Section: Anaesthesiology

Original Research Article

ENDOTRACHEAL TUBE CUFF PRESSURE MONITORING IN ICU- MANOMETER VS CONVENTIONAL METHOD

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Received *: 20/06/2026*
Received in revised form *: 11/07/2026*
Accepted *: 14/07/2026*

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DOI: 10.70034/ijmedph.2026.3.94

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (3); 575-580

ABSTRACT

Background: The ET Tube cuff ensures a tight seal within the subglottic tracheal structures and promotes effective mechanical ventilation. Maintenance of an adequate intracuff pressure is important to facilitate effective mechanical ventilation and to prevent complications of under inflation or over inflation of the cuff. **Objective:** to measure the ET tube cuff pressure and its variation in comparison with conventional method of cuff inflation and using a pressure manometer with regard to incidence of variation in cuff pressure, under inflation and over inflation.

Materials and Methods: This study was conducted in 80 adult patients aged above 18 years who were admitted to ICU on mechanical ventilation. Patients were randomized into 2 groups of 40 each:

- Group C - cuff inflated by conventional method.
- Group PM - cuff inflated by pressure manometer.

The cuff pressures were monitored over a period of 48 hours with 8th hourly interval. Under inflation of ET tube cuff is defined as cuff pressure less than 20 cm H2O and over inflation of ET cuff is defined as cuff pressure more than 30 cm H2O.

Results: The study groups were categorized into low (<20cms H2O), safe (20-30cms H2O) and high cuff pressure (>30cms H2O) at all the time intervals. Our study found that the cuff pressure measured at different time intervals were statistically significant. The cuff pressure observed was in the safe range in the Group PM, at each interval. On the contrary, the cuff pressure of the patients in the Group C, was at a high pressure range.

Conclusion: Routine use of cuff pressure manometer at regular intervals helps maintain cuff pressure at a safe range and prevents abnormal variations in mechanically ventilated patients.

Keywords: Cuff Pressure; Endotracheal Tube; Measurement; ICU; Conventional Method; Cuff Pressure Manometer.

INTRODUCTION

ETT are devices used to secure the airway for providing general anaesthesia and for mechanical ventilation. It constitutes a routine part in operation theatre and critical care. It protects the patients airway from aspiration of gastric contents, facilitates positive pressure ventilation during anaesthesia, in the post anaesthesia care unit (PACU) and in the Intensive Care Unit (ICU).1

The various functions of ET tubes are as follows: Minimizing aspiration, Isolates the lung, allows provision of clear surgical field during general anaesthesia, monitors laryngeal nerve damage during surgery, prevents airway fires during laser surgery, useful for administering medications.1

Polyvinyl chloride is the material used in designing most modern ET tubes. The ET tubes have a high volume low pressure cuff which adjusts to the shape of trachea. The cuffs are inflated most of the time with air to create an air tight seal. The cuff pressures

has to be maintained between 20 to 30 cm H2O, to minimize air leaks, loss of tidal volume due to underfilling of the cuff, to prevent injury/ischemia of the tracheal mucosa due to overfilling of the cuff.2 Cuff pressure measurements may deviate from the normal values by about 20 to 30 percent.3

The various methods of measuring cuff pressure are: minimal leak technique, minimal occlusive volume technique, finger palpation technique, predetermined volume technique and direct intra cuff pressure monitoring by pressure manometer.2,4,5,6,7 Though automatic cuff pressure control devices for artificial airways are available, there is a lack of standards /data to support their use.8

If the cuff pressure is less than 20cm of H2O, it can result in complications like: air leak, inadequate tidal volume, microaspiration and ventilator associated pneumonia, which can be severe and irreparable.9 If the cuff pressure is more than 30cms H2O this can result in ischemia, necrosis, stenosis, tracheal rupture due to the pressure on the tracheal mucosa.7,10, These complications are due to chronic inflammation and laryngeal fibrosis. Cases of airway obstruction and laryngeal edema after extubation have also been reported.11 A cuff pressure of more than 30 cms of water for 15 minutes can induce histological evidence of tracheal mucosal lesions.12 Hence monitoring of the ET tube cuff pressure is necessary in anaesthesia practice.

MATERIALS AND METHODS

The study was conducted on adults aged above 18 years admitted to the ICU in Chigateri General Hospital and Bapuji Hospital attached to JJM Medical College, Davangere. Duration of the study was September 2019 to September 2021

Inclusion Criteria

- Adults above 18 years of age admitted to ICU on mechanical ventilation
- Both sex

Exclusion Criteria

- Patients having contraindication for semi recumbent position
- Admitted to ICU with prior tracheostomy
- Patients with airway deformities

Methodology

A prospective randomized study was conducted on 80 mechanically ventilated patients who were either intubated in casualty or on arrival to intensive care unit in Bapuji hospital and Chigateri hospital Davangere, Karnataka.

After obtaining institutional ethical committee clearance and written informed consent from the patient's caregivers, 80 patients were randomly allocated into either Group C or Group PM by a computer generated randomization table.

Patients allocated to group C had their ET tube cuff inflated by a 10ml syringe using air. The cuff pressure was measured using a manometer and this was recorded as P0. If P0 was not within the normal range of 20-30 cm H2O, the cuff was deflated and re-inflated till the appropriate pressure is attained using the manometer. Thereafter the pressures were monitored every 8th hourly (P1,P2,P3) for a period of 48 hours.

Patients allocated to group PM had their ET tube cuff inflated with the pressure manometer between the range of 20-30 cm H2O and this was recorded as P0. Thereafter the pressures were monitored every 8th hourly for a period of 48 hours (P1,P2,P3).

The ET tube cuff was set to be underinflated when the cuff pressure was less than 20cms H2O. The ET tube cuff was set to be over inflated when the cuff pressure was more than 30cms H2O.

Statistical Analysis: The information collected regarding all the selected cases were recorded in a master chart. Continuous data was represented in terms of means and standard deviations. Categorical data was represented in the form of frequencies and proportions. Graphical representation of the data was done using Microsoft Excel and Microsoft Word.

Statistical Software SPSS version 22 (IBM SPSS Statistics, Somers NY, USA) was used to analyse the data. Appropriate tests of significance was used based on the type of data. P-value (Probability that the result is true) of <0.05 was considered as statistically significant after assuming all the rules of statistical tests.

RESULTS

The most common age group in the study was more than 60 years as a whole, and even in both the groups, which constitutes about 42.5% and 37.5% in the Group C and Group PM respectively. The next common age groups was 45-60 years, followed by 31-45 years and 18-30 years. The mean age of the participants in the Group C was 52.40 years with the standard deviation of around ±14.77 years. This was almost closer to the Group PM where the mean age was 53.02 years with the standard deviation of around ±15.36 years.

In the study, majority of the participants were males as a whole, and even in case of each group, which accounted for about 70.0% and 72.5% in the Group C and Group PM respectively. Remaining 30.0% and 27.5% in the Group C and Group PM respectively were females. On analysis, there was no statistical significant difference between the groups.

ASA GRADING DISTRIBUTION

Table 1: Distribution of the participants based on ASA grading in both the groups

ASA Grading	Group C	Group PM
Grade III	11 (27.5%)	12 (30.0%)
Grade IV	18 (45.0%)	15 (37.5%)
Grade V	11 (27.5%)	13 (32.5%)
Total	**40 (100.0%)**	**40 (100.0%)**
p-value	**0.785**	

None of the participants in the study belonged to ASA Grade I and II. Only those gradedas III and more were present in the study, and among them majority were Grade IV, as a wholeand even in both the groups, which constitutes about 45.0% and 37.5% in the Group C and Group PM respectively. On analysis, there was no statistical significant difference between the groups as shown in table 1.

ENDOTRACHEAL TUBE SIZE DISTRIBUTION

Table 2: Distribution of the participants based on the size of endotracheal tube in boththe groups

Size of ET Tube	Group C	Group PM
6.5 mm	4 (10.0%)	3 (7.5%)
7.0 mm	6 (15.0%)	5 (12.5%)
7.5 mm	9 (22.5%)	8 (20.0%)
8.0 mm	15 (37.5%)	17 (42.5%)
8.5 mm	6 (15.0%)	7 (17.5%)
Total	**40 (100.0%)**	**40 (100.0%)**
Mean ± SD (in mm)	**7.66 ± 0.60**	**7.75 ± 0.57**
p-value	**0.974**	

In the study, the participants were observed with respect to the size of the endotrachealtube used. Accordingly, the endotracheal tube of size 8.0 mm was used in majority i.e., about 37.5% and 42.5% of the participants in the Group C and Group PM respectively. The next commonly used size was 7.5 mm in both the groups as shown in table 2.

1) MEAN CUFF PRESSURE DISTRIBUTION

Table 3: Comparison of cuff pressure in both the groups at different intervals of time

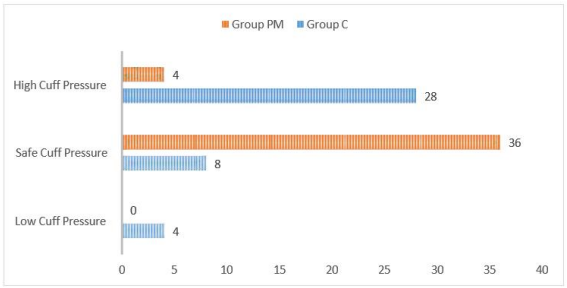
Intervals between Cuff Pressure readings	Group C Mean ± SD (in cm H_2O)	Group PM Mean ± SD (in cm H_2O)	p-value
At 0 hours	35.90 ± 9.36	29.97 ± 1.20	<0.001
At 8 hours	38.25 ± 6.34	28.24 ± 1.18	<0.001
At 16 hours	35.27 ± 6.24	26.82 ± 1.21	<0.001
At 24 hours	33.25 ± 5.99	25.53 ± 1.17	<0.001
At 32 hours	31.75 ± 5.76	24.07 ± 1.43	<0.001
At 40 hours	30.12 ± 5.97	22.75 ± 1.51	<0.001
At 48 hours	27.78 ± 5.81	21.18 ± 1.55	<0.001

In the study, the variation in cuff pressure was compared in both the groups every 8 hours, from the beginning of the intervention to 48 hours which showed statistically significant relation in all the time frames. This can be clearly distinguished as the mean cuff pressure with the standard deviations was statistically more in the Group C, compared to that in the Group PM, during each interval. This shows that the highest and lowest mean values of cuff pressure in Group C is significantly higher than the mean values in Group PM as shown in table 3.

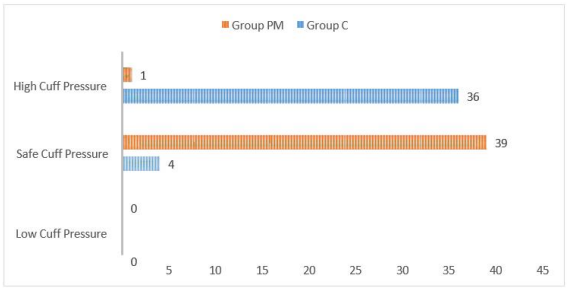
2) CUFF PRESSURE VARIATION IN BOTH GROUPS AT DIFFERENT TIME INTERVALS

Table 4: Distribution of the participants based on the cuff pressure in both the groups

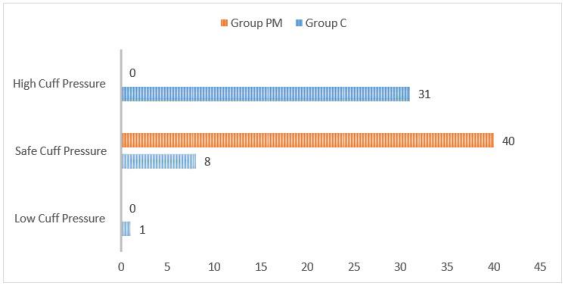
Intervals between Cuff Pressure readings		Low Cuff Pressure (<20 cm H_2O)	Safe Cuff Pressure (20-30 cm H_2O)	High Cuff Pressure (>30 cm H_2O)	p-value
At 0 hours	Group C	4 (10.0%)	8 (20.0%)	28 (70.0%)	<0.001
	Group PM	0 (0.0%)	36 (90.0%)	4 (10.0%)	
At 8 hours	Group C	0 (0.0%)	4 (10.0%)	36 (90.0%)	<0.001
	Group PM	0 (0.0%)	39 (97.5%)	1 (2.5%)	
At 16 hours	Group C	1 (2.5%)	8 (20.0%)	31 (77.5%)	<0.001
	Group PM	0 (0.0%)	40 (100.0%)	0 (0.0%)	
At 24 hours	Group C	1 (2.5%)	12 (30.0%)	27 (67.5%)	<0.001
	Group PM	0 (0.0%)	40 (100.0%)	0 (0.0%)	
At 32 hours	Group C	1 (2.5%)	17 (42.5%)	22 (55.5%)	<0.001
	Group PM	0 (0.0%)	40 (100.0%)	0 (0.0%)	
At 40 hours	Group C	2 (5.0%)	16 (40.0%)	22 (55.5%)	<0.001
	Group PM	4 (10.0%)	36 (90.0%)	0 (0.0%)	
At 48 hours	Group C	5 (12.5%)	20 (50.0%)	15 (37.5%)	<0.001
	Group PM	12 (30.0%)	28 (70.0%)	0 (0.0%)	



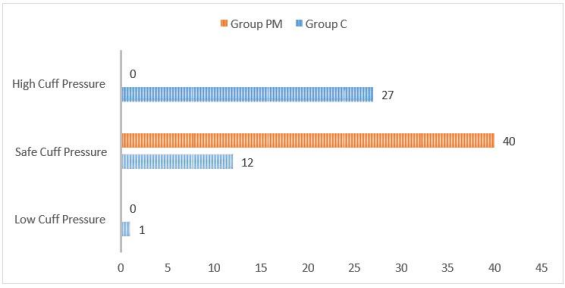
Graph 1: Distribution of the participants based on the cuff pressure at 0 hours in both the groups



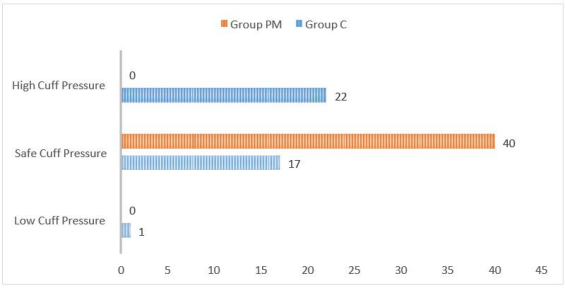
Graph 2: Distribution of the participants based on the cuff pressure at 8 hours in both the groups



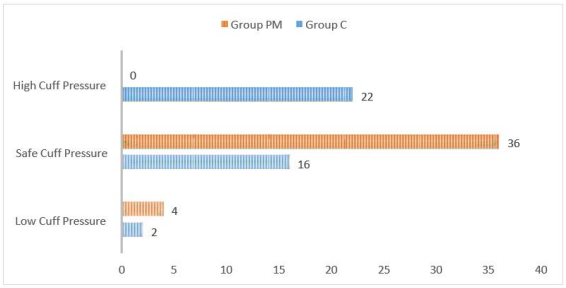
Graph 3: Distribution of the participants based on the cuff pressure at 16 hours in both the groups



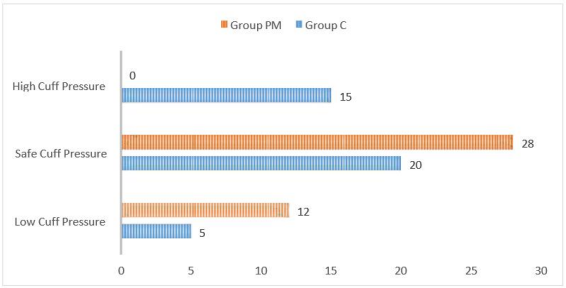
Graph4: Distribution of the participants based on the cuff pressure at 24 hours in both the groups



Graph 5: Distribution of the participants based on the cuff pressure at 32 hours in both the groups



Graph 6: Distribution of the participants based on the cuff pressure at 40 hours in both the groups



Graph 7: Distribution of the participants based on the cuff pressure at 48 hours in both the groups

The study groups were categorized into low (<20cms H2O), safe (20-30cms H2O) and high cuff pressure (>30cms H2O) at all the time intervals. On categorizing the cuff pressure into lower, safer and higher ranges, we found that the cuff pressure measured at different time intervals were statistically significant. The cuff pressure observed was in the safe range in the Group PM, at each interval. On the contrary, the cuff pressure of the patients in the Group C, was at a high pressure range as shown in table 4 and graph 1-7. The findings were statistically significant with p value<0.001S.

DISCUSSION

Endotracheal tube cuff pressure monitoring is an essential component of anaesthesia care whether in the OT, PACU or ICU care. The ET tube cuff pressure should be in such a range that it provides the prescribed tidal volume for mechanical ventilation, decreases the risk of micro-aspiration and at the same time does not compromise the tracheal mucosal perfusion pressure. The recommended safe cuff pressure that prevents aspiration and ventilator associated pneumonia is in the range of 20-30cm H2O.[13,14] Aspiration and ineffective ventilation can result from low cuff pressures.[15]

Airway complications like epithelial necrosis{with fistula formation}, tracheomalacia, laryngeal inflammation and stenosis have been reported with high cuff pressures.[16] The 2011 guidelines from the American Society of Anesthesiologists recommend endotracheal cuff pressure monitoring by a manometer immediately after intubation and throughout the course of mechanical ventilation.[17] All these said complications can be avoided in day

to day practice by maintaining optimal cuff pressures in the range of 20-30 cms H2O. The endotracheal tubes are selected based on standard formula. Ideal tube in average adult female is 7.5mm internal diameter and adult males is 8.5mm internal diameter. However there is great variation in sizes and shapes of trachea in adults. A linear relationship exists between the measured cuff pressure and the volume of air retrieved from the cuff. Sengupta et al,[18] in their study showed that a cuff pressure of 20-30cms of water is produced by injecting a volume of air of 2-4 ml. This is independent of the tube size.

In our study we have used ET tubes of sizes of 6.5mm ID -8.5 mm ID. In all patients belonging to group C the cuff was inflated with a 10ml syringe.[19] in their study observed that a higher cuff pressure was measured when a 20ml syringe was used as compared to 10ml syringe 37.73 ± 4.23 versus 40.74 ± 5.01 (86% vs. 52%, P = 0.013). Harm et al20 in their study observed that the ET tube cuff pressure in trauma patients intubated before aero-medical transport were too high. They suggested the use of a 5ml syringe instead of a traditional bigger size syringe.

The level of knowledge and practice guidelines of ET tube cuff pressure monitoring plays an important role in providing day to day anaesthesia care.[16] found that out of 150 participants, 66 (44.0%) were doctors. Only 46 (30.67%) participants had prior knowledge about ETT cuff manometer and 110 (73.33%) had never used a manometer.

In our study we have measured the cuff pressure at 8th hourly interval upto 48 hours. We found that there is a statistically significant relation in all time frames. The frequency of measuring the ET tube cuff pressure, whether in the ICU or OT, has wide variations around the world.

Sole et al,[21] has made a recommendation of measuring ET tube cuff pressure at least 3 times a day owing to the significant variability in the cuff pressure value during the day. In our study we noted that the mean values of the cuff pressure in Group C was significantly higher than the mean values in Group PM at all time intervals.

Nseir S et al,[22] has also suggested 8th hourly measurement in their study. Danielis et al,[23] observed varied cuff pressure recordings at different time intervals. They recommended continuous monitoring of ET tube cuff pressure.

Motoyama et al,[24] have recommended intracuff pressure measurement every 8-24 hours as the air inside the cuff may escape from the cuff surface or through the pilot balloon valve.[25] Asai S and colleagues have cautioned that the intracuff pressure may decrease due to gas escaping from the cuff with repeated connecting and reconnecting with the cuff inflator to the pillot balloon. This may result in loss of adequate intracuff pressure.[2] In their prospective clinical trial on frequent vs infrequent monitoring of ET tube cuff pressures concluded that frequent cuff pressure monitoring was not associated with any clinical benefit.

We classified both the groups in our study into three classes based on cuff pressure: low (<20cms H2O), safe (20-30cms H2O) and high cuff pressure (>30cms H2O) at all the time intervals. Our statistics showed that majority of pressure in Group C was in the high cuff pressure range whereas majority of Group PM lay in the safe cuff pressure range.

Nseir S, Brisson H et al,[26] confirmed that cuff pressure <20 cmH2O was associated with an increased risk of aspiration, and the incidence of tracheal stenosis as common with cuff pressures >30 cmH2O. Despite these best evidence majority of the ICU's in NHSL were neither equipped with local protocol or a dedicated space in the daily nursing charts for regular documentation of CPM.[27]

Wujtewicz et al,[28] found in an audit of 107 ITU patients that the over inflation is more frequent than under inflation of the ETT cuff. Our study showed that Group C had a higher incidence of over inflation, with respect to Group PM.

21 In their study on adult ICU patients, measured cuff pressure using an analogue manometer and found that 74% patients had suboptimal cuff pressure recordings while 30% of them had alarmingly high pressures.

CONCLUSION

Routine use of cuff pressure manometer to inflate the ET tube cuff and monitor the same at regular intervals maintains the pressure at normal range of 20-30 cmH2O. The cuff pressure manometer reduces the complications related to ET tube cuff and abnormal variations in the cuff pressure in the long term mechanically ventilated patients in the ICU.

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