Review Article

OPEN ACCESS
IJNHS

The Effect of Endotracheal Suction on Hemodynamics of Neurological Patients: A Literature Review

Rahaemil Jannah Aris[1,2], Rosyidah Arafat[1,3], Rini Rachmawaty[1]

Faculty of Nursing, Hasanuddin University, Indonesia[1]
Wahidin Sudirohusodo Hospital, Makassar, Indonesia[2]
Hasanuddin University Hospital, Makassar, Indonesia[3]

Article info

Article history:

Received: October 15th, 2024

Revised: March 28th, 2025

Accepted: August 15th, 2025

Corresponding author:

Name: Rosyidah Arafat

Address: Faculty of Nursing, Jl. Perintis Kemerdakaan Km 10

E-mail: rosidah@unhas.ac.id

International Journal of Nursing and Health Services (IJNHS)

Volume 8, Issue 4, August 20th, 2025

DOI: 10.35654/ijnhs.v8i4.844

E-ISSN: 2654-6310

Abstract

Introduction: One of the challenges in caring for neurology patients is the risk of increased intracranial pressure. Endotracheal suction is a routine nursing action but this procedure is reported can affect hemodynamic parameters. Artificial Airway Suction endotracheal recommends open and closed endotracheal suction safety and effective but several studies recommend the use of closed endotracheal suction therefore, this review aims to describe the effects of endotracheal suction use on hemodynamics in neurological patients. **Objective:** To determine the effect of endotracheal suction on hemodynamics of neurology patients. **Method:** This literature uses a literature review method that begins with a search for journals related to the topic. The author uses structured research questions with the PICO method from 3 database namely Pubmed, Science Direct and Google Scholar. Based on the filtering results, there were 11 articles that were relevant to the topic. **Results:** Based from 11 article neurology patients with mechanical ventilation, closed suction has a better impact than open endotracheal suction in maintaining the patient's physiological stability or hemodynamic parameter, effective in reduce changes in blood pressure, oxygen saturation, and the incidence of cardiac arrhythmias due to suctioning. This shows that closed endotracheal suction is safer to use in neurology patients with mechanical ventilation. **Conclusion:** The closed endotracheal suction is more recommended than the open endotracheal suction in neurological patients with mechanical ventilation in the ICU because of the more stable hemodynamic effect. Further research is needed to develop evidence-based clinical guidelines to minimize the side effects of endotracheal suction procedures.

Keywords: endotracheal suction, hemodynamic, neurology patient

INTRODUCTION

Neurological disorders present challenges to healthcare systems worldwide(1). Of 211 patients with intracranial non-traumatic and traumatic brain injury (TBI), 74% experienced increased Intracranial Pressure (ICP) and decreased consciousness(2).

Patients with severe neurological disorders are unable to control their airways, necessitating intubation and mechanical ventilation (3). The prevalence of neurological cases requiring mechanical ventilation is quite high. In addition, for neuro and neurosurgical ICU that specifically care for 100% of neurological patients (4,5), neurological patients with mechanical ventilation are also found in general ICU (6). Among 71 ICU patients on mechanical ventilation, 26.8% were neuro-surgical patients, and there were 74 patients (51.24%) with neurological conditions in the general ICU(7).

One of the routine nursing actions in the intensive care unit is endotracheal suctioning. Endotracheal suctioning is the process of removing mucus from the airway using a negative vacuum device (8). Endotracheal suctioning is performed to prevent airway obstruction (5,9,10), this procedure is reported very painful, causing discomfort and potentially affecting physiological parameters such as blood pressure (BP), oxygen saturation (O2), heart rate (HR), respiratory rate (RR), increased intracranial pressure (ICP), and Glasgow Coma Scale (GCS) (5) and additional complications include tissue trauma, bronchospasm, infection, pulmonary bleeding, increased intracranial pressure, and minute volume disturbances (11). Selecting the appropriate endotracheal suctioning method is one way to minimize these complications. Open and closed types of endotracheal suction are options for performing endotracheal suction.

Open and closed suction are both recommended by the Artificial Airway Endotracheal Suction (AARC) to be used to remove mucus from the airways in adult patients' safety and effectively (12). However, previous studies have suggested that open endotracheal suction has been reported to be unable to maintain Positive End Expiratory Pressure (PEEP), increase pulse, blood pressure and regular heart rhythm, while closed endotracheal suction is known to cause fewer physiological complications (13), closed endotracheal suction causes less arterial oxygen pressure than open endotracheal suction, this open endotracheal suction also triggers cardiac complications such as tachycardia and cardiac arrhythmias (14), suction causes hypoxemia and hypoxia which are common complications (15,16), closed endotracheal suction had a significant impact on cardiopulmonary parameters compared to open endotracheal suction (17). Both techniques have their own advantages and potential risks, especially in terms of hemodynamic stability.

The potential risks and advantages associated with each technique so further review is needed to get the strongest evidence and to gain a comprehensive understanding of the effects of endotracheal suctioning techniques on hemodynamics in neurological patients. Therefore, this review aims to describe the effects of endotracheal suction use on hemodynamics in neurological patients.

Objective

To determine the effect of endotracheal suction on hemodynamics of neurology patients

Methods

This literature uses a literature review method that begins with a search for journals related to the topic. There are 3 databases from the article search engine used, namely: Pubmed, Science Direct, & Google Scholar. The author uses Keywords: Endotracheal suctioning, hemodynamics, neurological patients, closed suctioning, open suctioning. The inclusion criteria are articles that discuss the effects of endotracheal suctioning in humans, article with Randomized Controlled Trials, available in full text in English or Indonesian, and were published within the last 10 years (2014–2024). The exclusion criteria are articles involving experimental animals, incomplete texts, or those published more than 10 years ago

The author uses structured research questions with the PICO method (patient, intervention, comparison and outcome (18) with the composition, namely P: Neurology Patient or Brain Injury or Traumatic Brain Injury, I: Endotracheal suction OR Open suctioning OR Closed Suctioning, C: -, O: Hemodynamic OR Fisiologic parameter. For critical appraisal was assessed using the PRISMA guidelines with focused on study design, sample size, methodology, bias, and the validity of results (19). Only high-quality RCTs and peer-reviewed articles were included to ensure the reliability of findings.

The research question is how does endotracheal suction affect the hemodynamics of neurology patients? Based on the results of the literature search, a total of 793 articles were obtained from three main databases, namely PubMed (471 articles), Science Direct (251 articles), and Google Scholar (71 articles). Furthermore, a screening process was carried out by applying inclusion criteria, namely: articles published in less than 10 years, articles in English, full text and free articles, articles involving humans as research subjects, and articles with a Randomized Controlled Trial (RCT) design. After the screening process was carried out based on these criteria, 11 articles were obtained that were relevant to the research topic (figure 1).

RESULTS

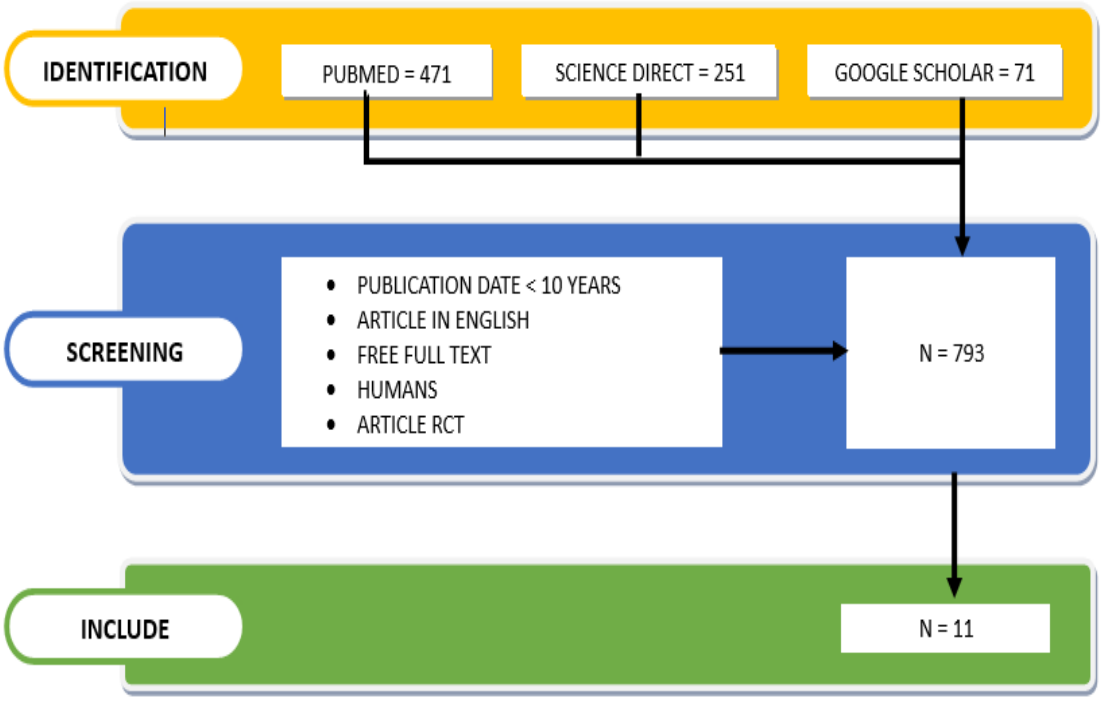
Design

Based on the inclusion criteria, there were 11 articles in several countries: Iran, Turkey, Saudi Arabia, Indonesia, Africa and Brazil. The articles in this literature review used design of study Randomised Controlled Trial (RCT). For instrument of study used hemodynamic observation sheet.

Endotracheal Suction on Hemodynamics of Neurological Patients

Most studies show that closed endotracheal suction has a better impact than open endotracheal suction in maintaining the patient's physiological stability. Closed endotracheal suction was more effective in reduce changes in blood pressure, oxygen saturation, and the incidence of cardiac arrhythmias due to suctioning (14,16,27,28). Open endotracheal suction led to increased airway resistance and higher peak inspiratory pressures compared to closed suction (29).

Several studies describe effect of suctioning on oxygen saturation. This indicates that both closed and open endotracheal suction are at risk of reducing SpO_2, but closed endotracheal suction is better able to maintain oxygen levels within more stable limits (30–32). Based impact on hemodynamic parameters closed suction



caused fewer disturbances in mean arterial pressure (MAP), heart rate, and blood pressure than open suction (17,27,33). This shows that closed endotracheal suction is safer to use in neurology patients' critical patients, especially those experiencing hemodynamic instability. Meanwhile for vital sign, closed endotracheal suction affected the patient's vital signs less than open endotracheal suction (34). This means that in ICU practice, the choice of suctioning method must consider its effect on the patient's stability condition.

DISCUSSION

Most of the research results show that the use of endotracheal suction provides more stable results in the closed endotracheal suction type. This is because disconnection of the patient from the ventilator when open endotracheal suction is performed can cause the inability to maintain Positive End Expiratory Pressure (PEEP), there is an increase in pulse, blood pressure and irregular heart rhythm, while closed endotracheal suction is known to cause fewer physiological complications (5,6). During the open endotracheal suction procedure, lung volume and oxygen saturation will decrease due to the disconnection of the ventilator from the patient so that hypoxemia can occur, blood pressure and heart rate can increase which affects the heart rhythm, while in closed endotracheal suction, complications such as decreased lung volume, hypoxemia, increased blood pressure and cardiac arrhythmias can be avoided (20). Closed endotracheal suction causes less arterial oxygen pressure than open endotracheal suction, this open endotracheal suction also triggers cardiac complications such as tachycardia and heart rhythm disturbances (14)

Endotracheal suctioning can significantly decrease oxygen saturation (30,32). Hypoxemia is caused by the temporary disconnection of the ventilator from the patient, which interferes with oxygenation. Although closed suction is better at maintaining oxygen saturation, some studies have shown that hypoxemia can still occur, especially in patients with pulmonary complications or acute respiratory failure such acute respiratory distress syndrom. To avoid hypoxemia during suction, FiO2 can be given with a high concentration of 100%. This is accordance with study which was conducted in the ICU room of the Klaten Islamic Hospital, which showed that there was an effect of pre-oxygenation on the hemodynamic status of patients with suction (35).

Based on the guidelines from Artificial Airway Suction (AARC), it is recommended that open and closed endotracheal suction can be used to remove mucus from the airway in adult patients safely and effectively (12) but on the findings in the table, closed suction is more recommended in ICU practice because it has a lower risk of hemodynamic compromise.

In neurological patients, the endotracheal suction procedure is one of the triggers for increased intracranial pressure. Open endotracheal suction increases intracranial pressure more than closed endotracheal suction, the mechanism of increased ICP due to suction procedures can be associated with three causes, namely the cough reflex, mechanical stimulation of the catheter during suction, and hypoxemia (36). Hemodynamic monitoring is a minimum neurological observation in neurological patients at risk of increased intracranial pressure in addition to the level of consciousness, pupil activity, and limb movements (37). Therefore, choosing a closed endotracheal suction method and technique is very appropriate to prevent complications due to increased intracranial pressure in neurological patients because its use results in more stable hemodynamics.

There are limitations of research gaps based on the table, such as the lack of long-term studies on the effects of suctioning in ICU patients with mechanical ventilation > 7 days and the lack of studies comparing the effects of suctioning in patients with specific conditions such as ARDS, stroke, or head trauma so further research is needed that can improve these limitations to improve the standard of care for ICU patients.

CONCLUSION

Based on the results of the analysis of 11 studies, endotracheal suctioning has a significant impact on patient hemodynamic parameters. Endotracheal suctioning can cause hypoxemia due to impaired oxygenation during suctioning and increased intracranial pressure (ICP), especially in patients with head trauma or stroke, which is at risk of worsening neurological conditions.

Studies show that closed endotracheal suction is more effective in maintaining hemodynamic stability, reducing the risk of hypoxemia, and minimizing fluctuations in blood pressure and heart rate during the suctioning procedure. In contrast, open endotracheal suction tends to cause more hemodynamic disturbances due to the release of the ventilator connection, which has the potential to cause decreased oxygenation and increased cardiac workload and increased intracranial pressure so that the closed endotracheal suction is more recommended than the open endotracheal suction in neurological patients with mechanical ventilation in the ICU.

There are several research gaps that still need to be explored further, such as the long-term effects of suctioning in ICU patients with prolonged mechanical ventilation have not been widely studied and variations in suctioning responses based on patient-specific conditions such as sepsis, heart failure, or stroke have not been widely evaluated. Further research is needed to develop evidence-based clinical guidelines to minimize the side effects of endotracheal suction procedures.

Table 1. Characteristic of Article

No.	Author/Country/Year/Title	Objective	Design/ sample/ Instrumen	Results
1	Ebrahimin et al (5)	To compare the severity of pain and variation of physiological indicators during closed tracheal suction system (CTSS) and open tracheal suction system (OTSS) in patients with traumatic brain injury	- Design: RCT - Sample: 112 - Instrument: Observation Sheet	Compared with OTSS, CTSS can cause a higher reduction in pain levels during and after suctioning in patients with head trauma and can also cause a higher improvement in physiological indicators, such as RR, O 2 saturation and EtCO 2
2	Dadkhah et al (4)	To compare changes in arterial oxygen saturation and the occurrence of cardiac dysrhythmias in head trauma patients undergoing open and closed suction	- Design: RCT - Sample: 88 - Instrument: Observation Sheet	To reduce Arterial Blood Oxygen Saturation and incidence of Cardiac Dysrhythmia due to endotracheal suctioning, the use of closed suction in the intensive care unit is recommended.
3	Pakizeh, Zainab et al (7)	To compare the effect of closed and open suction on the incidence of hypoxia and VAP in ICU patients	- Design: RCT - Sample: 184 - Instrument: Observation Sheet, Modified Clinical Pulmonary Infection Score (MCPIS) checklist, and pulse oximetry device	Closed suction is recommended to uses, due to the improvement of the hypoxia situation
4	Alshahrani et al. (20)	To compare the effects of open and closed suction on cardiopulmonary parameters in ventilated patients	- Design: RCT - Sample: 60 Instrument: Observation Sheet	Closed suction has a significant favourable impact on cardiopulmonary parameters such us Mean Arterial Pressure (MAP) and SpO2
5	Raimundo, et al (6)	To determine the effect of open and closed endotracheal suction systems on pulmonary function in mechanically ventilated patients	- Design: RCT - Sample: 66 - Instrument: Observation Sheet	Open suction caused a much greater increase in airway resistance and peak inspiratory pressure (P<0.001 and <0.01 in closed suction). Closed suction is recommended.
6	Afshari et al.(21)	To compare the effects of open and closed suction systems on blood pressure, mean arterial pressure, heart rate, arterial oxygen saturation percentage, time, and cost in mechanically ventilated patients	- Design: RCT - Sample: 40 - Instrument: Observation Sheet	Closed suction caused fewer disturbances in patients' hemodynamic condition so this method can replace open suction method in caring of severely critically ill patients.

7	Alsomali (22)	To identify the effect of closed and open suction on physiological parameters in mechanically ventilated patients	- Design: RCT - Sample: 74 - Instrument: Observation Sheet	Closed suction caused fewer changes in patients' physiological outcomes compared to open suction.
8	Elmelegy (23)	To investigate the effect of open and closed endotracheal suction systems on vital signs in mechanically ventilated patients	- Design: RCT - Sample: 40 - Instrument: Observation Sheet	Closed suction method causes less changes in patient's vital signs than open suction.
9	Septimar (24)	To investigate the effect of suctioning on oxygen saturation levels in critical patients in ICU Design: RCT Sample: 40 Instrument: Observation Sheet	- Design: RCT - Sample: 40 - Instrument: Observation Sheet	Suction action influence oxygen saturation levels in patients treated in the ICU of An-Nisa Hospital, Tangerang
10	Apui, et al.(25)	To investigate the effect of suctioning on oxygen saturation changes in unconscious patients in ICU RSD dr. H. Soemarno Sostroatmodjo	- Design: RCT - Sample: 15 - Instrument: Observation Sheet, pulse oximetry	Suction action affects changes in oxygen saturation in patients with decreased consciousness in the ICU Room of Dr. H. Soemarno Sostroatmodjo Hospital
11	Hammad, et al (26)	To analyze oxygen saturation levels before, during, and after endotracheal tube suctioning in ICU RSUD Ulin Banjarmasin	- Design: RCT - Sample: 25 - Instrument: Observation Sheet	Endotracheal Suction Action Has an Influence on Changes in Oxygen Saturation Levels in Adult Patients in the ICU Room of Ulin Banjarmasin Hospital

References

(1) Ningrum DNA, Kung WM. Challenges and Perspectives of Neurological Disorders. Brain Sci. 2023 Apr 18;13(4):676.

(2) Juelsgaard J, Rognås L, Knudsen L, Hansen TM, Rasmussen M. Prehospital treatment of patients with acute intracranial pathology: Adherence to guidelines and blood pressure recommendations by the Danish Air Ambulance. Scand J Trauma Resusc Emerg Med. 2018 Aug 22;26(1).

(3) Sacco TL, Delibert SA. Management of Intracranial Pressure: Part I: Pharmacologic Interventions. Dimensions of Critical Care Nursing. 2018 May 1;37(3):120–9.

(4) Dadkhah B, Maleh PA. Comparison of Changes in Arterial Blood Oxygen Saturation and Occurrence of Cardiac Dysrhythmia in Patients with Head Trauma undergoing Open and Closed Suction. Article in Journal of Research in Medical and Dental Science [Internet]. 2017; Available from: https://www.researchgate.net/publication/333668750

(5) Ebrahimian A, Tourdeh M, Paknazar F, Davari H. The effect of the open and closed system suctions on pain severity and physiological indicators in mechanically ventilated patients with traumatic brain injury: A randomised controlled trial. Turk J Anaesthesiol Reanim. 2020 Jun 1;48(3):202–7.

(6) Raimundo RD, Sato MA, da Silva TD, de Abreu LC, Valenti VE, Riggs DW, et al. Open and closed endotracheal suction systems divergently affect pulmonary function in mechanically ventilated subjects. Respir Care. 2021 May 1;66(5):785–92.

(7) Pakizeh Z, Asadizaker M, Shariati A, Savaie M, Saki A. Comparison of the effect of open and closed suction methods on the incidence of hypoxia and Ventilator-Associated Pneumonia (VAP) in the patients admitted to the ICU-A clinical trial study. 2023; Available from: https://doi.org/10.21203/rs.3.rs-3214173/v1

(8) Kostekli S, Celik S, Keskin E. Effect of deep and superficial endotracheal suctioning on hemodynamic parameters and pain in neurosurgical intensive care patients. Marmara Medical Journal. 2022 May 1;35(2):237–43.

(9) Rass V, Ianosi BA, Lindner A, Kofler M, Schiefecker AJ, Pfausler B, et al. Hemodynamic response during endotracheal suctioning predicts awakening and functional outcome in

subarachnoid hemorrhage patients. Crit Care. 2020 Jul 14;24(1).
(10) Arbi R, Susanti Monoarfa. tindakan suction dan perubahan saturasi oksigen pada pasien dengan penurunan kesadaran di ruangan icu rsud.prof.dr.h aloe saboe kota gorontalo. Intan Husada : Jurnal Ilmiah Keperawatan. 2023 Jul 26;11(02):114–22.
(11) Elmansoury A, Said H. Closed suction system versus open suction. Egyptian Journal of Chest Diseases and Tuberculosis. 2017 Jul;66(3):509–15.
(12) Blakeman TC, Scott JB, Yoder MA, Capellari E, Strickland SL. AARC Clinical Practice Guidelines: Artificial Airway Suctioning. Respir Care. 2022 Feb 1;67(2):258–71.
(13) Khayer F, Ghafari S, Saghaei M, Yazdannik A, Atashi V. Effects of open and closed tracheal suctioning on pain in mechanically ventilated patients. Iran J Nurs Midwifery Res. 2020;25(5):426.
(14) Ebrahimian A, Tourdeh M, Paknazar F, Davari H. The Effect of the Open and Closed System Suctions on Pain Severity and Physiological Indicators in Mechanically Ventilated Patients with Traumatic Brain Injury: A Randomised Controlled Trial. Turk J Anaesthesiol Reanim. 2020 May 29;48(3):202–7.
(15) Tavangar H, Javadi M, Sobhanian S, Jahromi FF. The Effect of the Duration of Pre-Oxygenation before Endotracheal Suction on Hemodynamic Symptoms. Glob J Health Sci. 2016 Jun 30;9(2):127.
(16) Pakizeh Z, Asadizaker M, Shariati A, Savaie M, Saki A. Comparison of the effect of open and closed suction methods on the incidence of hypoxia and Ventilator-Associated Pneumonia (VAP) in the patients admitted to the ICU-A clinical trial study. 2023.
(17) Alshahrani SH, Qureshi AA, Paulsamy P, Venkatesan K, Sethuraj P. The impact of open vs closed suction on cardio- respiratory parameters in mechanically ventilated patients. International Journal of Current Research in Chemistry and Pharmaceutical sciences. 2021 Jul 30;8(7):33–8.
(18) Eriksen MB, Frandsen TF. The impact of patient, intervention, comparison, outcome (PICO) as a search strategy tool on literature search quality: a systematic review. Journal of the Medical Library Association. 2018 Oct 4;106(4).
(19) Page MJ, Moher D, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. BMJ. 2021 Mar 29;n160.
(20) Alshahrani SH, Qureshi AA, Paulsamy P, Venkatesan K, Sethuraj P. The impact of open vs closed suction on cardio- respiratory parameters in mechanically ventilated patients. International Journal of Current Research in Chemistry and Pharmaceutical sciences [Internet]. 2021 Jul 30;8(7):33–8. Available from: https://ijcrcps.com/pdfcopy/2021/july2021/ijcrcps4.pdf
(21) Afshari A, Safari M, Oshvandi K, Soltanian AR. The effect of the open and closed system suctions on cardiopulmonary parameters: time and costs in patients under mechanical ventilation. Nurs Midwifery Stud. 2014 Jun;3(2):e14097.
(22) Alsomali MI, Elhady MM. The Effect of Open Versus Closed Tracheal Suctioning System on the Physiological outcomes of Mechanically Ventilated Patients. 8:74–80. Available from: www.iosrjournals.org
(23) Elmegely OEA, Ahmed R elsayed. Effect of Open versus Closed Endotracheal suctioning system on vital signs among mechanically ventilated patients in ICUl . IOSR Journal of Nursing and Health Science. 2016 Nov;5(6).
(24) Septimar ZM. Pengaruh Tindakan Penghisapan Lendir (Suction) terhadap Perubahan Kadar Saturasi

Oksigen pada Pasien kritis di ICU. Jurnal Ilmu Kesehatan Masyarakat. 2018 Mar 20;7(01):10–4.

(25) Apui SS, Wiyadi W, Arsyawina A. pengaruh tindakan suction terhadap perubahan saturasi oksigen pada pasien penurunan kesadaran di ruang icu rsd dr. h. soemarno sostroatmodjo. Aspiration of Health Journal. 2023 Mar 31;1(1):45–52.

(26) Hammad H, Rijani MI, Marwansyah M. Perubahan Kadar Saturasi Oksigen pada Pasien Dewasa yang Dilakukan Tindakan Suction Endotrakeal Tube di Ruang ICU RSUD Ulin Banjarmasin. Bima Nursing Journal. 2020 May 26;1(1):82.

(27) Afshari A, Safari M, Oshvandi K, Soltanian AR. The effect of the open and closed system suctions on cardiopulmonary parameters: time and costs in patients under mechanical ventilation. Nurs Midwifery Stud. 2014 Jun;3(2):e14097.

(28) Jongerden IP, Kesecioglu J, Speelberg B, Buiting AG, Leverstein-van Hall MA, Bonten MJ. Changes in heart rate, mean arterial pressure, and oxygen saturation after open and closed endotracheal suctioning: A prospective observational study. J Crit Care. 2012 Dec;27(6):647–54.

(29) Raimundo RD, Sato MA, da Silva TD, de Abreu LC, Valenti VE, Riggs DW, et al. Open and Closed Endotracheal Suction Systems Divergently Affect Pulmonary Function in Mechanically Ventilated Subjects. Respir Care. 2021 May 1;66(5):785–92.

(30) Hammad H, Rijani MI, Marwansyah M. Perubahan Kadar Saturasi Oksigen pada Pasien Dewasa yang Dilakukan Tindakan Suction Endotrakeal Tube di Ruang ICU RSUD Ulin Banjarmasin. Bima Nursing Journal. 2020 May 26;1(1):82.

(31) Apui SS, Wiyadi W, Arsyawina A. pengaruh tindakan suction terhadap perubahan saturasi oksigen pada pasien penurunan kesadaran di ruang icu rsd dr. h. soemarno sostroatmodjo. Aspiration of Health Journal. 2023 Mar 31;1(1):45–52.

(32) Septimar ZM. Pengaruh Tindakan Penghisapan Lendir (Suction) terhadap Perubahan Kadar Saturasi Oksigen pada Pasien kritis di ICU. Jurnal Ilmu Kesehatan Masyarakat. 2018 Mar 20;7(01):10–4.

(33) Alsomali MI, Elhady MM. The Effect of Open Versus Closed tracheal Suctioning System on the Physiological outcomesof Mechanically Ventilated Patients.

(34) Elmegely OEA, Ahmed RE. Effect of Open versus closed Endotracheal Suctioning System on Vital sign among mechanically ventilated patients in ICU. IOSR Journal of Nursing and health science . 2016;5(6).

(35) Agustin RW, Triyono T, Setiyawan S, Safitri wahyuningsih. Status Hemodinamik Pasien yang Terpasang Endotracheal Tube dengan Pemberian Preoksigenase sebelum Tindakan suction di Ruang Intensive Care Unit. Jurnal Ilmu Kesehatan. 2019 Feb 1;17.

(36) Uğraş GA, Aksoy G. The effects of open and closed endotracheal suctioning on intracranial pressure and cerebral perfusion pressure: A crossover, single-blind clinical trial. Journal of Neuroscience Nursing. 2012 Dec;44(6).

(37) Yogarajah M. Crash Course Neurologi . 1st ed. Lastri DN, editor. Singapore: Elsevier Singapore; 2018. 1–565 p.