EDITORIAL

Endotracheal Cuff-pressure Monitoring in ICU: A Standard of Care Yet to be Standardized, and Often Neglected

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Endotracheal intubation is one of the most performed procedures in the ICUs and the inflated cuff of the endotracheal tube provides an air-tight seal to the adjacent tracheal wall thereby facilitating mechanical ventilation and preventing aspiration of sub-glottic secretions. The pressure exerted by the inflated endotracheal cuff needs to be optimal so that potential complications of higher and lower cuff-pressures are prevented. The endotracheal cuff-pressure (ETCP) depends on patient-related factors, environmental and therapeutic settings. The ETCP recorded for a given volume of inflation thus depends on patient characteristics, ET tube size, initial cuff-pressure, and the methods employed for measurement. The factors determining ETCP also include tracheal compliance, cuff material, cuff volume, and the substance used to inflate the cuff. Other factors influencing the pressure include lateral wall pressure, cuff position, varying body positions, duration of endotracheal tube placement, temperature, and use of nitrous oxide. A "supra-optimal" cuff-pressure can cause ischemia of the tracheal mucosa which could progress to inflammation, ulceration, or severe ischemia causing wall damage, post-extubation stridor, subglottic stenosis due to granulation, tracheomalacia, scarring, hoarseness, herniation of cuff balloon, recurrent laryngeal nerve damage or even trachea-oesophageal fistula, trachea-carotid artery erosion, laryngeal stenosis or tracheal rupture; whereas a "sub-optimal" pressure could promote aspiration of sub-glottic contents resulting in ventilator-associated pneumonia and unwarranted extubations. There is little consensus regarding the optimal range of ETCP though most clinicians keep the cuff-pressure between 20 and 30 cm H_2O.[1]

In this issue of IJCCM, Olendrila Roy et al.[2] have published a prospective observational study on 31 intubated critically ill patients depicting the variation in ETCPs with positional changes in the 16 most employed body positions they were using for routine nursing care of critically ill. Statistically significant differences in ETCP were detected during neck positions of ante-flexion, hyper-extension, left lateral flexion, right lateral flexion, left lateral rotation, and right lateral rotation, 10° recumbent position, supine Trendelenburg position, and right lateral 30–45° positions. Maximum increase in ETCP was seen during ante-flexion of the neck (31 ± 4.5; 22–42 cm H_2O). Of the 492 cuff-pressure measurements 10.88% were higher than 30 cm H_2O, and 0.8% were less than 20 cm H_2O. The authors highlight the importance of cuff-pressure monitoring after each position change to prevent potential complications of cuff-pressures kept beyond the acceptable range.

Apart from the small sample size, another major limitation of the above study is that cuff-pressures were not measured over time though cuff-pressures are often expected to decrease over a period. Sole et al. documented that the change in ETCP following a change in body positions was often transient lasting for about 15 minutes.[3,4] Interestingly, the study by Olendrila Roy et al. did not show any effect of patient-related factors on ETCP likely due to the small sample size. Due to substantial within-patient variability of the measurements, the investigators of this study also failed to predict which patient would be having high cuff-pressure in a particular posture. Lizy C et al. published a similar study in 2014 on 12 intubated patients and noticed very similar findings.[5] In that study, among a total of 192 cuff-pressure measurements, 40.6% exceeded 30 cm H_2O and none were <20 cm H_2O. It should be remembered that a lower cuff-pressure even for a very short period (a few seconds to a few minutes) could significantly predispose the patient to micro aspiration though a higher cuff-pressure is expected to take more time (usually many minutes to few hours) to initiate ischemic changes on tracheal mucosa. Hence the risk of aspiration remains significantly low with changes in body positions based on the above studies. We need to conduct further large well-designed studies to strengthen the conclusion. The variation in endotracheal pressure measurements using conical cuff vs other cuff models also needs future evaluation.

There is a perceived global laxity in the implementation of ETCP monitoring in ICUs which could be due to many reasons including lack of adequate awareness of the need for monitoring, lack of adequate conviction for the necessity for regular measurements, increased work burden imposed on health care workers for frequent measurements and documentation, non-availability of appropriate equipment at bed side, availability of simpler (though unsupported by scientific data) options to assess the cuff-pressure, paucity of institutional, local, national or international guidelines with laxity in implementation even if available, and possible rarity of complications observed even with the ongoing lax practice. The commonly used method of assessing ETCP by finger palpation of pilot balloon results not only in overinflation of the endotracheal

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cuff but also in increased incidence of cough. Some authors believe that many complications related to ETCP manifest weeks or months after ICU discharge which makes the ICU staff less sensitized to such potential complications.

There is a clear shortage of regional, national, or international guidelines defining the "optimal" ETCPs, the frequency of cuff-pressure monitoring, and the methods to be employed for the same.[1] The "safe" cuff-pressure range described by researchers often varies between 19 and 40 cm H_2O.[6] Few studies have noted increased complications when the cuff-pressure is below 20 cm H_2O, with another study observing a 4 times increased risk for ventilator-associated pneumonia in a similar pressure settings.[7–9] Seegobin RD and van Hasselt GL. published two studies almost 4 decades ago suggesting that ETCP exceeding 30 cm H_2O may compromise local tracheal mucosal blood flow, especially in the anterolateral wall.[10,11] The lack of clear consensus on optimal intra-cuff-pressure could be because the available data is predominantly based on animal experiments wherein there could be gross variations not only in attaining pressure endpoints but also in the impact of local pressure on microcirculation depending on the experimented animals.[12–14] One also needs to be aware of the evolution of different modifications of endotracheal cuffs (varying size, shape, design, thickness, material, texture, etc.) in the past 2 decades which could have an impact not only on the elastance of the cuff but also on the impact of the cuff-pressure on local tracheal microcirculation. Though most clinicians keep the ETCP between 20 and 30 cm H_2O, it is high time that well-designed studies are conducted to compare the clinical outcomes of different cuff-pressures in homo-heterogenous population characteristics thereby trying to narrow down the "optimal" range and help to formulate a clear-cut guideline.

Frequency of measurement is another grey area with few people never attempting to measure the cuff-pressure, and the remaining at widely variable intervals. The study by Olendrila Roy et al. emphasizes the need for frequent measurement of ETCP with each change in position. A single-center prospective study involving 305 subjects regarding frequent vs infrequent measuring of ETCP did not show any identifiable clinical benefit between the two approaches.[15] Moreover, manual measurement of cuff-pressure has been noted to be associated with loss of pressure, and fluid leak around the cuff.[16] There are almost 10 different methods currently available to measure ETCP and the accuracy of measurements varies between methods/devices.[17] Continuous ETCP measurement by a transducer or an automatic cuff-pressure control device appears to be most appealing at this stage avoiding discrete measurements thereby also reducing workload on health care staff. The implementation of the transducer method is challenged by logistic and cost-related issues. The automatic pressure control devices are promising, but different devices have shown varying efficacy in maintaining the cuff-pressure within the optimal range. Moreover, the impact on the prevention of ventilator-associated pneumonia also varied among the devices indicating the need for further research and validation in this regard. It should be noted that the evidence-based 2022 update on strategies to prevent ventilator-associated pneumonia by the Society for Health Care Epidemiology (SHEA) and the Infectious Disease Society of America (IDSA) recommends against frequent ETCP monitoring or the use of automatic cuff-pressure devices.[18]

Real-time visualization of sub-glottic areas with fiber-optic micro-gadgets coupled with utilization of artificial intelligence/ machine learning to monitor the local tracheal microcirculation around the cuff may be the next step towards further innovation in coming decades.

To conclude, continuous (uninterrupted) measurement and monitoring of ETCP to keep it within the optimal range appears to be the way to go forward as supported by current observations. However, there is still an ongoing lack of clarity among clinicians regarding the need for cuff-pressure monitoring, optimal pressure range, frequency of monitoring and the ideal method/devices to be employed to achieve favorable clinical outcomes. We need further well-designed studies to clear the current fog pertaining to ETCP monitoring.

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