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Neuromonitoring in Thyroid Surgery: Attitudes, Usage Patterns, and Predictors of Use Among Endocrine Surgeons

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Abstract

Background The use of neuromonitoring in thyroid surgery is controversial. Attitudes about neuromonitoring, usage patterns, and predictors of use have not been formally studied. We hypothesized that attitudes would predict usage patterns and that the predominant strategy among endocrine surgeons would be no neuromonitoring during thyroid surgery.

Methods Members of the American Association of Endocrine Surgeons and registrants of the 2006 annual meeting were surveyed by e-mail. An Internet-based survey composed of simple answer and Likert questions was used. Central tendency was evaluated by modal response. Significance was analyzed by the chi-squared test, and strength of association was calculated by Cramér's V.

Results A total of 117 surveys were completed (41%). Respondents were placed into two groups based on use (37.1%), or nonuse (62.9%) of neuromonitoring. The use category was composed of routine (13.8%) and selective (23.3%) users. The nonuse category was composed of those who have never used neuromonitoring (49.1%) and those who have abandoned its use (13.8%). Nonusers were older ($p = 0.023$) and reported a lower case volume ($p = 0.003$), less familiarity with the technology ($p < 0.001$), and less access to the equipment ($p < 0.001$). Nonusers reported a lower frequency of patient-initiated discussions about neuromonitoring ($p < 0.001$) and were less likely to initiate a discussion with patients ($p < 0.001$). In total, 56% of users and 90% of nonusers believed neuromonitoring does not improve the safety of thyroidectomy ($p < 0.01$). There was no difference in perceived nerve injury rate between users and nonusers. Users agreed that benefits include facilitating identification of the recurrent laryngeal nerve, facilitating resident education, improving patient outcomes, and decreasing liability risk, whereas nonusers disagreed with these statements. Nonusers believed that neuromonitoring can lead to reliance on technology and loss of surgical technique or judgment, but users disagreed. There was consensus of opinion that neuromonitoring allows identification of an intact nerve, can lead to a false sense of security, drives up costs, is beneficial in <10% of cases, does not shorten the length of the procedure, and does not prevent nerve injury.

Conclusions Usage is associated with surgeon age, case volume, equipment availability and familiarity, beliefs about the degree of benefit, and frequency of patient or doctor initiated discussions.

Introduction

The incidence of permanent recurrent laryngeal nerve (RLN) injury for first-time thyroid operations is fortunately uncommon, occurring in fewer than 2% of cases in series from high volume thyroid centers [1–5]. In the hands of less experienced surgeons or in the setting of reoperative surgery, however, the incidence of permanent RLN injury has been reported to be much higher [1, 6, 7]. The gold

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standard method for RLN preservation during thyroidectomy is routine visual identification of the nerve [8]. One method proposed to reduce further the likelihood of RLN injury is intraoperative monitoring of nerve integrity. A review of the scientific evidence suggests that neuromonitoring may have some benefits, but it is not a panacea for thyroid surgery. Many studies are case series, underpowered, and/or lack appropriate control groups, preventing useful statistical analyses. The largest studies have demonstrated no statistically significant difference in the frequency of permanent RLN injury with the use of neuromonitoring when compared to visual identification of the RLN [8–14].

Because of the absence of level I evidence demonstrating a benefit of neuromonitoring, thyroid surgeons must use other factors in the decision of whether to employ neuromonitoring during thyroid surgery. The frequency of neuromonitoring during thyroid surgery is not known. Attitudes about neuromonitoring, usage patterns, and predictors of use have not been formally studied. We hypothesized that attitudes would predict usage patterns and that the predominant strategy among endocrine surgeons would be no neuromonitoring during thyroid surgery.

Methods

Approval for this study was granted by the Northwestern University Institutional Review Board. To test the hypothesis, an Internet-based survey composed of simple answer and Likert questions was developed. The survey was designed to collect data on demographics, practice setting, surgical volume, access and familiarity with technology, usage of neuromonitoring, perceived benefits or problems, and medicolegal issues. Members of the American Association of Endocrine Surgeons (AAES) and registrants of the 2006 annual meeting were sent a description of the study and a link to the survey by e-mail. The survey was distributed to the list of subjects by the American College of Surgeons acting as a third-party. The identities of respondents were not recorded. Data were collected and stored by SurveyMonkey.com during a 7-week survey period from September 26, 2006 through November 15, 2006. Compiled survey data were downloaded into spreadsheet format and analyzed by Microsoft Excel. Central tendency was evaluated by modal response where appropriate. Contingency tables were produced for the ordinal and nominal data from each question.

Significance was analyzed by the chi-squared test. Significance was set at $p < 0.05$. If the expected frequency in any cell was less than five, like categories were merged or Fisher's exact test was used. Strength of association was calculated by Cramér's V. Lambda (λ) was calculated to measure the extent to which the independent variables could predict or explain variation in the dependent variables. In cases of uncertainty regarding which variable was independent, λ was calculated twice by alternating variables, and the variable with the highest λ was considered independent.

Results

A total of 117 surveys were completed, yielding a response rate of 41%. Respondents were placed into two groups based on use (37.1%), or nonuse (62.9%) of neuromonitoring. The use category was composed of routine (13.8%) and selective (23.3%) users. The nonuse category was composed of those who have never used neuromonitoring (49.1%) and those who have used neuromonitoring in the past but have abandoned its use (13.8%).

Demographics

Respondents were asked to report their age in one of four categories: <35, 35–44, 45–55, and >55 years. Age 35–44 was the largest group, representing 37% of respondents; 53% of this age group reported neuromonitoring use. In all, 38% of respondents age 45–55 and only 22% of respondents >55 years of age used neuromonitoring. Response distribution is displayed in Fig. 1. This distribution was significant by the chi-squared test ($p = 0.032$). Cramér's V was 0.25 indicating a moderate association. The lambda (λ) statistic revealed that age was the independent variable predicting neuromonitoring usage with a probability of 63%. Interestingly, no respondents <35 years of age reported neuromonitoring use.

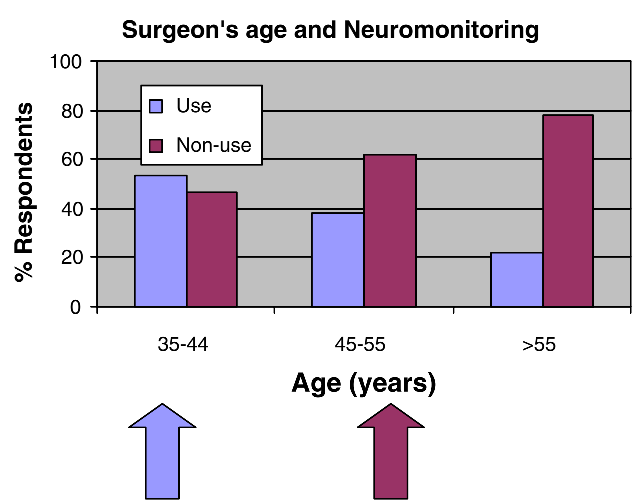

Fig. 1 Surgeon's age and neuromonitoring. Arrows indicate modal responses for each group. The distribution is statistically significant by the chi-squared test ($p = 0.03$)

Altogether, 61% of respondents reported completing a fellowship or receiving special training in thyroid surgery. In all, 36.6% of those with fellowship training and 37.7% of those without such training used neuromonitoring. The difference is not significant ($p = 0.90$).

Among the 117 respondents, 78% reported that they practice medicine in North America, 12% in Europe, 6% in Asia, 3% in Australia, and 1% in South America. In total, 40% of respondents from North America and 43% from Europe reported using neuromonitoring, whereas only one respondent (9%) from Asia, Australia, and South America combined reported usage.

Altogether, 87% of the respondents reported that they practice in a tertiary referral or university hospital. Of the respondents working in a tertiary setting 35% used neuromonitoring compared to 57% of those in a community hospital. The difference was not statistically significant ($p = 0.10$).

A total of 81% of respondents characterized their practice as "academic," 16% as "private practice," and 3% as "managed care." Altogether, 39% of academics and 32% of private practitioners reported neuromonitoring usage ($p = 0.33$). All managed care respondents reported that they have never tried neuromonitoring.

Many respondents (91%) reported that they are involved in training surgical residents. Among them, 39% used neuromonitoring, whereas only 18% of those without residents use neuromonitoring. The difference was not statistically different ($p = 0.17$).

Approximately half (51%) of the respondents reported that they are involved in training surgical fellows. Among them 38% reported using neuromonitoring compared to 36% of those who do not train fellows ($p = 0.77$).

Surgical volume and nerve injury

Respondents were placed in one of two categories based on the reported volume of thyroid surgery. They were designated "low volume" if they reported fewer than 100 thyroid operations per year and "high volume" if they reported 100 or more thyroid operations per year; 58% of respondents were designated "high volume." In total, 50% of high volume surgeons reported neuromonitoring compared to only 22% of low volume surgeons ($p = 0.003$). An interesting pattern was identified when evaluating exact neuromonitoring usage patterns by thyroid surgery volume (Fig. 2). High volume surgeons were the most likely to always employ neuromonitoring and least likely to have never tried neuromonitoring. High volume surgeons were also more likely to use neuromonitoring selectively. This distribution was significant by the chi-squared test ($p = 0.008$). Cramér's V was 0.33, indicating a moderate association between surgical volume and neuromonitoring usage. The λ statistic revealed that neuromonitoring usage was the independent variable predicting surgical volume (high or low) with a probability of 65%.

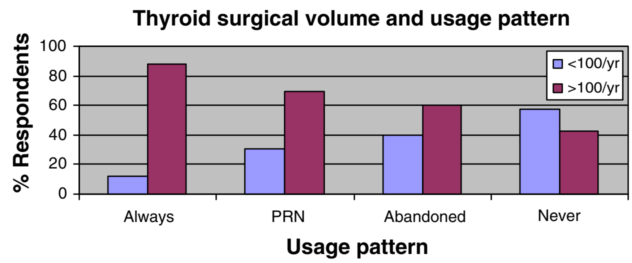

Fig. 2 Thyroid surgery volume and neuromonitoring usage pattern. The distribution is statistically significant by the chi-squared test ($p = 0.008$). Neuromonitoring usage pattern is the independent variable predicting thyroid surgical volume. PRN: as needed

A total of 76% of respondents reported that their permanent recurrent laryngeal nerve (RLN) injury rate for first-time surgery was <1% (low); 23% answered 1% to 2% (medium); and 1% reported a 2% to 5% (high) injury rate for first-time surgery. Altogether, 39% of those with a low RLN injury rate and 31% with a medium rate reported neuromonitoring usage. This distribution was not significant by the chi-squared test ($p = 0.32$).

A total of 39% of respondents reported that their permanent RLN injury rate for reoperative surgery was <1%, 43% reported a 1% to 2% risk, and 18% reported a 2% to 5% risk. In all, 29% of the surgeons with a low rate, 46% with a medium rate, and 38% with a high rate reported neuromonitoring usage. This distribution was not significant by the chi-squared test ($p = 0.24$).

Predictors of use

Altogether, 40% of all respondents classified themselves as novices with neuromonitoring technology, and only 7% considered themselves experts. Familiarity with neuromonitoring technology correlated with the usage pattern (Fig. 3) ($p < 0.001$). Most users of neuromonitoring considered themselves expert (14%) or advanced (40%) users. Conversely, most nonusers considered themselves intermediate (16%) or novice (59%) users. Those respondents who classified themselves as intermediate, advanced, or expert were more likely to use neuromonioring. Respondents who classified themselves as novice or unfamiliar were less likely to use neuromonitoring. Cramér's V was 0.72, indicating a strong association between familiarity and the usage pattern. The λ statistic revealed that familiarity was the independent variable correctly predicting neuromonitoring usage, with a probability of 84%.

In total, 43% of respondents reported that neuromonitoring was available to them for routine use, 11% reported limited availability based on a limited number of devices, 25% reported availability only by special arrangement, and 20%

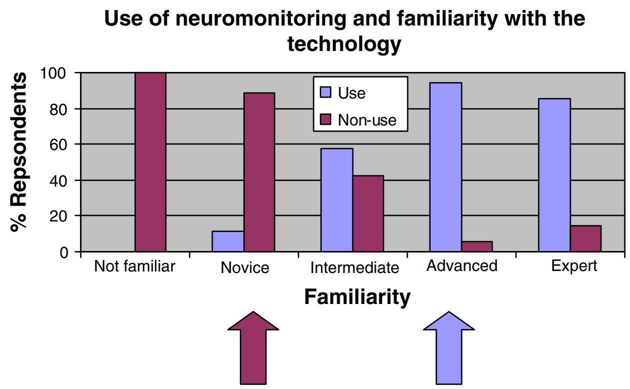

Fig. 3 Familiarity and usage of neuromonitoring technology. Arrows indicate modal responses for each group. The distribution is statistically significant by the chi-squared test ($p < 0.001$)

reported that neuromonitoring was not available to them. Altogether, 74% of users reported that neuromonitoring was available for routine use in their facility compared to only 22% of nonusers; 33% of nonusers reported that neuromonitoring is not available in their facility. A statistically significant distribution was found correlating availability of neuromonitoring technology and usage ($p < 0.001$), which is displayed in Fig. 4. Cramér's V was 0.57, indicating a relatively strong association between availability of neuromonitoring technology and usage. The λ statistic revealed that availability was the independent variable correctly predicting neuromonitoring usage, with a probability of 76%.

Interactions with patients

Among the respondents, 48% indicated that their patients never initiate a discussion about neuromonitoring with them, and this was the most common response. Only 3% responded that patients initiate a discussion on a daily basis. Altogether, 19% of users and 68% of nonusers responded that patients never initiate a discussion on the topic. A statistically significant distribution was found correlating frequency of patient-initiated discussions about neuromonitoring and usage (Fig. 5) ($p < 0.001$). Cramér's V was 0.59, indicating a relatively strong association between patient-initiated discussions regarding neuromonitoring and usage pattern. The λ statistic revealed that patient-initiated discussion was the independent variable correctly predicting neuromonitoring usage, with a probability of 78%.

A total of 59% of respondents replied that they never initiate discussions about neuromonitoring with their patients, and 8% responded that they initiate discussions about neuromonitoring on a daily basis. The modal response in the user group was that they initiate discussions on the topic approximately once or twice a month (33%). In all, 14% of users and 81% of nonusers replied that they never initiate discussions on the topic. A statistically significant distribution was identified between the two usage groups by the chi-squared test (Fig. 6) ($p < 0.001$) associating frequency of surgeon-initiated discussions about neuromonitoring and usage. Cramér's V was 0.70, revealing a strong association between surgeon-initiated discussions about neuromonitoring and usage. The λ statistic indicated that surgeon-initiated discussions about neuromonitoring was the independent variable correctly predicting neuromonitoring usage, with a probability of 83%.

A total of 42% of respondents replied that if a patient were to ask them to use neuromonitoring they would do so. This was the modal response. Another 39% replied that they would tell the patient that it was not necessary; 13% would

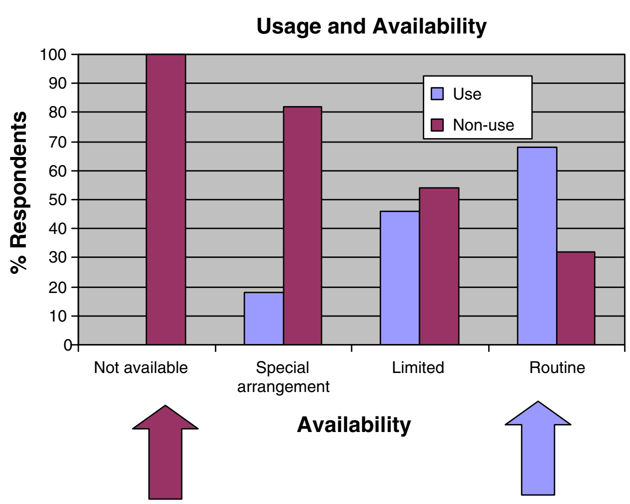

Fig. 4 Availability and usage. Arrows indicate modal responses for each group. The distribution is statistically significant by the chi-squared test ($p < 0.001$)

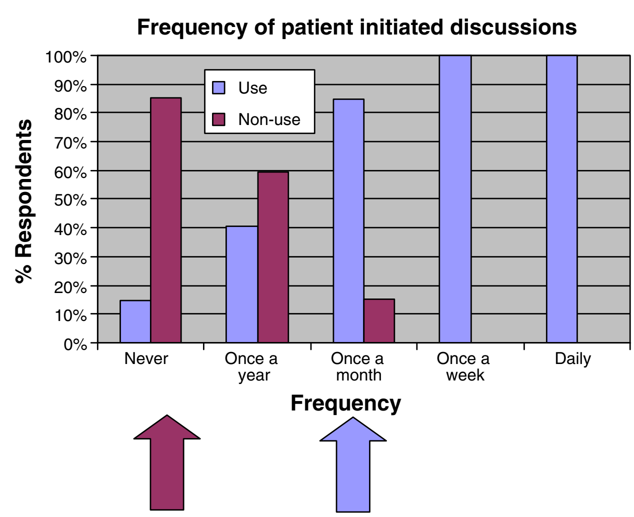

Fig. 5 Frequency of patient initiated discussions about neuromonitoring. Arrows indicate modal responses for each group. The distribution is statistically significant by the chi-squared test ($p < 0.001$)

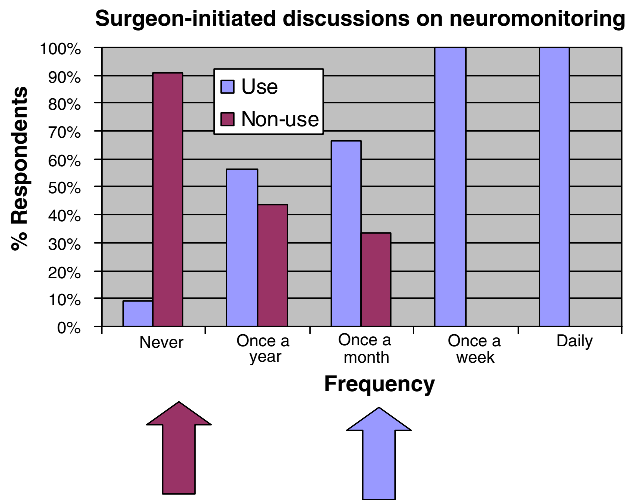

Fig. 6 Surgeon-initiated discussions on neuromonitoring. Arrows indicate modal responses for each group. The distribution is statistically significant by the chi-squared test ($p < 0.001$)

tell the patient that the device is not available; and 6% would refer the patient to another surgeon. In total, 84% of the use group responded that they would use a neuromonitoring device if asked to do so, compared to only 15% of the nonuse group; 54% of the nonuse group would reply that it is not necessary compared to only 16% of the use group (all selective users). This distribution in responses was significantly different by the chi-squared test ($p < 0.001$).

Selective usage based on operation and disease

A series of thyroid operations and diseases were listed, and respondents were asked how often they use neuromonitoring for those operations. Only data from respondents who use neuromonitoring selectively were evaluated ($n = 25$) and are presented in Table 1.

Attitudes

A total of 76% of all respondents answered that neuromonitoring does not improve the safety of thyroid surgery; 56% of all users and 90% of all nonusers believe neuromonitoring does not improve the safety of thyroidectomy. Of those respondents who think that neuromonitoring improves safety, most (73%) were users. In all, 69% of routine users, 30% of selective users, and 10% of nonusers believe neuromonitoring improves the safety of thyroidectomy. The distribution of responses was significant by the chi-squared test (Fig. 7) ($p < 0.001$). Cramér's V was 0.39 for this distribution, indicating a moderate association. The λ statistic indicated that neuromonitoring usage was the independent variable correctly predicting attitudes about improvement in safety, with a probability of 76%.

Respondents were given a series of questions regarding the possible benefits and problems associated with neuromonitoring. Possible responses were supplied on a 5-point Likert scale ranging from "strongly agree" to "strongly

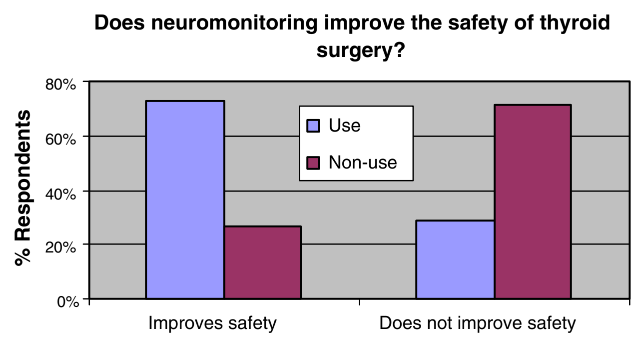

Fig. 7 Does neuromonitoring improve the safety of thyroid surgery?

Table 1 Selective use of neuromonitoring

Parameter	Neuromonitoring usage pattern		
	Never	Selectively	Always
Thyroid operation			
Hemithyroidectomy	12 (48%)	13 (52%)	0
Total thyroidectomy	11 (44%)	14 (56%)	0
Completion thyroidectomy	4 (16%)	20 (80%)	1 (4%)
Total thyroidectomy with limited neck dissection	7 (28%)	16 (64%)	2 (8%)
Reoperative thyroid surgery	0	13 (52%)	12 (48%)
Removal of substernal goiter via cervical incision	8 (32%)	14 (56%)	3 (12%)
Thyroid disease			
Hashimoto's thyroiditis	9 (36%)	16 (64%)	0
Benign neoplasm	15 (60%)	10 (40%)	0
Malignant neoplasm	4 (16%)	20 (80%)	1 (4%)
Graves' disease	11 (44%)	13 (52%)	1 (4%)
Goiter	12 (48%)	13 (52%)	0

disagree." Modal responses are listed for each question in Table 2. Significance was determined by the chi-squared test. Cramér's V and λ were calculated for each significant distribution.

Overall, 72% of respondents answered that neuromonitoring is beneficial in fewer than 10% of cases. This was the modal response overall and for each group. The distribution of responses, however, was different between groups: 47% of nonusers and 89% of users responded that neuromonitoring was beneficial in fewer than 10% of cases; 37% of users and 5% of nonusers responded that neuromonitoring is beneficial in 10% to 25% of cases; 16% of users and 6% of nonusers responded that neuromonitoring was beneficial in >25% of cases. This distribution in responses was significantly different by Fisher's exact test ($p < 0.001$). Cramér's V was 0.48, indicating a relatively strong association between neuromonitoring usage and belief that it is beneficial. The λ statistic indicated that the belief that neuromonitoring is beneficial was the independent variable correctly predicting neuromonitoring usage, with a 75% probability.

Legal issues

A total of 10% of users and 12% of nonusers have been named in a lawsuit due to RLN injury. This distribution was not significant by the chi-squared test ($p = 0.66$). Respondents were asked to estimate the effect on liability for three strategies of neuromonitoring: nonusage, selective usage, and routine usage.

Nonusage strategy

In all, 55% of users and 8% of nonusers responded that a nonusage strategy would increase the liability risk of thyroid surgery, whereas 45% of users and 91% of nonusers responded that nonusage would have no effect on liability. The distribution of responses was significant by Fisher's

Table 2 Selected questions with modal responses and statistical results

Statement	Modal response		p	Cramér's V
	Use group ($n = 43$)	Nonuse group ($n = 66$)		
Neuromonitoring facilitates identification of the RLN.	Agree	Disagree	<0.001	0.41
Neuromonitoring facilitates preservation of the RLN.	Disagree	Disagree	<0.001	0.46
The use of neuromonitoring allows demonstration that the RLN is intact or functional.	Agree	Agree	0.001	0.36
The use of neuromonitoring allows demonstration that the RLN is *not* intact or functional.	Agree	Neutral	0.043	0.24
Neuromonitoring facilitates surgical resident education in the operating room.	Agree	Disagree	<0.001	0.38
Neuromonitoring shortens the length of the procedure.	Disagree	Disagree	0.006	0.31
The use of neuromonitoring decreases liability risk.	Neutral	Disagree	0.001	0.35
The use of neuromonitoring increases billing rates.	Disagree	Neutral	0.278	
Neuromonitoring has a high false-positive rate.	Disagree	Neutral	<0.001	0.55
Neuromonitoring has a high false-negative rate.	Agree	Neutral	0.001	0.35
Neuromonitoring does not prevent nerve injury.	Agree	Agree	0.216	
Neuromonitoring may foster a reckless and nonsystematic dissection technique.	Disagree	Neutral	0.003	0.33
Neuromonitoring may give a false sense of security.	Agree	Agree	0.013	0.28
Excessive use of neuromonitoring may lead to reliance on technology and loss of sound surgical technique and/or judgment.	Disagree	Agree	0.004	0.32
The use of neuromonitoring increases OR time.	Neutral	Agree	0.001	0.35
The use of neuromonitoring drives up the cost of the operation.	Agree	Agree	0.280	
Neuromonitoring is a good marketing tool.	Neutral	Agree	<0.001	0.55
Neuromonitoring is a method to reduce the liability of thyroid surgery.	Neutral	Disagree	0.015	0.28
Neuromonitoring is a tool to improve patient outcomes.	Agree	Disagree	<0.001	0.43
Neuromonitoring is a tool to please my referring physicians.	Disagree	Neutral	0.355	

The survey gave the following instructions to the respondents: *Please tell us whether you agree with the following statements about neuromonitoring during thyroid surgery*

RLN: recurrent laryngeal nerve; OR: operating room exact test ($p < 0.001$). Cramér's V was 0.53, indicating a relatively strong association between the usage pattern and the belief that never using neuromonitoring would affect liability. The λ statistic indicated that the belief that never using neuromonitoring has an impact on liability was the independent variable correctly predicting neuromonitoring usage, with a 78% probability.

Selective usage strategy

A total of 12% of users and 8% of nonusers responded that a selective usage strategy would increase liability risk, whereas 40% of users and 65% of nonusers responded that this strategy would not affect liability risk. In all, 48% of users and 27% of nonusers responded that the selective usage strategy would decrease liability risk. This distribution was significant by the chi-squared test ($p = 0.042$). Cramér's V was 0.24, indicating a moderate association. The λ statistic indicated that the belief that a selective usage pattern affects liability was the independent variable correctly predicting neuromonitoring usage, with a 63% probability.

Routine usage strategy

In all, 2% of users and 5% of nonusers responded that a strategy of routine neuromonitoring would increase liability risk, whereas 45% of users and 76% of nonusers responded that there would be no impact on liability. A total of 52% of users and 20% of nonusers responded that a routine use strategy would decrease liability risk. This distribution in responses was significantly different by Fisher's exact test ($p = 0.001$). Cramér's V was 0.34, indicating a moderate association. The λ statistic indicated that the belief that a routine neuromonitoring strategy would affect liability was the independent variable correctly predicting neuromonitoring usage, with a 69% probability.

Discussion

Most of the respondents to this survey reported that they do not use neuromonitoring for thyroid surgery (62.9%). Furthermore, a large percentage of respondents (49.1%) reported that they have never used neuromonitoring. It was not surprising, then, to find that familiarity with neuromonitoring technology was the strongest predictor of usage (Cramér's V = 0.72). Most users of neuromonitoring consider themselves to have advanced familiarity with the technology, whereas most nonusers consider themselves novices. Calculating the λ statistic revealed that familiarity with neuromonitoring technology is the independent variable that influences the probability of neuromonitoring usage (dependent variable).

A total of 81% of nonusers reported that they never initiate a discussion with their patients on neuromonitoring, whereas only 14% of users never initiate such a discussion. Most users of neuromonitoring report that they initiate a discussion on the topic with their patents approximately once a month. This was the second strongest predictor of neuromonitoring use. The λ statistic shows that this behavior is the independent variable, and it influences the probability of usage.

The strongest associations with neuromonitoring usage (highest Cramer's V values) are listed in Table 3. The possible ranges for Cramér's V are 0 (indicating no association between variables) to 1 (indicating a perfect association). The most common results for Cramér's V fall between 0.2 and 0.6 for survey data.

Factors that were not related to the neuromonitoring usage pattern included fellowship training in thyroid surgery, geographic practice location, practice environment, academic or private setting, involvement in the training of surgical residents or fellows, personal estimation of complication rates, or history of being named in a lawsuit for RLN injury.

In this study, the authors hypothesized that the usage of neuromonitoring would be the dependent variable for the conditions studied. Questions were formulated and written from that framework, and the relation between variables was assumed to be asymmetric. Accordingly, λ was calculated to measure the extent to which the independent variables could predict or explain variation in the dependent variables. A value of 0 for λ means that the independent variable is not useful for predicting the dependent variable. A value of 1, however, signifies perfect ability to predict the dependent variable based on the independent variable. Variables were then ranked by their degree of influence on the dependent variable (use of neuromonitoring). The λ statistic was also used to confirm which variable was independent when the relation was not intuitive. For each statistically significant distribution of responses, λ was calculated twice, with each variable alternating as the independent. The variable with the greatest calculated λ was considered to be independent.

Usage of neuromonitoring was the dependent variable for most of the questions in the survey. In other words, we found that in most cases when the distribution of results was significantly different between groups the attitudes, behaviors, and demographic information we studied were the independent variables that influenced the respondent's likelihood of neuromonitoring usage. Neuromonitoring usage was found to be the independent variable in four survey questions.

1. When asked if neuromonitoring improves the safety of thyroid surgery, most users and nonusers responded that it does not. In the analysis of both groups,

Table 3 Factors associated with neuromonitoring ranked by strength of association

Factor	Cramér's V
Strong associations (Cramér's V = 0.60–0.79)	
Familiarity with neuromonitoring technology	0.72
More frequent surgeon-initiated discussions about neuromonitoring	0.70
Relatively strong associations (Cramér's V 0.40–0.59)	
More frequent patient-initiated discussion about neuromonitoring	0.58
Availability of neuromonitoring	0.57
Disbelief that neuromonitoring has a high false-positive rate	0.55
Belief that neuromonitoring improves patient outcomes	0.43
Belief that neuromonitoring facilitates identification of the RLN	0.41
Moderate associations (Cramér's V 0.20–0.39)	
Belief that neuromonitoring improves the safety of thyroid surgery	0.39
Belief that neuromonitoring facilitates resident education	0.38
Belief that neuromonitoring allows demonstration of an intact RLN	0.36
Belief that neuromonitoring has a high false negative rate	0.35
Belief that neuromonitoring decreases liability risk	0.35
Disbelief that neuromonitoring increases OR time	0.35
Belief that routine use decreases liability	0.34
Disbelief that neuromonitoring use fosters reckless dissection	0.33
>100 thyroid operations per year (high volume)	0.33
Disbelief that neuromonitoring results in loss of judgment	0.32
Belief that neuromonitoring shortens the operation	0.31
Disbelief that neuromonitoring may result in a false sense of security	0.28
Belief that neuromonitoring is a method to reduce liability	0.28
Younger age (35–44 years)	0.25
Belief that selective neuromonitoring may reduce liability	0.24
Belief that neuromonitoring allows demonstration of an RLN that is *not* intact	0.24

however, a significant difference in the response pattern was detected: 44% of users responded that it does improve safety compared to only 10% of nonusers. The strength of this association was moderate, and the λ statistic indicated that the use of neuromonitoring was the likely independent variable. The implication of this is that the use of neuromonitoring more strongly influences the belief that neuromonitoring is linked to safety than the converse (the belief that neuromonitoring is linked to safety influences the choice to use neuromonitoring). The λ statistic revealed a strong influence of both variables on the other, with a slightly larger λ for neuromonitoring usage.

2. Approximately half (50%) of high volume surgeons reported neuromonitoring compared to only 22% of low volume surgeons ($p = 0.003$). Cramér's V was 0.33, indicating a moderate association between surgical volume and neuromonitoring usage. The λ statistic revealed that neuromonitoring usage was the independent variable predicting higher surgical volume. The implication of this finding is that use of neuromonitoring somehow influences surgical volume more than surgical volume influences the use of neuromonitoring.
3. Most of the respondents from both groups were in consensus that neuromonitoring does not shorten the procedure. A greater percentage of users responded that they believe neuromonitoring shortens the procedure (14% vs. 2%). The λ statistic indicated that usage was the independent variable that influenced the belief that neuromonitoring shortens the procedure.
4. Most of the respondents from both groups were in agreement that the use of neuromonitoring may give a false sense of security during thyroid surgery. However, 23% of users and 5% of nonusers disagreed with this statement. The λ statistic indicated that neuromonitoring usage was the independent variable that influenced the difference in attitude between the two groups.

Conclusions

Selective users were most likely to employ neuromonitoring for completion thyroidectomy, reoperative surgery, and cancer operations. Nonusers were older, particularly those who had never used neuromonitoring. Nonusers reported a lower case volume and less familiarity and less access to the technology. Nonusers reported a lower frequency of patient-initiated discussions about neuromonitoring and were less likely to initiate such a discussion. Most respondents believe that neuromonitoring does not improve the safety of thyroidectomy. However, 69% of routine users, 30% of selective users, and 10% of nonusers believe that it does improve the safety of thyroidectomy. Users agree that the benefits of neuromonitoring include facilitation of identifying the RLN, facilitation of resident education, improving patient outcomes, and decreasing liability risk; nonusers disagree with these statements. Nonusers believe that neuromonitoring can lead to reliance on technology and loss of sound surgical technique or judgment; users disagree. There was a consensus of opinion among most of the respondents in both groups that neuromonitoring allows identification of an intact nerve, can lead to a false sense of security, drives up the cost of the operation, is beneficial in fewer than 10% of cases, does not shorten the length of the procedure, and does not prevent nerve injury.

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