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An Evidence Based Educational Module on the use of Disposable Laryngeal Electrodes for Intraoperative Neuromonitoring: A Quality Improvement Project

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Abstract

Background: Injury to the recurrent laryngeal nerve (RLN) is a significant concern in endocrine surgery, accounting for a substantial proportion of negligence litigation and malpractice lawsuits. Failure to identify and monitor the RLN during surgery can lead to transient or permanent vocal cord immobility. Therefore, the use of adjunct monitors for intraoperative neuromonitoring (IONM) is essential to aid in nerve identification and functional assessment. Despite efforts to prevent RLN injury through visual identification, transient and permanent RLN palsy still occur at notable rates. Various devices have been developed to help safely and efficiently preserve and identify the RLN. Continuous IONM (cIONM) offers major advantages. It enables better visualization and identification of the RLN, particularly in high-risk cases and it provides estimates of RLN functional potentials through electric stimulation, which is important as structural integrity does not guarantee functional viability or proper nerve signaling. However, cIONM is limited by frequent false positives, reducing its utility. One common reason for false positives is suboptimal positioning of endotracheal tube electrodes, particularly with devices that are susceptible to movement-related issues. The neural integrity monitoring (NIM) tube, for example, has specific limitations due to its engineering, including precise placement requirements, limited size options, and potential airway complications. On the other hand, disposable adhesive laryngeal electrodes offer a full 360-degree sensor coverage and can be applied to various endotracheal tube sizes, including half-sizes and pediatric tubes. Research supports the use of disposable laryngeal electrodes as efficient, cost-effective, minimally invasive, and user-friendly devices for RLN monitoring. In conclusion, this new technology can help prevent nerve injury by monitoring RLN function, while reducing cost, and improving ease of use.

Methodology: A quality improvement project was conducted on the use of Disposable Laryngeal Electrodes for Intraoperative Neuromonitoring. A pre and post questioner was utilized to assess attitude and knowledge towards the use of disposable laryngeal electrodes. Total N= 8 from a large community based hospital in South Florida.

Results: Attitudes towards the use of disposable laryngeal electrodes increased after the educational module: six participants (75.00%) were most likely, two participants (20.00%) was positive, and two participants (40.00%) were neutral. There were no negative or very negative attitudes expressed with the use of laryngeal electrodes after the educational module

Discussion: There was a statistical difference between the pre- and post-tests, according to the results. The disposable laryngeal knowledge pre-test had an average of 38.00% accurate answers, while the post-test had an average of 88.00% correct answers. Pre-test, 37.00% of providers used laryngeal electrodes, while 62.50% of providers were willing to employ laryngeal electrodes in the post-test. As a result, all respondents showed a considerable improvement in their understanding of laryngeal electrodes and their application, with >50.00% percent change. Overall, there was a 120.00% percent shift in the preference for using laryngeal electrodes in anesthetic practice. All respondents' sentiments about the use of laryngeal electrodes for PONV prevention improved significantly, with a 62.50% percent shift.

Keywords: NIM Tube, Disposable Laryngeal Electrodes, RLN injury, Nerve Monitoring

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DNP Project Title

An Evidence Based Educational Module on the use of Disposable Laryngeal Electrodes for Intraoperative Neuromonitoring: A Quality Improvement Project

PICO Question

In surgical patients requiring intraoperative laryngeal nerve monitoring, is the education of providers on the use of disposable surface laryngeal electrodes, in comparison to those embedded within an electromyograph tracheal tube, improve intraoperative monitoring of the recurrent laryngeal nerve?

Population: Surgical patients undergoing procedures requiring RLN nerve monitoring

Intervention: Disposable laryngeal electrodes

Comparison: ETT embedded with laryngeal electrodes

Outcome: Improve monitoring of RLN

Problem Identification

Recurrent laryngeal nerve (RLN) damage is considered a great barrier to surgical procedures that pose a risk to the vagus nerve. Surgical damage could potentially lead to postoperative vocal cord dysfunction with symptoms such as hoarseness, decreased swallowing reflex, difficulty breathing, and aphonia.[1] Although the incidence of RLN damage today has declined tremendously with the introduction of RLN monitoring devices, it continues to be a major risk factor leading to temporary paresis and permanent paralysis.[1, 2] These disabling complications vary based on surgeon experience, type of surgery, and underlying diseases such as cancer, goiters, etc.

Introduction

Injury to the RLN represents 5% of all negligence litigation and 60% of all malpractice lawsuits related to endocrine surgery.[3] This is a dreaded complication for surgeons and anesthesiologist alike leading to transient or permanent immobility of the vocal cords. Routine visual identification is often the primary form of nerve preservation and failure to do so has been reported to increase the incidence of injury 4-fold. This, in turn, explains the importance of adjunct monitors to aid in the identification of nerves and functional dynamics of neuromonitoring intraoperatively.

Despite best efforts to prevent nerve injury through anatomical visualization transient RLN palsy and permanent RLN palsy have been reported at 18% and 11% respectively. Since the early reporting of nerve injuries affecting the vocal cords, various devices have been developed to help preserve and identify the RLN safely and efficiently.

Surgical application of cIONM include:

- Carotid endarterectomy
- Cricopharyngeal myotomy
- Excision of Zenker's diverticulum
- Hemithyroidectomy
- Neck biopsy
- Neck dissection
- Parathyroidectomy
- Partial laryngectomy
- Substernal goiter
- Thyroidectomy

There are two major benefits to cIONM. The first, as stated before, is that the surgeon can better identify and maintain visualization of the RLN during surgery, especially those considered high-risk such as extensive malignancies and redo-operations.[3-5] This not only enables the surgeon to pre-determine risk of injury, but also minimize any unintended injury to nearby nerve structures. Secondly, cIONM can give estimates on the functional potentials of the RLN via electric stimulation.[3-5] This factor is important since structural integrity does not imply that nerves are still functional, nor they can conduct proper nerve signals.

Although there are benefits for cIONM, it is plagued by frequent and unintended false positives which lessens its utility.[5] One of the most common reasons for this false positive is failure of the endotracheal tube electrodes from being optimally positioned.[5] This is particularly problematic for some monitoring devices more than others, since the electrodes may not tolerate movement.[3-5] Various types of electrodes have been introduced and approved by the FDA in the recent years, and thus far there is no decision on the best electrode for nerve preservation. Herein, the author examined advantages/disadvantages, cost, device performance, and signal amplitudes of neural integrity monitor (NIM) electromyogram (EMG) endotracheal tube and new types of disposable adhesive electrode such as those that provide 360 degree coverage and the lantern laryngeal electrode (LLE).

Background

Recurrent laryngeal nerve injury is a significant complication affecting patients undergoing surgeries that call for proximity to the vagus or the recurrent laryngeal nerve (RLN).[1, 6-10] Over the last decade, cIONM of the RLN has received more attention in the hopes of preventing damage to nerves that could lead to transient or permanent vocal cord paralysis

causing significant deterioration of quality of life. The comparative rate of vocal cord paralysis post thyroid surgery has been documented as high as 7% on post-operative laryngoscopy.[6, 7, 10]

Traditional methods of monitoring (non-continuous) were plagued by injuries that are now considered preventable thanks to new advancements in technology.[1, 4, 7] The neural integrity monitor (NIM) electromyogram (EMG) endotracheal tube (continuous) is the current practice for procedures such as thyroid/parathyroid resection, carotid endarterectomy, neck dissection, and many more.[1, 3, 4] The NIM tubes contain embedded stainless-steel electrodes that must be placed precisely between the vocal cords for accurate monitoring of the RLN.[4] The tube comes with electrode cables that are then inserted into a nerve monitoring device that provides visual and audible alerts when the surgeon is near the nerves to prevent accidental damage.[4]

Scope of the Problem

The NIM tube comes with limitations caused by the engineering of the tube. First, the NIM tubes must be properly placed and maintained midline to assure precise alignment of the surface monitoring electrodes against the medial aspects of the vocal fold.[4, 6] This precise placement limits changes in patient positioning that may occur during the procedure or might lead to false signals due to tube displacement. Second, NIM tubes come in full sizes and not in half sizes, which is a serious limitation, especially for the pediatric population.[7, 10] The smallest size tube is targeted for adolescents ages 10-12.[7, 10] Lastly, the sizes provided by the manufacturer are in relation to the inner diameter, whereas the outer diameter remains fixed near 8mm increasing the chances of airway irritation, edema, and potential traumatic injury.[4]

Disposable adhesive laryngeal electrodes, on the other hand, provide a full 360 degrees of sensor coverage with eight electrode contacts.[11-12] Regardless of where you turn the ETT (left or

right), there is a higher rate of vocal cord contact so long as the tube is not displaced outwards or inwards.[13] The self-adhesive plate of surface electrodes can be applied onto any standard endotracheal tube, including half-sizes, pediatrics, and reinforced ETTs.[9-12] This reduces the chances of traumatic intubation from excessive tube diameter. The system is created to work with current in-hospital monitors. This cost-effective approach allows for the universal plug-and-play use of the device with most nerve monitoring devices that anesthesia providers and OR staff members are familiar with.[14-17] Although, different forms of RLN monitoring are currently being released to the healthcare market, the research points to these disposable laryngeal electrodes as the most efficient, cost-effective, least invasive, and user-friendly devices.[3, 14]

Consequences of the Problem- What is the cost of not fixing the problem?

Recurrent laryngeal nerve palsy is a well-recognized complication that increases morbidity where its risk constitutes less than 10% of thyroid-related cases and 11-50% in more involved cases such as in tracheoesophageal fistula (TEF) and esophageal atresia (EA).[7] Similar injuries have been reported in cardiac surgeries where the use of ice slush has caused hoarseness and RLN injury.[7, 15] Pediatric surgeries, such as patent ductus arteriosus (PDA) ligation, have also led to vocal cord paralysis with 4.2% reported injuries and as high as 8% for low-birth-weight infants.[7] Primary symptoms experienced by patients are stridor, dyspnea, dysphonia, and dysphagia.[12-18]

Knowledge Gap

cIONM provides quick feedback to the surgeon regarding the location and function of the RLN. Adult patients undergoing surgeries with a high risk of RLN injury demonstrated a negative predictive value of 99%, while a positive predictive value of 75% of signal loss and vocal cord

paralysis thanks to the immediate feedback from nerve monitoring.[18-20] It is without a doubt that nerve monitoring can foreseeably prevent vocal cord injuries. However, the U.S. continues to fall behind in introducing the latest advancements in neuromonitoring that could help increase the predictive values of these systems.

Development and Implementation of a Search Strategy

The author used a search strategy that ranged from the establishment of the database to September, 6th 2022. The databases utilized included CENTRAL, PubMed, Cochrane Library, and Medline. The author employed the expertise of an Florida International University (FIU) librarian for guidance on search terms: “recurrent laryngeal nerve”, “laryngeal electrodes”, “nerve monitoring”, “NIM tube”, “neuromonitoring”, “thyroid”, “parathyroid”, “VATS”, “Medtronic”, “Inomed”, “electromyography tube”, “systematic review”, “meta-analysis”.

The author used other search strategies to identify systematic reviews, which included manual searches in internet-related bibliographies. Furthermore, the author performed the initial literature screening and summarized the data through inclusion and exclusion criteria. Some of the data reviewed included authors' names, publication year, type of study, sample size, the country in which the studies were performed, types of laryngeal monitoring devices used, and outcomes.

Findings

The author identified 6 systematic reviews, 1 clinical trial, and 1 case report that referenced the use of disposable laryngeal electrodes for continued intraoperative nerve monitoring (cIONM).

Review of the Literature

NIM tube vs laryngeal electrodes

Parmeggiani et al.[3] performed a double blinded randomized study that observed 880 thyroidectomy surgeries. Of the 880 thyroid surgeries, 480 were performed using cIONM with a NIM tube and 400 were performed using cIONM with self-adhesive, disposable laryngeal electrode.[3] The parameters measured include mean operative time, postoperative bleeding, seromas, post-operative stay, incidence of transient or definitive laryngeal nerve lesions, uni- or bilateral, incidence of permanent or transient hypocalcemia, costs of the different procedures and evoked response profiles of RLN.[3] Examination pre and postoperatively (1-6 months after) by direct laryngoscopy or laryngofibroscopy was performed to check vocal cord mobility.[3]

For the NIM tube group, the study identified six cases of temporary RLN paralysis, three true positive and three false negative. Furthermore, the authors noted three cases of permanent RLN paralysis (0.75%), two true positive and one false negative that developed after ten days. The adhesive electrode group was found to have six cases of temporary RLN paralysis, two cases of permanent RLN paralysis (rate: 1.5 %, $p > 0.5$), two true positive, one false positive and four false negatives.[3] The authors found no statistically significative difference between the two groups for distribution of age, sex, epidemiological characteristics, type of pathology etc. However, significative difference was found on the second group (adhesive electrodes) in reducing the overall costs.[3]

Kandil et al.[5] performed a comparative prospective porcine study with 8 model animals. The purpose of the study was to examine the signal amplitudes of nerves as pre- and post-repositioning and movement states to evaluate the potential impact on IONM values utilizing

two different tube systems for IONM during thyroid surgery using the porcine model.[5] Neck movement and reposition were performed for all pigs. Signal data, including amplitude and latency, were collected for vagus nerve, recurrent laryngeal nerve (RLN), and external branch of superior laryngeal nerve (EBSLN) before and after repositioning. The differences of amplitude and latency by pre- and post-repositioning were compared for all animals.

For the ETT group, vagus nerve stimulation after head manipulation demonstrated a reduction in amplitude on the left side by 36.30% (P = .021) and on the right by 49.29% (P = .024), in RLN on the left by 30.22% (P = .014) and on the right by 42.34% (P = .004), and in EBSLN on the left by 63.62% (P = .003) and on the right by 13.58% (P = .010).[5] There was no case of loss of signal (LOS) in post movement evaluation in any of the animals. Baseline amplitude and latency were not significantly different comparing the two study groups.[5]

Propst et al.[8] used a prospective controlled trial to evaluate 1) the use of endotracheal tube (ETT) surface electrodes for recurrent laryngeal nerve (RLN) monitoring in thyroid surgery in children, and 2) the effects of thyroid surgery on the RLN in children.[8] Twenty-five children (44 nerves at risk), mean (standard deviation) age 13.1 (3.4) years (range 4.5-17.4 years), underwent thyroidectomy.[8] Twelve (46%) monitors were adhesive. One nerve had unobtainable responses.[8] Successful recordings were obtained using adhesive electrodes in children as young as 4.5 years of age, with endotracheal tubes as small as size 4.0.[8] The majority (92%) of data recordings were obtain-able, and only one nerve at risk (2.3%) was operated on without any responses being obtained.[8]

The results demonstrated the viability of applying this monitoring strategy in pediatric thyroid surgery. Furthermore, results proved the method's dependability, as seen by its high 92% success rate in acquiring data records.[8] Only one nerve at risk (2.3%) was operated on without

yielding any results, highlighting the significance of this monitoring strategy in risk mitigation.[8] This suggests that the use of ETT surface electrodes for RLN monitoring during pediatric thyroid operations offers a high degree of accuracy and safety.[8] This study also provides important new information on the suitability and efficacy of ETT surface electrodes for RLN monitoring in the setting of pediatric thyroidectomies.[8]

In conclusion, Propst et al. study adds to the increasing amount of data demonstrating the viability and effectiveness of ETT surface electrodes for RLN monitoring during pediatric thyroid surgery.[8] The study's favorable results highlight the possibility of improving children's surgical operations' safety and efficacy, opening the door for more research and possible incorporation of this monitoring method into guidelines for pediatric thyroid surgery.

Lawlor et al.[7] used a systematic review to identify pros and cons of techniques for (RLN) monitoring in surgical procedures which place the RLNs at risk for injury. Patients <18 years old undergoing thyroidectomy were included.[7] Vocal cord mobility was assessed pre- and postoperatively. RLNs were monitored using adhesive or integrated electrodes. Recordings were made before and after dissection, and area under the curve and latency were compared using mixed models.[7] Pros of adhesive electrodes: allows the user to apply single-channel electrodes to an ETT as small as 2.0 mm ID and monitor much smaller, younger patients. Confirms nerve stimulation at close of case.[7] Cons of adhesive electrodes: the user must apply electrodes to ETT since they don’t come imbedded as seen with the NIM tube. Adhesive electrodes may slip during surgery.[7] Pros of integrated electrodes: no slippage of surface electrodes and commercially available.[7] Cons of integrated electrodes: smallest size is 5.0 mm internal diameter, improper placement of electrodes, shifting of electrodes with positioning of patient may only alert surgeon after injury to nerve has occurred.[7]

Chai et al.[6] underwent multiple case studies with a total of 10 participants that examined the use of cIONM with disposable laryngeal electrodes during video-assisted thoracoscopic surgery (VATS) lobectomy for left lung cancer and evaluated its safety and usefulness.[6] Event of hemodynamic instability during CIOM, n= 4 Intraoperative use of cardiovascular medications, n = 0 Time for vagus dissection and APS application, min 6 (2, 15) Baseline amplitude, μV 981.[6] Presence of adverse events 4 Amplitude before removal of APS, μV 955 (254, 1705). Total CIONM time, min 27 with postoperative vocal cord palsy n=1.[6] Most common reason for IONM failure is malposition of the endotracheal tube, correctly placing the electrodes on the vocal cords is important for detecting a strong EMG signal.[6] CIONM, using disposable laryngeal electrodes, may be applied safely for VATS left lobectomy and may be used to predict postoperative vocal cord function.[6]

White et al.[10] explored two retrospective case series to gather data on, and assess the applicability of, intraoperative recurrent laryngeal nerve (RLN) monitoring during thyroidectomy and related cervical procedures in children and adolescents.[10] Intraoperative RLN monitoring was performed with the use of the Xomed NIM II monitor (Medtronic Xomed, Jacksonville, Florida), and the Xomed NIM monitoring endotracheal tube with surface electrodes designed to rest on the luminal aspect of the bilateral true vocal cords.[10]

The results for case 1 showed postoperative awake flexible laryngoscopy confirmed normal bilateral true vocal fold mobility.[10] Results for case 2: both the left and right RLNs were identified and demonstrably intact at the completion of the surgery.[10] The study showed successful use of the Xomed NIM tube monitoring system for passive and evoked intraoperative neural monitoring.[10] Also, the researchers found the endotracheal tube–based surface electrode system to be simple, noninvasive, and easy to use.[10] Principal disadvantage of the NIM tube is

the limitations in electrode endotracheal tube size which has a larger outer diameter preventing its use in ages <13.[10]

The study emphasized the usefulness of the Xomed NIM tube monitoring system in maintaining RLN integrity throughout pediatric surgical operations by demonstrating its effectiveness for both passive and provoked intraoperative neural monitoring.[10] The surface electrode device based on the endotracheal tube received accolades for its ease of use, noninvasiveness, and simplicity.[10] Nonetheless, the research also recognized a noteworthy constraint which is the NIM tube's greater external diameter, which limits its application for patients under the age of 13.

In conclusion, the study by White et al. shows that intraoperative RLN monitoring may be successfully used in juvenile thyroidectomy and associated operations. The study opens the door for more development and adaption of these approaches in pediatric surgical settings by providing insightful information on the benefits and drawbacks of the used monitoring systems.

Ghani et al.[11] through a systematic review explored the role of nerve monitoring intraoperatively during parathyroidectomy. Its purpose is to discuss the possible role of IONM in parathyroid surgery with regards to the accuracy, efficacy, and recent trends in the utilization of this technology.[11] The study found that routine use of IONM for thyroid and parathyroid surgery resulted in a decline in rates of injury to the RLN.[11] Furthermore, it reveals that a survey from American Association of Endocrine Surgery (AAES) revealed that almost 95% of surgeons use IONM in their practice.[11] In addition to this, data about its cost effectiveness in parathyroid exploration is unreported, but IONM is associated with increased equipment setup time and increased the cost of operation by 5-7%.[11] Regardless, considering the benefits, it outweighs the costs of the use of this novel technology, which has at least a 5% increase in the total hospital

cost as compared to procedures done conventionally without monitoring.[11] Lastly, this study identified a retrospective review of the use of IONM in 909 nerves at risk (NAR) which reported a sensitivity of 98.4% in predicting normal RLN function when a positive stimulation was observed.[11]

The study identifies several related expenses and issues even though it admits that detailed data on the cost-effectiveness of IONM in parathyroid exploration are available. The study indicates that the advantages of IONM, especially the noted drop in RLN injury rates, exceed the financial consequences even with these added expenses. The study's claim that using IONM raises hospital costs overall by at least 5% when compared to standard operations performed without monitoring highlights the described benefits.

Chen et al.[20] underwent a comprehensive clinical study involving a cohort of 3,029 patients who were undergoing thyroid surgery under general anesthesia. With 2,568 female patients and 461 male patients, the patient pool's demographics were wide with ages ranging from 19 to 71 years and weights ranging from 37 to 109 kg.[20] 2,313 of the patients in these cases had thyroid cancer surgically removed, demonstrating the frequency of thyroid-related disorders in the study group.[20] Remarkably, 189 instances required a third surgery, and 738 cases required secondary surgery, highlighting the intricacy and recurrence of thyroid-related problems in a sizable portion of patients.[20] All patients had the endotracheal tube placed successfully, and there were little side effects throughout any of the intubation procedures.[20] All patients had successful operation since the vagus nerve and the RLN signal (signal V/R) amplitude satisfied all monitoring parameters.[20] Analysis was done on the preoperative and postoperative issues with the most common complaint being sore throat, mild pharyngeal discomfort, and temporary hoarseness.[20]

The study's general conclusion emphasizes the importance of the large dataset in detecting frequent issues and difficulties related to thyroid surgery, especially when Intraoperative Neuromonitoring (IONM) is used. The abundance of data obtained from this extensive examination provides an essential basis for the formulation of precise and unambiguous instructions. The purpose of these recommendations is to improve the overall quality and safety of thyroid operations in various clinical circumstances by providing guidance for both the performance of thyroid surgery under IONM and the following post-operative follow-up and monitoring.[20]

Liddy et al.[2] executed a large prospective longitudinal study which sought to examine the possible relationship between the complex surgical architecture of the recurrent laryngeal nerve (RLN) during thyroid surgery and electrophysiologic responses. The study made use of a sizable multinational registry database that included 574 patients and prospectively gathered data from 17 locations over 5 continents.[2] For a methodical assessment, the International RLN Anatomic Classification System was utilized.[2] Remarkably, 3.5% of nerves had a loss of signal (LOS), and 34% of LOS nerves had irregular trajectories.[2] Additionally, 23% of nerves had altered intraoperative trajectories.[2] A number of variables have been linked to lymph adenopathy syndrome (LOS), including aberrant nerve trajectory, fixed entrapment, severe neural dissection, malignancy infiltration, and lateral lymph node dissection.[2] The most frequent type of RLN damage is traction injury, which has consequences for healing and define the basis for the importance of intraoperative RLN monitoring.[2]

The findings highlight the value of cross-border, multicenter research in expanding the knowledge of operative anatomy in thyroid surgery.[2] The results highlight the possible influence on the risk of neural damage by revealing significant diversity in the anatomic and intraoperative

features of the RLN.[2] This thorough investigation offers insightful information that may be used to reduce difficulties and guarantee precise and secure neuromonitoring during thyroid procedures, hence improving patient outcomes.

The study concludes by highlighting the intricate and variable architecture of the RLN following thyroid surgery and providing insight into possible associations with neurological damage. The basis for improving surgical techniques and standards is laid by the discovery of variables impacting the risk of complications. The study's multicenter and international scope contribute to its greater generalizability and relevance in forming our understanding of the complex link between surgical outcomes and RLN morphology in a range of patient demographics.[2]

In conclusion, we can assert that indirect stimulation of the RLN is superior to direct stimulation and that an intact acoustic EMG signal is highly predictive of intact postoperative RLN function. Doing so with a disposable laryngeal electrode, instead of a NIM tube, can provide the same results, yet reduce cost, improve monitoring outcomes and ease of use. These new technologies of laryngeal electrodes are feasible and reliable techniques, that can be used to avoid nerve injury and to increase the surgeon’s confidence but not to replace a systematic nerve identification and a careful dissection.

Literature Review Table

Citation	Design/Method	Sample/Setting	Major Variables Studied and Their Definitions	Measurement And Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Lawlor CM et al,[7] 2020	SR Purpose: Review techniques for (RLN) monitoring in surgical procedures which place the RLNs at risk for injury. Patients <18 years old undergoing thyroidectomy were included. Vocal cord mobility was assessed pre- and postoperatively. RLNs were monitored using adhesive or integrated electrodes. Recordings were made before and after dissection, and area under the curve and latency were compared using mixed models. -Inclusive of all literature from 2000-2022	N= NR Setting: OR surgeries requiring IONM Attrition: NR	IV= Intraoperative RLN monitoring DV 1 = Adhesive Laryngeal Electrodes DV 2 = Integrated Laryngeal Electrodes	Adhesive Laryngeal Electrodes Pros and Cons Integrated Laryngeal Electrodes Pros and Cons Frequency	Adhesive Pro: Can apply single-channel electrodes to ETT as small as 2.0 mm ID and monitor much smaller, younger patients Confirms nerve stimulation at close of case. Adhesive Con: Surgeon or anesthesia must apply electrodes to ETT Adhesive electrodes may slip during surgery Integrated Pro: No slippage of surface electrodes Commercially available Integrated Con: Smallest size is 5.0 mm ID Improper placement of electrodes Shifting of electrodes with positioning of patient May only alert surgeon after injury to nerve has occurred	Results: Twenty-five children (44 nerves at risk), mean (standard deviation) age 13.1 (3.4) years (range 4.5-17.4 years), underwent thyroidectomy. Twelve (46%) monitors were adhesive. One nerve had unobtainable responses.	Multiple techniques exist to monitor the RLN in children undergoing cervical, cardiac, and thoracic surgery. Monitoring the RLN during procedures that place the RLNs at risk may help decrease the rate of RLN injury.	Weakness: -No Prisma -No breakdown of data/numbers related to injuries per device Strengths: -Provides limitations per device -Identifies pros/cons Risks and benefits of the IONM techniques described Feasibility The use of disposable electrodes is a viable and feasible option for IONM Level of evidence = L-I

Propst EJ et al,[8] 2020	Prospective Controlled Trial Purpose: To prospectively evaluate 1) use of endotracheal tube (ETT) surface electrodes for recurrent laryngeal nerve (RLN) monitoring in thyroid surgery in children, and 2) effects of thyroid surgery on the RLN in children.	N = 24 Setting: undergoing thyroidectomy or thyroid-related surgery Attrition: NR	IV: Thyroid surgery DV: endotracheal tube (ETT) surface electrodes	Data/Measurement: Recordings Pre- and Post-RLN Dissection Measured Inferiorly in the Neck Recordings Post-RLN Dissection Measured Inferiorly and Superiorly in the Neck	Findings: Successful recordings were obtained using adhesive electrodes in children as young as 4.5 years of age, with endotracheal tubes as small as size4.0. The majority (92%) of data recordings were obtain-able, and only one nerve at risk (2.3%) was operated on without any responses being obtained.	Pre-surgery: Bucking 227 Over-secretion and unstable signal 19 Oral mucosa injury 1 Post-surgery: Throat pain 176 Pharyngeal discomfort 234 Voice hoarse and joint half-dislocation 19 Ear and neck numbness 21 Conjunctival congestion 49	Conclusion: ETT surface electrodes are reliable for RLN monitoring in thyroid surgery in children. Thyroid surgery is associated with a decrease in RLN stimulability that is related to tumor size. The site of RLN stimulation matters when evaluating the nerve.	Weakness: -No Prisma Strengths: -Provides limitations -Identifies pros/cons -Excellent statistical analysis Risks and benefits of the IONM techniques described Feasibility of use in practice: successfully incorporated adhesive and integrated recurrent laryngeal nerve monitoring into thyroid and thyroid-related Level of evidence = L-IV

Chen P et al.[20] 2015	SR Purpose: assess the complications related to anesthesia before and after thyroid surgery and evaluate the potential standardization of anesthesia technique under IONM in thyroid surgery. age ranged from 19 to 71 and weight ranged from 37 to 109 kg. Out of the total, 2,313 patients underwent the thyroid cancer surgery. The secondary surgery was performed in 738 cases and the third surgery in 189 cases.	N = 3,029 Setting: undergoing thyroidectomy or thyroid-related surgery Attrition: NR	IV: Complications during Thyroid surgery with RLN monitoring DV: Different techniques utilized	Data/Measurement: Complications encountered before and after surgery.	Findings: Improper use of video laryngoscopes can lead to the post-operative hoarseness and half-dislocation of cricoarytenoid joint. The patients should regain consciousness naturally in order to reduce the anesthesia complications such as restlessness. Conjunctival hyperemia and dry eye syndrome can occur	Results: higher than expected percentage of nerves followed an abnormal intraoperative trajectory (23%). LOS was identified in 3.5% of NARs, with 34% of LOS nerves following an abnormal intraoperative trajectory.	Conclusion: The large number of surgical cases covered in this study helped to identify the most common problems and complications associated with thyroid surgery under IONM. The study will form the basis for developing specific and clear guidelines both for thyroid surgery under IONM and for post-operative follow-up and monitoring.	Weakness: -No Prisma Strengths: -Provides limitations -Identifies pros/cons -Excellent statistical analysis Risks and benefits of the IONM techniques described Feasibility of use in practice: successfully incorporated adhesive and integrated recurrent laryngeal nerve monitoring into thyroid and thyroid-related Level of evidence = L-IV

Liddy W et al,[2] 2021	Multicenter Study Purpose: to better understand the variability of the surgical anatomy of the RLN with the use of the International RLN Anatomic Classification System as a means for standardized reporting of surgical anatomic detail and comparison with previously estimated prevalence data.	N = 574 Setting: patients undergoing thyroid surgery Attrition: NR	IV: Thyroid Surgery DV: anatomic variations of the RLN on nerve injury	Data/Measurement: Intraoperative anatomic data collected for the RLN were recorded according to the International RLN Anatomic Classification The Estimated International Recurrent Laryngeal Nerve Anatomic Classification System Versus Observed SAR Study Data	Findings: LOS was more likely in cases of abnormal nerve trajectory, fixed splayed or entrapped nerves (including at the ligament of Berry), extensive neural dissection, cases of cancer invasion, or when lateral lymph node dissection was needed. Traction injury was found to be the most common form of RLN injury and to be less recoverable than previous reports.	Results: Event of hemodynamic instability during CIOM, n = 4 Intraoperative use of cardiovascular medications, n = 0 Time for vagus dissection and APS application, min 6 (2, 15) Baseline amplitude, μV 981 (476–2700) Presence of adverse events 4 Amplitude before removal of APS, μV 955 (254, 1705) Total CIONM time, min 27 (21, 52) Postoperative vocal cord palsy 1	Conclusion: Multicenter international studies enrolling diverse patient populations can help reshape our understanding of surgical anatomy during thyroid surgery. There can be significant variability in the anatomic and intraoperative characteristics of the RLN, which can impact the risk of neural injury.	Strengths: -Provides limitations -Identifies different RLN anatomic classifications -Excellent statistical analysis, patient demographics, and data collection. Feasibility of use in practice: first large international multicenter registry database study with prospectively collected data of surgical RLN anatomy categorized by an international classification system and incorporating intraoperative electrophysiologic intraoperative data and postoperative outcome measures. Level of evidence = L-IV

Chai YJ et al,[6] 2020	Prospective trial Purpose: the feasibility and safety of applying CIONM during video-assisted thoracoscopic surgery (VATS) lobectomy for early-stage left lung cancer.	N = 10 Setting: patients undergoing VATS lobectomy while in the full left lateral decubitus position Attrition: NR	IV: VATS Lobectomy DV 1: Continuous IONM DV 2: Intermittent IONM	Data/Measurement: Threshold for Amplitude was used to determined post-operative vocal cord palsy. Data: NR	Findings: most common reason for IONM failure is malposition of the endotracheal tube, Correctly placing the electrodes on the vocal cords is important for detecting a strong EMG signal	Results: ETT group (Medtronic), vagus nerve stimulation after head manipulation demonstrated a reduction in amplitude on the left side by 36.30% (P = .021) and on the right by 49.29% (P = .024), in RLN on the left by 30.22% (P = .014) and on the right by 42.34% (P = .004), and in EBSLN on the left by 63.62% (P = .003) and on the right by 13.58% (P = .010).	Conclusion: CIONM may be applied safely for VATS left lobectomy and may be used to predict postoperative vocal cord function.	Weakness: No RCT Small sample size Strengths: -Provides limitations -Thorough understanding of equipment -Checklist for data collection Feasibility of use in practice: CIONM could be applied safely to VATS lobectomy for left lung cancer. The results offer a better understanding of the injury mechanisms of RLN, and how to help preserve the RLN during VATS lobectomy.

Kandil E et al,[5] 2020	Comparative, prospective porcine model study Purpose: examine the signal amplitudes of nerves as pre- and post-repositioning and movement states to evaluate the potential impact on IONM values utilizing two different tube systems for IONM during thyroid surgery using the porcine model.	N = 8 Setting: NR	IV: RLN DV: Lantern Laryngeal Electrode	Data/Measurement: Baseline Amplitude and Latency of Nerve Stimulation Classified by Type of Nerve, and Side Comparing Study Groups Based on Nerve Stimulation Modality. Trend analysis	Findings: There was no case of LOS in post movement evaluation in any of the animals. Baseline amplitude and latency were not significantly different comparing the two study groups	Results: The first group (NIM) specificity is 90.2% (433/480). 6 cases of temporary RLN paralysis (temporary paralysis rate: 1.25 % of patients), 3 true positive and 3 false negative. 3 cases of permanent RLN paralysis (0.75%), 2 truepositive and 1 false-negative developed after 10 days The 2nd group (Neurosign) specificity of 89 % (356/400). 6 cases of temporary RLN paralysis (rate: 1.5 %, $p > 0.5$), 2 true positive, 1 false positive and 4 false negative. 2 cases of permanent RLN paralysis (0.5% $p > 0.5$), 2 true-positive.	Conclusion: Surgeons should be aware of positional alterations in EMG-evoked amplitude during surgery. The degree of EMG signal stability during surgery may relate to configuration of recording electrodes. Further human studies are warranted.	Weakness: No RCT No human trials Small sample size Strengths: -Provides limitations -Excellent data analysis Feasibility: The newly developed LLE (Neurosign) is a device that is attachable to the usual endotracheal tube, and it has self-expandable electrodes in 360°. It has different electrode design than the traditional NIM tube. This makes it a feasible/cost effective choice.

Parmeggiani D et al,[3] 2012	RCT Purpose: To assess the advantages of a new technology in thyroid surgery. The first objective is to prevent nerve injury by using an intra-operative continuous nerve-electrophysiological monitoring techniques.	N = 880 Setting: Thyroidectomy surgery Attrition = NR	IV: RLN monitoring DV 1: NIM tube DV 2: Laryngeal electrodes	Data/Measurement: Parameters: mean operative time, postoperative bleeding, seromas, post-operative stay, incidence of transient or definitive laryngeal nerve lesions, uni- or bilateral, incidence of permanent or transient hypocalcaemia, costs of the different procedures and of course evoked response profiles of RLN Examination pre and postoperatively (1-6 months after) by direct laryngoscopy or laryngofibroscopy to check vocal cord mobility	Findings: No statistically significative difference between the two groups for distribution of age, sex, epidemiological characteristics, type of pathology etc. Significative difference in reduction of the costs in the second group- laryngeal electrodes.	Results: Case 1: Postoperative awake flexible laryngoscopy confirmed normal bilateral true vocal fold mobility. Case 2: Both the left and right RLNs were identified and demonstrably intact at the completion of the surgery.	Conclusion: Not useful for learning thyroid gland surgery, because can't preserve from an accurate dissection and nerve identification technique but can only support in nerve-at-risk thyroidectomy or during dissection can support expert surgeon's decision, having a clear pre-operative (post-anesthesiologist) and post-operative predictive value. First group roup has over-imposable results in terms of complications specificity and accuracy (no statistically significative differences), but it's a much cheaper procedure	Weakness: Dated study Strengths: Comprehensive study -Large sample size -Excellent data analysis and cost Feasibility: Data confirm a useful application of NIM and Neurosign in thyroid dissection nerve prevention.

White WM et al,[10] 2009	Retrospective case series review Purpose: To gather data on, and assess the applicability of, intraoperative recurrent laryngeal nerve (RLN) monitoring during thyroidectomy and related cervical procedures in children and adolescents.	N = 5 Setting: surgical excision of thyroid neoplasms or branchial pouch anomalies. Attrition = NR	IV: RLN monitoring DV 1: NIM tube DV 2: Laryngeal electrodes	Data/Measurement: Intraoperative RLN monitoring was performed with the use of the Xomed NIM II monitor (Medtronic Xomed, Jacksonville, Florida), and the Xomed NIM monitoring endotracheal tube with surface electrodes designed to rest on the luminal aspect of the bilateral true vocal cords. This system allows the documentation of both passive and evoked electromyographic (EMG) monitoring of the thyroarytenoid laryngeal muscle during surgery.	Findings: Successful use of the Xomed NIM II endotracheal tube RLN monitoring system for passive and evoked intraoperative neural monitoring. Principal disadvantage is limitations in electrode endotracheal tube size The researchers also found the endotracheal tube–based surface electrode system to be simple, noninvasive, and easy to use.			Weakness: Dated study Small sample size No RCT No breakdown of results Strengths: Thorough case disclosure Feasibility: Data confirm a useful application of NIM tube and Neurovision Medical electrodes in nerve preservation

Ghani U et al,[11] 2016	Retrospective case series review Purpose: To gather data on, and assess the applicability of, intraoperative recurrent laryngeal nerve (RLN) monitoring during thyroidectomy and related cervical procedures in children and adolescents.	N = 5 Setting: surgical excision of thyroid neoplasms or branchial pouch anomalies. Attrition = NR	IV: RLN monitoring DV 1: NIM tube DV 2: Laryngeal electrodes	Data/Measurement: Intraoperative RLN monitoring was performed with the use of the Xomed NIM II monitor (Medtronic Xomed, Jacksonville, Florida), and the Xomed NIM monitoring endotracheal tube with surface electrodes designed to rest on the luminal aspect of the bilateral true vocal cords. This system allows the documentation of both passive and evoked electromyographic (EMG) monitoring of the thyroarytenoid laryngeal muscle during surgery.	Findings: Successful use of the Xomed NIM II endotracheal tube RLN monitoring system for passive and evoked intraoperative neural monitoring. Principal disadvantage is limitations in electrode endotracheal tube size The researchers also found the endotracheal tube–based surface electrode system to be simple, noninvasive, and easy to use.	Results: Case 1: Postoperative awake flexible laryngoscopy confirmed normal bilateral true vocal fold mobility. Case 2: Both the left and right RLNs were identified and demonstrably intact at the completion of the surgery.	Conclusion: Intraoperative RLN monitoring can be a useful tool during cervical procedures that place the RLN at risk in children and adolescents. As has been demonstrated in adults, it is a safe and reliable technique that can be predictive of and may lessen the risk of RLN morbidity in this younger patient population.	Weakness: Dated study Small sample size No RCT No breakdown of results Strengths: Thorough case disclosure Feasibility: Data confirm a useful application of NIM tube and Neurovision Medical electrodes in nerve preservation

Proposal Solution

The use of cIONM continues to rise as the practice becomes more established with new research and medical advancements. The implementation of RLN monitoring is a new practice with limited research. Thus, the literature identifies the most important limitation in the use of disposable laryngeal electrodes as being related to a lack of standardization.[9] The American Academy of Otolaryngology-Head and Neck Surgery (AAOHNS), and the International Neural Monitoring Study Group (INMSG) in the UK, are the major contributors to clinical practice guidelines for neuromonitoring and they consist of multidisciplinary international groups of surgeons and researchers tasked with standardizing the field of neurophysiologic monitoring.[9]

To address the gap identified above, part of the standardization should include didactic and workshop sessions aimed at the concept of neuromonitoring with disposable laryngeal electrodes, its latest development, and its utilization in clinical practice. These disposable electrodes, similar to the standard NIM tubes, allow for the monitoring of EMG and help detect variations with sound feedback that warns the surgeon of proximity to the vagus and/or RLN.[15-20] These devices offer a clear advantage over the standard NIM tube not only to pediatric patients but to any surgery requiring proximity to the vagus nerve.[3, 4, 6, 8, 10]

Primary DNP Project Goal: To identify best practices currently available at the clinical site for RLN monitoring and implement an educational module on the use of laryngeal electrodes as standard practice to reduce cost and improve overall outcomes.

Gaps in research and future recommendations

Although there has been great progress made in nerve monitoring, there are still many challenges ahead regarding this topic. Regarding the use of laryngeal electrode use for patients

undergoing high risk RLN surgeries, there is a definite benefit in utilizing it in treatment plans. However, the current gaps in research are related to the optimal placement, training, and implementation of the new device within the clinical setting. One of the trademarks of the standard NIM tube has been the increase in rates of laryngeal injuries from traumatic intubations. Therefore, even though laryngeal electrodes is the goal, it may not always be possible to use them. That should not prevent researchers from inquiring about when to support the initiative to implement the electrodes. These adhesive electrodes offer an excellent advantage over the standard NIM tube given the ability to monitor in a 360-degree format, ease of use, and low cost. Unfortunately, these new devices have recently been introduced into CRNA training programs making it difficult to offer didactic and practical training on their use. This leads to a setback in their integration into clinical practice as more CRNAs rely on the standard NIM tube. Avoiding traumatic intubation and nerve injuries should be a priority as this will decrease the length of hospital stays and the complications of the surgery that contribute to a decrease in the quality of life. Therefore, the author recommends that future research about laryngeal electrodes should focus on earlier initiation in high-risk patients. The risk versus benefits must be weighted before initiating the use of NIM tubes, but that is the challenge that researchers and clinicians must face.

Future recommendations: New devices have been released to the healthcare market such as disposable laryngeal electrodes. These devices offer an excellent advantage over the standard NIM tube given the ability to monitor in a 360-degree format, ease of use, and low cost. Unfortunately, these new devices have not been integrated into CRNA training programs making it difficult to offer didactic and practical training on their use. This leads to a setback in their integration into clinical practice as more CRNAs rely on the standard NIM tube.

Educational needs: Workshops and symposium events focused on the latest evidence-based practices that can assist CRNAs in the selection and use of disposable laryngeal nerve monitoring devices.

Organizational Assessment

SMART Goals

Goal number 1: Over the next 3 months, CRNAs will help decrease the average number of laryngeal trauma/injuries with the use of laryngeal electrodes.

Objectives:

1. Patients requiring high risk RLN surgery should be intubated using glide scope and an appropriate size tube, along with the laryngeal electrodes in place.
2. Standard, evidence-based care such as oral care, elevated head of the bed, and other methods of ventilator care should be carried out to prevent other complications of invasive mechanical ventilation.

Goal number 2: Over the next 3 months, CRNAs will decrease the overall cost associated with the use of NIM tubes.

Objectives:

1. Laryngeal electrodes should be the mainstay initiative for patients requiring high-risk RLN surgery.
2. All packages are to be opened and prepared upon anesthesia start in the OR.
3. NIM tube should be reserved for surgeons' preferences.

Take into the site SWOT (strengths, weaknesses, opportunities, and threats) organizational assessment to achieve the project goal.

Program Structure – Educational Module

The educational module design of the program will seek to utilize the latest literature to increase providers awareness regarding the use of disposable laryngeal electrodes for endotracheal tubes during surgeries requiring recurrent laryngeal nerve monitoring. The setting will be a large community based hospital in south Florida with emphasis on operating room cases requiring intra-operative nerve monitoring and the participants will include certified registered nurse anesthetists (CRNA).

To begin the process of bringing an educational module on the use of laryngeal electrodes into practice, the research supporting this treatment needs to be presented to the practitioners in charge of caring for patient's undergoing these types of surgeries with a PowerPoint presentation. A participation form will be distributed to all CRNAs in the facility and those interested will provide their consent to participate and receive a PowerPoint presentation to learn about the topic.

Data will initially be collected from a pre-implementation questionnaire. Participating CRNAs will have to answer ten questions before and 10 questions after an educational module to assess provider knowledge and the success of the project. The participation will require about 20 minutes.

Benefit: the following benefits may be associated with participation in this project: increased participants knowledge on the use of adhesive EET electrodes, and as a result, reducing overall cost to patient and risk of traumatic injury to airway.The overall objective of the program is to increase the providers' knowledge based on the current literature.

Risks: the main risk or discomfort from this research is minimal. There will be minimal risks involved with this project, as would be expected in any type of educational intervention, which

may include mild emotional stress or mild physical discomfort from sitting on a chair for an extended period.

Confidentiality: the records of this project will be kept private and will be protected to the fullest extent provided by law. If, in any sort of report, PI might publish, it will not include any information that will make it possible to identify the participant. Records will be stored securely, and only the project team will have access to the records.

Compensation & Costs: There is no cost or payment to the participant for receiving the health education and/or for participating in this project.

The evaluation of this educational module will involve the use of questionnaires and the evaluation of the course from the participants. After the presentation, the results must be disseminated to identify any gaps in education and ways to improve the use of the adhesive electrodes.

Methodology

Setting and Participants

A large community based hospital in south Florida will host this DNP project. The anesthesia professionals will be the main project participants. The sample size is expected to range from 4 to 10 individuals, and participants will be recruited freely by email.

Description of Approach and Project Procedures

The proposed project's core methodology is to distribute an online educational module to anesthesia practitioners that focuses on enhancing providers' awareness of the use of disposable laryngeal electrodes for intraoperative neuromonitoring. The educational program can be performed entirely on a computer, tablet, or smartphone. In the first step, the project will be

implemented by administering an online pre-test to assess baseline knowledge and attitudes toward the subject. The second part will involve a PowerPoint presentation as the major means of learning, which will include critical information about the use of disposable laryngeal electrodes for intraoperative neuromonitoring versus NIM tubes. The final round of the research will include a post-test to assess information gained. The results will provide feedback regarding the impact of the educational intervention and how the use of Disposable Laryngeal Electrodes vs NIM tubes will influence anesthesia provider attitudes.

Protection of Human Subjects

The launch of the educational module is contingent on first project approval by Florida International University's (FIU) Institutional Review Board (IRB). The recruitment population for this QI research will comprise of anesthesia professionals and are involved in anesthesia practice. Recruitment efforts will be carried out by email, with the invitation emphasizing voluntary engagement with no penalty for leaving the QI project. Anesthesia practitioners who participate will benefit from increased knowledge and a more positive attitude about using disposable laryngeal electrodes for intraoperative neuromonitoring in adult surgical patients. The hazards associated with this quality improvement effort are minimal.

Data Collection

In this project, the major methods for assessing the success of the intervention will be a pre-test and post-test in the form of a survey. Qualtrics will be utilized to administer both 10-question surveys regarding disposable laryngeal electrode knowledge and use. Participants will also be asked to express their preferences for using a disposable laryngeal electrode vs a NIM tube. Other information gathered includes participant gender, age, ethnicity, degree of education, and years of experience.

The pre-test survey will assess baseline knowledge on the subject and identify any knowledge gaps that would need the deployment of the educational module. The post-test survey will indicate if participants learnt from the instructional module and are willing to apply what they learned in anesthetic practice. The data collected will be kept secret, and no subject identities will be recorded at any point during the QI research.

Data Management and Analysis Plan

The principal investigator and DNP project supervisor will have access to all data gathered. To ensure participant anonymity, no personal identifiers will be recorded. The efficacy of the intervention will be determined by comparing pre-test responses to post-test replies using statistical analysis.

Results

Test Demographics

Table 1 shows the demographics of the pre-test participants.

Demographic	n (%)
Total Participants	8 (100.00%)
Age	
25-34	5 (62.5%)
35-44	2 (25.0%)
45-54	1 (12.5%)
55-64	0 (0.00%)
65+	0 (0.00%)
Gender	
Male	3 (37.5%)
Female	5 (62.5%)
Ethnicity	
African American	1 (12.5%)
Caucasian	5 (62.5%)
Hispanic	2 (25.0%)
Other	0 (0.00%)
Medical Profession	
CRNA	8 (100.00%)
AA	0 (0.00%)
Anesthesiologist	0 (0.00%)
Other	0 (0.00%)
Highest Education	
Associate's degree	0 (0.00%)
Bachelor's degree	0 (0.00%)
Master's degree	0 (0.00%)
Doctoral degree	8 (100.00%)
Experience	
Less than 1 year	1 (12.5%)
1 to 5 years	5 (62.5%)
6 to 10 years	2 (25.0%)
More than 10 years	0 (00.00%)

There were eight participants in the pre- and post-test demographics, and all completed the survey. Most of the participants were female (n=5, 62.50%), as opposed to male (n=3, 37.50%). There were also a range of ethnicities represented: African American (n=1, 12.50%), Caucasian (n=5, 62.50%), Hispanic (n=2, 25.00%). Information was obtained regarding the participant's role at the hospital, and it was found that all participants were Certified Registered Nurse Anesthetists (CRNAs) (n=8, 100%). The participants were questioned about the length of time practicing, finding that the practice period ranged: less than one year (n=1, 12.50%), 1 to 5 years (n=5, 62.50%), 6 to 10 years (n=2, 25.00%), and more than 10 years (n=0, 00.00%).

Pre-Test vs Post-Test Disposable Laryngeal Electrodes vs NIM Tube

Table 2 shows the questionnaire results of the pre-test vs post-test answers.

Question	Correct in Pre-test	Correct in Post-test	Difference
What harm can occur to a patient when not using continuous intraoperative nerve monitoring? Select 2	50.00%	100.00%	50.00%
Which of the following could cause a loss of signal when monitoring with a NIM tube instead of a disposable laryngeal electrode?	0.00%	100.00%	100.00%
Disposable electrodes can attach to an ETT as small as:	0.00%	100.00%	100.00%
For which of the following procedures is the disposable laryngeal electrode capable of performing at the same as capacity as the NIM tube?	12.5%	100.00%	87.50%
NIM tubes come only in full sizes and not in half sizes. Whereas disposable electrodes can attach to any size tube.)	50.00%	100.00%	50.00%
Surface electrodes can be applied onto any standard endotracheal tube?	50.00%	100.00%	50.00%

When connecting the disposable electrode to the ETT, the provider will make sure to avoid sticking any part of the electrode to the air-filled cuff	62.50%	100.00%	37.50%
The most common reported downside when using a disposable laryngeal electrode is:	25.00%	100.00%	75.00%
The most common reported limitations when using a NIM tube is: Select 2	42.85%	80.00%	37.15%

Pre-Test vs Post-Test Disposable Laryngeal Electrodes vs NIM Tube

Anesthesia provider knowledge on the use of laryngeal electrodes improved overall after the educational module. Post-test all participants (n=8, 100.0%) knew the harms of not using intra-operative neuro monitoring vs pre-test (n=4, 50.00%). Post-test all participants (n=8, 100.00%) knew that changing head positions with a NIM tube can cause signal loss vs pre-test (n=0, 0.00%). When asked what is the smallest size ETT tube that disposable electrodes can attach to, the correct answer in the post-test was selected eight times (n=8, 100.00%) vs pre-test (n=8, 0.00%). When asked what procedures the disposable laryngeal electrode can be beneficial, the correct answer in the post-test was chosen eight-times (n=8, 100.00%) vs pre-test (n=1, 12.50%). When asked a true/false question on NIM tubes coming in full sizes and not in half sizes, whereas as disposable electrodes attaching to any ETT, the correct answer in the post-test was selected eight times (n=8, 100.00%) vs pre-test (n=4, 50.00%).

When asked a true/false question on whether disposable electrodes can be applied to any ETT tube, the correct answer in the post-test was selected eight times (n=8, 100.00%) vs pre-test (n=4, 50.00). When asked if providers should make sure to avoid sticking any part of the electrode to the air-filled cuff, all answered correctly in post-test (n=8, 100.00%) vs pre-test (n=6, 62.50). All participants (100.00%) knew the downsides to disposable electrodes in post-

test (n=8, 100.00%) vs pre-test (n=2, 25.00%). Lastly, when asked about the most common reported limitations of using a NIM tube in comparison to disposable electrodes, seven participants selected the correct answers in the post-test vs pre-test (n=4, 50.00%). There was a knowledge improvement noted in a majority of questions regarding the use of laryngeal electrodes for intra-operative monitoring. Table 2 shows the differences in responses from the pre- to post-test.

Pre-Test vs Post-Test Utilization of Disposable Laryngeal Electrodes vs NIM Tube

Table 3 shows the utilization results of the pre-test vs post-test participants.

Question	Pre-test	Post-test	Difference
How likely are you to utilize a disposable laryngeal electrode?			
Most likely (1)	12.50%	75.00%	20.00%
Somewhat likely (2)	25.00%	25.00%	46.67%
Somewhat unlikely (3)	37.50%	0.00%	37.50%
Most unlikely (2)	25.00%	0.00%	25.00%

Pre- vs Post-Test Utilization of Disposable Laryngeal Electrodes

The inclination to implement the use of disposable laryngeal electrodes into anesthesia practice prior to the educational module was low. One participant (12.50%) was most likely, and two participants (25.00%) were somewhat likely, three participants (37.50%) were somewhat unlikely, and two participants (25.00%) were most unlikely to implement the use of disposable laryngeal electrodes into anesthesia practice. Therefore, most participants (n=5, 62.50%) were

more inclined to using the NIM tube for intra-operative neuro monitoring before the educational module.

Attitudes towards the use of disposable laryngeal electrodes increased after the educational module: six participants (75.00%) were most likely, two participants (20.00%) was positive, and two participants (40.00%) were neutral. There were no negative or very negative attitudes expressed with the use of laryngeal electrodes after the educational module. Table 3 shows the differences in utilization from the pre- to post-test.

Discussion

Limitations

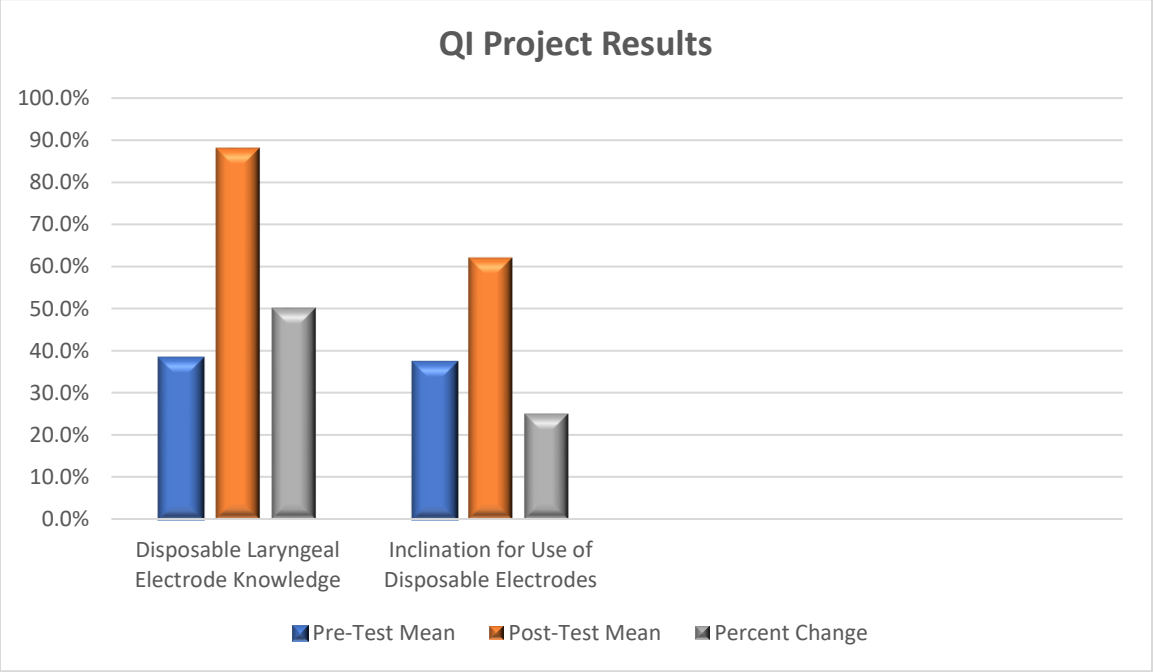
Despite inviting a large number of possible participants, there were limitations in this QI study. The first limitation was the small sample size. Only 8 of the 38 anesthesia practitioners who were asked to participate finished the pre-test and the post-test. An email reminder was sent to all initial practitioners after the training module was published, giving them two weeks to take the questionnaire. The nature of the project being online and the online style of the educational module added to its limitations. Another limitation of this QI investigation was the inclusion of just one hospital site. Potential considerations to alleviate constraints include addressing recruiting challenges, allowing for participation extension to new places, and extending the time to participate from two weeks to one month.

Summary

There was a statistical difference between the pre- and post-tests, according to the results. The disposable laryngeal knowledge pre-test had an average of 38.00% accurate answers, while the post-test had an average of 88.00% correct answers. Pre-test, 37.00% of providers used

laryngeal electrodes, while 62.50% of providers were willing to employ laryngeal electrodes in the post-test. As a result, all respondents showed a considerable improvement in their understanding of laryngeal electrodes and their application, with >50.00% percent change. Overall, there was a 120.00% percent shift in the preference for using laryngeal electrodes in anesthetic practice. All respondents' sentiments about the use of laryngeal electrodes for PONV prevention improved significantly, with a 62.50% percent shift. The graphic below depicts the findings.

Figure 7. QI Project Results



Plan for QI Next Steps

The next step is to develop a flow chart to determine the needs of the organization and create implementation strategies. First step is to evaluate organizational priorities and implementing the designed project in small scale. This is followed by evaluating the performance of the intervention and developing a plan to introduce the change systematically. The next step is monitoring performance and adjusting as necessary. There are two possible scenarios: the goal is achieved, or it is not achieved. If not achieved, creating a strategy and making adjustments promptly is key for a successful intervention. If achieved, no further work required asides from monitoring in a monthly or quarterly basis.

Plan for Sustaining the Practice Change

Sustaining the practice change is not easy since there are many moving parts during the entirety of the process. However, certain tasks can be implemented to ensure sustainability. These include:

- Determine viable fixes that might enhance the care systems.
- Recognize when to apply short-term remedies and longer-term fixes.
- Conduct a brief experiment in a small sample size and evaluate the outcomes before introducing a new change systematically.
- Refine plan for quality improvement.
- Create a schedule for carrying out future studies on the implemented change.
- Create clearly defined team roles.
- Implement the necessary changes to sustain the practice.
- Monitor the changes and remediation efforts.

Future Implications for Advanced Nursing Practice

The installation of the educational module might serve as a transition point in anesthetic practice reform. By displaying literature on the advantages of disposable laryngeal electrodes over NIM tubes, anesthesia providers can be influenced to use the electrodes in anesthesia practice to reduce the possibility of traumatic intubation, increase the efficiency of nerve monitoring, and lower overall healthcare costs. The intervention's impact is critical because its educational efficacy and potential to change anesthesia practitioners' attitudes toward the use of disposable laryngeal electrodes can improve adult surgery patient outcomes. The statistics demonstrated that the QI initiative was successful in boosting the knowledge and attitudes of anesthesia physicians. The outcomes of this QI investigation may inspire additional research into nerve integrity monitoring. Despite the significance of present literature, considering their recent debut and popularity in the hospital context, there is a need for more study on laryngeal electrodes.

Conclusion

The findings of this QI experiment provided significant insight into how an instructional module comparing the use of disposable laryngeal electrodes versus NIM tubes affects anesthesia professional knowledge and attitudes. The findings established a positive association; anesthesia provider knowledge of disposable laryngeal electrodes grew, as did the willingness to use electrodes in practice and overall attitudes. Finally, our QI experiment was able to provide an answer to the following research question: In surgical patients requiring intraoperative laryngeal nerve monitoring, is the education of providers on the use of disposable surface laryngeal electrodes, in comparison to those embedded within an electromyograph tracheal tube, improve intraoperative monitoring of the recurrent laryngeal nerve?

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Appendix A: QI Project IRB Exemption

FIU | Research & Economic Development
FLORIDA INTERNATIONAL UNIVERSITY

MEMORANDUM

To: Dr. Fernando Alfonso

CC: David Mercado-Hernandez

From: Carrie Bassols, BA, IRB Coordinator CeB

Date: March 9, 2023

Proposal Title: "An Evidence Based Educational Module on the Use of Disposable Laryngeal Electrodes for Intraoperative Neuromonitoring: A Quality Improvement Project"

The Florida International University Office of Research Integrity has reviewed your research study for the use of human subjects and deemed it Exempt via the **Exempt Review** process.

IRB Protocol Exemption #: IRB-23-0111 **IRB Exemption Date:** 03/09/23
TOPAZ Reference #: 112798

As a requirement of IRB Exemption you are required to:

1) Submit an IRB Exempt Amendment Form for all proposed additions or changes in the procedures involving human subjects. All additions and changes must be reviewed and approved prior to implementation.
2) Promptly submit an IRB Exempt Event Report Form for every serious or unusual or unanticipated adverse event, problems with the rights or welfare of the human subjects, and/or deviations from the approved protocol.
1) Submit an IRB Exempt Project Completion Report Form when the study is finished or discontinued.

Special Conditions: N/A

For further information, you may visit the IRB website at http://research.fiu.edu/irb.

Appendix B: QI Project Consent

FIU | FLORIDA INTERNATIONAL UNIVERSITY

CONSENT TO PARTICIPATE IN A QUALITY IMPROVEMENT PROJECT

An Evidence Based Educational Module on the Use of Disposable Laryngeal Electrodes for Intraoperative Neuromonitoring: A Quality Improvement Project

SUMMARY INFORMATION

Things you should know about this study:

- **Purpose:** Educational module to increase providers' awareness of the use of Disposable Laryngeal Electrodes for Intraoperative Neuromonitoring
- **Procedures**: If the participant chooses to participate, they will be asked to complete a pretest, watch a voice PowerPoint, and then a post test
- **Duration:** This will take about a total of 25 minutes total.
- **Risks**: There will be minimal risks involved with this project, as would be expected in any type of educational intervention, which may include mild emotional stress or mild physical discomfort from sitting on a chair for an extended period.
- **Benefits:** The main benefit to you from this research is increase the participants knowledge on the use of Disposable Laryngeal Electrodes for Intraoperative Neuromonitoring
- **Alternatives:** There are no known alternatives available to the participant other than not taking part in this quality improvement project.
- **Participation:** Taking part in this quality improvement project is voluntary.

Please carefully read the entire document before agreeing to participate.

NUMBER OF STUDY PARTICIPANTS:

If the participant decides to be in this study, they will be one of approximately 10 people in this research study.

PURPOSE OF THE PROJECT

The participant is being asked to be in a quality improvement project. The goal of this project is to increase providers' knowledge on ways to reduce recurrent laryngeal nerve injury with the use of adhesive laryngeal electrodes, along with ways in which they can be applied to any endotracheal tube. If you decide to participate, you will be 1 of approximately 10 participants.

DURATION OF THE PROJECT

The participation will require about 25 minutes

PROCEDURES

If the participant agrees to be in the project, PI will ask you to do the following things:

1. Complete an online 10 question pre-test survey via Qualtrics, an Online survey product for which the URL link is provided
2. Review the educational PowerPoint Module lasting 15 minutes via Qualtrics, an Online survey product for which the URL link is provided.
3. Complete the online 10 question post-test survey via Qualtrics, an Online survey product for which the URL link is provided.

RISKS AND/OR DISCOMFORTS
The main risk or discomfort from this research is minimal. There will be minimal risks involved with this project, as would be expected in any type of educational intervention, which may include mild emotional stress or mild physical discomfort from sitting on a chair for an extended period.

BENEFITS
The following benefits may be associated with participation in this project: increased participants knowledge on the use of adhesive EET electrodes, and as a result, reducing overall cost to patient and risk of traumatic injury to airway.The overall objective of the program is to increase the providers' knowledge based on the current literature.

ALTERNATIVES
There are no known alternatives available to the participant other than not taking part in this project. However, if the participant would like to receive the educational material, it will be provided to them at no cost.

CONFIDENTIALITY
The records of this project will be kept private and will be protected to the fullest extent provided by law. If, in any sort of report, PI might publish, it will not include any information that will make it possible to identify the participant. Records will be stored securely, and only the project team will have access to the records.

PARTICIPATION: Taking part in this quality improvement project is voluntary.

COMPENSATION & COSTS
There is no cost or payment to the participant for receiving the health education and/or for participating in this project.

RIGHT TO DECLINE OR WITHDRAW
The participation in this project is voluntary. The participant is free to participate in the project or withdraw the consent at any time during the project. The participant's withdrawal or lack of participation will not affect any benefits to which you are otherwise entitled. The investigator reserves the right to remove the participant without their consent at such time that they feel it is in their best interest.

RESEARCHER CONTACT INFORMATION
If you have any questions about the purpose, procedures, or any other issues relating to this

research project, you may contact David Mercado-Hernandez at 561-900-4177/dmerc034@fiu.edu and Dr. Alfonso, 305-348-3510/falfonso@fiu.edu

IRB CONTACT INFORMATION

If the participant would like to talk with someone about their rights pertaining to being a subject in this project or about ethical issues with this project, the participant may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

PARTICIPANT AGREEMENT

I have read the information in this consent form and agree to participate in this study. I have had a chance to ask any questions I have about this study, and they have been answered for me. By clicking on the "consent to participate" button below I am providing my informed consent.

Appendix C: QI Project Letter of Support

Miami Beach Anesthesiology Associates, Inc.

Mount Sinai Medical Center • Division of Anesthesia

February 7, 2023

Fernando Alfonso, DNP, CRNA, APRN
Clinical Assistant Professor
Department of Nurse Anesthesiology
Florida International University

Dr. Alfonso,

Thank you for inviting Miami Beach Anesthesiology Associates to participate in the Doctor of Nursing Practice (DNP) project conducted by David Mercado-Hernandez entitled "An Evidence Based Educational Module on the use of Disposable Laryngeal Electrodes for Intraoperative Neuromonitoring: A Quality Improvement Project" in the Nicole Wertheim College of Nursing and Health Sciences, Department of Nurse Anesthesiology at Florida International University. I have granted the student permission to conduct the project using our providers.

Evidence-based practice's primary aim is to yield the best outcomes for patients by selecting interventions supported by the evidence. This proposed educational module seeks to utilize the latest literature to increase providers awareness regarding the use of disposable laryngeal electrodes for endotracheal tubes during surgeries requiring recurrent laryngeal nerve monitoring.

We understand that participation in the study is voluntary and carries no overt risk. All Anesthesiology providers are free to participate or withdraw from the study at any time. The educational intervention will be conveyed by a 15-minute virtual PowerPoint presentation, with a pretest and posttest questionnaire delivered by a URL link electronically via Qualtrics, an online survey product. Responses to pretest and posttest surveys are not linked to any participant. The collected information is reported as an aggregate, and there is no monetary compensation for participation. All collected material will be kept confidential, stored in a password encrypted digital cloud, and only be accessible to the investigators of this study: David Mercado-Hernandez and Dr. Fernando Alfonso

Once the Institutional Review Board's approval is achieved, this scholarly project's execution will occur over two weeks. David Mercado-Hernandez will behave professionally, follow standards of care, and not impede hospital performance. We support the participation of our Anesthesiology providers in this project and look forward to working with you.

Respectfully,

Jampierre (J.P.) Mato, DNP, CRNA, APRN
Executive CRNA Director
SRNA Coordinator/Supervisor
Electronic Mail: Jampierre@bellsouth.net
Mobile Phone: 954-668-6080

4300 Alton Road, Suite 2454, Miami Beach, FL 33140
Office (305) 674-2742 • Facsimile (305) 674-9723

Appendix D: QI Project Pre-test and Post-test Survey

Pretest and Posttest Questionnaire:

An Evidence Based Educational Module on the Use of Disposable Laryngeal Electrodes for Intraoperative Neuromonitoring: A Quality Improvement Project

INTRODUCTION

The primary aim of this QI project is to increase providers awareness of Disposable Laryngeal Electrodes for Intraoperative Neuromonitoring

Please answer the question below to the best of your ability. The questions are either in multiple choice or true/false format and are meant to measure knowledge the use of laryngeal electrodes.

PERSONAL INFORMATION

1. **Gender:** Male Female Other_____
2. **Ages 25 and above: _____**
3. **Ethnicity:** Hispanic Caucasian African American Asian Other_____
4. **Position/Title:** CRNA Anesthesiologist Resident Anesthesiologist Assistant
5. **Level of Education:** Certificate Bachelors Masters DNP PhD
6. How many years have you been a perioperative provider?

   Over 10 5-10 years 2-5 years 1-2 years

QUESTIONNAIRE

1. **What harm can occur to a patient when not using continuous intraoperative nerve monitoring? SATA 2**
    a. Limb weakness
    b. Stroke
    c. Transient or permanent vocal cord paralysis
    d. Dysphonia
2. **Which of the following could cause a loss of signal when monitoring with a NIM tube instead of a disposable laryngeal electrode?**
    a. Increased peak pressures
    b. Changing head positions
    c. Interference during use of surgical electrocautery
    d. Use of Nitrous
    e. 150cc blood loss
3. **Disposable electrodes can attach to an ETT as small as:**
    a. 7.5 mm
    b. 8.0 mm
    c. 6.0 mm
    d. 2.0 mm
4. **For which of the following procedures is the disposable laryngeal electrode capable of performing at the same as capacity as the NIM tube?**
    a. Neck dissection
    b. Hemithyroidectomy

c. Carotid endarterectomy

d. All of the above

5. **NIM tubes come in full sizes and not in half sizes.** True or False

6. **Surface electrodes can be applied onto any standard endotracheal tube?** True or False

7. **How likely are you to ensure the proper functioning of a disposable laryngeal electrode?**

    a. Most likely

    b. Somewhat likely

    c. Somewhat unlikely

    d. Most unlikely

8. **How likely are you to utilize a disposable laryngeal electrode?**

    a. Most likely

    b. Somewhat likely

    c. Somewhat unlikely

    d. Most unlikely

9. **The most common reported downside when using a disposable laryngeal electrode is:**

    a. Cost

    b. Weight

    c. Constant loss of signal

    d. Applying the electrode to the ETT

10. **The most common reported downsides when using a NIM tube is: SATA 2**

    a. Size availability

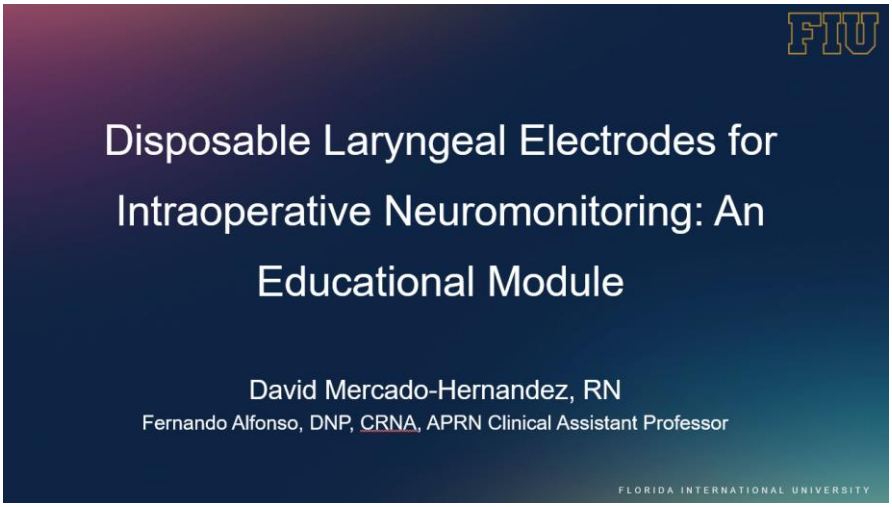
    b. Easy to catch on fire

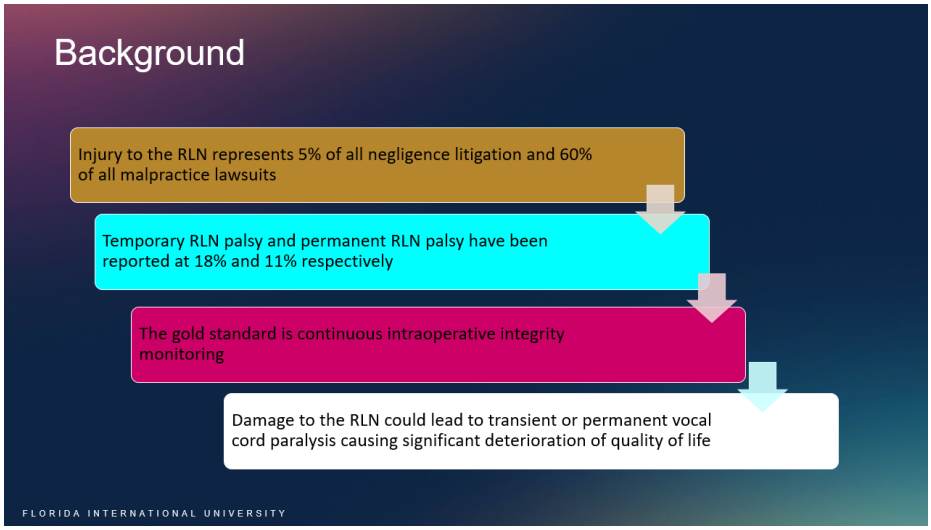
c. Only precise alignment guarantees RLN monitoring

d. The lack of color variety

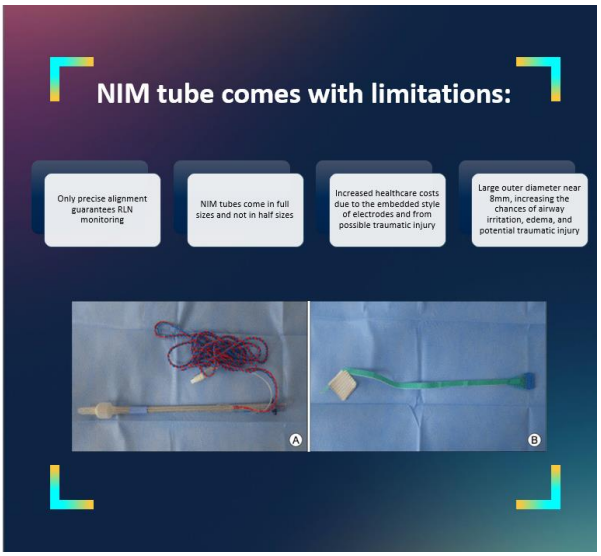
e. Large learning curve

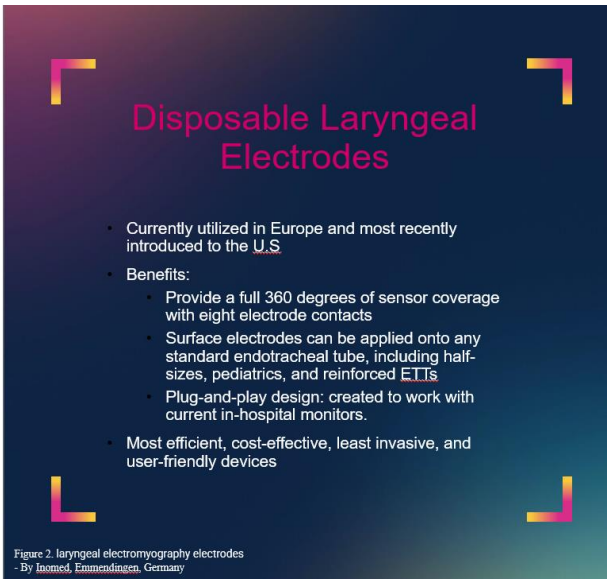
Appendix E: QI Project Educational Module





Scope of the Problem





NIM tube Vs Disposable Laryngeal Electrodes

No statistically significative difference between the two groups for distribution of age, sex, epidemiological characteristics, type of pathology etc.

Overall reduction in costs

Both devices had similar scores when identifying purposeful laryngeal injuries in different studies

Loss of signal was identified during head position changes with NIM tube, when compared to disposable electrodes

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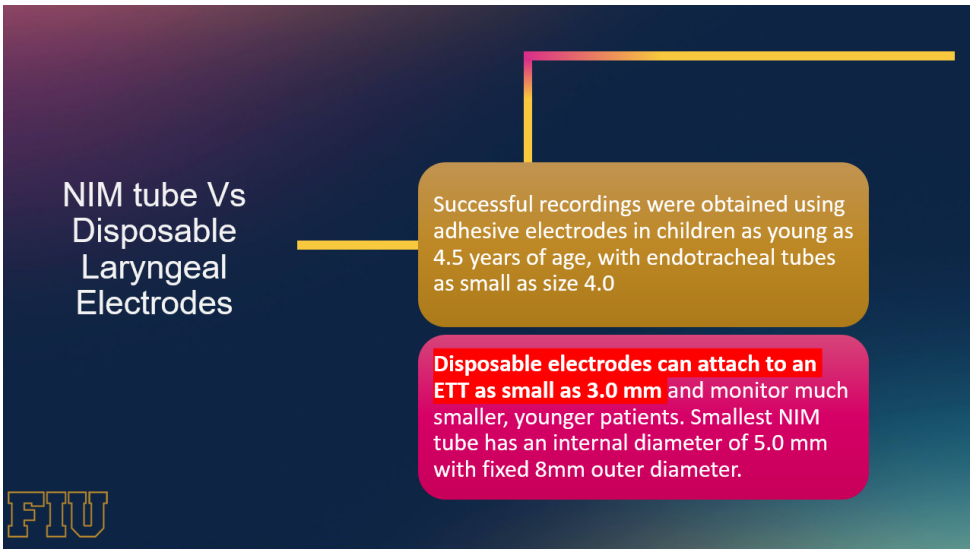
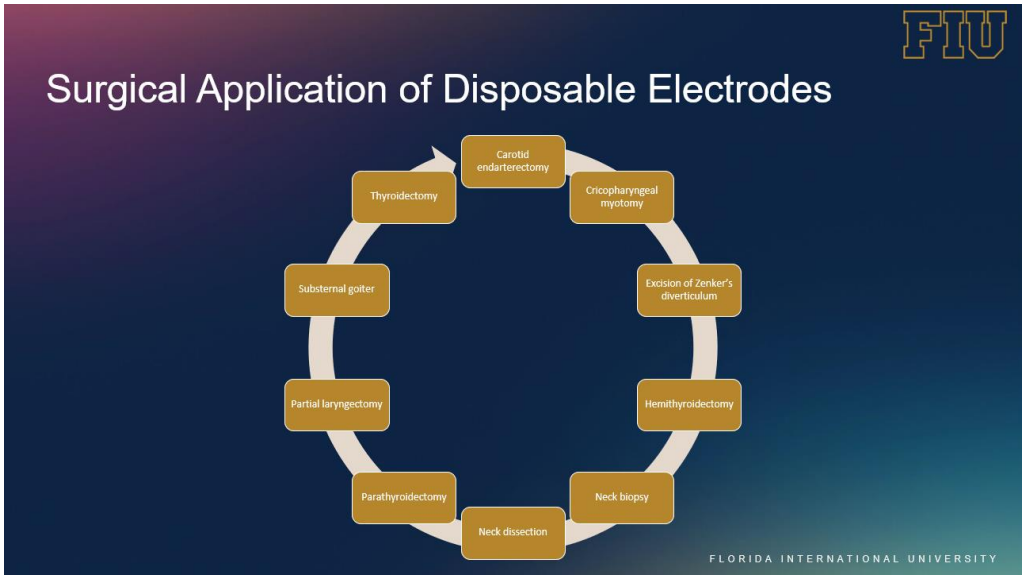

NIM tube Vs Disposable Laryngeal Electrodes
Successful recordings were obtained using adhesive electrodes in children as young as 4.5 years of age, with endotracheal tubes as small as size 4.0
Disposable electrodes can attach to an ETT as small as 3.0 mm and monitor much smaller, younger patients. Smallest NIM tube has an internal diameter of 5.0 mm with fixed 8mm outer diameter.
FIU


FIU
Surgical Application of Disposable Electrodes
Carotid endarterectomy
Cricopharyngeal myotomy
Excision of Zenker's diverticulum
Hemithyroidectomy
Neck biopsy
Neck dissection
Parathyroidectomy
Partial laryngectomy
Substernal goiter
Thyroidectomy
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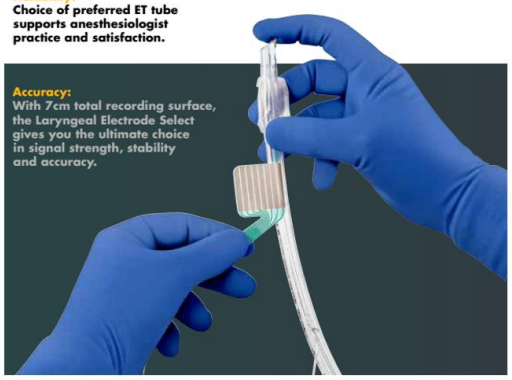
How to Properly Use Disposable Laryngeal Electrodes
inomed
Worldwide — Since 1991
Credit: Inomed, Emmendingen, Germany

How to Properly Use Disposable Laryngeal Electrodes

Flexibility:
Choice of preferred ET tube supports anesthesiologist practice and satisfaction.



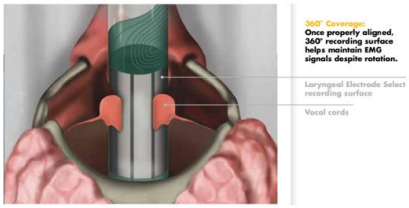


Figure 3. laryngeal electromyography electrodes
- By Inomed, Emmendingen, Germany

How to Properly Use Disposable Laryngeal Electrodes

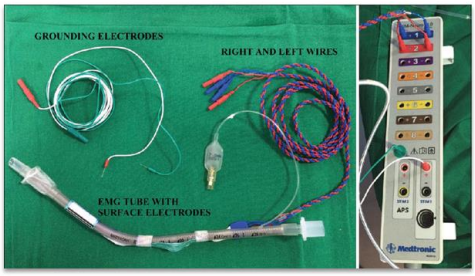


Figure 4. laryngeal electromyography electrodes and monitor
- By Inomed, Emmendingen, Germany

Take home points
Disposable Laryngeal Electrodes

- **360° recording surface** around ET tube simplifies placement and provides continuous contact through rotation
- Works with any non-silicone ET tube; **anesthesiologists' preference**
- Appropriate for **complex procedures** on the neck
- Operates in conjunction with **30+** needle electrodes, stimulation probes and paired subdermal electrodes
- Records 4 channels with the **strongest EMG signal automatically displayed** via Channel Select software
- **Two convenient sizes** simplify inventory
- Works with Stryker and other **compatible** nerve monitors
- **Keeps inventory in line** with hospital practices
- System performs **automatic electrode check** indicated by green checkmark
- **Green indicator** confirms successful stimulation current during use

A 5,000+ patient review showed the benefits of IONM during thyroidectomy:[1]

↓ risk of permanent vocal cord palsy

↑ identification of the RLN (P <0.001)

Ø bilateral RLN injuries

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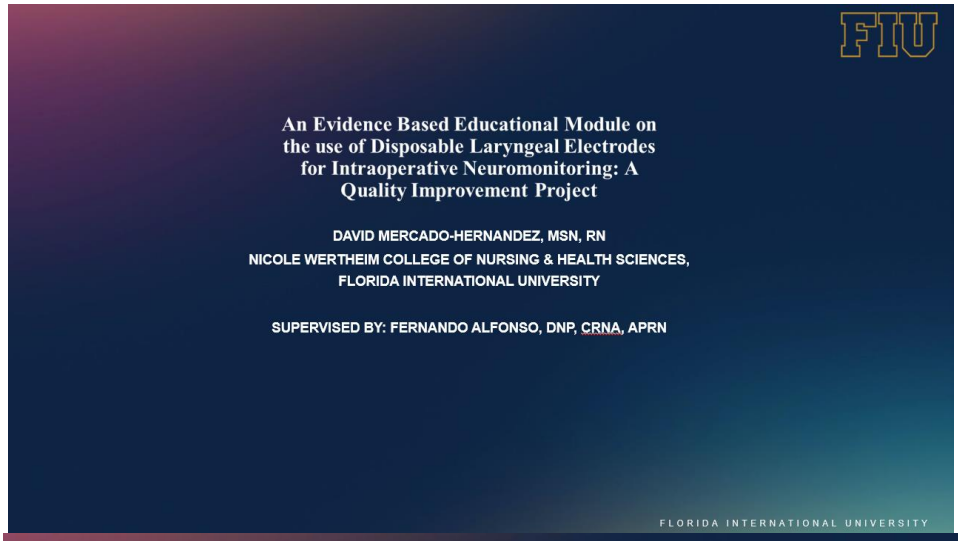
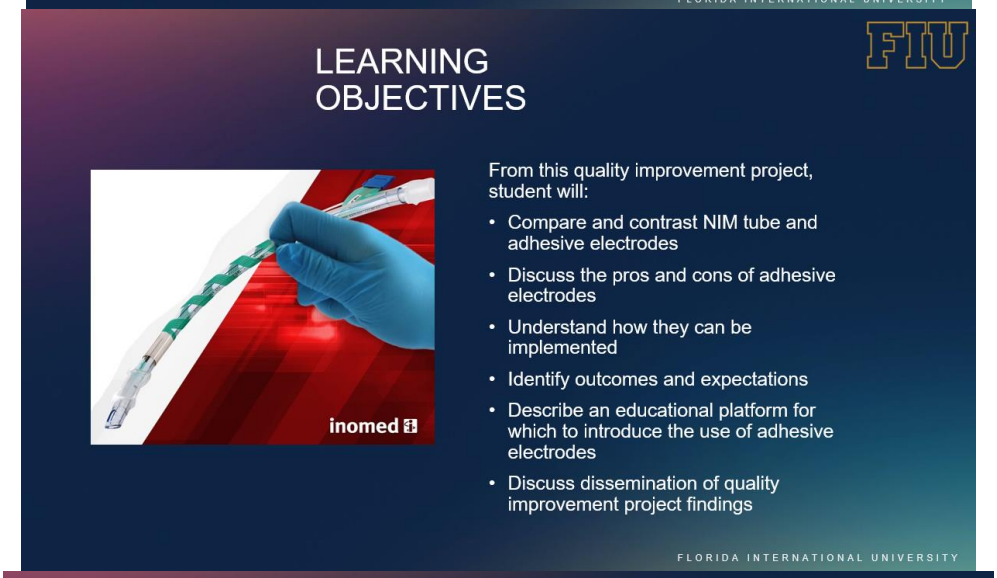
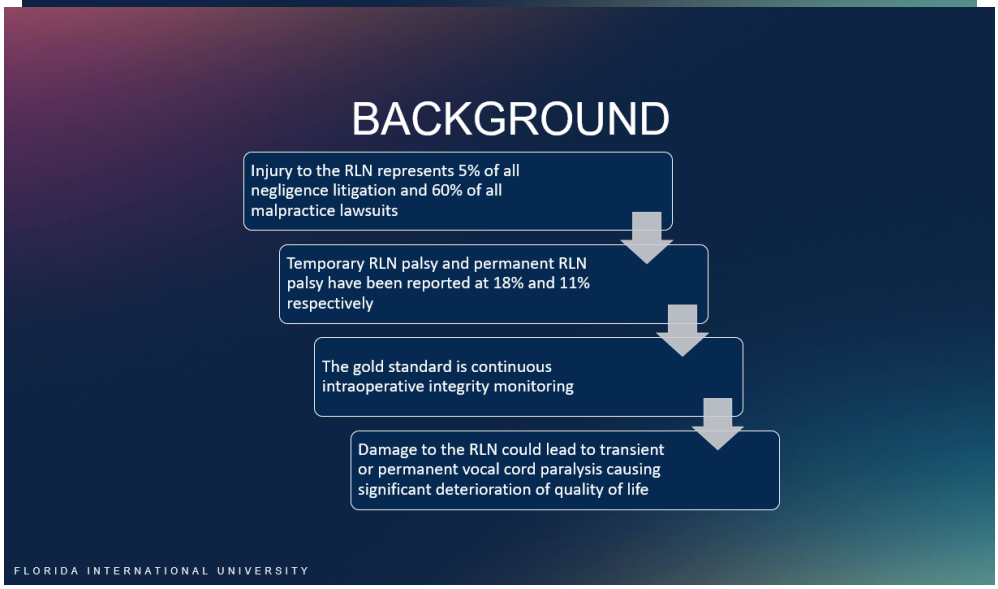
Appendix F: QI DNP Symposium Presentation







Problem Identification

Patent ductus arteriosus (PDA) ligation
- 4.2%

General thyroid-related cases
- 10%

Tracheoesophageal fistula (TEF) and esophageal atresia (EA)
- 11-50%

The incidence of recurrent laryngeal nerve (RLN) injury can be as high as 5% of all negligence litigation and 60% of malpractices lawsuits involving endocrine surgery.[3]

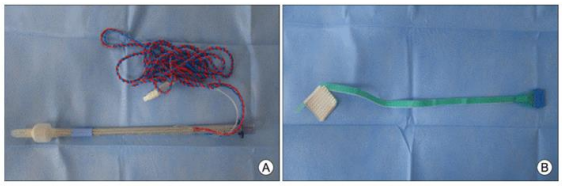
Problems related to RLN injury include:
- Stridor
- Dyspnea
- Dysphonia
- Dysphagia

FIU

Scope of the Problem

NIM tube comes with limitations:

- Only precise alignment guarantees RLN monitoring
- NIM tubes come in full sizes and not in half sizes
- Increased healthcare costs due to the embedded style of electrodes and from possible traumatic injury
- Large outer diameter near 8mm, increasing the chances of airway irritation, edema, and potential traumatic injury



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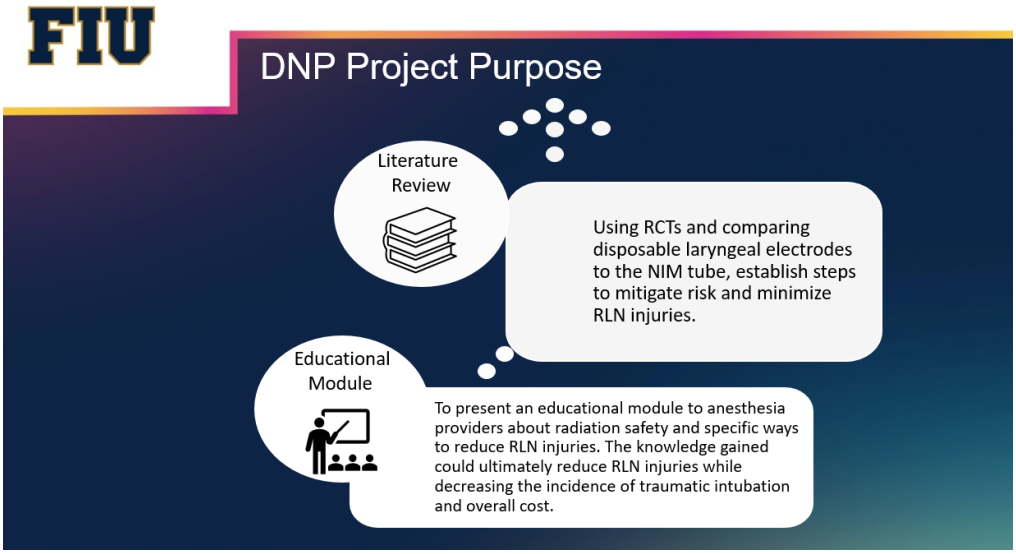
SCOPE OF THE PROBLEM CONSEQUENCES OF USING A NIM TUBE

- Poor Intraoperative Monitoring
- Traumatic Intubation
- RLN Damage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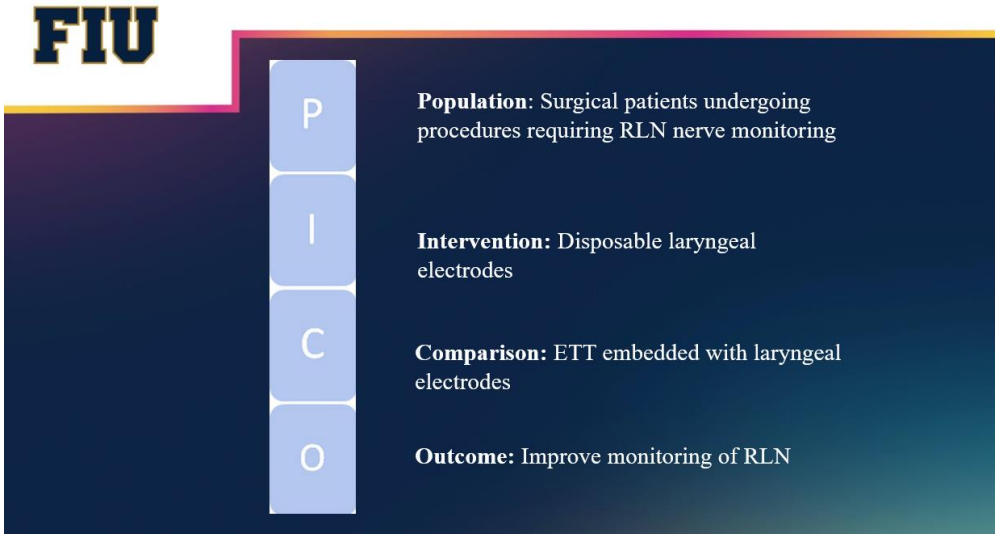
DNP Project Purpose
Literature Review
Using RCTs and comparing disposable laryngeal electrodes to the NIM tube, establish steps to mitigate risk and minimize RLN injuries.
Educational Module
To present an educational module to anesthesia providers about radiation safety and specific ways to reduce RLN injuries. The knowledge gained could ultimately reduce RLN injuries while decreasing the incidence of traumatic intubation and overall cost.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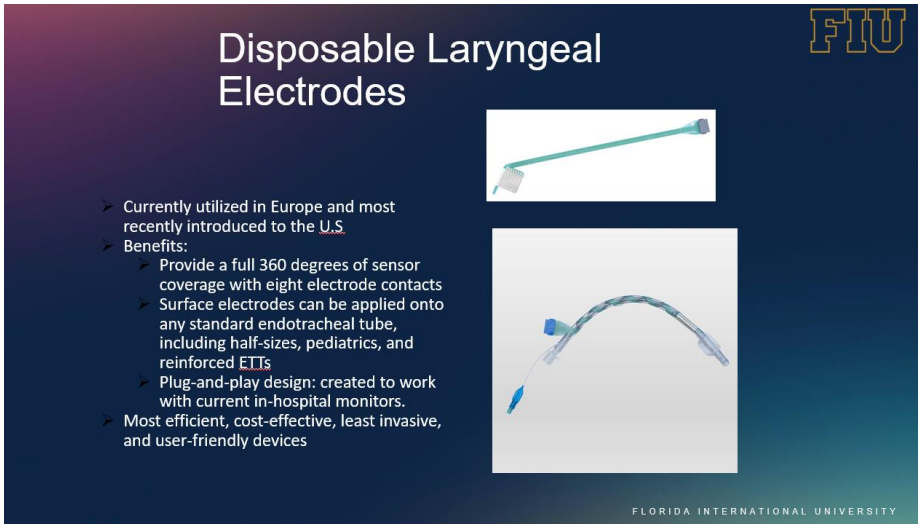
Population: Surgical patients undergoing procedures requiring RLN nerve monitoring
Intervention: Disposable laryngeal electrodes
Comparison: ETT embedded with laryngeal electrodes
Outcome: Improve monitoring of RLN


Disposable Laryngeal Electrodes
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Currently utilized in Europe and most recently introduced to the U.S
Benefits:
Provide a full 360 degrees of sensor coverage with eight electrode contacts
Surface electrodes can be applied onto any standard endotracheal tube, including half-sizes, pediatrics, and reinforced ETTs
Plug-and-play design: created to work with current in-hospital monitors.
Most efficient, cost-effective, least invasive, and user-friendly devices
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NIM tube Vs Disposable Laryngeal Electrodes

No statistically significative difference between the two groups for distribution of age, sex, epidemiological characteristics, type of pathology etc.

Overall reduction in costs

Both devices had similar scores when identifying purposeful laryngeal injuries in different studies

Loss of signal was identified during head position changes with NIM tube, when compared to disposable electrodes

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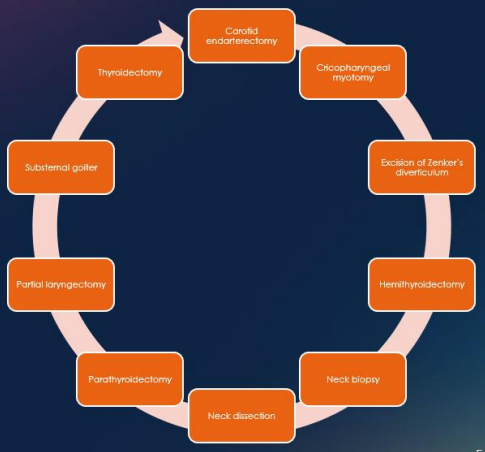
NIM tube Vs Disposable Laryngeal Electrodes Cont.

Successful recordings were obtained using adhesive electrodes in children as young as 4.5 years of age, with endotracheal tubes as small as size 4.0

Disposable electrodes can attach to an ETT as small as 3.0 mm and monitor much smaller, younger patients. Smallest NIM tube has an internal diameter of 5.0 mm with fixed 8mm outer diameter.

Surgical Application of Disposable Electrodes



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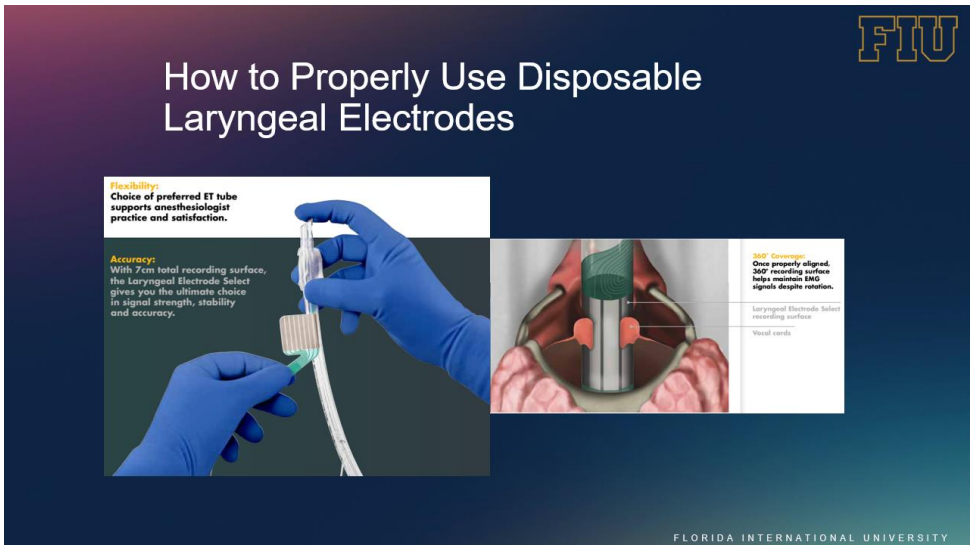


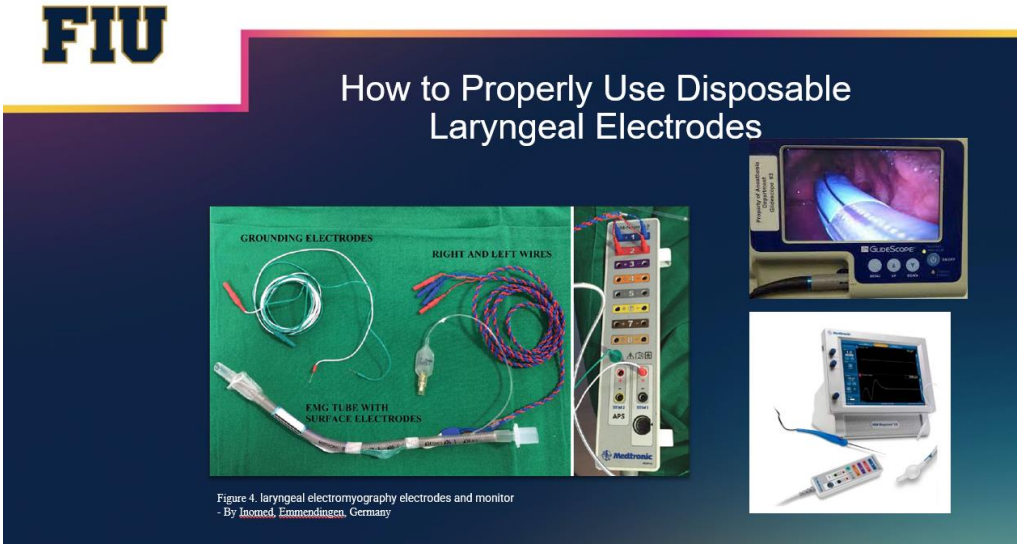
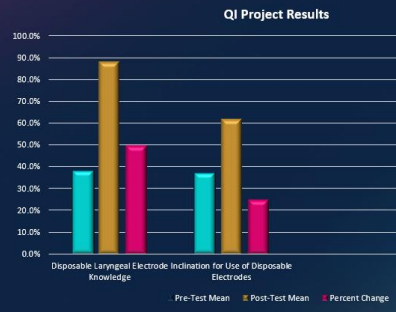


Figure 4. laryngeal electromyography electrodes and monitor - By Inomed, Emmendingen, Germany

Results

Demographic	n (%)
Total Participants	8 (100.00%)
Experience	
Less than 1 year	1 (12.5%)
1 to 5 years	5 (62.5%)
6 to 10 years	2 (25.0%)
More than 10 years	0 (00.00%)
Highest Education	
Associate's degree	0 (0.00%)
Bachelor's degree	0 (0.00%)
Master's degree	0 (0.00%)
Doctoral degree	8 (100.00%)
Medical Profession	
CRNA	8 (100.00%)
AA	0 (0.00%)
Anesthesiologist	0 (0.00%)
Other	0 (0.00%)
Ethnicity	
African American	1 (12.5%)
Caucasian	5 (62.5%)
Hispanic	2 (25.0%)
Other	0 (0.00%)
Gender	
Male	3 (37.5%)
Female	5 (62.5%)
Age	
25-34	5 (62.5%)
35-44	2 (25.0%)
45-54	1 (12.5%)
55-64	0 (0.00%)
65+	0 (0.00%)

Results



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Discussion

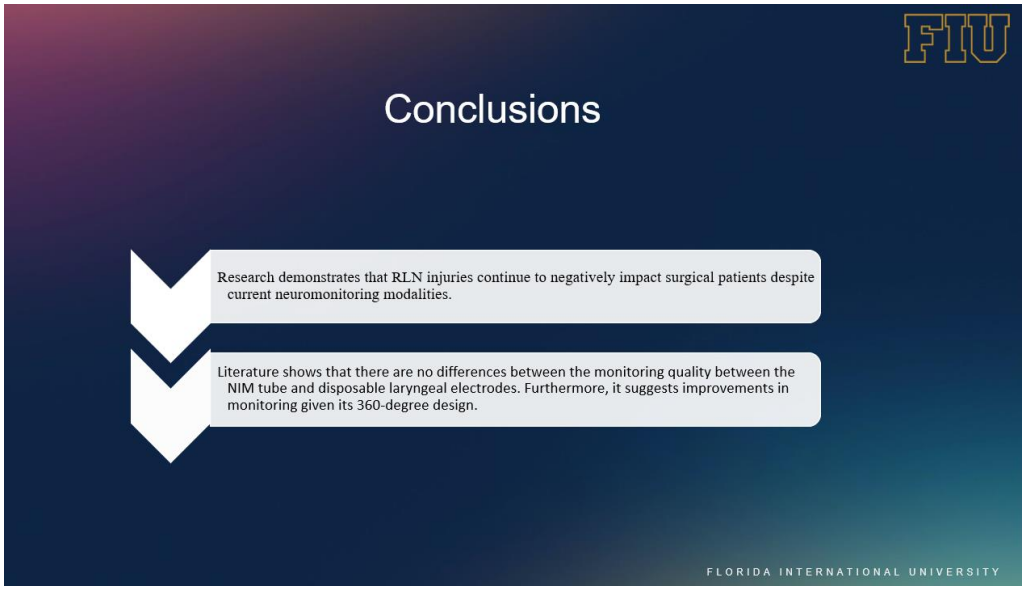
Limitations:

- Small Sample Size
- Online Project
- Only one hospital site

Discussion

Future Implications:

- More awareness of RLN Injuries
- Enhanced intra-operative neuro monitoring
- Reduction in cost


FIU
Conclusions
Research demonstrates that RLN injuries continue to negatively impact surgical patients despite current neuromonitoring modalities.
Literature shows that there are no differences between the monitoring quality between the NIM tube and disposable laryngeal electrodes. Furthermore, it suggests improvements in monitoring given its 360-degree design.
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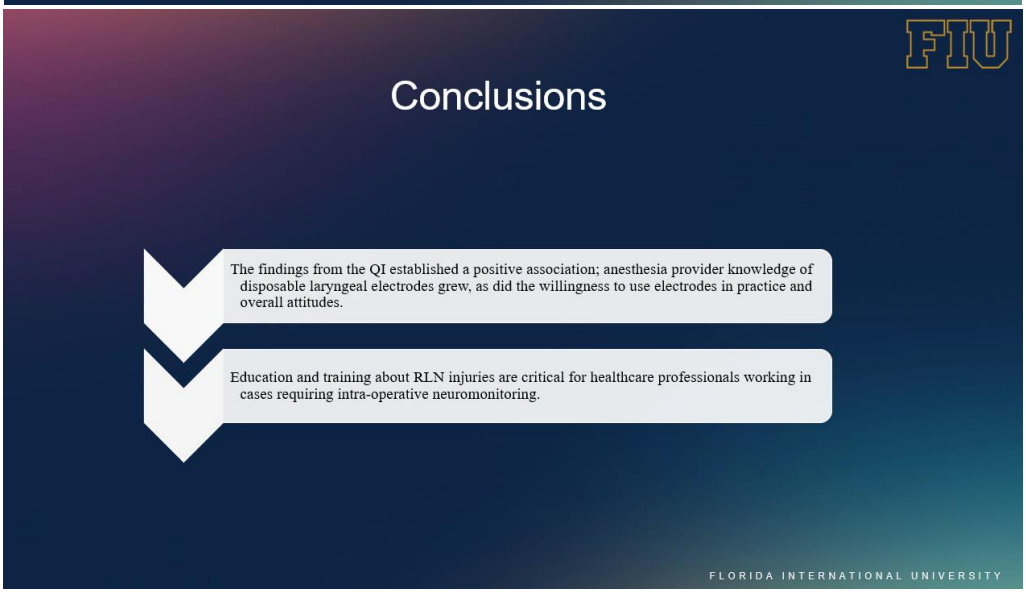
FIU
Conclusions
The findings from the QI established a positive association; anesthesia provider knowledge of disposable laryngeal electrodes grew, as did the willingness to use electrodes in practice and overall attitudes.
Education and training about RLN injuries are critical for healthcare professionals working in cases requiring intra-operative neuromonitoring.
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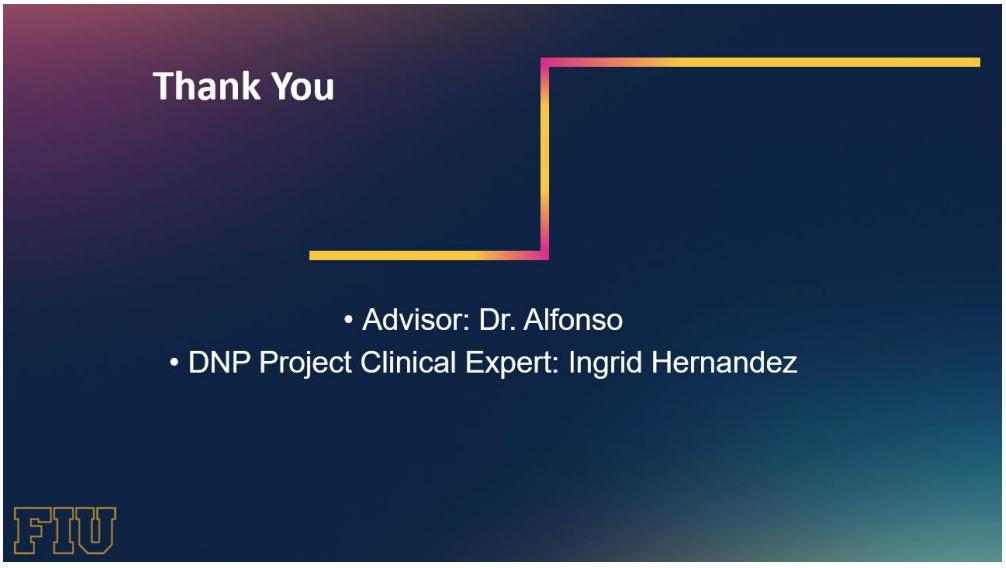
Thank You
• Advisor: Dr. Alfonso
• DNP Project Clinical Expert: Ingrid Hernandez
FIU

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