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UNILATERAL VOCAL CORD PARALYSIS AFTER THYROIDECTOMY: CURRENT CONCEPTS IN PATHOGENESIS, DIAGNOSIS, AND REHABILITATION

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Abstract

Background:
Unilateral vocal cord paralysis (UVCP) remains one of the most significant complications after thyroidectomy, often resulting in hoarseness, aspiration, and reduced quality of life. Despite advances in surgical techniques, the risk of recurrent laryngeal nerve injury persists.

Objective:
This review summarizes recent evidence (2018–2025) on the incidence, mechanisms, diagnostic approaches, and rehabilitation strategies for UVCP following thyroid surgery.

Methods:
A narrative review of peer-reviewed literature indexed in PubMed, Scopus, and Web of Science was conducted using the keywords *unilateral vocal cord paralysis*, *thyroidectomy*, *recurrent laryngeal nerve*, *neuromonitoring*, and *voice rehabilitation*.

Results:
The incidence of UVCP varies between 1% and 2% in primary thyroid surgeries and up to 8% in reoperations. The predominant cause is injury to the recurrent laryngeal nerve through traction, thermal damage, or ischemia. Modern diagnostic methods, including laryngeal electromyography and high-resolution ultrasound, enable early recognition. Intraoperative neural monitoring (IONM) significantly reduces permanent nerve injury rates. Rehabilitation options, such as voice therapy and injection laryngoplasty, improve phonatory outcomes and patient satisfaction.

Conclusion:
Early diagnosis, standardized intraoperative nerve monitoring, and structured voice rehabilitation are key to improving outcomes. Future research should focus on neuroregenerative therapies and advanced intraoperative visualization systems.

Keywords: unilateral vocal cord paralysis, thyroidectomy, recurrent laryngeal nerve, intraoperative neuromonitoring, laryngeal electromyography, voice rehabilitation

1. Introduction

Unilateral vocal cord paralysis (UVCP) is among the most frequent complications following thyroidectomy and other cervical surgeries. The disorder occurs due to injury of the recurrent laryngeal nerve (RLN) or, less frequently, the external branch of the superior laryngeal nerve.

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Clinically, UVCP manifests with hoarseness, breathy voice, aspiration during swallowing, and decreased phonatory efficiency, all of which can significantly affect communication, nutrition, and quality of life.

Globally, the reported incidence of UVCP ranges from **1–2% in primary thyroid surgeries** to **6–8% in revision or malignant cases** [1–3]. Although most cases are transient and resolve within months, up to **15–20% may become permanent**, requiring long-term rehabilitation or surgical correction.

Advances in intraoperative techniques—especially the introduction of intraoperative neural monitoring (IONM)—have led to a decline in permanent RLN injuries. However, the complexity of neck anatomy and variability in nerve course still pose risks.

This review aims to summarize current data on the mechanisms, risk factors, diagnostic methods, and management strategies for unilateral vocal cord paralysis after thyroidectomy, emphasizing modern approaches to early detection and rehabilitation.

2. Pathogenesis and Mechanisms of Nerve Injury

The recurrent laryngeal nerve (RLN) is responsible for motor innervation of nearly all intrinsic laryngeal muscles, except the cricothyroid. Damage to this nerve results in unilateral paralysis of the vocal fold on the affected side, leading to glottic insufficiency and impaired phonation.

2.1 Mechanisms of Injury

1. **Mechanical Traction or Stretching:**
During thyroid dissection, excessive traction on the thyroid lobe can cause elongation and micro-tears of the nerve fibers. This is the most common mechanism of transient postoperative paralysis [4, 5].
2. **Thermal Injury:**
The use of bipolar coagulation or ultrasonic scalpels near the nerve can result in thermal necrosis, even without direct contact [6]. Controlled energy application and maintenance of a 5 mm safety margin are recommended.
3. **Ischemic or Compression Injury:**
Vascular compromise or postoperative hematoma can lead to nerve ischemia. This mechanism often causes delayed onset of vocal fold paralysis [7].
4. **Ligation or Transection:**
In rare cases, especially during oncologic or reoperative thyroidectomy, the RLN may be inadvertently ligated or transected. Immediate identification during surgery offers the best prognosis for repair.
5. **Postoperative Fibrosis:**
Fibrotic scarring around the nerve may occur in the weeks following surgery, leading to chronic conduction block.

2.2 Anatomical Considerations

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The RLN displays considerable anatomical variability. On the right side, it loops around the subclavian artery, while on the left, it loops around the aortic arch, making the left nerve longer and more vulnerable to traction injury. Non-recurrent laryngeal nerve variants—found in approximately **0.5–1%** of patients—represent an additional risk factor for inadvertent injury [8].

The external branch of the superior laryngeal nerve (EBSLN) is at risk during ligation of the superior thyroid vessels. Injury to this branch leads to loss of high-pitch voice control, which is particularly disabling for professional voice users.

2.3 Pathophysiology

Following RLN injury, denervation of the affected vocal fold leads to atrophy of the thyroarytenoid and lateral cricoarytenoid muscles. Within weeks, synkinesis or aberrant reinnervation may occur, resulting in abnormal movement patterns. Spontaneous regeneration is possible in cases of neuropraxia or axonotmesis, typically within **3–6 months** [9].

Persistent paralysis beyond 12 months suggests irreversible nerve damage. Histopathological studies have shown segmental demyelination and axonal loss in chronic cases [10].

3. Epidemiology and Risk Factors

Unilateral vocal cord paralysis (UVCP) after thyroidectomy remains a significant concern worldwide. The reported incidence varies depending on the type of surgery, surgeon experience, and use of intraoperative monitoring.

3.1 Incidence

- **Primary thyroidectomy:** 1–2%
- **Reoperative thyroidectomy:** 4–8%
- **Thyroidectomy for malignancy:** up to 6%
- **Bilateral procedures:** increased risk if combined with neck dissection

Transient UVCP accounts for approximately **70–85%** of cases, with most resolving within 6 months. Permanent paralysis occurs in **15–20%**, which significantly impacts quality of life [11, 12].

3.2 Patient-related Risk Factors

1. **Age:** Patients over 60 years have a slightly higher risk due to reduced nerve elasticity.
2. **Comorbidities:** Diabetes mellitus, hypertension, and previous neck radiation may impair nerve recovery.
3. **Anatomical Variants:** Non-recurrent laryngeal nerves or high bifurcation of the RLN increase susceptibility to injury [8].

3.3 Surgery-related Risk Factors

1. **Surgeon experience:** Low-volume surgeons have a higher rate of RLN injury.

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2. **Extent of surgery:** Total thyroidectomy, central neck dissection, and reoperations carry higher risk.
3. **Intraoperative technique:** Use of energy devices close to the nerve without monitoring increases risk of thermal injury.

4. Diagnostic Approaches

Early and accurate diagnosis of UVCP is crucial for timely intervention and optimal functional recovery.

4.1 Clinical Evaluation

- **Voice changes:** Hoarseness, breathy voice, decreased projection
- **Swallowing difficulties:** Mild aspiration or choking on liquids
- **Cough reflex impairment**

A structured history and perceptual voice assessment form the first step in clinical evaluation. The GRBAS (Grade, Roughness, Breathiness, Asthenia, Strain) scale and Voice Handicap Index (VHI) are commonly used [13].

4.2 Laryngoscopic Examination

Flexible fiberoptic laryngoscopy or videostroboscopy allows direct visualization of vocal fold mobility. Findings include:

- Fixed paramedian or lateralized vocal fold
- Glottic insufficiency
- Compensatory movement of contralateral fold

Videostroboscopy is particularly useful for assessing vibratory patterns and identifying early synkinesis [14].

4.3 Electrophysiological Assessment

Laryngeal electromyography (LEMG) is considered the gold standard for distinguishing neuropraxia from axonotmesis or neurotmesis. Key benefits include:

- Prognostication of nerve recovery
- Guidance for timing of intervention
- Differentiation from mechanical fixation

4.4 Imaging Modalities

While not routinely required, high-resolution **ultrasound**, **CT**, or **MRI** may be indicated to exclude compressive lesions or hematoma in the postoperative neck.

4.5 Intraoperative Neural Monitoring (IONM)

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IONM has become an integral part of modern thyroid surgery. Continuous or intermittent monitoring of the RLN allows:

- Real-time identification of nerve stress
- Immediate feedback to the surgeon
- Reduction in permanent RLN injury rates by 30–50% in high-risk cases [15, 16]

5. Rehabilitation Approaches

Even with optimal surgical techniques and nerve preservation, some patients develop persistent unilateral vocal cord paralysis (UVCP). Early and structured rehabilitation is critical to restoring phonatory function and quality of life.

5.1 Voice Therapy

Voice therapy is the first-line intervention for patients with mild to moderate UVCP. Techniques include:

- **Resonant voice therapy** to improve vocal fold closure
- **Respiratory-phonatory coordination exercises**
- **Pitch glides and vocal function exercises**

Studies have shown that consistent voice therapy over 6–12 weeks can significantly improve VHI scores and reduce glottic gap [17, 18].

5.2 Injection Laryngoplasty

For patients with significant glottic insufficiency, **temporary or permanent injection of materials** (e.g., hyaluronic acid, calcium hydroxylapatite) into the paralyzed vocal fold improves closure and voice quality.

- **Temporary fillers** are suitable for expected spontaneous recovery (<6 months)
- **Permanent fillers or medialization thyroplasty** are indicated in irreversible cases [19, 20]

5.3 Surgical Medialization

When conservative measures are insufficient, surgical medialization of the paralyzed vocal fold (thyroplasty type I) is performed. Outcomes include improved voice quality, reduced aspiration risk, and enhanced patient-reported quality of life.

6. Future Research Directions

Despite advances in diagnosis and rehabilitation, several areas require further investigation:

1. **Neuroregenerative therapies:** Experimental approaches using growth factors, stem cells, or nerve grafting show promise for RLN recovery.

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2. **Advanced intraoperative visualization:** High-definition magnification, augmented reality, and fluorescence-guided surgery may improve RLN identification.
3. **Standardized monitoring protocols:** Multi-center studies are needed to optimize IONM parameters and validate predictive models for postoperative outcomes.
4. **Long-term quality-of-life studies:** Comprehensive assessment tools integrating phonatory, swallowing, and psychological outcomes are necessary.

7. Conclusion

Unilateral vocal cord paralysis remains a notable complication of thyroid surgery, with significant implications for voice, swallowing, and quality of life. Key points include:

- Early recognition through structured clinical evaluation, laryngoscopy, and electrophysiology is essential.
- Intraoperative neural monitoring has reduced permanent RLN injury rates.
- Rehabilitation strategies, including voice therapy, injection laryngoplasty, and surgical medialization, improve functional outcomes.
- Future research should focus on neuroregenerative techniques and advanced intraoperative tools to further minimize complications.

Continued multidisciplinary collaboration between surgeons, speech-language pathologists, and researchers is vital for optimizing patient outcomes.

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