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Clinical Study

Surgical Management of Thyroid Illnesses in Children

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Keywords
Calcium supplements
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Abbreviations
CLND - Central lymph node dissection
FNAC - Fine needle aspiration cytology
INM - Intra-operative neuromonitoring
MNG - Multi-nodular goiter
PC - Papillary carcinoma
RLN - Recurrent laryngeal nerve
SLN - Superior laryngeal nerve
TE - Thyroidectomy
TSH - Thyroid stimulating hormone

Abstract

Background: *Thyroid disorders represent a significant proportion of pediatric endocrine problems. Surgical intervention is often indicated in thyroid cancers, hyperthyroidism and solitary non-toxic nodules.*

Methods: *This study outlines the surgical experience with 116 pediatric patients who underwent a total of 124 thyroidectomies from 2001 to 2018 at the University Pediatric Hospital in San Juan, Puerto Rico. Analyzed data include patient age, gender, race, weight, medical history, type of thyroid disorder, nodule size, pre-operative ultrasound and fine-needle aspiration cytology (FNAC) findings, type of thyroid resection, operative duration, novel surgical techniques, recovery period, and complications.*

Results: *The diagnoses included well-differentiated thyroid carcinoma (39%), Hashimoto disease (16%), follicular adenoma (14%), and Graves' disease (12%). The most frequent procedures were total thyroidectomy with central lymph node removal (44%), hemithyroidectomy with isthmusectomy (35%), and total thyroidectomy alone (10%). Complications occurred in 7 patients. The common complications include recurrent laryngeal nerve injury (2%) and neck hematoma (2%).*

Conclusions: *Pediatric patients with thyroid disorders can benefit from thyroidectomy based on the specific condition and its stage. Accurate diagnosis, appropriate surgical treatment, and the application of innovative techniques resulted in 124 successful thyroidectomies with only seven complications. The use of intra-operative nerve monitoring and vascular hemostatic sealants reduced the risk of recurrent laryngeal nerve injury and shortened operative times. Postoperative oral calcium and calcitriol therapy effectively mitigated the risk of postoperative hypocalcemia following total gland removal.*

INTRODUCTION

Thyroid disorders forms a significant proportion of pediatric endocrine problems, ranking globally as the second most prevalent pathology. These disorders affect 37 out of 1,000 school-aged children in the United States, leading to metabolic abnormalities that impact growth and development. The clinical outcomes of thyroid illness vary depending on the child's age and the nature of the disorder.[1] Surgical management is common in thyroid disorders such as goiter, solitary non-toxic nodule, malignancy and auto-immune diseases (e.g. Graves disease). Surgical options range from removing the entire gland (total thyroidectomy) to removing a single lobe (hemithyroidectomy) or the isthmus (isthmusectomy). The extent of resection is often determined by the nature of the illness. Pediatric surgeons in the USA usually do 2-3 thyroidectomies per year. While thyroidectomies are generally safe and effective, they do carry specific risks such as hypocalcemia, recurrent laryngeal nerve (RLN) injury, cervical hematoma, wound infection and hypertrophied scars.

Over the past decade, several new techniques have emerged to reduce the complications of thyroid operations. One such technique is intraoperative neuromonitoring (INM) of the RLN that has been shown to improve the surgical outcomes.[2] This method enables real-time assessment of the nerve function before and after gland removal. It enables complete removal of gland with reduced incidence of RLN injury.[2] Another innovative technique is the hemostatic vascular sealants, which aim to minimize postoperative bleeding and expedite the surgical process.[3] Despite its widespread use, literature indicates that their effectiveness may be limited.[3]

This study is aimed to document the surgical experience of the authors in performing thyroid operations and to draw educative inferences from that. Additionally, the study sought to identify the surgical complications encountered during and after thyroid operations. The application of novel surgical techniques to improve the outcomes and to reduce the complications was also examined.

PATIENTS AND METHODS

This retrospective study involves 116 consecutive children who underwent a total of 124 thyroid operations between 2001 and 2018, under the care of the senior author (HLV) at the University Pediatric Hospital of Puerto Rico. Collected data include patient age, gender, race, weight, medical history, nature of the thyroid disorder, lesion size, pre-operative imaging details, fine-needle aspiration cytology (FNAC) results, type of resection, surgical duration, novel techniques used, hospital stay and complications.

All the patients were Hispanics. Among them, 90 (79%) were female, and 26 (21%) were male. The mean age at operation was 15 years (range 3-21 years) and the mean weight was 60 kg (range 16-150 kg).

RESULTS

The list of pathologies, nature of surgical operations done and complications are summarized in Tables 1 to 3.

Table 1. Frequency of thyroid disorders

Pathology	n (%)
Papillary Carcinoma	54 (39%)
Hashimoto Disease	23 (16%)
Follicular Adenoma	20 (14%)
Graves Disease	17 (12%)
Nodular Hyperplasia	11 (8%)
Diffuse Nodular Toxic Goiter	5 (4%)
Oncocytic Adenoma	4 (3%)
Adenomatoid Nodule	3 (2%)
Medullary Carcinoma	1(1%)
C-cell Hyperplasia	1(1%)
Multi-nodular Goiter	1(1%)

Table 2. Surgical intervention of thyroid disorders in children

Nature of Operation	n (%)	Mean OR time (min)	Mean Hospital stay (days)
Total TE + CLND	55 (44%)	123	1
Hemi-TE	44 (35%)	97	1
Total TE	13 (10%)	150	2
Completion TE†	7 (6%)	98	1
Lymphadenectomy	3 (2%)	-	-
Central TE*	2 (2%)	60	1
Total operations	124		

*TE - Thyroidectomy, CLND - Central lymph node dissection, OR - Operating Room. * Also known as isthumectomy, †Done within 7 days of initial operation*

Table 3. Complications of thyroid surgeries

Complications	n (%)
Injury to the recurrent laryngeal nerve*	2 (1.6%)
Hematoma	2 (1.6%)
Hypocalcemia	1 (0.8%)
Pulmonary edema	1 (0.8%)
Stitch abscess / silk granuloma	1 (0.8%)
Total	7

** Intraoperative neuromonitoring was done in 74cases*

All the patients with Graves disease were treated with total thyroidectomy. In 7 children, reversible complications occurred. There were 2 cases of recurrent laryngeal nerve (RLN) injury (1.6%). In the first case, INM detected nerve injury during total thyroidectomy for Graves disease with a 4kg goiter. The divided nerve was immediately repaired using an operating microscope, and the patient recovered completely 5 months later. The second case developed post-operative hoarseness due to RLN palsy, which resolved after 3 months. There were also two cases of hematoma, both requiring neck re-exploration within 24 hours of the original operation. They underwent hematoma drainage and fibrin glue application. One patient developed symptomatic hypocalcemia. Patients who underwent total thyroidectomy were post-operatively treated with 2.4g of oral calcium carbonate and 0.5 µg of oral vitamin-D supplement for 1 month, with the dosage being reduced gradually by every week.

INM of the RLN was used in 74 resections, and hemostatic vascular sealants in all the 124 cases. The mean operating time for various operations is shown in Table 2. Total thyroidectomy done for Graves disease took the longest operating time with a mean of 150 minutes. These patients also required the longest post-surgical hospital stay, averaging 2 days, primarily to manage temporary hypocalcemia.

DISCUSSION

The overall risk of post-operative complications after thyroidectomy is approximately 2%. The common complications include operative damage to the RLN, hypocalcemia and neck hematoma. Permanent hypoparathyroidism is a serious but rare complication of total thyroidectomy. It often requires lifelong supplementation of vitamin-D.[4] Transient hypoparathyroidism is more common due to perioperative reversible ischemia of the parathyroid glands. Fortunately, only 1-4% of the parathyroid deficiencies occurring after thyroidectomy are permanent.[4] In our series, all those who underwent total thyroidectomy received oral supplementation of 2.4g of calcium carbonate and 0.5µg of vitamin-D, resulting in a low incidence of postoperative hypocalcemia.

Thyroid surgery may cause temporary or permanent damage to the RLN and superior laryngeal nerve (SLN), resulting in hoarseness of voice, dysphonia, dysphagia, pulmonary aspiration and dyspnoea.[5,6]. Bilateral RLN damage can be life-threatening due to airway obstruction.[5,7] The RLN is particularly susceptible to operative injury during the separation of the thyroid gland at the

ligament of Berry. RLN injury occurs in 3-11% of cases. Factors influencing nerve damage include the nature of pathology (benign vs. malignant), the extent of thyroid resection (lobectomy vs. total thyroidectomy), the number of attempt of resection (primary vs. reoperation) and the experience of the surgeon.[8] Complications are common in patients with malignant tumors and lymph node involvement, or in those undergoing re-operation with neck dissection. Proper surgical exposure and identification of both nerves during surgery is crucial to avoid damage.[5,9] Over the past decade, INM has evolved as the technique of choice. In this technique, electrodes are placed through the endo tracheal tube to monitor the nerve function during the surgical dissections.[6] INM allows not only intra-operative identification of nerves but also enable recording their function, thus providing legal protection in case of damage.[9] INM can also locate the site of injury and determine if the injury is repairable, as demonstrated in one of our cases. INM also makes thyroid surgery safer for the inexperienced young surgeons and trainees.[10] It helps in identifying anatomical variations present in less than 5% of patients.[5] INM has become an asset in complex thyroid dissections, such as those involving sub-sternal goiters, re-do operations, and total thyroidectomy for Graves disease.[8,11,12] Electric nerve testing at the end of thyroidectomy can predict postoperative nerve function and prevent bilateral vocal cord paralysis.[5,10] Despite the lack of class-1 evidence from randomized controlled clinical trials, INM may be considered as the standard-of-care in pediatric thyroid operations. Currently, it is the only method available to verify the functional intactness of the RLN and SLN during the procedure.[6] Although rare, hypocalcemia and vocal cord paralysis can significantly impact the quality of life. RLN injury is a major cause of medico-legal litigation in thyroid and parathyroid surgeries, underscoring the need for INM.[2,13,14]

Hemostatic sealants are important in preventing post-operative bleeding, which can be life-threatening due to acute airway obstruction. It occurs in 1.5-4% of thyroidectomies.[15,16] Causes of post-operative bleeding include ligature slippage, re-opening of the cauterized veins due to retching or Valsalva maneuver during recovery, increased blood pressure, continued capillary oozing from the thyroid gland or inadequate hemostasis.[15,16] Neck hematoma may cause airway obstruction from tracheal compression, requiring urgent surgical intervention or sometimes immediate bedside decompression.[17,18] Hematomas typically develop within 24 hours of surgery, though 20% may occur as late as 3 days.[19] Patients with post-operative neck hematoma present with dyspnea, neck pain, dysphagia or local swelling.[17,19] Early recognition and prompt intervention, including intubation or tracheotomy, are essential to save life.[17-19] Many of the hematomas are caused by arterial bleeding from the upper pole vessels. The frequency of hematoma does not reduce with the usage of neck drains.[20] The risk of postoperative hemorrhage is a deterrent for outpatient thyroid surgery or early discharge from hospital.[15,20] Risk factors of neck hematoma include age, sex, race, obesity, geographic region, co-morbidities, Graves disease, bleeding disorders, previous neck operations and the nature of current surgical procedure. Total thyroidectomy, sub-sternal thyroidectomy and radical neck dissection are associated with increased frequency of hematoma.[16,19,21] Hospital characteristics such as the type of hospital (teaching vs. non-teaching), location and patient volume do not correlate with the risk of hematoma.[16,19,21] Parathyroidectomy has a lower incidence of neck hematoma as compared to thyroidectomy.

Thyroid nodules in children are four times more likely to be cancerous than in adults. They warrant estimation of serum levels of thyroid-stimulating hormone (TSH) and calcitonin, ultrasonography and FNAC. Elevated calcitonin level is suggestive of medullary thyroid cancer. Micro-calcification,

indistinct margins of the nodules and variable echo-texture are the sonographic features of malignant nodules.[22] FNAC is the most accurate method of diagnosing thyroid malignancy, but it is often limited by the nodule size.[23] The risk of malignancy increases in iodine-deficient regions or with autoimmune thyroiditis.

Papillary carcinoma (PC) is the most common thyroid malignancy in children. It has excellent overall prognosis with prompt surgery and radio-iodine therapy.[24-26]. It often presents with multi-focal nodules with neck metastasis.[26,27] Distant metastasis is more common in children than in adults.[24,25] PC spreads sequentially from the thyroid to the central lymph node and then to ipsi-lateral nodes. Routine central lymph node dissection (CLND) during total thyroidectomy for PC reveals impalpable histological metastasis in 50-60% of cases.[26-28] Cervical lymph node involvement in PC does not affect the overall survival, because the residual nodal disease is easily treated with radio-active iodine.[27,28] CLND enables accurate staging and improves the efficacy of radio-iodine treatment.[24-27] Routine prophylactic lateral neck dissection is not recommended in children with PC.[26,27] Rather, routine CLND is recommended in children with palpable nodes to increase disease-free survival.[24,25] A lymph node ratio > 0.45 correlates with a higher risk of loco-regional recurrences.[26,28] CLND decreases tumor burden and improves survival in children with positive nodal metastasis.[26,27] Total thyroidectomy with CLND enables accurate tumor staging and effective radioiodine therapy.[24,27]

Graves disease is the most common cause of hyper thyroidism. Total thyroidectomy is indicated when thyrotoxicosis is refractory to medical treatments such as the anti-thyroid drugs and radio-active iodine.[30,31] In the past 20 years, total thyroidectomy is increasingly preferred over medical treatment due to its near zero recurrence rate, predictable postoperative hypothyroidism and low complication rate.[30,31]

Hashimoto thyroiditis is the most common auto-immune disorder of the endocrine system. It is often complicated by malignancies, especially the PC.[32] Primary treatment of Hashimoto thyroiditis is conservative, although thyroidectomy is often done for malignancy or symptomatic goiters.[32,33]

Non-toxic multinodular goiter (MNG) refers to diffuse thyroid enlargement with multiple non-functioning nodules. It primarily affects adolescents.[34,35] About 8% of MNG may undergo malignant transformation, especially in familial cases or in those with previous cervical irradiation.[34] In MNG, total thyroidectomy has lower morbidity than subtotal thyroidectomy.[13,36]

Follicular adenomas are common benign thyroid neoplasms that present as solitary nodules. Differentiating them from follicular carcinoma is often difficult, yet important.[37] Hemithyroidectomy is recommended for follicular adenoma diagnosed by FNAC. However, if histology of the excised specimen shows malignancy, completion (total) thyroidectomy is essential. Nodular thyroid hyperplasia involves non-cancerous growth affecting the thyroid gland, potentially causing enlargement of one or both lobes.

CONCLUSION

Children with thyroid disorders are significantly benefited from thyroidectomy. Among the 124 thyroidectomies there were only 7 complications. This improved outcome is attributable to INM, hemostatic sealants and oral supplementation of calcium plus calcitriol which were instrumental in reducing the incidence of RLN injury, neck hematoma and hypocalcemia, respectively.

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