospital as *teaching* if it has an American Medical Association–approved residency program, is a member of the Council of Teaching Hospitals, or has a ratio above one-quarter when comparing training interns and residents to hospital beds. All authors with access to the KID completed the HCUP-required data use agreement training course prior to analysis of these data.

To gather our patient sample, KID core files were queried for procedural codes 06.2 (unilateral thyroid lobectomy), 06.31 (excision of lesion of thyroid), 06.39 (other excision of thyroid), and 06.4 (complete thyroidectomy). Patients were grouped into "partial" and "total" thyroidectomy categories via Microsoft Excel and separately examined for surgical complication incidence and procedural indication. "Respiratory" complications included codes associated with hypoxemia, surgical respiratory distress, and respiratory failure, while "infection" codes included surgical cellulitis, pneumonias, abscesses, and septicemia/bacteremia. In regard to goiter terminology, *ICD-9* codes for diffuse, multinodular, and uninodular goiter are represented in the analysis. Presumably, a unilateral lobectomy would be indicated for uninodular goiter, whereas diffuse goiters may have undergone total thyroid excision.

Analytic endpoints included patient age, sex, length of hospital stay, hospital charges (total billed hospital stay without physician fees, in US dollars), hospital type, and surgical incidence. Discharge costs were adjusted for inflation by utilizing US Department of Commerce Bureau of Economic Analysis website coefficients; 2009 patient data were adjusted to match totals for the year 2012. As this study utilized a publicly available nationwide database, it qualifies as nonhuman subject research and was thus exempted from needing Institutional Review Board approval.

Statistical Analysis

Data were grouped for analysis through SPSS 23 (IBM, Chicago, Illinois) and Microsoft Excel. Two-tailed chi-square tests, independent samples t tests, and analyses of variance were run to compare categorical and continuous samples where applicable with a threshold for statistical significance set at $P < .05$.

Results

National Incidence and Database Characteristics

An estimated 1099 nationwide cases of partial thyroid excision and 1654 cases of total thyroidectomy met inclusion criteria (**Table 1**). Females accounted for 73.5% and 79.1% of partial and total thyroidectomy procedures, respectively (**Table 1**). Children <1 year of age accounted for only 1% of patients but had significantly longer hospital courses ($P \leq .001$) and higher discharge costs ($P \leq .001$) than children >1 year old (**Table 1**). Regardless of procedure type, analysis of patients >1 year revealed a statistically significant increased length of stay among patients aged 1 to 5 years—7.8 days vs 2.15 days among patients aged 6 to 20 years ($P \leq .001$). As illustrated in **Figure 1** and **Table 1**, surgical incidence increased with age and was most common to the 16- to 20-year-old age group; this cohort accounted for 58.9% of partial and 60.8% of total thyroidectomy patients. Race was recorded in 86.1% of hospital stays (**Table 1**) and did not significantly contribute to one's length of stay or total charges for partial thyroidectomy; however, statistical variation was noted among cohorts undergoing total thyroidectomy procedures. In all, 73.3% of patients were treated at teaching hospitals (**Table 1**), and patients receiving total thyroidectomy procedures had higher hospital charges when treated at a teaching facility—\$39,160 vs \$33,927 (P = .012; **Table 1**). Thyroidectomy procedures accounted for an estimated >\$104 million in hospital charges during the 2 years analyzed.

Procedural Indication and Neck Dissection Analysis

Partial vs total thyroidectomy indications are outlined in **Figure 2**. Nodular goiters were more likely to require a

Table 1. Total and Partial Thyroidectomy Database Characteristics.[a]

	Partial Thyroidectomy			Total Thyroidectomy		
	n	LOS (SD)$^{P\ \mathrm{value}}$	Charges (SD)$^{P\ \mathrm{value}}$	n	LOS (SD)$^{P\ \mathrm{value}}$	Charges (SD)$^{P\ \mathrm{value}}$
All cases	1099	3.1 (15.34)	40,459 (147,209)	1654	2.6 (9.51)	37,892 (35,686)
Year						
2009	650	2.1 (5.36)$^{.001}$	29,724 (65,596)$^{.004}$	875	2.8 (12.64)$^{.587}$	33,567 (27,849)$^{<.001}$
2012	449	4.5 (23.06)	56,037 (25,550)	779	2.5 (3.59)	42,780 (42,343)
Sex						
Male	243	6.7 (22.37)$^{<.001}$	72,738 (263,453)$^{<.001}$	313	4.4 (21.21)$^{<.001}$	45,700 (53,933)$^{<.001}$
Female	808	2.2 (12.84)	31,074 (89,272)	1,308	2.2 (2.45)	35,834 (29,758)
Age, y						
<1	23	55.2 (87.1)$^{<.001}$	487,395 (864,400)$^{<.001}$	5	14.9 (12.1)$^{<.001}$	110,658 (96,836)$^{<.001}$
1-5	51	3.5 (7.6)	42,650 (64,881)	54	11.8 (50.0)	35,916 (25,364)
6-10	82	1.6 (1.05)	27,732 (16,011)	135	2.9 (3.31)	41,698 (35,986)
11-15	278	2.0 (5.99)	34,980 (88,953)	443	2.4 (3.38)	40,166 (43,664)
16-20	647	1.9 (4.11)	28,763 (28,107)	1006	2.2 (0.72)	35,960 (31,223)
Race						
White	545	2.6 (13.3)$^{.478}$	37,757 (167,477)$^{.909}$	889	2.2 (2.4)$^{<.001}$	36,847 (32,079)$^{.004}$
Black	89	5.1 (15.6)	53,496 (126,096)	100	2.6 (2.6)	36,778 (26,493)
Hispanic NW	199	2.4 (5.5)	38,344 (51,351)	287	2.9 (4.6)	44,582 (54,403)
Asian	28	3.9 (7.6)	47,148 (73,041)	72	2.0 (1.4)	43,437 (31,197)
O/NR	238	4.0 (23.6)	42,917 (163,902)	306	3.8 (21.2)	33,992 (25,902)
Hospital						
Teaching	763	3.6 (18.26)$^{.092}$	46,201 (176,023)$^{.057}$	1255	2.8 (10.74)$^{.396}$	39,160 (32,524)$^{.012}$
Nonteaching	336	1.9 (3.27)	27,590 (24,274)	399	2.3 (3.59)	33,927 (43,951)

Abbreviations: LOS, length of stay; NW, nonwhite; O/NR, other and not recorded.

[a]Statistical values represent interprocedural comparison. LOS is reported in days. Charges are reported in US dollars.

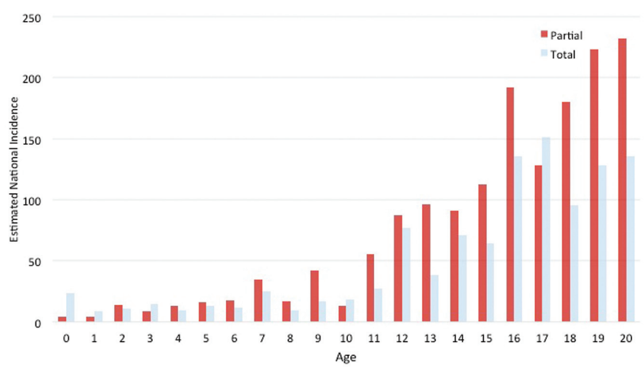

Figure 1. Estimated surgical incidence by age. Left-side (darker) columns represent partial thyroidectomy patients.

partial resection (**Figure 2**), and they accounted for a majority of all partial thyroidectomy cases—54.3% (**Table 2**). Malignant thyroid tissue was the most frequent diagnosis among total thyroidectomies: 51.9% (**Table 2**). These patients carried the highest hospital charges: $43,120 (**Table 2**) in the total thyroidectomy cohort. **Table 3** details the prevalence of an associated neck dissection in the cohort of patients with malignant disease. In all, 22.5% of this population received 1 of the detailed additional dissections. Patients receiving bilateral ''radical neck dissections'' following a total thyroidectomy had the longest subsequent hospitalization and the highest associated total costs—4.9 days and $66,875 (**Table 3**). As reported in **Table 3**, in the context of malignant disease, receiving a simple nodal excision or regional nodal excision yielded little additional morbidity to one's surgery. Length of stay and total charges were not statistically different among patients with malignant disease who received 1 of these procedures when compared with patients with no associated neck dissection—2.2 days vs 2.6 days (P = .143) and $37,020 vs $43,603 ($P$ = .079) in total thyroidectomy patients and 1.9 days vs 1.7 days (P = .452) and $33,781 vs $29,159 ($P$ = .165) in partial thyroidectomy patients. Conversely, total thyroidectomy patients receiving a bilateral ''radical neck dissection'' had significantly longer hospitalizations when compared with a malignant disease–positive patient without an additional dissection—4.9 vs 2.6 days (P = .010). Hospital charges were not statistically different ($66,875 vs $43,603, P = .069).

Procedural Complications

The 7 most common surgical and hospital stay complications are documented in **Table 4**. In total thyroidectomy patients, hypocalcemia was the most common reported complication (19.9%) and was associated with longer hospital stays (+1.38 days, P < .001) and increased total charges

Table 2. Hospital Stay Analysis Organized by Diagnosis Indication.[a]

	Partial Thyroidectomy			Total Thyroidectomy		
	n	LOS (SD)$^{P\ value}$	Charges (SD)$^{P\ value}$	n	LOS (SD)$^{P\ value}$	Charges (SD)$^{P\ value}$
All cases	1099	3.1 (15.34)	40,459 (147,209)	1654	2.6 (9.51)	37,892 (35,686)
Diagnosis						
Malignant	232	1.7 (1.6)$^{.003}$	30,493 (18,380)$^{.081}$	859	2.5 (3.0)$^{.662}$	43,120 (41,353)$^{<.001}$
Goiter[b]	597	1.5 (4.5)$^{.001}$	28,070 (62,658)$^{.005}$	361	1.8 (2.3)$^{.001}$	30,496 (29,294)$^{<.001}$
Graves	47	2.7 (2.4)$^{.451}$	32,156 (17,514)$^{.124}$	340	2.7 (10.5)$^{.988}$	36,707 (34,956)$^{.491}$
Other[c]	222	8.15 (32.4)$^{.004}$	81,902 (306,043)$^{.014}$	93	2.7 (9.8)$^{.251}$	38,210 (36,438)$^{.013}$
MEN	10	5.7 (10.9)$^{.970}$	54,970 (68,278)$^{.525}$	77	2.0 (9.5)$^{.070}$	28,933 (20,731)$^{<.001}$
Trauma	11	16.8 (18.1)$^{.051}$	120,248 (68,366)$^{.003}$	2	NA	NA

Abbreviations: LOS, length of stay; MEN, multiple endocrine neoplasia; NA, not applicable.
[a]Statistical values compare diagnosis vs diagnosis-free cohorts. Length of stay reported in days; charges reported in US dollars.
[b]Uninodular (partial thyroidectomy) or multinodular or diffuse (total thyroidectomy).
[c]Endocrine anomaly (not elsewhere classified), disorders of thyroid (not elsewhere classified), neoplasm of uncertain behavior of other and unspecified endocrine glands (not elsewhere classified), disorder of thyroid (not otherwise specified), cyst of thyroid.

Table 3. Malignant Tissue: Neck Dissection Analysis.

	Patients, n (%)	Length of Stay (SD), d	Charges (SD),[a] US$
Total	859		
Regional[b]	154 (17.9)	2.2 (1.9)	37,020 (24,250)
Radical: unilateral	18 (2.1)	3.5 (3.6)	57,025 (37,284)
Radical: bilateral	12 (1.4)	4.9 (3.7)	66,875 (47,625)
None	655 (76.2)	2.6 (3.2)	43,603 (44,536)
Partial	232		
Regional[b]	36 (15.4)	1.9 (1.4)	33,781 (16,020)
Radical: unilateral	3 (1.2)	1.5 (0.6)	59,728 (10,198)
Radical: bilateral	—	—	—
None	191 (82.3)	1.7 (1.6)	29,159 (18,483)

[a]Hospital charges for patients requiring neck dissection.
[b]Simple node excision or regional node excision.

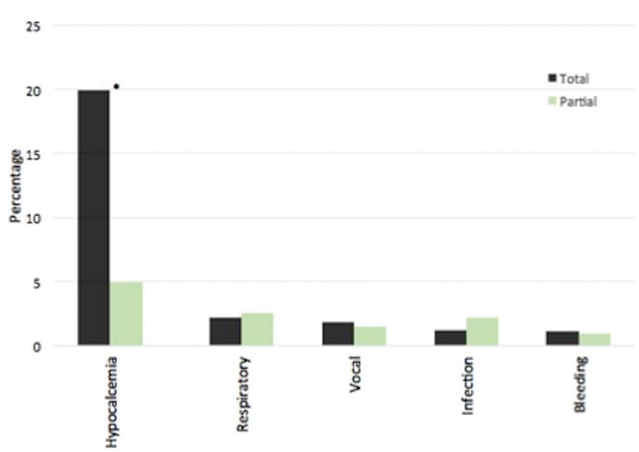

Figure 2. Procedure type by diagnosis. Left-side (darker) columns represent total thyroidectomy patients. Overlying asterisk represents statistically significant comparisons of total vs partial thyroidectomy incidence ($P < .05$).

(\$18,169, $P < .001$) when compared with a cohort free of this complication (**Table 4**). As one may expect, when compared against a cohort undergoing partial thyroidectomy procedures, total thyroidectomies were noted to carry an increased likelihood to cause hypocalcemia ($P < .05$; **Figure 3**); however, perhaps unexpectedly, hypocalcemia was listed as a diagnosis in 54 of the 1099 partial thyroidectomy procedures (4.9%). While possible that this information is coded correctly and clinically relevant, one must consider surgical context while entertaining this phenomenon (ie, second-side or completion procedures), which may be coded as partial thyroidectomies within the KID. Vocal cord paralysis/paresis (VCP) was noted in 46 patients (**Table 4**). These patients had longer hospital courses and increased hospital charges regardless of procedure type (**Table 4**). VCP was noted in 1.5% of partial thyroidectomy procedures and 1.8% of total thyroidectomy procedures. **Table 5** details complication rates for partial and total thyroidectomy procedures, grouped by patient demographics.

Table 4. Complication Effects.[a]

	Partial Thyroidectomy			Total Thyroidectomy		
	n (%)	LOS$^{P\ value}$	Charges$^{P\ value}$	n (%)	LOS$^{P\ value}$	Charges$^{P\ value}$
All cases[b]	1099	3.1 (15.34)	40,459 (147,209)	1654	2.6 (9.51)	37,892 (35,686)
Complication						
Hypocalcemia	54 (4.9)	+0.96$^{.231}$	+782$^{.918}$	329 (19.9)	+1.38$^{<.001}$	+18,169$^{<.001}$
Respiratory	28 (2.5)	+52.75$^{.002}$	+446,578$^{.009}$	36 (2.2)	+4.10$^{<.001}$	+42,346$^{<.001}$
VCP	16 (1.5)	+12.37$^{.001}$	+111,767$^{.003}$	30 (1.8)	+3.22$^{.006}$	+49,702$^{<.001}$
Infection	24 (2.2)	+53.02$^{.007}$	+180,752$^{.027}$	20 (1.2)	+27.98$^{<.001}$	+44,783$^{.006}$
Bleeding	10 (0.9)	+1.12$^{.435}$	+7212$^{.626}$	16 (1.0)	+29.73$^{<.001}$	+37,005$^{.018}$

Abbreviations: LOS, length of stay; VCP, vocal cord paralysis/paresis.
[a]Plus (+) represents an increase in LOS (in days) and charges (in US$) from uncomplicated cohort.
[b]For LOS and charges in this row, values are presented as mean (SD).

Table 5. Common Complication Incidence per Hospitalization.[a]

	Thyroidectomy		*P* Value
	Partial	Total	
All cases	0.17	0.44	<.001
Sex			
Male	0.25	0.52	<.001
Female	0.15	0.43	<.001
Age, y			
<1	0.97	1.29	.571
1-5	0.14	0.51	.003
6-10	0.14	0.64	.001
11-15	0.15	0.52	<.001
16-20	0.15	0.38	<.001
Race			
White	0.17	0.44	<.001
Black	0.17	0.56	<.001
Hispanic NW	0.17	0.41	<.001
Asian	0.30	0.43	.443
O/NR	0.14	0.41	<.001
Hospital			
Teaching	0.16	0.48	<.001
Nonteaching	0.19	0.32	<.001

Abbreviations: NW, nonwhite; O/NR, other and not recorded.
[a]Statistical analysis compares complication incidence in partial vs total thyroidectomy. Common complications include the ones delineated in Figure 2.

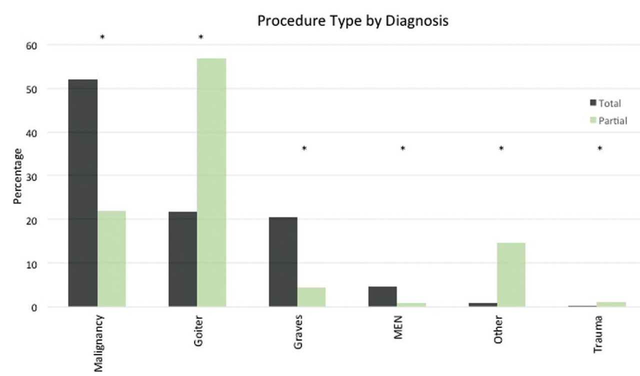

Figure 3. Hospital stay complications. Left-side (darker) columns represent total thyroidectomy patients. Percentages report complication incidence by procedure type. Overlying asterisks represent statistically significant comparisons of total vs partial thyroidectomy incidence ($P < .05$).

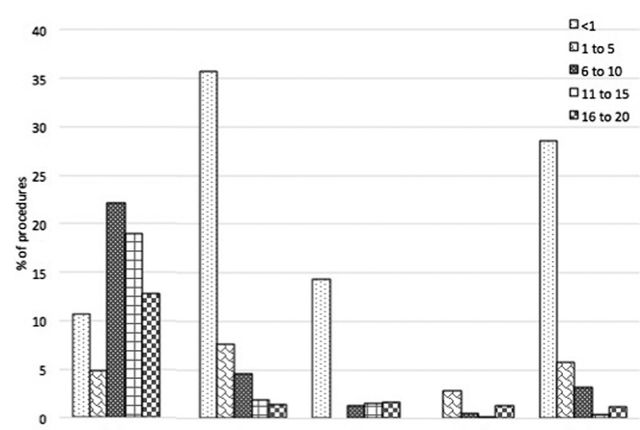

Figure 4. Complication rates grouped by patient age. Blood, bleeding complication; ↓ Ca, hypocalcemia; resp, respiratory complication; VCP, vocal cord paralysis/paresis.

Total thyroidectomy was associated with a greater risk of sustaining 1 of the outlined complications in **Table 4**—0.44 vs 0.17 complications per case ($P < .001$)—and children <1 year of age recorded the highest complication rates. **Figure 4** highlights a high propensity for this age group to suffer respiratory complications, VCP, and infectious processes.

Additional Procedures and Complications

Table 6 characterizes the hospital stay and demographic data for patients requiring parathyroid reimplantation or encountering VCP during their stay. Total thyroidectomy was associated with a 10.9% incidence of reimplantation, a statistically higher percentage than patients undergoing

Table 6. Paralysis, Paresis, and Parathyroid Reimplantation.[a]

	VCP$^{P\ \text{Value}}$	Parathyroid$^{P\ \text{Value}}$
Patients	46 (1.7)	214 (7.8)
Surgery		
Total	30 (1.8)$^{.300}$	181 (10.9)$^{<.001}$
Partial	16 (1.5)	34 (3.1)
Sex		
Male	9 (1.6)$^{.705}$	31 (5.6)$^{.011}$
Female	37 (1.7)	179 (8.5)
Age, y		
<1	4 (14.3)$^{<.001}$	2 (7.1)$^{.791}$
1-5	0 (0.0)	9 (8.6)
6-10	3 (1.4)	16 (7.4)
11-15	11 (1.5)	49 (7.0)
16-20	28 (1.7)	137 (8.3)
Hospital		
Teaching	37 (1.8)$^{.300}$	167 (8.3)$^{.085}$
Nonteaching	9 (1.2)	47 (6.4)
Stay		
Length of stay, d	+6.3 $^{<.001}$	+0.0 $^{.980}$
Charges, US$	+71,364 $^{.008}$	+3685 $^{.594}$

Abbreviation: VCP, vocal cord paralysis/paresis.
[a]Values presented as n (%) unless noted otherwise. *Parathyroid* indicates parathyroid tissue reimplantation. Percentage represents incidence of complication/procedure in all cohort-specific thyroid procedures.

partial thyroidectomy (**Table 6**). Patients undergoing reimplantation were also associated with higher rates of hypocalcemia (0.292 vs 0.143, $P \leq .001$). Tracheotomy was required in 21 patients, with a statistical predilection for ages <1 year ($P \leq .001$).

Discussion

To the best of our knowledge, the current analysis is the largest focused study evaluating thyroidectomy and complications in the pediatric population. The literature regarding this patient population is largely composed of case series, retrospective reviews, and smaller intrainstitutional analyses. Although all of these approaches have their merits, population-based analyses harbor strengths of their own. Notably, conclusions derived from the KID are likely more generalizable and have a greater degree of external validity than those with a single-institution perspective. Consequently, the figures reported in this analysis, such as the rates of specific complications, may be the most reliable source that we have to quote national complication rates and average lengths of stay to patients and their guardians in a comprehensive preoperative informed consent process. Importantly, although this is an adequate resource for reporting nationwide complication rates, surgeons should be familiar with their own complication rates and include this information in a preoperative discussion. In addition to affecting patient satisfaction, factors such as unclear expectations, poor physician-patient communication, and allegations of inadequate informed consent have been repeatedly cited as being significant in the initiation of medicolegal proceedings, with regard to pediatric surgical procedures as well as thyroidectomy.[8-11]

In 2015, the ATA released management guidelines for children with thyroid nodules and differentiated thyroid cancer.[4] The ATA task force gave a recommendation that for the majority of children with thyroid nodules for which a differentiated malignancy is suspected, total thyroidectomy is the recommended approach. This issue received a grade A recommendation, meaning that it is strongly recommended and based on good evidence of improved outcomes (ie, is not simply based on expert opinion). The task force's recommendation was based on numerous studies showing greater multifocal disease among children vs adults, with long-term studies demonstrating a decreased recurrence risk associated with total thyroidectomy.[4,12-15] Even without consideration of cases encompassing thyroid nodules that were ultimately benign (''goiter,''''other''), partial thyroidectomy was performed in 232 of 1091 cases (21.2%) with malignant pathology not related to multiple endocrine neoplasia syndrome. As the years that our current analysis examined precede this inaugural pediatric task force's recommendations, it would be of interest to revisit these data several years from now to see if surgical approaches have been affected. Also, in a similar analysis to ours, Harsha et al reported that in the years 1997 and 2000, the incidence of neck dissection in pediatric patients undergoing thyroidectomy for malignancy was 32%.[16] Our data, similarly reporting a 2-year incidence, indicated a decline in the associated dissection rate to 22.5%. It will be interesting to monitor whether the ATA's guidelines influence how frequent neck dissections are performed and whether or not patient outcomes are significantly improved on. Furthermore, in addition to retrospective reviews (as previously published) and population-based analyses such as this one, this discrepancy points to the need for double-blinded randomized controlled clinical trials evaluating the management of children with thyroid cancer, as the literature is lacking.[4]

Younger children, particularly infants, had significantly greater lengths of stay as well as an association with major complications in some cases. Notably, patients who experienced postoperative hypocalcemia (total thyroidectomy), respiratory sequelae, vocal cord paralysis, or infection all had significantly lengthier hospital stays and associated charges. These data suggest several potential precautions that may be taken, as well as areas for further study. Importantly, the greater potential incidence of respiratory complications among younger patients suggests the need for closer monitoring, possibly encompassing routine postoperative intensive care unit utilization in an attempt to minimize these sequelae. Additionally, these data strongly support delaying surgery to an older age, something most feasible when there is little concern for malignancy. Radioiodine treatment along with consideration of methimazole is currently first line in the management of Graves' disease among children.[7,17]

Apart from age, several key demographic differences were noted in this analysis. Males had significantly greater rates of the major complications evaluated and thus were noted to have significantly greater lengths of stay and hospital charges than females, findings not explained by differences in age distribution. These findings suggest a limitation of population-based resources and the complementary importance of more detailed retrospective intrainstitutional reviews. While population-based resources allow for large-enough samples to harbor adequate statistical power, the clinical details available in chart reviews also provide significant value. Hence, further analysis may be needed to elucidate why exactly there was such a sex gap in complications and, consequently, hospital course.

The impact of surgical volume and hospital setting has been studied in a variety of settings, including that among the pediatric population.[18,19] Population-based studies have largely noted that higher-volume centers, including teaching institutions, tend to have better outcomes and management of patients, with a variety of considerations suggested as being responsible for this. In the present analysis, patients undergoing thyroidectomy at teaching hospitals did appear to have greater lengths of stay than nonteaching institutions, both in comparisons for partial and total thyroidectomy, although this difference did not reach statistical significance. It is possible that children with more complicated or advanced disease may present to higher-volume teaching hospitals, and this certainly may influence outcomes. In our current health care environment, characterized by increasing consciousness of costs, this general theme is a major consideration in the debate surrounding the appropriateness of outcomes-based reimbursement, as practitioners and institutions willing to treat sicker patients may be at a significant disadvantage. One population that may benefit from the routine admission to high-volume centers is a group of patients <1 year old who are undergoing procedures on the thyroid. Complication rates for this cohort were significantly higher regardless of procedure type, and upon further analysis of these complications, we identified a plurality of patients with infection (29.9%), respiratory sequelae (35.2%), and an alarmingly high incidence of VCP—14.3% (**Figure 4**). Procedure indication did not seem to play a significant role in predicting these complications from occurring, with prophylactic total thyroidectomy patients and patients requiring a cystic excision among the affected.

Although the current analysis represents the largest focused sample to date evaluating the inpatient stays of children undergoing thyroidectomy, our study design has several inherent limitations. Beyond the measures reported, there was no further access to individual patient information, highlighting the complementary nature of intrainstitutional analysis. For example, this information could have been useful to help explain why males had greater complication rates or delineate why a portion of patients receiving partial thyroidectomy surgery required parathyroid reimplantation. Second-side or completion procedures—not uncommon among children following pathologic analysis of an initial lobectomy procedure—could account for the population of patients with hypocalcemia and parathyroid tissue reimplantation following single-lobectomy procedures. Unfortunately, *ICD-9* coding and patient identification methods offered within the KID contribute little insight to which procedures constitute this population, thus representing a limitation within our analysis. Furthermore, while *ICD-9* diagnosis codes identify many pre- and postsurgical states of interest, the core of this analysis relies heavily on the fact that accurate coding has been implemented. Another important limitation is the lack of detail regarding surgical pathology. Although we identified Graves' cases through coding and presumed that most children with multiple endocrine neoplasia syndrome who were undergoing thyroidectomy likely had medullary thyroid cancer, not differentiating between children who had papillary thyroid carcinoma and follicular carcinoma does represent a weakness. Importantly, however, follicular carcinoma is quite rare among children.[4] Furthermore, knowledge of preoperative workup, including fine-needle aspiration findings, would have been helpful but was not available. An additional limitation that we would be remiss not to mention is the lack of information regarding the operating surgeon. Otolaryngologists have been performing an increasing proportion of thyroid surgeries in recent decades,[20,21] although this trend has not been explored among the pediatric population. Identification of the specialty of the operating surgeon may be of interest, particularly with regard to outcomes, complications, and postoperative monitoring practices. Another potential limitation inherent to our study design regards the routine examination of patient vocal cords following surgery. While many practitioners at the primary author's home institution (P.F.S.; Wayne State University School of Medicine) routinely monitor postoperative thyroidectomy patients for VCP and report identified cases, this practice is likely not universal. Our identified 1.7% national incidence of VCP may underrepresent an actual occurrence if routine monitoring studies were not employed. Despite these weaknesses, population-based studies like these play an important role, allowing for adequate power to detect statistical differences. The rates of particular complications and lengths of stay can be quoted to parents in a preoperative informed consent discussion, and our results do bring up questions regarding whether the ATA guidelines are being followed and whether more vigilance is needed in the postoperative care of younger children.

Conclusion

Encompassing >2000 patients over a 2-year period, this analysis represents the largest focused sample evaluating the postoperative course of children undergoing thyroidectomy. Nearly 20% of children who underwent total thyroidectomy experienced postoperative hypocalcemia, emphasizing the urgent need for the development of postoperative calcium replacement algorithms to minimize the sequelae of hypocalcemia. Among total thyroidectomy patients, postoperative hypocalcemia, respiratory complications, vocal cord paresis/paralysis, infection, and bleeding resulted in significantly increased lengths of stay and charges. Children <6 years old, particularly infants, had significantly greater lengths of stay and hospital charges. Importantly, the greater incidence of respiratory complications among younger patients suggests the need for closer monitoring, possibly encompassing routine postoperative intensive care unit utilization, in an attempt to minimize these sequelae.

Author Contributions

Curtis Hanba, conception, design, analysis, drafting, final approval, interpretations; **Peter F. Svider,** conception design analysis and interpretation, revision, final approval, data acquisition; **Bianca Siegel,** conception, design, analysis, drafting, final approval, interpretations; **Anthony Sheyn,** conception, design, analysis, drafting, final approval, interpretations; **Mahdi Shkoukani,** conception, design, analysis, drafting, final approval, interpretations; **Ho-Sheng Lin,** conception, design, analysis, drafting, final approval, interpretations; **S. Naweed Raza,** conception, design, analysis, drafting, final approval, interpretations.

Disclosures

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References

1. Dinauer CA, Breuer C, Rivkees SA. Differentiated thyroid cancer in children: diagnosis and management. *Curr Opin Onc*. 2008;20:59-65.
2. Thompson GB, Hay ID. Current strategies for surgical management and adjuvant treatment of childhood papillary thyroid carcinoma. *World J Surg*. 2004;28:1187-1198.
3. Al-Qurayshi Z, Hauch A, Srivastav S, et al. A national perspective of the risk, presentation, and outcomes of pediatric thyroid cancer. *JAMA Otolaryngol Head Neck Surg*. 2016;142: 472-478.
4. Francis GL, Waguespack SG, Bauer AJ, et al. Management guidelines for children with thyroid nodules and differentiated thyroid cancer. *Thyroid*. 2015;25:716-759.
5. Rabon S, Burton AM, White PC. Graves' disease in children: long term outcomes of medical therapy. *Clin Endocrin (Oxf)*. 2016;85:632-635.
6. Rivkees SA. Pediatric Graves' disease: management in the post-propylthiouracil era. *Int J Ped Endocrinol*. 2014;2014:10.
7. Rivkees SA. Controversies in the management of Graves' disease in children [published online May 6, 2016]. *J Endocrinol Invest.*
8. Rose C, Svider PF, Sheyn A, et al. Protecting the most vulnerable: litigation from pediatric otolaryngologic procedures and conditions. *Laryngoscope*. 2014;124:2161-2166.
9. Svider PF, Eloy JA, Folbe AJ, et al. Craniofacial surgery and adverse outcomes: an inquiry into medical negligence. *Ann Otol Rhinol Laryngol*. 2015;124:515-522.
10. Svider PF, Sunaryo PL, Keeley BR, et al. Characterizing liability for cranial nerve injuries: a detailed analysis of 209 malpractice trials. *Laryngol*. 2013;123:1156-1162.
11. Ta JH, Liu YF, Krishna P. Medicolegal aspects of iatrogenic dysphonia and recurrent laryngeal nerve injury. *Otolaryngol Head Neck Surg*. 2016;154:80-86.
12. Handkiewicz-Junak D, Wloch J, Roskosz J, et al. Total thyroidectomy and adjuvant radioiodine treatment independently decrease locoregional recurrence risk in childhood and adolescent differentiated thyroid cancer. *J Nuclear Med*. 2007;48:879-888.
13. Hay ID, Gonzalez-Losada T, Reinalda MS, et al. Long-term outcome in 215 children and adolescents with papillary thyroid cancer treated during 1940 through 2008. *World J Surg*. 2010; 34:1192-1202.
14. Machens A, Lorenz K, Nguyen Thanh P, et al. Papillary thyroid cancer in children and adolescents does not differ in growth pattern and metastatic behavior. *J Pediatrics*. 2010; 157:648-652.
15. Welch Dinauer CA, Tuttle RM, Robie DK, et al. Clinical features associated with metastasis and recurrence of differentiated thyroid cancer in children, adolescents and young adults. *Clin Endocrinol*. 1998;49:619-628.
16. Harsha WJ, Perkins JA, Lewis CW, et al. Head and neck endocrine surgery in children: 1997 and 2000. *Arch Otolaryngol Head Neck Surg*. 2005;131:564-570.
17. Elfenbein DM, Katz M, Schneider DF, et al. Thyroidectomy for Graves' disease in children: indications and complications. *J Pediatric Surg*. 2016;51:1680-1683.
18. Chen K, Cheung K, Sosa JA. Surgeon volume trumps specialty: outcomes from 3596 pediatric cholecystectomies. *J Pediatric Surg*. 2012;47:673-680.
19. Tuggle CT, Roman SA, Wang TS, et al. Pediatric endocrine surgery: who is operating on our children? *Surgery*. 2008;144: 869-877.
20. Ramsden JD, Johnson AP, Cocks HC, et al. Who performs thyroid surgery: a review of current otolaryngological practice. *Clin Otolaryngol Allied Sci*. 2002;27:304-309.
21. Terris DJ, Seybt MW, Siupsinskiene N, et al. Thyroid surgery: changing patterns of practice. *Laryngoscope*. 2006;116: 911-915.