The role of intraoperative neuromonitoring of recurrent laryngeal nerve during thyroidectomy: A comparative study on 1000 nerves at risk

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Background. *The role of intraoperative neuromonitoring of recurrent laryngeal nerve (RLN) during thyroidectomy has not been well established. The present study evaluates whether RLN injury can be reduced by the application of this technique during thyroidectomy in a single center.*
Methods. *Of 1000 RLNs that were at risk of injury in 639 consecutive patients who underwent thyroidectomy, the outcome of 501 RLNs with the use of neuromonitoring was compared with that of 499 nerves that were operated by routine identification only. The incidences of RLN paralysis were compared between the 2 groups and the assigned risk subgroups.*
Results. *Postoperative palsy was identified in 47 RLNs (4.7%), with complete recovery in 37 of 44 RLNs (84%) without documented injury. The overall incidence of postoperative RLN paralysis was significantly higher during thyroidectomy for malignancy ($P = .025$) and secondary thyroidectomy ($P = .017$). There was no significant difference in postoperative, transient, and permanent paralysis rates between the neuromonitoring and control groups. In subgroup analysis, the postoperative RLN palsy rate was higher during reoperative thyroidectomy (19% vs 4.6%; $P = .019$) in the control group but not in the neuromonitoring group (7.8% vs 3.8%; $P > .05$).*
Conclusion. *Neuromonitoring of the RLN during thyroid surgery could not be demonstrated to reduce RLN injury significantly, compared with the adoption of routine RLN identification. However, its application can be considered for selected high-risk thyroidectomies. (Surgery 2006;140:866-73.)*

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RECURRENT LARYNGEAL NERVE (RLN) is prone to iatrogenic injury during thyroidectomy and accounts for most of the medicolegal claims that are related to complications of thyroid surgical procedures.[1] Apart from leading to functional and psychologic disturbances, RLN palsy can also affect the patient's social interaction and occupational status.[2] Various risk factors of RLN injury have been identified during thyroid surgical procedures,[3-5] and the adoption of routine identification of the RLN has been shown to be associated with a lower incidence of RLN injury.[6,7] Despite advances in surgical technique, an overall permanent RLN palsy rate of 1% to 2% is reported and is even higher for complex thyroidectomies in specialized centers.[3,7]

Surgical adjuncts such as intraoperative neuromonitoring (IONM) are being sought actively to prevent RLN injury during thyroidectomy. However, the objective documentation of the role of IONM to improve surgical outcome during thyroid surgical procedures has been limited to a few multicenter trials.[4,8,9] However, despite the absence of objective data to support its role, the routine use of IONM has been advocated during thyroid surgical procedures to enhance the surgical outcome. The objective of the present study was to determine the potential role of IONM in reducing the postoperative RLN palsy rate by a comparison of the out-

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come of patients with IONM with procedures that were performed by routine identification of RLN only during thyroidectomy in a single endocrine surgical center.

PATIENTS AND METHODS

Between January 2002 and August 2005, the cases of 639 of 647 consecutive patients who underwent thyroidectomy by a single surgical team were evaluated; the cases of patients with an intraoperative finding of tumor involvement of RLN (n = 8) were excluded. IONM was performed for 316 patients on the basis of the availability of the equipment and the choice of the operating surgeons (neuromonitoring group); 323 patients underwent thyroidectomies with routine identification of RLN only (control group).

The technique of IONM has been described previously.[10] In brief, the Neurosign 100 machine (Magstim Clarify Company, Whitland, UK) was used for IONM. A laryngeal surface electrode was applied and adhered to the concave surface of the endotracheal tube just proximal to the vocal cord. The RLN was identified at the tracheoesophageal groove early during dissection and was stimulated by the application of a bipolar probe to deliver an electric current that ranged from 0.5 to 1.5 mA at a frequency of 30 Hz. The identity of an intact RLN would be confirmed through a series of audible acoustic signals that were generated by the machine. The functional integrity of the nerve once again would be confirmed at the end of the thyroidectomy by the testing of the most proximal exposed portion of the nerve. The absence of a signal that was generated by the stimulator at any precise point along the nerve would be regarded as a positive test.

Routine vocal cord examination was performed for all patients at 24 to 48 hours before and within 2 weeks after the surgical procedure by otolaryngologists using an indirect or flexible laryngoscope. Any reduction in the movement of the cord was recorded as postoperative cord paralysis. For those patients with documented postoperative cord palsy, repeated examinations were performed periodically at 1, 3, 6, and 12 months after the operation until full recovery of vocal cord function had been confirmed. The presence of vocal cord paralysis for >12 months after thyroidectomy was regarded as permanent.

The primary outcome that was measured was the rate of postoperative, transient, and permanent nerve palsy that was calculated on the basis of the number of nerves that were at risk. Patients were also stratified to different risk subgroups according to the expected technical difficulty or inherited risk based on the nature of the operative procedures. The high-risk group was classified as secondary (reoperative) thyroidectomy for recurrent disease and surgical procedures for malignancy and retrosternal or toxic goiter. Information on patient demographics, indications and types of operative procedure, operative details, neuromonitoring signal results, disease, and postoperative outcomes were collected prospectively. Potential confounding variables for postoperative nerve palsy were tested with univariate analysis, and their associations were assessed by multivariate logistic regression. Comparison of characteristics between groups and the proportion of at-risk nerves injury according to the surgical risk subgroups were performed with the Student *t* test (continuous variables) and chi-square or Fisher's exact test, when appropriate (categoric variables). A probability value of $<.05$ was defined as significant.

RESULTS

There were 133 men and 506 women with a mean age of 49 years (range, 8-93 years). The operative procedures included total or near-total thyroidectomy (n = 358 patients), unilateral lobectomy (n = 241 patients), completion total thyroidectomy (n = 36 patients), and subtotal thyroidectomy (n = 4 patients). Unilateral and bilateral procedures were performed in 277 and 362 patients, respectively, which accounted for 1000 nerves that were at risk after the exclusion of the RLN injured patients during the previous operation with preoperative unilateral cord palsy. Concomitant lateral neck dissection was performed in 27 patients (4.2%). The final pathologic condition was benign nodular goiter in 357 patients (56%), thyroid malignancy in 141 patients (22%), Graves' disease in 86 patients (13%), follicular adenoma in 50 patients (8%), and thyroiditis in 5 patients (1%).

The number of nerves that were at risk was 501 and 499 in the IONM and control groups, respectively. A comparison of baseline characteristics between these 2 groups is shown in Table I. Age, gender, types of thyroidectomy, the proportion of bilateral procedures, concomitant neck dissections, estimated blood loss, operative time, and the pathologic condition did not differ significantly between the 2 groups, although the weight of resected specimens in the IONM group was heavier than that of the control group ($P < .008$). In addition, the overall risk group stratification was comparable between the 2 groups, although subgroup analysis showed that a greater proportion of the nerves that were at risk that underwent reop-

Table I. Demographics, operative details, and pathologic information of patients who underwent thyroidectomy with and without IONM

Variable	*IONM group* Procedures (n = 316)	*IONM group* Nerves at risk (n = 501)	*Control group* Procedures (n = 323)	*Control group* Nerves at risk (n = 499)	P *value*
Procedure					
Total thyroidectomy (n)	183	365*	171	342	.40
Unilateral lobectomy (n)	110	110	131	131	
Completion total thyroidectomy (n)	20	20	16	16	
Bilateral subtotal thyroidectomy (n)	2	4	2	4	
Near total thyroidectomy (n)	1	2	3	6	
Uni-/bilateral procedures (n/N)	130/186		147/176		.18
Lateral neck dissection (n)	17 (5.4%)		10 (3.1%)		.15
Estimated blood loss (mL)†	40 ± 62		40 ± 41		.88
Operative time (min)†	119 ± 51		116 ± 37		.41
Weight of specimens (g)†	65 ± 79		50 ± 54		.008
Disease (n)					
Nodular goiter	180 (57%)		177 (55%)		.10
Carcinoma	78 (25%)		63 (20%)		
Graves' disease	34 (11%)		52 (16%)		
Follicular adenoma	21 (7%)		29 (9%)		
Thyroiditis	3 (1%)		2 (1%)		

Age: IONM group, 50 ± 16 years; control group, 48 ± 15 years; P = .19.
Female patients: IONM group, 250 (79%); control group, 256 (79%); P = .96.
*One nerve had previous documented injury that was associated with preoperative cord palsy.
†Data presented as mean ± SD.

Table II. Comparison of patients who underwent thyroidectomy with and without IONM, based on risk group stratification

Variable	*IONM group (n)* Procedures (n = 316)	*IONM group (n)* Nerves at risk (n = 501)	*Control group (n)* Procedures (n = 323)	*Control group (n)* Nerves at risk (n = 499)	P *value*
Risk group					
High	167 (53%)	301 (60%)	160 (50%)	293 (58%)	.42
Low	149 (47%)	200 (40%)	163 (50%)	206 (42%)	
Carcinoma					
Yes	78 (25%)	142 (28%)	63 (20%)	115 (24%)	.056
No	238 (75%)	359 (72%)	260 (80%)	384 (76%)	
Reoperation					
Yes	29 (9%)	38 (8%)	18 (6%)	21 (4%)	.024
No	287 (91%)	463 (92%)	305 (94%)	478 (96%)	
Retrosternal goiter					
Yes	35 (11%)	59 (12%)	30 (9%)	52 (10%)	.58
No	281 (89%)	442 (88%)	293 (91%)	447 (90%)	
Toxic goiter					
Yes	46 (15%)	92 (18%)	62 (19%)	124 (24%)	.012
No	270 (85%)	409 (82%)	261 (81%)	375 (76%)	

erations (P = .024) and thyroidectomy for nontoxic goiter (P = .012) had IONM (P = .024), respectively (Table II).

Postoperative vocal cord paralysis was identified in 47 of 1000 nerves (4.7%) that were at risk from 45 patients; 1 patient in each group was documented to have bilateral nerve palsy. Inadvertent nerve injury was documented for 3 nerves during operations in the control group (P = .12). Complete recovery was documented in 37 of the 44 intact nerves (84%) after a median period of 6 months (range, 1-12 months), which accounted for

Table III. The incidences of RLN injury, based on risk stratification

		Rate of RLN palsy (n)		
	Nerves at risk (n)	*Transient*	*Permanent*	*Postoperative*
Overall	1000	37 (3.7%)	10 (1.0%)	47 (4.7%)
Risk group				
High	594	27 (4.5%)	7 (1.2%)	34 (5.7%)
No	406	10 (2.5%)	3 (0.7%)	13 (3.2%)
Carcinoma				
Yes	257	16 (6.2%)	3 (1.2%)	19 (7.3%)*
No	743	21 (2.8%)	7 (1.0%)	28 (3.8%)
Reoperation				
Yes	59	5 (8.5%)	2 (3.4%)	7 (11.9%)†
No	941	32 (3.4%)	8 (0.9%)	40 (4.3%)
Retrosternal goiter				
Yes	111	5 (4.5%)	1 (0.9%)	6 (5.4%)
No	889	32 (3.6%)	9 (1.0%)	41 (4.6%)
Toxic goiter				
Yes	216	6 (2.7%)	1 (0.5%)	7 (3.2%)
No	784	31 (4.0%)	9 (1.1%)	40 (5.1%)

$P > .05$ for all items between the low- and high-risk group and the subgroups, except $^*P = .025$ and $^\dagger P = .017$.

a transient and permanent palsy rate of 3.7% and 1%, respectively. All except 1 RLN in 2 patients with bilateral RLN palsy recovered completely. The postoperative overall, transient, and permanent rates of RLN injury were compared based on the risk group stratification in Table III. The overall incidence of RLN palsy was significantly higher in patients who underwent thyroidectomy for malignancy compared with those procedures for benign diseases (7.3% vs 3.8%; $P = .025$), and in those undergoing secondary, compared with primary, thyroidectomy (11.9% vs 4.3%; $P = .017$). In the multivariate logistic regression, secondary thyroidectomy ($P = 0.02$; odds ratio, 2.90), thyroidectomy for malignancy ($P = .05$; odds ratio, 1.93), and operative time (158 ± 64 minutes vs 123 ± 41 minutes; $P \leq .001$; odds ratio, 1.01) were independent risk factors for postoperative overall RLN palsy (Table IV). The adoption of IONM during thyroidectomy, however, was not associated with a statistically significant reduction in the incidence of the postoperative RLN palsy ($P = .21$).

The rates of postoperative RLN palsy were 4.2% (n = 21 patients) and 5.2% (n = 26 patients) in the IONM and control groups, respectively ($P > .05$; Table V). The rates of transient and permanent RLN palsy in the IONM and control groups were 3.4% versus 4.0% and 0.8% versus 1.2%, respectively ($P > .05$). Subgroup analysis failed to show any significant difference in the rates of transient, permanent, and postoperative RLN palsy between the IONM and control groups for the different assigned risk subgroups. In addition, within the IONM or control group, there was no difference in the transient, permanent, and postoperative nerve palsy rates for the different risk subgroups, except that the postoperative palsy rate of secondary thyroidectomy was significantly higher than that of primary procedure in the control group (19% vs 4.6%; $P = .019$), but not in the IONM group (7.8% vs 3.8%; $P = .21$). For secondary thyroidectomy, patients in the control group had a higher incidence of postoperative (19% vs 7.8%; $P = .23$), transient (14% vs 5.2%; $P = .34$), and permanent (4.8% vs 2.6%; $P = .99$) RLN palsy rates than those in the IONM group, although the difference was not statistically significant.

Table IV. Multivariate analysis with logistic regression of risk factors of RLN palsy

Variable	P *value*	*Odds ratio*	*95% CI*
Malignancy: No/yes	.05	1.93	0.99-3.76
Reoperation: No/yes	.02	2.90	1.16-7.23
Operative time	<.01	1.01	1.01-1.02

Table VI shows the correlation between the neuromonitoring signal results and the postoperative vocal cord outcome. Eleven of the 21 injured nerves (true positive) were predicted accurately by the neuromonitoring, although intact signals could be generated from the 10 injured nerves (false negative). In addition, the absence of a signal (false positive) was documented in another 27 nerves with intact postoperative vocal cord function. The sensitivity, specificity, and positive and negative

Table V. Rates of RLN palsy after thyroidectomy with and without IONM

	IONM group (n)				*Control group (n)*			
Variable	*Nerves at risk*	*Transient*	*Permanent*	*Postoperative*	*Nerves at risk*	*Transient*	*Permanent*	*Postoperative*
Overall	501	17 (3.4%)	4 (0.8%)	21 (4.2%)	499	20 (4.0%)	6 (1.2%)	26 (5.2%)
Risk group								
High	301	14 (4.7%)	3 (1.0%)	17 (5.7%)	293	13 (4.4%)	4 (1.4%)	17 (5.8%)
Low	200	3 (1.5%)	1 (0.5%)	4 (2.0%)	206	7 (3.4%)	2 (1.0%)	9 (4.4%)
Carcinoma								
Yes	142	9 (6.3%)	1 (0.7%)	10 (7.0%)	115	7 (6.1%)	2 (1.7%)	9 (7.8%)
No	359	8 (2.2%)	3 (0.8%)	11 (3.0%)	384	13 (3.4%)	4 (1.0%)	17 (4.4%)
Reoperation								
Yes	38	2 (5.2%)	1 (2.6%)	3 (7.8%)	21	3 (14.2%)	1 (4.8%)	4 (19.0%)*
No	463	15 (3.2%)	3 (0.6%)	18 (3.8%)	478	17 (3.6%)	5 (1.0%)	22 (4.6%)
Retrosternal goiter								
Yes	59	1 (1.7%)	1 (1.7%)	2 (3.4%)	52	4 (7.7%)	0	4 (7.7%)
No	442	16 (3.6%)	3 (0.7%)	19 (4.3%)	447	16 (3.6%)	6 (1.3%)	22 (4.9%)
Toxic goiter								
Yes	92	4 (4.3%)	0	4 (4.3%)	124	2 (1.6%)	1 (0.8%)	3 (2.4%)
No	409	13 (3.2%)	4 (1.0%)	17 (4.2%)	375	18 (4.8%)	5 (1.3%)	23 (6.1%)

$P > .05$ for all comparisons between the IONM and control groups or between different risk groups within the IONM and control groups, except when comparing secondary and primary thyroidectomy in the control group (*$P = .019$).

Table VI. Correlation of neuromonitoring results with postoperative outcomes

	Postoperative outcome (n)		
IONM	*Paralysis*	*No paralysis*	*Total (n)*
No signal (positive)	11	27	38
Intact signal (negative)	10	453	463
Totals	21	480	501

predictive values were 52%, 94%, 29%, and 98%, respectively.

DISCUSSION

Despite being described for >3 decades,[11,12] IONM of RLN with electrical stimulation during thyroid surgical procedures has not gained widespread popularity until recently[4,8-10,13-16] because of the availability of a more user-friendly system and the demand of applying new surgical technology. Nerve monitoring has been developed to facilitate the identification of RLN, to map its contour, to avoid its iatrogenic injury, and to obtain prognostic information about postoperative vocal cord functions during thyroid and parathyroid operations. Despite the increasing popularity of the adoption of this technology, the various roles of IONM in thyroid operations, in particular its impact in the avoidance of RLN injury or the reduction of the incidence of postoperative nerve palsy, remain doubtful. Although a prospective randomized controlled trial with an intent-to-treat analysis can yield a conclusive answer, an impractically large number of patients would be needed because of the rarity of RLN injury that is achieved in specialized centers. Based on our experience in the postoperative RLN palsy rate,[3] more than 7000 nerves should be recruited in each arm of the study to achieve significant results with statistical power.

In a large prospective multicenter trial, Thomusch et al[8] reported a statistically significant reduction in the permanent RLN injury rate for low-risk patients who underwent primary operations for benign goiter with the addition of electromyographic monitoring. The study was limited, however, by the lack of randomization, a large number of participating surgeons from centers with variable experience in thyroid surgery, the selection of a minority number of cases for IONM (19% of eligible cases), and the exclusion of a significant proportion of patients because the surgeons were noncompliant to the study protocol. Another multicenter study that included 29,998 nerves that were at risk[4] revealed no statistical difference in the frequency of RLN palsy with the adoption of IONM, compared with the use of visual identification only. A detailed subgroup analysis, however, showed a significant difference in the incidence of permanent RLN palsy between high- and low-volume surgeons. For low-volume surgeons, the use of RLN monitoring reduced the incidence of permanent RLN palsy.[4]

In the present study, the selection of patients for IONM depended solely on the availability of the equipment and the choice of the operating surgeons with standard selection criteria but was not based on a prospective randomization study protocol. One potential limitation of the present study was the selection bias by which IONM was tended to be used in patients of certain high-risk subgroups, particularly in reoperation. There was no significant difference observed in the baseline characteristics between the IONM and control groups, except the mean weight of the resected specimens, which itself was not identified as a risk factor for postoperative nerve palsy in the subsequent multivariate analysis. The IONM device and technique has been validated by us before.[10] In addition, our study was confined to a single surgical team that had adopted a standardized surgical and neuromonitoring technique to minimize other potential confounding variables. The various pathologic conditions managed and the nature or complexity of thyroidectomy performed reflect those conditions that commonly are encountered in other endocrine surgical practice and provide an opportunity to evaluate the impact of IONM in various surgical subgroups, especially for high-risk operations with a higher inherent risk of RLN injury.

Our incidences of postoperative RLN palsy were comparable with our previous results when routine RLN identification was adopted only[3] and with those reported in the literature from specialized centers.[4-7] There was no significant difference in the postoperative, transient, and permanent nerve palsy rates between the IONM and control groups. However, the incidence of postoperative RLN paresis was significantly higher during thyroidectomy for malignant disease and reoperations. In fact, these 2 factors, in addition to operative time that reflected the technical difficulty of the procedure, were both identified to be independent risk factors for adverse postoperative outcome in the multivariate analysis. For the evaluation of different risk subgroups, the use of IONM did reduce the incidence of postoperative RLN palsy for secondary thyroidectomy and thyroidectomy for malignancy and retrosternal goiter, but the sample size might be insufficient to show a statistically significant difference. On the other hand, for thyroidectomies without the use of the IONM, the overall incidence of RLN palsy was significantly higher during reoperation than during primary operation, but such a difference was no longer significant when IONM was used. In addition, when patients who underwent secondary thyroidectomy were compared, there was a positive trend for the reduction in postoperative overall, transient, and permanent RLN palsy rates from 19%, 14.2%, and 4.8% to 7.8%, 5.2%, and 2.6% for those procedures that were performed without and with IONM, respectively. Therefore, the adoption of IONM may facilitate secondary thyroidectomy or reoperative central compartment dissection by reducing postoperative RLN palsy. Further studies should be performed to evaluate its role for a larger number of patients in this specific high-risk procedure.

Different types of IONM have been validated to test the functional integrity of RLN,[10,13-16] although many potential plaudits and pitfalls have been reported.[10,15] The sensitivity, specificity, and positive and negative predictive values ranged from 34% to 75%, 92% to 98%, 33% to 62%, and 98% to 99%[10,13-16]; the present study validated the overall low sensitivity and positive predictive values of IONM. However, despite the potential pitfalls, the adoption of this technique should be considered for selected high-risk procedures because of their higher incidence of postoperative palsy and the improved accuracy.[10] Despite the lack of evidence for the reliable prediction or reduction of postoperative RLN palsy for all patients who undergo thyroidectomy, IONM may have a potential role in selected high-risk conditions. In low volume or less experienced surgical units, the use of IONM may facilitate nerve preservation by emphasizing its identification. In addition, during technically demanding procedures in which the high-volume surgeons might become less experience (such as thyroidectomies for malignancy or recurrence or reoperative central neck nodal dissection), the additional use of IONM may be associated with a better outcome. However, surgeons who use this technology should understand its potential pitfalls with respect to its improper set up, equipment failure, and the possibly confusing results to avoid inflicting harm on the patients.

In conclusion, the additional adoption of IONM compared with routine identification of the RLN during thyroid surgery could not be demonstrated in our patients to reduce RLN injury significantly. The routine application of IONM cannot prevent or avoid RLN injury necessarily for all types of thyroid surgical procedures and can be associated with potential confusions or limitations. For selected high-risk thyroidectomy, the use of IONM may be associated with an improved outcome.

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DISCUSSION

Dr John A. Chabot (New York, NY): That is a beautifully designed prospective study with clearly defined outcomes with the use of modern techniques. At the beginning of your study did you do a power calculation to understand how many nerves or how many patients you would need to enroll in this study to identify a pre-defined end point?

Dr Chan: Yes, we actually have performed a pilot study to show the incidence of the recurrent nerve palsy. For a formal randomized control trial, the sample size required would be approximately 7000 nerves in each arm (ie, approximately 14,000 nerves or 10,000 patients in the study).

Dr Samuel K. Snyder (Temple, Texas): This is an excellent effort in trying to answer a very important question, particularly trying to look at subgroups for which nerve monitoring may be more helpful.

But again, to really answer the question that you were asked, the number of patients that are needed, as demonstrated by Dr Dralle's study, is in the thousands to tens of thousands. So to come up with statistically significant data was almost impossible based on the number of patients and nerves that you were studying.

However, looking at your data, it does seem that there was a reduced incidence of nerve injury, both transient and permanent, in the nerve monitoring group. This is in the face of selected patients.

You had an opportunity to choose which patients had the nerve monitoring. It seemed like the patients who were more likely to be chosen were the patient who were perceived to require more difficult operations, to have a higher weight of thyroid gland, to need secondary operations, or to have malignancy. I do not know whether you looked closely at whether that was statistically significant in your selection process, because that influences the data.

I am concerned about the incidence of low sensitivity to your study, because it has not been my experience with the use of this technique. When the nerve stimulates intraoperatively, it functions when the nerve stimulates functions postoperatively. I have seen that occasionally in patients who were paralyzed preoperatively.

Did you use strict criteria that you have to stimulate the most proximally visible portion of the nerve? In some cases that includes trying to stimulate the vagus nerve to make sure that you identify a nerve that is functioning. Perhaps it is a difference of instrumentation as well.

Dr Chan: For the first question regarding the possibility of a selection bias, this is definitely 1 of the limitations of a nonrandomized study. Basically, the decision for the use of the IONM was dependent on the availability of the machine. There may be some sort of selection bias that you can see from our study in terms of the weight of the specimen and also the relatively higher proportion of patients in the high-risk group whose conditions required neuromonitoring. The type of operation and details of operative procedures were all quite comparable. We hope that all this can reduce the effect of the bias.

Regarding your second question, I agree with you that testing the vagus nerve may increase the sensitivity, but it probably would be at the expense of time in dissecting the vagus nerve. So we try to stimulate the most proximal part of the RLN.

Dr Peter Angelos (Chicago, Ill): Based on my experience, I would agree with all of your conclusions. I have 1 question. Given the fact that you would suggest that the nerve monitor is valuable only in selected situations, do you think that it makes sense to use it only in selected situations? If you do not use it regularly, will you not find it effective in those selected situations?

Dr Chan: I think both are correct. You must acquire a relatively long learning curve in the use of this stimulator. So I think we try to use it as much as possible and try to figure out a potential pitfall. After you have gone through the learning curve, then you can consider using it in selected high-risk procedures.

Dr Henning Dralle (Halle, Germany): I think that the standard of care should be that the vagal nerve is stimulated before and after resection.

Dr Chan: We actually use the total loss of the signal at the end of the procedure to be the definition. The maximal amplitude that we used as a cut-off point was 1 mA.

Dr Dralle: You did not use the vagus stimulation in every case, only in selected?

Dr Chan: Only the RLN was stimulated.

Dr Dralle: I think that this should be the standard of care: that the stimulation signal only from the vagus nerve is taken as the way of response.