ORIGINAL ARTICLE

NECK ULTRASOUND FOR PREDICTION OF RIGHT NONRECURRENT LARYNGEAL NERVE

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Abstract: Background. Nonrecurrent laryngeal nerve (NRLN) is 1 of the important causes for nerve damage during neck surgery. The anomaly is almost associated with congenital vascular abnormality. Most neck vascular anomalies can be detected by ultrasound.

Methods. Both 3.5-MHz and 10-MHz probe neck ultrasound scans were performed for 2330 patients undergoing thyroidectomy preoperatively. Absence of innominate artery (INA) was defined as positive with right NRLN.

Results. Of 13 positive patients found by 10-MHz probe, 11 were also identified by 3.5-MHz probe, and proved to be with right NRLN during operation. Two false-positive patients (18%) found by 10-MHz probe were due to short INA and tortuous INA, respectively. The incidence of right NRLN was 0.47% in Chinese people. Both the sensitivity and specificity for predicting right NRLN by 3.5-MHz probe were 100%.

Conclusion. A 3.5-MHz probe neck ultrasound scan can accurately demonstrate right NRLN. Applying this tool for neck surgery to reduce the nerve damage is highly advised. © 2009 Wiley Periodicals, Inc. Head Neck 32: 844–849, 2010

Keywords: nonrecurrent laryngeal nerve; innominate artery; ultrasound; nerve damage; vascular anomaly

Postoperative hoarseness is often a troublesome outcome of neck surgery. A nonrecurrent laryngeal nerve (NRLN) is found in 0.3% to 0.7% of the population and is an important factor of nerve damage.1–6 Developmentally, this nerve anomaly is almost always associated with a congenital vascular abnormality.1–3,6 Neck ultrasound has been widely applied in neck surgery for preoperative assessment and/or intraoperative localization.7 Most vascular anomalies of the neck and aortic arch can be detected by neck ultrasound, permitting indirect prediction of NRLN. The present report is a prospective preoperative study to assess right NRLN by detection of a vascular anomaly using neck ultrasound.

MATERIALS AND METHODS

During the period 1995 to 2007, 2330 patients with thyroid disease underwent thyroidectomy (632 with a right-side lesion and 1698 with bilateral lesions). Two types of neck ultrasound, 1 with a 3.5-MHz convex probe and 1 with a 10-MHz linear probe, were routinely performed.
FIGURE 1. Normal innominate artery. (A) An MRA. (B) Sonogram obtained with a 10-MHz ultrasound probe. (C) Sonogram obtained with a 3.5-MHz ultrasound probe. IN, innominate artery; CC, common carotid artery; SC, subclavian artery. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

FIGURE 2. The absence of the innominate artery. Right aberrant subclavian artery (arteria lusoria) arises from aortic arch (arrow). (A) An MRA. (B) Sonogram obtained with a 10-MHz ultrasound probe. (C) Sonogram obtained with a 3.5-MHz ultrasound probe. IN, innominate artery; CC, common carotid artery; SC, subclavian artery. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]
preoperatively. The ultrasound probe was placed on the sternal notch and rotated toward the anterior mediastinum to detect the relations among the innominate, right subclavian, and right common carotid arteries (Figure 1). Absence of the innominate artery (INA) was defined as positive with right NRLN (Figure 2), and the presence of the INA was defined as negative. The bilateral inferior laryngeal nerve was identified during surgery for bilateral lesions, and the right inferior laryngeal nerve was identified for right-side lesions. Magnetic resonance angiography (MRA) was performed for all patients with absence of the innominate detected with the 10-MHz linear probe. This study was reviewed and approved by the Institutional Review Board committee, and informed consent was obtained from all patients.

RESULTS

Of 13 patients designated as positive for right NRLN with the 10-MHz ultrasound probe, 11 were also identified with the 3.5-MHz probe, and these findings were consistent with surgical findings and absence of the INA by MRA. Of the remaining 2 patients shown to be positive with

![Figure 3](image1.png)

**FIGURE 3.** A low insertion of the bifurcation of the common carotid and subclavian arteries with a short innominate artery. (A) Right recurrent nerve normally hooks around right subclavian artery. (B) An MRA. (C) Sonogram obtained with a 10-MHz ultrasound probe. (D) Sonogram obtained with a 3.5-MHz ultrasound probe. IN, innominate artery; CC, common carotid artery; SC, subclavian artery. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

![Figure 4](image2.png)

**FIGURE 4.** Tortuosity of the IN artery (arrow) observed by MRA. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]
the 10-MHz probe, 1 had low insertion of the bifurcation of the common carotid and subclavian arteries with a short INA, as determined by both MRA and the 3.5-MHz probe (Figure 3). The other patient had tortuosity of the INA (Figure 4). No instances of left NRLN were found among the 1698 patients with bilateral lesions.

Of the 11 patients with right NRLN identified above, 10 had nerves that followed a transverse course parallel to the trunk of the inferior thyroid artery; 1 was below the trunk, and 9 were above the trunk. In the remaining patient, the nerve ran together with the vessels of the superior thyroid peduncle (Figure 5).

The incidence of right NRLN was 0.47% (11/2330) in this series. There were no false-negatives in the prediction of right NRLN with either ultrasound probe (Table 1 and Table 2). The sensitivity and specificity for predicting right NRLN with the 3.5-MHz probe was 100%. However, the 10-MHz probe showed 99% specificity and an 18% false-positive rate (Table 1).

**DISCUSSION**

During embryonic development, the inferior laryngeal nerve originates from the vagus nerve and takes a recurrent course under the distal portion of the sixth left and right aortic arches. During normal development, the fifth left and right aortic arches and the distal portion of the sixth right aortic arch regress. Thus, on the right side, the inferior laryngeal nerve runs

**Table 1. Detection of right nonrecurrent laryngeal nerve with a 10-MHz ultrasound probe.**

<table>
<thead>
<tr>
<th>Ultrasound</th>
<th>Operative finding</th>
<th>Operative finding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nonrecurrent nerve</td>
<td>Normal recurrent nerve</td>
</tr>
<tr>
<td>Absence of innominate artery</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Presence of innominate artery</td>
<td>0</td>
<td>2317</td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>2319</td>
</tr>
</tbody>
</table>

Sensitivity, 100%; specificity, 99%; false positive, 15%; false negative, 0%; accuracy, 99.9%.

**Table 2. Detection of right nonrecurrent laryngeal nerve with a 3.5-MHz ultrasound probe.**

<table>
<thead>
<tr>
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Sensitivity, 100%; specificity, 100%; false-positive, 0%; false-negative, 0%; accuracy, 100%.
under the fourth arch, which becomes the right subclavian artery. On the left side, it passes under the fourth arch, which forms the aortic arch. The right recurrent laryngeal nerve normally hooks around the right subclavian artery, and the left recurrent laryngeal nerve hooks around the aortic arch. Nonrecurrence of the right inferior laryngeal nerve is the most frequent anomaly, usually resulting from absence of the INA and the presence of a right aberrant subclavian artery, termed the arteria lusoria. A left NRLN may occur in association with more complex vascular anomalies such as coarctation of the aorta or right aortic arch with absence of the left INA. In very rare cases, no vascular anomalies are observed. A right arteria lusoria arises from the distal aortic arch and passes to the right, behind the esophagus, forming a ring around the trachea and esophagus. The ring is usually not tight enough to compress the esophagus or trachea but can occasionally cause dysphagia. None of the 11 patients in this series had difficulty swallowing. To date, the incidence of NRLN in the Asian population is unknown. Therefore, the prevalence of right NRLN reported here (0.47%) represents the first quantification in Asia and also the first prospective study of right NRLN.

Theoretically, NRLN may originate from any portion of the cervical vagus nerve. Similar to the report of Toniato et al,9 we identified 3 sites of right NRLN origin. The nerve running above the inferior thyroid artery trunk is the most common site of origin. Galen’s loop (anastomosis between the recurrent and superior laryngeal nerves) or the cervical branch between the right inferior laryngeal and cervical sympathetic nerves may mimic NRLN during surgical dissection. However, in both cases, they are not associated with vascular anomaly, and an intact inferior laryngeal nerve is observed.

High-energy (7.5–12 MHz) ultrasound probes are routinely used for neck examination. The higher energy allows for shallow penetration. Because high-energy probes rarely penetrate deeply to the aortic arch, a short or tortuous INA can be mistaken for absence of the INA. Lower-energy (3.5–5.0 MHz) ultrasound probes have deeper penetration to the aortic arch and thus detect NRLN well.

The occurrence of nerve injury of the NRLN in thyroid surgery has been reported to be 12.9% compared with 1.8% for recurrent nerves with a normal course. During thyroidectomy or a right anterior approach to the cervical spine, the soft tissue elements between the common carotid artery and the thyroid gland are usually ligated and divided. Although this procedure may be safe for patients with normal recurrent nerves, there is a high risk of damaging the NRLN because most instances are located in that area.

Although routine identification of the nerve in order to avoid damage is advocated by experts, fibrous tissue, particularly in reoperative patients, and atherosclerotic vessels may mimic a nerve, making nerve identification difficult. A recently developed intraoperative nerve monitoring system has been used for laryngeal nerve identification. We did not perform intraoperative nerve monitoring. We found that preoperative analysis and determination of the possible nerve route assisted greatly in the identification of an abnormal nerve during dissection in a 51-year-old patient with an NRLN running together with the vessels of the superior thyroid peduncle. With the use of preoperative ultrasound analysis, no temporary or permanent injury occurred in the 11 patients identified with right NRLN.

In summary, preoperative neck ultrasonography with a 3.5-MHz probe can easily and accurately predict the presence of right NRLN. Routine application of this tool for all neck procedures is advised to reduce the rate of injury to the inferior laryngeal nerve.

**REFERENCES**

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