a personal history of skin cancer were less likely to have residual cancer present in subsequent excision specimens. There was a trend toward clearance of NMSC with longer wait times between biopsy and excision (Table 1). The resident surgeon correctly predicted residual cancer in 47 of the 76 cases of residual BCC (61.8%) and in 21 of 31 cases of residual SCC (67.7%). The attending surgeon correctly predicted residual cancer in 45 of the 76 cases of residual BCC (59.2%) and in 22 of 31 cases of residual SCC (71.0%). Overall, residents estimated that 55.5% of cases of BCC and 56.1% of cases of SCC would have residual cancer present in the excision specimens, whereas attending surgeons estimated 43.6% and 49.3%, respectively. The sensitivity, specificity, and positive and negative predictive values for identification of residual cancer by resident and attending surgeons are shown in Table 2.

Discussion | Previous studies have shown high spontaneous clearance rates regarding NMSC after biopsy.2-4 The ability to predict cancer clearance based on lesion and patient characteristics would enable patients to avoid unnecessary surgical procedures and would allow health care resources to be used more efficiently. Residual cancer existed in the majority of cases of NMSC in our study. The cases of SCC showed higher rates of spontaneous clearance (42 of 73 cases [57.5%]) than did the cases of BCC (34 of 110 cases [30.9%]). No patient-specific risk factors were identified. There was a trend toward clearance of lesions with longer wait times between biopsy and excision, which suggests that close clinical surveillance may be appropriate for some low-risk lesions. Surgeons had difficulty predicting the persistence of cancer based on the appearance of the biopsy scar alone, regardless of experience. Future studies are needed to determine additional patient and lesion characteristics that contribute to clearance of NMSC after biopsy.

Sarah E. Sasor, MD
Naveed N. Nosrati, MD
Terrence Katona, DO
William A. Wooden, MD
Adam Cohen, MD
Imtiaz A. Munshi, MD
Sunil S. Tholpady, MD, PhD

Author Affiliations: Division of Plastic Surgery, Department of Surgery, Indiana University, Indianapolis (Sasor, Nosrati, Wooden, Tholpady); Richard L. Roudebush VA Medical Center, Indianapolis, Indiana (Katona, Wooden, Cohen, Munshi, Tholpady).

Corresponding Author: Sunil S. Tholpady, MD, PhD, Division of Plastic Surgery, Department of Surgery, Indiana University, 705 Riley Hospital Dr, RI 2514, Indianapolis, IN 46202 (stholpady@iupui.edu).


Author Contributions: Drs Tholpady and Sasor had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Sasor, Nosrati, Katona, Wooden, Cohen, Tholpady.

Acquisition, analysis, or interpretation of data: Sasor, Nosrati, Wooden, Munshi, Tholpady.

Drafting of the manuscript: Sasor, Nosrati, Wooden, Tholpady.

Critical revision of the manuscript for important intellectual content: Nosrati, Katona, Cohen, Munshi, Tholpady.

Statistical analysis: Nosrati, Tholpady.

Administrative, technical, or material support: Sasor, Nosrati, Wooden, Munshi, Tholpady.

Study supervision: Wooden, Cohen, Munshi, Tholpady.

Conflict of Interest Disclosures: None reported.

Previous Presentation: This paper was presented at the 39th Annual Meeting of the Association of VA Surgeons; May 4, 2015; Miami Beach, Florida.


A Novel Method of Neuromonitoring in Thyroidectomy and Parathyroidectomy Using Transcutaneous Intraoperative Vagal Stimulation

Intraoperative neuromonitoring (IONM) of recurrent laryngeal nerve (RLN) function is commonly performed for patients undergoing thyroidectomy or parathyroidectomy.1 Although its routine use remains controversial, IONM has demonstrated utility in selected situations, such as cases of reoperation.2-3 Intraoperative neuromonitoring using specific stimulation of the more proximal vagus nerve is thought to provide more complete anatomic analysis of RLN integrity than that of isolated distal segments of the RLN alone.4 However, current vagal IONM methods typically entail placing an electrode around the vagus for continuous electrical stimulation. This requires additional dissection of, and fixation to, the

<table>
<thead>
<tr>
<th>Table 2. Prediction of Residual Cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prediction</strong></td>
</tr>
<tr>
<td><strong>Residual cancer</strong></td>
</tr>
<tr>
<td>Resident correct</td>
</tr>
<tr>
<td>Attending correct</td>
</tr>
<tr>
<td><strong>No residual cancer</strong></td>
</tr>
<tr>
<td>Resident correct</td>
</tr>
<tr>
<td>Attending correct</td>
</tr>
<tr>
<td><strong>Residents</strong></td>
</tr>
<tr>
<td>Sensitivity</td>
</tr>
<tr>
<td>Specificity</td>
</tr>
<tr>
<td>PPV</td>
</tr>
<tr>
<td>NPV</td>
</tr>
<tr>
<td><strong>Attendings</strong></td>
</tr>
<tr>
<td>Sensitivity</td>
</tr>
<tr>
<td>Specificity</td>
</tr>
<tr>
<td>PPV</td>
</tr>
<tr>
<td>NPV</td>
</tr>
</tbody>
</table>

Abbreviations: BCC, basal cell carcinoma; NPV, negative predictive value; PPV, positive predictive value; SCC, squamous cell carcinoma.
nerve, which, in theory, adds time and increases risk.\(^5\) We hypothesize that a novel method of transcutaneous intraoperative vagal stimulation (TIVS) in the upper neck is less invasive and is feasible in thyroidectomy and parathyroidectomy.

### Methods

This study was approved by the institutional review board of the University of California, San Francisco. Four patients (2 undergoing thyroidectomy and 2 undergoing parathyroidectomy) with intermittent TIVS provided written informed consent and were examined. The patients were intubated with an electromyography (EMG) endotracheal tube to monitor vocal cord function. A pair of tiny subdermal needle electrodes were placed at the right and left upper neck overlying the mastoid insertion point of the sternocleidomastoid muscle, at the approximate level of the jugular foramen and proximal vagus nerve. These transcutaneous electrodes were easily placed using standard anatomic landmarks for head/neck neurimonitoring procedures, and their small caliber and superficial location ensured safe placement. Each transcutaneous site was stimulated independently with pulses of 0.2-millisecond duration at a sufficient intensity (approximately 25 mA) to produce a consistent EMG response from the vocal cord-recording electrode, signifying integrity of the circuit from proximal vagus nerve to RLN. Spontaneous EMG waveforms and responses to both TIVS and direct surgical probe stimulation (1-2 mA) of the vagus nerve and the RLN were recorded at intermittent time points throughout the procedure. The main measures for confirmation of a meaningful TIVS signal were (1) the presence of amplitude and waveform patterns characteristic of vagal stimulation and (2) an appropriately longer latency (ie, time of action potential migration along the nerve) from stimulation at the proximal vagus nerve to the detection of the EMG response at the vocal cord.

### Results

Transcutaneous intraoperative vagal stimulation produced consistent vagus waveforms (Figure), with minimal background twitching from contraction of muscles around the stimulating electrodes. Vocal cord responses from left-sided TIVS had longer latency periods (mean latency period, 12.9 milliseconds) than those from right-sided stimulation (mean latency period, 8.7 milliseconds), consistent with the longer anatomic path of the left RLN; this provided consistently correct lateralization information. On each side, latency was longest with TIVS—owing to its proximal point of stimulation and longer path of nerve conduction to the vocal cord—and decreased sequentially at more distal sites along the surgically dissected vagus nerve and RLN (Figure). In addition, the waveform characteristics from both vagal and RLN stimulations were consistent with normative data reported in the literature (Table).\(^6\) These findings, in aggregate, are consistent with successful lateralized vagal stimulation with TIVS. In one patient, stretching of the RLN during critical dissection at the ligament of Berry produced increased spontaneous EMG activity and a 30% decrease in stimulated waveform amplitude, which returned to normal after removal of the specimen. There were no complications associated with this IONM method. The results of all the patients’ postoperative voice assessments and laryngeal examinations were normal.

### Conclusions

To our knowledge, this is the first report to describe the successful application of TIVS at the upper neck for vagal IONM in thyroidectomy and parathyroidectomy. This method allows minimally invasive monitoring of vagal-RLN

---

**Figure.** Representative Traces Recorded From Endotracheal Electrode to Stimulation at 3 Different Anatomic Sites

A: Proximal vagus nerve at upper neck/skull base (transcutaneous stimulation)

B: Vagus nerve at midneck (direct stimulation)

C: RLN at midneck (direct stimulation)

The latency periods progressively shorten from the proximal vagus nerve to the midcervical vagus nerve and then to the recurrent laryngeal nerve (RLN) (horizontal calibration, 2 milliseconds/division; vertical calibration, 100 μV/division).

**Table.** Mean Latency Periods and Amplitudes of Vocalis Muscle Response to Stimulation at Different Anatomic Levels\(^a\)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Proximal Vagus Nerve at Upper Neck</th>
<th>Vagus Nerve at Midneck</th>
<th>RLN at Midneck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latency period, ms</td>
<td>Left: 12.9 Right: 8.7</td>
<td>Left: 6.8 Right: 5.7</td>
<td>Left: 4.5 Right: 3.9</td>
</tr>
<tr>
<td>Amplitude, μV</td>
<td>103.0 Left: 112.9 Right: 131.0</td>
<td>327.0 Left: 343.0 Right: 381.0</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) The proximal vagus nerve was stimulated using the transcutaneous method, whereas the vagus nerve and the recurrent laryngeal nerve (RLN) in the midneck were stimulated directly in the operative field.
function without the need to deliberately dissect and directly stimulate the vagus nerve. Further studies are needed to confirm the utility of TIVS as an accurate, less-invasive, and cost-effective method of IONM of patients undergoing thyroidectomy or parathyroidectomy.

Insoo Suh, MD
Charles Yingling, PhD
Gregory W. Randolph, MD
Quan-Yang Duh, MD

Author Affiliations: Endocrine Surgery Section, Department of Surgery, University of California, San Francisco, Medical Center at Mount Zion, San Francisco (Suh, Duh); Surgical Service, Veterans Affairs Medical Center, San Francisco, California (Suh, Duh); Golden Gate Neuromonitoring, San Francisco, California (Yingling); Department of Otolaryngology, Massachusetts Eye and Ear Infirmary, Massachusetts General Hospital, Boston (Randolph).

Corresponding Author: Insoo Suh, MD, Endocrine Surgery Section, Department of Surgery, University of California, San Francisco, Medical Center at Mount Zion, 1600 Divisadero St, Room A-725, San Francisco, CA 94115 (insoo.suh@ucsf.edu).


Author Contributions: Drs Suh and Duh had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: All authors.

Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: All authors.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: Suh.

Administrative, technical, or material support: Suh, Randolph.

Study supervision: Suh, Randolph, Duh.

Conflict of Interest Disclosures: None reported.


6. Sritthan N, Chase M, Kamani D, Randolph M, Randolph GW. The vagus nerve, recurrent laryngeal nerve, and external branch of the superior laryngeal nerve have unique latencies allowing for intraoperative documentation of intact neural function during thyroid surgery. Laryngoscope. 2015;125(2):E84-E89.

Femoral Hernias in Patients Undergoing Total Extraperitoneal Laparoscopic Hernia Repair: Including Routine Evaluation of the Femoral Canal in Approaches to Inguinal Hernia Repair

The incidence of femoral hernia is not clearly defined; however, femoral hernias are considered to be relatively rare and less common in men than women. Hernias can be repaired by either an open or laparoscopic approach. The purported benefits of laparoscopic hernia repair include less postoperative pain and earlier return to normal activity with apparent equivalent rates of recurrence compared with open tension-free mesh-based repairs. An additional benefit of the laparoscopic approach is the ability to visualize all hernial orifices in the groin area bilaterally. The purpose of this study was to determine the incidence of femoral hernia in patients who preoperatively received a diagnosis of inguinal hernia before undergoing total extraperitoneal laparoscopic hernia repair, with particular attention to cases of reoperation.

Methods | Because our study used existing and deidentified data, institutional review board approval was not required. Data were collected on 250 consecutive male patients undergoing elective total extraperitoneal laparoscopic surgery for an inguinal hernia diagnosed by 1 of 2 surgeons at a Veterans Affairs medical center or a university-associated medical center over a 33-month period. Bilateral exploration was routinely performed during hernia repair. Femoral hernias were determined in association with a diagnosed ipsilateral inguinal hernia preoperatively or were found on the contralateral side where no previous hernia was diagnosed.

Results | Of the 250 patients (mean [SD] age, 51 [14] years; mean body mass index [calculated as weight in kilograms divided by height in meters squared], 27.2 [2.1]), 105 (42%) had previously undergone open surgery for an inguinal hernia either on the ipsilateral side (with a diagnosed recurrence) or on one of the sides but with diagnosed bilateral hernia. Of the 250 patients, 145 (58%) received a diagnosis of bilateral inguinal hernia preoperatively, and 22 (8.8%) received the diagnosis at the time of operation. For bilateral hernias in primary hernia repairs, 9 of 102 patients (8.8%) preoperatively received a diagnosis of unilateral hernia. For bilateral hernias in recurrent hernia repairs, 13 of 65 patients (20%) preoperatively received a diagnosis of unilateral hernia. Eighty-seven percent of patients were asymptomatic with pain. The overall incidence of femoral hernia was 13% (33 of 250 patients). No femoral hernia was diagnosed preoperatively; 4 cases were isolated femoral hernias. In the recurrent population, the incidence of femoral hernia was 19% (20 of 105 patients), whereas in the initial operative intervention population, the incidence was 9% (13 of 145 patients). In addition, femoral hernias were found in 5

---

**Table 1. Types of Unilateral Hernias Found at the Time of Total Extraperitoneal Laparoscopic Hernia Repair**

<table>
<thead>
<tr>
<th>Type of Hernia</th>
<th>Patients, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary Group (n = 43)</td>
</tr>
<tr>
<td>Direct</td>
<td>6 (14)</td>
</tr>
<tr>
<td>Indirect</td>
<td>24 (56)</td>
</tr>
<tr>
<td>Combined</td>
<td>10 (23)</td>
</tr>
<tr>
<td>Femoral</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Femoral and inguinal</td>
<td>1 (2)</td>
</tr>
</tbody>
</table>

Copyright 2016 American Medical Association. All rights reserved.