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Proposal of integrated clinical pathway in the management of perioperative recurrent laryngeal nerve injury post thyroid and parathyroid surgery

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Early intervention is the current paradigm shift in the management of recurrent laryngeal nerve (RLN) injury post thyroidectomy and parathyroidectomy. Thus, an integrated clinical pathway is needed to enable early detection of RLN injury. A prospective longitudinal study was conducted from 2015 until 2021 in a single tertiary centre. A clinical pathway was developed where routine perioperative laryngeal assessments were implemented for all patients who underwent thyroidectomy and parathyroidectomy. Following an RLN injury, early surgical intervention was performed for unilateral vocal fold paralysis (UVFP). Data on patient demographics, risk factors, timing of RLN injury detection and type of intervention received were recorded in a proforma and analysed. 397 patients were included, involving 660 nerves at risk. The incidences of permanent RLN injury following thyroidectomy and parathyroidectomy were 5% and 1.8% respectively. The usage of intraoperative neuromonitoring was the only significant factor that affected the RLN injury according to multivariate analysis. 15% of RLN injuries were detected intraoperatively and 98% within two days. 70% of patients with UVFP received intervention in less than two weeks. The integrated clinical pathway has improved the validity of RLN injury incidence. It allows early detection of RLN injury and facilitates immediate intervention.

Keywords Recurrent laryngeal nerve injury, Thyroidectomy, Parathyroidectomy, Vocal fold paralysis, Risk factors, Complications

Recurrent laryngeal nerve (RLN) injury is a potential complication in thyroid and parathyroid surgery. The symptoms can be life-threatening, including upper airway obstruction due to bilateral vocal fold palsy (BVFP). Although unilateral vocal fold palsy (UVFP) patients may be devoid of airway compromise, the common issues of hoarseness, aspiration and chronic cough, significantly affect the postoperative quality of life[1–3].

In a systematic review, the incidence of permanent RLN palsy varies widely from none to 18%. A wider range of incidence was seen in temporary RLN palsy (1.4–38.4%). Different diagnostic methods have been used to identify nerve injury, which has led to underreporting of RLN injury in thyroid and parathyroid surgery[1]. This causes delays in managing nerve injuries according to the current recommendations. Early phono-surgical interventions have been shown to prevent muscle tension dysphonia and avoid permanent surgical intervention later[4,5]. The discrepancy also may be attributed to selection bias[1]. However, the reported risk factors for RLN injury have been inconsistent between studies, raising doubt about the validity of these selection biases[6–10].

The American Head and Neck Society has proposed targeted pre-operative laryngeal assessment only for high-risk thyroidectomies[11]. However, we have adopted routine laryngeal assessment peri-operatively in all patients undergoing thyroid or parathyroid surgery[9,12]. Early surgical intervention has been employed in our centre, including early temporary injection laryngoplasty and/ or immediate non-selective laryngeal reinnervation (NSLR). The present study aims to investigate the incidence of RLN injury in patients undergoing

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thyroidectomy and parathyroidectomy by reviewing longitudinal data from routine laryngeal assessments using a standard proforma, then evaluating the integrated clinical pathway that has been employed in managing acute UVFP.

Methods

A six-year observational longitudinal study was conducted in a tertiary referral centre. All patients who underwent thyroidectomy or parathyroidectomy from January 2015 until December 2021 were included in this study. The exclusion criteria were patients with pre-operative recurrent laryngeal nerve palsy or paresis; incomplete peri-operative laryngeal assessment; inaccessible medical records; and patients who defaulted follow-up within 6 months.

Demographic data such as patient age, gender, ethnicity, and comorbidities were collected. Perioperative laryngeal assessment proformas were reviewed and patients with post-operative RLN injury were categorized as having either nerve paresis, temporary nerve palsy or permanent nerve palsy. RLN injury showing no signs of recovery after six months was considered to be permanent palsy[8,10,13]. Medical records were reviewed to identify the possible risk factors for RLN injury, such as type of disease, recurrent disease, recurrent surgery, tumour greatest dimension and tumour weight. Operative notes were evaluated to detect the use of intraoperative neuromonitoring and intraoperative findings. In cases of UVFP, medical records were further explored to detect the duration of diagnosis and intervention offered following injury.

All patients undergoing thyroid or parathyroid surgery in our centre are referred for laryngeal assessment and subsequently follows the integrated clinical pathway. The pre-operative assessments include patient self-report questionnaires, such as Bahasa Malaysia version Voice Handicap Index (mVHI-10)[14], Eating Assessment Tool (EAT-10)[15] and reflux symptom index (RSI)[16]. Patients are then asked to read a standardized script with a video recording fixed at 30 cm away from the patient's lips. The voice is evaluated using an index auditory-perception assessment, resulting in a GRBAS score[17]. Acoustic analysis is performed via OperaVOX version 2.2 software installed on an iPod. The vowel /a/ is used for the voice recording, while data such as maximum phonation time (MPT) and acoustic parameter (fundamental frequency, jitter%, shimmer%, and noise to harmonic ratio) are obtained[18].

Following a complete head and neck examination, a flexible nasopharyngolaryngoscopy (FNLPS) was performed to examine the larynx particularly the vocal fold mobility. The collected data was registered into a proforma developed by our centre. All assessments were reviewed by the senior author (MMB), who is a laryngologist. For high-risk cases in which RLN injury was highly anticipated, intraoperative interventions such as injection laryngoplasty or NSLR were offered to the patients preoperatively. A repeat laryngeal assessment was conducted two days post-surgery, or earlier if the patient complained of voice-related symptoms. Video laryngostroboscopy was used to further evaluate any vocal fold paresis or palsy. Figure 1 demonstrates the integrated

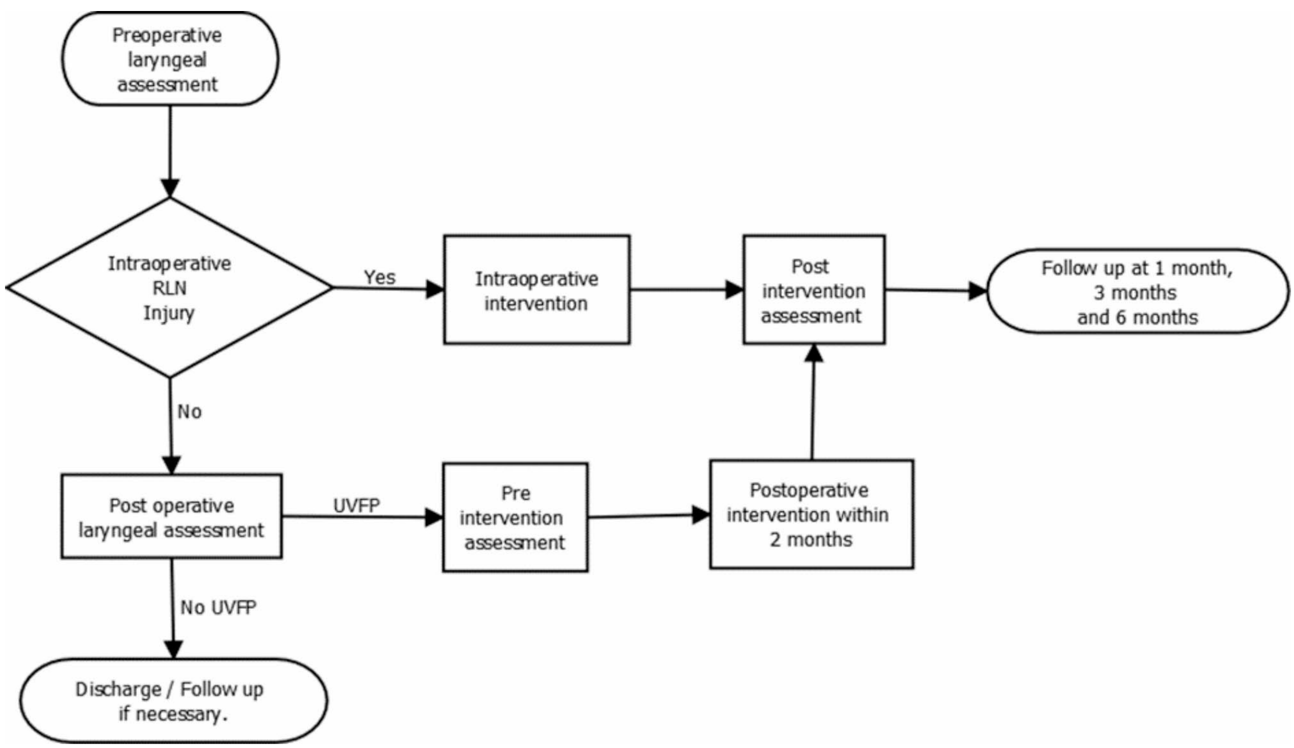

Fig. 1. Integrated clinical pathway of recurrent laryngeal nerve injury post thyroidectomy and parathyroidectomy.

clinical pathway of patients who underwent thyroid and parathyroid surgery, and subsequent management if the patients develop RLN injury.

The thyroid and parathyroid surgeries were performed mainly by three main consultants specializing in breast and endocrine surgery. Two types of intraoperative neuromonitoring (IONM) were used during the surgery. The intermittent IONM (I-IONM) uses a handheld stimulation probe to differentiate nerve from other tissue. An auditory signal is presented only when the surgeon uses the probe to stimulate the nerve. Meanwhile, continuous IONM (C-IONM) provides real-time monitoring of the nerve status throughout the surgery. The vagus nerve needs to be delineated in between carotid and internal jugular vein and exposed 360 degrees to place the electrode. C-IONM has been adopted as a standard practice in our centre for the last 8 years. However, certain surgeons prefer direct visualization or at least I-IONM and reserve C-IONM for high-risk and complicated cases. If there is evidence of signal loss (type 3a or 3b injury), an otorhinolaryngologist will be consulted for intraoperative intervention[19–21]. In such cases, transoral injection laryngoplasty is commonly performed in the same setting. Hyaluronic acid gel is injected into the paraglottic space to augment the vocal fold position and achieve glottic competence[22]. When the unilateral RLN is inadvertently or intentionally cut during surgery, NSLR is performed using either RLN-to-RLN or ansa cervicalis-to-RLN neurorrhaphy. This procedure is often combined with transoral injection laryngoplasty for optimal voice outcomes[23]. For UVFP detected postoperatively, percutaneous injection laryngoplasty can be performed as an office-based procedure.

Analysis was performed using SPSS version 23.0. The incidence rate of RLN injury was based on the number of nerves at risk (NAR) and presented in percentages. Univariate and multivariate analysis were used to determine the risk factors of RLN injury where *P* value less than 0.05 was considered as statistically significant[24]. Chi-square test was used to find the association of type of IONM and RLN injury risk. Descriptive analysis is used to analyse data of patients that receive early intervention. Ethics approval was attained from the Research Ethics Committee, The National University of Malaysia (FF-2020-348) and this study was conducted in accordance with these guidelines.

Results

397 out of 494 patients met the inclusion criteria which involved 660 NAR. Of these, 311 (78.2%) were thyroidectomy cases while 86 (27.7%) were parathyroidectomy cases. Table 1 provides the demographic data of the patients, including age, gender, race, and comorbidities. Both groups have a similar mean age, 50 and 52 years old. More than half of the patients were of Malay ethnicity (69%, 72.1%) and female (64%, 80.1%). About two-thirds (63.7%) of thyroidectomies had one or more comorbidities. In parathyroidectomies, 93% of patients had multiple comorbidities.

There were 188 cases of total thyroidectomy and 123 cases of hemithyroidectomy. These surgeries placed 499 RLN at risk during thyroidectomy, where 56 nerves were injured (11.2%) of which 25 nerves had permanent palsy (5%), 22 nerves had temporary palsy (4.4%) and 9 nerves had paresis (1.8%). The latest consensuses on RLN injury classification post thyroid and parathyroid surgery are also described, as presented in Table 2. In parathyroidectomies, the incidence of permanent RLN palsy is low at 1.8%. Meanwhile, the rate of temporary RLN palsy was 3.7% and the rate of RLN paresis was 2.4%.

Tables 3 and 4 showed risk factors that were included in this study, consisting of type of lesion (benign or malignant), disease recurrence, tumour extension (retrosternal or other surrounding structure), recurrent surgery, extend of surgery (total or hemithyroidectomy), the usage of IONM (no monitoring or either intermittent or continuous), tumour weight and tumour greatest dimension. A higher frequency of RLN injury was seen in malignant lesions (15.6%), recurrent disease (20.8%), invasion of tumour to surround structure (19%), recurrent

Demographic	Thyroidectomy (n = 311)	Parathytoidectomy (n = 86)
Age, years		
Mean (SD*)	52 (± 15.6)	50 (± 13)
Range	13–80	24–78
Gender		
Male (%)	62 (19.9)	31 (36)
Female (%)	249 (80.1)	55 (64)
Race		
Malay (%)	217 (69.8)	62 (72.1)
Chinese (%)	74 (23.8)	20 (23.3)
India (%)	18 (5.8)	3 (3.5)
Others (%)	2 (0.6)	1 (1.2)
Comorbidities		
None	113 (36.3)	2 (2.3)
Single	70 (22.5)	4 (4.7)
Multiple	128 (41.2)	80 (93)

Table 1. Demographic profile of thyroidectomy and parathyroidectomy patients. *SD; Standard deviation.

Type of nerve injury	Number of nerves injured in Thyroidectomy (n = 499)	Number of nerves injured in Parathyroidectomy (n = 161)
Permanent RLN* palsy (No recovery after more than 6 months)	**25 (5.0%)**	**3 (1.8%)**
Temporary RLN* palsy (Recovery less than 6 months)	**22 (4.4%)**	**6 (3.7%)**
RLN paresis	9 (1.8%)	4 (2.4%)
SLN** palsy	8 (1.6%)	1 (0.62%)
Immediate vocal fold paralysis (Vocal fold palsy regardless of prognosis)[25]	47 (9.4%)	9 (5.59%)
Partial neural dysfunction (Sensory or motor dysfunction of SLN** and RLN*)[25]	17 (3.4%)	5 (3.11%)

Table 2. Types of nerve injury post thyroidectomy and parathyroidectomy. *RLN; recurrent laryngeal nerve, **SLN; superior laryngeal nerve. Significant values are in bold.

Variables	RLN injury		Univariate logistic regression B, OR* (*P*-Value)	Multivariate logistic regression B, OR* (*P*-Value)
	No N = 591	Yes N = 69		
Type of Lesion				
Benign	472 (90.1%)	47(9.1%)	**0.62, 1.86 (0.03)**	0.53, 1.71 (0.08)
Malignant	119 (84.4%)	22(15.6%)		
Disease recurrence				
No	572 (89.9%)	64(10.1%)	0.86, 2.35 (0.10)	
Yes	19 (79.2%)	5(20.8%)		
Tumor Extension				
No extension	495 (90%)	55(10%)	0.28, 1.32 (0.25)	
Retrosternal	79 (88.8%)	10(11.2%)		
Invading surround structure	17 (81%)	4(19%)		
Recurrent Surgery				
No	543(90.2%)	59(9.8%)	0.65, 1.92 (0.08)	
Yes	48(82.8%)	10(17.2%)		
Extent of surgery				
Hemi	120(90.2%)	13(9.8%)	0.09, 1.10 (0.77)	
Total	471(89.4%)	56(10.6%)		
Intraoperative neuromonitoring				
No monitoring	9(33.3%)	18(66.7%)	**-2.90, 0.05 (0.00)**	**-2.93, 0.05 (0.00)**
Intermittent or Continuous	447(90.1%)	49(9.9%)		

Table 3. Risk factors for RLN injury in thyroidectomy and parathyroidectomy using univariate and multivariate analysis. *OR; Odds ratio. Significant values are in bold.

Variables	Mean (SD*)	Range	Univariate logistic regression B, OR** (*P*-Value)
Thyroid			
Weight	97.18 g (± 105.9)	2.4 g–790 g	0.00, 1.00 (0.79)
Greatest dimension	7.08 cm (± 2.53)	2 cm–15 cm	**0.11, 1.12 (0.02)**
Parathyroid tumour			
Weight	2.29 g (± 0.86)	0.1 g–23.5 g	0.10, 1.10 (0.12)
Greatest dimension	2.34 cm (± 3.01)	0.7 cm–6.5 cm	-0.04, 0.96 (0.90)

Table 4. Tumour's weight and greatest dimension and its association with RLN injury. *SD; Standard deviation, **OR; Odds ratio. Significant values are in bold.

surgery (17.2%) and total thyroidectomy or parathyroidectomy (10.6%). Whereas a lower frequency of RLN injury was observed in nerves monitored using intraoperative neuromonitoring (9.9%).

Univariate logistic regression has been conducted to determine which factors significantly contributed to RLN injury. The findings revealed that type of lesion (B = 2.08, OR = 1.86, $p < 0.05$) and IONM (B = -2.09, OR = 0.05, $p < 0.05$) significantly predicts RLN injury. Those with malignant lesion are 1.86 times more likely to get RLN injury as compared to those with benign lesions. Patients who had IONM applied were less likely to get

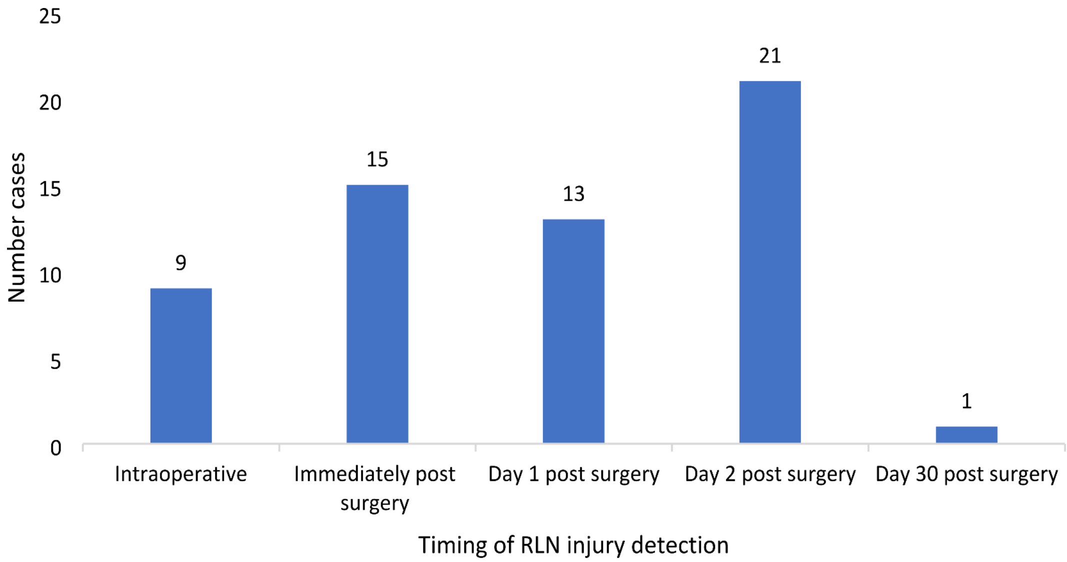

Fig. 2. Timing of RLN injury detection.

Type of UVFP intervention	Number of UVFP cases intervened		
	Less than 2 weeks	**2 weeks to 2 months**	**After 2 months**
Injection laryngoplasty	11	5	2
Non-selective laryngeal reinnervation	1	-	-
Non-selective laryngeal reinnervation with injection laryngoplasty	5	-	-
Total	**17 (70%)**	**5 (21%)**	**2 (8%)**

Table 5. Type of UVFP intervention and timing of surgery. Significant values are in bold.

RLN injury with odds ratio 0.05. However, recurrent disease (B = 0.86, OR = 2.35, $p > 0.05$), tumour extension (B = 0.28, OR = 1.32, $p > 0.05$), recurrent surgery (B = 0.65, OR = 1.92, $p > 0.05$) and extent of surgery (B = 0.09 OR = 0.77, $P > 0.05$) did not significantly predict RLN injury. Further analysis was performed via multivariate logistic regression, showing that the usage of IONM significantly affected RLN injury (B = -2.93, OR = 0.05, $p < 0.05$). Type of lesion whether malignant or benign did not significantly affect RLNI (B = 0.53, OR = 1.71, $p > 0.05$).

The average thyroid weight was 97.18 ± 105.97 g and the greatest dimension was 7.08 ± 2.53 cm. Univariate logistic regression showed that tumour greatest dimension significantly predicts RLN injury (B = 0.112, OR = 1.118, $p < 0.05$). Patients who had larger tumour dimension is 1.118 time more likely to get RLN injury as compared to those with smaller dimension. However, the tumour weight did not significantly cause RLN injury (B = 0.00, OR = 1.00, $P > 0.05$). For parathyroid tumours, the mean and standard deviation for tumour weight was 2.29 ± 0.86 g while tumour greatest dimension was 2.34 ± 3.01 cm. Statistical analysis also demonstrated parathyroid greatest dimension (b = -0.039, OR = 0.962, $p > 0.05$) and weight (B = 0.099, OR = 1.104, $p > 0.05$) did not significantly affect RLN injury.

To evaluate data on case detection and intervention, number of cases are used instead of NAR. The intraoperative RLN injury was detected in 9 cases (15%) either via intraoperative neuromonitoring or, direct vision when the nerve was transacted. A majority of RLN injury cases were diagnosed during routine postoperative laryngeal assessment. Overall, 58 (98.3%) RLN injuries were detected within two days post-surgery, while all RLN injuries were successfully identified within one month, Fig. 2.

RLN injury post thyroidectomy and parathyroidectomy were identified in 59 patients: 40 cases of UVFP, 11 cases of unilateral paresis, and 8 cases of bilateral vocal fold palsy. Among UVFP patients, 16 patients refused surgical intervention and opted for conservative management instead. Seventeen of 24 cases (71%) underwent successful intervention within two weeks, while 90% of cases underwent intervention within two months, as shown in Table 5.

Discussions

This study proposed an integrated clinical pathway for intraoperative RLN injury in thyroid and parathyroid surgery. Through this prospective study, a true incidence of RLN injury and associated risk factors were observed. The type of intervention and its timing were reviewed to evaluate our compliance to the proposed clinical pathway. The strength of this study is attributed to routine perioperative laryngeal assessment which may detect asymptomatic vocal fold palsy preoperatively. The surgeons' voice assessment alone did not meet the desired sensitivity as a screening tool for patients with underlying vocal fold palsy[12]. Routine laryngeal assessment assists in pre-operative planning and counselling, as well as enhancing the validity of post-operative laryngeal findings[26]. The assessment protocol enables early detection of RLN injury and permits early intervention following acute UVFP.

Our incidence of RLN injury post thyroidectomy was at 4.4% for temporary and 5.0% for permanent palsy, based on NAR. Meanwhile, in parathyroidectomy the incidence rates of permanent and temporary RLN palsy were 1.8% and 3.7%, respectively. In comparison to Steurer et al., which also emphasized routine laryngeal assessment, the incidence of temporary RLN palsy was reported at 3.4% for benign thyroid disease, 7.2% for malignant thyroid disease and 2.5% for parathyroid lesions. As two years period was used to label a RLN palsy as permanent, lower incidence rates were observed at 0.3%, 1.2%, and 0%, respectively[27]. A similar study design by Joliat et al. estimated the incidence of RLN injury based on number of cases instead of NAR and defined permanent RLN palsy by one-year period. In comparison to our findings, the temporary RLN palsy was higher (10.6% vs 4.5%), and lower incidence was observed for permanent RLN palsy (1.1% vs 6.3%)[9]. A local study with a shorter waiting period to diagnose permanent RLN palsy (6 months) revealed that the incidence of temporary RLN injury was 7.3% and 4.9% for permanent[13], nearing our incidence. However, the peri-operative laryngeal assessment was inadequately described. Another local study reported no RLN injury following thyroidectomy in benign cases, but the method of laryngeal assessment was not explained[28]. Our RLN injury incidence is still within the range derived from a systematic review involving 27,000 patients, with 9.8% (1.4–38.4%) in temporary RLN palsy and 3.2% (0–18.6%) in permanent RLN palsy[1].

In 2020, the Endocrine Committee of American Head and Neck Society proposed a new RLN injury terminology in keeping with the current shift in management. In contrast to conventional "temporary" and "permanent" palsy, "immediate vocal fold paralysis" refers to all vocal palsy post thyroid surgery, regardless of prognosis. Meanwhile, partial neural dysfunction addressed the complexity of RLN injury which involved both motor and sensory dysfunction, including nerve paresis and also superior laryngeal nerve function[25]. Using this terminology in the present study, the incidence of immediate vocal fold paralysis is of 9% in thyroidectomy and of 5.59% in parathyroidectomy. Partial neural dysfunction accounts for 3% for both thyroidectomy and parathyroidectomy. Thus, in our setting, immediate vocal fold paralysis is more common and should be actively detected to permit early intervention in acute UVFP.

The risk factors for RLN injury post thyroid and parathyroid surgery vary across studies[6–10,29–32]. We reported statistically significant higher odds of RLN injury in cases of malignancy, large tumour size and absence of IONM, based on univariate analysis. Malignant thyroid lesions increase the risk of overall RLN by almost two-fold (OR 1.86, $p < 0.05$) and these findings were consistent with previous reports[6,7,29,30,33]. In fact, the incidence of permanent RLN palsy is higher in malignant thyroid disease[8,33,34]. Neoplasia can cause desmoplastic changes to the surrounding tissue or directly infiltrate the nerve. Malignant tumours require more extensive surgery with paratracheal neck dissection for oncological clearance[29,30] This causes RLN to have a greater risk of injury. Tumour size significantly influences the risk of RLN injury (OR 1.12, $p < 0.05$) and this is coherent with other studies despite various techniques being used to calculate the size. A tumour size of more than 100 ml increases the risk of temporary RLN palsy due to stretch injury[31,33]. While the higher odds seen in retrosternal extension and recurrent surgery were not statistically significant, a meta-analysis by Głód et al. using a larger sample size has demonstrated that these risk factors are highly significant for RLN injury[33].

Under multivariate analysis, the usage of IONM is the only significant risk factor which affects RLN injury (OR 0.05, $p < 0.05$). This finding is parallel to other retrospective studies[29,35,36], but several systematic reviews have shown the opposite. The meta-analysis derived no conclusive evidence to support the advantage of IONM over direct visualization in preventing RLN injury[37,38]. However, more studies advocate its usage in reducing the severity of RLN injury[20,39]. According to Wojtczak et al., IONM consistently reduced the odds of vocal fold paralysis across 12 subgroups of risk factors except in low-volume surgeon experience[39]. C-IONM has been shown to increase RLN identification rate, recognize nerve stress, thus reducing neuropraxia and guide surgeons either to proceed with surgery on the opposite or not if there is signal loss in bilateral thyroid disease[19,40–42]. The C-IONM positive predictive value is up to 99.5% with low false positive (0.3%)[43]. False positive signal may still occur which can be due to inconsistent cut-off point to define signal loss or intubation injury[37]. Thus, hinders the chance for intraoperative intervention. Our sub-analysis in comparing C-IONM and I-IONM in reducing RLN injury was not statistically significant ($p = 0.5$) as the sample rate for I-IONM was too small (N = 430 vs 66). The small sample may be due to recall bias where surgeons did not routinely document the usage of IONM during the early phase of this study.

Surgical interventions in UVFP post thyroid and parathyroid surgery aim to improve voice quality, eliminate aspiration and therefore, improve quality of life[44,45]. The previous treatment algorithm delays any permanent surgical intervention until one year. However, within this period, hoarseness and aspiration can worsen and affects quality of life further[3]. This will end up worsening patients' trust in their surgeons[46]. The timing of intervention in RLN palsy influences voice outcome according to meta-analysis[5,47,48]. Reversible intervention such as injection laryngoplasty has proven to produce the greatest voice improvement between pre and post treatment if done within 12 months compare to those performed after one year. The meta-analysis also concluded that permanent intervention should be performed after 12 months. Option of permanent intervention such as nonselective laryngeal reinnervation (NSLR) is proven to be more effective than type 1 thyroplasty[49]. Primary intervention (NSLR with concurrent injection laryngoplasty) is beneficial in limiting morbidities and improving quality of life related to UVFP, and outcomes are better if performed early[23,47]. Meanwhile, a long term study has shown that reinnervation surgery provide better outcome than injection laryngoplasty even after 36 months follow up[50]. Fancello et al. proposed to integrate reversible intervention in to reinnervation surgery as it may require up to six months for recovery[51].

To achieve these optimal outcomes, proper pre-thyroidectomy planning is essential. Input from the pre-operative laryngeal assessment may guide surgeons in counselling patient for the possibility of phonosurgical interventions. In the present study, the early detection of RLN injury allowed intraoperative intervention (15%) and therefore reduced the number of subsequent general anaesthesia procedures. Moreover, early intervention is possible in our setting, as the RLN palsy detection rate was the highest at two days post operation. Thus, 70% of cases received intervention within two weeks and up to 90% in two months. Those who refused interventions may be either asymptomatic or experienced mild symptoms; hence, a long-term study is needed to observe the outcome in this group of patients.

Approximately 10% of the cases were excluded because of incomplete laryngeal assessment. This is considered an acceptable dropout rate[52]. This may, however, have led to an underestimation of the actual incidence rate of RLN injury in our centre. The incomplete assessments were mainly observed during the early part of our study and as the working system is more familiarised, lesser unsatisfactory assessment were encountered. In our centre, the average thyroid weight and dimension was more than 80 g and 4 cm, respectively, values which indicate a large thyroid mass[53]. This may contribute to selection bias and overestimate the incidence of RLN palsy.

Conclusions

The incidence rates of permanent and temporary RLN injury following thyroidectomy were 5% and 4.4%, respectively. While for parathyroidectomy, the incidence rates were 1.8% for permanent palsy and 3.2% for temporary palsy. Malignant lesion, tumour size and absence of intraoperative neuromonitoring were associated with higher odds of developing RLN injury. The integrated clinical pathway enabled early detection of RLN injury and subsequently allowed surgical intervention immediately. These management strategies are vital to shift the current practice towards the updated treatment recommendations.

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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