ISSN: **2518-8631**

# COMPARISON OF TWO LEVELS OF NEGATIVE PRESSURE IN OPEN TRACHEAL SUCTIONING ON OUTCOME OF CARE METRICS AMONG ADULT PATIENTS IN CRITICAL CARE UNIT IN A KENYAN HOSPITAL: A RANDOMIZED CONTROLLED TRIAL

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**Abstract**

**Background:** Tracheal Tube Suctioning is a necessary procedure on intubated patients receiving mechanical ventilation that optimizes oxygenation and ventilation. Unfortunately, there are differences in opinion and practice on the most suitable suction pressure. The objective of this study was to compare 180mmHg and 100mmHg negative suction pressures in open tracheal tube suctioning among adult patients in Intensive Care Unit at Machakos Level Five Hospital on outcome of care metrics.

**Methods:** This study was a randomized controlled trial involving 76 participants randomly allocated to either 180mmHg or to 100mmHg negative suction groups to establish any differences in outcome of care metrics. Independent t test or its non-parametric equivalent was used to determine the differences in the duration of: mechanical ventilation, tracheal tube and stay in the Intensive Care Unit; and Chi-square test was used to determine homogeneity and mortality between the groups.

**Results:** Average duration of mechanical ventilation was 3.6 days, duration of tracheal tube of 4.7 days, length of stay in the Intensive Care Unit of 5.7 days and overall mortality of 54%. There was no significant difference between the two groups on length of mechanical ventilation, duration of tracheal tube, length of stay in ICU and mortality in ICU (p=0.328, p=0.411, p=0.839, and p=0.162, respectively).

**Conclusion:** The two negative suction pressures tested did not differ on critical care outcome metrics though inherently different in their suction potential with 180mmHg being more powerful.

**Keywords:** *suction, pressure, Intensive Care Unit, mechanical ventilation,*

## INTRODUCTION

Tracheal intubation among critically ill patients not only facilitates oxygenation and ventilation but also creates a pathway for secretions removal to clear the airway. The physical presence of these artificial tubes together with depressed cough reflex among the critically ill patients are the very reasons for requiring an efficient Tracheal Tube Suctioning (TTS) (Guillon et al., 2018). This TTS is associated with complications such as desaturation, hemodynamic instability, Ventilator-Associated Events (VAE) or even Ventilator Associated Pneumonia (VAP), tracheal bleeding, pain, anxiety and increased intra-cranial pressure (Mohammed, 2017; Yazdannik et al., 2019). The amount of suction pressure used determines the incidence and intensity of these manifestations (Yousefi et al., 2014). These complications prolong mechanical ventilation days, length of stay in the Intensive Care Unit (ICU) and in the hospital (Koulenti et al., 2017).

Drippling of secretions from the mouth down to the lower respiratory airways is the likely cause of bacterial colonization posing a risk for Ventilator Associated Pneumonia, which is still one of the commonest causes of morbidity and mortality in the critical care unit (Pouly et al., 2020; Papazian et al., 2020).

In Europe, the VAP rate is 18.3 per 1000 Ventilator days with a mortality of 19.6%. It increases ICU mortality by 6% and leads to elongated mechanical ventilation and hospital days (Koulenti et al., 2017). In Kenya, a study done at KNH by Siikwa & Chokwe (2015), found VAP incident rate of 20.6%. Mortality in the Critical Care Units in Kenya is approximately 38.6% (Lalani et al.,2018; Ongondi et al., 2016). This is much higher compared to the world-wide level of 16.2% (Vincent et al., 2014; Weissman, 2020). The reasons for this difference are largely unknown but tracheal tube suctioning being an invasive procedure is suspect.

Low tracheal suction pressures in adults are likely to have higher incidences of lower respiratory system infections due to many catheters passes and inadequate secretion removal, creating a possibility of leakage downwards leading to Infection-related Ventilator Associated Complication (IVAC) or Ventilator Associated Pneumonia (VAP) but on the other hand, low suction pressures lead to more stable respiratory and hemodynamic indices (Rajakumari et al., 2020). IVAC and VAP result in prolonged mechanical ventilation days and length of stay in Intensive Care Unit (ICU) and hospital. Further, IVAC is associated with two-fold increase in mortality (Dexter & Scott, 2019; Klompas et al., 2011; Sole et al., 2018).

On the contrary, higher suction pressures cause more physiological instability (Yousefi et al., 2014). Suctioning at negative pressures above 150mmHg is associated with more adverse effects (Gilder et al., 2018; Hess et al., 2011; Yousefi et al., 2014). But some studies have shown that suction pressures above 150mmHg (including up to 300mmHg) are safe and effective (Hahn, 2010; Maras et al., 2020). According to Blakeman et al. (2022) suctioning beyond 200mmHg is increasingly associated with unwanted effects. The Nursing Council of Kenya, in her manual of clinical procedures in nursing and midwifery directed use of a suction level of 80-120mmHg in adults (NCK, 2019), a level that practitioners have felt ineffective due to its slowness. The choice of suitable suction pressure should therefore consider the risk of complications that may prolong critical care outcome metrics i.e. the length of mechanical ventilation, length of stay in ICU, length of tracheal intubation and mortality in ICU.

In view of the above concern, this study was designed to compare 180mmHg and 100mmHg suction levels on critical care outcome metrics. The specific objectives were: To determine the effects of negative pressures at 100mmHg and 180mmHg on patient care outcomes in open tracheal tube suctioning and to compare patient outcome metrics between those on negative pressures at 100mmHg and 180mmhg in open tracheal tube suctioning among adult mechanically ventilated patients.

The hypotheses for the study were:

$H_o$: There is no significant difference in critical care outcomes between the 100mmHg tracheal suction group and 180mmHg tracheal suction group among adult mechanically ventilated patients'
$H_1$: There is a significant difference in critical care outcomes between the 100mmHg tracheal suction group and 180mmHg tracheal suction group among adult mechanically ventilated patients.

## METHODS

This was a randomized controlled trial (RCT) study in which the 180mmHg suction level was the experimental suction pressure while the 100mmHg suction level was the control suction pressure.
The study was conducted at Machakos County Level Five Hospital Intensive Care Unit. The hospital is ranked position six among county hospitals in Kenya

in terms of ICU bed capacity and additionally, it has an elaborate prehospital care service (Barasa et all., 2020).

Seventy-six *(*76) ICU intubated and mechanically ventilated patients, 18 years and above were recruited from a total of 137 patients admitted into the ICU from November 2023 to October 2024.

The sample size calculation was done as follows: of sample size (Graeme et al., 2018; Vickerstaff et al., 2019; Walters et al. 2019).

$$n = \frac{2\sigma^2(Z1-\alpha/2 + Z1-\beta)^2}{(\delta)^2}$$

Out of literature reviewed, the smallest level of $\delta$ = 6.8 and the largest of $\sigma$ = 10.5 were adopted. Other variables of the formula are as tabulated below:

Table 1: Sample size formula indices

| Parameter | Value |
|---|---|
| $\alpha$ | 0.05 |
| $(Z1-\alpha/2)$ | 1.960 |
| $\beta$ | 0.2 |
| $(Z1-\beta)$ | 0.842 |

$n = 2 \times 10.5^2 \times (1.960 + 0.842)^2/6.8^2$
$n = 2 \times 10.5^2 \times (2.802)^2/6.8^2$
$n = 2 \times 110.25 \times 7.8512/46.24$
$n = 37.44$
n =38 (per group of the study)

Sampling was a two-step process. Participants were placed into diagnostic categories (strata) and then allocated to study groups using simple random sampling. 39 participants were randomly allocated to Experimental group while 37 participants were randomly allocated to the Control group (block randomization).

The inclusion criteria were Admission into the ICU, Mechanical ventilation through a tracheal tube and Age ≥ 18 years old. While exclusion criteria were Non-invasive ventilation, confirmed chest infection, intubated before arrival to hospital, Known blood coagulation disease and Patient with/during cardiac arrest.

The Independent variable was Suctioning at either 180mmHg (Experimental-Expt) or 100mmHg (Control-Ctrl). Dependent variables were Length of mechanical ventilation, tracheal tube, stay in ICU, and mortality. Confounding Variables were Sex, Age, Smoking status, Tracheal Tube Size, Daily Fluid balance, Suction catheter size, Sedation and Mode of mechanical ventilation. The effects of these variables were mitigated by randomization. Comparison between the groups in respect to these extraneous variables was done using Chi-square.

The study was approved by Jomo Kenyatta University Scientific and Ethics Review Committee granted permission to undertake the study (Re:JKU/ISERC/02316/0914 & JKU/2/4/896B). The National Commission for Science, Technology and Innovation issued study permit (Re: NACOSTI/P/23/28497 & NACOSTI/P/24/37702). The Machakos County government provided authority to conduct the study at the County Level Five Hospital (Re: MKS/DHES/RSCH/VOL1/317 & MKS/DMS/RESEARCH APPROVALS/2024/30). Individual participants or their guardians provided informed consent that was documented.

Data on socio-demography, patient assessment, days of mechanical ventilation, days in ICU, days on tracheal tube and death or discharge was obtained and documented on a tool that had been prepared by the researcher from the literature reviewed and validated by experts (critical care physician & nurses, anaesthesiologists, medical statistician at Defence Forces Memorial Hospital) and subsequently subjected validity testing. The Content Validity Index was 0.88. It was a double-blind study where the participants and the person conducting suctioning did not know the suction grouping of the patient. The

chief investigator compiled data on duration of mechanical ventilation, duration of tracheal tube and length of stay in ICU upon patients' discharge or death for all the participants.

Data was sorted out, cleaned and entered IBM SPSS software version 26 for analysis. Descriptive and inferential statistics were calculated. Independent t-test or its non-parametric equivalent was used to compare the two groups quantitative confounding variables and between the two groups' metric variables. Chi-square test was used to determine homogeneity of groups categorical variables and for comparison of mortality. Alpha level of 0.05 was chosen

## RESULTS

*Demographics:*
General: There were 41 male (53.9%) and 35 female (46.0%) subjects, with a mean age of 41.47 years (range 18-96 years).

Table 2:Within group demographics

| ITEM | Expt (180mmHg) | Ctrl (100mmHg) |
|---|---|---|
| Age | $\bar{x}$=40.51, SD=17.81, Mdn=35.00, IQR=5.05 | $\bar{x}$=42.43, SD=17.63, Mdn=39.00, IQR=30.00 |
| Sex | Male=21 (53.8%) Female=18 (46.2%) | Male= 20 (54.1%) Female= 17 (45.9%) |

Expt: Experimental; Ctrl: Control
The two groups of the study did not differ on sex (p=0.985), age (p= 0.621), smoking (p= 0.688), Endotracheal Tube size (p= 0.670), daily fluid balance (p= 0.306), suction catheter size (p= 0.233), sedation (p= 0.170), mode of mechanical ventilation (p= 0.472). The two groups were therefore similar in terms of these perceived Extraneous Variables (p>0.05).

***Effect of open tracheal tube suctioning on critical care outcome metrics***
Data pertaining to length of mechanical ventilation, duration of tracheal tube, length of stay in the ICU and Mortality in ICU for each group of study was collected and presented as shown in table 3.

Table 3:Effect of suctioning on specific patient care outcome metrics between Experimental and Control groups

| Serial | Outcome measures | Expt 180mmHg | | Ctrl 100mmHg | | Grand Mean |
|---|---|---|---|---|---|---|
| | | Mean ($\bar{x}$) | Standard Deviation (SD) | Mean ($\bar{x}$) | Standard Deviation (SD) | |
| 1. | Length of Mechanical Ventilation days (MVD) | 3.37 (Mdn=1.60) | 6.27 | 3.85 (Mdn=2.00) | 5.78 | 3.61 |
| 2. | Duration of TT (days) | 4.91 (Mdn=1.60) | 11.45 | 4.47 (Mdn=2.00) | 6.76 | 4.69 |
| 3. | Length of Stay in ICU (days) | 6.05 (Mdn=3.25) | 11.18 | 5.41 (Mdn=3.00) | 6.71 | 5.73 |
| 4. | Mortality in ICU | Yes=18 (46.2%) No=21 (53.8%) | | Yes=23 (62.2%) No=14 (37.8%) | | 54% |

ICU: Intensive Care Unit; MVD: Mechanical Ventilation Days; TT: Tracheal Tube

The mean length of mechanical ventilation and ICU mortality was higher for the Control Group than the Experimental Group while the mean duration of tracheal tube and length of stay in the ICU was higher for the Experimental Group compared to the Control Group.

***Comparison of Metrics on Outcome of Critical Care***

Data pertaining to length of mechanical ventilation, duration of tracheal tube, length of stay in the ICU and Mortality in ICU for each group of study was collected, analysed and compared in order to test the hypothesis that 'There is no significant difference in critical care outcomes between the 100mmHg tracheal suction group and 180mmHg tracheal suction group among adult mechanically ventilated patients.'

Comparison was therefore done using Independent Samples' t-test or its non-parametric equivalent for length of mechanical ventilation, duration of tracheal tube and length of stay in ICU, and Chi-square test for mortality in ICU.

There was no significant difference between the 180mmHg suction group and the 100mmHg suction group in terms of length of mechanical ventilation, duration of Tracheal Tube, length of stay in the ICU and Mortality in ICU ($p=0.328$, $p=0.411$, $p=0.839$ and $p=0.162$ respectively).

Table 4:Comparison on Specific Outcomes of Care Metrics

| Serial | Outcome | Expt (180mmHg) n=39 | Ctrl (100mmHg) n=37 | Statistical test | Test statistic | p-value |
|---|---|---|---|---|---|---|
| **1.** | Length of Mechanical Ventilation (days) | $\bar{x}$= 3.37 Mdn=1.60 SD = 6.27 | $\bar{x}$= 3.85 Mdn=2.0 SD = 5.78 | Mann Whitney U Test | .977 | 0.328 |
| **2.** | Duration of TT (days) | $\bar{x}$= 4.91 Mdn=1.60 SD = 11.45 | $\bar{x}$= 4.47 Mdn=2.0 SD = 6.76 | Mann Whitney U Test | .821 | 0.411 |
| **3.** | Length of Stay in ICU (days) | $\bar{x}$= 6.05 Mdn=3.25 SD = 11.18 | $\bar{x}$= 5.41 Mdn= 3.00 SD = 6.71 | Mann Whitney U Test | .203 | 0.839 |
| **4.** | Mortality in ICU | Yes=18 No=21 | Yes=23 No=14 | $X^2$ (1, N=76) =1.958 | | 0.162 |

NB: ICU: Intensive Care Unit; MVD: Mechanical Ventilation Days; TT: Tracheal Tube

## DISCUSSION

The two groups of the study constituted a good balance of participants in terms of mean age (40.51 vs 42.43) and sex (53.8% vs 54.1% for male; 46.2% vs 45.9% for female). This also approximates closely the general gender ratio in the Intensive Care Unit of 60% male and 40% female (Zettersten et al.,2019).

The length of mechanical ventilation, duration of Tracheal Tube, length of ICU stay and mortality are nearly comparable to a study on ideal depth of endotracheal tube in Asian population by lai et al. (2018); The registry-based cohort study in Kenya on ICU outcomes by Njoki et al. (2024); and Mortality Prediction in Rural Kenya: A Cohort Study of Mechanical Ventilation in Critically Ill Patients by Parker et al. (2019); i.e. average of: 3 (IQR 3-8) mechanical ventilation days; 2 (IQR 2-4) tracheal tube days; 4 (IQR 2-8) days stay in the ICU; and a mortality of (30.9-60.7)%.

In order to test the hypothesis that 'There is no significant difference in critical care outcomes between the 100mmHg tracheal suction group and 180mmHg tracheal suction group among adult mechanically ventilated patients', mean values on length of mechanical ventilation, length of ICU stay, and duration of tracheal tube were compared using Mann Whitney U test and comparison on ICU mortality done using Chi square. The results showed no significant difference between the Experimental and Control groups ($p>0.05$) on all the four variables. Therefore, the researcher failed to reject the null hypothesis. However, the risk of death in the 180mmHg suction group was 52.2% (OR=.522, 95% CI: 0.209,1.303) compared

to the overall risk of death of 74.2% (OR=.742, 95% CI: 0.487,1.132) for both groups and hence 22.0% less.

## STUDY LIMITATIONS

This study was conducted on adult mechanically ventilated patients at the Machakos Level Five Hospital. The findings are therefore not exactly applicable to other age groups. Though, the study was double blind, the nurses were able to differentiate between high pressure and low-pressure suctioning, nevertheless, the pressure gauge remained obscured, and the nurses were encouraged to bear with the seemingly slow suction level often presented by the lower suction pressure of 100mmHg.

## CONCLUSION

Clearance of the airway among intubated mechanically ventilated patients is a life-saving procedure in the Critical Care Unit intended to promote good oxygenation and ventilation and requires safe and effective negative suction pressure. The 180mmHg suction pressure, inherently more powerful than 100mmHg tested in this study demonstrated no adverse effects on main critical care outcome metrics. It is therefore potentially more beneficial for open tracheal tube suctioning compared to lower suction pressures.

## RECOMMENDATION

Its hereby noted that 180mmHg is a low-risk suction pressure in open tracheal tube suctioning and it's therefore recommended for open tracheal tube suctioning. Further research is needed to:

Establish effects of open tracheal tube suctioning at 100mmHg and 180mmHg on intra-cranial pressure.

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