Selection of laryngeal electrodes for intraoperative laryngeal nerve monitoring

Madam,

Neurophysiological monitoring for localization of the laryngeal nerve is achieved through surface contact between laryngeal muscles and specialized laryngeal electrode. These electrodes are commercially available as disposable surface adhesives or embedded within an electromyograph (EMG) tracheal tube. Besides understanding the structure and function, it is prudent for anesthesiologists to be cognizant of commercially available options to allow discerning selection for the best fit that is essential for its function [Table 1]. Electrode embedded EMG tracheal tubes are commercially available in sizes from 6 to 9 mm internal diameter (I.D.). Compared to the earlier Medtronic Xomed tracheal tube, the newer TriVantage tracheal tube has a smaller outer diameter that is comparable with standard tracheal tubes. Its possible availability in 5 mm I.D. further improves its suitability for smaller adults and children. However, lack of ½ sizes with EMG tubes remains a major shortcoming for paediatric use. The other option is commercial surface laryngeal electrode adhesives which are available in sizes that fit tracheal tube ranging from 4 to 10 mm I.D., enabling utility in younger or smaller patients. These electrodes are designed to adhere onto preselected tracheal tubes of specified I.D. as recommended by manufacturers. To optimize the fit with the true vocal cords to allow detection of bilateral laryngeal responses, selected tracheal tube are prepared by adhering the surface adhesives to the tube at appropriate shaft position. Compared to the typical flush design of other laryngeal electrodes, the newer bulb design of Neurosign’s lantern laryngeal electrode has the advantage of ensuring contact with the vocal cords even if tracheal tube position is suboptimal. Adhesion of contact electrodes onto the tracheal tube shaft nevertheless increases the rigidity and adds to its overall outer diameter. For children, the wider selection of commercial brands and sizes makes adhesive electrodes a feasible option though there is still lack of adhesive electrodes fitting tracheal tube sizes smaller than 4-mm I.D. When larger electrode than recommended is used, care must be taken to minimize overlapping of electrodes for proper functioning.

Complications and Food and Drug Administration recall of EMG electrodes from market had been reported and are also summarized in Table 1. Reported complications of use of embedded EMG tracheal tubes included cuff perforation from dislocated or distorted electrodes during stylet-assisted intubation,[2] cuff herniation,[3] and tracheal tear.[4] Airway complication from electrode sheath malfunction has also been reported in locally prepared electromyography tube in paediatric use.[5]

As recurrent laryngeal nerve monitoring is still relatively new. Knowledge of available sizing of electrodes for the best fit and awareness of problem from user experience are another important practical consideration for selection of the most appropriate laryngeal electrodes

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Conflicts of interest
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### Table 1: Types of laryngeal electrodes

| Types | Embedded in tracheal tube | Stick on surface electrodes on endotracheal tubes |
|-------|---------------------------|--------------------------------------------------|
| Brand | Medtronic | NIM contact reinforced EMG tube (Jacksonville, FL) | Inomed Medizintechnik (GmbH, Emmendingen, Teningen Germany) |
|       | Xomed (Jacksonville, FL) | Medtronic Trivantage (Jacksonville, FL) | Neurosign Magstim Inc (Wales, UK) |
|       | Stick on surface electrodes on endotracheal tubes | Lantern Neurosign Medical (Ventura, CA) | Dragonfly Neurovision Medical |
|       | Medtronic Trivantage (Jacksonville, FL) | Laryngeal Electrode, TechnoMed Europe (Amerskalaan, Netherlands) | Laryngeal Surface Invotec International (Jacksonville, FL) |

| Sizes | Tube size ID/OD (mm) | Sizes | Tube Fit ID (mm) |
|-------|---------------------|-------|------------------|
| Age (yo) | 5.0/7.8 | 6.0/8.8 | 7.0/9.8 | 8.0/10.8 |
| 6/9 | 5/6.5 | 6/8.4 | 6/9.7 | 7/10.3 |
| 7/10.5 | 6.5/8.9 | 6/10.8 | 8.0/10.1 | 9.0/11.2 |
| 8/11.5 | 7/9.5 | 7/9.5 |
| 32×29 mm | 6-7 | 32×37 mm | 7-9.5 | 8-9 |
| 8-9 |
| 8-9.5 |
| 8-9 |
| 6-7 |
| 7.5-10 |

| Tracheal tube use | NA | NA | NA | * |
|------------------|----|----|----|----|
| FDA recall and field safety notice | Class 2 device recall for NIM EMG tracheal tube in 2016 due to exposed wire. | Class 1 device recall for NIM Trivantage EMG tube in 2013 due to cuff leakage in the intraoperative cuff deflation necessitating reinflation or replacement of the deflated tube to ensure the continued ventilation of the patient. | Voluntary recall of NIM Flex EMG tube by Medtronic in 2013 due to potential inner lumen herniation constricting inner lumen of tracheal tube. | Class 2 device recall for Dragonfly 2 Channel laryngeal surface electrode (Neurovision) in 2010 due to migration of adhesive creating an electrical short. Use of such defective electrodes could lead to failure in monitoring. |
| Any standard tracheal tube | Any standard tracheal tube or armoured tracheal tube | Any endotracheal tube (non-silicon) | Non-silicon tracheal tube |
| Any standard tracheal tube | Any standard tracheal tube or armoured tracheal tube | Any endotracheal tube (non-silicon) | Non-silicon tracheal tube |
| Any standard tracheal tube | Any standard tracheal tube or armoured tracheal tube | Any endotracheal tube (non-silicon) | Non-silicon tracheal tube |
| Any standard tracheal tube | Any standard tracheal tube or armoured tracheal tube | Any endotracheal tube (non-silicon) | Non-silicon tracheal tube |

* Class 2 device recall for NIM EMG tracheal tube in 2004 due to reports of wires out of channel leading to patients' injuries.

Contd...
### Table 1: Contd...

**Laryngeal nerve monitoring with surface laryngeal electrode**

| Types                                      | Embedded in tracheal tube                                                                 | Stick on surface electrodes on endotracheal tubes                                                                 |
|--------------------------------------------|------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Complication Reported in literature        | Perforation of cuff of EMG tube (Medtronic NIM Response®Nerve Integrity Monitoring System) from distortion of electrodes from use with a lightwand.\(^1\) | Separation of electrode sheath and kink at cable entry point in locally prepared EMG tube resulted in obstruction during removal of tube in 16 months old.\(^1\) |
|                                            | Perforation of cuff of EMG tube (Medtronic Xomed) from dislocated electrodes from use with a glidescope and Rusch stylet.\(^1\) |                                                                                                               |
|                                            | Ineffective ventilation resulting from cuff herniation of reinforced EMG tube (Medtronic Xomed, Nerve Integrity monitoring).\(^1\) |                                                                                                               |
|                                            | Tracheal Tear in a case of underlying tracheomalacia after using an NIM EMG tube (Medtronic).\(^1\) |                                                                                                               |

*prototype investigative, + No mention, NA Not applicable*

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