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MORTALITY DETERMINANTS IN SEVERE TRAUMATIC BRAIN INJURY WITH PNEUMONIA: A RETROSPECTIVE STUDY

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ABSTRACT

Introduction: Traumatic brain injury (TBI) is defined as an acute brain injury caused by mechanical forces to the head, excluding those related to drugs, alcohol, medications, or other conditions, such as systemic injuries, psychological trauma, or coexisting medical issues. TBI is a global public health issue responsible for significant disability and mortality, with an estimated global incidence of 69 to over 100 million new cases annually. This burden may be higher due to underreporting, particularly in low- and middle-income countries (LMICs). Several methods have been established to classify TBI, one of them is based on its severity with the Glasgow Coma Score (GCS). Pneumonia is a frequent complication in traumatic brain injury (TBI) patients, especially those on prolonged mechanical ventilation. Pneumonia could be classified based on the source of infection into ventilator-associated pneumonia (VAP), hospital-associated pneumonia (HAP), and community-acquired pneumonia (CAP).
Objective: To evaluate the mortality and risk factors of severe traumatic brain injury (sTBI) with pneumonia.
Methods: This study is a cross-sectional study with observational analytical investigations. The sample of this study is sTBI patients who were treated in Dr. Soetomo General Academic Hospital in 2023. Descriptive statistics were used to summarize the patients' characteristics. Chi-square tests and logistic regression were used to find relationship between factors that increase the risk of death and the development of pneumonia.
Results: In 2023, we documented 832 TBI cases, of these, 479 cases (57.6%) were mild TBI, 273 cases (32.8%) were moderate brain injuries, while severe brain injuries (sTBI) with 80 cases (9.6%). Our study shows that 50% of patients with sTBI have pneumonia, and VAP itself is one of the contributing factors to mortality in this population ($p<0.001$).
Conclusion: Of all types of pneumonia in this study, there is a statistical correlation between mortality and VAP in sTBI patients.

Keywords: Developing Countries; Mortality; Pneumonia; Traumatic Brain Injury

ABSTRAK

Pendahuluan: Cedera otak traumatis (TBI) didefinisikan sebagai cedera otak akut yang disebabkan oleh kekuatan eksternal mekanik ke kepala, tidak termasuk yang terkait dengan obat-obatan, alkohol, pengobatan, atau kondisi lain seperti cedera sistemik, trauma psikologis, atau masalah medis yang terjadi bersamaan. TBI adalah masalah kesehatan masyarakat global yang bertanggung jawab atas kecacatan dan kematian yang signifikan, dengan perkiraan kejadian global 69 hingga lebih dari 100 juta kasus baru setiap tahunnya. Beban ini mungkin lebih tinggi karena kurangnya pelaporan, terutama di negara-negara berpenghasilan rendah dan menengah (LMIC). Beberapa sistem klasifikasi telah digunakan dalam praktik sehari-hari, salah satunya adalah berdasarkan derajat keparahan dengan menggunakan *Glasgow Coma Score* (GCS). Pneumonia merupakan komplikasi yang sering terjadi pada pasien cedera otak traumatis (TBI), terutama mereka yang menggunakan ventilasi mekanis dalam jangka panjang. Pneumonia dapat diklasifikasi berdasarkan dari sumber infeksinya menjadi *ventilator associated pneumonia* (VAP), *hospital associated pneumonia* (HAP), dan *community acquired pneumonia* (CAP).
Tujuan: Mengevaluasi faktor risiko yang berkontribusi pada tingkat mortalitas pada pasien cedera otak berat dengan pneumonia.
Metode: Penelitian ini merupakan penelitian cross-sectional dengan pendekatan analitik observasional. Sampel penelitian ini adalah pasien TBI yang dirawat di RSUD Dr. Soetomo pada tahun 2023. Statistik deskriptif digunakan untuk meringkas karakteristik pasien. Uji chi-square dan regresi logistik digunakan untuk mengidentifikasi hubungan antara faktor risiko mortalitas dengan kejadian pneumonia.
Hasil: Pada tahun 2023, kami mendokumentasikan 832 kasus TBI, dari jumlah tersebut, 479 kasus (57,6%) dengan cedera otak ringan, cedera otak sedang pada 273 kasus (32,8%), dan cedera otak berat (sTBI) pada 80 kasus (9,6%). Studi kami menunjukkan bahwa >50% pasien dengan sTBI menderita pneumonia, dan VAP sendiri merupakan salah satu faktor yang berkontribusi terhadap mortalitas pada populasi ini ($p<0,001$).
Kesimpulan: Dari semua jenis pneumonia, didapatkan korelasi pada tingkat mortalitas dan VAP.

Kata kunci: Negara Berkembang; Mortalitas; Pneumonia; Cedera Otak Traumatis

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INTRODUCTION

Traumatic brain injury (TBI) is defined as an acute brain injury caused by mechanical forces to the head, excluding those related to drugs, alcohol, medications, or other conditions such as systemic injuries, psychological trauma, or coexisting medical issues (1). TBI is typically classified by severity (mild, moderate, or severe), mechanism of injury (closed or penetrating), and clinical presentation (focal or diffuse injuries). The severity of a traumatic brain injury is usually measured using the Glasgow Coma Scale (GCS), where a score of 13-15 indicates a mild injury, 9-12 indicates a moderate injury, and 3-8 indicates a severe injury, which can lead to long periods of unconsciousness and a higher risk of death (2).

Closed TBIs, often caused by falls, motor vehicle accidents, or sports injuries, involve non-penetrating trauma that leads to brain movement within the skull. In contrast, penetrating TBIs, typically from objects breaching the skull, are linked with severe damage and increased mortality. Clinical presentation further divides TBIs into focal injuries, like contusions and hematomas, and diffuse injuries, such as diffuse axonal injury (DAI), which results from rotational forces and carries poor outcomes (2). Understanding these classifications is critical for optimizing treatment and improving patient outcomes.

TBI is a global public health issue responsible for significant disability and mortality, with an estimated global incidence of 69 to over 100 million new cases annually. This burden may be higher due to underreporting, particularly in low- and middle-income countries (LMICs) (3). In LMICs, road traffic accidents (RTAs) account for nearly 60% of all TBIs (4), while in high-income countries (HICs), falls especially among the elderly have become the leading cause, followed by motor vehicle accidents and sports-related injuries (5). Young males, particularly those aged 15-24, are disproportionately affected by TBIs due to risky behaviors like impaired driving and poor seatbelt use (2,6), while the elderly suffer primarily from fall-related TBIs due to factors like osteoporosis and cognitive impairment (2,7).

Differences in healthcare access and rehabilitation around the world make TBI outcomes worse, especially in LMICs, where there is not enough trauma care and medical help is often delayed, leading to more deaths and worse results (3). This indicates that it requires improved prevention strategies, public health education, and continued research to address the global burden of TBI (2,5).

Pneumonia is a common complication in TBI patients, particularly those requiring prolonged mechanical ventilation. Community-acquired pneumonia (CAP) happens outside of hospitals and is usually caused by germs like Streptococcus pneumoniae and Haemophilus influenzae, while hospital-acquired pneumonia (HAP) and ventilator-associated pneumonia (VAP) occur in patients in hospitals or on ventilators, often involving tougher germs like Pseudomonas aeruginosa and MRSA, which can lead to higher death rates (3). TBI mechanisms include blunt trauma, often seen in acceleration-deceleration injuries, leading to diffuse axonal injury (DAI) and coup-contrecoup damage, commonly from falls or car accidents. Penetrating injuries from bullets or shrapnel cause localized brain damage with high infection and mortality risks (2,5). Hypoxic-ischemic injuries, such as those following cardiac arrest, and repetitive head trauma, often seen in athletes and military personnel, further complicate TBI management, leading to chronic traumatic encephalopathy (CTE) (5,7).

In Indonesia, TBI patients frequently develop VAP, especially in ICUs where prolonged mechanical ventilation is common (3). The prevalence of pneumonia in severe TBI patients is high, reaching up to 40% in some studies, which points to the important of stringent infection control and timely management. Limited healthcare resources further contribute to delayed diagnosis and treatment, worsening patient outcomes in many regions (8). The long-term

consequences of TBI include chronic physical, cognitive, and emotional impairments, which place a heavy burden on healthcare systems, particularly in under-resourced regions.

This study aims to evaluate the mortality rates comprehensively and identify the associated risk factors of severe traumatic brain injury (sTBI) in patients with pneumonia in Dr. Soetomo General Academic Hospital, taking into account the impact of various clinical findings, secondary CT-scan findings, and microbiological culture. The authors specifically chose sTBI since it has an increased risk of VAP, mainly due to low GCS scores and prolonged use of mechanical ventilation.

METHODS

This study employed a retrospective observational design with a case-control approach. Data collection occurred from January to December 2023, focusing on patients diagnosed with severe traumatic brain injury (sTBI) admitted to Dr. Soetomo General Academic Hospital. All patients meeting the predetermined inclusion criteria throughout the designated study period were systematically enrolled, ensuring complete population capture rather than representative sampling. This thorough method removes any bias from sampling and gives strong evidence for assessing how VAP affects the risk of death in sTBI patients. The Commission of Ethics, Dr. Soetomo Academic General Hospital, granted the ethical clearance for this study on October 29th, 2024. (1808/LOE/301.4.2/X/2024)

The study population consisted of all patients with severe traumatic brain injury (GCS 3-8) admitted to Dr. Soetomo General Academic Hospital from January to December 2023. The inclusion criteria required patients to have a confirmed diagnosis of TBI and be admitted to the ICU. Exclusion criteria included penetrating craniocerebral injuries and cases complicated by coexisting conditions such as chronic infections and malignancies. The final sample consisted of all eligible patients during the study period.

Data were collected from patients' medical records, including written informed consent, demographic information, clinical history, types of surgical interventions, types of pathogens identified, pneumonia classification (community-acquired, hospital-acquired, or ventilator-associated), post-traumatic seizure history, CT imaging findings, and the presence of cranial base or impression fractures. Pneumonia diagnosis was confirmed through clinical criteria, radiological evidence, and microbiological testing. Patients with incomplete medical records or missing essential variables were excluded from the study to ensure data completeness.

Data were analyzed using both descriptive and inferential statistical methods with SPSS Statistics 30.0.0. Descriptive statistics were applied to summarize the characteristics of the patients, while chi-square tests and logistic regression were employed to identify associations between risk factors and pneumonia development. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to determine the strength of associations. A p-value of < 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

The demographic data for brain-injured patients at Dr. Soetomo General Academic Hospital show a total of 832 documented cases, classified according to the Glasgow Coma Score (GCS). Of these, 479 cases (57.6%) were categorized as mild, representing the majority of brain injuries. Moderate brain injuries accounted for 273 cases (32.8%), while severe brain injuries (sTBI) were the least common, with only 80 cases (9.6%). Due to incomplete patient data, this study focused on 74 cases of sTBI.

The survival outcomes of the 74 patients with severe traumatic brain injury (sTBI) with pneumonia incidence were also analyzed. Among these patients, 39 developed pneumonia, while 35 did not. Overall, 38 patients succumbed to their injuries, while 36 survived. Of the 39 patients with pneumonia, 25 (64.1%) passed away, compared to

13 (37.1%) fatalities among the 35 patients who did not develop pneumonia. This suggests that pneumonia, particularly ventilator-associated pneumonia (VAP), may significantly contribute to mortality in sTBI patients.

Table 1 records the sTBI patients with epidural hemorrhage (EDH) and their rate of mortality. For patients with EDH, 30 cases were documented. Among them, 11 patients had EDH without any other associated lesions. However, for the remaining 19 patients who had additional lesions, the mortality rate reached up to 84%, suggesting that the presence of additional lesions may worsen the outcome in EDH cases.

Table 1. Demographics of sTBI patients with EDH

EDH incidence		Survive N (%)	Dead N (%)	Total N (%)
EDH (N=30)	With other lesions (n=19)	3 (16)	16 (84)	19 (100)
	Without other lesions (n=19)	7 (64)	4 (36)	11 (100)
Non-EDH (N=50)		32 (64)	18 (36)	50 (100)

In SAH cases, there were 26 patients, three of whom had no other lesions. The survival rate for patients without additional lesions, the percentage was 33%. However, for the 23 patients with additional lesions, the mortality rate reached 61%, indicating that SAH in conjunction with other injuries is associated with poorer outcomes. The details are shown in Table 2.

Table 2. Demographics of sTBI patients with SAH

SAH incidence		Survive N (%)	Dead N (%)	Total N (%)
SAH (N=26)	With other lesions (n=23)	9 (39)	14 (61)	23 (100)
	Without other lesions (n=3)	1 (33)	2 (67)	3 (100)
Non-SAH (N=54)		35 (59)	22 (41)	54 (100)

Subdural hemorrhage (SDH) involved 41 patients, of whom only 3 had isolated SDH without other lesions, as shown in Table 3. The mortality rate in this group was 47%. Among the remaining 38 patients with additional lesions, the mortality rate was 45%, further highlighting the high mortality risk associated with SDH, with or without associated lesions.

Table 3. Demographics of sTBI patients with SDH

SDH Incidence		Survive N (%)	Dead N (%)	Total N (%)
SDH (N=41)	With other lesions (n=38)	21 (55)	17 (45)	38 (100)
	Without other lesions (n=3)	0 (0)	3 (100)	3 (100)
Non-SDH (n=39)		21 (53)	18 (47)	39 (100)

Intracranial hemorrhage (ICH) was present in 29 patients, with 4 cases involving isolated ICH. The survival rate in isolated ICH is 75%. However, among the 25 patients with ICH and additional lesions, the survival rate dropped dramatically to 36% (only 9 out of 25 survived). This suggests that while isolated ICH may have a favorable prognosis, the presence of additional lesions significantly worsens the outcome. Table 4 demonstrates sTBI patients with pneumonia and ICH.

Table 4. Demographics of sTBI patients with ICH

ICH Incidence		Survive N (%)	Dead N (%)	Total N (%)
ICH (N=29)	With other lesions (n=25)	9 (36)	16 (64)	25 (100)
	Without other lesions (n=4)	1 (25)	3 (75)	4 (100)
Non-ICH (N=51)		31 (68)	19 (32)	51 (100)

The study also classified pneumonia types in sTBI patients and examined their association with survival outcomes. Of the 40 cases of pneumonia, 27 resulted in death, and 13 patients survived. Ventilator-associated pneumonia (VAP) was linked to the highest mortality, with 24 out of 33 patients succumbing to their illness. Hospital-acquired pneumonia (HAP) was observed in 4 cases, with only 1 fatality and 3 survivors. Community-acquired pneumonia (CAP), which was documented in 3 patients, showed the most favorable outcome, with all patients recovering. This data indicates that VAP is strongly associated with higher mortality rates compared to HAP and

CAP. The distribution of sTBI patients with and without pneumonia is described in Table 5.

Table 5. The distribution of sTBI patients associated with pneumonia

Characteristics	VAP	HAP	CAP	Non-pneumonia	Total
Number of patients (n (%))	33 (41.25)	4(5)	3 (3.75)	40(50)	80 (100)
Mortality (n (%))					
Survive	9(11)	1(1)	3(3)	27(34)	42(52)
Dead	24(30)	3(3)	0(0)	11(16)	38(48)

In terms of pathogens, *Klebsiella pneumoniae* was the most common organism identified, responsible for 11 infections. *Pseudomonas aeruginosa* and *Enterobacter cloacae* each accounted for 5 cases. Other significant pathogens included *Acinetobacter baumannii*, *Staphylococcus aureus, and Staphylococcus coagulase*, each causing 2 infections. Additionally, there was 1 case of infection caused by COVID-19. The "Others" category, which included rare pathogens such as *Stenotrophomonas maltophilia*, *Proteus mirabilis*, and *Klebsiella aerogenes*, accounted for 12 cases. This distribution highlights *Klebsiella pneumoniae* as the leading pathogen in these pneumonia cases, as shown in Table 6.

Table 6. Etiology of pneumonia in sTBI patients

Microbacteria	Total
Klebsiella pneumoniae	11
Pseudomonas aeruginosa	5
Enterobacter cloacae	5
Acinetobacter baumannii	2
Staphylococcus aureus	2
Staphylococcus coagulase	2
Covid-19	1
Others (Stenotropomonas maltophilia, Proteus mirabilis, Klebsiella aerogenes)	12

Patients with acute neurological impairment, such as traumatic brain injury (TBI), and stroke, are at a higher risk of developing pneumonia due to compromised protective reflexes and the increased likelihood of aspiration (9). In a study involving 74 patients with severe TBI (sTBI), those who developed pneumonia had a significantly higher mortality rate of 64.1% compared to 37.1% in those without pneumonia. Ventilator-associated pneumonia (VAP) was particularly lethal, with a mortality rate of 77.4%, underscoring its severity. Hospital-acquired pneumonia (HAP), although less deadly, still had a notable mortality rate of 20%. These findings align with other studies that have shown VAP to be associated with longer ICU stays, increased complications, and worsened outcomes in sTBI patients (10).

Our study confirms that VAP significantly impacts mortality in sTBI patients ($p < 0.001$, CI = 95%), driven by prolonged mechanical ventilation and extended ICU stays, as shown in Table 7. This multivariate analysis of sTBI mortality factors reveals pneumonia as the sole statistically significant predictor (OR = 1.854, $p = 0.01$), nearly doubling mortality risk. Notably, ventilator-associated pneumonia (VAP) showed the strongest univariate association ($p < 0.001$) but lost significance in multivariate modeling, suggesting confounding variables. Other factors, including multitrauma, culture positivity, various hemorrhage types (ICH, SAH, SDH, EDH), skull base fractures, and surgical interventions, demonstrated no significant independent association with mortality outcomes.

This is supported by Marjanovic et al. (11), who found that VAP in sTBI patients leads to higher illness rates and a trend towards increased mortality. Furthermore, Plurad et al. (12) demonstrated that bilateral dependent consolidation observed on chest CT scans upon admission can predict VAP occurrence and is independently associated with increased mortality in severe TBI cases. This suggests that VAP has a profound impact on patient outcomes, especially in those with predisposing factors.

The elevated risk of pneumonia following TBI can be attributed to both mechanical factors, such as the increased likelihood of aspirating oropharyngeal contents and immunological factors. TBI often leads to immune suppression, making patients more vulnerable to infections. Vermeij et al. demonstrated in an experimental

model that TBI-induced immune suppression is driven by an imbalance in acetylcholine, linked to increased vagal tone, resulting in immunoparalysis. This condition complicates the body's ability to fight off infections like pneumonia.

Table 7. Multivariate analysis of related factors to mortality in sTBI patients

Determinant	Univariate Analysis		Multivariate Analysis	
	Chi-square (χ^2)	p-value	Odds Ratio (OR)	p-value
Pneumonia	15.557	**0.001***	1.854	0.11**
VAP	11.707	**<0.001***	-	-
HAP	0.094	0.759	-	-
CAP	1.397	0.237	-	-
Multitrauma	0.222	0.683	0.473	0.386
Culture	12.65	0.081	1.084	0.58
SBF	0.343	0.558	**2.826**	0.078
Impression	0.802	0.37	2.552	0.344
Constusio	1.928	0.165	0.462	0.187
ICH	2.256	0.133	1.784	0.334
SAH	0.622	0.43	2.252	0.251
SDH	0.222	0.638	0.975	0.971
ICH	0.334	0.563	0.685	0.538
Surgical intervention	4.766	0.312	1.11	0.566

VAP: ventilator-associated Pneumonia; HAP: hospital-acquired pneumonia.; CAP: community-acquired pneumonia; SBF: skull base fracture; ICH: intracranial hemorrhage; SAH: subarachnoid hemorrhage; SDH: subdural hemorrhage; EDH: epidural hemorrhage

*Based on the chi-square test, significant if $\alpha < 0.05$

**Based on the logistic regression test, significant if $\alpha < 0.05$

The connection between the central nervous system (CNS) and the immune system plays a pivotal role in the development of immunoparalysis following TBI. When the blood-brain barrier (BBB) is disrupted, immune cells and inflammatory mediators enter the CNS, activating microglia and attracting peripheral immune cells. While this immune response is initially aimed at limiting further damage and initiating repair, it can become dysregulated, resulting in excessive inflammation. This heightened inflammatory response not only exacerbates brain injury but also weakens systemic immune function, a hallmark of immunoparalysis (13).

The autonomic nervous system (ANS) also contributes significantly to immune regulation post-TBI. During the acute phase of TBI, the sympathetic nervous system (SNS) is activated, leading to the release of catecholamines like adrenaline and noradrenaline, which suppress immune cell function. This reduces the body's ability to combat infections. Conversely, the parasympathetic nervous system (PNS) exerts an anti-inflammatory effect through the cholinergic anti-inflammatory pathway, mediated by the vagus nerve, which inhibits pro-inflammatory cytokine production (14).

Additionally, neurohormonal changes, particularly in the hypothalamic-pituitary-adrenal (HPA) axis, play a critical role in immunosuppression following TBI. The activation of the HPA axis leads to increased cortisol levels, which suppress immune responses by reducing cytokine production and limiting immune cell proliferation. These neurohormonal effects further compromise the immune system's ability to respond to infections such as pneumonia (15).

Ventilator-associated pneumonia (VAP) was defined as pneumonia occurring 48 hours or more after endotracheal intubation, meeting at least two of the following criteria: fever greater than 38.3°C, leukocytosis or leukopenia, and purulent tracheal secretions. Among patients with severe traumatic brain injury (sTBI), the mortality rate for VAP in patients with severe traumatic brain injury (sTBI) is particularly high, with 77.4% (24 out of 31) of those affected succumbing to the condition, often

exacerbated by prolonged mechanical ventilation and the resultant complications. In comparison, hospital-acquired pneumonia (HAP) showed a mortality rate of 20% (1 out of 5), indicating a considerably lower impact than VAP. Notably, none of the three patients who developed community-acquired pneumonia (CAP) died, reflecting a relatively better prognosis for sTBI patients with CAP. However, it is important to acknowledge the limited sample size for CAP and HAP, which introduces bias into these findings.

Previous studies corroborate the detrimental effect of pneumonia, especially VAP, on outcomes in TBI patients. Kesinger et al. (16) demonstrated that hospital-acquired pneumonia significantly worsened long-term outcomes in sTBI patients. Similarly, Li et al. (17) identified VAP as a frequent complication in TBI patients, associated with extended ICU stays and increased morbidity.

Although our study did not establish a statistically significant relationship between specific pathogens and mortality, it was observed that Klebsiella pneumoniae was the most common pathogen responsible for VAP (35.4%). *K. pneumoniae* is a globally recognized pathogen, often associated with VAP and heightened mortality, particularly due to its multidrug-resistant (MDR) strains. Studies highlight the global prevalence of *K. pneumoniae* in ICU patients, especially in countries such as China, India, and Iran, where carbapenem resistance has become a growing concern (18,19). The mortality rate in patients with K. pneumoniae VAP can exceed 40%, particularly when carbapenem-resistant strains or Klebsiella pneumoniae carbapenemase (KPC)-producing strains are involved (20). Early detection and tailored antimicrobial therapy, including the use of polymyxins, have been shown to improve outcomes, although MDR pathogens continue to present major treatment challenges (21).

In patients with severe TBI, Klebsiella pneumoniae VAP is associated with poor clinical outcomes, particularly when MDR strains are involved. A meta-analysis by Li et al. (22) reported a 36% incidence of VAP in TBI patients, risk factors such as blood transfusion and high injury severity scores contribute to the increased likelihood of VAP, with the odds ratio (OR) for the injury severity score being 4.65 (95% CI: 1.96–7.34, $p < 0.001$), indicating a strong correlation between more severe injuries and the risk of VAP. Moreover, patients with VAP had significantly longer mechanical ventilation (OR: 5.45; 95% CI: 3.78–7.12) and hospital stays (OR: 10.92; 95% CI: 9.12–12.72), indicating the heavy burden of this complication.

Xu et al. (19) further emphasized the role of carbapenem-resistant K. pneumoniae (CRKP) in VAP among TBI patients, identifying ICU stays longer than 7 days (OR: 2.793; 95% CI: 1.439–5.421, $p < 0.01$) and previous antibiotic use (OR: 1.977; 95% CI: 1.025–3.812, $p < 0.05$) as major risk factors for CRKP infection. Mortality was significantly higher in CRKP-infected patients, highlighting the complexity of managing such resistant infections.

Chen et al. (23) reported a 42% incidence of VAP in TBI patients, highlighting its substantial impact on survival, particularly in critically injured patients. Tsikritsaki et al. (24) supported these findings by showing that VAP extended mechanical ventilation and ICU stays, while also increasing mortality, especially in older patients with comorbidities. These findings collectively underscore the urgent need for effective prevention and control measures for VAP in sTBI patients.

While community-acquired pneumonia (CAP) theoretically leads to high mortality, especially within the first 30 days of hospitalization (25,26), factors such as advanced age, comorbidities, and illness severity are critical contributors to poor outcomes (27–29). Studies also indicate long-term mortality associated with CAP, suggesting that its effects extend beyond the initial hospitalization period (30). Early intervention is key to reducing mortality in CAP cases (31,32).

Hospital-acquired pneumonia (HAP) is another significant cause of mortality, particularly in hospitalized patients with severe underlying conditions. HAP, occurring after at least 48 hours

in the hospital, is often caused by multidrug-resistant bacteria, complicating treatment and increasing mortality rates. Research indicates that HAP-related mortality can reach up to 30%, with more aggressive bacteria and compromised immune systems contributing to poorer outcomes (33). Despite these associations, our study was unable to demonstrate statistically significant relationships between CAP (p = 1.397, CI = 95%) and HAP (p = 0.094, CI = 95%) with mortality in sTBI patients, which is a limitation of the research.

While VAP had a statistically significant effect on mortality, our study did not establish a statistically significant relationship between CAP or HAP and mortality, likely due to the limited sample size. Nonetheless, pneumonia remains a critical complication in sTBI, emphasizing the need for enhanced prevention, early intervention, and targeted antimicrobial therapy to improve patient survival and reduce the burden of infection in this vulnerable population.

CONCLUSION

This study reinforces the significant impact of pneumonia, particularly ventilator-associated pneumonia (VAP), on mortality in patients with severe traumatic brain injury (sTBI). VAP, driven by prolonged mechanical ventilation and immune suppression, was associated with a higher mortality rate, highlighting the need for early detection and prevention strategies. Hospital-acquired pneumonia (HAP) also contributed to increased mortality, albeit to a lesser extent. The high prevalence of multidrug-resistant pathogens, especially *Klebsiella pneumoniae*, further complicates treatment and underscores the importance of stringent infection control measures in reducing VAP-related mortality.

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Conflict of Interest

The authors declare there are no conflicts of interest in this study.

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Authors' Contributions

All authors have made substantial contributions to every aspect of this research process.

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Original Research Article

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COMPARING HEMODYNAMIC RESPONSES TO INTUBATION IN HYPERTENSIVE PATIENTS: CLEARVUE® VIDEO LARYNGOSCOPE VERSUS MACINTOSH DIRECT LARYNGOSCOPE

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ABSTRACT

Introduction: The ClearVue® video-laryngoscope (CVL) is believed to alleviate the stress response associated with intubation by providing superior laryngeal views, minimizing oropharyngo-laryngeal stimulation, and potentially reducing the pressor response.
Objective: This study aims to assess and compare how effective and safe intubation is when using a CVL versus a Macintosh direct laryngoscope (MDL) in patients with high blood pressure who are having surgery.
Methods: This prospective, randomized, interventional study was conducted on 140 hypertensive patients on antihypertensive medication undergoing elective surgery under general anesthesia (GA), who were allocated into two groups, CVL group (n = 70) and MDL group (n = 70). Hemodynamic parameters, including mean arterial pressure (MAP), mean heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP), were monitored at baseline, induction, and at various intervals post-intubation (1, 2, 3, 4, 5, and 10 minutes). Other metrics, such as intubation time, intubation attempts, ease of intubation, and associated complications, were documented.
Results: Significant differences in heart rate were observed between the groups, right at intubation and at 1, 2, and 3 minutes post-intubation (p-values: 0.011; 0.028; 0.002; 0.003). SBP showed significant differences at intubation and during the first four minutes post-intubation (p-values < 0.001 except for the fourth minute, p = 0.001). DBP and MBP also showed significant differences at various intervals post-intubation (p-values < 0.001 to 0.025 and < 0.001 to 0.020, respectively). No significant difference in airway complications was noted.
Conclusion: The CVL offers advantages over MDL in patients with controlled hypertension, specifically in reducing hemodynamic changes during intubation without increasing airway complications. At the same time, MDL offered less intubation time overall than CVL.

Keywords: Blood pressure; ClearVue® video-laryngoscope; Hemodynamic response; Macintosh laryngoscope

ABSTRAK

Pendahuluan: Video-laringoskop ClearVue® (CVL) diharapkan dapat mengurangi stres saat intubasi dengan memberikan pandangan yang lebih jelas pada laring, mengurangi rangsangan di area mulut dan tenggorokan, serta mungkin menurunkan tekanan darah.
Tujuan: Penelitian ini ingin menilai dan membandingkan seberapa efektif dan aman intubasi yang dilakukan dengan CVL dan laringoskop langsung Macintosh (MDL) pada pasien hipertensi yang menjalani operasi.
Metode: Studi prospektif, acak, dan intervensional ini dilakukan pada 140 pasien hipertensi yang menggunakan obat antihipertensi dan menjalani operasi elektif dengan anestesi umum. Pasien dibagi menjadi dua kelompok yaitu, grup CVL (n = 70) dan grup MDL (n = 70). Parameter hemodinamik, seperti tekanan darah rata-rata (MAP), denyut jantung rata-rata (HR), tekanan darah sistolik (SBP), dan tekanan darah diastolik (DBP), diperiksa pada awal, saat induksi, dan pada beberapa waktu setelah intubasi (menit ke-1, 2, 3, 4, 5, dan 10). Parameter lain seperti waktu intubasi, jumlah percobaan intubasi, kemudahan intubasi, dan komplikasi yang terkait juga didokumentasikan.
Hasil: Terdapat perbedaan signifikan pada denyut jantung antara kedua kelompok pada saat intubasi dan menit ke-1, 2, dan 3 setelah intubasi (nilai p: 0,011; 0,028; 0,002; 0,003). SBP menunjukkan perbedaan signifikan pada saat intubasi dan selama empat menit pertama pasca-intubasi (nilai p < 0,001, kecuali menit ke-4, p = 0,001). DBP dan MBP juga menunjukkan perbedaan signifikan pada berbagai interval pasca-intubasi (nilai p < 0,001 hingga 0,025 dan < 0,001 hingga 0,020, secara berturut-turut). Tidak ditemukan perbedaan signifikan dalam komplikasi jalan napas.
Kesimpulan: CVL lebih menguntungkan daripada MDL untuk pasien dengan hipertensi terkontrol, terutama dalam mengurangi perubahan hemodinamik selama intubasi tanpa menambah komplikasi jalan napas.

Kata kunci: Tekanan darah; Video-laringoskop ClearVue®; Respons hemodinamik; Laringoskop Macintosh

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INTRODUCTION

Laryngoscopy and endotracheal intubation are critical skills for anesthesiologists, especially for unconscious and critically ill patients. However, these procedures can stimulate the sympathetic nervous system, leading to increased catecholamine levels and adverse cardiovascular effects like arrhythmia, hypertension, and tachycardia. The hemodynamic changes during laryngoscopy and intubation are influenced by factors such as oropharyngo-laryngeal stimulation and the force and duration of laryngoscopy. These responses typically begin within 5 seconds, peak within 1-2 minutes, and return to baseline within 5 minutes.

Hypertensive patients are particularly vulnerable to exaggerated catecholamine release, which can increase myocardial oxygen demand and decrease oxygen supply, potentially causing severe cardiovascular events like cardiac arrhythmias, myocardial infarction, pulmonary edema, and cerebrovascular hemorrhage (1–3). Patients with high blood pressure often have hardening of the arteries and poor blood flow in the throat nerves, making their airway tissues more likely to get hurt during intubation (4).

The Macintosh laryngoscope has long been the gold standard for laryngoscopy and intubation (5), requiring precise alignment of the oral, pharyngeal, and laryngeal axes and significant force (about 5.4 kg) to expose the glottis. However, newer devices like video laryngoscopes (VL) require significantly less force (0.5-1.4 kg), offering superior laryngeal visualization without the need for such alignment. This reduces oropharyngo-laryngeal stimulation and mitigates the pressor response.

Laryngoscopy and intubation-related stress response can be minimized by several medications such as beta-blockers, clonidine, lignocaine, propofol, and opioids, but nowadays different intubating skills are available, like video laryngoscopy and fiber-optic intubation.

Drugs such as beta-blockers, clonidine, lignocaine, propofol, and opioids are effective in reducing the stress response associated with laryngoscopy and intubation. Modern intubation techniques, such as video laryngoscopy and fiber-optic intubation, enhance patient safety and comfort by reducing the associated stress response, highlighting the importance of adopting these advanced methods (6).

METHODS

This prospective, randomized, interventional study was conducted at Swai Man Singh Medical College, Jaipur, India, from August to October 2023. This research has obtained approval from the office of the ethics committee, Swai Man Singh Medical College and attached hospitals, Jaipur (No. 403/MC/EC/2023, dated April 21st, 2023) and the trial was registered under the Clinical Trial Registry (CTRI) of India with registration number CTRI/2023/06/053510. Informed written consent was obtained from all patients considered for inclusion in the study.

Inclusion criteria included patients of either sex, aged 30 to 60 years, with controlled hypertension (blood pressure (BP) < 140/90 mm Hg) on antihypertensive medications and classified as American Society of Anesthesiologist (ASA) Grade II, planned for scheduled surgery under general anesthesia (GA) involving endotracheal intubation.

Criteria for exclusion included the presence of an anticipated difficult airway or intubation (inter-incisor gap < 2.5 cm, Mallampati Grade (MPG) grading 3 & 4), obesity (body mass index (BMI) > 30 kg/m^2), history of coronary artery disease, cervicospinal disease, gastroesophageal reflux, chronic respiratory, kidney, and liver diseases, pregnancy, drug allergy, and patients requiring rapid sequence induction (RSI).

Patients were divided into 2 groups using a computer-generated random number sequence list: CVL group (n = 70), intubated with ClearVue® video laryngoscope, and MDL group (n = 70), intubated with Macintosh direct laryngoscope.

All patients underwent evaluation by a cardio-physician to optimize their medication for

hypertension and exclude other cardiovascular conditions. At the pre-anesthetic check (PAC) clinic, selected patients were instructed to fast for 8 hours, continue their antihypertensive medications on the preceding night and the morning of surgery with a small amount of water, and take 0.25 mg of Alprazolam the night before surgery. A comprehensive preanesthetic assessment was conducted, including a detailed airway assessment. Measurements such as Modified Mallampati scores (MMP), thyromental distances, and inter-incisor distances were recorded, along with the patients' antihypertensive medication regimens.

Upon arrival in the operating theatre, the patient's fasting status, written informed consent, pre-anesthetic evaluation, and the antihypertensive medication taken before surgery were verified. Standard monitoring devices, including non-invasive blood pressure (NIBP), SPO2, and echocardiography (ECG) were applied, and baseline hemodynamic parameters such as heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and SPO2 were documented. An intravenous cannula was also inserted.

The patients were premedicated with intravenous metoclopramide (0.2 mg/kg), midazolam (0.02 mg/kg), glycopyrrolate (0.01 mg/kg), and fentanyl (2 mcg/kg). Pre-oxygenation was performed with 100% oxygen for 3-5 minutes. Hemodynamic parameters were recorded prior to induction, which began with intravenous propofol (2 mg/kg), and then they used atracurium (0.5 mg/kg) to relax the muscles.

Adequate mask ventilation was assured, and laryngoscopy was performed using either the Macintosh or CVL according to the assigned group. Modified Cormack and Lehane grading, intubation time, number of attempts, need for external laryngeal manipulations, and ease of the intubation score were noted. The correct position of the tube was confirmed by 5-point auscultation and $EtCO_2$ readings. Hemodynamic parameters were recorded at specified intervals: during intubation and at 1, 2, 3, 4, 5, 10 minutes post-intubation. Complications, including esophageal intubation, mucosal bleeding, lip and dental injury, episodes of desaturation (SPO2 < 92%), ischemia, and bronchospasm, were also documented.

Anesthesia was maintained with sevoflurane (1.5–2.0%) and a 50:50 mixture of O_2:N_2O, along with a maintenance dose of Inj. Atracurium (0.1 mg/kg). At the conclusion of the surgery, all anesthetic agents were stopped, and reversal was achieved using Inj. Neostigmine (0.06 mg/kg) and Inj. Glycopyrrolate (0.01 mg/kg). Patients were then extubated and transferred to the recovery room.

RESULTS AND DISCUSSION

A total of 140 patients (controlled hypertensives) of either sex, with age group 30 to 60 years, belonging to ASA Grade II and Mallampati Grade 1 & 2, scheduled to undergo elective surgery under general anesthesia requiring oral endotracheal intubation.

There were no statistically significant differences in the demographic parameters (age, sex, weight, ASA grading), airway examination (Inter-incisor gape, Mallampati Grade), CL grading, number of attempts required for intubation, and the difference in complications [Table 1].

We observed a statistically significant difference between Group CVL and Group MDL in terms of external laryngeal manipulation (ELM) with p-value < 0.001 (S). In Group CVL, consisting of all 70 subjects (100%), did not required during intubation. Conversely, in Group MDL, which comprised 25 out of 70 subjects (35.7%) required ELM (non-comparable). All intubations were done on the first attempt in both groups. We observed a statistically significant difference between Group CVL and Group MDL in terms of mean insertion time. It was higher in the case of Group CVL at 18.99 ± 3.40 seconds, while in the case of Group MDL, it was 13.98 ± 2.78 seconds (p = 0.001) (non-comparable).

Table 1. Demographic Data

Parameters	Group CVL (n=70)	Group MDL (n=70)	p-Value
Age (years) (mean ± SD)	44.23 ± 12.63	44.53 ± 12.15	0.714**
Sex			
Male [n (%)]	54 (77.14)	53 (75.71)	1.00*
Female [n (%)]	16 (22.86)	17 (24.29)	
Weight (kg) (mean ± SD)	71.6 ± 11.81	69.21 ± 10.77	0.214**
Height (cm) (mean ± SD)	163.8 ± 11.29	162.2 ± 12.14	0.425**
Mallampati Grade			
MMP l [n (%)]	36 (51.4)	30 (42.9)	0.397*
MMP ll [n (%)]	34 (48.6)	40 (57.1)	
Modified Cormack–Lehane (CL) Grading			
Grade 1 [n (%)]	37 (52.9)	25 (35.7)	0.0397*
Grade 2a [n (%)]	33 (47.1)	45 (64.3)	
Antihypertensive Medication Status			
CCBs [n (%)]	50 (71.4)	49 (70)	0.688**
βBs [n (%)]	2 (2.9)	6 (8.6)	
CCBs + βBs [n (%)]	15 (21.4)	12 (17.1)	
CCBs + TZ [n (%)]	3 (4.3)	3 (4.3)	

*Results of the chi-square test, it is significant if $\alpha < 0.05$
**Results of the independent T-test, it is significant if $\alpha < 0.05$
CCBs: Calcium channel blockers; βBs: β Blockers; ARBs: Angiotensin II receptor blockers; Th: Thiazides; MMP: Modified Mallampati grade; SD: Standard deviation; $P < 0.05$ is considered significant.

We observed a statistically significant difference between Group CVL and Group MDL in terms of ease of intubation. In the CVL group, all 70 patients underwent intubation effortlessly, while in the MDL group, 45 patients experienced (non-comparable) easy intubation and 25 patients reported satisfactory-grade ease of intubation (non-comparable) [Table 2].

Table 2. Airway Management Observation

Variable	Group CVL (n=70)	Group MDL (n=70)	p-Value
Mean Intubation Time [mean ± SD]	18.99 ± 3.40	13.98 ± 2.78	**<0.001***
Number of Attempts Required	1	1	-
External Laryngeal Manipulation			
Yes [n (%)]	0 (0)	25 (35.71)	**<0.001****
No [n (%)]	70 (100)	45 (64.29)	
Ease of Intubation			
Easy [n (%)]	70 (100)	45 (64.29)	**<0.001****
Satisfactory [n (%)]	0 (0)	25 (35.71)	
Difficult [n (%)]	0 (0)	0 (0)	

*Results of the independent T-test, it is significant if $\alpha < 0.05$
**Results of the chi-square test, it is significant if $\alpha < 0.05$

At baseline, before intubation, both CVL and MDL groups exhibited comparable heart rates, with means of 86.51 x/min and 85.86 x/min, respectively. However, upon intubation, there was a notable divergence in heart rate dynamics between the two groups. Following intubation, at the first minute, the heart rate for the CVL group remained relatively stable, showing a minor increase to 86.61 beats per minute, whereas the MDL group experienced a more pronounced elevation to 92.94 beats per minute. This trend continued with successive minutes, with the MDL group showing consistently higher heart rates compared to the CVL group [Figure 1]. Statistical analysis revealed significant differences between the groups at all time points post-intubation up to three minutes, with p-values ranging from 0.011 to 0.003, denoted as statistically significant (S). However, beyond the three minutes, the disparity diminished, with p-values exceeding 0.05,

indicating no significant difference in heart rate between the two groups. Overall, these findings suggest that intubation induces a notable transient increase in heart rate, with the response being more pronounced in patients with MDL compared to those with CVL [Table 3].

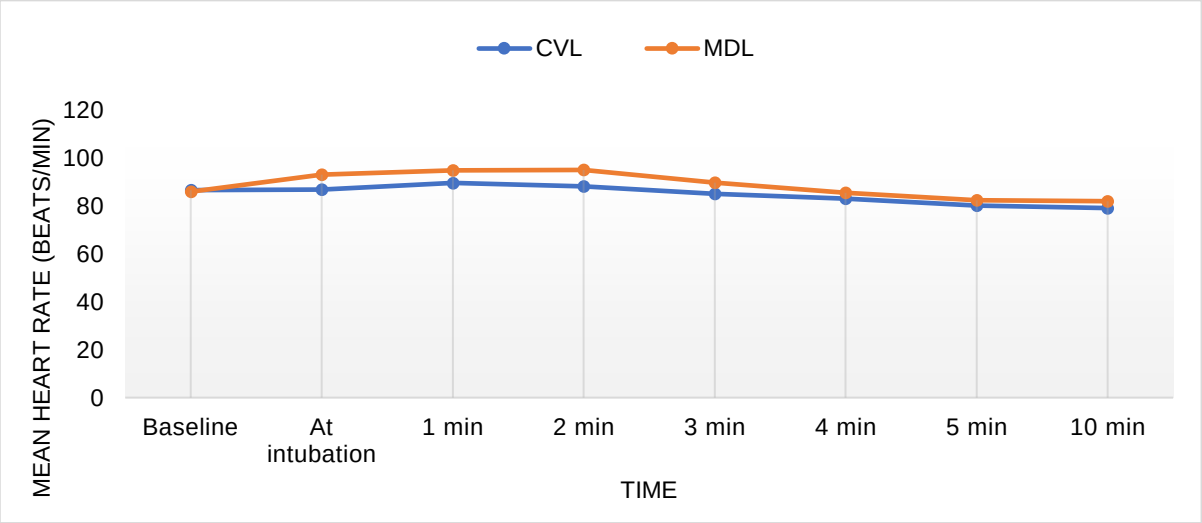

Figure 1. Mean Heart Rate (beats per minute) Over Time Following Intubation Using CVL and MDL
The graph shows the mean heart rate (HR) in beats per minute at various time points: baseline, at intubation, and 1, 2, 3, 4, 5, and 10 minutes post-intubation. The blue line represents the CVL group, while the orange line represents the MDL group.

Similarly, significant differences were noted in systolic blood pressure (SBP) at the time of intubation and during the first four minutes post-intubation, with p-values consistently below 0.001 except for the fourth minute ($p = 0.001$). Furthermore, DBP showed significant differences at the time of intubation and throughout the first five minutes post-intubation, with p-values ranging from < 0.001 to 0.049. Additionally, MAP [Figure 2] exhibited significant differences between the groups at the time of intubation and during the first four minutes post-intubation, with p-values ranging from < 0.001 to 0.008, and at five-minute p-values of 0.020 (non-comparable). [Table 3]

In our study, we found that the use of CVL resulted in a significantly smaller increase in blood pressure following intubation compared to MDL. The hemodynamic response to intubation results from the stimulation of oropharyngeal structures during laryngoscopy and the tracheal stimulus caused by the insertion of the endotracheal tube. The design of the CVL blade, with its curvature, minimizes the need for precise alignment of the 3 axes (oral, pharyngeal, and laryngeal) during intubation, which in turn decreases the required upward lifting force to 0.5-1.5 kg, compared to 5.4 kg with the traditional Macintosh laryngoscope (7).

Our findings align with a study by Meshram T. M. et al. (5), which compared the Macintosh direct laryngoscope with the GlideoScope video laryngoscope (GVL) in controlled hypertensive patients undergoing orotracheal intubation. They also observed a significant difference in blood pressure (SBP, DBP, MAP) at intubation and at 1-, 2-, and 3-minute post-intubation, although there was no significant difference in heart rate at post-intubation intervals. GVL was associated with a reduced hemodynamic response compared to the Macintosh laryngoscope.

Similarly, our study's findings were consistent with the study by Jain P. et al. (8), which compared the hemodynamic response between direct laryngoscopy and video laryngoscopy in hypertensive patients. They found that video laryngoscopes induced fewer variations in hemodynamic response compared to direct laryngoscopy.

Video laryngoscopy requires less force on the upper airway, leading to a more even distribution of pressure across the blade. In contrast, with the MDL, the force is focused on the distal part of the blade, which is likely to result in a higher hemodynamic response (9,10). Various studies have demonstrated reduced cervical spine movement using video laryngoscopy compared to MDL (11). Video laryngoscopy provides a better view of the glottis, which reduces the need for excessive upward lifting force and makes the procedure easier for novice users (12).

Table 3. Hemodynamic Response to Intubation (mean ± SD)

Hemodynamic Parameters	Timeline							
	Baseline	**At Intubation**	**At 1 min**	**At 2 min**	**At 3 min**	**At 4 min**	**At 5 min**	**At 10 min**
Heart Rate (x/min)								
CVL group	86.51 ± 12.55	86.61 ± 14.73	89.49 ± 14.09	87.99 ± 12.43	84.93 ± 9.55	82.83 ± 11	80.14 ± 12.76	79 ± 12.18
MDL group	85.86 ± 12.54	92.94 ± 14.22	94.69 ± 13.86	94.89 ± 12.8	89.6 ± 9.01	85.27 ± 11.6	82.36 ± 9.28	81.86 ± 12.54
P-Value	0.757	**0.011**	**0.028**	**0.002**	**0.003**	0.203	0.242	0.174
Systolic Blood Pressure (mmHg)								
CVL group	129.04 ± 5.99	130.51 ± 8.15	131.34 ± 10.53	126.94 ± 19.97	120.64 ± 11.49	118.37 ± 14.51	116.16 ± 9.42	115.84 ± 10.42
MDL group	128.7 ± 5.52	147.81 ± 11.67	151.36 ± 10.93	140.77 ± 13.26	135.76 ± 13.38	127.41 ± 17.5	119.7 ± 12.25	117.57 ± 14.5
P-Value	0.725	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.001**	0.057	0.419
Diastolic Blood Pressure (mmHg)								
CVL group	84.14 ± 3.63	86.89 ± 5.74	87.67 ± 8.57	84.49 ± 8.31	78.96 ± 8.25	76.96 ± 10.42	73.93 ± 9.28	72.87 ± 8.15
MDL group	84.44 ± 3.97	93.14 ± 6.8	95.2 ± 8.35	94.83 ± 6.82	88.19 ± 7.52	80.13 ± 8.85	77.09 ± 7.05	75.4 ± 6.91
P-Value	0.641	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.054	**0.025**	0.050
Mean Arterial Pressure (mmHg)								
CVL group	99.11 ± 3.11	101.43 ± 5.48	102.23 ± 7.9	98.64 ± 10.01	92.85 ± 8.77	90.76 ± 11.53	88 ± 8.71	87.2 ± 8.54
MDL group	99.2 ± 3.5	111.37 ± 6.9	113.92 ± 7.65	110.14 ± 7.62	104.04 ± 7.96	95.89 ± 11.07	91.29 ± 7.72	89.46 ± 8.8
P-Value	0.878	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.008**	**0.020**	0.125
Spo2 (%)								
CVL group	98.96 ± 0.82	98.93 ± 0.82	99.07 ± 0.79	99.03 ± 0.8	99.03 ± 0.76	99.21 ± 0.81	99.03 ± 0.87	99.06 ± 0.8
MDL group	99.13 ± 0.8	98.94 ± 0.81	98.99 ± 0.86	99.17 ± 0.78	98.99 ± 0.81	99.2 ± 0.86	98.97 ± 0.83	99.07 ± 0.84
P-Value	0.213	0.981	0.539	0.286	0.747	0.920	0.692	0.918
Rate Pressure Product								
CVL group	11153.89 ± 1629.7	11297.51 ± 2011.73	11715.46 ± 1816.06	11195.64 ± 2489.21	10277.46 ± 1820.07	9831.94 ± 1970.51	8984.81 ± 1846.2	8758.83 ± 1306.59
MDL group	11040.03 ± 1616.74	13713.87 ± 2259.66	14695.04 ± 2184.54	13397.91 ± 2601.21	12216.9 ± 2229.12	10912.47 ± 2481.97	9876.14 ± 1717.82	9607.97 ± 1739.74
P-Value	0.679	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.005**	**0.004**	0.056

Results of the Independent T-test, it is significant if $\alpha < 0.05$

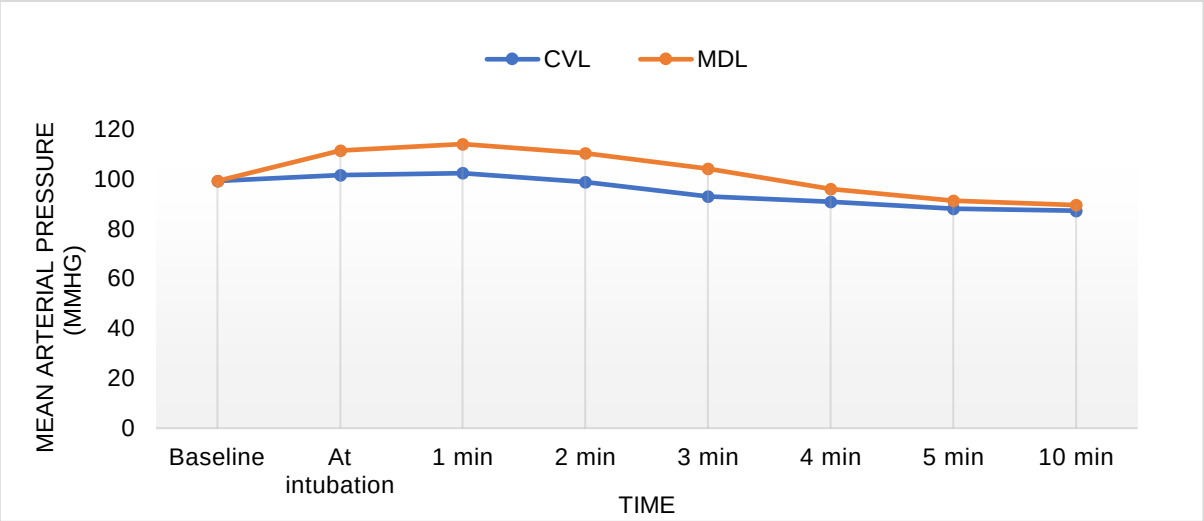

Figure 2. The graph illustrates the mean arterial pressure (MAP) Measured in millimeters of mercury (mmHg) at various time points: baseline, at intubation, and 1, 2, 3, 4, 5 and 10 minutes post-intubation. The blue line represents the CVL group, and the orange line represents the MDL group.

These studies focused exclusively on controlled hypertensive patients, with all intubations carried out by experienced hands. The anesthesiologist required less upward force to expose the glottis, which helped minimize the hemodynamic responses to laryngoscopy. In our study, the intubation time with CVL (18.99 ± 3.40 seconds) was significantly longer than with MDL (13.98 ± 2.78 seconds). The increased intubation time with CVL is attributed to the need for an intubating stylet to maintain the tracheal tube's curvature in alignment with the CVL blade. The stylet needs to be removed as soon as the tracheal tube reaches the larynx, which may lead to a longer intubation time (13). Furthermore, the blade's anterior curvature may cause the tracheal tube to become caught on the front wall of the upper trachea, requiring tube rotation for the removal of the CVL blade (14).

Samal R. L. et al. (15) compared the Truview video laryngoscope and Macintosh laryngoscope for endotracheal intubation and concluded that the mean intubation time was longer (37.16 ± 8.23 seconds) with video laryngoscopy compared to Macintosh laryngoscopy (29.80 ± 6.75 seconds; P = 0.025). Although intubation times were longer, the use of CVL did not lead to an increased hemodynamic response to tracheal intubation.

CVL minimizes complications during tracheal intubation by exerting less pressure on soft tissue structures and offering improved glottic visualization, thereby reducing the risk of esophageal intubation. The complication rates during laryngoscopy and intubation were comparable between the two groups.

The study's limitations include the involvement of an experienced anesthesiologist in performing tracheal intubations. Additionally, the lack of blinding and no data regarding the duration of hypertension and use of different antihypertensive treatments, so hemodynamic response may be different, included only ASA I and II patients, not including emergency intubation, awake, and obstetric patients, though challenging to implement in such research, could introduce bias. Furthermore, realize that a single proficient operator might introduce some degree of bias into the findings.

CONCLUSION

The CVL offers advantages over MDL in patients with controlled hypertension, specifically in reducing hemodynamic changes during intubation without increasing airway complications. At the same time, MDL offered less intubation time overall than CVL. Further research

should compare CVL and MDL to better balance blood pressure control and intubation speed in controlled hypertension.

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Conflict of Interest

The authors state that they have no conflicts of interest to disclose.

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This research did not receive any funding.

Authors' Contributions

RKV, SM, JS, and RKS were involved in the study's conception and design, data collection and analysis, and drafting and revising the manuscript with significant intellectual contributions. The authors also provided administrative, technical, and material support, conducted the literature review, oversaw the study, coordinated its execution, and approved the final manuscript for submission.

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Original Research Article

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PROPHYLACTIC EFFECTIVENESS OF PHENYLEPHRINE 100 MCG AND EPHEDRINE 10 MG ON THE INCIDENCE OF SPINAL ANESTHESIA INDUCED HYPOTENSION IN PATIENTS UNDERGOING CESAREAN SECTION

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ABSTRACT

Introduction: Birth by cesarean section (C-section) has increased significantly, with a high risk of maternal hypotension due to spinal anesthesia.
Objective: This study aims to compare the prophylactic effectiveness of phenylephrine 100 mcg and ephedrine 10 mg in preventing spinal anaesthesia induced hypotension in C-section patients. With a focus on safety and reducing the incidence of fetal acidosis, the results of the study are expected to provide clinical insights that can improve the safety and quality of care for pregnant women undergoing this procedure.
Methods: This study compared the effectiveness of phenylephrine 100 mcg and ephedrine 10 mg in preventing hypotension due to spinal anesthesia in cesarean section patients in four hospitals in Medan, Indonesia. Using a double-blind design, 40 patients aged 18-40 years were randomly selected, and blood pressure and heart rate were measured before and after anesthesia. Data were analyzed using SPSS, and ethical aspects were taken care of through informed consent.
Results: This study found that phenylephrine 100 mcg was more effective than ephedrine 10 mg in preventing spinal anaesthesia induced hypotension in cesarean section, with more stable blood pressure and mean arterial pressure (MAP) at the 5th, 10th, and 15th minutes (p-value < 0.05). Although ephedrine remained above 100 mmHg for systolic blood pressure (SBP), the incidence of nausea and vomiting was slightly higher in the ephedrine group. Results support phenylephrine as the primary choice for hypotensive management.
Conclusion: Phenylephrine 100 mcg is more effective than ephedrine 10 mg in preventing hypotension due to spinal anesthesia, without increasing heart rate. Despite causing nausea, ephedrine has a higher incidence of vomiting. Ephedrine is recommended if phenylephrine is not available, with further studies needed for lower doses of phenylephrine.

Keywords: Cesarean section; Ephedrine; Hypotension; Phenylephrine; Spinal Anaesthesia

ABSTRAK

Pendahuluan: Kelahiran melalui seksio sesarea (C-section) mengalami peningkatan signifikan, dengan risiko hipotensi maternal yang tinggi akibat anestesi spinal.
Tujuan: Penelitian ini bertujuan untuk membandingkan efektivitas profilaksis fenilefrin 100 mcg dan efedrin 10 mg dalam mencegah hipotensi yang dipicu oleh anestesi spinal pada pasien C-section. Dengan fokus pada keamanan dan pengurangan insiden asidosis janin, hasil penelitian diharapkan memberikan wawasan klinis yang dapat meningkatkan keselamatan dan kualitas pelayanan bagi ibu hamil yang menjalani prosedur ini.
Metode: Penelitian ini membandingkan efektivitas fenilefrin 100 mcg dan efedrin 10 mg dalam mencegah hipotensi akibat anestesi spinal pada pasien seksio sesarea di empat rumah sakit di Medan, Indonesia. Dengan desain *double-blind*, 40 pasien berusia 18-40 tahun diambil secara acak dan diukur tekanan darah serta denyut jantung sebelum dan sesudah anestesi. Data dianalisis menggunakan SPSS, dan aspek etika dijaga melalui informed consent.
Hasil: Penelitian ini menemukan bahwa fenilefrin 100 mcg lebih efektif daripada efedrin 10 mg dalam mencegah hipotensi akibat anestesi spinal pada seksio sesarea, dengan tekanan darah dan tekanan darah rata-rata (MAP) yang lebih stabil pada menit ke-5, ke-10, dan ke-15 (p-value < 0,05). Meskipun tekanan darah tetap di atas 100 mmHg untuk tekanan darah sistolik (SBP), kejadian mual dan muntah sedikit lebih tinggi pada kelompok efedrin. Hasil mendukung fenilefrin sebagai pilihan utama untuk manajemen hipotensi.
Kesimpulan: Fenilefrin 100 mcg lebih efektif daripada efedrin 10 mg dalam mencegah hipotensi akibat anestesi spinal, tanpa meningkatkan denyut jantung. Meskipun menyebabkan mual, efedrin memiliki insiden muntah lebih tinggi. Penggunaan efedrin disarankan jika fenilefrin tidak tersedia, dengan penelitian lebih lanjut diperlukan untuk dosis fenilefrin yang lebih rendah.

Kata kunci: *Cesarean section*; Efedrin; Hipotensi; Fenilefrin; Anaesthesi spinal

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INTRODUCTION

Births by cesarean section (C-section) have seen a significant increase in recent decades. In England and Wales, data from the National Sentinel Caesarean Audit shows that C-section rates increased from 4% in the early 1960s to 21% in 2001, accounting for 32,222 births out of a total of 150,139 deliveries (1). The Indonesian Basic Health Research (*Riset Kesehatan Dasar*/RISKESDAS) 2018 recorded that the C-section delivery rate was 17.6%, with North Sumatra province recording the highest rate at 23.9% (2).

The safety of anesthesia for C-sections has improved considerably, with a decrease in anesthesia-related maternal mortality. However, the incidence of hypotension remains a significant problem, with the incidence reaching 25-75% in patients undergoing spinal anesthesia, and approximately 60-70% in C-section patients (3,4). Maternal hypotension can affect uteroplacental perfusion, potentially leading to serious complications such as fetal asphyxia and impaired acid-base status (4,5).

Spinal anesthesia is the primary choice for C-section, but side effects such as hypotension need to be well managed. Various approaches have been considered to prevent this problem, including intravenous fluid administration and the use of vasopressors. Ephedrine and phenylephrine are two commonly used vasopressors, each with a different mechanism of action and side effect profile (4,6). Phenylephrine, in particular, shows better potential in reducing the incidence of foetal acidosis compared to ephedrine, thus, it is increasingly recommended as the first choice in hypotensive management (5,7).

Some studies suggest that phenylephrine is more effective in preventing hypotension after spinal anesthesia. Research conducted by Veeser et al. found that the use of ephedrine increased the risk of fetal acidosis five-fold compared to phenylephrine (8). In addition, the study by Muneer et al. also indicated that phenylephrine has a better safety profile with a lower incidence of fetal acidosis (9,10).

This study aims to compare the effectiveness of phenylephrine 100 mcg prophylaxis with ephedrine 10 mg in preventing the incidence of spinal anaesthesia induced hypotension in patients undergoing C-section. The results of the study are expected to provide new insights that are useful in clinical practice and improve the safety and quality of service for pregnant women undergoing C-sections.

METHODS

In this study, a cross-sectional observational analytic design was used. During July to August 2024, this study was conducted to evaluate the relationship between pain assessment with delirium using the critical-care pain observation tool (CPOT) scale and the confusion assessment method for the intensive care unit (CAM-ICU) in intubated patients. The study has been done in the Intensive Care Unit (ICU) of 4 hospitals in Medan, Indonesia, namely H. Adam Malik General Hospital, Prof. Dr. Chairuddin P. Lubis Hospital Medan, Haji Hospital Medan, and Dr. Pirngadi Hospital Medan City, after obtaining ethical clearance from the Universitas Sumatera Utara ethics committee for the implementation of health research No. 811/KEPK/USU//2024 dated 04th July 2024. This study also obtained ethical clearance and research permits from each multi-center institution with the following ethical research permit number information:

1. H. Adam Malik General Hospital, No. DP.04.03/D.XXVIII/6822/2024, dated 01st August 2024
2. Prof. Dr. Chairuddin P. Lubis Hospital, No. 3056/UN5.5.6.D2/PPM/2024, dated 24th July 2024
3. Haji Hospital Medan, No. 196/PSDM/RSUHM/VII/2024, dated 16th July 2024
4. Dr. Pirngadi Hospital Medan City, No. 161/B.LitBang/2024, dated 17th July 2024

The sample was drawn based on the predetermined inclusion and exclusion criteria, and the sample size was calculated using the formula for the relationship test (11). Inclusion criteria were intubated adult patients aged 18-40 years old who underwent elective cesarean section with spinal anesthesia technique and were admitted to the ICU. Exclusion criteria were vegetative patients, patients or patients' families who refused to participate in the study. The sample size estimate is calculated according to the sample formula for the relationship test:

$$n_1 = n_2 = 2\{\frac{(1{,}96+0{,}84)11{,}32}{117{,}2-106{,}43}\}^2$$

$$n_1 = n_2 = 2\{\frac{31{,}696}{10{,}77}\}^2$$

$$n_1 = n_2 = 16{,}82$$

$$n_1 = n_2 = 17$$

The results of the sample formula calculation obtained n1 = n2 = 17 samples. To anticipate drop out, 10% of the 17 samples needed were added. This resulted in each group requiring 19 samples, with a minimum total sample requirement of 38 samples. The sampling technique was performed using the simple random sampling method, ensuring that all subjects met the specified criteria.

In the course of the study, patients will be randomly divided into two groups: the phenylephrine group, receiving 100 mcg of phenylephrine and ephedrine group, receiving 10 mg of prophylactic ephedrine. The procedure begins with the measurement of blood pressure and heart rate before and after spinal anesthesia, at predetermined times. The data obtained from the measurements will be analyzed using SPSS software version 29, where descriptive and inferential analyses will be performed to assess the differences between the two groups.

The ethical aspects of the study were maintained by providing informed consent to each participant, explaining the purpose, benefits, and risks of the study. During the study, emergency management procedures were also in place to ensure patient safety. The results of this study are expected to provide significant information regarding the effectiveness of both prophylactic drugs in preventing spinal anaesthesia induced hypotension.

RESULTS AND DISCUSSION

This study was conducted from July to August 2024 in 40 people. The sample was divided into two groups of 20 people each. Subject characteristics showed that in the phenylephrine group, the mean age was 30.8 ± 5.1 years. This study utilizes body weight in kilograms as a reference, as the dosage of medication administered to pregnant women is adjusted according to their weight. Additionally, the study does not employ Body Mass Index (BMI) as a reference, considering that the subjects are pregnant women. This decision is based on concerns that BMI calculations for all subjects may indicate obesity. Mean body weight was 65.65 ± 8.5 kg, and the mean height was 157.45 ± 3.9 cm. In contrast, in the ephedrine group, the mean age was 30 ± 5.04 years, the mean body weight was 67.45 ± 6.8 kg, and the mean height was 159.4 ± 5.38 cm.

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Table 1. Characteristics of research subjects

Characteristics	Group		p-value*
	Phenylephrine (n=20)	Ephedrine (n=20)	
Age (years) [mean ± SD]	30.8 ± 5.1	30 ± 5.04	0.464*
Body Weight (kg) [mean ± SD]	65.65 ± 8.5	67.45 ± 6.8	0.613*
Height (cm) [mean ± SD]	157.45 ± 3.9	159.4 ± 5.38	0.612*
Gravida [n (%)]			
1st pregnant	11 (27.5)	5 (12.5)	
2nd pregnant	4 (10)	6 (15)	0.974**
3rd pregnant	4 (10)	7 (17.5)	
4th pregnant	1 (2.5)	2 (5)	
Pregnancy Age [n (%)]			
37-38 weeks	8 (20)	7 (17.5)	0.526**
38-39 weeks	5 (12.5)	5 (12.5)	
39-40 weeks	2 (5)	13 (32.5)	

*Results of the Independent T-test, it is significant if $\alpha < 0.05$
**Results of the Chi-square test, it is significant if $\alpha < 0.05$

Analysis based on gravida and gestational age showed that in the phenylephrine group, the majority of patients were first gravida, with 11 people (40%) and a gestational age of 38-39 weeks, as many as 10 people (50%). In the ephedrine group, most patients were 3rd gravida, with 7 individuals (35%) and a gestational age of 39-40 weeks, including 13 individuals (65%). These data show that both groups had no statistically significant differences between the two groups for age, body weight, height, gravida status, and pregnancy age, as all p-values are greater than the significance level of $\alpha < 0.05$ [Table 1].

Table 2 shows the results of systolic blood pressure measurements, which show that phenylephrine is more effective than ephedrine in maintaining systolic blood pressure (SBP). At the 5th minute (T1), 10th minute (T2), and 15th minute (T3), the phenylephrine group showed higher blood pressure values with statistically significant differences (p-value < 0.05). Although the ephedrine group experienced a decrease in blood pressure over time, they were still able to maintain SBP above 100 mmHg.

Table 2. Comparison of Systolic Blood Pressure in the Phenylephrine 100 mcg and Ephedrine 10 mg Prophylaxis Groups

SBP	Group		p-value*
	Phenylephrine (n=20)	Ephedrine (n=20)	
0th minute (T0)	126.75 ± 11.77	122.25 ± 7.8	0.188
5th minute (T1)	125.35 ± 7.0	115.95 ± 6.86	0.001
10th minute (T2)	123.6 ± 7.64	110.5 ± 9.13	0.001
15th minute (T3)	124.05 ± 5.57	108.15 ± 9.58	0.0001

*Results of the Unpaired T-test, it is significant if $\alpha < 0.05$

Table 3 presents the results of diastolic blood pressure measurements between phenylephrine and ephedrine, which found that both drugs can maintain diastolic blood pressure (DBP) starting from the 5th minute (T1), 10th minute (T2), and 15th minute (T3) with statistically significant results, p-value < 0.05. The DBP measurement in the phenylephrine group was higher than in the ephedrine group.

Table 3. Comparison of Diastolic Blood Pressure in the Phenylephrine 100 mcg and Ephedrine 10 mg Prophylaxis Groups

DBP	Group		p-value*
	Phenylephrine (n=20)	Ephedrine (n=20)	
0th minute (T0)	80.15 ± 6.25	77.05 ± 7.3	0.186
5th minute (T1)	76.95 ± 6.5	76.85 ± 7.56	0.001
10th minute (T2)	77.8 ± 1.04	68.85 ± 7.44	0.001
15th minute (T3)	75.1 ± 1.7	67.4 ± 7.92	0.006

*Results of the Unpaired T-test, it is significant if $\alpha < 0.05$

Mean Arterial Pressure (MAP) between phenylephrine and ephedrine was found to increase MAP in the phenylephrine group higher than ephedrine at the 5th minute (T1), 10th minute (T2), and 15th minute (T3) with a statistically significant difference *p-value* < 0.05. MAP in the phenylephrine group remained > 90mmHg while in the ephedrine group > 80mmHg [Table 4].

Table 4. Comparison of Mean Arterial Pressure in the Phenylephrine 100 mcg and Ephedrine 10 mg Prophylaxis Groups

MAP	Group		p-value*
	Phenylephrine (n=20)	Ephedrine (n=20)	
0th minute (T0)	96.55 ± 7.9	86.3 ± 13.63	0.092
5th minute (T1)	91.8 ± 5.5	85.95 ± 5.8	0.006
10th minute (T2)	91.75 ± 5.92	82.75 ± 7.61	0.001
15th minute (T3)	93 ± 5.56	82.45 ± 10.15	0.001

*Results of the Unpaired T-test, it is significant if $\alpha < 0.05$

Table 5 shows the results of measuring the average heart rate between the phenylephrine and ephedrine groups. There was an increase in the average heart rate in the ephedrine group starting at minute 10 (T2) and minute 15 (T3).

Table 5. Comparison of Heart Rate in the Phenylephrine 100 mcg and Ephedrine 10 mg Prophylaxis Groups

Heart Rate	Group		p-value*
	Phenylephrine (n=20)	Ephedrine (n=20)	
0th minute (T0)	86.8 ± 6.13	80.6 ± 6.9	0.007
5th minute (T1)	82.35 ± 7.52	85.9 ± 5.47	0.124
10th minute (T2)	79.9 ± 7.6	92.5 ± 7.4	0.0001
15th minute (T3)	74.05 ± 6.21	98.9 ± 5.92	0.0001

*Results of the Unpaired T-test, it is significant if $\alpha < 0.05$

Table 6 presents the results of observations on the incidence of nausea and vomiting in the phenylephrine and ephedrine groups. Where in the phenylephrine group there were 5 people who were nauseous and 2 people who experienced vomiting. In the ephedrine group, 7 people were nauseated and 2 people were vomited.

Table 6. Frequency of Nausea and Vomiting in the Phenylephrine 100 mcg and Ephedrine 10 mg Prophylaxis Group

Side effects	Phenylephrine (n=20)	Ephedrine (n=20)	Total
Nausea	5 (41.6)	7 (58.3)	12 (100)
Vomiting	2 (50)	2 (50)	4 (100)

Vasopressors play a key role in managing spinal anesthesia induced hypotension, which is caused by sympathetic blockade and loss of arteriolar tone. Ephedrine has long been considered the best vasopressor to manage maternal hypotension. However, studies have shown that ephedrine may increase the risk of fetal acidosis by up to five times compared to phenylephrine. Nowadays, phenylephrine is gaining popularity as the primary choice in preventing and managing spinal anesthesia induced hypotension in cesarean section surgery, despite its potential to decrease heart rate and cardiac output due to its non-beta-mimetic mechanism of action.

In this study, blood pressure measurement results showed the prophylactic effectiveness of phenylephrine and ephedrine in preventing spinal anesthesia induced hypotension. Figures 1 and 2 provide a clear picture of the comparison, which supports the use of phenylephrine as a safer alternative despite the possible side effects. These results suggest that appropriate selection of vasopressors is essential to minimize risks to both mother and fetus during surgical procedures (6).

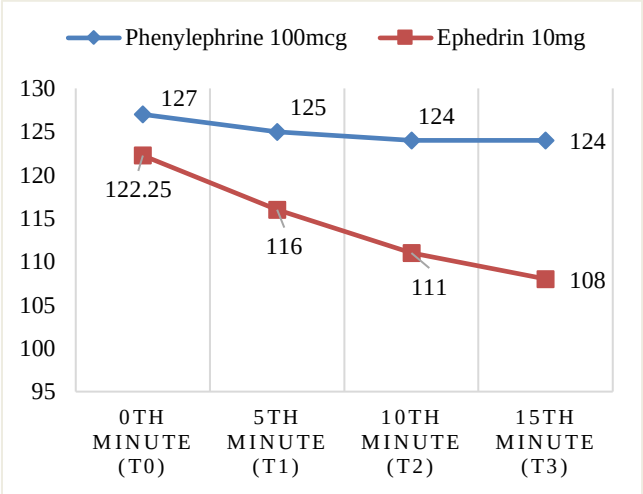

Figure 1. Comparison of Systolic Blood Pressure in the Phenylephrine 100 mcg and Ephedrine 10 mg Prophylaxis Groups

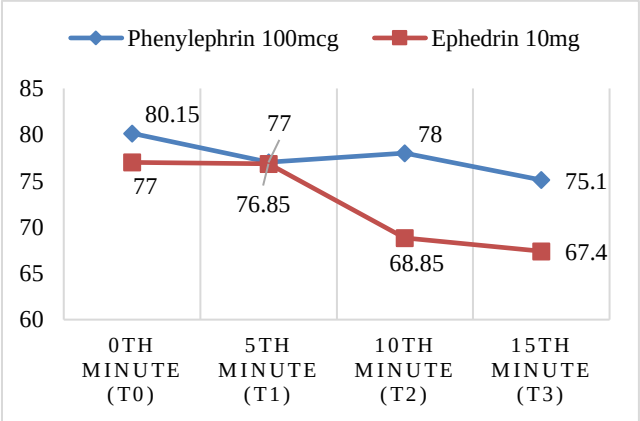

Figure 2. Comparison of Diastolic Blood Pressure in the Phenylephrine 100 mcg and Ephedrine 10 mg Prophylaxis Groups

Phenylephrine and ephedrine were effective in maintaining systolic blood pressure in spinal anesthesia patients, with significant results at minutes 5, 10, and 15 (p-value < 0.05). Phenylephrine was superior in maintaining systolic blood pressure compared to ephedrine, following the findings of Dusitkasem et al. (7) and Chauhan et al. (8) who noted an increase in

blood pressure after prophylactic administration. Phenylephrine works as an α1 adrenergic receptor agonist, whereas ephedrine functions as an agonist at α and β adrenergic receptors, which increases heart rate and cardiac output.

Both drugs also successfully maintained mean arterial pressure (MAP) significantly (p-value < 0.05) during the measurement. These results suggest that they can be effectively used to prevent spinal anaesthesia induced hypotension, as illustrated in Figure 3. The selection of appropriate prophylaxis is important to minimize the risk of complications during surgical procedures.

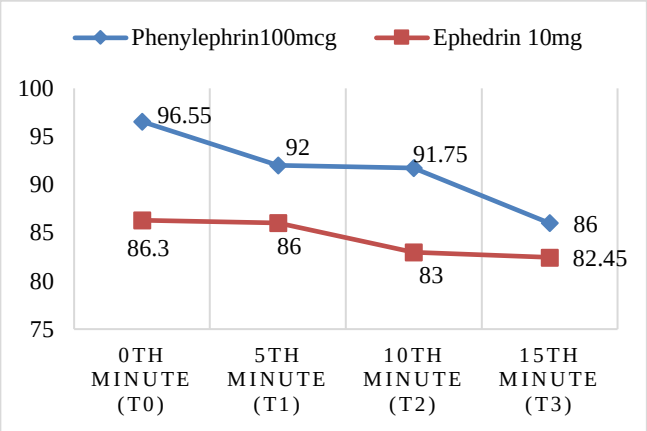

Figure 3. Comparison of Mean Arterial Pressure in the Phenylephrine 100 mcg and Ephedrine 10 mg Prophylaxis Groups

The results showed that both phenylephrine and ephedrine were effective in maintaining mean arterial pressure (MAP) during the prevention of spinal anesthesia induced hypotension, with p-value < 0.05 in all measurements. However, phenylephrine was superior, giving higher results. As an α-adrenergic agonist, phenylephrine increases systemic vascular resistance through sympathomimetic effects, while ephedrine has no major beta-mimetic effect but increases MAP through arteriolar vasoconstriction (6). These findings are in line with the study by Muneer et al. (12) which states that both drugs are effective in maintaining MAP, although phenylephrine shows superiority in this regard.

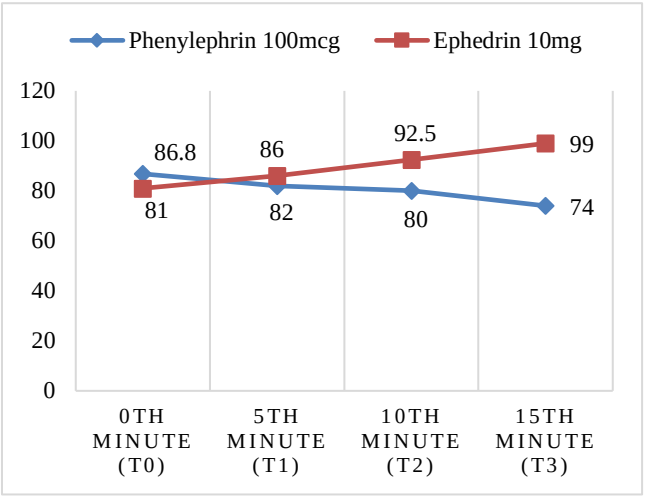

Figure 4. Comparison of Heart Rate in the Phenylephrine 100 mcg and Ephedrine 10 mg Prophylaxis Groups

The results showed that the heart rate in the group receiving phenylephrine prophylaxis decreased below 80x/min, while in the ephedrine group, it increased to above 90x/min. This can be seen in Figure 4. This finding is in line with Chauhan et al. (8), which noted that phenylephrine did not cause an increase in heart rate, while 19 out of 40 samples in the ephedrine group experienced an increase. The increase in heart rate caused by ephedrine was primarily due to its predominant effects on β1 receptors, whereas phenylephrine did not influence those receptors, resulting in a decrease in cardiac output. Although the decrease in cardiac output with phenylephrine may raise concerns regarding placental perfusion, the study suggests that higher cardiac output is needed in high-risk pregnant women (5,6).

Regarding side effects, the incidence of nausea and vomiting was higher in the ephedrine group, as also found by Chauhan et al. (8). Nausea and vomiting occurred even though systolic blood pressure did not fall below 100 mmHg, probably because no antiemetic was given as premedication. The study by Muneer et al. (12) found no significant difference in the incidence of nausea and vomiting between phenylephrine and ephedrine, and the study by Jaitawat et al. (5) showed that the incidence was not related to the dose of phenylephrine administered. A meta-

analysis by Chao et al. (13) also showed that the incidence of intraoperative nausea and vomiting was lower in the phenylephrine group.

This study found that prophylactic phenylephrine 100 mcg is more effective than ephedrine in preventing spinal anesthesia induced hypotension, mainly because phenylephrine does not increase heart rate excessively. This finding contradicts the meta-analysis by Dusitkasem et al (7) which stated that both drugs are equally effective in maintaining hemodynamics. Similar results were also found by Chao et al. (13), indicating that the effectiveness of both drugs is still a matter of debate.

Limitations in this study include the unavailability of phenylephrine at the sampling sites and the lack of data regarding the timing of the occurrence of adverse events of nausea and vomiting. Further studies are needed to elucidate the relationship between vasopressor administration and the incidence of adverse events and their impact on pregnant patients.

CONCLUSION

Phenylephrine 100 mcg is more effective as prophylaxis in preventing spinal anesthesia induced hypotension than ephedrine 10 mg, without excessively increasing heart rate. There were significant differences in systolic, diastolic, mean arterial pressure and heart rate between the two groups. Although phenylephrine caused nausea in some patients, ephedrine showed a higher incidence of vomiting. It is suggested that ephedrine should be used if phenylephrine is not available, and further studies are needed to compare lower doses of phenylephrine with ephedrine, taking into account cost-benefit aspects.

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Conflict of Interest

There is no conflict of interest in this study.

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The authors declared that this research has received no financial support.

Authors' contributions

All authors have contributed to all processes in this research.

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Original Research Article

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COMPARISON OF INTERCOSTAL NERVE BLOCK VERSUS PATIENT-CONTROLLED INTRAVENOUS ANALGESIA FOR POST-THORACOTOMY PAIN

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ABSTRACT

Introduction: Acute pain after thoracic surgery is frequent, intense and can raise morbidity. Effective postoperative pain control is essential to support early mobilization, optimal respiratory function, and recovery. Different pain relief methods, such as systemic opioids, patient-controlled analgesia, and intercostal nerve blocks, have been studied to reduce problems and enhance recovery for patients who have had thoracic surgery.
Objectives: This research aims to compare the difference in analgesic effect of intercostal nerve block (ICNB) versus patient-controlled intravenous analgesia (PCIA) for post-thoracotomy analgesia in cardiac surgery.
Methods: This prospective, single-blind, randomized comparative study involved 128 patients aged 30-60 years undergoing cardiac surgery through a thoracotomy under general anesthesia. Patients were randomly assigned to two groups. Group A received ICNB with 2.5 mg/kg of 0.5% ropivacaine and 0.5 mcg/kg fentanyl at the end of surgery; rescue analgesia with fentanyl 1mcg/kg was given if VAS score exceeded 4 within 24 hours post-intubation. Group B received PCIA with IV fentanyl (25 mcg/ml) at a basal rate of 1 ml/hour, with 1 ml bolus doses available every 15 minutes post-extubation for 24 hours. Pain was assessed using the Visual Analogue Scale (VAS), and total fentanyl consumption and sedation score were recorded. Significance level was kept at 95%.
Results: The demographic data were comparable between the two groups. The VAS score was significantly lower in the ICNB group than in the PCIA group (p value < 0.05). The total dose of fentanyl required in 24 hours after extubation was significantly higher in the PCIA group than in the ICNB group. The mean Ramsay sedation score was higher in the PCIA group compared to the ICNB group. Patients in ICNB group showed a lower incidence of side effects.
Conclusion: Our study suggests that the ICNB is more effective than PCIA for post-thoracotomy analgesia and also requires a lesser total dose of opioid.

Keywords: Fentanyl; Intercostal Nerve Blocks; Patient-Controlled Intravenous Analgesia; Thoracotomy

ABSTRAK

Pendahuluan: Nyeri akut setelah operasi torakotomi adalah hal yang sering terjadi, bersifat intens, dan dapat meningkatkan morbiditas. Pengendalian nyeri pascaoperasi yang efektif sangat penting untuk mendukung mobilisasi dini, fungsi pernapasan yang optimal, dan pemulihan pasien. Berbagai strategi analgesik, termasuk opioid sistemik, analgesia intravena yang dikendalikan pasien, dan blok saraf intercostal, telah dieksplorasi untuk meminimalkan komplikasi dan meningkatkan hasil pada pasien pembedahan toraks.
Tujuan: Penelitian ini bertujuan membandingkan efek analgesik antara blok saraf interkostal (ICNB) dan analgesia intravena terkendali (PCIA) untuk analgesia pasca torakotomi pada pembedahan jantung.
Metode: Penelitian ini merupakan studi prospektif, *single-blind*, dan acak terkontrol yang melibatkan 128 pasien usia 30-60 tahun yang menjalani operasi jantung melalui torakotomi dengan anestesi umum. Pasien dibagi secara acak menjadi 2 kelompok. Kelompok A menerima ICNB dengan 2,5 mg/kg ropivakain 0,5% dan 0,5 mcg/kg fentanil di akhir operasi; analgesia tambahan diberikan berupa fentanil 1 mcg/kg bila skor VAS > 4 dalam 24 jam pasca ekstubasi. Kelompok B menerima PCIA dengan IV fentanyl (25 mcg/ml) dengan laju infus basal 1 ml/jam dan bolus 1 ml tersedia setiap 15 menit selama 24 jam pasca ekstubasi. Skor nyeri diukur menggunakan Skala Analog Visual (VAS), total konsumsi fentanil, dan skor sedasi dicatat. Tingkat signifikansi ditetapkan pada 95%.
Hasil: Data demografis sebanding antara kedua kelompok. Skor VAS secara signifikan lebih rendah pada kelompok ICNB dibandingkan dengan kelompok PCIA (nilai p < 0,05). Dosis total fentanyl yang diperlukan dalam 24 jam setelah ekstubasi secara signifikan lebih tinggi pada kelompok PCIA dibandingkan dengan kelompok ICNB (nilai p < 0,05). Rata-rata skor sedasi Ramsay lebih tinggi pada kelompok PCIA dibandingkan kelompok ICNB. Pasien dalam kelompok ICNB menunjukkan insiden efek samping yang lebih rendah.
Kesimpulan: Studi kami menunjukkan bahwa Blok Saraf Interkostal lebih efektif daripada PCIA untuk analgesia pasca torakotomi dan juga memerlukan dosis total opioid yang lebih rendah.

Kata kunci: Fentanil; Blok saraf interkostal; Analgesia intravena terkendali; Torakotomi

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INTRODUCTION

Pain is the major concern for both the patient and the anesthesiologist in the perioperative period (1). Acute pain after thoracic surgery is common and severe, increasing morbidity (2). The pain hinders the patient from coughing effectively, breathing deeply, or moving. Severe post-operative pain, in general, increases post-operative complications and may lead to chronic pain (3). Optimal postoperative pain management for cardiothoracic surgery patients enables early mobilization, respiratory physiotherapy, and sufficient sleep. It also reduces stress, mechanical breathing time, stay duration in the hospital, and the risk of comorbidities like pneumonia, atelectasis, deep vein thrombosis, and cardiac ischemia (4). Systemic opioid-based treatment regimens, intramuscular or intravenous opioids, nonsteroidal anti-inflammatory drugs, per rectal administration of drugs, intercostal nerve block (ICNB), thoracic epidural block, thoracic paravertebral block, and erector spinae block are all options for controlling acute pain after thoracic surgery (1,3).

Patient-controlled analgesia (PCA) allows patients to self-administer modest bolus doses of opioids, allowing them to achieve effective blood concentrations as needed. It shortens the interval between pain perception and drug administration and reduces the overall analgesic dose necessary (1).

Morphine, tramadol, fentanyl, sufentanyl, oxycodone, and ketamine are among the drugs that can be utilized in a PCA pump. Continuous morphine infusion increases morphine intake, sedation, and, most likely, the prevalence of respiratory depression (5). Fentanyl has analgesic strength comparable to morphine, and its high lipid solubility shortens the onset time, making it suited for IVPCA. Unlike morphine, fentanyl does not create active metabolites that cause respiratory depression and has a shorter duration of effect. However, the use of IVPCA with fentanyl for acute post-thoracotomy pain management is still uncommon (6). Because nociception travels primarily through the intercostal nerves in the thorax, blockade of the intercostal nerve is used to provide analgesia after thoracic surgery. Intercostal nerve blocks are a regular component of multimodal analgesia following thoracic surgery (2).

Intercostal nerve blocks are an efficient means of relieving post-thoracotomy pain that can be performed using anatomic landmarks or ultrasound guidance (3). It offers technical simplicity, analgesia, enhanced pulmonary mechanics, less central nervous system depression, and avoidance of urine retention (5). It is also quite simple to perform and, when administered at the desired dermatome level, delivers segmental analgesia. Cardiac surgery by thoracotomy has the added benefit of allowing ICNB to be administered directly at the location before the surgical incision is closed. Ropivacaine has a low-fat solubility, cardiac and central nervous system toxicity (7), and is likely to provide a longer duration of anesthesia in digital nerve blocks than bupivacaine and lidocaine (5).

In this study, we compared the intercostal nerve block (ICNB) versus patient-controlled intravenous analgesia (PCIA) for relief of post-thoracotomy pain for adult cardiac surgery.

METHODS

This prospective, randomized, comparative study was conducted at a tertiary care cardiothoracic center after approval from the Institutional Ethical Committee No. 34/MC/EC/2021. The study was registered in the Clinical Trial Registry (CTRI/2022/10/046882). The study included 128 American Society of Anesthesiologists (ASA) physical status II-III patients in the age group of 30-60 years scheduled for an elective cardiac surgery through a thoracotomy incision. Written informed consent was obtained after a complete explanation of the study protocol and the procedures. Patients who had prior chest surgeries, were allergic to ropivacaine, could not complete the visual analogue scale (VAS) score, had trouble using the

PCIA pump, or did not provide informed consent were not included in the study.

Sample Size

A sample size of 64 patients in each group was required at 95% confidence and 80% power to verify the expected difference of 0.7±1.4 µg/kg in the mean difference of total amount of fentanyl used after surgery between the two groups (5). Pre-procedure complete blood counts, chest X-ray (CXRs), electrocardiogram (ECGs), and coagulation profiles were acquired for every patient.

Intravenous (IV) access was acquired, and standard monitors were connected after establishing nil per oral status. An internal jugular line & an arterial line were secured under local anesthesia. General anesthesia (GA) was induced with an injection of Midazolam 0.05 mg/kg, Fentanyl 3 mcg/kg, Etomidate 0.3 mg/kg and Rocuronium 0.9 mg/kg for pre-anesthetic drugs, intermittent positive pressure ventilation (IPPV) was done for 60 seconds, and the patient was intubated with a proper-size cuffed endotracheal (ET) tube. Following standard institutional policy, GA was maintained in conjunction with capnography and bispectral index monitoring. The hemodynamic parameters were maintained within 20% of baseline.

A computer-generated random number table was used to divide the patients into two groups of 64 each, and coded, opaque, and sealed envelopes were used to keep them concealed. VAS score, dose of fentanyl needed, and sedation score were assessed immediately, and 1, 2, 4, 6, 8, 10, 12, and 24 hours after extubation. Total dose of fentanyl, Time to first rescue analgesia, length of stay in the Intensive Care Unit (ICU) and side effects if any were assessed for 24 hours post-extubation.

A day prior to the procedure, the patient's complete medical and surgical history, including any known drug allergies, was obtained. Vital parameters (blood pressure, pulse rate, temperature and respiratory rate), and body weight of the patients were noted. Standard monitors were attached once intravenous (IV) access was secured after establishing nil per oral status. General anesthesia was given, and hemodynamic parameters were maintained within 20% of baseline.

Group A (ICNB)

After completion of surgery, an intercostal nerve block was given. The area between the adjacent ribs showed the contour of three layers of intercostal muscles: the innermost, internal, and external. The needle was then gently inserted and advanced into the innermost layer of intercostal muscle, and divided doses of 0.5% ropivacaine and 0.5 µg/kg fentanyl were given at the incisional level and two spaces below and above the incision [after negative aspiration for air or blood]. The total drug amounted to 2.5 mg/kg ropivacaine & 0.5 µg/kg fentanyl, and rescue analgesia was provided in the form of 1 µg/kg IV fentanyl whenever the VAS was ≥ 4.

Group B (PCIA)

IV fentanyl (25 µg/mL) at a basal infusion rate of 1mL/hour (fentanyl 25 µg/hour) was started after extubation, and a bolus of 1mL (fentanyl 25 µg) was given by patients him/herself whenever needed with a lockout interval of 15 minutes.

Statistical analysis

Categorical or nominal variables were summarized as numbers and proportions and were analyzed using the chi-square test or Fisher exact test as applicable. Continuous variables were summarized as mean and standard deviation and were analyzed using an independent sample t-test as applicable, for comparison between two groups. A p-value < 0.05 was taken as statistically significant.

RESULTS AND DISCUSSION

The study was conducted on 128 patients, were divided into 2 groups, each consisting of 64 patients. The demographic profile and baseline characteristics were comparable between the two

groups. There were no significant differences between age, weight, height, MAP, and heart rate (HR) of group A and group B [Table 1].

Table 1. Demographic and Baseline Data

Variable	Group A (ICNB)	Group B (PCIA)	p-Value
Age (Years)	42.61±10.12	42.14±8.9	0.781
Weight (kg)	61.78±12.68	61.63±11.12	0.941
Height (cm)	166.5±5.62	166.13±5.62	0.707
MAP	76.00±4.02	75.96±4.39	0.957
Heart Rate	103.56±15.8	97.77±14.6	0.052

*Result of the independent T-test, it is significant if α < 0.05

Total fentanyl dose requirement in 24 hours was higher in group B (648.44±35) than in group A (90.63±15) [Figure 1], and fentanyl mean dose requirements at different time intervals were significantly different (p < 0.001) in group A than in group B [Table 2].

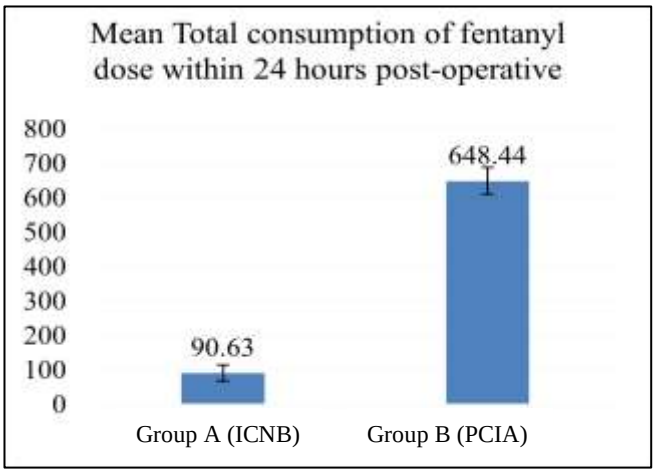

Figure 1. Mean total consumption of fentanyl (mcg) in the two groups in 24 hours

The mean time for first rescue analgesia requirement was significantly longer in group A (11.84±3.69) than in group B (3.59±1.34). In contrast with time of first rescue analgesia, the length of stay in the ICU was not statistically different, the mean was longer in group B than in group A [Table 3].

Table 2. Fentanyl dose (µg) between two groups in 24 hours

Time intervals	Group A (ICNB)	Group B (PCIA)	p-Value
Immediately after extubation	-	-	-
1st hour	-	-	-
2nd hour	2.81±5.77	27.34±7.34	**<0.001**
4th hour	3.43±5.47	64.45±13.22	**<0.001**
6th hour	4.84±5.34	67.97±18.08	**<0.001**
8th hour	7.34±6.66	59.38±12.2	**<0.001**
10th hour	23.43±9.03	51.56±6.1	**<0.001**
12th hour	30.15±12.68	53.13±11.36	**<0.001**
24th hour	13.35±12.43	-	-

*Result of the independent T-test, it is significant if α < 0.05

The mean postoperative VAS score at different time intervals in both study group was significantly higher in group B than group A at almost all times intervals (p value < 0.05) except at 10 hours. Mean sedation score in group B was significantly higher than in group A (p value < 0.05) at all intervals [Table 4].

Table 3. Time of first rescue analgesia requirement and length of stay in ICU

Variable	Group A (ICNB)	Group B (PCIA)	p-Value
Time for first rescue analgesia requirement (hour)	11.84±3.69	3.59±1.34	**<0.001**
Length of stay in ICU (day)	3.58±0.85	3.78±0.77	0.158

*Result of the independent T-test, it is significant if α<0.05

The incidence of nausea, vomiting, and pruritus was higher in group B than in group A, while this difference in proportion was significant for nausea only (p value < 0.05) and insignificant for vomiting and pruritus (p value > 0.05). None of the patients had respiratory depression and bradycardia [Table 5]. Hemodynamic parameter measured in this study was mean arterial pressure (MAP) between both the groups was comparable throughout the study periods [Figure 2].

Table 4. Mean VAS score and Mean sedation score at different time intervals

Time intervals	VAS Score		p-Value	Mean Sedation Score		p-Value
	Group A (ICNB)	Group B (PCIA)		Group A (ICNB)	Group B (PCIA)	
Immediately after extubation	1.98±0.58	1.91±0.5	0.697	1.8±0.16	2.89±0.36	**<0.001**
1st hour	2.16±0.54	2.88±0.33	**<0.001**	2.31±0.26	3.09±0.41	**<0.001**
2nd hour	2.78±0.42	4.52±0.59	**<0.001**	2.34±0.49	3.1±0.49	**<0.001**
4th hour	2.95±0.49	5.17±0.92	**<0.001**	2.53±0.52	3.15±0.5	**<0.001**
6th hour	2.97±0.25	5.03±0.99	**<0.001**	2.93±0.46	3.32±0.59	**<0.001**
8th hour	2.91±0.39	4.78±0.81	**<0.001**	2.57±0.48	3.51±0.74	**<0.001**
10th hour	4.09±1.26	3.02±0.13	**<0.001**	2.11±0.56	3.19±0.52	**<0.001**
12th hour	4.2±0.86	4.66±0.54	**<0.001**	1.95±0.34	2.81±0.41	**<0.001**
24th hour	4±0.78	4.61±0.58	**<0.001**	1.62±0.21	2.64±0.38	**<0.001**

*Result of the independent T-test, it is significant if $\alpha < 0.05$

After thoracic surgery, acute discomfort can be managed in a variety of methods. These include systemic opioid-based treatment, thoracic epidural block, intercostal nerve block, and newer methods of fascial plane block (3). We compared intercostal nerve block versus patient-controlled intravenous analgesia for thoracotomy pain.

Table 5. Distribution of side effects between the two groups

Side effects	Group A (ICNB) (N (%))	Group B (PCIA) (N (%))	X^2	p-Value
Nausea	1 (1.6)	11 (17.2)	7.448 (Df=1)	**0.006**
Respiratory depression	0	0	-	-
Bradycardia	0	0	-	-
Vomiting	0	2 (3.1)	0.508 (Df=1)	0.476
Pruritus	0	2 (3.1)	0.508 (Df=1)	0.476

*Result of the Fisher exact test, it is significant if $\alpha < 0.05$

In this study, consumption of fentanyl was significantly more ($p < 0.001$) in group B as compared to group A, and also the time to administer the first dose of rescue analgesic (fentanyl 1 µg/kg) was significantly longer in group A (11.84±3.69 hours) as compared to group B (3.59±1.34 hours). M Luo et al. (5) also found in their study that fentanyl dose requirement more in PCIA group (6.65 mcg/kg) than ICNB group (2.66 mcg/kg) in the Nuss procedure in children for postoperative period of 24 hours. The results were also similar to the study conducted by Jinghong Xu et al. (8) where the fentanyl dose requirement was statistically significantly ($p < 0.001$) more in the PCIA group (27.96±8.49) than in the ICNB group (14.37±4.20). Z Ahmed et al. (9) in their study reported that 24-hour morphine consumption was lower in the ICNB group than in the PCIA group.

K Mahmoudi et al. (3) in their study found that time for first rescue analgesia requirement in the ICNB group was 13.2±3.8 hours, and a study conducted by Rohan Magoon et al (10), mean time to rescue analgesic (fentanyl 0.5-1 mcg/kg) requirement in the ICNB group (using 0.5% ropivacaine) was (10.92±0.61 hours) for post-thoracotomy analgesia in cardiac surgery, which is almost similar to our study.

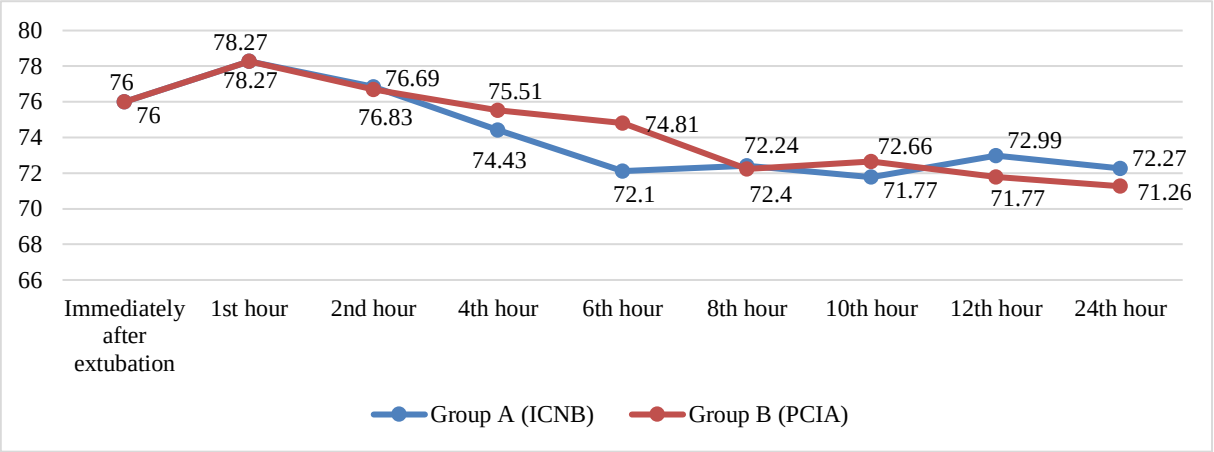

Figure 2. Comparison of Mean Arterial Pressure (MAP) of two groups

In the present study, the mean VAS score at different time intervals after extubation was less than 4 in the ICNB group in comparison to the PCIA group, which was more than 4 till 8 hours. Mean VAS was significantly higher ($p < 0.001$) in the PCIA group than the ICNB group at different time intervals. J Xu et al. (8) also found that mean VAS score was higher ($p < 0.05$) in the PCIA group than the ICNB group for 24 hours study period. Similar results were seen by M Luo et al. (5) where FPS-R score was significantly ($p < 0.05$) less in the UG-ICNB group (< 3) than the PCIA group (> 4) throughout the study period of 24 hours in the Nuss procedure in children.

The Ramsay sedation score in group A was between 1.5 and 3 at all research time intervals, indicating that patients in this study group were calm, comfortable, and responding to commands for most of the time during the study period since they had good pain relief and were not sedated. However, in group B, the sedation score was between 2 and 3 for the majority of the time due to the fentanyl PCIA pump, and the patients were somewhat sedated but arousable. In a study conducted by J Xu et al. (8) sedation score for the ICNB group (using 0.375% ropivacaine) and the PCIA group (using fentanyl) was also between 2 and 3.

On comparing the two groups with regard to adverse effects, the incidence of nausea was significantly higher in group B than in group A. The incidence of vomiting and pruritus was also common in group B. None of the patients had respiratory depression and bradycardia. M Luo et al. (5) found that 5.9% of patients in the ICNB group and 17.8% of patients in the PCIA group had nausea and vomiting, which is quite similar to our study. In their study 2.9% patient in the ICNB group and 28.6% patients in the PCIA group also had respiratory depression.

The advantages of intercostal nerve block over patient-controlled intravenous analgesia include technical simplicity, effective analgesia, improved pulmonary mechanics, and less central nervous system depression, which is more common with systemic opioid-based treatment regimens (11). One of the factors that may make PCIA an effective postoperative analgesia technique is that it allows the patient to regulate their pain management. Many drugs can be used. Since fentanyl acts more quickly and produces less sedation than morphine, we used it. As fentanyl is not eliminated by renal excretion, it is appropriate for patients with renal insufficiency.

CONCLUSION

Intercostal nerve block is more effective than patient-controlled intravenous analgesia for postoperative pain in patients undergoing cardiac surgery through thoracotomy incision. ICNB was linked to a lower fentanyl dose required and a lower sedation score. There are no notable side effects associated with the administration of intercostal nerve blocks.

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ALBUMIN LEVELS IN NONTRAUMATIC ACUTE ABDOMEN PATIENTS UNDERGOING EMERGENCY LAPAROTOMY: A RETROSPECTIVE STUDY IN THE INTENSIVE OBSERVATION WARD OF DR. SOETOMO GENERAL ACADEMIC HOSPITAL

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ABSTRACT

Introduction: Acute abdomen is a critical medical emergency characterized by the abrupt onset of severe abdominal pain, often requiring emergency laparotomy. Emergency laparotomy, due to limited preoperative preparation, generally has a higher morbidity and mortality rate than elective surgery. Optimizing perioperative care, particularly by monitoring albumin levels, may improve outcomes, as albumin plays a crucial role in maintaining fluid balance, wound healing, and controlling inflammatory responses. Postoperative emergency patients at Dr. Soetomo General Academic Hospital are closely monitored in a specific ward known as the Intensive Observation Ward (*Ruang Observasi Intensif*/ROI).
Objective: To evaluate albumin levels in nontraumatic acute abdomen patients treated in ROI following emergency laparotomy.
Methods: This study used a retrospective descriptive study design and was conducted from January to June 2022. Patients under 18 with malignancy, trauma, gynecological or obstetrical cases, and incomplete medical records were excluded.
Results: The male and female number of 90 patients was equal, most patients were aged 41-50, and had a normal BMI. Generalized peritonitis was the most common indication, followed by acute appendicitis and bowel obstruction. Appendectomy and exploratory laparotomy were the primary procedures, mostly done in under 3 hours. Most patients had no prior laparotomy history. Most patients had normal albumin levels preoperatively, but these shifted to mild hypoalbuminemia postoperatively. Of 13 deaths, 12 involved preoperative hypoalbuminemia. The predominant PS-ASA scores were 2 and 3. Electrolyte imbalance, especially hypokalemia, was the prevalent preoperative complication. Frequent comorbidities included kidney disorders and hypertension. The average ROI stay was 2.1±1.59 days, with most patients staying for 1 to 3 days. Operation-related complications included intra-abdominal infections and bleeding, while medical complications involved electrolyte imbalances, sepsis, and metabolic acidosis.
Conclusion: Nontraumatic acute abdomen patients with low preoperative albumin levels tend to have higher rates of postoperative complications and mortality.

Keywords*:* Albumin Levels; Emergency Laparotomy; Intensive Observation Ward; Intensive Care Unit; Nontraumatic Acute Abdomen

ABSTRAK

Pendahuluan: Akut abdomen adalah keadaan darurat medis yang kritis, ditandai dengan timbulnya nyeri perut yang mendadak dan berat, sering kali memerlukan laparotomi darurat. Laparotomi darurat, karena persiapan preoperatif yang terbatas, umumnya memiliki tingkat morbiditas dan mortalitas yang lebih tinggi dibandingkan dengan operasi elektif. Mengoptimalkan perawatan sebelum dan sesudah operasi, terutama dengan memeriksa kadar albumin, dapat memperbaiki hasil, karena albumin penting untuk menjaga keseimbangan cairan, penyembuhan luka, dan mengatur respons peradangan. Pada RSUD Dr. Soetomo, pasien darurat pascaoperasi dipantau secara intensif di ruang khusus, yaitu Ruang Observasi intensif (ROI).
Tujuan: Mengevaluasi kadar albumin pada pasien abdomen akut nontraumatik pascalaparotomi darurat yang dirawat di Ruang Observasi Intensif (ROI).
Metode: Penelitian ini menggunakan desain studi deskriptif retrospektif dan dilakukan dari Januari hingga Juni 2022. Pasien di bawah 18 tahun, dengan keganasan, trauma, kasus ginekologi atau obstetri, dan rekam medis yang tidak lengkap dieksklusi.
Hasil: Jumlah pasien laki-laki dan perempuan dari total 90 pasien adalah sama, sebagian besar berusia 41-50 tahun, dan memiliki BMI normal. Peritonitis generalisata merupakan indikasi paling umum, diikuti oleh apendisitis akut dan obstruksi usus. Apendektomi dan laparotomi eksplorasi adalah prosedur utama, sebagian besar dilakukan kurang dari tiga jam. Sebagian besar pasien tidak memiliki riwayat laparotomi. Sebagian besar pasien memiliki kadar albumin normal sebelum operasi, tetapi berubah menjadi hipoalbuminemia ringan setelah operasi. Dari 13 kematian, 12 nya mengalami hypoalbuminemia sebelum operasi. Skor PS-ASA yang dominan adalah 2 dan 3. Ketidakseimbangan elektrolit, terutama hipokalemia, sebagai komplikasi preoperatif yang paling umum. Komorbiditas yang sering ditemukan meliputi gangguan ginjal dan hipertensi. Rata-rata lama tinggal di ROI adalah 2,1±1,59 hari dengan sebagian besar pasien dirawat selama 1-3 hari. Komplikasi terkait operasi meliputi infeksi intra-abdomen dan perdarahan, sementara komplikasi medis meliputi ketidakseimbangan elektrolit, sepsis, dan asidosis metabolik.

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Kesimpulan: Pasien abdomen akut non-trauma dengan kadar albumin preoperatif rendah cenderung memiliki tingkat komplikasi dan mortalitas pascaoperasi yang lebih tinggi.

Kata kunci: Kadar albumin; Laparotomi Darurat, Ruang Observasi Intensif (ROI), Unit Perawatan Intensif; Akut Abdomen Nontraumatik

INTRODUCTION

Acute abdomen, a critical medical emergency, accounts for a significant proportion of surgical admissions globally, necessitating prompt diagnosis and intervention to prevent life-threatening complications (1). Emergency laparotomy, a common surgical intervention for acute abdominal conditions, is associated with significant postoperative risks despite advancements in surgical techniques and perioperative care (2). Mortality rates range from 13% to 18%, with major complications affecting up to 50% of cases (3). These complications include intra-abdominal infections, bleeding, sepsis, and anastomotic leakage, all of which contribute to prolonged hospital stays (4,5).

Preoperative and postoperative albumin can be a predictor of outcomes of emergency laparotomy (6). Low preoperative and postoperative albumin levels were related to adverse postoperative surgical site infection, delayed wound healing, and death within 30 days. Besides, it is also significantly associated with postoperative complications (7). The other related risk factors include length of surgery, advancing age, high Physical Status-American Society of Anesthesiologists (PS-ASA) score (PS-ASA score ≥3), obesity, anemia, and the presence of comorbidities (8–12). A thorough understanding of risk factors, particularly in the case of hypoalbuminemia, is necessary for prevention. Patients classified as high-risk may benefit from close monitoring and early intervention.

Albumin is the major protein of human plasma. It constitutes approximately 60% of the total plasma protein; its normal serum concentration is 3.5–5.0 g/dl. Because its levels fall during injuries and sepsis, albumin is regarded as a negative acute phase protein (7). The hypoalbuminemia condition is characterized by increases in the acute-phase proteins c-reactive protein (CRP), tumor necrosis factor (TNF)-α, interleukin (IL)-1, and IL-6, which are associated with enhanced morbidity and mortality, as well as prolonged inflammation. Hypoalbuminemia slows down the healing of wounds by reducing the activity of important proteins like epidermal growth factor receptor (EGFR), extracellular signal-regulated kinases (ERK)1 or ERK2, transforming growth factors (TGF)-β, and collagen (13). Thus, preoperative serum albumin is critical in determining a patient's postoperative outcome after major surgery (14). Low serum albumin also indicates postoperative complications and longer hospital stays (6).

Therefore, this study investigated the albumin levels in patients with nontraumatic acute abdomen who are treated in the Intensive Observation Ward after emergency laparotomy.

METHOD

This study used a descriptive observational design with a retrospective approach. Ethical clearance was granted by the Ethics Committee of Dr. Soetomo General Academic Hospital on November 30, 2023 under approval number 1534/LOE/301.4.2/XI/2023.

The study included all patients with nontraumatic acute abdomen who were treated in the Intensive Observation Ward (Ruang Observasi Intensif/ROI) of Dr. Soetomo General Academic Hospital in Surabaya, Indonesia, after having emergency laparotomy between January and June 2022, totaling 251 patients.

Patients were excluded based on the following criteria: age under 18 years (n = 55), malignancy (n = 30), trauma (n = 16), obstetric cases (n = 19), gynecological cases (n = 16), and incomplete medical records (n = 25). After exclusions, 90 patients were included in the final sample.

All data were obtained from the patients' medical records and processed using Microsoft Excel and Statistical Product and Service Solutions (SPSS) version 30 to generate descriptive statistics. The statistical measures used included frequency, percentage, mean, and standard deviation.

RESULTS AND DISCUSSION

Gender-wise, the male and female patients were equally distributed, having 1:1 female-to-male ratio. Other studies found that men were slightly more afflicted than women in non-traumatic acute abdomen. Shown in a study conducted by Danish et al. (15), the male-to-female ratio was 1.14:1. Likewise, a study in India found that the male-to-female ratio was 1.22:1 (1). One of the possible reasons behind the higher number of male patients was the exclusion of obstetrical and gynecological cases.

Table 1. Demographic characteristics of the Patients

Variables	N (%)
Sex	
Female	45 (50)
Male	45 (50)
Age (years)	
18-20	8 (8.89)
21-30	15 (16.67)
31-40	10 (11.11)
41-50	20 (22.22)
51-60	8 (8.89)
61-70	17 (18.89)
>70	12 (13.33)
Mean±SD (47±18.94)	
Nutritional Status	
Severely Underweight	2 (2.22)
Underweight	13 (14.44)
Normal Weight	44 (48.89)
Overweight	19 (21.11)
Moderately Obese	9 (10)
Severely Obese	3 (3.33)
Morbidly Obese	0 (0)

As shown in Table 1, the patients were dominated by the age group of 41-50 (22.22%), followed by the 61-70 (17%) age group. Most of the other studies found that acute abdomen in their productive age, especially in the 2nd and 3rd decades. However, those studies also include nonsurgical intervention for acute abdomen (1,16). The age group in this study possibly differs because the surgical intervention was more needed in the older age group, as in this study. The majority of the patients have a normal body mass index (BMI) (48.89%), followed by overweight (21.11%) and underweight groups (14.44%).

Table 2. Indication of laparotomy

Indication	N (%)
Generalized Peritonitis	30 (33.33)
Acute Appendicitis with Perforation	27 (29.99)
Bowel Obstruction	12 (13.33)
Hernia	6 (5.55)
Sigmoid Volvulus	3 (3.33)
GI Perforation	5 (5.55)
Burst Abdomen	3 (3.33)
Intestinal Evisceration	2 (2.22)
Periappendicular Abscess	4 (4.44)
Leakage Anastomosis	1 (1.11)
Complicated Intraabdominal Infection	1 (1.11)

As provided in Table 2, the most common indication in this study was generalized peritonitis (33.33%), followed by acute appendicitis (27.77%) and bowel obstruction (13.33%). Peritonitis mostly results from perforated appendicitis and hollow organ perforation. Peritonitis was also found as the most common indication for laparotomy in the Intensive Care Unit (ICU) of Prof. Dr. Kandou Central General Hospital, Indonesia (17). Similar findings were also found at a tertiary care facility in India (18). Contrary to these findings, cross-sectional studies in Ethiopia and India found that the most common disease was acute appendicitis, followed by peritonitis and intestinal obstruction (15,19). The indicational difference may be due to the time of self-admission or referral from other centers.

The most common procedure done was appendectomy (43.33%), followed by exploratory laparotomy (30%). Similar findings were also found in a retrospective study conducted in Afghanistan (15). Most patients did not have a laparotomy history (73.33%). There is only one patient who had undergone laparotomy three times with the indication of recurrent incisional hernia. Among the nontraumatic acute abdomen surgical admissions in Arba Minch General Hospital, Southern Ethiopia,

only 7.1% of patients had a history of abdominal surgery (20). Whereas about 15% of patients in a tertiary care facility in India had a history of abdominal surgery (16).

Table 3. Operative Variables

Variables	N (%)
Procedure	
Appendectomy	39 (43.33)
Exploratory Laparotomy	27 (30)
Stoma Creation	10 (11.11)
Hernia Repair	6 (6.67)
Bowel Resection	6 (6.67)
Perforation Repair	4 (4.44)
Abscess Drainage	3 (3.33)
Burst Abdomen Repair	2 (2.22)
Duodenal stump	1 (1.11)
Number of Previous Surgeries	
0	66 (73.33)
1-2	23 (25.56)
≥3	1 (1.11)
Length of Surgery	
<3 hours	71 (78.89)
≥3 hours	19 (21.11)

Length of surgery was also positively correlated with postoperative complications (21). This study showed that 71 out of 90 cases (78.89%) are done in less than 3 hours, and the rest are done in 3 hours or more (21.11%). However, the length of the surgery can be determined by many factors. One of the possible factors is the preoperative complications of the patients. In this study, patients with ≥4 complications and comorbidities, such as diabetes mellitus and hypertension, generally have longer surgical durations.

As one of the risk factors, the preoperative and postoperative albumin and hemoglobin levels were recorded in Table 4. Out of 90 patients, the level of postoperative albumin was decreased in 81 patients. The rest of the patients had the postoperative albumin increased, and one patient had the same albumin level. The increase in albumin levels is possibly due to the albumin infusion, which is not recorded in this study. A decrease in postoperative serum albumin levels was also found in a study conducted by (6,7).

Table 4. Albumin and Hemoglobin Levels

Variables	N (%)	Mean ± SD
Albumin Levels		
Preoperative		3.39±0.58
Marked Hypoalbuminemia (<2.5 mg/dL)	7 (7.78)	2.18±0.19
Mild Hypoalbuminemia (2.5-3.5 mg/dL)	39 (44.44)	3.08±0.26
Normal albumin (3.5-4.5 mg/dL)	42 (46.67)	3.82±0.21
Hyperalbuminemia (>4.5 mg/dL)	2 (2.22)	4.69±0.07
Postoperative		3.03±0.57
Marked Hypoalbuminemia (<2.5 mg/dL)	17 (18.89)	2.19±0.23
Mild Hypoalbuminemia (2.5-3.5 mg/dL)	51 (56.67)	2.95±0.30
Normal albumin (3.5-4.5 mg/dL)	22 (24.44)	3.74±0.20
Hyperalbuminemia (>4.5 mg/dL)	0 (0)	-
Hemoglobin Levels		
Preoperative		12.17±2.56
Severe Anemia (<8 g/dL)	4 (4.44)	7.08±0.46
Moderate Anemia (8-10 g/dL)	25 (27.78)	9.66±0.86
Mild Anemia (M=11-12.9 g/dL, W=11-11.9 g/dL)	16 (17.58)	11.64±0.60
Normal (M >13 g/dL, W >12 g/dL)	45 (50)	14.19±1.54
Postoperative		11.50±2.00
Severe Anemia (<8 g/dL)	1 (1.11)	6.7±0.00
Moderate Anemia (8-10 g/dL)	33 (36.67)	9.59±0.79
Mild Anemia (M=11-12.9 g/dL, W=11-11.9 g/dL)	29 (32.22)	11.71±0.52
Normal (M >13 g/dL, W >12 g/dL)	27 (30)	14.01±1.22

M = Man, W = Woman

Half of the patients (50%) in this study presented with a normal preoperative hemoglobin level. Our study also observed a decrease in mean hemoglobin levels postoperatively. A reduction in postoperative hemoglobin levels was also observed in colorectal surgery (22). This condition is likely caused by the worsening of preoperative anemia, blood loss, and reduced erythropoiesis due to surgery-associated inflammation (23).

The distribution of outcomes according to the preoperative albumin levels is also observed, as shown in Table 5.

Table 5. Distribution of Outcomes According to Preoperative Albumin Levels

Preoperative Albumin Levels	Outcomes			
	No complication N (%)	Complication N (%)	Death N (%)	Total N (%)
Marked Hypoalbuminemia (<2.5 mg/dL)	0 (0)	4 (4.44)	3 (3.33)	7 (7.78)
Mild Hypoalbuminemia (2.5-3.5 mg/dL)	9 (10)	21 (23.33)	9 (10)	39 (43.33)
Normal albumin (3.5-4.5 mg/dL)	26 (28.89)	15 (16.67)	1 (1.11)	42 (46.67)
Hyperalbuminemia (>4.5 mg/dL)	2 (2.22)	0 (0)	0 (0)	2 (2.22)
Total	37 (41.11)	40 (44.44)	13 (14.44)	90 (100)

The levels of albumin were significantly correlated with postoperative outcomes (24). More than half of the patients (57.14%) with marked hypoalbuminemia experienced complications, and the rest (42.86%) did not survive during the stay in ROI. The death percentage occurred in marked hypoalbuminemia, also higher than in the mild hypoalbuminemia group (23.08%). The majority of the patients who experienced mild hypoalbuminemia before surgery had postoperative complications. Compared to patients with normal albumin, the majority of the patients were discharged from ROI without complications. Whereas all of the hyperalbuminemic patients were being discharged from ROI without complications. Worse outcomes in hypoalbuminemia patients were also found in a study conducted by (24,25).

As provided in Table 6, the PS-ASA score was measured preoperatively to predict the operative risks. The patients were dominated with PS-ASA scores of II (35.56%) and III (34.44%). PS-ASA score II was considered as low risk, and PS-ASA score III was considered as intermediate risk (26).

Most of the patients had more than one preoperative complication and comorbidity. Pin-on *et al*. also found hypokalemia as the most common electrolyte imbalance before surgery (27). The most common preoperative complication observed was hypokalemia (25.56%), followed by sepsis (24.44%). On the other hand, the most common comorbidity observed was a kidney disorder (22.22%), followed by hypertension (14.44%) and liver disorder (13.33%). Contrary to this finding, a study in Denmark showed heart disorder as the most common comorbidity (28). Another study found hypertension to be the most common comorbidity (3). However, comorbidity can be associated with many factors, including the demographics of the patients and lifestyle factors.

Table 6. PS-ASA Score, Preoperative Complication, and Comorbidity

Variables	N (%)
PS-ASA Score	
I	4 (4.44)
II	32 (35.56)
III	31 (34.44)
IV	23 (25.56)
V	0 (0)
Preoperative Complication (N of patients=90)	
Sepsis	22 (24.44)
Septic shock	5 (5.56)
Electrolyte Imbalance	
Hyponatremia	10 (11.11)
Hypernatremia	8 (8.89)
Hypokalemia	23 (25.56)
Hyperkalemia	2 (2.22)
Hypochloremia	1 (1.11)
Hypocalcemia	1 (1.11)
Acid-Base Disorder	
Metabolic Acidosis	7 (7.78)
Metabolic Alkalosis	3 (3.33)
Respiratory Acidosis	1 (1.11)
Comorbidity	
DM	4 (4.44)
Hypertension	13 (14.44)
DM+HT	2 (2.22)
Cardiovascular Disorder	10 (11.11)
Kidney Disorder	20 (22.22)
Liver Disorder	12 (13.33)
Respiratory Disorder	10 (11.11)
Bleeding Disorder	9 (10)
Thyroid Disorder	3 (3.33)
Allergy	2 (2.22)
HIV	3 (3.33)
Hepatitis B	2 (2.22)
COVID-19	1 (1.11)

The duration of patients' stay in the ICU was recorded. Patients were categorized based on the length of stay. To assess the potential of preoperative

albumin levels, the mean ± SD of albumin values was compared across the different length-of-stay groups, as detailed in Table 7.

Table 7. Length of ROI Stay

Length of ROI Stay	N (%)	Mean±SD of Pre-op Albumin Levels
Mean±SD (2.1±1.59)		
1-3 days	75 (83.33)	3.48±0.55
4-6 days	14 (15.55)	2.87±0.50
≥7 days	1 (1.11)	3.63

The patients stayed in the ROI on average for 2.1±1.59 days before either being discharged or passing away during the stay. Patients who stayed for 4-6 days had lower average pre-op albumin levels than patients who stayed for 1-3 days. Patients who stayed for ≥7 days had the highest mean value of pre-op albumin levels. This is more likely because there is only one patient who stayed for ≥7 days. Although that patient had a normal preoperative serum albumin level, the level dropped to <3 mg/dL postoperatively.

Table 8. Patients' Outcome

Outcome	N (%)	Preoperative Albumin Levels (Mean±SD)
Death	13 (14.44)	2.83±0.48
Survival		
With postoperative complications	40 (44.44)	3.28±0.57
Without postoperative complications	37 (41.11)	3.70±0.43

During the stay in ROI, 13 (14.44%) patients passed away with a mean preoperative albumin level value of 2.83±0.48 mg/dL. Among 13 dead patients, 12 patients were in a hypoalbuminemic state, and only one patient was in a normal albumin state. Of the 77 survived patients, 40 (44.44%) patients experienced postoperative complications with a mean preoperative albumin level value of 2.83±0.46. On the other hand, 37 (41.11%) patients survived without complications with a mean preoperative albumin level value of 3.39±0.46. As we can see, the highest mean preoperative albumin level was found in the group of patients without complications.

One patient can experience more than one complication. Ylimartimo et al. (29) found that medical complications appear earlier than operation-related complications. This condition is relevant to this study since the complications were only observed during the stay in the ICU, the complications that occurred later are not recorded. The majority of the patients in this study experienced medical complications, which aligned with a study conducted in Finland (29). The most common medical complication observed was metabolic acidosis, followed by hypocalcemia. Similar findings were also found in postoperative traumatic brain injury patients (27). The high incidence of metabolic acidosis can be induced by hyperchloremia from excessive 0.9% saline or Ringer's lactate solution administered intraoperatively. Tissue hypoperfusion during the surgical procedures can also induce metabolic acidosis (30).

There are still limited studies that investigate the role of serum albumin as a predictor of morbidity and mortality in patients who underwent emergency laparotomy with a nontraumatic cause of acute abdomen, especially in Dr. Soetomo General Academic Hospital. Hence, I conducted this study to provide an advanced understanding regarding this case.

CONCLUSION

This study revealed that patients with low preoperative albumin levels tend to have higher rates of postoperative complications and mortality. These findings also provide valuable data on the profile of nontraumatic acute abdomen patients and the associated risk factors. Identifying high-risk patients based on albumin levels and providing targeted interventions may improve surgical outcomes.

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Conflict of Interest

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Author's Contribution

All authors contributed to all aspects of the research process.

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Original Research Report

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PREOPERATIVE GASTRIC VOLUME ASSESSMENT IN FULL-TERM PREGNANT AND NON-PREGNANT FEMALES: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Introduction: Perioperative pulmonary aspiration (PA) of gastric contents is a serious anesthetic complication that can lead to significant morbidity and mortality. Obstetric patients, due to substantial anatomical and physiological changes, face a significantly higher risk of PA compared to non-pregnant individuals undergoing planned gynecological or other procedures.
Objective: The objective of this study is to compare gastric contents and volume through point-of-care gastric ultrasound (PoCUS) in full-term pregnant women and non-pregnant females scheduled for elective surgeries.
Methods: This single-center, prospective, observational study included 140 patients who underwent surgery between March 2022 and July 2023. Quantitative and qualitative measurements of the stomach were performed using PoCUS.
Results: The study included 140 patients with a mean age of 25±2.5 years (pregnant, range: 22-31 years) and 29±6 years (non-pregnant, range: 21-30 years), respectively. Patients in the pregnant group are classified as ASA II (70 (100%)), while those in the non-pregnant group (ASA I: 22 (31%); ASA II: 48 (69%)) are mixed. In Perlas, a 3-point grading system was used to classify the antrum based on the presence or absence of clear fluid in the supine position. The majority of the pregnant patients' antrum levels were reported to contain clear fluid (37 (53%)), while in non-pregnant patients, they were empty (45 (64%)). The average gastric antrum cross-sectional area (302.63±4.87 cm^2) and gastric volume (1.85±0.5 mL) were found to be high in pregnant females.
Conclusion: PoCUS was proven to be a simple, non-invasive method that can evaluate and offer a more precise bedside measurement of gastric volume, both qualitatively and quantitatively, in patients at risk for PA.

Keywords: Gastric volume; Non-pregnant women; Pregnant women; Pulmonary aspiration; Qualitative and quantitative assessment

ABSTRAK

Pendahuluan: Aspirasi paru perioperatif (PA) pada isi lambung merupakan komplikasi anestesi serius yang dapat menyebabkan morbiditas dan mortalitas yang signifikan. Khususnya pada pasien obstetri, yang menghadapi risiko PA yang jauh lebih tinggi dibandingkan dengan pasien tidak hamil yang menjalani prosedur ginekologi atau prosedur lain yang direncanakan karena perubahan anatomi dan fisiologis yang substansial.
Tujuan: Tujuan dari penelitian ini adalah untuk membandingkan isi dan volume lambung melalui USG lambung di tempat perawatan (PoCUS) pada wanita hamil cukup bulan dan wanita tidak hamil yang dijadwalkan untuk operasi elektif.
Metode: Penelitian observasional prospektif dengan pusat tunggal ini melibatkan 140 pasien, yang menjalani operasi antara Maret 2022 hingga Juli 2023. Dimana pengukuran lambung secara kuantitatif dan kualitatif dilakukan menggunakan PoCUS.
Hasil: Penelitian ini melibatkan 140 pasien dengan usia rata-rata 25±2.5 tahun (hamil, kisaran: 22-31 tahun) dan 29±6 tahun (tidak hamil, kisaran: 21-30 tahun). Seluruh pasien kelompok hamil adalah ASA II (70 (100%)), dan pada kelompok tidak hamil (ASA I: 22 (31%); ASA II: 48 (69%)) adalah campuran. Sistem penilaian 3 poin Perlas digunakan untuk mengklasifikasikan antrum berdasarkan ada tidaknya cairan bening pada posisi terlentang. Mayoritas kadar antrum pasien hamil dilaporkan terdapat cairan bening (37 (53%)) dan pada pasien tidak hamil, cairan kosong (45 (64%)). Rata-rata luas penampang antrum lambung (302,63±4,87 cm^2) dan volume lambung (1,85±0,5 mL) ditemukan tinggi pada wanita hamil.
Kesimpulan: PoCUS terbukti menjadi metode sederhana dan non-invasif yang dapat mengevaluasi dan menawarkan pengukuran volume lambung yang lebih tepat, baik secara kualitatif maupun kuantitatif, pada pasien yang berisiko terkena PA.

Kata Kunci: Volume lambung; Wanita tidak hamil; Ibu hamil; Aspirasi paru; Penilaian kualitatif dan kuantitatif

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INTRODUCTION

Perioperative pulmonary aspiration (PA) of stomach contents is a rare event; its consequences can be catastrophic, especially in obstetrics, causing anesthesia-related morbidity and mortality (1). Major morbidity events include conditions like acute respiratory distress syndrome, aspiration pneumonitis, aspiration pneumonia, brain damage, multiple organ dysfunction, and subsequent bacterial infections (2). The degree of PA-related morbidity is also largely dependent on pH, volume, and nature of the aspirated contents (3).

Incidents of PA are largely varied and highly dependent on the area of work or department. In a clinical setting, the general incidence of PA was reported at 2-7 per 20,000 anesthetic cases. However, its incidence was reported to be increased from 0.5% to 3% in emergency situations in the hospitals that were not within the operating room (4). To avoid any such instances and given patients' safety, preoperative fasting guidelines were designed by anesthesiology societies and the American Society of Anesthesiologists (ASA), providing direction for clinical practice in healthy patients undergoing elective surgeries (5). Even after considering all the set guidelines, fasting intervals are not reliable or applicable in emergency surgeries. Changes in anatomical and physiological conditions particularly affect obstetric patients.

Advanced technologies have emerged, yet there are no validated non-invasive tests available to assess the contents of the stomach. The application of point-of-care gastric ultrasound (PoCUS) as a diagnostic tool for assessing gastric volume was deemed straightforward and practical in clinical environments, particularly when gastric contents are unclear or uncertain (4,6–10). In these situations, clinicians evaluate the gastric antrum with strong intra- and inter-rater reliability and simultaneously obtain real-time data on the amount and type of gastric contents (solid, thick liquid, clear liquid, or none) utilizing PoCUS.

In this study, we aimed to compare gastric contents and volumes between fasting term pregnant patients and fasting non-pregnant surgical women posted for elective surgeries using PoCUS.

METHODS

Study Design

Ethical permissions were obtained from Saveetha College of Allied Health Sciences (SCAHS/IRB/2021/MARCH/060) on March 25, 2021 and from the Clinical Trials Registry - India (CTRI/2022/06/043329). This observational, prospective, comparative single-center study was conducted at a tertiary medical center from March 2022 to July 2023. Consent from all study participants was obtained before the start of the research.

Study Sample and Eligibility Criteria

A total of 140 eligible patients participated and were grouped as group A (n=70), representing the term pregnant females undergoing elective lower segment caesarean section (LSCS), and group B (n=70), representing non-pregnant female patients undergoing elective surgeries.

Patients aged between ≥18 and ≤45 years, with ASA scores of 1 and 2, and pregnant/non-pregnant female patients posted for elective surgeries were included. Whereas, patients of ASA score of 3 and 4, with multiple gestations, pre-existing abnormalities of the upper GI anatomy (previous surgery of the lower esophagus or stomach, hiatal hernia, and gastric malignancy), and who refused to give consent were excluded.

Fasting guidelines

Before going for elective surgery, all the patients have followed the recommended ASA fasting guidelines as presented: a minimum of two hours for consuming clear liquids, six hours for consuming light meals, and a minimum of eight hours for meals that include fried or fatty foods.

Preoperative procedures

A day prior to surgery, preoperative visits and thorough clinical evaluations were conducted by a multidisciplinary team, as required. All the patients

were kept nil oral prior to surgery for 8 hours, and as a pre-medication, H2 blockers were given at night. On the next day after shifting to the operating theater, all the vital parameters were checked and recorded. Preoperatively, all the patients were examined using PoCUS (both qualitatively and quantitatively) by staff anesthesiologist.

Qualitative assessment of the antrum and patient's classification as per the Perlas grading system

As per the Perlas' grading system (11,12) a 3-point grading system was used to classify the antrum according to the detection of clear fluid while in the right lateral decubitus (RLD) and supine positions.

Grade 0 – the antrum is empty in both RLD and supine.

Grade 1 – antrum with appreciable clear fluid in the RLD.

Grade 2 – antrum with clear fluid in both RLD and supine.

From the third trimester, instead of supine, semi-recumbent positions are preferred.

Quantitative assessment

The quantitative assessment was based on evaluating gastric volume by measuring the gastric cross-sectional area (GCSA). Whereas the gastric fluid volume was calculated using the formula by Schmitz:

$$Gastric\ volume\ (ml/kg) = [0.0093\ X\ gastric\ central\ area\ (sq.mm) - 0.9]$$

Where gastric fluid volume ≤1.5 ml is considered safe, and more than >1.5 ml is considered higher risk.

Statistical Analysis

Data was descriptively analyzed using SPSS (Version 24.0, USA). The data is presented in frequency and percentation for each parameter.

RESULTS AND DISCUSSION

All 140 patients were divided into two groups with 70 patients each (group A for pregnant and group B for non-pregnant) to study the gastric volume. All participants were female, with a mean age of 25±2.5 years for group A (range: 22-31 years) and 29±6 years for group B (range: 21-30 years), respectively. All the patients of group A are of ASA II (70, 100%), and group B (ASA I: 22, 31%; ASA II: 48, 69%) is mixed.

Table 1. Qualitative and quantitative assessments of the study population

Parameters	Pregnant (n=70)	Non-pregnant (n=70)
Qualitative		
Age (years) [mean±SD]	25±2.5	29±6
Height (cm) [mean±SD]	157±6	158±6
Weight (kg) [mean±SD]	63±6	58±7
ASA Score [n (%)]		
ASA I	--	22 (31)
ASA II	70 (100)	48 (69)
Perlas grading [n (%)]		
0	26 (37)	51 (73)
1	44 (63)	19 (27)
Quantitative		
Antrum level [n (%)]		
Empty	26 (37)	45 (64)
Clear fluid	37(53)	18 (26)
Solid	7 (10)	7 (10)
Anteroposterior diameter (cm) [mean±SD]	13.63±1.02	11.78±1.94
Transverse diameter (cm) [mean±SD]	22.16±1.24	21.83±1.61
Gastric cross-sectional area (cm^2) [mean±SD]	302.63±4.87	257.85±3.42
Gastric volume (mL) [mean±SD]	1.85±0.5	1.44±0.4

ASA: American Society of Anesthesiologists; SD: Standard deviation.

The majority of the pregnant patients' antrum level was reported as clear fluid (37, 53%), and in non-pregnant patients was empty (45, 64%). The mean GCSA of the antrum (302.63±4.87 cm^2) and gastric volume (1.85±0.5 mL) was found to be high in pregnant women. Other qualitative and quantitative parameters were presented in Table 1.

Literature has already proven the PA as a severe condition, where patients have died or suffered severely from its consequences (13). However, as of this date, no treatment protocols were available to intervene in the PA except for its management or support. Given the patient's safety, identifying and mitigating such PA-related risks preemptively, preoperative fasting guidelines were introduced. Until recently, in the acute settings, there were no non-invasive diagnostic tools to assess the gastric content. The only available methods, such as gastric content aspiration, polyethylene glycol dilution, radiolabeled diet, electrical impedance tomography, and paracetamol absorption, were all invasive and practically not applicable in the perioperative period, and they are the only options left for all the patients who are going to undergo sedation and anesthetic care perioperatively.

However, it was only recently that along with recommended preoperative fasting guidelines, PoCUS has been used as a diagnostic method for the examination of stomach contents. In a study conducted by Richelle et al. (3) the qualitative and quantitative accuracy and sensitivity of PoCUS in detecting the gastric contents and its volume were proven highly effective. Considering PA and its related risks in uncertain and emergency cases, PoCUS was often recommended over unnecessary airway interventions, cancellations, or surgical delays. Recent editorials by Lucas and Elton (14), Mahmood et al. (15), and Benhamou (16) have also suggested including the PoCUS as a curriculum for anesthesiologists to make it a basic armamentarium of their daily clinical practice.

Even though the use of PoCUS in clinical anesthesia has existed over the last forty years, its role in obstetric anesthesia was developed very recently (14,17). In the present study, the same PoCUS was used to assess and compare qualitatively and quantitatively the parameters in both non-pregnant and pregnant women undergoing selective surgery. All participants in this study were females with ASA grades I and II. In the present study, H2 blockers were used in contrast to proton-pump inhibitors (PPIs) 8 hours prior to surgery (18,19). This might be one of the reasons why we have observed a lesser volume of gastric aspiration in our patients, affecting their overall gastric residual volume in the end. This could be because PPIs target terminal receptors and exert a more immediate effect than histamine antagonists (18). Our results are consistent with Arzola et al. (20), where the GCSA has a positive correlation with weight and BMI but not with the fasting time. However, multiple studies have validated the strong linear relationship between GCSA and gastric volume in both pregnant and non-pregnant populations (3,11,12,21). Animal studies suggested that a stomach volume greater than 0.8 mL/kg is associated with a high risk of PA (22). However, recent studies have shown that up to 1.5 mL/kg of gastric residue is considered safe and does not indicate an increase in the risk of PA (23).

Whereas with the gastric volume, studies have reported no significant difference between fasting non-pregnant women and post-term pregnant women (24,25). In a cross-sectional observational study conducted by Riveros et al. (26), results have suggested a need to adjust the perioperative fasting guidelines in pregnant patients, especially those who fall under the obese and morbidly obese pregnant category, to avoid PA. In our study cohort, a minor difference in gastric CSA and gastric volume was observed. Such discrepancy in our data can be attributed to the obese patients presented in our cohort or it can be a poor correlation and agreement between gastric CSA and gastric volume measurements of different assessors. Such poor inter-assessor correlation and agreement were reported earlier too. In a randomized study conducted by Jeson et al. (7),

inter-assessor variability was evident, confirming the need for more training for the assessors to attain proficiency.

Outcomes from our study also highlight the need to take preventive measures against PA in laboring females regardless of overnight fasting, as fasting alone cannot be a confirmation for an empty stomach. In such instances, bedside PoCUS was proven to be an efficient diagnostic tool in assessing the gastric volume.

The small sample size, single-center nature, and inability to assess inter-observer agreement as determined in PoCUS are the primary limitations of this study.

CONCLUSION

To conclude, PoCUS was proven to be simple, life-saving, readily accessible, non-invasive, and capable of evaluating and providing more accurate gastric volume assessment at the bedside, both qualitatively and quantitatively, in patients at risk for PA. To confirm and validate the current results, more research would probably be needed, most likely a multi-center, prospective, observational study.

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Conflict of Interest

All other authors declare no competing interests.

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Author Contributions

NDG contributes in concepting, designing, supervision, materials' preparation, collecting and processing data, analysis and interpretation, literature search, manuscript writing, and critical review.

RK contributes in materials' preparation, analysis and interpretation.

RP contributes in materials' preparation, analysis and interpretation.

LR contributes in supervision, materials' preparation, analysis and interpretation.

MS contributes in concepting, designing, supervision, materials' preparation, collecting and processing data, analysis and interpretation, literature search.

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Case Report

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MANAGEMENT OF ANESTHESIA IN PEDIATRIC PATIENTS WITH BRONCHOSCOPY LATE ONSET FOREIGN BODY ASPIRATION

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ABSTRACT

Introduction: Aspiration of foreign bodies in the airways is a severe and fatal condition if it occurs in children, because the risk of life-threatening obstruction is higher. Bronchoscopy is the main choice of procedure for treating foreign body aspiration, either with rigid bronchoscopy or flexible bronchoscopy. Anesthesia techniques are used with comprehensive anesthesia considerations, such as premedication, induction of anesthesia, maintenance of anesthesia, and monitoring.
Objective: To evaluate the management of anesthesia in a pediatric patient with foreign body aspiration in late-onset settings.
Case report: We report a case of anesthesia management in a child who aspirated a foreign body (peanuts) three days before being delivered to the hospital and undergoing a rigid bronchoscopy procedure. The patient experienced respiratory failure, and atelectasis was found in the right lower lobe of the lung upon arrival at the Emergency Unit (ER) due to the late onset of the case, so a secure airway must be performed before rigid bronchoscopy. Post-treatment care is carried out by observation and monitoring in the Intensive Care Unit (ICU) with complications of pneumonia. After three days of ICU treatment, the patient was transferred to the High Care Unit (HCU) in improved condition. The patient was discharged after three days of treatment in the low care Unit.
Conclusion: Rigid bronchoscopy is the best modality for extracting foreign bodies in the pediatric airway. Delayed onset effects from foreign body aspiration in the respiratory tract cause greater complications after bronchoscopy. Pneumonia is the most common complication. Comprehensive anesthesia evaluation and preparation are the keys to the success of this procedure.

Keyword: Anesthesia management; Bronchoscopy; Foreign body aspiration in children's airway; Intensive care unit

ABSTRAK

Pendahuluan: Aspirasi benda asing dalam saluran napas merupakan kondisi yang sangat serius dan fatal apabila terjadi pada anak-anak, karena risiko kematian akan lebih tinggi akibat obstruksi total saluran napas. Bronkoskopi merupakan pilihan utama dalam penanganan aspirasi benda asing, baik dengan bronkoskopi rigid maupun bronkoskopi fleksibel. Teknik anestesi yang digunakan dengan pertimbangan anestesi komprehensif, seperti premedikasi, induksi anestesi, rumatan anestesi, dan monitoring**.**
Tujuan: Untuk mengevaluasi manajemen anestesi pada pasien pediatri yang mengalami aspirasi benda asing dalam fase onset lambat.
Kasus: Tindakan anestesi pada anak yang mengalami aspirasi benda asing (kacang tanah) sejak 3 hari sebelum dibawa ke rumah sakit dan dilakukan tindakan bronkoskopi rigid. Pasien mengalami gagal nafas dan sudah didapatkan atelektasis pada lobus inferior paru kanan saat tiba di Unit Gawat Darurat (UGD) akibat late onset dari kasus tersebut sehingga harus dilakukan secure airway sebelum dilakukan tindakan bronkoskopi rigid. Perawatan pasca tindakan dilakukan observasi dan monitoring di *Intensive Care Unit* (ICU) dengan komplikasi Pneumonia. Pasca tiga hari perawatan ICU, pasien dipindahkan ke *High Care Unit* (HCU) dengan kondisi perbaikan. Pasien dipulangkan setelah perawatan *low care* Unit selama tiga hari terakhir.
Kesimpulan: bronkoskopi rigid merupakan modalitas terbaik pada tindakan ekstraksi benda asing pada saluran nafas anak. Adanya efek *delayed* onset dari aspirasi benda asing di saluran nafas menimbulkan komplikasi pasca tindakan bronkoskopi lebih besar. Pneumonia merupakan komplikasi yang paling sering terjadi. Evaluasi dan persiapan Anestesi yang komprehensif merupakan kunci keberhasilan prosedur ini.

Kata kunci: Tindakan anestesi, Rigid Bronkoskopi, Aspirasi benda asing pada saluran napas anak; *Intensive Care Unit*

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INTRODUCTION

Foreign body aspiration is a serious and potentially lethal condition resulting from the entry of a foreign object into the airway. The symptoms that arise depend on the grade of airway obstruction. Death is a complication of foreign body aspiration that obstructs the airway. Foreign body (FB) aspiration is a common and serious problem in childhood, as it requires early recognition and treatment to avoid potentially fatal consequences. Foreign body aspiration could occur at any age, but it is more common in children. In adults, the incidence of foreign airway aspiration is related to conditions of decreased consciousness. Suspecting a foreign body and getting a satisfactory medical history are the most important steps in foreign body aspiration. Bronchoscopy is the main choice in treating foreign body aspiration. This procedure can be performed using flexible bronchoscopy or rigid bronchoscopy. Rigid bronchoscopy is the main choice for aspiration extraction of foreign bodies in children (1–3).

Rigid bronchoscopy is used to evaluate the upper and lower airways. This assessment is useful for diagnosis and for therapeutic purposes. Complications caused by foreign objects in the airways can also arise from bronchoscopy, which is considered iatrogenic. Apart from that, aspiration of foreign objects in the airways is influenced by 3 things, there are geographical conditions, food variations, and environmental conditions. The most common aspiration of foreign bodies in the airways in children is peanut aspiration. In previous research, it was noted that at the age of 0-3 years, 50% of foreign body aspirations occurred, while at the age of 4-15 years, the incidence of foreign body aspiration occurred in the range of 75-85%. This is different from adults, the incidence of foreign body aspiration often occurs at old age (geriatric populations), and the number of males is greater than that of females (ratio 2:1). The cause of the high rate of foreign body aspiration in children is because of the tendency to put everything into their mouths, because children often cry, scream, and run around with food in their mouths, and also because the molar teeth in children have not yet formed, so the chewing process is not yet complete, and poor swallowing and easy aspiration into the airway in children (4–6).

Airway Anatomy

Anatomically, the respiratory system consists of the upper respiratory tract, consisting of the nose, pharynx, and larynx, and the lower respiratory tract, consisting of the trachea, bronchi, bronchioles, alveolar ducts, and alveoli. The pharynx is a tube-like channel 12.5 cm long that connects the posterior nasal cavity and oral cavity to the esophagus and larynx. The larynx is where the vocal cords are located below the epiglottis. During the swallowing process, the posterior part of the tongue together with the upper part of the larynx is pushed upwards, making the epiglottis close to prevent food or foreign objects from entering the larynx, however, if a foreign object enters the larynx and hits the vocal cords, a cough reflex will arise to expel the foreign object (7).

The trachea is a tube 11-14 cm long that connects the cricoid cartilage in the larynx with the primary bronchus. In the anterior part the trachea is formed from C-shaped cartilage and in the posterior part by muscle and connective tissue with a flat surface. The diameter of the trachea in adult males is 1.3-2.5 cm, while in adult females it is around 1.0-2.1 cm and consists of 16-20 tracheal rings. The tracheal ring functions to prevent the trachea from collapsing and plays a role in the flexibility of movement in the neck. The trachea then continues into the right main bronchus, which is wider, shorter (2.2 cm), and more vertical than the left main bronchus (5 cm), thereby increasing the opportunity for foreign objects to enter the main bronchial airway, especially the right main bronchus. The anatomy of the right main bronchus is divided into several subdivisions, namely 3 branching lobes, and then the

left main bronchus is divided into several subdivisions, branching into two lobes (8).

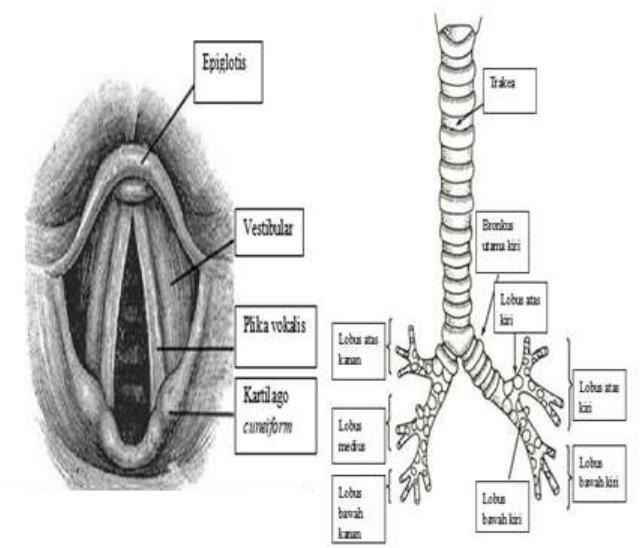

Figure 1. Larynx and Trachea (8)

Diagnosis of Foreign Body Aspiration

The diagnosis of foreign body aspiration in children is not easy, patients often do not remember a history of choking due to a foreign body. In Rodriguez et al.'s (9) research, it was found that 6 out of 14 patients who experienced aspiration of metallic foreign bodies experienced a delay in diagnosis of more than 30 days. Posteroanterior (PA) and lateral chest x-rays are performed to evaluate the soft tissue of the neck area as an initial modality for suspected aspiration of foreign bodies in the upper airway. According to research by Pinto et al. (10), chest X-ray examination can identify foreign body aspiration in only 22.6% of cases, because the identification of the location of a foreign body depends on the material of the foreign body. And the chest X-ray image can be normal within the first 24 hours after the history of aspiration because that newest study by Wang et al. (11) stated a chest CT scan is the highest rate sensitivity to confirm the diagnosis of foreign body airway obstruction.

Computed tomography (CT) is the gold standard and more sensitive for identifying foreign bodies. According to Wang et al. (11), CT-guided bronchoscopy has a sensitivity of 100% and a specificity of 75% in identifying foreign bodies. The clinical symptoms of foreign body aspiration depend on the location of the obstruction caused by the foreign body. If obstruction occurs in the larynx, symptoms of choking will appear with hoarseness, aphonia, and cyanosis and even death. Obstruction in the trachea can cause stridor and coughing, while obstruction in the bronchi can cause symptoms of coughing, wheezing, hemoptysis, shortness of breath, chest pain, and decreased breath sounds but can also be normal on physical examination. When diagnosis is delayed, the period between aspiration and the onset of worsening symptoms depends on airway obstruction and foreign body material (organic or inorganic) (8,12).

Foreign objects enter the airway when the larynx is open or when aspiration occurs. A foreign object that enters the airway will cause a cough reflex, then symptoms will appear according to the location, size of the obstruction, and length of time the foreign object has been in the airway. Foreign objects that enter the airways will cause a reaction in the surrounding tissue. The resulting reactions can include local inflammation, airway oedema, ulceration and the formation of granulation tissue, which can result in airway obstruction. As a result of this obstruction, air trapping, emphysema, atelectasis, lung abscess and bronchiectasis will occur in the distal part of the airway obstruction. Reduced mucociliary movement will cause a buildup of secretions resulting in atelectasis. The local inflammatory reaction causes oedema and increased airway mucoid secretions. If an infection occurs, it can cause the formation of pus and granulation tissue in the airways (4,13–15).

Peanuts are hygroscopic organic foreign bodies that are soft and often swell with water and cause irritation to the respiratory tract mucosa. This condition can cause severe inflammation of the airways and initiate the formation of airway granulation tissue. The reaction took place quickly. Apart from that, peanuts in the tracheobronchial airway can cause moderate to severe respiratory tract infections known as arachidic bronchitis. Typical

symptoms that appear after 24 hours are a cough with purulent phlegm accompanied by fever. Other symptoms are choking in 85%, coughing in 57%, and airway obstruction in 5%, while on physical examination you will find wheezing breath sounds in 40%, decreased breath sounds in the side with the foreign object in 10%, and asymptomatic in 40%, but if there is total obstruction in the airway, main breath will cause cyanosis (16–18).

A study conducted by Shlizerman et al. (19), regarding the effects of delayed diagnosis and treatment due to late-onset symptoms of misdiagnosis from aspiration of foreign bodies in the respiratory tract found pneumonia and atelectasis. Another study by Rance et al. (20), found that the most common late complications are bronchial stenosis and bronchiectasis, but only a few patients need surgical intervention.

Management of Foreign Body Aspiration

The principle of managing airway foreign body aspiration is to remove the foreign object immediately under minimal conditions and trauma. Foreign objects in the bronchus can be removed using rigid bronchoscopy or flexible bronchoscopy. The success rate is 91.3% in infants and children with relatively small airway diameters, it is better to use rigid bronchoscopy so that it can maintain airway patency. Before carrying out a bronchoscopy procedure, what to know is to visualize the object using chest x-ray radiology imaging, then determine the diameter of the scope, which is adjusted to the diameter of the child's tracheobronchi. After that, steroids and antibiotics are given before action is taken as prophylaxis against infection and complications of airway oedema, especially in cases that are treated late (14,17).

Rigid bronchoscopy, as the name suggests, uses a rigid material in the form of a metal tube with a lighting source proximal to the scope. The diameter and length of the metal tube vary according to the cross-section of the bronchus to be examined. Rigid bronchoscopy is chosen in pediatric cases such as massive hemoptysis, lung abscess, bronchial obstruction with thick secretions, narrow trachea, and foreign objects in the trachea or bronchus. The advantages of choosing this procedure are that breathing is more controlled, the lighting quality is better and the lumen is larger, making it easier to see the airways more clearly. Besides that, it can handle massive airway bleeding better and the process of removing foreign objects is easier (17).

Table 1. Size of bronchoscope according to age (17)

Age	Size
Premature	3 mm x 20 cm
Infant	3.5 mm x 25 cm
3-6 months	3.5 mm x 30 cm
12 months	4 mm x 30 cm
2 years	4 mm x 30 cm
4 years	5 mm x 35 cm
5-7 years	5 mm x 35 cm
8-12 years	6 mm x 35 cm 7 mm x 40 cm

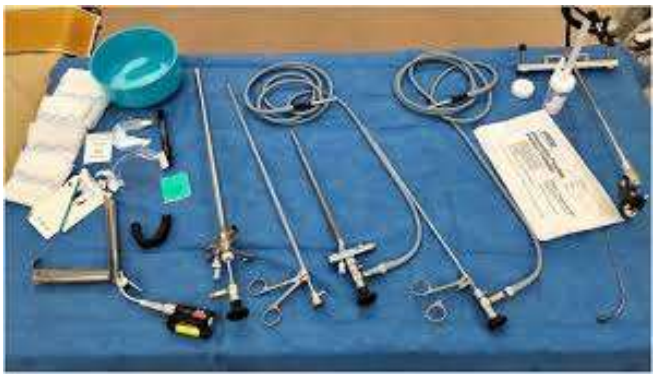

Figure 2. Rigid bronchoscopy (21)

Anesthesia management

Both rigid and flexible bronchoscopy procedures require special skills from anesthesiologists as well as bronchoscopy operators. The difficulty is due to the anesthesia and the intervention being performed on the airway. Both actions work on the airway, therefore maneuvers are needed to maintain the airway by maintaining oxygenation and iavoiding hypoxemia. Several ventilation options can be used and vary from nasal

cannulas and masks to LMA (laryngeal mask airway) and endotracheal tube (ET/endotracheal tube), each of which has advantages and disadvantages (22,23).

Pre-Anesthesia Evaluation

Bronchoscopy performed under general anesthesia requires standard preoperative assessment. Patients must be examined and it must be determined which physical status category they fall into according to the American Society of Anesthesiologists (ASA). Preoperative assessment is the same as for patients undergoing surgery and consists of serial physical examination, basic laboratory, and coagulation tests. Pulmonary function tests must be performed on patients who have severe respiratory obstruction, and CT scans need to be carried out on hemoptoe patients, especially those suspected of suffering from malignancy. Blood gas examinations are carried out for evaluation in several patients with the aim of determining hypokalemia or hypercarbia. Pay particular attention to the anesthesiologists on the patient's mouth opening, jaw, and neck movements. Patients who already suffer from dyspnoea and require oxygen or are hemodynamically unstable are at high risk of intra and postoperative complications (4). When a foreign body is suspected in the airway, preoperative assessment must include several things (24–26):

a) The location of the foreign object: if it is in the trachea, there is a risk of total obstruction, and it is best to take immediate action in the operating room.
b) Aspirated materials: Organic materials can absorb fluid and swell, oils from nuts can cause local inflammation, and sharp objects can cause injury to the airway.
c) Aspiration time: Airway oedema, connective tissue granulation and infection can complicate the extraction.
d) When the last meal was taken must be known to avoid the risk of further aspiration.
e) Airway patency must be controlled.

When the aspirated foreign body does not cause distal airway obstruction or causes minimal lower tract airway obstruction, the physician still has time to complete other preparations for bronchoscopy and prepare the patient to be fasted. The optimal fasting time is 4 to 6 hours for solid foods and 2 hours for clear liquids. Fasting is mandatory to reduce the risk of farther aspiration because, during the procedure, the airway cannot be fully protected (22–27).

Premedication

The topical anesthesia is hand-nebulized lidocaine and lidocaine jelly as a lubricant, as well as instillation of 3 ml of 1% or 2% lidocaine in the carina and if necessary, into the lower respiratory tract, with a maximum lidocaine dose of 45 mg/kg. Midazolam is given by dose titration to produce mild sedation, the total dose should not be more than 20 mg. The patient's clinical condition, analgesia drugs, or muscle relaxant drugs determine the type and level of sedation achieved by titrating the sedation dose in rigid and flexible bronchoscopy procedures to maintain oxygenation and prevent the patient from resisting the ventilator. Synthetic narcotics, such as fentanyl, suppress coughing and provide sufficient analgesia. Other sedations, such as benzodiazepines or propofol, can also be used, while light sedation can also be given to patients using topical anesthesia or using lignocaine injections during rigid bronchoscopy or flexible bronchoscopy procedures. Premedication generally uses anti-sialogue drugs (atropine injection 10 mcg/kg body weight intramuscularly), benzodiazepines (midazolam 0.05-0.07 mg/kg body weight intravenously), and bronchodilators (22–24).

Monitoring

Pediatric patients undergoing a bronchoscopy procedure are being monitored in the same way as other anesthesia procedures under general anesthesia. Special consideration should be given to pulse oximetry monitoring, which will show

desaturation percentage before clinical signs appear (skin color and others). In addition, the rate of change in saturation provides hints as to how the patient tolerates apnoeic episodes. Blood gas analysis (BGA) provides an inconclusive estimate of end-tidal pCO_2 levels, because most of the aspirated gas comes out from around the bronchoscopy scope. Intraoperative monitoring uses standard monitors, including electrocardiography (ECG), pulse oximetry, and non-invasive blood pressure (NIBP) (28).

Induction of anesthesia

Induction of anesthesia through the inhalation or intravenous route for rigid bronchoscopy or flexible bronchoscopy for aspiration of a foreign body, however, operators prefer to use rigid bronchoscopy, especially in children. Anesthesia induction is based on the protocol of each educational or training institution, but the basic principle is that spontaneous ventilation must be maintained until it is clear that the pediatric patient can be ventilated well. Anesthesia induction is based on the protocol of each educational or training institution, but the basic principle is that spontaneous ventilation must be maintained until it is clear that the pediatric patient can be ventilated well. Based on research, intravenous induction has a higher risk of aspiration outcomes than inhalation induction.

A survey from the Society for Pediatric Anesthesia found that the majority of anesthesiologists prefer mask induction without cricoid compression for pediatric patients with foreign body aspiration. In this case, the anesthesiologist also prefers to use induction with an inhalation anesthetic, such as sevoflurane. Other Studies indicate that sevoflurane has fewer side effects compared to halothane when used for induction in pediatric bronchoscopy cases. Another induction option for bronchoscopy is the topical application of lidocaine spray to the vocal cords and trachea. The advantage of using lidocaine spray is that the volume used is larger with a short duration of around 10 minutes, and the dose is 4 mg/kg, which has been proven to have no complications in pediatric patients, but it is necessary to reduce the dose given to children aged < 2 years and in patients who have dry mucosa. The ideal type of anesthesia for extracting foreign bodies from the airway is a combination of hypnosis, analgesia, and muscle relaxation. The drugs used include propofol, etomidate, or ketamine along with fentanyl or remifentanil. Fentanyl boluses and short-acting beta-blockers may be used to avoid the pain response. Plica vocalis with topical anesthesia lignocaine 4% can be used to avoid postoperative laryngospasm (24).

Anesthesia Maintenance

Anesthesia is maintained with remifentanil or propofol, continuous inhalation agents. The use of NO_2 is still contraindicated in air-trapping patients because of the high risk of excessive lung air inflation. Deep sedation is also used but still carries the risk of hypoventilation and laryngospasm. Ventilation in patients with rigid bronchoscopy is a challenge for all anesthesiologists, most patients who undergo bronchoscopy have abnormal lung function. Therefore, special techniques and strategies are needed to ventilate patients, such as spontaneous assisted ventilation, controlled ventilation, manual jet ventilation, and high-frequency jet ventilation. Preoxygenation aims to denitrogenate with 100% oxygen and relax muscles using short-acting muscle relaxants. The oropharynx is closed with gauze around the rigid bronchoscope. Spontaneous assisted ventilation typically employs total intravenous analgesia (TIVA), while oxygenation is provided through bronchoscopy. Oxygenation is provided via bronchoscopy, and ventilation assistance is provided. Anesthesia was maintained with continuous intravenous medication. Controlled ventilation in bronchoscopy is used in conjunction with an endotracheal tube for positive ventilation, while for jet ventilation high-pressure gas is used using a small catheter (25).

Complication

One of the fatal complications of removing a foreign object from the airway is airway obstruction caused by unpredictable movement of the foreign object in the airway. This can occur if the foreign object falls or breaks apart towards the proximal part of the airway. The treatment for this condition involves pressing the foreign object into the distal part of one of the main bronchi in the airway. Several case reports suggest that the type of ventilation has little effect on the incidence of complications compared with the skill of the operator and the bronchoscopy equipment used. Repeated manipulation of rigid bronchoscopy can cause trauma to the gums and vocal folds. Laceration until perforation of the airway can occur in the posterior wall of the trachea, posterior subglottis, and medial wall of the left or right main bronchus just below the carina. Lacerations of the vocal folds and the anterior wall may also occur, leading to bleeding. The bleeding that occurs can be treated with cauterization and local compression with a scope added with epinephrine. If the bleeding is > 250 ml, an emergency thoracotomy is required. Another event that may occur is a fire or explosion, so in this condition, immediate action is needed, stopping ventilation and removing the oxygen source, while air embolism can also occur due to the connection between the airways and blood vessels (26).

Recovery

In most cases of airway foreign body extraction without complications, the patient can be sent home immediately (one-day care). However, in severe cases, longer treatment may be needed if complications occur during the bronchoscopy procedure by administering antibiotic treatment to treat infections due to delays and handling cases of airway foreign body extraction. After the bronchoscopy procedure, it is recommended to maintain the patient's temperature optimally and monitor for signs of respiratory distress in the recovery room. What must be considered is whether the patient is completely conscious before being moved to the recovery room after being given general anesthesia during the bronchoscopy procedure. If the patient is desaturated and there are blood and mucous secretions in the airway, then ET must be observed and maintained. After leaving the operating theater, a bronchodilator agent is needed to be administered to prevent bronchospasm after the bronchoscopy procedure (28). The objective of this study is to evaluate the management of anesthesia in pediatric patient with foreign body aspiration in late-onset settings.

CASE REPORT

A 7-month-old boy weighing 10 kg came to the P1 Emergency Room at Saiful Anwar General Hospital Malang, presenting with shortness of breath. According to the patient's history, he exhibited signs of shortness of breath for the last 3 days before being admitted to the hospital, which worsened after one day in the hospital. Previously, the patient inhaled peanuts while playing alone next to his mother, who was preparing them. Shortly after being inhaled, the patient appeared to be coughing continuously. He tried to expel it using his hands but the cough persisted. The patient was then taken to the Ear, Nose, and Throat (ENT) polyclinic in Situbondo City and advised to refer immediately to Saiful Anwar General Hospital for further treatment. The patient was referred to Saiful Anwar General Hospital on the day of the incident, but the patient's mother refused to undergo surgery at that time, and the patient was taken home, but the patient got worse and the patient's mother decided to take him back to Saiful Anwar General Hospital.

Physical examination showed results, increased heart rate (HR) 164 x/min and respiration rate (RR) 36 x/min with Non-Rebreathing Mask (NRM) SpO_2 100%. Suprasternal, intercostal, and supraclavicular retraction, but was presented without gargling or stridor signs.

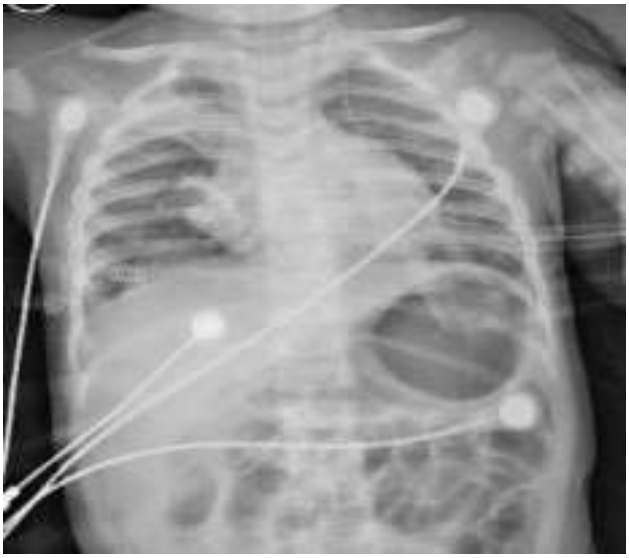

Figure 3. A pre-surgery chest X-ray shows signs of right lower lobe atelectasis

From the results of the history taking, physical examination, and radiological examinations, the patient was diagnosed with a foreign body (peanut) in the right bronchus with respiratory distress. The patient was then referred to the Anesthesia Department by the ENT department for an immediate exploratory bronchoscopy. A secure airway procedure was carried out with direct intubation in the emergency room using 25 mcg of fentanyl, 30 mg of propofol given by titration, and 5 mg of atracurium due to the threat of respiratory failure. Once the airway condition is safe, the patient is immediately taken to the emergency operating room for further procedures.

The patient is treated with general anesthesia (GA) via endotracheal tube (ETT) for approximately 1 hour from preparation for anesthesia until the patient has finished the procedure. During the procedure, maintenance was given an additional 20 mcg fentanyl and 5 mg atracurium with 2% sevoflurane dial anesthetic gas.

The patient was positioned to sleep on his back after anesthesia, and his head was positioned to sleep hyperextended by the ENT team. Then the bronchoscopy scope was inserted, and a round, brownish foreign body was seen in the right bronchus. Extraction was carried out using teleforceps, and 6 peanut fragments were obtained. After the fragments were removed, an evaluation was carried out on the trachea to the right and left bronchi and no remaining corporal fragments were found, only secretions were found without any lacerations. After suctioning and ensuring that the secretions are clean, the bronchoscopy scope is removed.

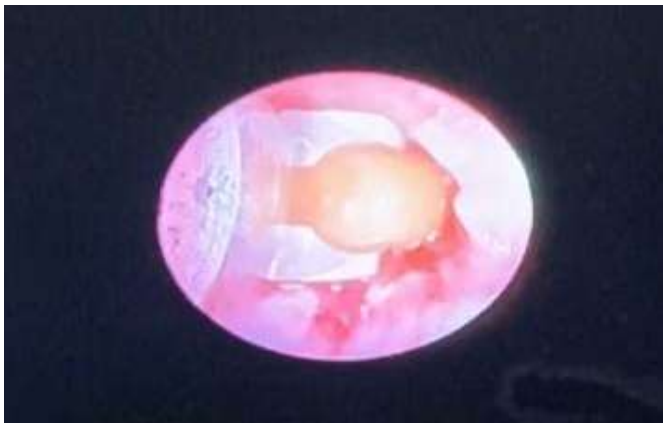

Figure 4. Roundish brownish foreign body in left bronchus (picture taken from bronchoscopy video)

For postoperative care, the patient is admitted to the tube-in Intensive Care Unit (ICU) for further observation and monitoring. The patient was treated in the ICU for 2 days, and the condition showed an improvement. During ICU treatment, the patient received intravenous therapy with ampicillin sulbactam 4x375 mg, dexamethasone 3x2 mg, ranitidin 2x10 mg, and metamizole 4x10 mg. Oral medication was also given such as NAC 2x100mg and Ventolin nebulization every 8 hours. The patient was decided to be extubate on the second day after the procedure, and his condition was stable during treatment 24 hours after extubation.

The patient was transferred to the High Care Unit (HCU) on the fourth day after the procedure. During 24 hours of HCU treatment, the patient had no complaints, then he was transferred to a low-care room and discharged three days later.

DISCUSSION

One case of aspiration of a foreign object (peanut) in the right main bronchus in a 7-month-old boy has been reported. This case is by various

literature that the incidence of foreign body aspiration is 75-85% in children aged <15 years and 50% in children aged <3 years (5,6). Children with immature molar teeth and immature swallowing coordination and crying conditions are factors that cause foreign body aspiration in this case. In this case the foreign object that was aspirated was peanuts. Based on the results of the study, it was stated that peanuts were the most common cause of around 52.3% of aspiration of foreign objects in the respiratory tract, followed by other foods (12.2%), other grains (5.3%), bones (1.5%), plastic materials (15.1%), metals (4.5%), small stones (0.8%), and tablets (1.2%) (5,6,29).

The peanut foreign body in this patient had been lodged for 6 days. The patient was taken to the hospital on the third day after aspiration, but the family refused the bronchoscopy procedure, however, the patient came back 3 days later in worsening condition, with symptoms like severe shortness of breath and loss of consciousness.

The findings on bronchoscopy were an inflammatory reaction in the respiratory tract, the mucosa appeared hyperemic with thick secretions covering the peanuts, where the peanuts did not contain skin and that was why the peanuts expanded easily because they were hygroscopic. The patient in this case was also given corticosteroids (dexamethasone) 6 hours before the bronchoscopy procedure and was also given during the bronchoscopy procedure. Apart from that, this patient was also given antibiotics because this patient was a case of late bronchoscopy due to a neglected family who did not agree to the procedure, so to reduce oedema and the risk of serious infection, adequate antibiotics were needed. The Pediatric Acute Lung Injury Consensus Conference (PALICC) guideline does not recommend the routine use of corticosteroids for pediatrics with acute respiratory distress syndrome (ARDS), however research conducted by Fernandez et al. (30) in 2018 shows that this is still controversial. A Randomized Controlled Trial (RCT) pilot study by Drago BB et al. (31) on 35 pediatric patients with ARDS. Patients receiving steroids compared to the group of patients receiving placebo within the first 72 hours of mechanical ventilation at a dose of 2 mg/kg/day and tapering off after 7 days were said to have had better results, especially in population groups with a history of asthma, pneumocystis pneumonia, and chronic obstructive pulmonary disease.

The diagnosis of a foreign body in the airway was only made after 3 days when the patient aspirated peanuts, as the patient was taken to the hospital after this delay. Therefore, there was no delay in determining the diagnosis itself; rather, the cause of the delayed diagnosis stemmed from the prolonged timing of the patient's visit and subsequent delays in performing the bronchoscopy procedure. The peanut extraction procedure with the bronchoscopy procedure was delayed for up to 6 days, not because of the negligence of the bronchoscopy team, but because of the family's inability to carry out the procedure at the beginning of the first visit, in fact it gave the impression that the family was delaying the bronchoscopy procedure for reasons that were not yet clear. According to ding et al.'s study, the diagnosis of foreign body aspiration can be made within 0-1 days (45%), 2-7 days (22%), 7-30 days (14%), and >30 days (17%). This shows that the percentage of early diagnoses is higher, and it is possible that earlier diagnoses can be made with a better prognosis, which also depends on the clinician's experience in establishing the diagnosis (20,30).

A chest x-ray examination at the first visit of this patient revealed an abnormality in the form of right lower lobe atelectasis with a picture of homogeneous right paracardial opacity that pulled the right diaphragm, indicating that there was an almost total blockage in the right lower bronchial segment. When compared with the second patient's chest x-ray 24 hours after the procedure, it was found that the chest x-ray picture of pneumonia (new process), right upper lobe atelectasis (new

lesion), and lower lobe atelectasis was relatively the same as the previous chest x-ray picture, so it can be concluded that the patient experienced disease progression due to peanut aspiration, because a delay in bronchoscopy treatment caused blockage in other lung lobes and lung infection could not be avoided.

In this patient, rigid bronchoscopy was performed for a definite diagnosis and at the same time evacuation of the foreign object (peanut). Rigid bronchoscopy is the best modality for airway foreign body extraction in children, with the advantages of ensuring airway patency and clear visualization of the airway. The difficulty in extracting peanuts in this patient is the deep location and narrower diameter of the airways accompanied by purulent secretions covering the peanuts so that extraction is done more than once because they are slippery. Then the bronchoscopy procedure took more than 20 minutes because of this. The theory states that bronchoscopy should take less than 20 minutes to avoid complications. The complications that occur are divided into 2, such as minor complications (mucosal injuries: pharyngitis, acute laryngitis, hypoxia, fever and mild-moderate bleeding) and major complications (tension pneumothorax, severe bleeding, severe hypoxia, and heart failure). From the results of examinations and observations before and during the procedure, as well as after the bronchoscopy procedure, no serious complications were found in this patient (5,6,12).

In patients with severe conditions and late-onset treatment, endotracheal intubation with a tidal volume of 5-8 ml/kg with a PEEP >15 cm H_2O is recommended, taking into account the clinical characteristics of patients on mechanical ventilation. To maximize ventilation and oxygenation, the guidelines recommend administering sedation and a combination with muscle relaxants while still paying attention to the patient's nutritional coverage and fluid management, the same as patients in critical conditions in other ICUs. Management of atelectasis by adjusting ventilator settings and treating pneumonia according to the guidelines results in an improvement in the patient's condition (5,20,28).

One of the main limitations of this case report is its inherent lack of generalizability, as it describes the anesthetic management of a single pediatric patient with late-onset foreign body aspiration. While the case provides valuable insights into clinical decision-making, including preoperative assessment, induction technique, and airway management strategies, the findings cannot be universally applied to all similar cases due to variations in patient anatomy, type and location of the foreign body, and institutional resources.

CONCLUSION

Foreign body aspiration is a serious condition that can potentially be fatal. Bronchoscopy is the main choice for the extraction of foreign bodies, it can be done with rigid bronchoscopy or flexible bronchoscopy. It is recommended that a highly experienced team be available for foreign body aspiration cases, especially in paediatric patients.

Good anesthetic management, evaluation, and preparation, including patient history, comorbidity, and preexisting lung infection before the procedure are key elements for the successful management of this problem. Anesthesia agents for premedication, induction, and inhalation maintenance during the procedure had to be chosen carefully and based on patient selection, especially in pediatric patients. Further research with serial cases is needed to evaluate standard anesthesia drugs for the pediatric bronchoscopy procedure.

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Conflict of interest

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Author contribution
RS contributes to the study concept or design, data collection and writing the paper. RV contributes in the study concept or design, data collection, analysis and interpretation, oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team.

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Case Report

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ANESTHETIC AND SURGICAL CONSIDERATIONS IN AWAKE CRANIOTOMY FOR ELOQUENT AREA TUMOR

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ABSTRACT

Introduction: Awake craniotomy is a specialized neurosurgical technique in which the patient remains conscious during surgery, enabling real-time functional mapping of the cerebral cortex. This procedure is primarily employed when a brain tumor or lesion is situated near critical areas responsible for motor, visual, or language functions. Its application minimizes the risk of postoperative neurological deficits, ensuring the preservation of vital brain functions.
Objective: The objective of this case report is to highlight the use of the awake craniotomy technique for a patient with a brain tumor located in the left parietal lobe, emphasizing the surgical and anesthetic considerations necessary for successful outcomes.
Case Report: The patient, diagnosed with a brain tumor in the left parietal lobe, presented unique surgical challenges due to the tumor's proximity to the cortical centers governing movement and speech. To mitigate the risk of neurological impairment, an awake craniotomy was performed. Bilateral scalp nerve blocks were administered for effective pain management, alongside dexmedetomidine to provide conscious sedation. The "awake-wake-wake" protocol was followed, ensuring the patient remained alert throughout critical phases of the surgery. This allowed the surgical team to conduct real-time assessments of motor and language functions, optimizing tumor resection while preserving neurological integrity.
Conclusion: This case underscores the importance of the awake craniotomy technique in neurosurgical interventions involving eloquent brain regions. The use of dexmedetomidine and precise nerve blocks provided effective sedation and analgesia, enabling active patient participation during functional mapping. The procedure highlights the value of interdisciplinary collaboration between neurosurgeons and anesthesiologists to achieve optimal patient outcomes while minimizing neurological risks.

Keywords: Awake craniotomy; Bupivacaine; Dexmedetomidine; Tumor

ABSTRAK

Pendahuluan: *Awake craniotomy* adalah teknik bedah saraf khusus di mana pasien tetap dalam keadaan sadar selama operasi, memungkinkan pemetaan fungsional korteks serebral secara real-time. Prosedur ini terutama digunakan ketika tumor atau lesi otak terletak di dekat area kritis yang bertanggung jawab atas fungsi motorik, visual, atau bahasa. Penerapan teknik ini bertujuan untuk meminimalkan risiko defisit neurologis pascaoperasi serta menjaga fungsi vital otak.
Tujuan: Laporan kasus ini bertujuan untuk menyoroti penggunaan teknik kraniotomi sadar pada seorang pasien dengan tumor otak yang terletak di lobus parietal kiri, dengan penekanan pada pertimbangan bedah dan anestesi yang diperlukan untuk hasil yang optimal.
Laporan Kasus: Pasien dengan diagnosis tumor otak di lobus parietal kiri menghadapi tantangan bedah yang kompleks karena lokasi tumor yang dekat dengan pusat kortikal yang mengatur gerakan dan bicara. Untuk mengurangi risiko gangguan neurologis, dilakukan prosedur kraniotomi sadar. Blok saraf kulit kepala bilateral diberikan untuk manajemen nyeri yang efektif, dan dexmedetomidine digunakan untuk memberikan sedasi sadar. Protokol "awake-wake-wake" diikuti, memastikan pasien tetap waspada selama fase-fase kritis operasi. Hal ini memungkinkan tim bedah melakukan penilaian fungsi motorik dan bahasa secara langsung, sehingga reseksi tumor dapat dioptimalkan tanpa mengorbankan integritas neurologis.
Kesimpulan: Kasus ini menekankan pentingnya teknik kraniotomi sadar dalam intervensi bedah saraf yang melibatkan area otak yang berfungsi penting. Penggunaan dexmedetomidine dan blok saraf yang tepat memberikan sedasi dan analgesia yang efektif, memungkinkan partisipasi aktif pasien selama pemetaan fungsional. Prosedur ini menyoroti pentingnya kolaborasi multidisipliner antara ahli bedah saraf dan ahli anestesi untuk mencapai hasil terbaik bagi pasien sekaligus meminimalkan risiko neurologis.

Kata kunci: *Awake craniotomy*; Bupivacaine; Dexmedetomidine; Tumor

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INTRODUCTION

Awake craniotomy stands as a well-established technique for the excision of brain tumors situated in close proximity to critical cerebral centers (1). This approach facilitates maximal tumor mass reduction while preserving the integrity of pivotal functional areas, encompassing motor, speech, and visual centers (2). Various anesthetic modalities have been employed for awake craniotomy, including the "sleep-wake-sleep" technique, with or without mechanical ventilation, and the administration of local or regional scalp anesthesia to manage "wide awake" patients. The requisite level of sedation and analgesia fluctuates across different phases of the surgical procedure; however, paramount is the maintenance of the patient's wakefulness and alertness during brain function assessments (3).

Several sedative agents have been utilized in this context, notably dexmedetomidine, propofol, and remifentanil, each carrying distinct advantages and side effects (4,5). Dexmedetomidine is favored for its superior respiratory maintenance, whereas propofol is associated with a diminished occurrence of intraoperative seizures (6). The short duration of action of remifentanil makes it advantageous for managing pain during surgery and ensuring patient comfort in both conscious and unconscious states, although it carries a higher risk of side effects such as nausea, vomiting, and respiratory depression (7).

Effective patient education and preparation preoperatively, coupled with the expertise of anesthesiologists and surgical techniques aimed at averting the tension on intracranial structures sensitive to pain, constitute pivotal principles in enhancing the efficacy of pain control during surgery and ensuring postoperative patient contentment (8).

This case report aims to demonstrate the application of the awake craniotomy technique in managing a brain tumor situated in the left parietal lobe. It focuses on discussing the key surgical and anesthetic strategies that contribute to achieving a successful and safe outcome for the patient.

CASE REPORT

The patient was a 48-year-old man who underwent an awake craniotomy operation in Al-Zahra Hospital in Isfahan in March 2023. The patient's weight was 82 kg, height 177 cm, and body mass index 26, with initial symptoms of seizures. After examination and imaging, the initial diagnosis of glioblastoma was made in the left parietal lobe [Figure 1].

The patient's seizures were controlled with valproic acid tablets 500 mg per day. In the preoperative evaluation, since the tumor was anatomically located close to the patient's motor and speech centers, after an interdisciplinary consensus involving the anesthesia and neurosurgery team, the decision was made to conduct an awake craniotomy for intraoperative monitoring, with the goal of preserving speech functions. And the move was made. This should be done during tumor removal. Several counseling sessions were conducted two weeks before the operation by the anesthesiologist with the patient and first-class companion, and the necessary explanations and the necessity of cooperation during the operation were explained to them. Prearranged questions and exercises were conducted to evaluate the patient’s cognitive and language abilities. Also, the patient had a history of cough and allergy during the preoperative examination, and a pulmonary consultation was performed and he was treated with medication. In cardiovascular evaluation and consultation, non-obstructive surgery was reported. Sensory and motor function and preoperative tests were completely normal.

An informed consent form was obtained, and anticonvulsants were administered on the morning of the surgery. Upon entering the operating room, the patient was carefully positioned supine, and standard anesthesia monitoring was initiated, including electrocardiogram, pulse oximetry, and non-invasive blood pressure measurement. The initial vital signs recorded were a blood pressure of 115/75 mmHg, a heart rate of 85 beats per minute, and an arterial oxygen saturation of 96%. Excess oxygen of 3 to 5 L/min was measured through the

nasal cannula and exhaled carbon dioxide was measured through the capnograph. Then midazolam 3 mg and fentanyl 100 µg were administered intravenously. An arterial line was placed in the left radial artery under local anesthesia with lidocaine. In order to control the intracranial pressure, 5 vials of half percent hypertonic saline and 20 mg of Lasix were prescribed 30 minutes before administration. Conscious sedation with spontaneous breathing was initiated by targeted injection of dexmedetomidine at a dose of 0.7 µg per kg of body weight for ten minutes before scalp block and fixation of the head in a Mayfield frame. Then bilateral scalp nerves were blocked with bupivacaine 0.25% in 6 areas on each side including supraorbital, supratrochlear, oricotemporal, zygomatic and temporal, small and large occipital nerves with the amount of 2 cc in each area (total dose 24 cc) by an anesthesiologist. Dexamethasone 8 mg and ondansetron 4 mg were prescribed to prevent nausea and vomiting. After ten minutes, the dose of dexmedetomidine was reduced to 0.5 µg per kg body weight per hour. The surgery started without pain and with complete relaxation of the patient. During the operation, the patient opened his eyes by calling and sometimes by skin contact and fully executed the verbal and movement commands. His level of conscious sedation varied, but he remained conscious throughout the procedure.

Vital signs and hemodynamics were completely stable during the operation, and the patient was very calm and followed motor and verbal commands and had a good understanding of the instructions. In addition to being fully sedated, the patient was so aware of time and place during the operation that he asked us to tell his wife, who was outside the operating room, that he was fine and not to worry, which was a very interesting point. The amount of bleeding was calculated to be about 200 cc, and blood sugar and arterial blood gases were checked during the operation, which were reported to be normal. After the end of the operation, which lasted for 4 and a half hours, the patient was transferred to the recovery room, and after 2 hours of hospitalization in the recovery room and ensuring full consciousness and the absence of possible complications, the patient was transferred. He went to the intensive care unit and was discharged after two days in good general condition.

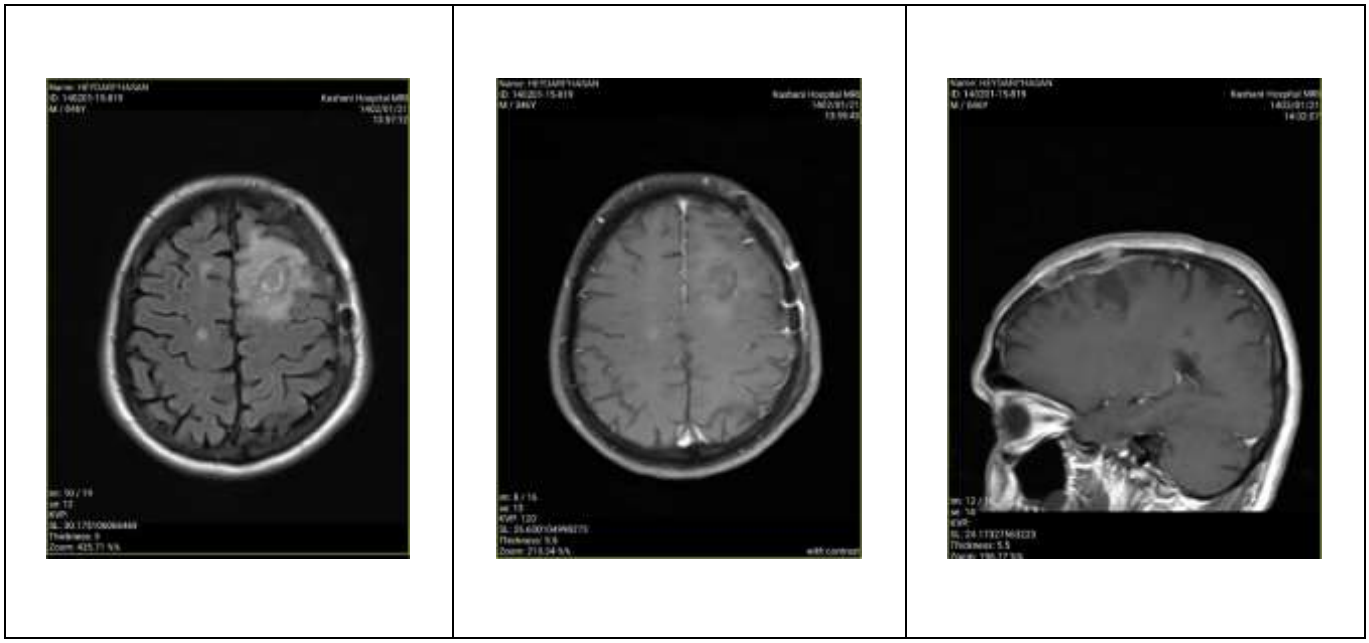

Figure 1. CT scan of the brain (parietal lobe tumor)

DISCUSSION

Awake craniotomy has gained increasing popularity in tumor surgery in recent years. However, it carries potential complications, including seizures, cerebral edema, nausea and vomiting, altered consciousness, neurological deficits, pain, and a loss of patient cooperation. As a result, this technique requires continuous monitoring, the use of short-acting agents, and careful consideration of regional blocks (such as local scalp anesthesia). A key concern during the procedure is ensuring a stable airway and maintaining patient cooperation. The avoidance of tracheal intubation helps prevent coughing or airway irritation, which could increase intracranial pressure and brain swelling. Intubation can also be challenging during such procedures. The incidence of nausea and vomiting can vary depending on factors such as the patient's medical history, the nature of the injury, medication administration, and the type of anesthesia used (9).

Successful awake craniotomy largely depends on careful patient selection, which includes assessing the airway, the patient's ability to cooperate, the risk of sedation failure, potential intraoperative complications, and ensuring proper psychological preparation before the procedure. Various drug regimens have been used across different protocols, with the most common being propofol, remifentanil, dexmedetomidine, and midazolam. Due to their short half-lives, both dexmedetomidine and propofol enable early awakening once the infusion is stopped, making them the preferred choices for awake craniotomy (10).

In the patient of this report, a scalp block was performed with bupivacaine and sedation with dexmedetomidine, which was completely satisfactory. A different approach was chosen, involving a combination of local anesthetics and conscious sedation, resulting in the implementation of the 'Awake–Awake–Awake' technique. Although no complications occurred during the operation. Combining these two methods made it possible to remove the maximum tumoral mass with minimal nerve damage for the patient. The skill and knowledge of the anesthesiologist in the selection and titration of the drug and the close emotional connection with the patient before and during surgery are key and important points for a successful conclusion.

CONCLUSION

Awake craniotomy technique, although challenging for anesthesiologists, is a very reliable and useful technique for assessing brain function during surgery and minimizing neurological complications. Therefore, it is recommended to use this method with the necessary precautions in mind. In addition, there is a need for more research and studies in this field. More studies are needed, especially in relation to possible complications during the operation and their control and treatment. Also, predicting and preparing for the management of complications during surgery is one of the most important key points. Since the patient is awake, in case of possible complications, one should keep calm and manage the crisis while not worrying and stressing.

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Conflict of Interest

There are no conflicts of interest disclosures.

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Patient Consent for Publication

Written informed consent for the publication of clinical details and any associated photographs was acquired from the patient (or the patient's parent/legal guardian, if relevant). The patient was assured that personal information would remain confidential and that measures would be implemented to guarantee anonymity. A copy of the

signed consent form is accessible and can be supplied to the journal upon request.

Authors's Contributions

MMI and MMA are responsible for the study design, data analysis and interpretation, and drafting and finalizing the article.

NA is responsible for drafting and finalizing the article.

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SUCCESSFUL ONE-LUNG VENTILATION WITH FOGARTY BALLOON FOR THORACOTOMY LOBECTOMY IN A 5-YEAR-OLD GIRL

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ABSTRACT

Introduction: Pediatric thoracic surgery, particularly lung resection, has special difficulties due to anatomical and physiological differences compared to adults. One-lung ventilation (OLV) is often necessary to optimize surgical exposure while minimizing lung injury. Traditional methods, like double-lumen endotracheal tubes, can be difficult to use in children due to their smaller airways and the risk of trauma. Thus, alternative approaches, such as bronchial blockers like Fogarty occlusion catheters, have gained prominence.
Objective: This case report aims to highlight the use of the Fogarty balloon in a pediatric patient undergoing lobectomy for organized pleural effusion linked to pneumonia.
Case Report: A 5-year-old girl with recurrent pneumonia presented with persistent cough, intermittent fever, and respiratory distress. Physical examination revealed decreased breath sounds and mild cyanosis. Imaging confirmed a large organized pleural effusion, suspected to be empyema. The surgical team chose a right thoracotomy lobectomy to remove the affected lung tissue. Preoperative consultations included pediatric surgery, anesthesiology, and respiratory therapy to ensure comprehensive care. A multi-modal pain management strategy, emphasizing regional anesthesia through epidural blocks, was implemented. For OLV, the anesthetic team selected a Fogarty balloon catheter to minimize airway trauma. After intubating with a single-lumen endotracheal tube, the balloon was inserted into the right main bronchus and inflated to occlude it, allowing ventilation of the left lung.
Discussion: The Fogarty balloon effectively provided lung isolation while preserving airway integrity, facilitating optimal surgical exposure and stable oxygenation. Continuous monitoring of oxygenation during OLV was crucial for patient safety.
Conclusion: The use of a Fogarty balloon for bronchial blockade and epidural anesthesia was successful in this pediatric lobectomy case. These techniques enhanced surgical safety, efficacy, and postoperative recovery, suggesting that there must be ongoing research to establish standardized protocols for pediatric thoracic procedures.

Keywords: Bronchial Blocker; Fogarty Balloon; One-Lung Ventilation; Pediatric Medicine; Thoracic Surgery

ABSTRAK

Pendahuluan: Bedah toraks pediatrik, terutama yang melibatkan reseksi paru, menghadirkan tantangan unik karena perbedaan anatomi dan fisiologis dibandingkan dengan orang dewasa. Ventilasi satu paru (OLV) sering diperlukan untuk mengoptimalkan eksposur bedah sambil meminimalkan cedera paru. Teknik tradisional, seperti tabung endotrakeal ganda, dapat sulit diterapkan pada anak-anak karena saluran napas yang lebih kecil dan risiko trauma. Oleh karena itu, metode alternatif seperti penghalang bronkial, termasuk kateter oklusi Fogarty, semakin menarik perhatian.
Tujuan: Laporan kasus ini bertujuan untuk menyoroti penggunaan balon Fogarty pada pasien pediatrik yang menjalani lobektomi akibat efusi pleura terorganisasi yang berkaitan dengan pneumonia.
Laporan Kasus: Seorang gadis berusia 5 tahun dirawat karena riwayat pneumonia berulang, dengan gejala batuk persisten, demam intermiten, dan distress pernapasan. Pemeriksaan fisik menunjukkan suara napas yang menurun dan sianosis ringan. Pencitraan mengonfirmasi adanya efusi pleura besar terorganisir dengan kecurigaan empyema. Tim bedah memutuskan untuk melakukan lobektomi torakotomi kanan untuk mengangkat jaringan paru yang terkena. Konsultasi praoperatif melibatkan tim bedah pediatrik, anestesiologi, dan terapi pernapasan.
Diskusi: Penggunaan balon Fogarty sebagai penghalang bronkial terbukti efektif dalam memberikan isolasi paru sambil menjaga integritas saluran napas. Metode ini memungkinkan eksposur bedah yang optimal dan oksigenasi yang stabil. Pemantauan oksigenasi selama OLV sangat penting untuk memastikan keselamatan pasien.
Kesimpulan Integrasi balon Fogarty dan anestesi epidural dalam kasus ini menunjukkan keberhasilan dalam menangani lobektomi pada pasien pediatrik. Teknik inovatif ini tidak hanya meningkatkan keselamatan bedah tetapi juga memperbaiki pemulihan pascaoperasi. Penelitian lebih lanjut diperlukan untuk menstandarkan protokol isolasi paru dan manajemen nyeri pada bedah toraks pediatrik.

Kata Kunci: Penghalang Bronkial; Balon Fogarty; Ventilasi Satu Paru; Ilmu Kedokteran Anak; Bedah Toraks

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INTRODUCTION

Pediatric thoracic surgery, particularly procedures involving lung resection, poses special difficulties due to anatomical and physiological differences compared to adult patients. One-lung ventilation (OLV) is commonly necessary during these procedures to optimize surgical exposure and minimize lung injury (1). Traditional techniques, including the use of double-lumen endotracheal tubes, can be difficult to implement in children due to their smaller airways and the potential for airway trauma (2). Consequently, alternative methods, such as the use of bronchial blockers, including Fogarty occlusion catheters, have gained attention (1–3). This report examines the successful utilization of a Fogarty balloon as a bronchial blocker in a 5-year-old girl undergoing lobectomy due to organized pleural effusion associated with pneumonia.

CASE REPORT

A five-year-old girl was referred to our facility with a history of repeated episodes of pneumonia. Her symptoms included persistent cough, intermittent fever, and noticeable respiratory distress. Mild cyanosis, tachypnea, and diminished right-sided breath sounds were detected by auscultation. Initial imaging studies, including a chest X-ray, revealed a significant accumulation of fluid in the right-sided pleural cavity. Subsequent chest ultrasound and CT imaging confirmed the presence of an organized pleural effusion, with suspicion of empyema and a localized lesion in the right lower lobe.

The patient’s medical history included a previous hospitalization for pneumonia six months prior, during which she was treated with antibiotics. She was fully immunized for her age and had no known drug allergies. Laboratory tests revealed moderate anemia, likely secondary to chronic disease or recurrent infections, but the patient maintained a satisfactory nutritional status and was otherwise healthy.

Preoperative Evaluation

Preoperative assessments included a thorough evaluation of the patient’s respiratory status and nutritional condition. Pulmonary function tests were performed to evaluate her baseline lung capacity, although their interpretation was limited by her age. The patient was also seen by a pediatric nutritionist to ensure optimal nutritional support leading up to the surgery.

Informed consent was obtained from the guardians after thoroughly discussing the surgical procedure, potential complications, and the anesthetic plan. The anesthetic approach focused on minimizing perioperative stress and pain, particularly given the patient's age and underlying respiratory condition.

Anesthetic Management

The anesthetic team planned a multi-modal approach for pain management, emphasizing the importance of regional anesthesia. The choice of epidural anesthesia was made to provide effective analgesia throughout the surgical procedure and postoperative recovery.

One-Lung Ventilation Strategy

For OLV, a Fogarty balloon catheter was selected as the bronchial blocker. This decision was based on the catheter's ability to provide effective lung isolation while minimizing the risk of airway trauma, particularly in small pediatric patients. The Fogarty balloon, TufTex® Embolectomy Catheter size 4Fr, was prepared for insertion, ensuring that it was compatible with the size of the patient’s airway.

The approach involved introducing the Fogarty balloon into the right main bronchus following the insertion of a single-lumen endotracheal tube. First, a 4.5-cuffed endotracheal tube was inserted and auscultation was performed to ensure and measure the depth when both lungs were symmetrically ventilated. After the initial insertion of the endotracheal tube, it was advanced further to confirm that ventilation was more effective in the right lung than in the left.

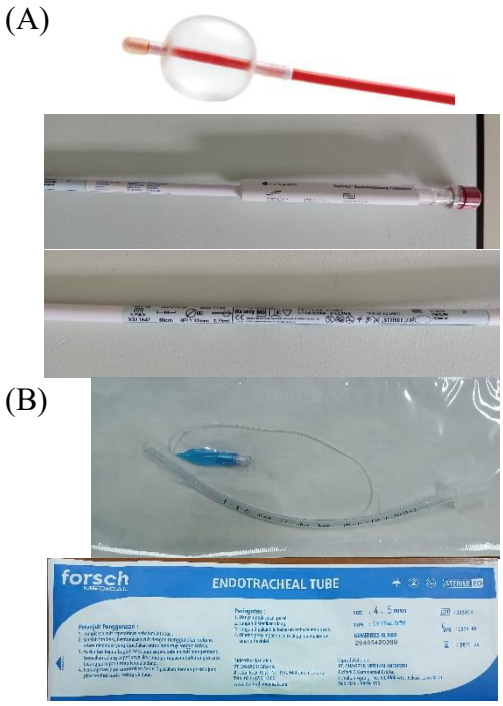

Figure 1. (A) Fogarty balloon TufTex® Embolectomy Catheter size 4Fr, length 80 cm, balloon volume 0.75 ml, Inflated Balloon Diameter 10.5 mm, Deflated Balloon Diameter 1.32 mm; (B) Endotracheal tube Forsch Medical size 4.5 cuffed, diameter 6.0 mm

Figure 2. Bronchial block procedure in a patient. (A) Intubation using Endotracheal tube; (B) Forgaty catheter placement using three-way stopcock; (C) Forgaty catheter placement using mountpiece

This step was vital for establishing proper one-lung ventilation by ensuring that the Fogarty balloon catheter was established in the main right bronchus to facilitate lung isolation. The endotracheal tube was then retracted to its initial measured depth while ensuring that the position of the Fogarty balloon catheter remained stable. To verify successful isolation of the right lung, auscultation was performed both before and after inflating the Fogarty balloon.

Epidural Anesthesia Technique

An epidural puncture was performed at the L2-L3 interspace using a sterile technique. The anesthesiologist carefully advanced the epidural catheter until T9-T10. 0.25% bupivacaine with a total volume of 12 mL was given, with careful monitoring for any signs of intravascular or intrathecal placement. After confirming the efficacy of the epidural, a continuous infusion of 0.1% bupivacaine was planned postoperatively at a rate of 12 mL every 12 hours.

Surgical Procedure

The patient was transported to the operating room and carefully monitored. Standard monitoring devices, including electrocardiogram (ECG), pulse oximetry, and non-invasive blood pressure monitoring, were established.

Once the patient was adequately anesthetized, the single-lumen endotracheal tube was placed. After intubation, the Fogarty balloon was gently inserted into the right main bronchus using direct visualization with a flexible bronchoscope. The balloon was inflated to achieve lung isolation.

The right lateral thoracotomy was then initiated. The surgical team carefully assessed the thoracic cavity, taking care to minimize trauma to surrounding structures. The procedure involved resection of the affected lung tissue and drainage of the pleural effusion, which was found to be purulent. The operation lasted approximately 90 minutes, during which the patient's vital signs remained stable, and oxygen saturation levels consistently exceeded 95%.

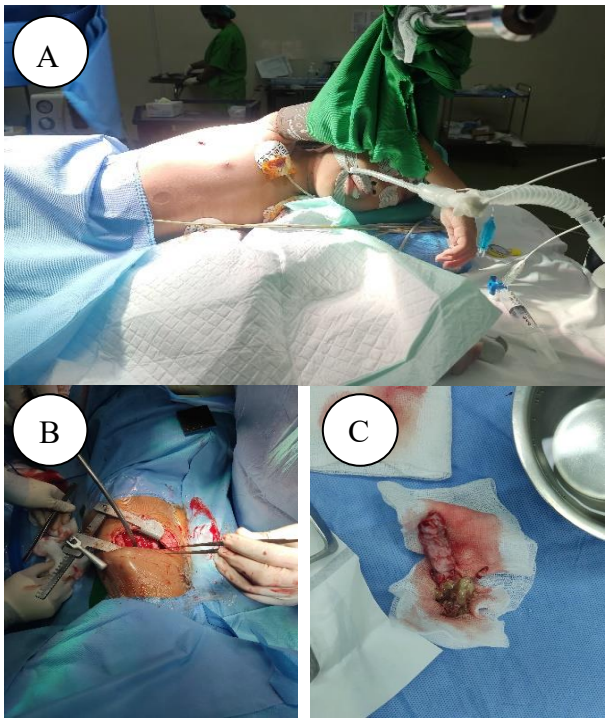

Figure 3. Positioning for the procedure patient. (A) Left Lateral Decubitus (B) One lung ventilation with the collapsed right lung (C) Successful lobectomy

Once the lobectomy was completed, the Fogarty balloon was deflated and withdrawn. The thoracic cavity was thoroughly irrigated and inspected for bleeding before closure.

Postoperative Care

Upon completion of the procedure, the patient was shifted to the post-anesthesia care unit (PACU) for monitoring. Extubation was performed four hours postoperatively, following careful assessment of her respiratory function and overall stability. Continuous monitoring of vital signs and oxygen saturation was maintained throughout her recovery.

The epidural catheter was connected to the infusion pump for continuous delivery of 0.1% bupivacaine at a rate of 12 mL every 12 hours. This approach effectively managed postoperative pain and minimized the need for systemic opioids, which could complicate recovery.

Postoperative recovery was uneventful. The patient was observed for signs of respiratory distress, infection, or complications related to the surgical procedure. By postoperative day two, she was transitioned to oral analgesics and demonstrated good pain control, allowing for early mobilization.

DISCUSSION

The management of pediatric thoracic surgery demands a customized method that takes into account the distinct physiological and anatomical features of children. Issues related to managing the airway in newborns are significant contributors to morbidity, as they can lead to oxygen desaturation and hypoxia. Pediatric groups possess unique physiological characteristics, including higher oxygen consumption and limited oxygen reserves, making them less tolerant of episodes of apnea (4). Selecting the appropriate size of the airway device for pediatric patients undergoing general anesthesia can be a challenging and meticulous process. Multiple attempts at intubation may result in airway swelling or injury, potentially leading to serious complications (5). In this case, the integration of a Fogarty balloon for OLV and the use of epidural anesthesia for pain management proved to be successful strategies that enhanced the patient's surgical experience and recovery.

OLV Techniques

OLV is crucial during thoracic surgeries, especially when clear visualization and exposure to the surgical site are crucial. The Fogarty balloon catheter as an airway occluder provides several advantages in pediatric patients. Unlike traditional double-lumen tubes, the Fogarty balloon offers effective lung isolation with a lower risk of trauma to the airway, which is particularly important given the smaller size and delicate nature of pediatric airways.

The Fogarty occlusion embolectomy catheter, developed by Dr. Thomas J. Fogarty by the end of 1940s, was primarily intended for vascular applications. Nonetheless, numerous cases have documented the efficient use of the Fogarty catheter to occlude the bronchus. In 1969, Vale and Lines both noted the use of the Fogarty catheter to

control ventilation in the lung being surgically treated. It serves as an effective bronchial occluder for both adults and children (2).

An optimal bronchial occluder should have a small volume balloon, secured in the bronchus, be adaptable, and feature a route for air release and drainage located beyond the blocker (6). The Fogarty catheters offer effective lung isolation and shield the dependent lung from contamination from the non-dependent lung. However, they have considerable drawbacks. When the Fogarty catheter is in place with the balloon inflated, suctioning of the operated lung is not feasible. While frequent suctioning and ventilation of the lung, require releasing the air from the balloon, potentially leading to contaminant exposure of the dependent lung. Additionally, lung collapse after isolation is often partial and usually results from the absorption atelectasis of the blocked lung. The balloon at the tip of the Fogarty catheter is built for high pressure, and excessive air inflation carries the risk of bronchial rupture. The reported bronchial blocker malpositioning rate ranges between 7 and 33% (7).

In this case, the technique was executed smoothly, with the Fogarty balloon allowing for optimal surgical exposure while maintaining sufficient airflow of the left lungs. The ability to inflate and deflate the balloon as needed provided flexibility during the procedure, enabling the surgical team to manage the airway effectively. A previous case report by the same anesthesiologist had shown the successful single lung ventilation using a fogarty catheter as the endobronchial occluder (8).

Various methods have been outlined for the extraluminal positioning of Fogarty catheters (1). Three methods for inserting a Fogarty catheter include extraluminal, intraluminal, and the slip joint section techniques [Figure 4].

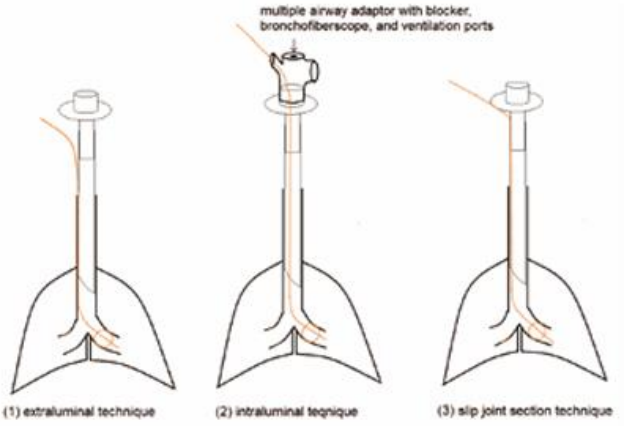

Figure 4. Three methods for inserting a Fogarty catheter (1)

Table 1. Average Balloon Size of Fogarty Catheters (9)

Age Category (yrs)	Average Balloon Caliber After Rapid Inflation (mm)	Smallest Internal Bronchial Caliber (mm)	Ratio of Balloon Caliber After Rapid Inflation to Smallest Bronchial Caliber (%)	Average Internal Bronchial Caliber (mm)	Ratio of Balloon Caliber After Rapid Inflation to Average Internal Bronchial Caliber (%)	Size of Fogarty (F)
1-2	5.4	3.5	152.9	4.2	127.4	3
2-4	8.0	4.0	199.0	5.6	142.1	5
4-6	8.0	3.6	221.1	5.4	147.4	5
6-8	8.0	4.6	173.0	6.7	118.8	5
8-10	8.0	5.7	139.6	7.3	109.0	5
10-12	8.0	6.4	124.4	7.8	102.1	5
12-14	8.7	7.2	120.7	8.9	97.6	7
14-16	8.7	9.2	94.5	10.0	86.9	7

In the extraluminal approach, a Fogarty catheter is introduced into the trachea before intubating, with the endotracheal tube then being placed afterward through its side. The intraluminal technique requires the insertion of the Fogarty catheter into the trachea via a multi-airway adapter equipped with dedicated ports for both the catheter and fiberscope. The adapter cannot be detached while the Fogarty catheter is being utilized. In the slip-joint technique, the catheter is introduced into the trachea through the slip-joint connection after intubation. This procedure necessitates a multi-

airway adapter equipped with a fiberscope port. Once the Fogarty catheter is correctly placed and adjusted, the adapter can then be removed.

Providing oxygen to an anesthetized patient undergoing one-lung ventilation is a complicated process that relies on factors such as hemoglobin levels, oxygen saturation, and cardiac output. It is essential for oxygen delivery to surpass oxygen consumption to prevent cellular hypoxia. Decreases in oxygen transport have a multiplicative effect rather than an additive one, and desaturation caused by anemia or reduced cardiac output can lead to harmful consequences during the intraoperative period. Intraoperatively, it is often the peripheral oxygen saturation component that garners the most attention (10).

Extrapolating data from outside of the operating room, it seems plausible that mild transient (85–90%) hypoxemia would be well tolerated when coexisting with adequate cardiac output and hemoglobin.

Mechanical ventilation strategy during OLV should be adjusted to deal with two different challenges: oxygenation and lung protection. In some cases, application of positive end-expiratory pressure (PEEP) during OLV increases functional residual capacity, improves the V/Q relationship in the dependent lung, and prevents alveolar collapse at end-expiration (11). High FiO2 (1.0) should be avoided unless necessary. "Protective ventilation" has three intraoperative components: low tidal volume, recruitment maneuvers, and positive end-expiratory pressure. The combined use of these 3 components can avoid both hypoxemia and acute lung injury.

During OLV, an unavoidable intrapulmonary shunt can lead to hypoxemia due to the collapse of the non-dependent lung and the expansion of atelectatic regions in the dependent lung. This hypoxemic condition triggers hypoxic pulmonary vasoconstriction, causing the vascular smooth muscle in the pulmonary circulation to contract in response to reduced local partial pressure of alveolar oxygen. As a result, this method minimizes shunting by diverting blood flow to the well-oxygenated dependent lung (12). The occurrence of hypoxemia during one-lung ventilation (OLV) has decreased to below 4%, largely due to the use of flexible fiberoptic bronchoscopy, which ensures precise positioning for effective lung isolation. During one-lung ventilation, the non-operative lung receives approximately 60% of pulmonary blood flow, resulting in greater perfusion, while the operative lung accounts for the remaining 40%.

Wesley et al. found that hypoxemia and severe hypoxemia were frequently observed in pediatric patients undergoing this procedure. Additionally, the use of a bronchial occluder in surgeries requiring single lung ventilation was associated with a decreased risk of oxygen deprivation (13).

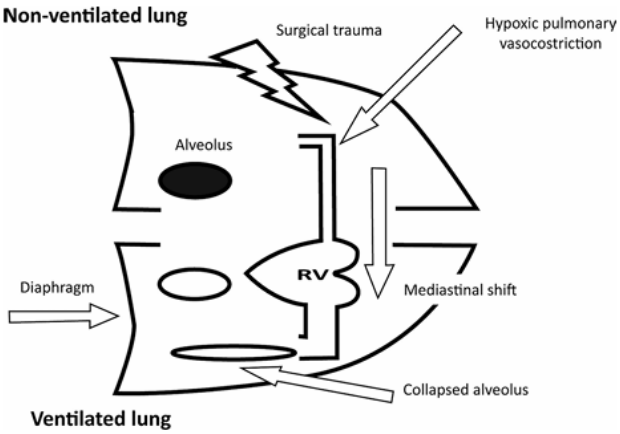

Figure 5. Factors involved in hypoxia during one lung ventilation and compensatory mechanism (14)

Epidural Anesthesia in Pediatric Surgery

Epidural anesthesia has become an increasingly popular choice for managing postoperative pain in pediatric patients. It provides localized analgesia, reducing the reliance on systemic opioids and their related adverse effects, including respiratory suppression and gastrointestinal issues. The successful implementation of continuous epidural infusion in this case contributed to effective pain control and facilitated early recovery.

The multi-modal approach to pain management, which included both regional anesthesia and oral analgesics, exemplifies best

practices in pediatric anesthetic management. This strategy not only improves patient comfort but also enhances overall surgical outcomes by promoting early mobilization and reducing complications.

Monitoring and Management of Hypoxemia

Hypoxemia remains a significant concern during OLV, particularly in young children. Continuous monitoring of oxygenation is critical to ensuring patient safety throughout the procedure. In this case, the careful management of ventilation and oxygenation, facilitated by the use of the Fogarty balloon, contributed to stable oxygen saturation levels during surgery.

The importance of proactive monitoring and intervention during OLV cannot be overstated, as hypoxemia can have serious consequences, including cardiac complications and prolonged recovery times. Future research and clinical protocols should continue to explore effective strategies for managing oxygenation during single lung ventilation, particularly in children.

This case report has several limitations. First, the selection of the Fogarty balloon catheter is still not based on objective measurements using imaging modalities, which poses a risk of size mismatch either the balloon being too small or too large. The author recommends measuring the internal bronchial diameter and comparing it to the diameter of the inflated Fogarty balloon catheter to ensure proper sizing. This approach may help minimize the risk of bronchial wall ischemia due to excessive pressure from an oversized balloon, as well as the risk of bronchial block leakage caused by an undersized balloon. Second, as previously mentioned, the use of a Fogarty balloon catheter does not allow for suctioning of the ipsilateral lung, thus posing a risk of contamination to the other branch of the bronchus, even to the contralateral lung when the balloon is deflated. Although no complications related to suspected contamination from the contralateral lung were observed in this patient, this potential risk must remain a main consideration, particularly for anesthesiology professionals intending to use bronchial blockade techniques with a Fogarty balloon catheter. Third, thoracic epidural catheter insertion in this patient was still performed using a conventional technique based on estimated vertebral corpus height without objective confirmation via ultrasound, which might have more accurately determined the catheter tip position and potentially estimated the required local anesthetic volume used.

CONCLUSION

This case illustrates the effective use of a Fogarty balloon bronchial occluder and epidural anesthesia in a 5-year-old girl undergoing lobectomy for organized pleural effusion. The integration of these innovative techniques not only enhanced surgical safety and efficacy but also improved postoperative recovery.

As pediatric thoracic surgery evolves, it is crucial to continuously study and establish comprehensive, standardized protocols for lung isolation and pain management. By integrating these innovations, medical professionals can enhance not only treatment results but also the overall care for pediatric patients undergoing thoracic surgeries.

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Conflict of Interest

The authors declare that there is no potential conflict of interest in this case report.

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Patient Consent for Publication

Written informed consent was obtained from the patient's parent or legal guardian for the

publication of this case report and accompanying images.

Author's Contributions

All authors contributed significantly to the preparation of this case report.

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Literature Review

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HEALTH IMPACTS AND MEDICAL INTERVENTIONS ON PHYSICAL VIOLENCE AMONG ADOLESCENTS: A REVIEW AND STRATEGIES IN INDONESIA

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ABSTRACT

Introduction: Violence against adolescents is a global public health issue with significant impacts on physical and psychological health. Data shows that many children around the world experience physical, sexual, or emotional violence, with a high prevalence in Indonesia. Based on data from the 2013 Child Violence Survey, violence against adolescents in Indonesia remains very high, with significant impacts on their physical and psychological health, as well as their academic performance.
Objective: This study aims to identify the causes of violence, including family dynamics, social media, and mental health, as well as its impacts, such as health disorders and decreased academic performance.
Review: Various factors causing physical violence among adolescents in Indonesia include family influence, social media, and peers. The impact is very detrimental, both in the short and long term, both in terms of physical and mental health. The findings indicate the need for early intervention and additional education in schools to effectively address adolescent violence. The synergy between various disciplines at the Faculty of Medicine is key to creating evidence-based prevention strategies. To mitigate the negative impact, additional education in schools and early interventions involving various disciplines are greatly needed. The synergy between educational programs, government policies, and social support is key to preventing violence. With the strengthening of legal protection, as well as increased attention from parents and the social environment, it is hoped that a safer environment for teenagers can be created.
Summary: Overall, this review emphasizes the importance of holistic interventions involving families, schools, and communities to address violence among adolescents and improve their quality of life. There is a need for preventive efforts that involve education in schools, family interventions, and stricter government policies. The success of preventing and addressing physical violence among adolescents heavily relies on the collaboration of all parties involved.

Keywords: Adolescents; Health Impact; Medical Interventions; Physical Violence; Violent Prevention

ABSTRAK

Pendahuluan: Kekerasan terhadap remaja merupakan masalah kesehatan masyarakat global dengan dampak signifikan pada kesehatan fisik dan psikologis. Data menunjukkan bahwa banyak anak di seluruh dunia mengalami kekerasan fisik, seksual, atau emosional, dengan prevalensi tinggi di Indonesia. Berdasarkan data dari Survei Kekerasan Terhadap Anak (SKTA) tahun 2013, kekerasan terhadap remaja di Indonesia masih sangat tinggi, dengan dampak yang signifikan terhadap kesehatan fisik dan psikologis remaja, serta prestasi akademis mereka.
Tujuan: Penelitian ini bertujuan untuk mengidentifikasi faktor penyebab kekerasan, termasuk dinamika keluarga, media sosial, dan kesehatan mental, serta dampaknya seperti gangguan kesehatan dan penurunan kinerja akademis.
Review: Berbagai faktor penyebab kekerasan fisik pada remaja di Indonesia termasuk pengaruh keluarga, media sosial, dan teman sebaya. Dampaknya sangat merugikan baik dalam jangka pendek maupun jangka panjang, baik dari sisi kesehatan fisik maupun mental. Temuan menunjukkan perlunya intervensi dini dan pendidikan tambahan di sekolah untuk mengatasi kekerasan remaja secara efektif. Sinergi antara berbagai disiplin ilmu di Fakultas Kedokteran penting untuk mengembangkan strategi pencegahan yang berbasis bukti. Untuk mengurangi dampak negatif tersebut, pendidikan tambahan di sekolah dan intervensi dini yang melibatkan berbagai disiplin ilmu sangat dibutuhkan. Sinergi antara program pendidikan, kebijakan pemerintah, dan dukungan sosial menjadi kunci dalam pencegahan kekerasan. Dengan penguatan perlindungan hukum, serta perhatian lebih dari orang tua dan lingkungan sosial, diharapkan dapat tercipta lingkungan yang lebih aman bagi remaja.
Rangkuman: Secara keseluruhan, review ini menekankan pentingnya intervensi holistik yang melibatkan keluarga, sekolah, dan masyarakat untuk mengatasi kekerasan pada remaja dan memperbaiki kualitas hidup mereka. Perlu adanya upaya preventif yang melibatkan pendidikan di sekolah, intervensi keluarga, dan kebijakan pemerintah yang lebih tegas. Keberhasilan pencegahan dan penanganan kekerasan fisik pada remaja sangat bergantung pada kolaborasi semua pihak.

Kata Kunci: Remaja; Dampak Kesehatan; Intervensi Medis; Kekerasan Fisik; Pencegahan terhadap Kekerasan

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INTRODUCTION

Violence is a behavior that is intentionally carried out, causing physical injury or psychological distress. Campbell and Humphrey define child violence as any action that harms or potentially endangers the health and well-being of a child, carried out by individuals who have responsibility for that child. This responsibility can be held by family, friends, or the surrounding community (1). It is estimated that around 50% or more of the 1 billion children worldwide aged 2 to 17 years experienced physical, sexual, and emotional violence or neglect in one year in 2018, particularly in the regions of Africa, Asia, and North America. A 2002 report by the World Health Organization (WHO) showed a decline in the quality of life for women due to acts of violence, with mortality rates reaching 40-70% as a result of violence perpetrated by partners. In the United States, every 9 minutes a woman becomes a victim of physical violence, and 25% of women are killed by their male partners (2).

Based on the results of the Child Violence Survey in 2013, it was found that violence against adolescents in Indonesia is still very high. This survey involved respondents aged 13-17 who were asked to report their experiences of violence in the past 12 months. The results indicates that 1 of 4 boys have experienced physical violence, 1 of 8 have experienced emotional violence, and 1 of 12 have been victims of sexual violence. Meanwhile, among girls, 1 of 7 were reported to have experienced physical violence, 1 of 9 experienced emotional violence, and 1 of 19 became victims of sexual violence (3). This data illustrates the urgency of addressing violence against adolescents in Indonesia.

The purpose of this literature review is to identify the causes of violence, its impacts, and what interventions can be implemented to reduce violence among adolescents in Indonesia.

REVIEW

Types of Violence

Violence among teenagers is generally divided into three categories: direct violence (such as physical aggression, threats, and mockery), indirect violence (such as spreading false news and ostracism), and intimidation. According to the Integrated Service Center for the Protection of Women and Children, violence against children includes physical violence (hitting, kicking), emotional violence (threats, insults), sexual violence (pornography, harassment), neglect (failing to meet the child's basic needs), and economic violence (employing children for economic purposes or involving them in prostitution) (4) (5).

Impact of Violence

Peer violence has a significant negative impact on physical and psychological health. Physically, it can trigger psychosomatic symptoms such as headaches, fatigue, stomachaches, and dizziness. The psychological impacts include low self-esteem, depression, anxiety, sleep disturbances, feelings of loneliness, despair, and even suicidal thoughts. In addition, this violence also impacts academic performance, with several studies showing a decline in achievement and attendance issues at school (6).

Factors that Trigger Violence in Teenagers

Several factors that trigger violence in adolescents include a less active family role, exposure to violence in the media, pressure from aggressive peers, mental health disorders such as attention deficit hyperactivity disorder (ADHD) or bipolar disorder, and experiences of violence during childhood (1).

Peers of the same age have a significant influence on adolescent violence. The presence of peers often triggers violence, as teenagers seek attention that they might not receive from their parents. Peers play an important role as sources of knowledge and information, as well as in the

problem-solving process. Research shows that peer involvement in adolescent relationship violence often occurs due to a lack of affection and attention from parents. Therefore, parents need to pay special attention to their child's social environment, as most of their life is spent with peers. Guidance and attention from parents are essential, as they should have the closest relationship with their child (7).

A study discusses the influence of social media on violence in teenage relationships. The study shows that 57.6% of respondents experienced relationship violence due to social media use, while 10.1% were unaffected by social media. Statistical analysis shows a significant relationship between social media use and youth violence (p-value = 0.012), as well as exposure to online violence (59.8%), which is also closely related to relationship violence (p-value = 0.048). In conclusion, social media and the internet play a role in increasing the risk of dating violence among teenagers (8).

Knowledge does not have a significant impact on violence in teenage relationships. Although teenagers have a solid understanding of violence, this is not always reflected in their behavior. Exposure to violence in the surrounding environment often makes violence seem normal, so they do not realize that such actions are considered violence. Therefore, schools need to improve education on the definition, forms, and prevention of relationship violence by implementing additional programs outside of regular class hours or through non-formal education provided by teachers (9).

The role of the family significantly influences violence in teenage relationships. Permissive parenting, with high freedom and low control, can make teenagers feel that their desires must always be fulfilled. If their desires are not fulfilled, teenagers might express their frustration through violence towards their partner. Many teenagers feel neglected by their parents and rarely share their problems with them. To prevent violence, parents need to improve communication, become friends with their children, and spend more time together, thereby strengthening family bonds and reducing the risk of violent behavior (10).

Violence Against Teenagers in Indonesia

Violence against teenagers has become a significant issue in Indonesia for several reasons. The violence experienced by teenagers can cause mental disorders such as depression, anxiety, and trauma. Such conditions can affect their emotional and social development in the future. Teenagers who are victims of violence can experience a decline in academic performance, high absenteeism, or even drop out of school due to the physical and psychological impacts caused. Data shows that the rate of violence against children and adolescents in Indonesia continues to rise, making it an urgent issue to address. Teenagers often become victims of domestic violence or violence in their living environment. The perpetrators are often parents or close relatives, which exacerbates the trauma. Although laws have been enacted to protect children and adolescents, their implementation and enforcement are often ineffective. Many cases of violence go unreported or are not handled well. Exposure to violent content on social media and a lack of understanding of how to resolve conflicts without violence also contribute to the increase in violent behavior among teenagers.

Based on the Indonesian Demographic and Health Survey in 2017, most teenagers start relationships at the age of 15-17, with women slightly higher (45%) compared to men (44%). The 2017 National Commission on Violence Against Women noted that 19% of domestic violence or personal relationship violence is teenage relationship violence, with 1,873 cases, ranking third. Boyfriends are the most common perpetrators of sexual violence, with 1,528 cases. This data shows that violence in teenage relationships is a serious problem in society (11).

Data inputted in 2024 from the beginning of the month until September shows a total of 17,141 cases of violence, with 3,667 males and 14,872

females. East Java second ranked in the number of reported violence cases after West Java. The number of female victims in East Java is 766 per 100,000 women in each province of Indonesia (11).

There are 1198 victims per 10,000 children in East Java. The highest number of cases based on the location of the incident occurs in households. The most common form of violence experienced is sexual violence, with the majority of cases occurring in the 13-17 age range. The perpetrators, based on the most common relationships, are boyfriends or girlfriends, followed by husbands or wives and parents. This data was collected in real-time from the Ministry of Women's Empowerment and Child Protection website, focusing on violence until September 2024. (11)

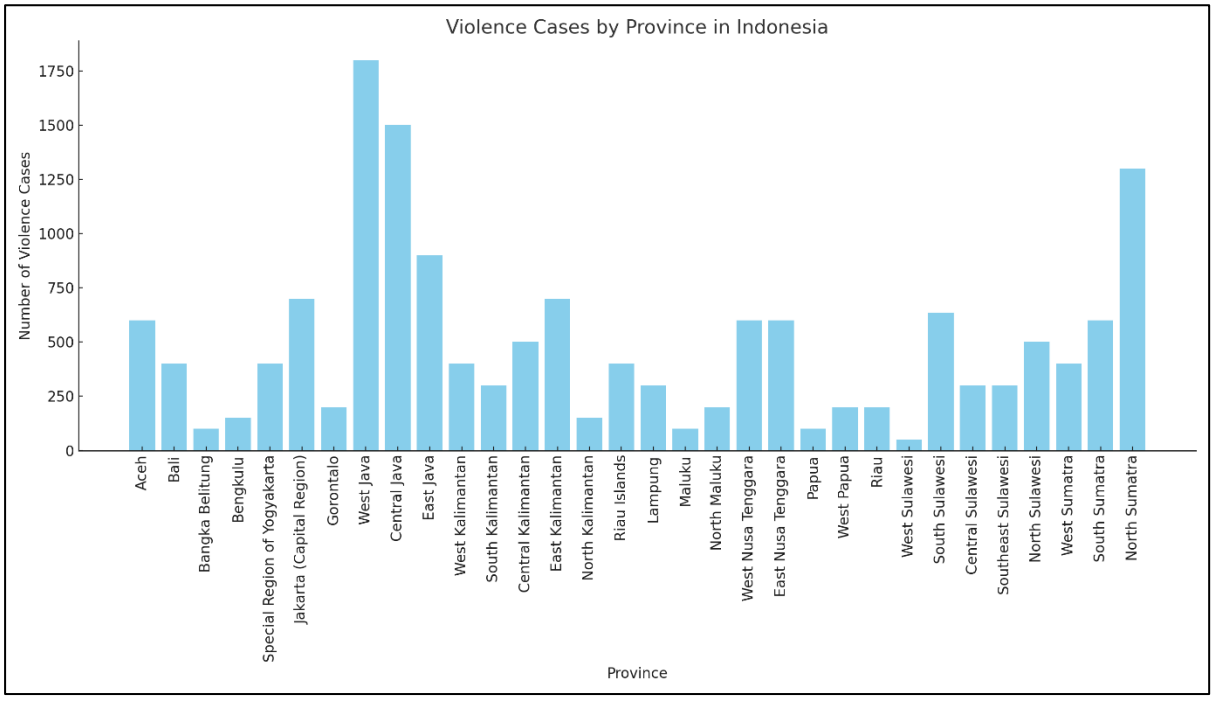

Figure 1. Distribution Map of Violence Cases (11)

Teenage relationships violence in Indonesia is a serious issue, with 19% of domestic or personal relationship violence falling into this category. Globally, violence in teenage relationships is also considered a widespread public health issue. Research shows that social media has a significant influence on youth violence in Indonesia, in line with global findings that link exposure to media violence with increased aggressive behavior. Furthermore, the lack of attention and support from parents in Indonesia is associated with the risk of violence in adolescent relationships, in line with global research highlighting the important role of family dynamics (1).

The Legal Basis for Violence Against Adolescents in Indonesia

The protection and welfare of children in Indonesia, including violence against adolescents, are regulated by several key laws. Law Number 35 of 2014 on Child Protection regulates children's rights and protective measures against violence and exploitation. Law Number 11 of 2012 on the Juvenile Criminal Justice System regulates a special judicial system to handle cases involving children as perpetrators or victims of criminal acts. Government Regulation Number 4 of 2006 provides technical implementation guidelines for the child protection law. Law Number 23 of 2004 on the Elimination of Domestic Violence also protects children from violence within the family environment. In addition, Presidential Regulation

Number 87 of 2014 strengthens child protection policies in various sectors, and Minister of Education and Culture Regulation Number 82 of 2015 regulates the prevention and handling of violence in the educational environment (12).

Violent Prevention among Adolescents Undertaken by the Government in Indonesia

The Ministry of Women's Empowerment and Child Protection of Indonesia runs various programs to protect children and adolescents, including the development of policies and guidelines for violence prevention. They also conduct awareness campaigns and provide support for victims of violence through services such as the Child Crisis Center. In addition, the Ministry of Education and Culture of Indonesia implements an anti-violence education program in schools, aimed at educating students about healthy relationships and ways to resolve conflicts without violence. Teachers and educators also receive special training to recognize signs of violence and provide the necessary support (13).

Law Number 35 of 2014 on Child Protection provides a legal basis for protecting children from violence and establishes children's rights as well as the measures that must be taken to protect them. In addition, Law Number 11 of 2012 on the Juvenile Criminal Justice System regulates the handling of cases involving children as perpetrators or victims of crimes, including violence in teenage relationships. Regulation of the Minister of Education and Culture Number 82 of 2015 also establishes policies for the prevention and handling of violence in school environments, which encourages the creation of a safe and supportive learning environment (13). Law No. 12 of 2022 regulates various forms of criminal sanctions for perpetrators of sexual violence, including imprisonment and fines. Perpetrators who attempt to obstruct the related legal process can also be sentenced to up to 5 years in prison (14).

Various non-governmental organizations (NGOs), such as the National Commission on Violence Against Women and the Pulih Foundation, are actively engaged in awareness campaigns, providing support to violence victims, and advocating for policy changes. Community initiatives often include training and workshops for parents, teenagers, and community members to increase knowledge about violence, its prevention, and how to provide support. Additionally, some communities have crisis centers and support services that provide counseling, legal assistance, and protection for teenagers and families involved in cases of violence (13).

Several comprehensive efforts need to be implemented to prevent violence among teenagers in Indonesia. First, education and awareness play a key role. Education in schools should include material on relationship violence, reproductive health, and skills for building healthy relationships. This should be done in an engaging and relevant way for teenagers, and it should involve training for teachers to effectively teach these topics. Additionally, community awareness campaigns through social media, television, and radio are crucial for increasing general knowledge about violence, ways to prevent it, and resources available for victims (13).

Second, the role of the family is very important in preventing violence. Training programs for parents can help them understand how to effectively support and guide their children, as well as build open and understanding communication. Support programs should also be available for families experiencing stress or conflict, which can help prevent domestic violence and ensure a stable and supportive family environment for teenagers (15).

Third, youth development programs should focus on providing positive activities and opportunities for self-development that can divert teenagers' attention from violent behavior. This includes extracurricular activities that build skills, interests, and self-confidence. Counseling services should also be available for teenagers experiencing emotional issues or trauma, as well as support for those involved in violent relationships, to help

them address their problems and find healthier ways to manage emotions and conflicts (13).

Fourth, the improvement of policies and regulations must be carried out to effectively address violence against adolescents. This includes strict law enforcement against perpetrators of violence, as well as ensuring that the legal and judicial systems handle violence cases seriously and fairly. Continuous monitoring of child protection and violence prevention policies is also necessary to ensure their effectiveness and make the necessary adjustments. Moreover, the involvement of various parties, including the government, non-governmental organizations, and communities, is crucial in creating a safe and supportive environment for adolescents (16).

The Impact of Violence on Adolescents Based on Medical Science

Childhood abuse is a significant risk factor that affects various aspects of physical and mental health. Adverse experiences in early life, such as abuse, not only increase the risk of mental health disorders like depression, post-traumatic stress disorder (PTSD), anxiety, and alcohol and drug dependence, but also contribute to physical health problems, including cardiovascular diseases, metabolic disorders, and neurological issues. Research shows that these traumatic experiences can be biologically embedded in the body, altering brain function, the neuroendocrine axis (especially the hypothalamic pituitary adrenal (HPA) axis), and the immune system (17).

The HPA axis plays a crucial role in coordinating the body's response to stress and maintaining homeostatic balance. Activation of this axis triggers the release of corticotropin hormone, leading to the secretion of glucocorticoids (cortisol in humans), which function to regulate energy and control the stress system through negative feedback. Child abuse disrupts the activity of the HPA axis, leading to dysregulation of the cortisol response, particularly in its diurnal pattern. Children who experience abuse show abnormal cortisol levels, either increased or decreased, which are associated with psychological conditions such as PTSD and depression (18). Adults with a history of abuse, low morning cortisol levels and a flattened diurnal pattern are often found, which are associated with vulnerability to physical and mental illnesses. Research indicates that the impact of HPA axis dysregulation can persist into adulthood, contributing to the risk of immune disorders and chronic diseases.

The immune system plays a crucial role in the body's response to pathogens, including the inflammatory response triggered by stress from childhood abuse. Several studies have shown an increase in pro-inflammatory markers, such as C-reactive protein (CRP) and interleukin-6, in individuals who have experienced abuse, both during childhood and adulthood. Abuse is also associated with a decrease in adiponectin, which weakens the body's anti-inflammatory mechanisms, as well as an increased antibody response to viruses such as Epstein Barr virus (EBV) and Herpes Simplex virus (HSV), indicating a disruption in cellular immunity. As a result, individuals who experience childhood abuse are at a higher risk of chronic diseases later in life (19).

Epigenetic modifications, such as deoxyribonucleic acid (DNA) methylation, alter gene function without changing the DNA sequence itself. Research shows that experiences of childhood abuse are associated with changes in DNA methylation, particularly in the glucocorticoid receptor gene, which plays a role in stress response and mental disorders. Studies also show that abuse and placement in orphanages are associated with significant differences in gene methylation. This provides evidence that child abuse can affect stress system function, the immune system and increase the risk of mental disorders and chronic diseases (20).

Potential Clinical Interventions

The importance of early preventive interventions for children who experience abuse to

alter their health risk trajectories and avoid the biological embedding of disease must be emphasized. Dysregulation of the HPA axis activity in abused children can be modified through interventions that focus on more sensitive and responsive caregivers or by placing children in environments that facilitate healthy and supportive relationships. Some family-based intervention programs, such as Attachment and Biobehavioral Catch-up and Early Intervention Foster Care, have proven effective in improving cortisol secretion patterns in children who have experienced abuse (21).

Another research shows that psychosocial and cognitive interventions, especially those involving parent-child relationships, can have a significant impact on cortisol regulation and inflammation. One example is the increase in morning cortisol levels observed in infants from families experiencing abuse after their mothers received child-parent psychotherapy interventions. The intervention proved effective in reducing the negative impact on the child's biological system involved in the stress response, leading to cortisol levels more similar to those of children from non-violent families (22).

Although the results are promising, research on the biological impacts of various types of interventions, especially those involving temporary care, kinship care, and open adoption remains limited. Moreover, the impact of childhood neglect on a child's biological systems is relatively understudied. Programs like the Nurse-Family Partnership (NFP) are internationally recognized as the gold standard in child abuse prevention, although this program is not yet widely available in countries like Canada (23).

Further research is needed to evaluate evidence-based interventions that can reverse the biological negative impacts of child abuse. Focusing on long-term follow-up and expanding the use of biomarkers as outcome measures can help strengthen our understanding of the effectiveness of interventions and the potential to prevent diseases related to childhood abuse.

The Role of Medical Science in Addressing Violence among Adolescents

Physical violence among adolescents is a complex phenomenon that involves various aspects of health and requires the involvement of different departments at the Faculty of Medicine. Public health plays a role in studying the epidemiology of physical violence, including prevalence studies, identification of risk factors, and trends in violence among adolescents. Additionally, biostatistics and preventive medicine conduct data analysis and surveys that support the development of evidence-based violence prevention strategies.

In terms of physical impact, basic medical sciences study the effects of physical violence on organs and body systems, including acute and chronic injuries. Surgery and orthopedics play a role in the medical management of these injuries, including surgical procedures and rehabilitation. Meanwhile, pediatric health sciences study the impact of violence on the physical development of adolescents, who are still in the growth stage. Physical violence also leaves significant psychological impacts. The Department of Psychiatry and psychological disorders such as PTSD, depression, and anxiety, while the Child and Adolescent Psychiatry focuses on the specific psychological impacts experienced by teenagers and the development of psychiatric interventions. Medical psychology studies the coping mechanisms used by victims in dealing with emotional trauma.

In clinical intervention and management, internal medicine addresses the long-term physical and psychological consequences arising from violence. Forensic medicine plays a crucial role in identifying injuries caused by violence and collecting medical evidence, while family medicine offers a holistic approach to managing cases of violence in clinics or family practices. The social and environmental aspects of violence are also a focus of research. Public health studies the social, economic, and environmental factors that influence the risk of violence, while behavioral and health sciences examine the impact of individual

and group behavior on violence. Environmental medicine studies how physical and social environments affect the health of adolescents.

In the prevention of physical violence, public health develops health promotion programs, while medical education and medical ethics focus on training medical personnel to be able to conduct early detection and intervention against violence. Health law also plays an important role in legal advocacy to protect adolescents.

In the legal and ethical aspects, forensic medicine plays a role in the legal process related to reporting violence cases, while Health law examines the rights of victims and their protection within the legal system. Medical Ethics highlights various ethical dilemmas that may arise in the handling of violence. Recent research and innovations in violence prevention involve community medicine in the development of community-based interventions, as well as health informatics, which contributes through the use of technology to detect and prevent violence. Rehabilitation medicine is also developing innovations in the care and recovery of violence victims.

The Department of Neurology also plays an important role in research on physical violence among adolescents, with involvement in various aspects of the impact of violence. The Department of Neurology studies head injuries and brain trauma, such as concussions or traumatic brain injuries (TBI), that result from physical violence and its impact on physical health. They also study the long-term effects of neurological injuries, including cognitive, motor, and sensory function disorders experienced by adolescents. For clinical intervention and violence management, the Neurology Department is involved in the clinical handling of neurological injuries caused by violence. The work includes the diagnosis and management of head injuries as well as rehabilitation to restore neurological function. Additionally, they play a role in multidisciplinary teams to address the neurological aspects of the impact of violence, contributing to a holistic approach in patient care.

SUMMARY

Violence against teenagers, both physical and psychological, has a significant impact on their health and academic performance. The factors causing violence involve the role of family, social media, peer pressure, and mental health issues. In Indonesia, violence in teenage relationships is often caused by a lack of parental attention and exposure to violence on social media. Childhood abuse also contributes to long-term health issues. Early intervention and family-based programs are crucial for reducing negative impacts and improving health outcomes. The synergy between various academic departments is necessary to develop effective prevention strategies.

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AUTHOR GUIDELINES

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Acknowledgments

Personal **acknowledgments** should be limited to appropriate professionals who contributed to the paper, including technical help and financial or material support, also general support by a department chair-person.

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Tables and its title should be included in the text. Tables should be numbered in arabic numerals, captions should be brief, clearly indicating the purpose or content of each table. Provide a footnote to each table, identifying in alphabetical order all abbreviations used. Number tables consecutively in the order of their first citation in the text and supply a brief title for each. Do not use internal horizontal or vertical lines. Give each column a short or an abbreviated heading. Identify statistical measures of variations, such as standard deviation and standard error of the mean. Be sure that each table is cited in the text. If you use data from another published or unpublished source, obtain permission and acknowledge that source fully.

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For measurements use S.I. (System International) units. Measurements should be abbreviated (e.g. mm, kcal, etc.) in accordance to the Style Manual for Biological Sciences and using the metric system. Measurements of length, height, weight, and volume should be reported in appropriate scientific units. Temperatures should be in degrees Celsius. Blood pressures should be in millimeters of mercury (mmHg). Drug concentrations may be reported in either SI or mass units, but the alternative should be provided in parentheses where appropriate.

References

References are written in Vancouver Style and be limited to the last decade. Minimum 10 to 20 references for case report and original article and 30 references for review. References should in general be limited to the last decade. Avoid using abstracts as references. Information from manuscripts submitted but not yet accepted should be cited in the text as "unpublished observations" with written permission from the source. Papers accepted but not yet published may be included as references; designate the journal and add "Forthcoming". Avoid citing "personal communication" unless it provides essential information not available publically, name the person and date of communication, obtain written permission and confirmation of accuracy from the source of a personal communication. Authors is recommended to use reference management software, in writing the citations and references such as: Mendeley®, Zotero®, EndNote®, and Reference Manager®.

Here are some examples of the references:

1. Standard journal article

Up to six authors, list all the authors.

- Yi Q, Li K, Jian Z, Xiao Y. Risk factors for acute kidney injury after cardiovascular surgery: Evidence from 2,157 cases and 49,777 controls - A meta-analysis. Cardio Renal Med. 2016; 6: 237–50

More than six authors, list the first six authors, followed by et al.

- Amini S, Najafi MN, Karrari SP, Mashhadi ME, Mirzaei S, Tashnizi MA, et al. Risk factors and outcome of acute kidney injury after isolated cabg surgery: A prospective cohort study. Brazilian J Cardiovasc Surg. 2019; 34(1): 70–5.

2. A book

McKnight CL, Burns B. Pneumothorax. In: StatPearls. StatPearls Publishing; 2021.

3. *Homepage/Web site*

Ikatan Dokter Anak Indonesia. Rekomendasi Ikatan Dokter Anak Indonesia: Asuhan Nutrisi Pediatrik (Pediatric Nutrition Care). Paediatric. 2011; 3(2): 5–6.

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