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Communication

Evaluation of Endotracheal Cuff Pressure and Volume of Air for Inflation of CUFF Following Intubation After General Anaesthesia for Elective Surgery

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Abstract: *Background:* Endotracheal intubation is part of general anesthesia. The endotracheal cuff situated near the end of the tube is inflated following successful intubation (above the carina) to secure the airway. A critical function of the endotracheal tube (ETT) cuff during general anesthesia is to seal the airway thus preventing aspiration of pharyngeal contents into the trachea and leaks during positive pressure ventilation. From the literature, we know that excessive cuff pressure decreases tracheal capillary perfusion which has the potential to lead to endothelial necrosis, while insufficient cuff pressure leads to pulmonary aspiration of oro-pharyngeal contents and leads to ventilator-associated pneumonia and pulmonary pneumonitis. *Methodology:* All the patients above the age of 18 years who presented to The Aga Khan University Hospital, Nairobi for elective surgical procedures under general anesthesia and requiring endotracheal intubation for the surgical procedure were included in the audit. Patients were induced and intubated according to routine practice by the attending anesthesiologist and the cuff was subsequently inflated by the anesthetic assistant, anesthesia resident, instructor, or consultant anesthesiologist. Patients were maintained with volatile anesthetic agents or total intravenous anesthesia in a mixture of oxygen and air according to the anesthesiologist's choice. The volume of the air used to inflate the cuff was recorded and the intra-cuff pressure was measured by one of the investigators after securing the endotracheal tube (before positioning the patient) with an aneroid manometer connected to the pilot balloon of the ETT cuff. *Results:* The volume of air used to inflate the endotracheal cuff was in the range of 3ml and 15ml with the mean volume being 7.64 ml, median of 8ml, and mode of 10ml. The resultant cuff pressure ranged between 10 cmH_2O to 110 cmH_2O with a median of 40 ml and mode of 22 ml. Overall 14% of the total patients had intra-cuff pressure of less than normal which is below 20 cmH_2O, 23% of patients had normal cuff pressure between 20 to 30 cmH_2O, and 63% had more than normal pressure which was more than 30 cmH_2O. *Conclusion:* The average volume of air inflated for the endotracheal cuff was 7.64 ml and the cuff pressure was 46.71 cmH_2O. *Recommendations:* The endotracheal tube cuff is inflated under the guidance of a manometer to a target pressure of 20-30 cmH_2O.

Keywords: Endotracheal Intubation, General Anesthesia, Cuff Pressure Measurement, Cuff Volume Assessment

1. Introduction

Tens of patients per day have an endotracheal tube sited by an anaesthesiologist as a part of general anesthesia. This is done to secure the airway after correctly siting the endotracheal tube in the trachea (above the carina) and the cuff, situated near the distal end of the endotracheal tube is inflated via a pilot balloon. A critical function of the endotracheal tube (ETT) cuff during general anesthesia is to seal the airway thus preventing aspiration of pharyngeal contents into the trachea and leaks during positive pressure ventilation. From the literature, we know that excessive cuff pressure decreases tracheal capillary perfusion which has the potential to lead to endothelial necrosis, while insufficient cuff pressure leads to pulmonary aspiration of oro-pharyngeal contents and leads to

ventilator-associated pneumonia and pulmonary pneumonitis [1, 2].

The Cuff pressure of the endotracheal tube must be within a range to minimize the leak around the cuff for the delivery of the preset tidal volume and without compromising the tracheal perfusion. At the same time cuff pressure should be enough to reduce the risk of aspiration of the secretions that accumulate above the cuff. A cuff pressure of 20–30 cm of water is recommended for the prevention of aspiration and ventilator-associated pneumonia [3-5].

Although, the most common method of endotracheal tube cuff pressure (ETCP) assessment after intubation and cuff inflation is pilot balloon palpation, its accuracy is disputed [6-9]. The measurement of ETCP with a manometer is necessary to reduce the rate of complications associated with endotracheal tube cuff pressure [10, 11]. However, in many settings, the manometer may not always be immediately available and these pilot balloon palpation techniques end up being employed instead. Some reports suggested that the experience of anesthesia staff may improve the safety of the palpation technique [12] and some others proposed a negative role for the experience [13].

One of the most common complications of endotracheal intubation is a sore throat. It can result from tracheal ischemia as a result of over-inflation of the cuff with a resultant increased cuff pressure

Manometer use is not part of standard practice in our setting and as such the endotracheal tube cuff is most commonly inflated by the anesthetic assistant after tube placement, the volume of air used being dictated by palpation of the pilot balloon with or without assessing for loss of an audible leak. We thus carried out an audit to assess the amount of air inflated by the anesthetic assistant/resident/consultant and the resultant cuff pressure.

2. Primary Objective

To assess the cuff pressure after endotracheal intubation for elective surgical procedure at The Aga Khan University Hospital, Nairobi after routine endotracheal intubation for general anesthesia.

3. Secondary Objective

To assess the volume of air which was used to inflate the endotracheal tube cuff.

4. Methodology

Ethical approval exemption was obtained from the Aga Khan University Hospital Research and Ethics Committee (IREC) prior to commencing the audit. A waiver of consent was obtained from the IERC because this was an audit of the current practice.

The audit was conducted at Aga Khan University Hospital, Nairobi (AKUH, N). The AKUH, N is a 254-bed private hospital that provides tertiary and secondary level health care services.

All the patients above the age of 18 years who presented to The Aga Khan University Hospital, Nairobi for elective surgical procedures under general anesthesia and requiring endotracheal intubation for the surgical procedure were included in the audit.

Obstetric patients and patients presenting for emergency procedures requiring rapid sequence induction were excluded from this audit.

Patients were induced and intubated according to routine practice by the attending anesthesiologist and the cuff was subsequently inflated by the anesthetic assistant, anesthesia resident, instructor, or consultant anaesthesiologist. Patients were maintained with volatile anesthetic agents or total intravenous anesthesia in a mixture of oxygen and air according to the anesthesiologist's choice. In our setting, Anaesthetic assistants prepare for the intubation and keep a 20 ml syringe ready for inflating the cuff. The same 20 ml syringe was used according to the practice to inflate the endotracheal tube cuff. The volume of the air used to inflate the cuff was also recorded and the intra-cuff pressure was measured by one of the investigators after securing the endotracheal tube (before positioning the patient) by using an aneroid manometer connected to the pilot balloon of the ETT cuff.

For this clinical audit, data were collected from 100 patients following intubation. This was deemed a reasonable sample size and will allow the study to serve as a pilot project to lead to further prospective studies.

The patient's age, weight, and sex were documented. Endotracheal tube size, volume used for cuff inflation, and the person (Anaesthetic assistant / Anaesthesia resident / instructor / consultant) inflating the cuff were recorded. The cuff pressure was measured by one of the investigators after securing the endotracheal tube (before positioning) by using an aneroid manometer connected to the pilot balloon of the ETT cuff.

Data collection started in April 2020 but was interrupted due to the COVID-19 pandemic, completed in November 2021, and analyzed in December 2021.

5. Results

Demographic and anthropometric characteristics of the patients were described below. 32% of the patients were male and the remaining 68% were female patients. The majority of the patients were female as shown from the data. The ages varied from 19 to over 78 years with a mean age of 45.59 years.

The findings of this audit showed that the majority of the participants had a weight of 75 kg. The minimum weight was 53 and the maximum weight was 115.

70.7% (70) of the endotracheal tube (ETT) were size 7.0, with 9.1% being size 6.5 and 20.2 % being size 7.5. Endotracheal tube 7 was the most commonly used tube during this audit followed by 7.5 and 6.5 was the least commonly used tube size.

As mentioned earlier, an Anesthetic Assistant (AA) prepares and inflates the endotracheal cuff immediately after intubation. Based on the data collected, it appears that the healthcare cadre most commonly inflating the ETT (Endotracheal Tube) was the AA (Anesthesiologist Assistant) with a frequency of 82%. They were followed by consultants, who inflated the ETT with a frequency of 12%. The remaining 6% of ETT inflations were performed by residents. Our main objective was to observe the volume of air used to inflate the cuff and measure intra-cuff pressure. According to our audit, the volume of air used to inflate the endotracheal cuff was in the range of 3ml and 15ml with the mean volume being 7.64 ml, median of 8ml, and mode of 10ml. The resultant cuff pressure ranged between 10 cmH_2O to 110 cmH_2O with a median of 40 ml and mode of 22 ml.

Overall 14% of the total patients had intra-cuff pressure of less than normal which is below 20 cmH_2O, 23% of patients had normal cuff pressure between 20 to 30 cmH_2O, and 63% had more than normal pressure which was more than 30 cmH_2O.

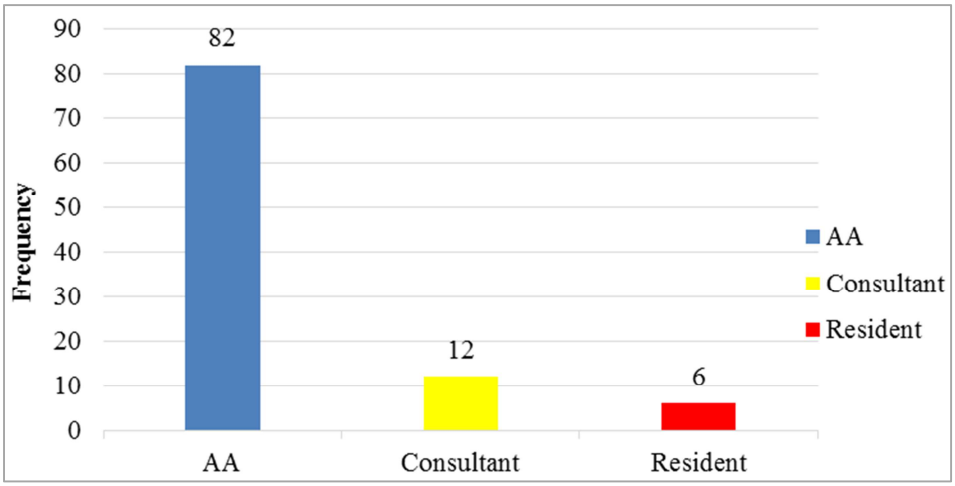

Figure 1. *Person inflating the ETT.*

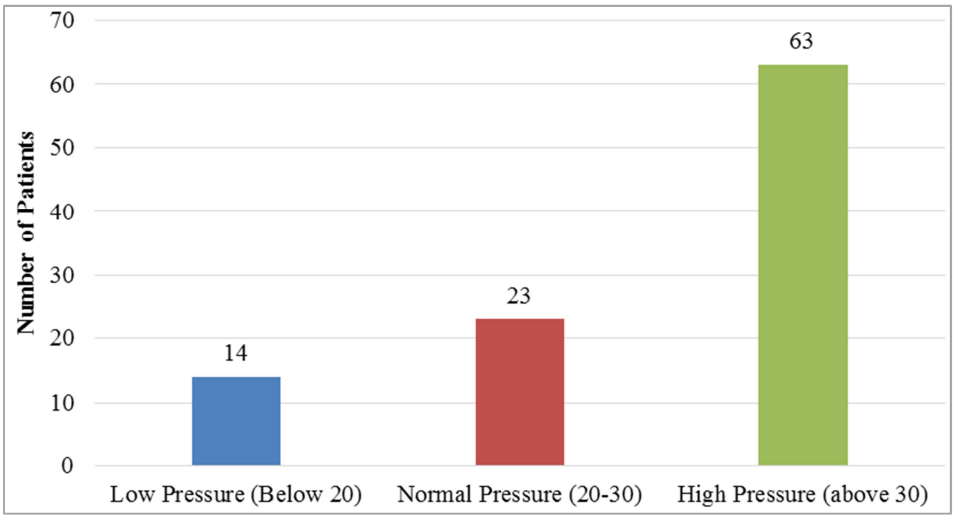

Figure 2. *Number of Patients and Pressure.*

Table 1. *Demographic statistics.*

Demographic Statistics							
		Age	**Weight**	**ETT Size**	**Gender**		**Frequency Sex**
N	Valid	100	97	100		Female	68
	Missing	0	3	0	Valid	Male	32
Mean		44.22	75.263	7.065		Total	100
Median		43.00	75.000	7.000			
Mode		39[a]	70.0[a]	7.0			
Minimum		19	53.0	6.5			
Maximum		78	115.0	7.5			

Table 2. *Volume of air and Intra-Cuff Pressure.*

		Cuff Pressure (CM\H2O)	Volume of Air inflated for Cuff
N	**Valid**	**100**	**100**
	Missing	**0**	**0**
Mean		46.670	7.75
Median		40.000	8.00
Mode		22.0	10
Std. Deviation		27.0607	2.595
Variance		732.284	6.735
Range		100.0	12
Minimum		10.0	3
Maximum		110.0	15
Sum		4667.0	775
Percentiles	25	24.000	5.00
	50	40.000	8.00
	75	68.750	10.00

6. Discussion

The ideal range for tracheal tube cuff pressures is usually taken to be between 20 to 30 cmH2O [8, 17, 22, 23]. This is easily measured with a cuff pressure manometer and should be used for all patients following endotracheal intubation [21]. Endo-tracheal tube cuff pressure is important as shown by a wide range of airway complications that can occur with high or low cuff pressures. High cuff pressures can lead to sore throat and hoarseness [15, 24] (due to tracheal stenosis, necrosis, and even tracheal rupture [7, 25-27]. In such cases, it has been assumed that the cause of this reduced blood flow to the mucous membrane of the trachea is due to the increased cuff pressure on the inner wall of the trachea. This hypothesized ischemic injury leads to healing fibrosis after months or even years [1, 28-30]. On the other hand, lower cuff pressures can increase the risk for aspiration leading to aspiration pneumonitis and pulmonary pneumonia [3, 31]. The cuff pressure should be adequate enough not to impair the mucosal blood flow [14]. It has been shown that continuous lateral wall cuff pressure above 30 cm H2O compromises tracheal wall blood flow, and cuff pressure above 50 cm H2O completely obstructs the tracheal wall blood flow. (1) It has been shown that compromised blood flow for 15 min resulted in superficial endo-tracheal mucosal damage [15]. It has been described that the endotracheal cuff pressure for more than 15 minutes resulted in reduced blood flow to the endotracheal mucosa leading to the destruction of the columnar epithelium and exposure of the basement membrane. [14-16]. The measurement of the endotracheal cuff pressure with a manometer and adjustment of the pressure resulted in a significantly lower incidence of post-intubation complications e.g. sore throat, hoarseness of the voice, and blood-stained oral secretions [17]. The measurement of the endo-tracheal cuff pressure and its adjustment can be a good estimate of the pressure exerted on the tracheal mucosa [18].

On the other side, low cuff pressures can lead to an increased risk for aspiration of gastric contents resulting in aspiration pneumonitis and pulmonary pneumonia. In view of all these complications, the authors recommend that cuff pressure should be measured after all intubations [19].

The range of the recorded cuff pressures according to our audit was 10 to 110 cmH2O with a mean of 46.6 and the majority of the patients, 63% had cuff pressure of more than 30 cmH2O which can cause a post-intubation sore throat and hoarseness of voice. 110 cmH2O is inappropriately high for the endotracheal tube and if it stayed for a longer period it could have caused serious post-intubation complications. We can't conclude these complications since we did not record the duration of the intubation. The only way to prevent possible post-intubation complications is by using a manometer to avoid such high pressures.

Only 23 % of patients had a normal range of pressure between 20-30 and 14% had less than 20 cmH2O. In our audit, we observed that a 20 ml syringe is used for inflating the endotracheal cuff which resulted in pushing a bigger volume of air leading to high cuff pressure. One of the studies showed a linear relationship between the cuff pressure and the volume inflated. Our study also showed a similar relationship except for a few cases of high cuff pressure with small volumes. That could be because we have endotracheal tubes from different companies. According to our audit, the volume of air used ranged from 3 ml to 15 ml with a mean of 7.75 and mostly it was done by the AA (79%) who end up pushing a lot of volume with the 20 ml syringe. Sengupta et al. [20] showed that 2 and 4 ml of air usually produce cuff pressures between 20 and 30 cm H2O, independent of tube size for the same type of tube. Harm et al. recommend that the endotracheal pressure manometer should be used routinely to prevent very high cuff pressure. He also suggested using a 5 ml syringe instead of the traditionally bigger size syringe [21].

7. Conclusion

We observed an average of 7.64 ml of volume for inflation of the endotracheal cuff with highest of 15ml and the average cuff pressure of 46.71 CmH_2O with highest of 100 CmH_2O in our setting. This high pressure can lead to post-operative sore throat.

8. Recommendations

This study's results recommend the use of a small syringe

for cuff inflation and training of AA and other anesthesia personnel regarding endotracheal cuff inflation and measurement technique with a manometer instead of balloon pump palpation. We recommend the endotracheal tube cuff be inflated under the guidance of a manometer to a target pressure of 20-30cmH_2O.

We also recommend more studies to evaluate post-operative sore throat vs the risk of aspiration following monitored versus non-monitored cuff pressure.

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