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The preoperative evaluation prevent the postoperative complications of thyroidectomy

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HIGHLIGHTS

- Thyroid surgery depends on careful preoperative planning.
- Evaluation for lesions, adjuvant devices, and surgical modalities are important.
- Preoperative evaluation affects the hypocalcemia.
- Intraoperative monitor may reduce RLN injury.

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ABSTRACT

Objective: Thyroid surgery is generally a safe surgery but its complications are still common. We wish to identify preoperative factors that predict postoperative complications.
Methods: A nationwide survey was conducted by senior surgeons from 16 medical centers and 5 regional hospitals in Taiwan to thyroid operations performed over 3 years. 3846 cases were retrospectively examined to identify factors influencing complications: indication for surgery, preoperative evaluation, such as ultrasonography, chest X-ray, computed tomography and magnetic resonance imaging, isotope scanning, fine-needle aspiration cytology (FNAC) and thyroid function test, and patient characteristics.
Results: Eighty-four percent of patients were female. Seven percent of the patients had immediate postoperative hypocalcemia (mild and severe) and 2.3%, hoarseness (recurrent laryngeal nerve (RLN) injury, temporary/permanent). Logistic regression analysis identified an association between hypocalcemia and RLN injury with age, hospital category, surgical procedure types (total thyroidectomy, unilateral, bilateral subtotal or total resection). A lower incidence of hypocalcemia was related to preoperative neck ultrasound and FNAC analysis (the odds ratio (OR) = 0.5 and 0.65, [95% confidence interval (CI) 0.331–0.768 and 0.459–0.911], $P = 0.0014$ and 0.0127, respectively), while RLN injury was not associated with any preoperative evaluation. The ORs of hypocalcemia and RLN injury for patients older than 50 years were 0.55 and 2.15, [0.393–0.763 and 1.356–3.4], $P < 0.001$ and 0.0012, respectively.
Conclusions: The success of thyroid surgery depends on careful preoperative planning, including a preoperative neck ultrasound to determine the proximity of the nodule to the recurrent laryngeal nerve course, and the consideration of the type of anesthesia, adjuvant devices for intra-op monitoring of the RLN, and surgical modalities. Our results suggest that preoperative evaluation implementations are positively associated with strategy of surgery and postoperative hypocalcemia prevention.

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1. Introduction

Thyroid surgery has not changed substantially over the past decades with the improvement of aseptic technique and anesthesia [1–3]. However, it carries potential complications of hypocalcemia and recurrent laryngeal nerve (RLN) injury [4,5]. Hypocalcemia can have long-term deleterious effects on bone metabolism or cardiac function and RLN injury often results in persistent vocal and laryngeal dysfunction [5].

Complications associated with thyroidectomy are related to the category of diseases, extent and type of resection, usage of monitor, and surgeon's training or experience [6–11]. Less complication rates and shorter length of stay for thyroidectomy are associated with surgeon with more experience [12]. However, increasing year in practice is also associated with a risk of inpatient death, especially among with doctors with more than 20 years' experience [13]. Weariness to a high surgical volume or non-clinical tasks of senior surgeons has been associated with these complications [3]. In addition, even experienced surgeons can inadvertently injure the nerve due to variability in RLN anatomy and difficulties in nerve identification under challenging conditions [14]. Careful preoperative planning, including lesion pattern evaluation, and the consideration of adjuvant devices, surgical modalities, and anesthesia types [15], would help preventing the post-surgery complications. Since diagnostic procedures are applied to identify the type, location and size of lesions, we hypothesized that preoperative examinations would be helpful for the preoperative planning and the post-operative complication prevention.

Few physicians examined the effect of preoperative planning steps on the postoperative complications for thyroidectomies. Thus present study aimed to investigate the association of preoperative evaluation implementation and the incidence of postoperative complications in patients with thyroidectomy.

2. Methods

2.1. Study design and population

A multi-centric cross-sectional survey by Taiwan Endocrine Surgeons Study Group was conducted in 15 medical centers (6 public, 9 private) and 8 regional hospitals (all private) in Taiwan. In each hospital, one senior surgeon retrieved all the thyroidectomies performed between September 1, 2000 and December 31, 2003 and administered a thyroid surgery quality questionnaire for each operation. A total of 3927 operation records were reviewed. After ruling out reoperations, enucleations, cases of younger than 20 years old or older than 80 years old, and invalid entries or excessive missing data, 3428 charts (87.29%) were finally used in our analysis.

2.2. The survey

The survey was designed to collect data on the applications of preoperative diagnostic procedures, the type of postoperative complication, and its potential confounders, which included items relevant to demographics, surgical indication, and surgical type. The *complication* included none, hematoma, immediate hypocalcemia (serum calcium level < 7.6 mg/mL with/without clinical symptoms that mild was treated by oral calcium and severe, calcium infusion), RLN injury (immediate hoarseness), prolonged intubation due to tracheomalacia, wound infection, death, and rehospitalization within 2 weeks after surgery for other reasons. Severe hypocalcemia (seizures, tetany, refractory hypotension, or arrhythmias) was identified by the application of calcium infusion. Mild hypocalcemia was determined by oral calcium repletion.

The *preoperative evaluation* comprised basic examination (disease history examination, physical examination), advanced examination (thyroid function test), imaging examination (computed tomography scanning, ultrasonography, isotope scanning, chest X-ray, and magnetic resonance imaging) and fine-needle aspiration cytology (FNAC). In addition, intraoperative biopsy was prepared as frozen section for immediate pathology examination.

The *demographic data* comprised patient's age, gender, and the institutional characteristics such as the institution location (north, central, south, and east), category (public and private), and level (medical center and regional hospital). The items of *surgical indication* involved reasons to surgery (recognized or suspicious malignancy, airway compression, aesthetic considerations, hyperthyroidism, and others). The *surgical type* included bilateral total thyroidectomy (BTT), unilateral thyroidectomy and contralateral subtotal thyroidectomy (UCT), unilateral thyroidectomy (UT; including unilateral partial and total thyroidectomy), and bilateral incomplete thyroidectomy (BIT; including bilateral subtotal and bilateral partial thyroidectomy). The implementation of neck lymph node dissection (LND) was also investigated. General anesthesia was used in all cases.

2.3. Statistical analysis

The characteristics of the data were expressed by frequency (percentage) for categorical variables and mean ± standard deviation (SD) for continuous variables. Chi-squared test for contingency table, fisher's exact test, and *t*-test were applied, as appropriate, to evaluate the bivariate association among complication incidence, preoperative examination implementation, and the above mentioned confounders. The stepwise selection was used in logistic regression analysis for the incidence of each complication. The estimated odds ratio (OR), 95% confidence interval (CI), and *P*-value were reported. A statistically significance was indicated by a *P-value* of less than 0.05 throughout this article. Since the incidence of complications other than hypocalcemia and RLN injury were relatively rare, inferential statistical analyses were not carried out on the rest complications.

3. Results

3.1. Study sample characteristics

A total of 3428 operations were included: 2823 (82.35%) from medical center, 605 (17.65%) from regional hospital, 917 (26.75%) from public hospital and 2511 (73.25%) from private hospital. The operation cases distribution by location was 55.11%, 8.2%, 33.98%, and 2.71% for the northern, central, southern, and eastern areas. The female-to-male ratio was 5.24 to 1. The overall mean age was 44.38 ± 13.62 years and 65.7% were younger than 50 years old. The mean age for male and female respectively were 46.31 ± 14.64 and 44.01 ± 13.39 years ($P = 0.0007$).

Cases with older patients were observed in public hospitals (46.56 ± 13.92 years), or medical centers (44.69 ± 13.71) against those in private hospitals (43.58 ± 13.42) or regional hospitals (42.94 ± 13.12), $P < 0.0001$ and 0.0042, respectively. Sex distribution was not significantly different across hospital level, public or private category, and location ($P = 0.8172$, 0.1105, and 0.0713, respectively).

The distribution of surgical type and indications are displayed in Table 1. There were 45%, 4%, 2%, and 1% operations accompanied with a neck lymph node dissection among BTT, UCT, UT and BIT, respectively. Among the 1031 cases with airway compression, 76% had only one symptom (swallowing obstructed, tracheal shift, breathing difficulty, chest varicose, hoarseness or pronunciation

Table 1
The characteristics of the 3428 cases of thyroidectomy.

Variables	*n*	%
Surgical type		
Bilateral total thyroidectomy (BTT)	496	(14.47%)
Unilateral thyroidectomy and contralateral subtotal thyroidectomy (UCT)	572	(16.69%)
Unilateral thyroidectomy (UT)		
Unilateral partial thyroidectomy	454	(13.24%)
Unilateral total thyroidectomy	792	(23.10%)
Bilateral incomplete thyroidectomy (BIT)		
Bilateral subtotal thyroidectomy	833	(24.30%)
Bilateral partial thyroidectomy	281	(08.20%)
Preoperative examination procedures[a]		
Preoperative basic examinations		
Disease history examination	3338	(97.37%)
Physical examination	3273	(95.48%)
Preoperative advanced examinations		
Thyroid function determination	2961	(86.38%)
Biopsy	1050	(30.63%)
Preoperative imaging examinations		
Computed axial tomography (CAT) scanning	112	(03.27%)
Ultrasonography	2956	(86.23%)
Isotope scanning	459	(13.39%)
Others (ex: X-ray, MRI)	466	(13.59%)
Preoperative fine-needle aspiration cytology (FNAC)	1654	(48.25%)
Surgical indications[b]		
Malignancy		
Recognized	268	(7.82%)
Suspicious	950	(27.71%)
Airway compression	1031	(30.08%)
Aesthetics	839	(24.47%)
Hyperthyroidism	821	(23.95%)
Others	288	(8.40%)
Complication types[b]		
Hematoma	20	(0.58%)
Hypocalcemia	240	(7.00%)
Mild (Symptoms treated by oral calcium)	159	(4.64%)
Severe (Symptoms treated by calcium infusion)	81	(2.36%)
RLN injury	78	(2.28%)
Suspicious unilateral RLN injury	74	(2.16%)
Bilateral RLN injury with tracheostomy required	4	(0.12%)
Wound infection	21	(0.61%)
Others	10	(0.29%)

[a] The percentage of cases in the whole sample.
[b] Multiple responses. Other uncertain surgical indications included physician recommended or reason undocumented. Other complications included 0.12% prolonger intubation due to tracheomalacia and 0.18% re-hospitalization within 2 weeks after surgery.

fatigue); 18%, multiple (2–4) symptoms; and 6% lacked symptom description. Tracheal shift was the most common (14%) symptom.

3.2. The case distribution of complications and examination procedures

In all examined cases, 42 (1%) had no preoperative basic examination records and 3386 had basic examination records. Cases had any one of the advanced examination, imaging examination, or FNAC before surgery were 90, 92, and 48%, respectively. Cases having all kinds of preoperative examinations were 40%.

The incidence of postoperative complications was 10%, among which 5% (17/351) had multiple complications. No deaths were found in this study. Hypocalcemia (7%) and RLN injury (2%) were the two most common postoperative complications. Symptoms of RLN injury could be relieved spontaneously within two months and therefore it was difficult to categorize as temporary or permanent injury in this study. Wound infection was 0.6% with the preoperative antibiotics used (cephalosporins (70%) or combined with aminoglycosides (24%)). The detailed frequencies of complications and examination procedures are listed in Table 1.

3.3. Complications and examination implementation, demographics, and surgical factors

The distribution of hypocalcemia and RLN injury in subgroups of preoperative examination procedures, demographic variables, surgical type and indications are listed in Table 2. The results showed that the incidence of hypocalcemia was significantly related to the implementation of preoperative advanced or imaging examinations, age, the level, category and location of hospitals, surgical type, as well as surgical indications. The incidence of RLN injury was significantly related to the implementation of histological examinations, age, the level and location of hospitals, surgical type, and surgical indications.

3.4. Examination implementation and the characteristics of institutions and surgeries

As compared to regional hospitals, medical centers had higher recording rate for preoperative basic examination (100% *vs*. 95%, $P < 0.0001$) and less implementation rates of preoperative advanced, and imaging examination (88 *vs*. 93% and 91 *vs*. 97%, respectively; $P = 0.0015$ and <0.0001). The usage frequency of FNAC was not significantly different between the two levels of hospitals (48% *vs*. 49%, $P = 0.5657$). The implementation rates of all the examination procedures other than basic examination were significantly associated with surgical types ($P < 0.0001$, 0.0248, and <0.0001 for preoperative advanced examination, preoperative imaging examination, and FNAC, respectively).

Apart from basic examinations, imaging examinations were the most common examination procedure for cases with surgical indications of malignancy, airway compression, aesthetic reasons, or other reasons (the implementation rates ranged from 93% to 97%). For cases with an indication of hyperthyroidism, the thyroid function determination was the most common examination procedure, except the basic examinations, and was more frequently implemented, compare to other cases (94% *vs*. 84%, $P < 0.0001$). Cases with an indication of malignancy had higher implementation rates of imaging examinations, and FNAC analysis (95% and 73%), while they had lower implementation rates of thyroid function determination and biopsy (81% and 25%), compared to cases without such an indication (the corresponding implementation rates were 91, 35, 89 and 34%, respectively with $P < 0.0001$).

Both postoperative complications and preoperative examination procedures were associated with many of demographics, surgical type, and surgical indications. Those variables were all involved in the multiple logistic regression model selection analysis.

3.5. Logistic regression analysis of hypocalcemia

The incidence of hypocalcemia was significantly lower in cases of older than 50 years, in regional hospitals, and having a surgical indication of aesthetic reasons; the odds ratio (OR)s were respectively 0.55, 0.36, and 0.42 (see Table 3 for the detailed estimates). Cases in the northern, central and southern areas showed significantly higher incidence of hypocalcemia, compared to cases in the eastern Taiwan and the incidence increased from the northern to southern areas. Lower risks of hypocalcemia were observed in cases underwent surgical types of UCT, UT, or BIT against those underwent BTT, in those underwent UT or BIT *vs*. UCT, and in those underwent UT *vs*. BIT. After adjusting the demographics, surgical type and indications, cases underwent imaging examinations or FNAC analysis prior to operations had significantly lower hypocalcemia incidence.

Table 2
The bivariate association analyses for complications.

Covariates	Total	Hypocalcemia			RLN injury		
		n	%	*P-value*	*n*	%	*P-value*
Demographics							
20–49, 50–79	2255, 1173	181, 56	(8.03, 4.77)	0.0004[c]	37, 41	(1.64, 3.50)	0.0006[c]
Male, Female	549, 2879	33, 204	(6.01, 7.09)	0.3630	18, 60	(3.28, 2.08)	0.0850
Cen., Reg.	2823, 605	215, 22	(7.62, 3.64)	0.0005[c]	52, 26	(1.84, 4.30)	0.0002[c]
Public, Private	917, 2511	77, 160	(8.40, 6.37)	0.0390[c]	27, 51	(2.94, 2.03)	0.1120
H. at North	1889	89	(4.71)	0.0001[b,c]	41	(2.17)	0.0110[b,c]
H. at Central	281	18	(6.41)		1	(.36)	
H. at South	1165	129	(11.07)		36	(3.09)	
H. at East	93	1	(1.08)		0	(0)	
Surgical type							
BTT	496	104	(20.97)	0.0001[c]	28	(5.65)	0.0001[c]
UCT	572	80	(13.99)		12	(2.10)	
UT	1246	13	(1.04)		24	(1.93)	
BIT	1114	40	(3.59)		14	(1.26)	
Neck lymph node dissection							
Yes, No	286, 3142	45, 192	(15.73, 6.11)	0.0001[c]	14, 64	(4.90, 2.04)	0.0020[c]
Surgical indication[a] (present, no)							
Malignancy	1218, 2210	114, 123	(9.36, 5.57)	0.0001[c]	38, 40	(3.12, 1.81)	0.0138[c]
Airway comp.	1031, 2397	33, 204	(3.20, 08.51)	0.0001[c]	24, 54	(2.33, 2.25)	0.8925
Aesthetics	839, 2589	16, 221	(1.91, 8.54)	0.0001[c]	11, 67	(1.31, 2.59)	0.0311[c]
Hyperthyroidism	821, 2607	97, 140	(11.81, 7.13)	0.0001[c]	16, 62	(1.95, 2.29)	0.4718
Others	288, 3140	13, 224	(4.51, 7.13)	0.0935	06, 72	(2.08, 2.29)	0.8194
Preoperative examinations[a] (used, no)							
Basic	3383, 45	235, 2	(6.95, 4.44)	0.7670[b]	77, 01	(2.28, 2.22)	1.0000
Advanced	3053, 375	198, 39	(6.49, 10.40)	0.0050[c]	67, 11	(2.19, 2.93)	0.3650
Imaging	3162, 266	193, 44	(6.10, 16.54)	0.0001[c]	71, 07	(2.25, 2.63)	0.6850
FNAC	1654, 1774	114, 123	(6.89, 6.93)	0.9620	47, 31	(2.84, 1.75)	0.0320[c]

Abbreviations: Cen.: center; Reg.: regional; H.: hospital; BTT: Bilateral total thyroidectomy; UCT: Unilateral thyroidectomy and contralateral subtotal thyroidectomy; UT: Unilateral thyroidectomy; BIT: Bilateral incomplete thyroidectomy; comp.: compression. Preoperative examination included basic (history, physical examination), advanced (thyroid function), imaging (computed tomography scanning, ultrasonography, isotope scanning, chest X-ray, and magnetic resonance imaging) and fine-needle aspiration cytology (FNAC).

[a] Multiple responses.

[b] Fisher's exact test.

[c] A *P*-value < 0.05 indicated that the complication distribution had statistically significant difference across subgroups. P-values of less than 0.0001 were denoted as 0.0001.

3.6. Logistic regression analysis of RLN injury

A high risk of RLN injury was associated with age of older than 50 years, regional hospitals, and public hospitals; the ORs were respectively 2.15, 3.57, and 1.63 (see Table 3 for other details). Lower risk of RLN injury was related to hospitals in central Taiwan and to the surgical types of wider extent. Cases underwent types other than BTT had significantly lower RLN injury risk; the ORs ranged from 0.25 to 0.44 (see Table 3). A surgery, regardless of type, accompanied with a neck LND had higher RLN injury risk then that without a neck LND (6.08, [95% confidence interval (CI) 1.652, 22.39]; $P = 0.0066$). The increased risk that associated with surgeries of UCT, UT and BIT accompanied with neck LND was nonsignificant as compared with BTT. After adjusting the demographics, surgical type and indications, no preoperative examination implementations showed significant association with the incidence of RLN injury.

4. Discussion

In this multi-center cross-sectional study, association between the preoperative examination implementation and incidence of postoperative hypocalcemia and RLN injury of thyroidectomy was investigated with simultaneously adjusted demographics (including institutional characteristics), surgical type and indications. The incidence of hypocalcemia (7%) and RLN injury (2.28%) were within the range of other studies: 0.6–38% and 1–10%, respectively [5,16–19]. We found that preoperative imaging examination and FNAC analysis were related to lower incidence of hypocalcemia but not RLN injury. This suggested that preoperative examination might have a positive effect on preventing the postoperative hypocalcemia. Our result corroborates a recent report that states a successful thyroid surgery can be achieved by careful preoperative testing, thoughtful consideration of the type of anesthesia and surgery modality and postoperative care [15].

Thyroid surgery is a safe procedure that has a low mortality rate since 1889 attributing to the Swiss surgeon, Theodor Kocher (1841–1917) [14]. However, the postoperative complication of bleeding, hoarseness, infection, hypocalcemia and RLN injury remains albeit the medical progress at the present time [4,5] and this still needs improvement. Recent studies focused on the advancing of techniques for detection (preoperative detection of vitamin D deficiency), treatment (oral calcium supplementation or infusion), key operation procedure training (carefully searching for parathyroid glands and insuring their vascular supply by meticulous dissection and sparing of the periglandular fat), and adjuvant devices (intraoperative neuromonitoring or visual inspection techniques) [5,15]. To our knowledge, the present study is the first to investigate the effect of preoperative evaluation on the postoperative complications for thyroidectomies.

Thyroid surgeries of wider extent are associated with higher complication incidence [9]. The significant descending order was observed in this study for hypocalcemia incidence as: BTT > UCT > BIT > UT. The incidence of RLN injury was significant higher in cases underwent BTT than in those underwent UCT, UT, or BIT; the risk was also increased significantly for neck LND implementation, regardless of surgical type.

Cases with malignancy had higher implementation rates of imaging examinations, and FNAC analysis (95% and 73%, respectively) than those without (91and 35, respectively, $P < 0.0001$). In

Table 3
Logistic regression analysis for the incidence of complications.

Complications	Hypocalcemia			RLN injury		
Covariates	OR	95% CI	*P-value*	OR	95% CI	*P-value*
Age, ≥50 *vs.* <50 (years)	00.55	(0.393, 0.763)	0.0004[a]	2.15	(1.356, 3.4)	0.0011[a]
Hospital level						
Regional *vs.* Center	0.36	(0.221, 0.602)	0.0001[a]	3.57	(2.101, 6.098)	0.0001[a]
Hospital categories						
Public *vs.* private				1.63	(0.968, 2.757)	0.0658
Hospital location						
Northern *vs.* eastern area	10.99	(1.495, 80.715)	0.0185[a]			
Central *vs.* eastern area	19.48	(2.500, 151.804)	0.0046[a]			
Southern *vs.* eastern area	25.18	(3.440, 184.359)	0.0015[a]			
Central *vs.* northern	1.77	(0.983, 3.200)	0.0571			
Southern *vs.* northern	2.29	(1.682, 3.125)	0.0001[a]			
Southern *vs.* central	1.29	(0.732, 2.283)	0.3765			
Central *vs.* other areas				0.08	(0.011, 0.605)	0.0141[a]
Surgical types						
UCT *vs.* BTT	0.51	(0.355, 0.736)	0.0003[a]	0.44	(0.217, 0.878)	0.0201[a]
UT *vs.* BTT	0.04	(0.023, 0.076)	0.0001[a]	0.30	(0.167, 0.536)	0.0001[a]
BIT *vs.* BTT	0.13	(0.080, 0.196)	0.0001[a]	0.25	(0.129, 0.486)	0.0001[a]
UT *vs.* UCT	0.08	(0.044, 0.149)	0.0001[a]	0.68	(0.331, 1.416)	0.3066
BIT *vs.* UCT	0.25	(0.162, 0.374)	0.0001[a]	0.57	(0.260, 1.262)	0.1670
BIT *vs.* UT	3.04	(1.579, 5.834)	0.0009[a]	0.84	(0.417, 1.678)	0.6159
UCT+LND *vs.* BTT				2.66	(0.608,11.615)	0.1941
UT+LND *vs.* BTT				1.82	(0.500, 6.617)	0.3639
BIT+LND *vs.* BTT				1.52	(0.353, 6.571)	0.5733
UT+LND *vs.* UCT				4.16	(1.061, 16.324)	0.0408[a]
BIT+LND *vs.* UCT				3.48	(0.756, 16.045)	0.1092
BIT+LND *vs.* UT				5.09	(1.030,25.144)	0.0459[a]
Preoperative examination						
Imaging	0.50	(0.331, 0.768)	0.0014[a]			
FNAC	0.65	(0.459, 0.911)	0.0127[a]			
Surgical indication						
Aesthetics *vs.* otherwise	0.42	(0.243, 0.721)	0.0017[a]			

[a] A *P*-value < 0.05 indicated that the complication distribution had statistically significant difference across subgroups. *P*-values of less than 0.0001 were denoted as 0.0001.

our practice, the findings of palpably firm nodule by physical examine and suspicious tracheal compression from chest X-ray film were routinely followed by more imaging examinations and FNAC. This would help the disease diagnosis and surgical planning as discussed by several investigators [15,20,21].

After adjusting age group, hospital characteristics, surgical types, and preoperative examination implementation, most surgical indication was not associated with the incidence of hypocalcemia and RLN injury, even though they presented significantly association with complications in preliminary bivariate association analysis (Table 2). It is understandable that postoperative complications depend mostly on the surgeon [3] and hence that the surgical indications no longer as a principal predictor to the postoperative complications provided that effects of other human manipulation factors were considered.

Patient over 50 year of age had a lower risk of hypocalcemia and a higher risk for RLN injury than those younger than 50 years (OR = 0.55 and 2.15, [95% CI: 0.393–0.763 and 1.356–3.40, respectively], $P < 0.0005$). It has been reported that older age has a protective effect for postoperative hypocalcemia. Each one-year increase in age is associated with a 1% decreased risk of postoperative hypocalcemia (OR = 0.990 [0.988–0.992], $P < 0.001$) [22]. By 10 year increase, the adjusted OR is 0.84 [0.71–0.99] [3]. This is also consistent with our own experience that it was easier to separate and handle parathyroid gland from older patients that had a looser connective tissue in the thyroid lobe. An aging process may aggravate the injury of vulnerable areas during the surgery such as Berry's ligament, Zuckerkandl's tubercle, tracheo-esophageal groove, inferior and superior thyroid poles [14] and the RLN is prone to injury during the practices of transection, stretch, traction, pressure, crush, electrical, ischemia or dislodging cricoid cartilage in a thyroidectomy. We observed that RLN was not firmly in its normal position for older patient (>50 years old), therefore RLN injury could be reduced by a careful procedure and applying intraoperative neuromonitoring [23,24]. Thus, a surgeon must be fully aware and well-prepared for the complex anatomy of the central visceral compartment of the neck and recognize the most prevalent anatomic variations concerning the recurrent nerve, the external branch of the superior laryngeal nerve and the parathyroid glands, in order to decrease operative morbidity [14]. These results indicate that a successful thyroidectomy is correlated with preoperative planning and intraoperative management which corroborates the statement from the American Thyroid Association [15].

In this study, the level, location, and category of hospitals expressed association with postoperative hypocalcemia and RLN injury. The institutional characteristics may reflect the practice of training, surgical experience, and surgical team. Specifically, more detailed exposure of RLN structure was performed during operation in medical centers for teaching demonstration. Patients of more complicated or severe illnesses tend to visit larger or public hospitals; therefore, surgeons in medical centers or public hospitals more likely to perform larger extent surgery [10]. However, it is difficult to measurement of surgeons' skillfulness from institutional characteristics [12,13]. Effect of these factors on postoperative complications awaits further studies.

There were some limitations in this study. First, since the data were collected by chart reviewing, the complication incidence might be underestimated due to the lack of medical recording. Nevertheless, this was negligible because the record of medical practice (examinations, prescription, operation, or outpatient expense) was a necessary requirement for claiming the corresponding payment from the national health insurance. The severity

of complication was not defined in the assessment from each hospital and therefore, it could not be compared. Second, it was difficult to collect the covariates related to surgeons' experience in a multi-center survey for the sake of personal information protection. Some studies illustrated those were essential confounders of postoperative complications, while the effect of institution characteristics in a certain extent could represent a group-averaged effect of surgeons' characteristics, as aforementioned. Finally, adjuvant devices had not proposed during the study period, therefore effects of intraoperative inspection techniques for parathyroid gland or neuromonitoring for reducing the postoperative complications await further study.

5. Conclusions

A well-prepared surgeon must be mentally ready for multiple correct and proper maneuvers to meet the challenge of anatomic variations of RLN and parathyroid glands. Age has a protective effect for postoperative hypocalcemia because of the loose anatomic attachment of parathyroid gland. Implementing the preoperative imaging is helpful to identify the parathyroid glands and prevent postoperative hypocalcemia in younger patients, while the reduction of RLN injury largely depends on intraoperative monitor to avoid the injury to more vulnerable RLN in older patients. Therefore, complete preoperative evaluation and mental readiness may have a positive effect on prevention of postoperative complications.

Conflict of interest

All authors have no conflicts of interest.

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Ethical approval

IRB of Tungs' Taichung MetroHarbor Hospital (IRB no. 103203N).

Author contribution

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References

[1] Sun GH, DeMonner S, Davis MM. Epidemiological and economic trends in inpatient and outpatient thyroidectomy in the United States, 1996-2006. Thyroid 2013;23:727–33.
[2] Hegner CF. A history of thyroid surgery. Ann Surg 1932;95:481–92. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1391584/- fn1.
[3] Duclos A, Peix JL, Colin C, Kraimps JL, Menegaux F, Pattou F, et al. Influence of experience on performance of individual surgeons in thyroid surgery: prospective cross sectional multicentre study. BMJ 2012;344. d8041.
[4] Wagner HE, Seiler C. Recurrent laryngeal nerve palsy after thyroid gland surgery. Br J Surg 1994;81:226–8.
[5] Christou N, Mathonnet M. Complications after total thyroidectomy. J Visc Surg 2013;150:249–56.
[6] Landerholm K, Wasner AM, Järhult J. Incidence and risk factors for injuries to the recurrent laryngeal nerve during neck surgery in the moderate-volume setting. Langenbecks Arch Surg 2014;399(4):509–15.
[7] Godballe C, Madsen AR, Sørensen CH, Schytte S, Trolle W, Helweg-Larsen J, et al. Risk factors for recurrent nerve palsy after thyroid surgery: a national study of patients treated at Danish departments of ENT head and neck surgery. Eur Arch Otorhinolaryngol 2014;271(8):2267–76.
[8] Lamadé W, Renz K, Willeke F, Klar E, Herfarth C. Effect of training on the incidence of nerve damage in thyroid surgery. Br J Surg 1999;86. 388e91.
[9] Thomusch O, Machens A, Sekulla C, Ukkat J, Lippert H, Gastinger I, et al. Multivariate analysis of risk factors for postoperative complications in benign goiter surgery: prospective multicenter study in Germany. World J Surg 2000;24. 1335e41.
[10] Huang SM, Lee CH, Chou FF, Liaw KY, Wu TC, Taiwan Endocrine Surgeons Study Group. Characteristics of thyroidectomy in Taiwan. J Formos Med Assoc 2006;104:6–11.
[11] Cherenfant GM, Mangold K, Du H, Moo-Young T, Winchester DJ, Prinz RA. Trends in thyroid surgery in Illinois. Surgery 2013;154:1016–23.
[12] 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. 320e30.
[13] Southern WN, Bellin EY, Arnsten JH. Longer lengths of stay and higher risk of mortality among inpatients of physicians with more years in practice. Am J Med 2011;124:868–74.
[14] Cernea CR, Brandão LG, Hojaij FC, De Carlucci D, Montenegro FL, Plopper C, et al. How to minimize complications in thyroid surgery? Auris Nasus Larynx 2010;37:1–5.
[15] Chen AY, Bernet VJ, Carty SE, Davies TF, Ganly I, Inabnet 3rd WB, et al. American Thyroid association statement on optimal surgical management of goiter. Thyroid 2014;24:181–9.
[16] Wong KP, Lang BH, Ng SH, Cheung CY, Chan CT, Lo CY. A prospective, assessor-blind evaluation of surgeon-performed transcutaneous laryngeal ultrasonography in vocal cord examination before and after thyroidectomy. Surgery 2013;154:1158–64.
[17] Jiang Y, Gao B, Zhang X, Zhao J, Chen J, Zhang S, et al. Prevention and treatment of recurrent laryngeal nerve injury in thyroid surgery. Int J Clin Exp Med 2014;7:101–7.
[18] Edafe O, Antakia R, Laskar N, Uttley L, Balasubramanian SP. Systematic review and meta-analysis of predictors of post-thyroidectomy hypocalcaemia. Br J Surg 2014;101:307–20.
[19] Agarwal G, Aggarwal V. Is total thyroidectomy the surgical procedure of choice for benign multinodular goiter? an evidence-based review. World J Surg 2008;32:1313–24.
[20] Carpi A, Mechanick JI, Nicolini A, Rubello D, Iervasi G, Bonazzi V, et al. Thyroid nodule evaluation: what have we really learned from recent clinical guidelines? Biomed Pharmacother 2006;60:393–5.
[21] Perros P. 2009 American thyroid association guidelines on thyroid nodules. Clin Oncol 2010;22:469–71.
[22] Baldassarre RL, Chang DC, Brumund KT, Bouvet M. Predictors of hypocalcemia after thyroidectomy: results from the nationwide inpatient sample. ISRN Surg 2012;2012:838614.
[23] Barczyński M, Konturek A, Stopa M, Honowska A, Nowak W. Randomized clinical trial of visualization versus neuromonitoring of the external branch of the superior laryngeal nerve during thyroidectomy. World J Surg 2012;36:1340–7.
[24] Zheng S, Xu Z, Wei Y, Zeng M, He J. Effect of intraoperative neuromonitoring on recurrent laryngeal nerve palsy rates after thyroid surgery – a meta-analysis. J Formos Med Assoc 2013;112:463–72.