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CLINICAL REPORT

The effect of esophagogastroduodenoscopy probe insertion on the intracuff pressure of airway devices in children during general anesthesia

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Abstract Given the size of the esophagogastroduodenoscopy (EGD) probe and the compressibility of the pediatric airway, the EGD probe may increase the intracuff pressure (IP) of an airway device. The current study evaluated IP changes during EGD examination under general anesthesia in pediatric patients. Following the induction of anesthesia, a laryngeal mask airway (LMA) or endotracheal tube (ETT) was placed without neuromuscular blockade. The IP was measured at baseline, during EGD probe insertion, while the EGD probe was in place, and after probe removal. The study cohort included 101 patients (mean age 11.3 years). The airway was secured with an LMA and an ETT in 88 and 13 patients, respectively. The IP increased from 27 ± 15 cmH_2O at baseline to 34 ± 17 cmH_2O during probe insertion ($p < 0.001$), remained at 33 ± 16 cmH_2O while the probe was in place, and decreased to 26 ± 14 cmH_2O after probe removal. The IP of the LMA or ETT increased during EGD probe insertion and remained elevated while the probe was in place. High IP may compromise mucosal perfusion resulting in a sore throat when using an LMA or the potential for airway damage if an ETT is used. Removal of air from the cuff and titration of the IP should be considered after EGD insertion.

Keywords Esophagogastroduodenoscopy · Intracuff pressure · Probe insertion

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Introduction

Pediatric patients usually require general anesthesia or deep sedation for esophagogastroduodenoscopy (EGD). Given the size of the EGD probe and the compressibility of the pediatric esophagus and trachea, the EGD probe may compress the airway device and increase the intracuff pressure (IP). Prolonged increases in IP may result in mucosal damage and a sore throat when a laryngeal mask airway (LMA) is used or the potential for airway trauma if an endotracheal tube (ETT) is used.

Although the LMA is perhaps the most commonly used airway device during the provision of anesthetic care, the placement techniques have not been standardized [1]. Cuff pressures >40 cmH_2O increase the incidence of a sore throat and may result in a less effective seal with impaired ventilation [2–7]. Although not all of the manufacturers provide guidelines regarding the optimal IP, it is generally recommended that the IP should be <60 cmH_2O. Despite these concerns, the routine measurement of the IP of an LMA is not routine [8]. The current study evaluated IP changes during EGD examination in pediatric patients.

Clinical report

This study was approved by the Institutional Review Board of Nationwide Children's Hospital (Columbus, OH, USA) and registered at ClinicalTrails.gov (NCT02645019). Informed consent was obtained from a parent and, where age appropriate, assent was obtained from the patient. The study cohort included patients up to 18 years of age who were scheduled for EGD. Patients with a history of a previous difficult endotracheal intubation or airway

pathology were excluded. After the induction of anesthesia, an LMA or ETT was placed without the administration of neuromuscular blockade. There was no control over who (resident, faculty, CRNA, SRNA, or fellow) placed the airway device or the technique used. A single type of LMA (Ambu® AuraOnce™) and ETT (Microcuff®; Halyard Health, Alpharetta, GA, USA) were used. Anesthesia was maintained with sevoflurane or desflurane in air and oxygen. Nitrous oxide was not used for maintenance anesthesia. The IP was continuously monitored using our previously described technique [9]. The IP was assessed at baseline, during EGD probe insertion, while the EGD probe was in place, and after probe removal. The IP was compared between sequential time points using paired *t* tests. Repeated measures analysis of variance (ANOVA) was used to identify differences in IP change by age category or airway device type.

The study cohort included 101 patients (50 boys and 51 girls with a mean age of 11.3 ± 4.8 years). An LMA was used in 88 patients and an ETT was used in 13 patients. The demographic data and type of airway device are outlined in Table 1. The IP increased from 27 ± 15 cmH_2O at baseline to 34 ± 17 cmH_2O during insertion ($p < 0.001$), remained at 33 ± 16 cmH_2O while the probe was in place, and decreased to 26 ± 14 cmH_2O after probe removal (Table 2). Comparisons across age groups found that the IP increase from baseline to insertion was least among patients in the 16 to 18 year age group with an increase from 31 ± 12 to 35 ± 13 cmH_2O; $p = 0.008$ (Table 2). The change was greatest among patients in the 7 to 10 year age group with a change from 25 ± 12 to 35 ± 15 cmH_2O; $p < 0.001$. However, repeated measures ANOVA did not find any statistically significant difference in this change across the age groups ($p = 0.187$). Although the baseline IP was higher with the LMA versus the ETT, the absolute change in IP was similar regardless of the type of airway device used (Table 3). When comparing IP by the type of airway device, the decrease in IP after probe removal was significantly less in the ETT group compared to the LMA group ($p = 0.029$). In the ETT group, the change in IP was not significant after probe removal (24 ± 25 during the examination to 21 ± 25 cmH_2O after probe removal, $p = 0.070$), whereas the decline in IP between these time points was significant in all LMA groups at $p < 0.001$

Table 1 Patient demographics and airway device used

Variables	All ($n = 101$)	Age 3–6 years ($n = 21$)	Age 7–10 years ($n = 24$)	Age 11–15 years ($n = 29$)	Age 16–18 years ($n = 27$)
Age (years)	11.3 ± 4.8	4.2 ± 1.6	9.0 ± 1.0	13.2 ± 1.5	16.9 ± 0.7
Gender (female)	50 (50%)	13 (62%)	7 (29%)	17 (59%)	14 (52%)
Airway device					
LMA size 2	18 (18%)	15 (71%)	2 (8%)	1 (3%)	0
LMA size 2.5	13 (13%)	2 (10%)	11 (46%)	0	0
LMA size 3	32 (32%)	0	8 (33%)	17 (59%)	7 (26%)
LMA size 4	24 (24%)	0	0	7 (24%)	17 (63%)
LMA size 5	1 (1%)	0	0	0	1 (4%)
ETT	13 (13%)	4 (19%)	3 (13%)	4 (14%)	2 (7%)

Data are shown as mean ± SD or number (%)

LMA laryngeal mask airway, *ETT* endotracheal tube

Table 2 Intracuff pressure in cmH_2O over time in the study cohort groups

Cohort	All ($n = 101$)	Age 3–6 years ($n = 21$)	Age 7–10 years ($n = 24$)	Age 11–15 years ($n = 29$)	Age 16–18 years ($n = 27$)	*p* value
Baseline	27 ± 15	14 ± 13	25 ± 12	35 ± 17	31 ± 12	
During probe insertion	34 ± 17	21 ± 14	35 ± 15	40 ± 19	35 ± 13	<0.001[b]
With probe in place	33 ± 16	22 ± 14	35 ± 15	37 ± 16	36 ± 12	0.620[c]
After probe removal	26 ± 14	14 ± 11	27 ± 13	30 ± 15	29 ± 12	<0.001[d]

Data are shown as mean ± SD or number (%)

[a] *p* value from paired *t* test in entire cohort ($n = 101$) comparing current time point to previous time point. Statistical significance of differences in the change from the previous time point across age groups, assessed by repeated measures ANOVA, is denoted by superscript

[b,c,d] *p* value of variation across age groups in change from previous time point: [b] $p = 0.187$, [c] $p = 0.407$, [d] $p = 0.920$

Table 3 Intracuff pressures in cmH_2O compared across type of airway device

Airway device	LMA 2 ($n = 18$)	LMA 2.5 ($n = 13$)	LMA 3 ($n = 32$)	LMA 4 ($n = 24$)	ETT ($n = 13$)	Difference from previous time point p value[a]
Baseline	15 ± 13	25 ± 10	34 ± 10	32 ± 10	19 ± 26	–
During probe insertion	22 ± 14	34 ± 9	41 ± 15	37 ± 12	24 ± 25	<0.001[b]
With probe in place	22 ± 14	35 ± 9	39 ± 13	36 ± 11	24 ± 25	0.619[c]
After probe removal	15 ± 11	26 ± 10	31 ± 11	29 ± 10	21 ± 25	<0.001[d]

Data are shown as mean ± SD

[a] p value from paired t test in entire cohort ($n = 100$) comparing current time point to previous time point. Statistical significance of differences in the change from the previous time point across airway device type, assessed by repeated measures ANOVA, is denoted by superscript. One case with LMA size 5 is excluded

[b,c,d] p value of variation across airway device type in change from previous time point: [b] $p = 0.657$, [c] $p = 0.961$, [d] $p = 0.029$

(Table 2). In the study cohort, we noted no complications from airway management such as difficulties in airway maintenance, laryngospasm, sore throat immediately after the procedure or significant blood indicative of trauma with LMA removal.

Discussion

The current study prospectively evaluated changes in the IP of an LMA or ETT during general anesthesia for EGD examinations. The IP of both airway devices increased during EGD probe insertion and remained elevated while the probe was in place. Given various clinical advantages including ease of placement, the LMA has become the airway of choice for many types of surgical and endoscopic procedures. The LMA airway device was used in the majority of EGD procedures (88%) in our study cohort. Despite its ease of placement and other clinical advantages, concern has been expressed regarding the potential for morbidity due to hyperinflation of the cuff with pressure on the oropharyngeal mucosa. Periglottic and supraglottic structures can be damaged by direct trauma and reduction in blood flow [10, 11]. Sore throats are common following LMA use, being reported in up to 40–50% of patients [10]. Although the LMA does not exert pressure on the mucosa as predictably as an ETT, higher pressures in the LMA cuff may result in airway complications including recurrent laryngeal nerve injury and distortion of pharyngeal anatomy [12]. Current manufacturer recommendations advise against an IP $\geq$60 cmH_2O when using an LMA. Cuff pressures >40 cmH_2O may increase the incidence of sore throat and result in a less effective seal and impaired ventilation [10].

Our clinical observations have suggested that there may be great variability in regard to insertion and inflation techniques for LMA placement. Our routine practice is to remove the LMA from the package and place the partially inflated device without adding or removing air. Following placement, additional air is placed into the cuff as needed to seal the airway. The IP is not routinely monitored. Our intent was not to determine which placement technique was best, but rather to evaluate the effect of EGD probe insertion on the IP of airway devices over a wide range of anesthesia providers and placement techniques.

Manometry has been suggested as one means to ensure an appropriate IP when using an LMA and perhaps decreasing the incidence of issues such as sore throat due to high IP pressures and poor sealing of the airway related to underinflation [10, 13]. Routine use of a manometer does not appear to be feasible or cost effective. These devices are expensive ($300–400 each), need to be cleaned between each patient use, and may be lost or broken in a busy pediatric operating room. Other novel devices include an inflating syringe that allows a color coded or digital readout of the IP pressure or a device that is pre-attached to the LMA [14–16]. Even if the IP is checked following placement, various factors may alter the IP after placement including insertion of an EGD probe as noted in our study [17]. These data suggest that the IP is a dynamic process and therefore some means of continuous pressure monitoring may be needed.

As with the LMA, adverse perioperative effects may be noted with excessively high IP when using an ETT [18]. However, unlike with an LMA, a high IP can directly damage the mucosa by direct trauma or a reduction in blood flow resulting in acute and long-term issues of subglottic edema and even stenosis. Although an ETT was used in a fewer number of patients for EGD placement, as with the LMA, we noted a statistically significant increase in IP following insertion of the EGD probe, thereby demonstrating another dynamic process which may affect the IP of an ETT.

In summary, regardless of whether an LMA or ETT was used, we noted an increase in IP when the EGD probe was placed. The magnitude of the increase was similar for both

the LMA and the ETT. No clinically significant difference was noted based on the age of the patient. One limitation of our current study was that we did not rigorously control the technique for LMA/ETT placement and cuff inflation. However, in the majority of cases, the IP pressure was within the clinically recommended range at baseline. Additionally, we did not perform long-term follow-up to determine the incidence of adverse effects, including sore throat, related to the airway device. However, no patient required hospital admission related to airway problems. We believe that our preliminary study provides initial data for the planning of more robust follow-up studies to explore the relationship between high IP and clinical adverse events. The current study provides additional data to support the fact that the IP of airway devices is a dynamic process that is affected by several factors. Given the potential morbidity related to long-term elevations in the IP of these devices, continuous monitoring of IP may be indicated.

Compliance with ethical standards

Conflict of interest All authors have no conflict of interest.

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