Assessment of Pre-Extubating Recurrent Laryngeal Nerve Palsy Using Ultrasound in Postoperative Patients with Thyroidectomy: A Prospective Observational Study

Abstract

Background: Recurrent laryngeal nerve (RLN) palsy is a major complication after thyroidectomy. Early detection before extubation may help anticipate airway compromise and guide timely management. Transcutaneous laryngeal ultrasonography (TLUSG) offers a noninvasive bedside option, but its pre-extubation utility remains insufficiently studied. **This study aimed to** evaluate the inter-rater reliability and diagnostic performance of pre-extubation ultrasound for detecting RLN palsy after thyroidectomy, using post-extubation video-assisted laryngoscopy as the reference standard. **Methods:** This prospective observational study included 30 adults undergoing elective thyroidectomy under general anesthesia. Vocal cord mobility was assessed before extubation by ultrasound and independently interpreted by three raters; a consensus assessment was also generated. After extubation, vocal cord mobility was reassessed using video-assisted laryngoscopy. **Results**: Video-assisted laryngoscopy confirmed RLN injury in 5/30 patients (16.7%). Pre-extubation ultrasound identified RLN injury in 20.0%, 16.7%, and 13.3% of patients by raters 1, 2, and 3, respectively. Overall inter-rater agreement was fair (Fleiss' Kappa [κ]=0.28, P=0.008). Agreement with the reference standard was highest for rater 3 and the consensus assessment (κ=0.609, P=0.009). Both showed 60.0% sensitivity, 96.0% specificity, 75.0% positive predictive value, 92.3% negative predictive value, and 78.0% accuracy. RLN injury was significantly associated with male sex and longer operative duration. **Conclusion:** Pre-extubation ultrasound is a feasible, safe, and noninvasive adjunct for RLN assessment after thyroidectomy. Its high specificity and negative predictive value support bedside screening use, but modest sensitivity and operator dependence limit its role as a standalone alternative to laryngoscopy.

Keywords: Thyroidectomy, Recurrent Laryngeal Nerve, Ultrasonography, Vocal Cord Palsy, Laryngoscopy.

Introduction:

Injury to the recurrent laryngeal nerve (RLN) remains one of the most serious and concerning complications of thyroid and parathyroid operations, owing to its substantial impact on postoperative outcomes and patient quality of life [1]. As the RLN supplies motor innervation to nearly all intrinsic laryngeal muscles, with the exception of the cricothyroid muscle, damage to this nerve can lead to impaired vocal cord mobility ranging from paresis to complete paralysis. Clinically, affected patients commonly develop postoperative voice changes, while some may also experience dysphagia or respiratory distress. The clinical course is variable and depends largely on the mechanism and severity of nerve insult, which may include traction, compression, thermal damage, or complete transection [2].

Confirmation of the diagnosis is typically achieved by direct visualization of vocal cord motion using laryngoscopy or bronchoscopy. Despite their diagnostic value, these techniques may be uncomfortable and poorly tolerated by patients. More recently,

transcutaneous laryngeal ultrasonography (TLUSG) has emerged as a promising alternative for vocal cord assessment. It offers the advantages of being bedside applicable, noninvasive, and free of procedure-related complications. Nevertheless, most published studies have evaluated vocal cord paralysis with ultrasonography only after extubation, while pre-extubation diagnosis has been reported only rarely, including a single case of bilateral vocal cord paralysis identified before tube removal [3].

Detecting vocal cord paralysis prior to extubation is clinically important, as it may help predict the need for urgent airway support, including reintubation or tracheostomy, and allows the team to prepare appropriately for potential airway compromise [4].

Therefore, this study aimed to examine the versatility (interrater reliability) and usefulness of ultrasound for evaluating the movement of vocal cords before extubation.

Patients and methods:

Patients:

This prospective observational study enrolled 30 adult patients undergoing elective thyroidectomy under general anesthesia at Benha University Hospitals over a 12-month period, from February 2025 to February 2026. Written informed consent was obtained from all participants after a full explanation of the study objectives and procedures. The study protocol was approved by the Research Ethics Committee of the Faculty of Medicine, Benha University (Approval No. MS 36-12-2024).

Eligibility criteria

Eligible participants were adults aged 18 to 60 years, of either sex, classified as ASA physical status I or II, and scheduled for elective thyroidectomy under general anesthesia. Patients were excluded if they had uncontrolled hypertension, hepatic or renal impairment, neurological or psychiatric disorders, or if they declined participation.

Preoperative Assessment

All patients underwent comprehensive preoperative evaluation that included detailed medical and surgical history taking, complete clinical examination, and routine laboratory investigations. The laboratory workup comprised CBC, coagulation profile, renal function tests, liver function tests, and thyroid profile. In addition, all patients were subjected to preoperative video-assisted laryngoscopic examination to assess baseline vocal cord mobility before surgery. Chest X-ray was also performed to evaluate the possibility of retrosternal extension.

Anesthetic Technique

Upon arrival in the operating room, all patients were connected to standard routine monitors. General anesthesia was induced with intravenous propofol 2 mg/kg, fentanyl 1 μg/kg, and atracurium 0.5 mg/kg to facilitate endotracheal intubation. Anesthesia was maintained using isoflurane. Because ordinary polyvinyl chloride endotracheal tubes may kink beneath surgical drapes and predispose to airway

obstruction, an armored endotracheal tube was preferred for airway management in all patients to minimize the possibility of tube kinking during thyroid surgery. At the end of surgery, and after complete recovery from neuromuscular blockade, pre-extubation assessment of vocal cord mobility was performed using ultrasound while the endotracheal tube was still in place. After extubation, vocal cord mobility was reassessed using a video-assisted laryngoscope, which was considered the reference standard for comparison.

Ultrasound Assessment of Vocal Cord Mobility

Pre-extubation ultrasound examination was performed at the completion of surgery before extubation, after full recovery from muscle relaxation, using an ultrasound machine (LOGIQ e series, GE Medical Systems (China) Co., Ltd., China) with a linear transducer probe (frequency not readable from the provided images). The examination was carried out to assess the mobility of the vocal cords and identify possible RLN palsy. Ultrasound findings were independently evaluated by three raters. Each rater assessed vocal cord motion separately, and the result of each rater was documented. A consensus assessment was also derived for comparison with the post-extubation gold standard result. The use of multiple raters aimed to evaluate the inter-rater reliability and versatility of ultrasound in detecting RLN injury before extubation.

Video-Assisted Laryngoscopic Assessment

Following extubation, vocal cord mobility was evaluated using a video-assisted laryngoscope (C-MAC video laryngoscope, Karl Storz SE & Co. KG, Tuttlingen, Germany). This examination was considered the gold standard for the diagnosis of RLN palsy. The ultrasound findings obtained before extubation were compared with the post-extubation laryngoscopic findings to determine the diagnostic performance of ultrasound assessment.

Outcome Measures

The primary outcome of the study was the comparison between pre-extubation ultrasound assessment of vocal cord movement and post-extubation video-assisted laryngoscopic assessment in detecting RLN palsy. The secondary outcomes included postoperative airway- and voice-related complications, namely hoarseness of voice, dysphonia, and dysphagia. In addition, inter-rater agreement among the ultrasound raters was evaluated, along with the diagnostic accuracy of each rater relative to video-assisted laryngoscopy.

Statistical analysis

Data were processed and analyzed using IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY, USA). The distribution of quantitative variables was assessed using the Shapiro–Wilk test together with visual inspection. Quantitative data were expressed as mean ± standard deviation for normally distributed variables or as median and range for non-normally distributed variables, whereas categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using the independent-samples t test or the Mann–Whitney U test, as appropriate, based on data distribution. Interobserver agreement among ultrasound assessors was evaluated using Fleiss' kappa (κ), while concordance

between pre-extubation ultrasonographic findings and post-extubation video-assisted laryngoscopy was examined using Cohen's kappa. The diagnostic performance of pre-extubation ultrasound was determined by calculating sensitivity, specificity, PPV, NPV, and overall accuracy, with video-assisted laryngoscopy considered the reference standard. All statistical tests were two tailed, and a P value < 0.05 was considered statistically significant.

Results:

The studied patients had a mean age of 36 ± 10 years and a mean body mass index (BMI) of 27 ± 4 kg/m². Most patients were females (80%), while males represented 20% of the cohort. Smoking was reported in 6.7% of patients, diabetes mellitus in 13.3%, and hypertension in 10%. Regarding ASA physical status, 60% of patients were classified as ASA I and 40% as ASA II. Difficult intubation was encountered in 16.7% of patients, whereas traumatic intubation occurred in 10%. The median time of intubation was 0.25 minutes (range: 0.25–1.5 minutes), and the median surgery duration was 90 minutes (range: 60–180 minutes). **Table 1**

Pre-extubation RLN injury was identified in 20% of patients by rater 1, 16.7% by rater 2, and 13.3% by rater 3. Overall inter-rater agreement among the ultrasound raters in detecting RLN injury was fair, with a κ of 0.28 (95% Confidence Interval [CI]: 0.073–0.487), and this agreement was statistically significant ($P = 0.008$). Post-extubation RLN injury as assessed by video-assisted laryngoscope was detected in 16.7% of the studied patients. **Table 2**

Postoperative complications among the studied patients showed that hoarseness of voice was the most frequent complication, reported in 40% of patients, followed by dysphonia in 36.7%. Stridor was observed in 13.3% of patients, while dysphagia was the least frequent complication, occurring in 3.3% of patients. **Table 4, Figure 11**

Agreement between each ultrasound rater and the gold standard in detecting RLN injury varied across raters. Rater 1 showed moderate agreement with the video-assisted laryngoscope ($\kappa = 0.444$, $P = 0.041$), while rater 2 showed fair agreement that did not reach statistical significance ($\kappa = 0.28$, $P = 0.183$). Rater 3 demonstrated the highest agreement, with a substantial and statistically significant concordance ($\kappa = 0.609$, $P = 0.009$). Similarly, the consensus assessment also showed substantial and statistically significant agreement with the gold standard ($\kappa = 0.609$, $P = 0.009$). **Table 3**

Diagnostic performance varied among the ultrasound raters in detecting RLN injury using video-assisted laryngoscope as the gold standard. Rater 1 showed a sensitivity of 60.0%, specificity of 88.0%, positive predictive value (PPV) of 50.0%, negative predictive value (NPV) of 91.7%, and an overall accuracy of 74.0%. Rater 2 showed the lowest diagnostic performance, with a sensitivity of 40.0%, specificity of 88.0%, PPV of 40.0%, NPV of 88.0%, and an overall accuracy of 64.0%. Rater 3 demonstrated the best diagnostic performance, with a sensitivity of 60.0%, specificity of 96.0%, PPV of 75.0%, NPV of 92.3%, and an overall accuracy of 78.0%. The consensus assessment showed identical diagnostic indices to rater 3, with 60.0% sensitivity, 96.0% specificity, 75.0% PPV, 92.3% NPV, and 78.0% overall accuracy. **Table 4, Figure 2**

The studied patients were classified according to RLN injury by the gold standard method (video-assisted laryngoscope) into 25 patients without RLN injury and 5 patients with RLN injury. Patients with RLN injury had a significantly higher proportion of males than those without RLN injury (60% vs. 12%, respectively, P = 0.041). In addition, patients with RLN injury had a significantly longer surgery duration than those without RLN injury, with a median of 120 minutes (range: 120–180) versus 90 minutes (range: 60–180), respectively (P = 0.007). **Table 5**

Discussion:

In the present study, pre-extubation ultrasound detected RLN injury in a minority of patients across the three raters, while post-extubation video-assisted laryngoscopy confirmed injury in a similar proportion. In harmony with our findings, Kaneko et al. [3] reported that pre-extubation ultrasound was able to identify true cases of RLN palsy before tube removal in patients undergoing radical esophageal cancer surgery. Their reported incidence was somewhat higher than in our study, which may be explained by the more extensive dissection and greater risk to the RLN during esophageal surgery compared with elective thyroidectomy. By contrast, Zavdy et al. [5] reported only one confirmed case of vocal cord paralysis in a pediatric cohort undergoing thyroid surgery. This lower rate compared with our study may be related to the smaller sample, fewer events, pediatric population, differences in surgical case mix, and their lobe-based rather than patient-based analysis.

The current work revealed that the most frequent postoperative complications were hoarseness of voice (40%) and dysphonia (36.7%), followed by stridor (13.3%) and dysphagia (3.3%). Similarly, Kaneko et al. [3] observed that hoarseness and pneumonia were more frequent among patients with confirmed RLN paralysis, with hoarseness occurring in 42.9% of patients with paralysis compared with 4.3% of those without paralysis, and pneumonia occurring in 28.6% versus 4.3%, respectively.

Our results showed only fair overall inter-rater agreement among the three ultrasound raters, while agreement with the gold standard varied from fair to substantial, with the best performance observed for rater 3 and the consensus assessment. These findings suggest that the versatility of pre-extubation ultrasound is still limited and that its reliability is strongly operator-dependent. This is likely because TLUSG requires both proper technical skill in probe positioning and sufficient experience in interpreting dynamic vocal cord motion, particularly in cases of partial rather than complete movement impairment. In agreement with our findings, Kaneko et al. [3] also reported variable agreement between observers, supporting the view that ultrasound assessment of vocal cord mobility is not uniformly reproducible and depends greatly on examiner training and experience. However, our study demonstrated better agreement for the best-performing rater and for the consensus result, which may reflect differences in clinical context, image acquisition quality, or familiarity with postoperative thyroidectomy anatomy. Similarly, Yamamoto et al. [6] described a case in which pre-extubation laryngeal ultrasonography successfully identified absent vocal cord opening in an intubated patient after esophageal surgery, and the finding was later confirmed by direct laryngoscopy. This report supports the feasibility of ultrasound as a noninvasive bedside tool for early detection of vocal cord dysfunction before extubation and for anticipating possible airway compromise.

In the current study, rater 3 showed the best diagnostic performance, and the consensus assessment yielded the same results. This likely reflects better examiner expertise in both image acquisition and interpretation. Accurate laryngeal ultrasonography depends on familiarity with laryngeal sonoanatomy, consistent probe positioning, and the ability to recognize subtle asymmetry or restriction of vocal cord motion. Because this technique is strongly operator-dependent, even minor differences in skill or interpretation can affect performance. The identical results of the consensus assessment further suggest that combining judgments helped reduce individual observer error. Overall, the superior performance of rater 3 most likely reflects the positive effect of training, experience, and better pattern recognition.

Consistently, Kaneko et al. [3] found that pre-extubation ultrasound performed by an experienced examiner achieved a diagnostic pattern very similar to ours, which supports the reproducibility of these findings across different surgical settings. In agreement with our results, Zavdy et al. [5] also showed that greater resident experience was associated with better correlation between intraoperative ultrasound and flexible nasoendoscopy, reinforcing that ultrasound performance improves with training and examiner expertise. On the other hand, Rossi et al. [7] reported markedly higher diagnostic performance in patients undergoing total thyroidectomy. This may be explained by the use of a single experienced operator, a standardized examination protocol, dynamic assessment maneuvers, and inclusion of only patients with evaluable vocal cords, all of which may reduce variability and improve agreement with the reference method. Similarly, the systematic reviews by Kim et al. [8] and Patel et al. [9] demonstrated generally high diagnostic accuracy of TLUSG and emphasized that technical optimization and operator expertise can substantially improve its performance.

Further support for the importance of training comes from Kuryga et al. [10], who showed that surgeons trained in intraoperative neuromonitoring had lower rates of RLN palsy than untrained surgeons, indicating that better outcomes depend not only on the technology itself but also on the operator's ability to use and interpret it correctly. Likewise, Figueroa-Bohorquez et al. [11] reported good diagnostic performance of surgeon-performed TLUSG and demonstrated that the learning curve stabilized after repeated examinations, highlighting the major role of accumulated experience in improving ultrasound accuracy and explaining inter-rater variability in our study.

According to the gold standard assessment, RLN injury was identified in a small proportion of patients. Those with nerve injury were significantly more likely to be male and had a significantly longer operative duration than patients without injury. The association with prolonged surgery is clinically plausible, as longer procedures may indicate more difficult dissection, more extensive disease, or greater manipulation around the nerve, all of which may increase the risk of traction, compression, or thermal injury.

This study was limited by its single-center design and relatively small sample size, with only a few confirmed cases of RLN injury, which may reduce generalizability and statistical power. It was also limited by the operator-dependent nature of ultrasound, reflected by variable agreement and diagnostic accuracy among raters, together with the modest sensitivity of pre-extubation ultrasound as a standalone tool. In addition, differences in rater training and experience were not formally standardized or analyzed, which may have influenced the observed performance.

Conclusion:

Pre-extubation ultrasound is a feasible, safe, and noninvasive adjunct for assessing RLN injury after thyroidectomy. It showed fair overall inter-rater reliability and fair-to-substantial agreement with video-assisted laryngoscopy, with the best performance achieved by the most experienced rater and the consensus assessment. Its high specificity and negative predictive value support its use as a bedside screening tool before extubation; however, its modest sensitivity means it should not replace laryngoscopy when suspicion remains high. Its wider use depends on adequate training and operator experience.

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None to be declared.

Author contribution

The authors contributed equally to the study.

Conflicts of interest

None to be declared.

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Table 1: General and clinical characteristics of the studied patients.

General characteristics		**(n = 30)**
Age (years)	Mean ±SD	36 ±10
Sex		
Males	n (%)	6 (20)
Females	n (%)	24 (80)
BMI (kg/m²)	Mean ±SD	27 ±4
Smoking	n (%)	2 (6.7)
Diabetes mellitus	n (%)	4 (13.3)
Hypertension	n (%)	3 (10)
ASA physical status		
I	n (%)	18 (60)
II	n (%)	12 (40)
Difficult intubation	n (%)	5 (16.7)
Traumatic intubation	n (%)	3 (10)
Time of intubation (minutes)	Median (range)	0.25 (0.25 - 1.5)
Surgery duration (minutes)	Median (range)	90 (60 - 180)

n: number.

Table 2: Pre-extubation RLN injury as assessed by each ultrasound rater, post-extubation RLN injury by video-assisted laryngoscope, and overall agreement

Pre-extubation RLN injury by US	n (%)	Overall inter-rater agreement among ultrasound raters	
		Fleiss' kappa (95% CI)	P-value
Rater 1	6 (20)		
Rater 2	5 (16.7)	0.28 (0.073 - 0.487)	**0.008***
Rater 3	4 (13.3)		
Post-extubation RLN injury by video-assisted laryngoscope	5 (16.7)		

n: number, RLN: recurrent laryngeal nerve, CI: confidence interval, *: Significant P-value.

Table 3: Agreement between each ultrasound rater and the gold standard (video-assisted laryngoscope) in detecting RLN injury (n = 30)

	Video-assisted laryngoscope	
	Kappa	**P-value**
Rater 1	0.444	**0.041***
Rater 2	0.28	0.183
Rater 3	0.609	**0.009***
Consensus	0.609	**0.009***

*: Significant P-value.

Table 4: Diagnostic performance of each ultrasound rater and consensus assessment for detecting RLN injury using video-assisted laryngoscope as the gold standard

	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Overall accuracy (95% CI)
Rater 1	60.0 (23.1 - 88.2)	88.0 (70.0 - 95.8)	50.0 (18.8 - 81.2)	91.7 (74.2 - 97.7)	74.0 (54.8 - 88.2)
Rater 2	40.0 (11.8 - 76.9)	88.0 (70.0 - 95.8)	40.0 (11.8 - 76.9)	88.0 (70.0 - 95.8)	64.0 (44.5 - 80.6)
Rater 3	60.0 (23.1 - 88.2)	96.0 (80.5 - 99.3)	75.0 (30.1 - 95.4)	92.3 (75.9 - 97.9)	78.0 (59.2 to 91.0)
Consensus	60.0 (23.1 - 88.2)	96.0 (80.5 - 99.3)	75.0 (30.1 - 95.4)	92.3 (75.9 - 97.9)	78.0 (59.2 to 91.0)

CI: confidence interval, PPV: positive predictive value, NPV: negative predictive value.

Table 5: General and clinical characteristics according to RLN injury classified by video-assisted laryngoscope

		RLN injury		
		No (n = 25)	**Yes (n = 5)**	**P-value**
Age (years)	Mean ±SD	35 ±10	42 ±9	0.167
Sex				
Males	n (%)	3 (12)	3 (60)	**0.041***
Females	n (%)	22 (88)	2 (40)	
BMI (kg/m²)	Mean ±SD	26 ±4	28 ±2	0.177
Smoking	n (%)	1 (4)	1 (20)	0.31
Diabetes mellitus	n (%)	3 (12)	1 (20)	0.538
Hypertension	n (%)	1 (4)	2 (40)	0.064
ASA physical status				
I	n (%)	16 (64)	2 (40)	0.364
II	n (%)	9 (36)	3 (60)	
Difficult intubation	n (%)	4 (16)	1 (20)	1
Traumatic intubation	n (%)	3 (12)	0 (0)	1
Time of intubation (minutes)	Median (range)	0.25 (0.25 - 1.5)	0.5 (0.25 - 0.5)	0.746
Surgery duration (minutes)	Median (range)	90 (60 - 180)	120 (120 - 180)	**0.007***

n: number, RLN: recurrent laryngeal nerve, SD: standard deviation, BMI: body mass index, ASA: American Society of Anesthesiologists, *: Significant P-value.

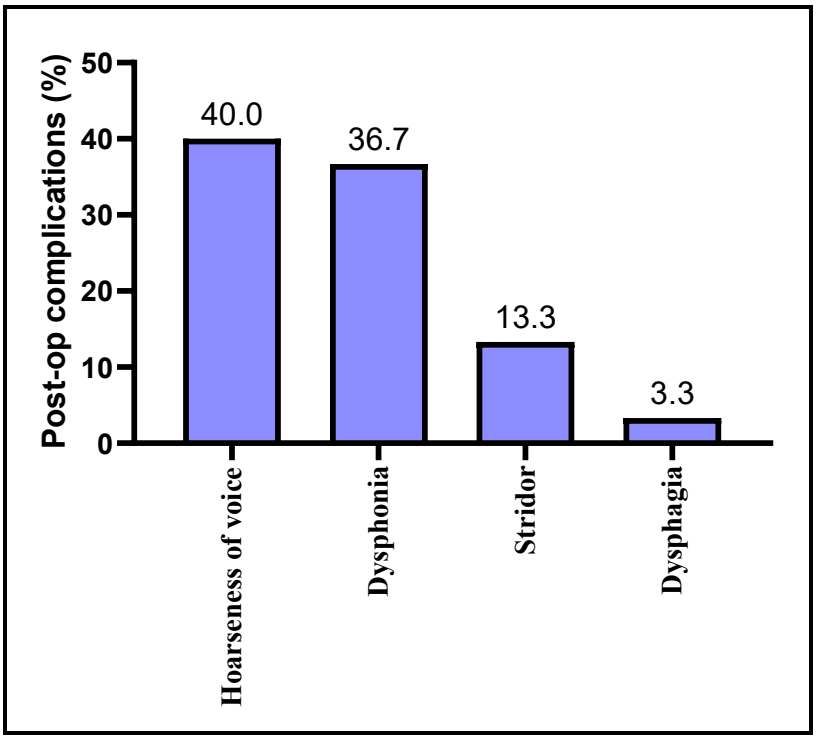

Figure 1: Postoperative complications among the studied patients

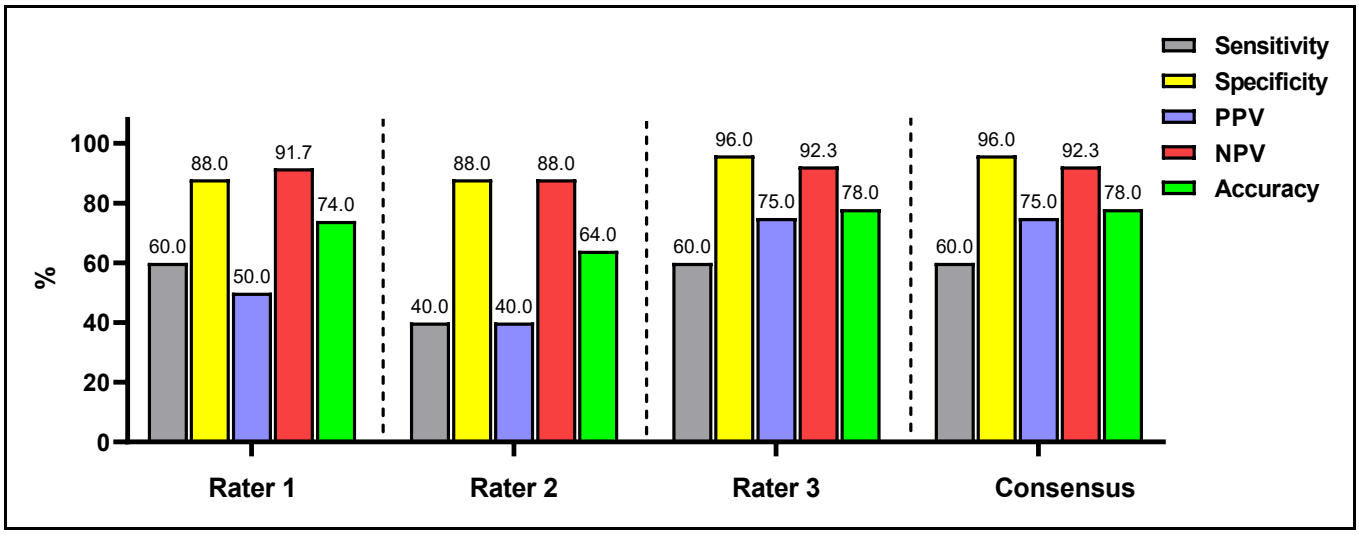

Figure 2: Diagnostic performance of each ultrasound rater and consensus assessment for detecting RLN injury using video-assisted laryngoscope as the gold standard