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Original Research Article

INITIAL SOFA SCORE AND MORTALITY OF SEPSIS PATIENTS IN THE INTENSIVE CARE UNIT OF HAJI ADAM MALIK HOSPITAL MEDAN: DOES IT CORRELATE?

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ABSTRACT

Introduction: Sepsis is a life-threatening organ dysfunction or failure that is the primary cause of death in infectious disease. the Sepsis-3 Task Force recommends The Sequential (Sepsis-Related) Organ Failure Assessment (SOFA) Score as a means of Sepsis identification. **Objective:** To determine the correlation between sepsis patients' deaths in the intensive care unit (ICU) of Haji Adam Malik Hospital Medan and their initial SOFA score. **Materials and Methods:** This study uses a cross-sectional study design and an observational analytical investigation. The sample for this study was sepsis patients who were treated in the ICU of Haji Adam Malik Hospital Medan in 2021-2022, and they were selected using the purposive sampling method. After calculating the Slovin formula, 61 samples are required. The researchers obtained the data from patient medical records. The analyses used are univariate and bivariate, with the Independent-T test and Fisher's exact. **Results:** From 71 patients, there were 36 patients (50.7%) in the age group of 46-65 years old; 39 patients (54.9%) were male; 50 patients (70.4%) had comorbidities; and 50 patients (70.4%) had non-surgical disease. The average initial SOFA score was 9.89 ± 3.95, with mortality for sepsis patients in the ICU of 74.6%. The findings of the statistical analysis indicated a substantial difference ($p<0.001$) in the SOFA scores of those who survived and those who did not, as well as a significant correlation ($p<0.001$) between the initial SOFA score and mortality. **Conclusion:** There is a correlation between initial SOFA score and the mortality of sepsis patients in the ICU of Haji Adam Malik Hospital.

Keywords: Intensive Care Unit; Mortality; Organ Dysfunction; Sepsis; SOFA Score

ABSTRAK

Pendahuluan: Sepsis merupakan disfungsi atau kegagalan organ yang mengancam jiwa dan merupakan penyebab utama kematian pada penyakit menular. *The Sequential (Sepsis-Related) Organ Failure Assessment* (SOFA) Score direkomendaikan oleh *The Sepsis-3 Task Force* dalam mengidentifikasi Sepsis. **Tujuan:** Mengetahui hubungan antara pasien sepsis yang meninggal di ruang rawat intensif RSUP Haji Adam Malik Medan dengan Skor SOFA pada awal masuk. **Bahan dan Metode:** Penelitian ini menggunakan design study *cross-sectional* dan merupakan penelitian analitik observasional. Sampel penelitian ini adalah pasien sepsis yang dirawat di ruang rawat intensif RSUP Haji Adam Malik Medan tahun 2021-2022 dan dipilih menggunakan metode *purposive sampling*. Setelah dihitung dengan rumus Slovin, jumlah sampel yang dibutuhkan sebanyak 61 sampel. Data yang digunakan berasal dari rekam medis pasien. Analisis yang digunakan adalah analisis univariat dan bivariat dengan uji T-Independen dan *Fisher's Exact*. **Hasil:** Dari 71 pasien, didapatkan 36 pasien (50,7%) berusia 46-65 tahun, 39 pasien (54,9%) laki-laki, 50 pasien (70,4%) dengan komorbid, dan 50 pasien (70,4%) mempunyai kasus penyakit non-bedah. Rerata skor SOFA awal pasien adalah 9,89±3,95, dengan mortalitas pasien sepsis di ruang rawat intensif sebesar 74,6%. Hasil analisis statistik menunjukkan perbedaan yang signifikan antara skor SOFA pasien yang hidup dan yang meninggal ($p < 0,001$), dan terdapat hubungan antara skor SOFA awal dengan mortalitas ($p < 0,001$). **Kesimpulan:** Terdapat hubungan antara skor SOFA pada awal masuk rawat dengan mortalitas pasien sepsis di ruang rawat intensif RSUP Haji Adam Malik Medan.

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Kata kunci: Unit Perawatan Intensif; Mortalitas; Disfungsi Organ; Sepsis; Skor SOFA

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INTRODUCTION

A major global health concern, sepsis was responsible for 11 million deaths and 49 million cases globally in 2017, accounting for 20% of all deaths that year. A review from 2020 found that 189 adult cases of sepsis out of every 100,000 people had a mortality rate of 26.7%. The review also highlighted the large number of cases of sepsis in intensive care units, where 58 cases out of every 100,000 people had a mortality rate of 42% (1).

Sepsis is a major contributor to preventable deaths, impacting infectious diseases, injuries, and non-communicable illnesses. Sustainable Development Goal 3's achievement depends on effective progress in sepsis prevention and treatment (2).

The definition of sepsis has evolved, emphasizing organ dysfunction. The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3) define sepsis as a potentially fatal organ failure or dysfunction brought on by an imbalanced host response to infection. Organ dysfunction is indicated by a ≥2-point increase due to infection in the SOFA score. Early diagnosis of moderate organ dysfunction during infection is crucial, with the Sequential Organ Failure Assessment (SOFA) score serving as an objective tool to assess organ failure severity over time. A significant increase in the SOFA score indicates organ failure, correlating with a higher mortality risk (3).

Early detection is critical for sepsis patient prognosis, enabling prompt intervention to reduce mortality rates. Previous research has found a different link between SOFA scores at admission and patient outcomes(4–7). However, more research is needed, especially at Haji Adam Malik Hospital Medan, to see how well initial SOFA scores are at predicting sepsis patient mortality rates in the intensive care unit.

MATERIALS AND METHODS

This study uses a cross-sectional study design and an observational analytical investigation. The sepsis patients who were treated in the ICU of Haji Adam Malik Hospital Medan in 2021-2022 were selected using the purposive sampling method (8). After calculating the Slovin formula, 61 samples are required. The patient's medical records were used to collect the data.

Seventy-one patients (aged over eighteen) receiving ICU treatment and receiving a Sepsis-3 diagnosis of sepsis were included in the sample, out of the 158 medical records. Exclusion criteria include medical records that did not meet the SOFA scoring requirements.

The data collected include the patient's age, gender, comorbidities, disease case, initial SOFA score, and mortality status. The data were analyzed using Statistical Program for Social Sciences (SPSS) v27.0 software to conduct univariate and bivariate. Univariate analysis shows the frequency and percentage of the variables. The mean difference between the initial SOFA score of the patients who survived and the ones who died was determined using the independent T-test following the completion of the Kolmogorov-Smirnov/Shapiro-Wilk test to determine the data's normality.

A fisher's Exact test was performed to determine the relationship between the initial SOFA score and mortality. The Commission of Ethics, Faculty of Medicine, Universitas

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Sumatera Utara, granted ethical clearance for this study (656/KEPK/USU/2023).

RESULT AND DISCUSSION

There were 71 sepsis patients in all who satisfied the inclusion requirements. The distribution of patient characteristics is shown in Table 1. The results revealed that there were more male patients than female patients, with a total number of male patients of 39 (54.9%) and 32 female patients (45.1%). This study shows the same result as the cohort study conducted by Ko et al (9). The study revealed that sepsis incidence was higher in males (56.7%) than females (43.3%) (9). Another study conducted by Kabi et al. (10) also revealed that the incidence of septicaemia in males was higher than in females (62% vs. 38%).

Table 1. Patients' Characteristics Distribution

Variable	Description	
	Group	N (%)
Gender	Male	39 (54.9)
	Female	32 (45.1)
Age	≤25	12 (16.9)
	25-45	8 (11.3)
	46-65	36 (50,7)
	>65	15 (21.1)
Comorbidities	With Comorbidities	50 (70.4)
	Without Comorbidities	21 (29.6)
Disease Case	Surgical	21 (29.6)
	Non-surgical	50 (70.4)
Mortality	Died	53 (74.6)
	Survived	18 (25.4)

The underlying reasons for the higher incidence of sepsis in men remain unclear, but some studies suggest that hypotheses include physiological characteristics that contribute to differences in vulnerability to infection, a higher propensity for infections to escalate from mild to serious, and disparities in sepsis treatment between genders. Other factors, such as smoking and alcohol consumption, may also affect the chance of coming into contact with infectious diseases in the environment (11).

There were 36 patients (50.7%) in the age group of 46-65 years old in this study. These findings are consistent with a study carried out by Kartika et al. (12), which states that most sepsis patients (40%) are in the age range of 45-65 years.

In this study, sepsis patients with comorbidities (70.4%) were found to be more than patients without comorbidities (29.6%). These findings are consistent with the study carried out by Sinapidis et al. (13) which stated that comorbidities increase the risk of progression of infection to sepsis. Based on the disease case, we found that the proportion on non-surgical sepsis cases (70.4%) was higher than that of surgical sepsis cases (29.6%). The results obtained are different from the research conducted by Mewes et al (14) which found more surgical sepsis patients than non-surgical sepsis. Variations in sample size and sampling site may account for discrepancies in the study's findings. In this study, the number of sepsis patients who died in the intensive care unit was 53 patients (74.6%), and 18 patients survived (25.4%).

Figure 1 displays the distribution of patients' initial SOFA score, Figure 2 displays the initial SOFA score of patients who did not survive, and Figure 3 displays the initial SOFA score of patients who survived. In this study, 9 patients, or 12.6% of the total, had the highest initial SOFA score of 11, with a mean score of 9.89 to 3.95. The initial SOFA score of patients who died was highest with a score of 11, namely 8 patients (15.1%), while the initial SOFA score of patients who survived was highest with a score of 4, namely 5 patients (27.7%).

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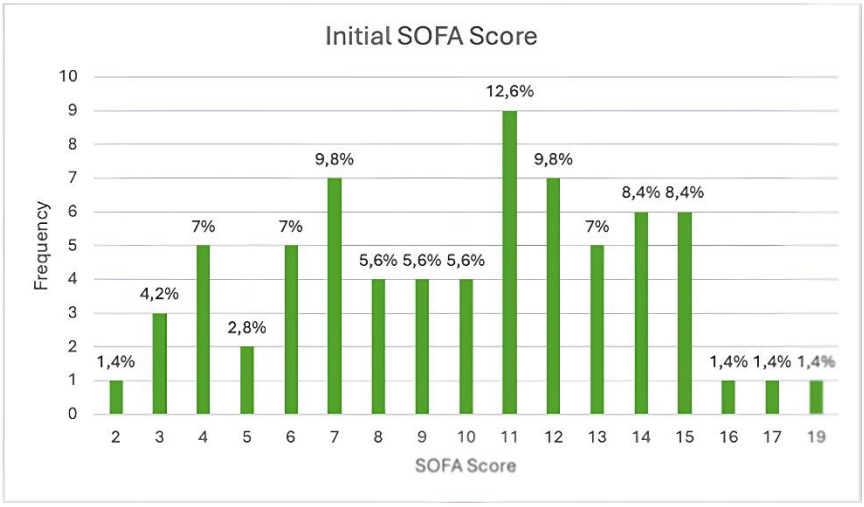

Figure 1. Initial SOFA Score

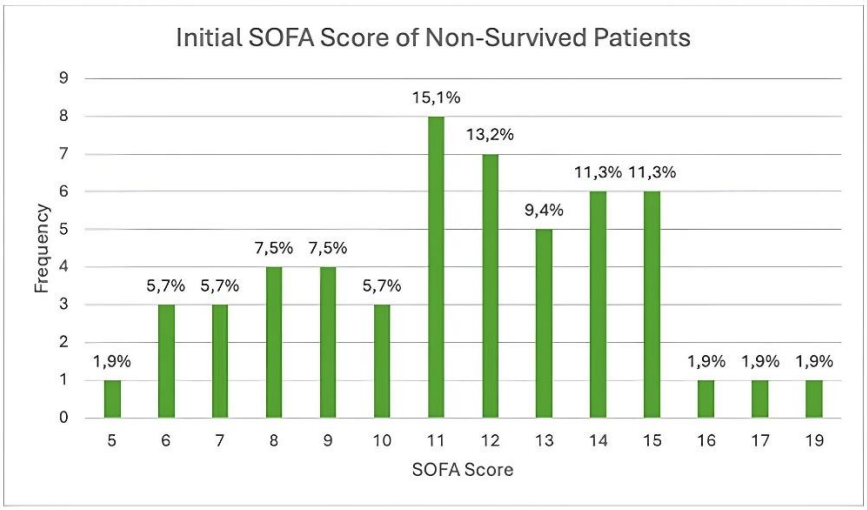

Figure 2. Initial SOFA Score of Non-Survived Patients

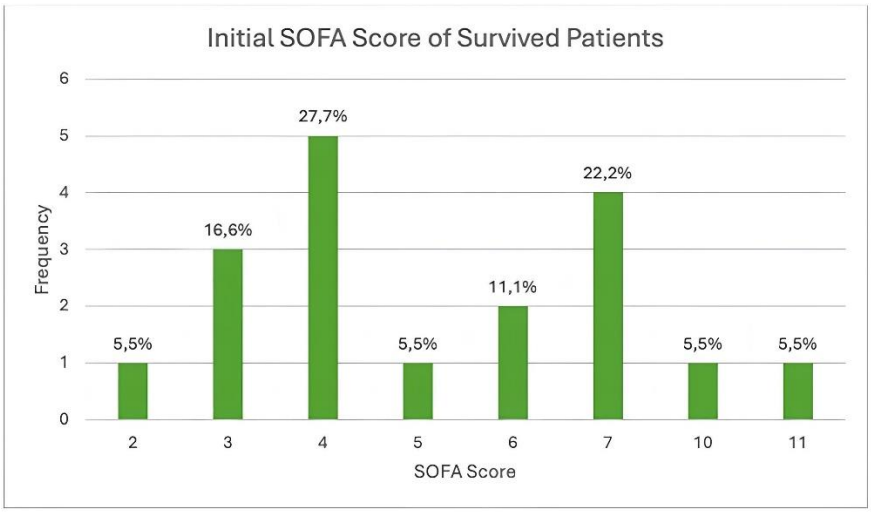

Figure 3. Initial SOFA Score of Survived Patients

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An independent-T test was conducted to determine the mean difference between the initial SOFA scores of patients who lived and those who died, as shown in Table 2.

Table 2. Initial SOFA Score Comparison

Initial SOFA Score	N (%)	Mean	SD	p-value
Died	53 (74.6)	11.42	3.12	< 0.001*
Survived	18 (25.4)	5.39	2.45	
Total	71 (100)	9.89	3.95	

* Independent-T Test (unpaired, normal distribution)

The result showed that the mean initial SOFA score of the patient who died (11.42 ± 3.12) was higher than those who survived (5.39 ± 2.45). The results showed a significant difference between the two groups ($p < 0.001$). These results are similar to the research conducted by Kartika et al. (12) in the intensive care unit at Dr. Saiful Anwar Hospital Malang, which stated that the mean SOFA score of patients who died (8.63 ± 3.55) was significantly higher than patients who lived (5.47 ± 3.11).

Table 3. Correlation Between Initial SOFA Score and Mortality

Initial SOFA Score	Mortality		p-Value
	Died N (%)	Survived N (%)	
< 7	4 (5.6)	12 (16.9)	< 0.001*
≥ 7	49 (69)	6 (8.5)	
Total	53 (74.6)	18 (25.8)	

* Fisher's Exact test

The correlation between the initial SOFA score and mortality is shown in Table 3. Considering the study's results, it is known that patients with an initial SOFA score ≥ 7 have a mortality rate of 69%, which is higher than patients with an initial SOFA score < 7, which is 5.6%. An analysis of the correlation between sepsis patients' deaths in the intensive care unit (ICU) and their initial SOFA score was measured using the Fisher's Exact test, and $p < 0.001$ was obtained. The outcomes show the significance of the relationship between the two variables.

The results of this study are in line with the research conducted by Kartika et al. (12) in the intensive care unit of Dr. Saiful Anwar Hospital Malang.They found a link between the patient's SOFA score when they were admitted and their death in the intensive care unit ($p < 0.05$). Patients with SOFA scores ≥7 had a higher death rate than patients with SOFA scores <7, which was 35.8%. These results are also in line with the research conducted by Iskandar and Siska (5), which stated that patients with SOFA scores ≥7 have a 3.8-fold greater chance of dying compared to patients who have SOFA scores <7.

Sepsis is a result of the host's response to infection aimed at eliminating the pathogen. An unbalanced inflammatory response is the primary cause of sepsis pathogenesis, and it manifests itself throughout the sepsis course (15). Oxygenation disorders caused by vasodilation, microvascular thrombosis, and mitochondrial damage will lead to reduced oxygen delivery in sepsis, which will then cause septic shock and multiple organ dysfunction syndrome (16). Higher SOFA scores in patients who experience mortality indicate a higher level of organ dysfunction in patients and are related to a higher chance of mortality (3).

Thakur et al. (6) mentioned that the SOFA score system is a useful technique for predicting mortality and morbidity in patients suffering from sepsis, and the correlation of early SOFA with mortality showed significant results. The study also stated that the SOFA score on day 2 (SOFA score at 48 hours) was a better predictor of 30-day mortality. However,

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this study did not analyze the correlation between mortality and serial SOFA score, which is a limitation of this study.

In future studies, a serial SOFA score and cut-off measurement will be needed to provide a more detailed picture of the correlation between SOFA scores and mortality in sepsis patients in the ICU of Haji Adam Malik Hospital Medan.

CONCLUSION

The results showed a significant difference between the SOFA scores of patients who lived and those who died, and there was a correlation between the initial SOFA score and mortality in the ICU of Haji Adam Malik Hospital Medan.

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Conflict of Interest

The authors declare no conflict of interest.

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Author's Contributions

All authors have contributed to all processes in this research.

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Original Research Article

A RANDOMIZED CONTROLLED STUDY: COMPARING THE EFFECTIVENESS OF iSCOPE 3 AND AIRTRAQ VIDEO LARYNGOSCOPE EXAMINATIONS IN PATIENTS UNDERGOING TRACHEAL INTUBATION

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ABSTRACT

Introduction: Nowadays, indirect laryngoscopy is a commonly used technique for teaching airway control skills. Incorporating small, less expensive, and yet more reliable video cameras into laryngoscopes has given the process of laryngoscopy and intubation, a big leap. The AirTraq has shown promise in several settings, while the iSCOPE 3 video laryngoscope is a newly launched device, and no literature is available to our understanding. **Objective:** To compare the effectiveness of the iSCOPE 3 video laryngoscope with the AirTraq optical laryngoscope. **Material and Method**: It was a randomized controlled study conducted among sixty patients after approval from the Board of Study and ethical clearance, divided into two groups. In Group AT, patients were intubated with AirTraq, and in Group IS, patients were intubated with iSCOPE 3 as per the protocol. The primary outcome metric was the duration of tracheal intubation. Secondary outcomes were measured by the quantity of tries and intubation ease, glottic view or percentage of the glottic opening score (POGO), and Cormack & Lehane grade. **Results:** In the iSCOPE 3 and AirTraq groups, comparable mean intubation times were observed. (19.50 s vs. 19.16 s). The ease of intubation was significantly better with iSCOPE 3 ($p< 0.05$), single attempt was needed to intubate 96.7% of patients in the iSCOPE 3 group compared to 70% of patients in the AirTraq group ($p< 0.05$). POGO score and Cormack & Lehane grade were also significantly better with iSCOPE 3 ($p <0.05$). **Conclusion:** Pogo and CL grade were better with iSCOPE 3 than AirTraq, and hence the success rate of intubation, number of attempts, and ease of intubation were significantly better with iSCOPE 3.

Keywords: AirTraq Video Laryngoscope; iSCOPE 3 Video Laryngoscope; Research; Tracheal intubation

ABSTRAK

Pendahuluan: Saat ini, laringoskopi tidak langsung adalah teknik yang umum digunakan untuk mengajarkan keterampilan pengendalian jalan napas. Pemasangan kamera video kecil, lebih murah, dan lebih andal pada laringoskop telah memberikan lompatan besar dalam proses laringoskopi dan intubasi. AirTraq telah menunjukkan hasil yang menjanjikan dalam beberapa pengaturan, sementara iSCOPE 3 video laryngoscope adalah perangkat baru yang belum ada literatur yang tersedia sejauh pengetahuan kami. **Tujuan:** Membandingkan efektivitas iSCOPE 3 video laryngoscope dengan AirTraq optical laryngoscope. Bahan dan Metode: Penelitian ini merupakan studi acak terkontrol yang dilakukan pada enam puluh pasien setelah mendapatkan persetujuan dari Dewan Studi dan izin etik, yang dibagi menjadi 2 kelompok. Pada kelompok AT, pasien diintubasi dengan AirTraq, dan pada kelompok IS, pasien diintubasi dengan iSCOPE 3 sesuai dengan protokol. Parameter utama untuk hasil adalah durasi intubasi trakea. Hasil sekunder diukur dengan jumlah percobaan dan kemudahan intubasi, tampilan glotis atau persentase skor pembukaan glotis (POGO), dan derajat Cormack & Lehane. **Hasil:** Waktu intubasi rata-rata yang sebanding terlihat pada kelompok iSCOPE 3 dan AirTraq (19,50 detik vs. 19,16 detik). Kemudahan intubasi secara signifikan lebih baik dengan iSCOPE 3 ($p< 0,05$), satu kali percobaan diperlukan untuk mengintubasi 96,7% pasien pada kelompok iSCOPE 3 dibandingkan dengan 70% pasien pada kelompok AirTraq ($p< 0,05$). Skor POGO dan derajat Cormack & Lehane keduanya juga secara signifikan lebih baik dengan iSCOPE 3 ($p <0,05$). **Kesimpulan:** Skor POGO dan derajat Cormack & Lehane lebih baik dengan iSCOPE 3 dibandingkan AirTraq, sehingga tingkat keberhasilan intubasi, jumlah percobaan, dan kemudahan intubasi secara signifikan lebih baik dengan iSCOPE 3.

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Kata Kunci: *AirTraq Video Laryngoscope*; *iSCOPE 3 Video Laryngoscope*; Penelitian; Intubasi Tracheal

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INTRODUCTION

Endotracheal intubation is a highly taught ability, but painful endotracheal intubation is nonetheless a significant adverse occurrence (1). Video laryngoscopes (VL) have shown promising results in managing difficult airways. Nowadays, a variety of VLs are available on the market. So, it becomes crucial to choose a VL that will be useful in the worst situation of a difficult laryngoscope and intubation. In addition, it should have a high success rate of intubation, require less adjustment manoeuvre, technique which mimics conventional laryngoscopy, be reused, and inexpensive.

We have taken a new video laryngoscope, i.e. the iSCOPE 3 (VYGON), which has a detachable and disposable non channelled blade of Macintosh type, and can be attached to a handle with a screen, and can be rotated up to 180°. The screen can be connected to multiple screens with Wi-Fi. Since it is a newly launched VL, its efficiency as an intubating device in comparison to the well-established AirTraq should be evaluated before iSCOPE 3 can be considered as a part of a difficult airway cart. AirTraq has numerous pieces of literature mentioning its use in DA (2–4)and in patients at low (5) and higher risk (6–8) for difficult tracheal intubation and in simulated difficult airway scenarios in manikins (9).

We postulated that, in contrast to the AirTraq video laryngoscope, the iSCOPE 3 VL makes intubation less challenging due to its operational peculiarities. Therefore, we aimed to compare the iSCOPE 3 video laryngoscope with the AirTraq optical laryngoscope as an intubation aid.

MATERIAL AND METHODS

The study was carried out at Jawaharlal Nehru Medical College Hospital on 60 patients undergoing elective general surgery under general anesthesia after being approved by the Board of Studies, Department of Anesthesiology, and Institutional Ethical Committee (Ethical clearance: JNMC/IEC/D.No.1548/FM dated October 20, 2018). All study participants provided written informed consent. All patients had a thorough pre-anesthetic check-up, and those meeting the criteria were included in the study. ASA I and II patients of either sex, ages 20-50 with a BMI ≤ 30 and all classes of MMP were included in the study.

Two groups of patients were randomly assigned. A computer-based random number generator was used for the randomization process, and the allocation was hidden within sealed envelopes that weren't unsealed until patient permission was received. Patients in Group AT (n = 30; control) were intubated using an AirTraq laryngoscope. Patients in Group IS (n = 30; study) were intubated using an iSCOPE 3 video laryngoscope. If intubation was not achieved, the patient was declared to have failed intubation, and the airway was managed with 2nd generation SAD.

The premedication was administered uniformly with injections of midazolam (0.03 mg/kg), ondansetron (0.10 mg/kg), and fentanyl (1µg/kg) as part of a routine anesthetic method. Patients in the operating room were monitored for ECG, pulse rate, SpO2, NIBP, and EtCO2 using a multichannel monitor (Nihon Kohdon). The baseline ECG, pulse rate, SpO2, and NIBP were recorded before the induction of anesthesia. Following

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preoxygenation, anesthesia was induced with Propofol injection (2 - 2.5 mg/kg) and neuromuscular blockade were achieved with Suxamethonium injection 1 - 2mg/kg.

The patients were then intubated with either an AirTraq laryngoscope with installed smart phone over the adaptor to make it a VL. Depending on the allocated group, either the AirTraq laryngoscope (Group AT) or the iSCOPE 3 video laryngoscope (Group IS) was used for intubation. They were initially intubated in a neutral position with or without OLEM (optical laryngeal external manipulation) or airway adjuncts (stylets). If failed, then intubation was done in the sniffing position with or without OLEM or airway adjuncts. Following tube installation confirmation, the trial was terminated. All patients were intubated by the same researcher to avoid observer variability. After intubating ten separate patients and manikins at least twenty times using both devices, the study acquired the learning curve. Both the total number of intubations attempts and the intubation duration were noted by the observer. Any incidents that occurred during intubation, such as injuries to the lips or teeth, were also noted.

We considered a failed intubation if the trachea remained un-intubated after a maximum of three attempts, despite all necessary adjusting maneuvers. The technique was abandoned, and a 2nd-generation SAD was inserted as a rescue device, and the case was undertaken.

The intubation time was defined as the duration starting from the blade insertion between the teeth and ending when the endotracheal tube (ETT) was successfully positioned through the vocal chords. An assistant uses a stopwatch to measure time in seconds.

Ease of tracheal intubation was graded as (10):

Grade 1: No extrinsic manipulation of the larynx was required.

Grade 2: External manipulation of larynx was required to intubate.

Grade 3: Failed intubation.

Individually, the frequency of effective intubation was documented for each laryngoscope, both in the neutral and sniffing positions.

POGO Scoring (Percentage of Glottic Opening) (11) is seen while directly visualizing over the screen of the video laryngoscope.

0%: When no glottis structures were visible (not even arytenoids);

33%: Only the lower 1/3rd of the vocal cords and arytenoids were visible;

100%: When entire glottis aperture was visualized.

Cormack and Lehane Grading: This was assessed and recorded by the attending anesthetist.

Grade 1: Most of the glottis was visible. No difficulty.

Grade 2: Only the posterior part of the glottis was visible. Pressure on the larynx may improve the view, and intubation was possible with slight difficulty.

Grade 3: The epiglottis was visible, but none of the glottis could be seen. A bougie was used. There was severe difficulty.

Grade 4: There was no visible epiglottis at all. Intubation is usually impossible without special techniques.

The statistical analysis was conducted using IBM SPSS version 20 software. The findings are displayed in the form of numerical numbers, including the mean, standard

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deviation, and appropriate percentages. Demographic data between the groups was analyzed using chi square and unpaired t-tests. The data on the duration of intubation was analyzed using an unpaired t-test. The data on the number of attempts and ease of intubation were analyzed using a chi-square test. For all statistical analyses, a significance level of $P < 0.05$ was used to determine statistical significance.

RESULTS AND DISCUSSION

The demographic data and preoperative airway examination of patients were similar in both groups (Table 1). The time of intubation and ease of intubation were comparable between the two devices. However, the number of attempts, POGO score, and Cormack & Lehane grade between the two devices were statistically significant (Table 2).

Table 1. Characteristics of the Patients in Both Groups

Characteristics	Groups		p-Value*
	AirTraq VL N (%) / Mean±SD	iSCOPE 3 VL N (%) / Mean±SD	
Age in years	37.63±8.389	34.60±7.895	0.157
Sex			
Male	15 (25.0)	18 (30.0)	0.436
Female	15 (25.0)	12 (20.0)	
BMI (Kg/m^2)	23.04±2.01	24.10±2.29	0.064
MP Grade			
I	21 (35.0)	15 (25.0)	0.236
II	6 (10.0)	8 (13.3)	
III	3 (5.0)	7 (11.7)	
ASA GRADE			
I	18 (30.0)	24 (40.0)	0.091
II	12 (20.0)	6 (10.0)	

**chi-square and independent t-test were used to test proportion and compare means respectively. A p-value <0.05 is considered significant.*

The intubation time in patients intubated with iSCOPE 3 was 19.50 ± 4.14 and with AirTraq was 19.16 ± 4.21, which was similar to previous studies (12–20). Further, there are studies that reported increased intubation time as compared to our study (3,17,21–25). The number of patients who were intubated within 15 seconds using AirTraq was 5, while the number using Iscope 3 was 10. As the same researcher was intubating in both groups and also demographic profile was comparable in both groups, the increased time taken with AirTraq could be because the Macintosh blade which is present in iSCOPE 3, had an advantage over AirTraq, although both the devices are rigid. Anesthesiologists typically prefer utilizing the Macintosh blade for rigid laryngoscopy from the beginning of their anesthetic practice. As a result, the researcher would likely be able to readily make any necessary real-time adjustments during laryngoscopy and intubation using the iSCOPE 3.

However, the AirTraq®, with its prepared curvature and channel for ETT insertion, likely offered limited opportunities for precise modifications with the ETT during intubation. And also, with a mobile adaptor mounted on AirTraq which is fixed, it becomes difficult to manipulate. To make adjustments, the entire assembly, including the device and the ETT, had to be moved. This likely resulted in a rise in the quantity and length of intubation attempts, ultimately resulting in a general

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prolongation of the time required for intubation with AirTraq®. However, one could argue that there was a learning curve associated with the equipment before the study began. The learning curves essentially involve mastering device manipulation and acquiring intubation techniques. Proficiency is attained quickly with regular and frequent usage of the Macintosh blade.

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Table 2. Comparison of Intubation Parameters between the AirTraq and iSCOPE 3 Groups

Parameters	Group		p-Value*
	AirTraq N (%) / Mean±SD	iSCOPE 3 N (%) / Mean±SD	
Successful intubation	100 (30)	100 (30)	
Intubation time	19.50 ± 4.14	19.16 ± 4.21	0.759
Intubation			
< 15 seconds	5 (16.67)	10 (33.3)	0.136
>15 seconds	25 (83.33)	20 (66.7)	
Number of attempts			
One	21 (70.0)	29 (96.7)	**0.006**
Two	9 (30.0)	1 (3.3)	
POGO score			
33%	10 (33.3)	2 (6.7)	**0.010**
100%	20 (77.7)	28 (93.3)	
Ease of intubation			
Grade I	16 (53.3)	24 (80.0)	**0.028**
Grade II	14 (46.7)	6 (20.0)	
Sniffing position			
Required	7 (23.3)	1 (3.3)	0.052
Not required	23 (76.7)	29 (96.7)	
Total	30 (100.0)	30 (100.0)	

**chi-square and independent t-test were used to test proportion and compare means respectively. A p-value <0.05 is considered significant.*

The current study found that the overall intubation success rate was comparable across the two devices which is similar to the study by Ahmed et al (21). Better results for AirTraq were also reported by many studies (12,16,26,27). A significant difference was observed in this study with ease of intubation as 80.0% of patients in the iSCOPE 3 group needed no extrinsic manipulation of the larynx compared to 53.3% of patients in the AirTraq group. Similar to this study, Bogdański et al. (27) and Mathew et al. (22) reported better ease of intubation with other laryngoscopes compared to AirTraq. However, significantly favorable results for AirTraq, were reported by many studies (12,20,28) but Raza et al. (16) got an insignificantly favorable result for AirTraq. We found significantly better visualization of the larynx by POGO score with iSCOPE 3 in comparison to Airtraq. Results were similar to study, Rao et al. (29) reported that the POGO score was significantly higher (>50%) while using LMA CTrach™ compared to Airtraq® (P = 0.037). However, there are various studies (12,13,15) showed the advantage of using AirTraq over other laryngoscopes.

We also found a significant difference in Cormack and Lehane grade between the two groups. CL Grade I was observed in 83.3% of patients in the iSCOPE 3 group and in 53.3% of patients in the AirTraq group (p = 0.020). In accordance with our study, Ferrando et al. (30)

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reported significantly better Cormack-Lehane grades for other laryngoscopes compared to AirTraq devices (p = 0.04). However, Mathew et al. (22) reported comparable glottis views in both AirTraq and the Macintosh group (p = 0.269). Contrary to our study, significantly better results for AirTraq compared to other laryngoscopes were observed in various studies. (15,28,31,32) In the present study in AirTaq 7 patients required sniffing positions, whereas in iSCOPE 3, only 1 patient required sniffing positions (p = 0.006). This could be due to the less manipulation required by iSCOPE 3 as the screen can be rotated for adjustment, whereas in AirTraq, for better visualization, more adjustment and maneuvering are required.

Therefore, it could be inferred from the above discussion that, for predicted easy laryngoscopy and intubation, both devices had outstanding intubation performances. Whereas iSCOPE 3 is a new device with no literature available related to its use, in our study we could not compare it with the results of any other research. However, the intubation parameters were comparable with the AirTraq in our research. However, in terms of number of attempts and POGO scoring, we get better results with iSCOPE 3.

The present study has a few limitations. Initially, it was not feasible to prevent the anesthesiologist from being aware of the devices because they had distinct variations in their shape and size. So, this study had the potential for observer bias. Furthermore, the study exclusively focused on elective general surgical patients, therefore, the findings cannot be extrapolated to emergency room procedures or other specific populations such as obstetricians, obese individuals, or those with cervical immobilization. Hence, the application of our results in such patients may not be justifiable.

CONCLUSION

Our analysis indicates that both devices exhibit high rates of successful intubation. However, iSCOPE 3 outperforms AirTraq regarding intubation attempts, ease of intubation, achieves superior POGO, scores and Cormack-Lehane grades. Further studies should be done with a large sample, a multicentric approach, and among difficult patients in emergency situations to get a better comparative analysis.

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Conflict of Interest

The authors declare no competing interests.

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Authors' Contributions

Sania Parveen and Syed Moied Ahmed contributed in Concepting, designing, definition of intellectual content, literature searching, data acquisition, data analysis, statistical analysis, manuscript preparation, editing, and review.

Mohd Najmul Aqib Khan contributed in literature searching, data analysis, statistical analysis, manuscript preparation, editing, and review.

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Original Research Article

COMPARISON OF AUSCULTATION METHOD VERSUS LUNG ULTRASOUND TECHNIQUE TO EVALUATE THE ACCURACY OF POSITIONING OF LEFT DOUBLE LUMEN TUBE IN PATIENTS UNDERGOING CARDIOTHORACIC SURGERY

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ABSTRACT

Introduction: Cardiothoracic surgery is a complex and highly specialized medical field requiring precise surgical techniques and meticulous patient management. One critical aspect of this type of surgery is the accurate placement of the endobronchial double-lumen tube (DLT), which facilitates lung isolation and one-lung ventilation (OLV) during the procedure. Proper positioning of the DLT is essential to ensure adequate oxygenation, prevent complications, and optimize surgical access. **Objective**: This study aimed to compare the accuracy of positioning of the left DLT by the auscultation method versus the lung ultrasound technique in patients undergoing cardiothoracic surgery in both supine and lateral positions. **Material and methods:** A prospective, observational, and cross-sectional study was conducted in a single group of 62 patients based on the eligibility criteria. After general anesthesia, a DLT was inserted and rotated until resistance. Placement was confirmed by auscultation, ultrasound, and fibreoptic bronchoscopy. The evaluation process was done initially in a supine position, followed by a lateral position. **Results:** After insertion of the left DLT, initially evaluated in the supine position, sensitivity and specificity for auscultation were found to be 65.2% and 37.5%, respectively, sensitivity and specificity for ultrasonography were 82.6% and 75%, respectively. The accuracy of lung ultrasound at 80.7% (69.2%-88.6%) was higher than the accuracy of auscultation at 58.1% (45.7%-69.5%). This was followed by evaluation in lateral position, where sensitivity and specificity for auscultation were found to be 76.1% and 25% respectively, sensitivity and specificity for ultrasonography were 95.7% and 62.5%, respectively. The accuracy of lung ultrasound at 87.1% (76.6%-93.3%) was higher than the accuracy of auscultation at 62.9% (50.5%- 73.8%). **Conclusion:** Lung ultrasound is a superior method for assessing lung isolation and determining Double Lumen Tube position as compared to auscultation.

Keywords: Auscultation; Double Lumen Tube; Fibreoptic Bronchoscopy; Lung Ultrasound

ABSTRAK

Pendahuluan: Bedah kardiotoraks merupakan bidang medis yang kompleks dan sangat khusus yang memerlukan teknik bedah yang presisi dan manajemen pasien yang teliti. Salah satu aspek penting dalam bedah kardiotoraks adalah penempatan yang akurat dari endobronkial *double-lumen tube* (DLT) yang memfasilitasi isolasi paru dan ventilasi paru tunggal (OLV) selama prosedur. Penempatan DLT yang tepat sangat penting untuk memastikan oksigenasi yang memadai, mencegah komplikasi, dan mengoptimalkan akses bedah. **Tujuan:** Studi ini bertujuan untuk membandingkan akurasi penempatan DLT kiri dengan metode auskultasi versus teknik ultrasonografi paru pada pasien yang menjalani bedah kardiotoraks dalam posisi supin dan lateral. Studi prospektif, observasional, dan potong lintang yang dilakukan pada satu kelompok yang terdiri dari 62 pasien berdasarkan kriteria kelayakan. Setelah anestesi umum, DLT dimasukkan dan diputar hingga ada resistensi. Penempatan dikonfirmasi dengan auskultasi, ultrasonografi, dan bronkoskopi serat optik. Proses evaluasi dilakukan awalnya dalam posisi supin diikuti dengan posisi lateral. **Hasil:** Hasil menunjukkan bahwa setelah pemasangan DLT kiri, evaluasi awal dalam posisi supin, sensitivitas dan spesifisitas untuk auskultasi adalah 65,2% dan 37,5% masing-masing, dan sensitivitas serta spesifisitas untuk ultrasonografi adalah 82,6% dan 75% masing-masing. Akurasi ultrasonografi paru 80,7% (69,2%-88,6%) lebih tinggi daripada akurasi auskultasi 58,1% (45,7%-69,5%). Evaluasi selanjutnya dalam posisi lateral menunjukkan bahwa sensitivitas dan spesifisitas untuk auskultasi adalah 76,1% dan 25% masing-masing, dan sensitivitas serta spesifisitas untuk ultrasonografi adalah 95,7% dan 62,5% masing-masing. Akurasi ultrasonografi paru 87,1% (76,6%-93,3%) lebih tinggi daripada akurasi auskultasi 62,9% (50,5%-73,8%). **Kesimpulan:**

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Ultrasonografi paru adalah metode yang lebih unggul untuk menilai isolasi paru dan menentukan posisi Double Lumen Tube dibandingkan dengan auskultasi.

Kata kunci: Auskultasi; Bronkoskopi serat optic; *Double Lumen Tube*; Ultrasonografi paru

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INTRODUCTION

Selective one-lung ventilation is commonly accomplished during thoracic surgery with the use of a double-lumen tube (DLT), most commonly a left-sided DLT. To allow for surgical access to the chest cavity, one-lung ventilation entails breathing into one lung while allowing the other lung to collapse. One lung ventilation serves the protective purpose of preventing the other lung's fluid, such as blood, lavage fluid, malignant or purulent secretions, or other potentially hazardous substances, from harming the first lung. To isolate the lungs, methods such as bronchial blockers, double lumen tubes, and selective endobronchial intubation can be used. Anesthetic treatment in thoracic surgery relies on the correct placement of double-lumen tubes (DLTs), which are commonly employed to create one-lung ventilation. The exact location of the DLTs is critical for effective lung isolation.

Electrical Impedance Tomography (EIT) (1), clinical evaluation by auscultation and observation of chest wall movement, VivaSight DLT (2), lung ultrasound (3), and fibreoptic bronchoscopy (4) are some of the methods that have developed over the years to evaluate DLT installation. The use of lung ultrasonography in airway management has expanded substantially. To determine the distribution of ventilation in different regions, researchers have used indicators from lung ultrasound (LUS), such as lung sliding (LS) and lung pulse (LP), and they have discovered that LUS is a straightforward, non-invasive way to ensure lung isolation after DLT placement (5,6). This is in addition to the many other approaches that have been developed for confirming DLT positions. There are two main types of techniques: those that look at where the double lumen tube (DLT) is in the airway (e.g., fluoroscopy, fiber-optic bronchoscopy (FOB)) and those that look at how the lungs collapse and breathe (e.g., electrical impedance tomography, computerized analysis of breath sounds using microphones, auscultation, and capnography). The availability of instruments and operator expertise are the two main factors that influence the use of these techniques, which are combined to find the correct placement of DLT. For the visualization of DLTs in the trachea and bronchia, fiber-optic bronchoscopy has been considered the gold standard (7).

Lung ultrasonography is a useful tool for evaluating one-lung ventilation because it clearly and efficiently shows the diaphragm and pleura in motion. This research looks at how well lung ultrasonography and auscultation work for confirming the left DLT position in patients who are having cardiothoracic surgery while lying on their back or on their side.

Identifying how often patients need to be repositioned after going from a supine to a lateral position and keeping track of how long it takes for auscultation and ultrasonography to establish the patient's position are secondary goals. Although there have been numerous studies comparing the efficacy of lung ultrasonography and auscultation in confirming DLT insertion in the supine position, relatively few have examined the results in both positions.

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MATERIAL AND METHODS

Following clearance from the S.M.S. Medical College Ethics Committee and registration in Clinical Trials Registry India (CTRI/2023/09/057585) on April 26, 2023, this prospective, observational, and cross-sectional investigation was carried out in the Cardio-Thoracic Operation Theatre at SMS Hospital. Everyone involved, including patients and their relatives, signed an informed consent. After approval, this study included 62 elective patients. In every case, the left-sided DLT was employed, and the tube size was determined by the tracheal diameter estimated from the chest X-ray. Typically, Fr DLT values of 35, 37, and 39 were selected, while 33 and 41 Fr DLT were also utilized in certain instances. Patients must be at least 18 years old and categorized as having an ASA Grade II or III cardiac or thoracic surgery for elective purposes. Patients who have undergone thoracic surgery or have had a tracheostomy are not eligible to participate. The patient's pulmonary function test results are abnormal, and they have a history of pleurodesis, pneumothorax, pleural effusion, or empyema (ASA Grade IV). We found that 86% of USG and 63% of auscultation cases were sensitive when done in the supine position with left DLT. This was based on the assumptions of 80% research power and a 0.05 alpha error. The initial 56 patients needed for the sample size were increased to 62 patients for the current trial, with the expectation of a 10% dropout rate.

Upon entering the operating room, the results of the pre-anesthesia assessment and the nil per oral status of the patients were checked. A variety of standard routine monitors were connected, and baseline parameters such as heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), temperature, and oxygen saturation (SpO2) were recorded. Under local anesthesia, we inserted catheters into the femoral artery and internal jugular vein to allow for invasive blood pressure and central venous pressure monitoring. Injections of 0.3 mg/kg of etomidate induced general anesthesia, whereas injections of 1 mg/kg of rocuronium relaxed the muscles. With the patient's height serving as a guide for the depth of DLT insertion, the trachea was intubated using a left double-lumen tube under direct laryngoscopy. After the endobronchial cuff was passed through the vocal cord, the stylet was removed, and the tube was rotated 90° (towards the left side) and advanced until resistance was felt. Inflating the tracheal and bronchial cuffs after intubation allowed us to record the patient's initial depth of insertion. Tracheal intubation was confirmed by an appropriate $ETCO_2$.

Evaluation in Supine Position

Both approaches started evaluating DLT consecutively immediately after intubation. One point was the meeting point between the midclavicular line and the second intercoastal space; another was the midclavicular line and the fifth intercoastal space. In the midaxillary line, at comparable intercostal intervals, the other two points were put in the axilla. During the auscultation evaluation, these four places were used to assess the DLT in a supine posture. While lying on one side of the hemithorax, all four sites were auscultated. Shortly after intubation, puffing up the tracheal cuff allowed us to hear patients breathing on either side of the chest. Once the tracheal lumen was pinched and the bronchial cuff was inflated, the patient's left side could be heard breathing while the right side was silent. When we clamped the bronchial lumen, we were able to hear breath sounds on the right side but none on the left side, confirming our previous observations. As a result, the DLT site was auscultated, confirming successful placement. It was necessary to take

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three deep breaths while examining each point. Manual ventilation was used to conduct the auscultation technique.

After the auscultation evaluation was completed, we moved on to the USG approach, which involved preparing an ultrasound probe (EVITRON) before intubation. Our investigation utilized a linear probe with a frequency of 12 MHz. The same spots that were fixed during the auscultation were also used for evaluation. During the USG examination, the standard pleural sliding sign was noted on both sides before clamping. After inflating the bronchial cuff and clamping the tracheal lumen, we can see pleural sliding between the shadows of the left ribs, but there is no such evidence on the right. In cases where pleural sliding was present, the M mode revealed a beach sign; in cases where no such sliding was present, the barcode sign was visible. There was thought to be ventilation on one side of the lung if pleural sliding was present, and no ventilation on the other side if no pleural sliding was present.

Following auscultatory and ultrasonographic evaluations, the location of DLT was confirmed using a fibreoptic bronchoscope (FOB). To achieve adequate lung isolation and proper placement of the bronchial cuff, repositioning was performed by FOB.

Evaluation in Lateral Position

The patient was moved from a supine posture to a lateral one because that's how most thoracic procedures are done. The patient was re-evaluated for DLT placement after changing positions using the same steps as when they were supine: auscultation, USG, and FOB.

Statistical Analysis

Tables and figures were used to display the compiled data. To assess nominal and categorical data, the Chi-square test was used to summarize them as percentages and frequencies. To compare the two approaches, we calculated the means and standard deviations of the continuous variables and ran the numbers through a paired t-test. Using fibreoptic as the gold standard, we computed the sensitivity, specificity, positive and negative predictive value, and diagnostic accuracy, at a 95% confidence interval for both approaches. At a p-value of < 0.05, statistical significance was considered. We used the statistical program Epi info version 7.2.1.0 to conduct all of our analyses.

RESULTS AND DISCUSSION

This study was done on 62 eligible patients of >18 years of age with ASA Grades II and III undergoing elective cardio-thoracic surgery under general anesthesia after obtaining informed written consent. The study was conducted in a single group in which the placement of the left DLT was assessed using two methods; auscultation and ultrasonography sequentially, one after the other, and final confirmation was done using a fibreoptic bronchoscope in both the supine and lateral positions. No significant differences were found among the general demographic data of patients such as age, height, weight, body mass index, tracheal width, and the type of surgery as shown in Table 1.

Table 1. General Data of Patient Demographics

Patient Demographics	Left DLT N (%) / Mean±SD
ASA	
II	40 (64.5)
III	22 (35.5)
Age (years)	42±15
Gender	
Male	50 (80.6)
Female	12 (19.4)
Height (cm)	161.9±9.69
Weight (kg)	58.71±12.15
BMI (kg/m^2)	22.35±1.01
Tracheal width (cm)	17.19±2.05

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The evaluation time was compared between auscultation and ultrasonography in both the supine and lateral position and it was found that the ultrasonography technique required more time for evaluation as compared to the auscultation method. Furthermore, the evaluation time in the lateral position was slightly longer than in the supine position for both auscultation and ultrasonography, and the results were statistically significant, as shown in Table 2.

Table 2. Comparison of evaluation time by Auscultation and USG

Variable	Auscultation (sec) Mean±SD	USG (sec) Mean±SD	p-Value
Supine Position	99.48 ± 13.65	108.7 ± 13.94	**<0.001***
Lateral Position	102.5 ± 16.69	112.7 ± 12.34	**<0.001***

*This result based on a paired t-test with p-value < 0.05 means significant.

From the observation of our study as seen in Figure 1, we found that 48.3% of left DLT were found as good placement, and 9.6% were found as bad placement by both auscultation and fibreoptic in the supine position. Similarly, when observed by USG, we found that 61.2% of left DLT were found to be in good placement, and 19.3% were found to be in bad placement by both USG and fibreoptic in the supine position. In the same way, when similar observations were done in lateral position, we found that 56.4% of left DLT were found to be in good placement and 6.4% were found to be in bad placement by both auscultation and fibreoptic. Likewise, when observed by USG in lateral position, we found that 70.9% of left DLTs were found as good placement and 16.1% were found as bad placement by both USG and fibreoptic.

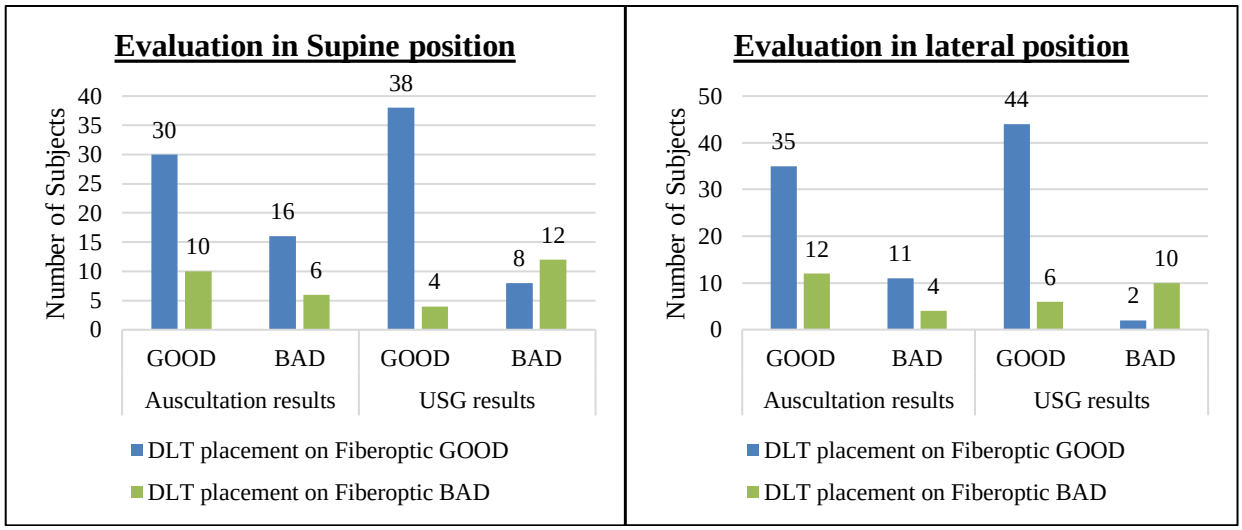

Figure 1. Evaluation in Supine and lateral Position between Auscultation and USG about FOB

From Table 3, it is known that when left-sided DLT was used, in the supine position, sensitivity and specificity for auscultation were 65.2% (50.8%-77.3%) and 37.5% (18.5%-61.4%) respectively, and sensitivity and specificity for ultrasonography were 82.6% (69.3%-90.9%) and 75% (50.5%-89.8%), respectively. The Positive Predictive Value (PPV) of auscultation was 75% (59.8%- 85.8%) and Negative Predictive Value (NPV) was 27.3% (13.2%- 48.2%). Whereas, the Positive Predictive value of USG was 90.5% (77.9%-96.2%) and the Negative Predictive Value was 60% (38.7%- 78.1%). The accuracy of

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ultrasonography at 80.7% (69.2%-88.6%) was higher than the accuracy of auscultation at 58.1% (45.7%-69.5%) in the supine position.

While, left-sided DLT was used, in lateral position, sensitivity and specificity for auscultation were 76.1% (62.1%-86.1%) and 25% (10.2%-49.5%) respectively, and sensitivity and specificity for ultrasonography was 95.7% (85.5%-98.8%) and 62.5% (38.6%-81.5%). The Positive Predictive Value of auscultation was 74.5% (60.5%- 84.8%) and the Negative Predictive Value was 26.7% (10.9%-52%). Whereas for USG, the Positive Predictive Value was 88% (76.2%-94.4%) and the Negative Predictive Value was 83.3% (55.2%-95.3%). The accuracy of ultrasonography at 87.1% (76.6%-93.3%) was higher than the accuracy of auscultation at 62.9% (50.5%- 73.8%) in the lateral position.

Table 3. Diagnostic parameters of auscultation and USG method for diagnosis of the correct position of DLT

Parameter	Auscultation Supine position	USG Supine position	Auscultation Lateral position	USG lateral position
Sensitivity	65.2% (50.8-77.3)	82.6% (69.3- 90.9)	76.1% (62.1-86.1)	95.7% (85.5- 98.8)
Specificity	37.5% (18.5- 61.4)	75% (50.5- 89.8)	25% (10.2- 49.5)	62.5% (38.6- 81.5)
Positive Predictive Value	75% (59.8- 85.8)	90.5% (77.9- 96.2)	74.5% (60.5- 84.8)	88% (76.2- 94.4)
Negative Predictive Value	27.3% (13.2- 48.2)	60% (38.7- 78.1)	26.7% (10.9- 52)	83.3% (55.2- 95.3)
Diagnostic accuracy	58.1% (45.7- 69.5)	80.7% (69.2- 88.6)	62.9% (50.5- 73.8)	87.1% (76.6- 93.3)

***Data in the table shows the Sensitivity, Specificity, PPV, NPD, and Diagnostic accuracy with the 95% Confidence Interval

From the above observations, we can conclude that lung ultrasound demonstrated higher sensitivity and specificity as compared to auscultation in both the supine and lateral positions.

Furthermore, lung ultrasound had higher PPV and NPV than auscultation. This meant that the positive and negative results from lung ultrasound were more likely to accurately show where the DLT was. Besides this, lung ultrasound also demonstrated significantly higher diagnostic accuracy compared to auscultation in both positions.

If we want to avoid intraoperative hypoxia and accompanying complications during thoracic procedures, we have to make sure that the DLT is properly positioned to allow for one-lung ventilation and sufficient lung separation. Clinical approaches such as auscultation and examination of chest wall motions, as well as electrical impedance tomography, lung ultrasonography, fibreoptic bronchoscopy (FOB), and other similar techniques, have been employed to verify the location of DLT. To assess the efficacy of DLT in supine and lateral positions, our research compared the auscultation method with a lung ultrasonography methodology.

We found that ultrasonography had higher diagnostic accuracy than auscultation in both the supine and lateral positions of the body. Comparing the transthoracic LUS with clinical methods for left DLT position confirmation in 105 patients, Alvarez-Diaz et al. (6) demonstrated that LUS had better sensitivity (98.6% vs. 84.5%), specificity (52.9% vs. 41.1%), accuracy (83.8% vs. 70.4%), PPV (81.4% vs. 75.0%), and NPV (94.7% vs. 56.0%), similar to our study.

The distribution of ventilation is most often evaluated by auscultation, a non-invasive technique. However, this is frequently subjective and is dependent on factors such as tidal volume, underlying lung tissue

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consistency, skin-to-pleura distance, operating room noise level, stethoscope sensitivity, individual hearing acuity, and so on. On top of that, the conductivity of sound from the contralateral side might also confuse auscultating breath sounds on one side of the chest. The results of the study by Liaquat Ali et al. (8) show that auscultation cannot be relied upon to confirm the site of a DLT, in their study, all patients demonstrated proper DLT positioning with appropriate ventilation during auscultation, however only 60% of patients had correct DLT placement and 40% of patients had partially misplaced DLT on fibreoptic; as a result, FOB was required to ensure correct placement. In most cases, FOB is necessary to validate the DLT position because prior research has shown that auscultation is not an accurate procedure.

Recent years have seen increased acceptance of lung USG for endotracheal tube positioning confirmation in critical care situations and its utility in OT airway management in general (9–11). The diaphragm and pleura's motion, which are indirect quantitative and qualitative markers of lung expansion (12), can be seen in real-time with the non-invasive lung USG approach. A hyperechoic line, or "pleural line," depicts the boundary between the chest wall's soft tissue and the ventilated lung in an intercoastal ultrasonographic image. Pleural sliding, which manifests as a back-and-forth movement of this pleural line, is instantly apparent at the pleural interface during lung breathing. Pulsatile movement at the pleural interface becomes visible as soon as ventilation is halted; this happens in both right and left selective intubation, but is more common on the left side since the heart is closer and is termed as “lung pulse” sign. Therefore, functional isolation and proper DLT positioning can be presumed if USG shows a pleural sliding sign on one side and a lung pulse indication on the other part.

Finally, FOB was used to confirm the position of DLT after auscultation and USG had evaluated it. How DLT is positioned and the results are affected by changes in body position as well. Since most thoracic surgeries are performed in the lateral position, and because it is often required to readjust the position of the DLT to prevent the tube displacement while changing positions from supine to lateral, it would be insufficient to simply discuss the evaluation in the supine position. Consequently, we conducted additional research in the lateral position after the evaluation was conducted in the supine position using both methodologies. In both roles, the procedures followed the same pattern.

Additionally, we evaluated the assessment times required to validate the DLT location using both methods and positions. We discovered that auscultation had a significantly quicker evaluation time than ultrasound. Also, both approaches took more time while evaluating in a lateral position. In contrast to Ramsingh et al. (13), whose study recorded an evaluation time of 162±38 seconds for ultrasound, our investigation found a shorter duration. Methodological discrepancies likely explained these variations; Ramsingh evaluated the pleural gliding sign in addition to the cricothyroid membrane and ETT cuff. Because of this, his study's evaluation duration was lengthened.

When compared to ultrasound, our findings showed that auscultation had inferior sensitivity and specificity in both the supine and lateral positions. Ultrasound also outperformed auscultation in terms of diagnostic accuracy in both supine and lateral positions. Ultrasound excelled in comparison to auscultation. Ultrasound makes it easy to see the diaphragmatic excursion, lung pulse, and

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pleural sliding sign (14,15). Ultrasound has a higher specificity for verifying the DLT location is accurate, as Po-Kai Wang et al. (16) discovered, which is consistent with our findings. Also useful was the M-mode ultrasound, which shows two signs—the beach sign when pleural sliding is present and the barcode indication when it isn't. Previous research has shown that the lung sliding sign can be used in clinical practice to certify that the left-sided double-lumen tube is properly positioned (17). Ultrasound, on the other hand, is less biased and more objective. Ultrasound could supplant auscultation in DLT positioning.

Repositioning was done if needed after final confirmation using fibreoptic bronchoscopy to establish the exact position. As bronchoscopy allows for direct viewing of the bronchial structure and cuff location, it is useful for patients with abnormal anatomy or challenging airway situations (18). Confirmation via FOB is necessary for both positions since thoracic procedures are typically performed in the lateral position, which increases the risk of dislocating the DLT during position changes. While 5.3% of tubes were found to be dislocated when placed in the lateral decubitus position by auscultation in the study by S M Mireskandari et al., FOB reported a higher number of 10.5% (19). When it concluded that FOB must be routinely and continuously used in modern practice, multiple other researches reached the same conclusion (20).

Therefore, compared to clinical approaches, transthoracic lung ultrasonography is better for confirming DLT location because it is a quick and non-invasive procedure. As a result, when paired with FOB, lung USG is preferable to clinical techniques. Nevertheless, it may not serve as a replacement for FOB, as FOB offers numerous noteworthy benefits over lung ultrasonography. For instance, FOB can guide the positioning of the right DLT so that the lumen is in line with the right upper lobe's orifice. If DLT has progressed beyond secondary carina, FOB can readily detect it. It is recommended to use FOB when adjusting DLT during surgery.

Our investigation had several limitations. To start, with a sample size of only 62 patients, our study was on the smaller side. Secondly, any patients who needed right DLT were not included in our study; we solely focused on left DLT. Finally, our findings are based on the individuals who were eligible to participate in our study; this may have introduced selection bias as we did not include patients who did not have pleural sliding. So, we don't know what we could have learned from the patients who weren't a part of our study.

CONCLUSION

Our study findings indicate that lung ultrasonography is a more effective tool than auscultation for accurately positioning the left double-lumen tube during elective thoracic surgery, regardless of whether the patient is in a supine or lateral position. This result needs further study which requires a bigger sample size and includes patients with right DLT and tracheostomised patients and patients with pleural pathology whose breath sounds and/or pleural sliding are not obvious.

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Conflict of interest

The authors declare there is no conflict of interest.

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Authors' Contributions
SA, IV, JS, ND: study concept and design, data collection and processing, analysis and interpretation of the data, drafting of the manuscript, revision of the manuscript for important intellectual content, administrative, technical, or material support, Literature search, and study supervision.

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Case Series

ULTRASOUND-GUIDED PERIPHERAL NERVE BLOCK AS POST-OPERATIVE MANAGEMENT OF LOWER ABDOMINAL SURGERY IN KSATRIA AIRLANGGA FLOATING HOSPITAL

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ABSTRACT

Introduction: Enhanced Recovery After Surgery (ERAS) implementation in remote areas by operating hospital ships is immensely helpful due to high patient turnover, reducing costs, and minimizing the effects of surgical stress. Utilization of regional anesthetics, namely ultrasound-guided Transversus Abdominis Plane (TAP) block or Quadratus Lumborum (QL) block, is applicable and beneficial in this setting. **Objective:** Due to the limited time, facilities, and health personnel available in floating hospital services surgery, several adjustments in anesthetic methods are required to rapidly return patients to their preoperative physiologic state. Therefore, we wrote this case report. **Case Series:** We presented case series of lower abdominal surgery performed in Ksatria Airlangga Floating Hospital with the implementation of peripheral nerve blocks as one of the ERAS protocols in one of the remote islands in Indonesia, Gili Iyang Island. Two patients underwent TAP blocks, while the remaining two received QL Blocks. A peripheral nerve block was performed under ultrasound guidance and a 20-mL injection of 0.25% levobupivacaine to QL muscle or TAP. During the observation, we found Visual Analogue Score (VAS) of 1-2 after surgery, no post-operative sedation needed, only 1 patient experienced nausea without vomiting, and the length of health facility stay were less than 3 days. **Discussion:** Nearly all of our patients who underwent lower abdomen surgery got benefits from the application of peripheral nerve block. Because there was no opioid consumption in our cases, the risk of unwanted effect of opioids like postoperative nausea and vomiting, were also decreased. **Conclusion:** Peripheral nerve block, as mentioned TAP Block and QL Block, has emerged as a promising alternative to prevent and manage post-operative pain in remote medicine settings, namely Ksatria Airlangga Floating Hospital, particularly in areas with few medical facilities.

Keywords: ERAS; Floating Hospital; Good Health and Well-being; Ksatria Airlangga; Peripheral Nerve Block

ABSTRAK

Pendahuluan: Penerapan Enhanced Recovery After Surgery (ERAS) di daerah terpencil dengan penggunaan trumah sakit terapung sangat penting karena meningkatkan pergantian pasien, mengurangi biaya, dan meminimalisir efek stres pasca pembedahan. Anestesi regional seperti blok Transversus Abdominis Plane (TAP) atau blok Quadratus Lumborum (QL) dengan bantuan *ultrasound* dapat diterapkan dan bermanfaat dalam situasi ini. **Tujuan:** Keterbatasan waktu, fasilitas, dan tenaga kesehatan terkait layanan bedah di rumah sakit terapung memerlukan beberapa penyesuaian metode anestesi agar pasien dapat segera kembali ke keadaan fisiologis sebelum operasi. Oleh karena itu, kami menulis laporan kasus ini. **Serial Kasus:** Kami melaporkan serial kasus mengenai operasi daerah abdomen yang dilakukan di Rumah Sakit Terapung Ksatria Airlangga dengan penerapan blok saraf tepi sebagai salah satu protokol ERAS di salah satu pulau terpencil di Indonesia, Pulau Gili Iyang. Dua pasien menjalani blok TAP, sedangkan dua sisanya menerima Blok QL. Blok saraf tepi dilakukan

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dengan panduan USG dan injeksi 20 mL levobupivacaine 0,25% ke otot QL atau TAP. Setelah observasi, seluruh pasien dengan Visual Analogue Score (VAS) 1-2 setelah operasi, lama rawat inap di fasilitas kesehatan kurang dari 3 hari dan tidak diperlukan sedasi pasca operasi. Hanya 1 pasien yang mengalami mual tanpa muntah. **Pembahasan:** Semua pasien kami yang menjalani operasi perut bagian bawah mendapatkan manfaat dari penerapan blok saraf tepi. Karena tidak adanya penggunaan opioid, risiko efek opioid yang tidak diinginkan seperti mual dan muntah pasca operasi juga menurun. **Kesimpulan:** Blok saraf perifer, seperti Blok TAP dan Blok QL, telah muncul sebagai alternatif yang menjanjikan untuk mencegah dan menangani nyeri pasca operasi di lingkungan pengobatan terpencil, yaitu Rumah Sakit Terapung Ksatria Airlangga, khususnya di daerah dengan fasilitas medis yang terbatas.

Kata Kunci: ERAS; Rumah Sakit Terapung; Kesehatan dan Kesejahteraan yang Baik; Ksatria Airlangga; Blok Saraf Perifer

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INTRODUCTION

Enhanced recovery after surgery (ERAS) is an evidence-based approach to surgical care that aims to minimize the stress of surgery and facilitate patients to recover rapidly by preserving normal physiology (1). One of the important components of ERAS is the use of regional anesthesia to minimize the stress of surgery and reduce opioid use, Ultrasound-guided transversus abdominis plane (TAP) blocks or Quadratus Lumborum (QL) blocks, provide analgesia that might be superior to other techniques for some patients, namely oral pain medications or opioids (2).

Ksatria Airlangga Floating Hospital is a hospital ship that was established in 2017, providing health services and community development. A trip to Gili Iyang Island, from May 15–22, is one of the Ksatria Airlangga floating hospital trips to remote islands in 2022. We have surgical facilities and equipment on board, allowing doctors to perform surgery and anesthesia for indicated patients. The problem depicted in the previous hospital's ship design was not intended for medical treatment activities and does not adhere to hospital building or operating rooms guidelines. ERAS in this setting are highly beneficial due to patient's need for early mobilization, reducing costs through efforts to quickly return patients to their preoperative physiologic state and diminishing the effects of surgical stress.

Limited time and facilities in floating hospital services and limited monitoring facilities, health personnel, and equipment or drugs in the remote island require several adjustments in anesthetic methods to rapidly return patients to their preoperative physiologic state. Therefore, we wrote this case report.

CASE SERIES

Here we present 4 cases of lower abdomen surgery performed in Ksatria Airlangga Floating Hospital during the trip to Gili Iyang Island with implementation of peripheral nerve blocks as one of ERAS protocols. The inclusion criteria of this case series are that patients must be above the age of 17 and scheduled for lower abdominal surgery. The surgery should take no more than two hours and require a PS ASA score of 1-2. The exclusion criteria are: 1. Prolonged operative duration, 2. Switching from regional to general anesthesia during the surgery 3. History of cerebrovascular and cardiovascular accidents (stroke, Congestive Heart Disease, history of heart surgery, cardiac stent, anticoagulant or antiplatelet therapy, and/or congenital heart

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defects), 4. Any history of spinal abnormalities, 5. wounds or infections at the puncture site, 6. Coagulopathy, or history of spontaneous bleeding without any clear cause, 7. haemodynamic disturbances/shocks, 8. Patients with respiratory failure, or, 9. There are signs of increased ICP (severe headache, nausea, projectile vomiting, and/or decreased consciousness), 10. There is no history of drug allergies related to the medication being administered; and 11. The patient or family does not consent.

In this case series, the sample collection technique is total sampling (all eligible patients will receive the same treatment), and there is no control group.

Table 1. Clinical Characteristics, Durante, and Post-operative Data of Patients

Variable	Case 1	Case 2	Case 3	Case 4
Age *(years)*	58	62	50	50
Weight *(kg)*	65	45	54	50
Height *(cm)*	157	156	152	152
Previous or current health condition and medication	Hypertension, diabetes, and other past medical history denied, no medication taken regularly	Hypertension, diabetes, and other past medical history denied, no medication taken regularly	Hypertension, diabetes, and other past medical history denied, no medication taken regularly	Hypertension, diabetes, and other past medical history denied, no medication taken regularly
Vital Sign before surgery				
Blood Pressure *(mmHg)*	145/90	118/60	157/94	150/80
Pulse *(x/minute)*	70	55	80	95
SpO2 *(%)*	98	98	99	99
Respiratory Rate *(x/minute)*	18	18	19	18
Temperature *(°C)*	36.5	36.8	36.6	36.6
Diagnosis; Surgery Type	Hydrocele; Incision and drainage	Right Lateral Reducible Hernia; Herniotomy and Hernioraphy	Right Lateral Reducible Hernia; Herniotomy and Hernioraphy	Right Lateral Reducible Hernia; Herniotomy and Hernioraphy
ASA	2	2	2	2
CRI	2	2	2	2
Anesthesia	Low-dose spinal anesthesia with hyperbaric Bupivacaine 12.5 mg	Low-dose spinal anesthesia with hyperbaric Bupivacaine 12.5 mg	Low-dose spinal anesthesia with hyperbaric Bupivacaine 12.5 mg	Low-dose spinal anesthesia with hyperbaric Bupivacaine 12.5 mg
PONV Prophylaxis and Preventive Analgetic	Ondancentron 8 mg IV, paracetamol 1 gram as preventive analgetic	Ondancentron 8 mg IV, paracetamol 1 gram as preventive analgetic	Ondancentron 8 mg IV, paracetamol 1 gram as preventive analgetic	Ondancentron 8 mg IV, paracetamol 1 gram as preventive analgetic
PNB Technique (QL/TAP Block)	QL Block (injection of 0.25% levobupivacaine 20 mL with Ultrasound guidance) (Fig.1-A)	QL Block (injection of 0.25% levobupivacaine 20 mL with Ultrasound guidance)	TAP Block (injection of 0.25% levobupivacaine 20 mL with Ultrasound guidance) (Fig.1 - B))	TAP Block (injection of 0.25% levobupivacaine 20 mL with Ultrasound guidance)
Vital Signs after surgery				
Blood Pressure *(mmHg)*	130/90	120/80	120/80	145/80
Pulse *(x/minute)*	72	60	68	80
SpO2 *(%)*	99	99	99	99
Respiratory Rate *(x/minute)*	18	18	19	19
Temperature	36.5	36.5	36.5	36.5
VAS 2 hours after surgery	1	2	1	1

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Continuation of Table 1. Clinical Characteristics, Durante, and Post-operative Data of Patients

Variable	Case 1	Case 2	Case 3	Case 4
VAS D-1	VAS 2 when moving, VAS 1 without moving	1	1	1
Rescue Opioid	No	No	No	No
Bromage Score	4	4	4	4
PONV	No	Nausea without vomiting	No	No
Post-operative drug	IV Ketorolac 30 mg once, followed by paracetamol 1 gram q8hr and orally mefenamic acid 500 mg q8hr	IV Ketorolac 30 mg once, followed by paracetamol 1 gram q8hr, orally mefenamic acid 500 mg q8hr, and antacid q8hr	IV Ketorolac 30 mg once, followed by paracetamol 1 gram q8hr and orally mefenamic acid 500 mg q8hr	IV Ketorolac 30 mg once, followed by paracetamol 1 gram q8hr and orally mefenamic acid 500 mg q8hr
Length of Stay (*days*)	1	3	1	1

DISCUSSION

The Floating Hospital Ksatria Airlangga frequently engages in social service activities that span between one to two weeks each year around the Indonesian archipelago. On this trip, health-worker volunteers include two surgeons, two anesthesiologists, an obstetrician-gynecologist, a dentist, and two surgical nurses.

This hospital ship equipped with one operating room that can accommodate two operating tables for minor to major procedures. The recovery room in front of the operating room at the Floating Hospital Ksatria Airlangga is designed for one patient with one vital sign monitor (3). The type of surgery performed is short duration of surgery, around 1-2 hours, easy to moderate cases, (not surgery involving the airway), and the PS-ASA of the patient must be 1-2. We also have tools and medicines to handle airway, respiration, and circulation emergencies in limited quantities (supply depends on the amount brought at the start of the mission departure and the amount that has been used during surgery in the previous island).

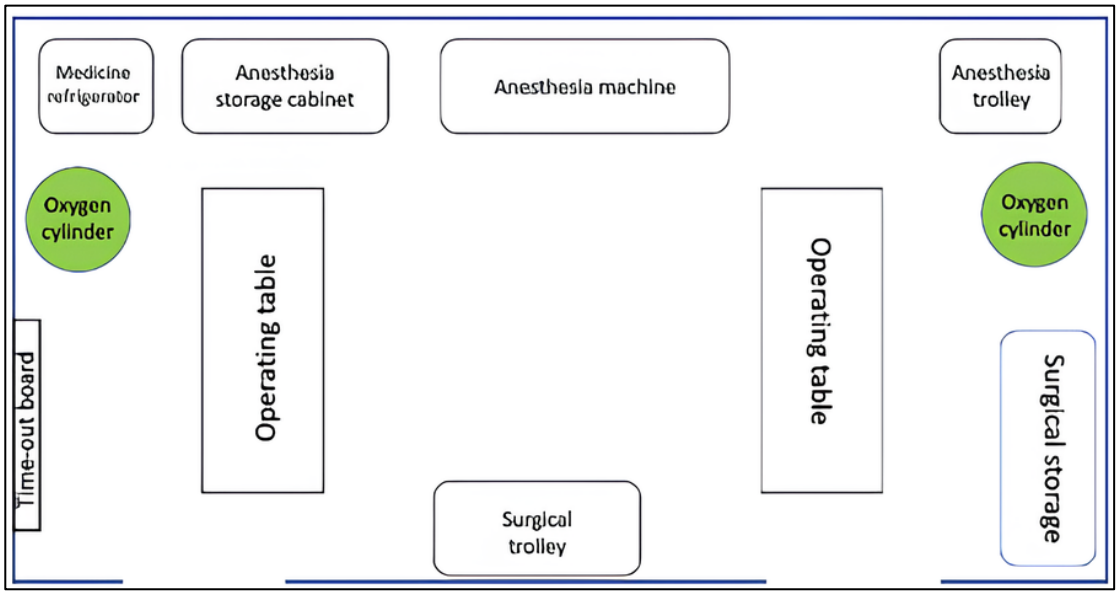

Figure 1. Detail of Ksatria Airlangga Floating Hospital Operating Room (3)

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Effective pain relief is of the utmost importance to anyone treating patients undergoing surgery. The objective of postoperative pain management is to reduce or eliminate pain and discomfort with a minimum of side effects to promote early mobilization and recovery.

ERAS protocol is highly recommended in medical services based on remote medicine as Ksatria Airlangga Floating Hospital, due to transportation and limited facility.

Postoperative pain management is limited to administering paracetamol, NSAIDs, or a combination. In previous operational missions of Ksatria Airlangga Floating Hospital, post-operative administration of opioids was avoided due to the short transit time of the medical team, limited health workers and monitoring facilities on the remote island, as well as the unavailability or limited availability of equipment and drugs for emergency treatment if side effects from using opioids occurred.

The Gili Iyang Island has one Community health center, and only one nurse and four midwives were accessible as healthcare workers. One general practitioner resides in Sumenep island and only comes to Gili Iyang island three days in a week. There were no monitors, and only oral medication was available. Intravenous medicine was not always available, depending on the supply from the bigger island. Monitoring of patients' conditions and outcomes were difficult, and in this mission, we only had a few days to observe and monitor all patients' conditions before we continued our trip to the next island.

In this situation, peripheral nerve block has emerged as a promising alternative for preventing and managing postoperative pain. Nearly all of our patients who underwent lower abdomen surgery got the benefits from the application of peripheral nerve block as mentioned QL Block and TAP block, which was proven by Visual Analogue Score (VAS) of 1-2 after surgery, no post-operative sedation needed, only 1 patient experience nausea without vomiting, and the length of health facility stay were less than 3 days.

When measured on a visual analog scale or a numerical rating scale, QLB has a remarkable analgesic effect, reducing pain to a 1-2/10, and this effect often lasts for more than 24 hours. This finding is consistent with a study by Ishio, et al., which found that patients who receive QLB as part of postoperative pain therapy experience less discomfort when resting and moving, which is important for early mobilization. (4)

Patients who received QL blocks experienced less pain following surgery without experiencing the unfavorable impacts of opioids, such as nausea, vomiting, and itching (5). A randomized controlled trial by Krohg, et al. demonstrated a opioid-sparing effect of the QL block during the first 24 hours postoperatively after cesarean delivery, when administered with multimodal analgesia in the absence of neuraxial morphine, and reduced VAS post-operatively (6). Another study by McDonnel, et al. described patients receiving active no-opioid consumption in our cases, the risk of the unwanted effects of opioids like postoperative nausea and vomiting was also decreased.

TAP blocks were also performed in our patient due to difficulties in QL muscle identification. QLB was usually performed with a high-frequency linear probe (5-10 MHz) which is attached to the triangle of Petit until the QL is confirmed (7). Unfortunately, our floating hospital only had access to convex

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array ultrasound probes. Due to limited time and facility, TAP blocks were performed as an alternative.

The QL block, a regional variant of TAP blocks, has been proposed as a more reliable method for treating pain following abdominal surgery when compared to TAP blocks. A meta-analysis by Liu, *et al.* which included 8 RCTs involving 564 patients found that after abdominal surgery, QL block offers better pain control while using less opioids than TAP block. In terms of PONV, TAP and QL blocks are identical (8,9).

In the QL Block, local anesthetics may spread from the trans to the paravertebral space, resulting in an indirect paraspinal block. Therefore, it has an effect on both visceral pain and abdominal incision pain (10). QL block also provides a more extensive spread of injectate (T10-L3vs.T10-T12) (11).

Some scholars also found that the two treatments have the same postoperative analgesic effects and are equally likely to cause adverse reactions. Zhu et al. discovered no significant difference in VAS ratings between patients receiving QL and TAP blocks 4 and 8 hours after surgery (9,12).

After we left the island, monitoring was performed by contacting the nurses in charge and there were no complaints or other symptoms after the surgery.

In this case series, all patients receive the same treatment. The limitation of this case series is the absence of a control group to compare the VAS, PONV, and LOS between the treatment and control group, and the outcome of PNB actions is operator-dependent (depending on the volunteer anesthesiologist taking part in the mission).

CONCLUSION

Peripheral nerve blocks such as TAP Block and QL Block have become a promising adjuvant therapy to traditional postoperative pain management to prevent and manage post-operative pain in remote medicine such as Ksatria Airlangga Floating Hospital. In all patients we found VAS of 1-2 after the surgery, less post-operative nausea and vomiting, no post-operative sedation needed, and length of health facility stay less than 3 days.

To better understand the efficacy of this PNB method, further research is recommended, including a control group to compare VAS, PONV, and LOS between the treatment and control groups. Besides, a thorough cost analysis needs to be carried out in order to evaluate the viability of this method ensuring it remains an economically feasible alternative for social services. The method should be validated to ensure it is safe and comfortable for patients, as demonstrated by favorable VAS, PONV, and LOS.

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Conflict of Interest

There is no conflict of interest.

Funding

None.

Author Contribution

VLS, AH, and KMF conceived of the presented idea. VLS, SCS, JDS, MHK, IPA, RTA, BMK, and IKM contributed to the patient's follow-up, collection of data, draft manuscript preparation, and revision. VLS andSCS contributed to the analysis and interpretation. KMF and AH contributed to

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organizing, supervising, and mentoring during the process. All authors reviewed the results and approved the final version of the manuscript.

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Case Report

PERIOPERATIVE ANAESTHETIC MANAGEMENT IN REPAIR DIAPHRAGMATIC HERNIA WITH ATRIAL SEPTAL DEFECT AND PULMONARY HYPERTENSION

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ABSTRACT

Introduction: Patients who had suffered disease of atrial septal defect (ASD) coming by pulmonary hypertension (PH) often present a clinical dilemma. Both of these disorders are congenital anomalies that often appear in pediatrics. Anaesthetic management in diaphragmatic hernia repair with this comorbidity requires precision and accuracy to avoid morbidity and mortality during surgery. The right management and care of anesthetic procedures is needed for patients who will be operated on with these two disorders. **Objective:** To describe the anesthetic management of a diaphragmatic hernia repair patient with comorbid ASD and pulmonary hypertension. **Case report:** The patient, a 1.5-month-old female baby born, has presented with shortness of breath complaints since the birth. Those were born spontaneously at the midwife's office and did not cry immediately, and a history of blueing and decreased consciousness was admitted for 20 days. Based on the examination, the diagnosis of diaphragmatic hernia from echocardiography foundASD and PH with a left ventricular ejection fraction of 64%. The patient was planned for diaphragmatic hernia repair under general anesthesia. Induction of anesthesia was performed with 5 mcg of fentanyl and inhalation anesthetic 3.5 vol% sevoflurane. After the endotracheal tube (ETT) was attached, the patient was desaturated to 50%, then the hyperventilated oxygenation was performed and positioned with knee chest position, and then milrinone at a dose of 1 mcg/min was given, saturation rose to 100%. During intraoperative ventilation control with manual bagging and maintenance anesthesia with inhalation ansethetic sevoflurane of 3.2 vol%. After surgery, the patient was admitted and observed in the pediatric intensive care unit for 2 days before extubation. **Conclusion:** Appropriate perioperative management in ASD patients with PH can reduce perioperative morbidity and mortality.

Keywords: Anaesthetic Management; Atrial Septal Defect (ASD); Diaphragmatic Hernia; Pulmonary Hypertension (PH); Human and Health

ABSTRAK

Pendahuluan: Pasien dengan atrial septal defek (ASD) disertai hipertensi pulmonal (PH) sering menimbulkan dilema klinis. Kedua kelainan ini termasuk kelainan kongenital yang sering muncul pada pasien pediatri. Manajemen anastesi pada repair hernia diafragma dengan komorbid ini memerlukan ketelitian dan kecermatan agartidak terjadi morbiditas dan mortalitas selama operasi. Diperlukan manajemen anastesi khusus dan cermat pada pasien yang akan dilakukan operasi dengan kedua kelainan ini. **Tujuan:** Pada laporan kasus ini penulis akan memaparkan manajemen anastesi pada pasien repair hernia diafragma dengan komorbid ASD dan hipertensi pulmonal. **Laporan kasus:** Melaporkan Pasien Bayi perempuan 1.5 bulan lahir cukup bulan datang dengan keluhan sesak nafas sejak lahir. Pasien lahir spontan di bidan tidak langsung menangis dan riwayat membiru dan penurunan kesadaran dirawat 20 hari. Berdasarkan pemeriksaan, pasien di diagnosis dengan hernia diafragma dari pemeriksaan echokardiografi ditemukan adanya ASD dan PH dengan ejeksi fraksi ventrikel kiri 64%. Pasien kemudian direncanakan operasi repair hernia diafragma dengan anastesi umum. Induksi anastesi dilakukan dengan menggunakan agen analgetik fentanyl 5 mcg dan anastesi inhalasi sevofluran 3.5 vol%. Setelah selang endotrakeal tube (ETT) terpasang dengan baik, pasien mengalami desaturasi hingga 50%, sehingga dilakukan oksigenasi hiperventilasi dan pasien diposisikan dengan *knee chest position* diberikan milrinon dosis 1 mcg/menit, saturasi naik hingga 100%. Selama intraoperasi dilakukan kontrol ventilasi dengan manual bagging. Maintenace anastesi dengan menggunakan anastesi inhalasi sevofluran 3.2 vol%. Setelah operasi selesai pasien dirawat dan diobservasi di ruangan intensive pediatrik selama 2 hari sebelum akhirnya dilakukan ekstubasi. **Kesimpulan:** Manajemen perioperatif yang tepat pada pasien ASD

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dengan PH dapat menurunkan morbiditas dan mortalitas perioperatif.

Kata Kunci: Manajemen Anastesi; Atrial Septal Defek (ASD); Hernia Diaframa; Hiperteni Pulmonal (PH); Manusia dan Kesehatan

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INTRODUCTION

Atrial septal defect (ASD) is a common congenital heart disease with a prevalence of 1.6 per 1000 births and accounts for 8-10% of congenital heart defects (CHD). Pulmonary hypertension (PH) is defined as systolic pulmonary artery pressure (PASP) ≥40 mmHg and occurs in 6% to 35% of patients withASD, of which 9%-22% of cases are moderate to severe. PH in ASD can be caused by several etiologies. Post calpillary PH can be due to increased left ventricular end diastolic pressure (LVEDP). Pre-capillary PH occurs due to the presence of a large shunt (1).

Diaphragmatic hernia is a complex and severe condition, but it is rare. It occurs in 1: 2000 - 5000 pregnancies, male to female ratio is 2: 1. In this hernia, there is a defect in the diaphragm muscle that allows intra-abdominal organs to enter the chest cavity. It is more common in the left hemithorax, with a prevalence of 85%-90%. However, most cases occur before or during the period after birth. Management delays will increase morbidity in these patients. Anesthetic management in diaphragmatic hernia repair patients with congenital heart defects such as ASD and PH is different from those without such defects. This case report will present the perioperative management of a patient undergoing diaphragmatic hernia repair with comorbid ASD and PH (1).

CASE REPORT

The patient was a 1.5 months old female infant with complaints of breathlessness since birth. She was born spontaneously at full term in a private clinic. At birth, the baby did not cry immediately with blue lips and fingertips, and resuscitation was carried out and the baby cried and started to turn red. After 5 days at home, the patient returned to blueness and shortness of breath. The patient did not want tobreastfeed and every time the patient vomited and turned blue. Those who suffered were hospitalized and reported to the perinatology room with a diagnosis of atrial septal defect, pulmonary hypertension and diaphragmatic hernia. The patient was consigned to surgery and anesthesia for emergent laparotomy, exploratory adhesiolysis, repair diaphragmatic hernia surgery.

The patient was stabilized and treated for 30 days and given furosemide 2x1mg, Sildenafil 2x1 mg, and ramipril 1x0.25mg. From the physical examination of the patient with a body weight of 2900 grams, alert consciousness, respiratory frequency of 60 x/min, heart rate of 172 x/min, and peripheral oxygen saturation 96%-98% using a nasal cannula 1 liter per minute. Examination of the thoracic wall found intercostal retraction (+), left hemithorax movement is left, on auscultation vesicular breathing sound weakened in the left hemithorax, ronkhi and wheezing are not found, and regular heart sounds with mur-mur (+). The patient's laboratory examination showed HB 10.4 g/dL, other values were within normal limits (Table 1).

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Table 1. Laboratory Value

Parameter	Value
HB	10.4 g/dL
WBC	10.000 /uL
Platelet	453.000 /uL
HCT	31.9 %
PT	14.5 seconds
APTT	33.2 seconds
INR	1.02
AST	35 U/L
ALT	22 U/L
Random Blood Glucose	89 mg/dL
Albumin	4.1 g/dL
Ureum	9 mg/dL
Creatinine	0.38 mg/dL
Na	139 mmol/L
K	5.1 mmol/L
Cl	97 mmol/L

On chest X-ray, the heart size was difficult to assess, with multiple cavities in thesinistra hemithorax suspected of sinistradiaphragmatic hernia (Figure 1). Echocardiography found a small secundum ASD of 2.6 mm, a left to right shunt, moderatetricuspid regurgitation, a pressure gradient (PG) of 64 mmHg, left ventricular function with an ejection fraction of 64%, and systolic function of 32%. Figure 2 depicts the impression of a small secundum ASD in conjunction with pulmonary hypertension.

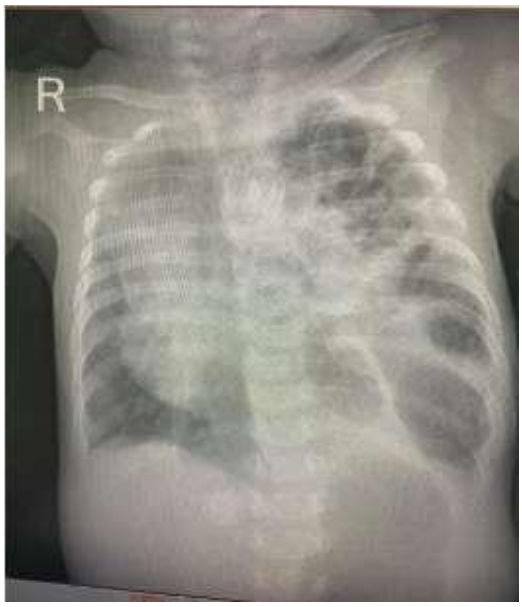

Figure 1. Chest X-ray

Based on the examination, the patient was diagnosed with a primary diagnosis of diaphragmatic hernia and was planned to undergo laparatomy exploration and repair hernia under general anesthesia. On pre-anesthetic evaluation, the patient was labeled American Society of Anesthesiologists (ASA) Physical Status III with pulmonary hypertension and an atrial septal defect.

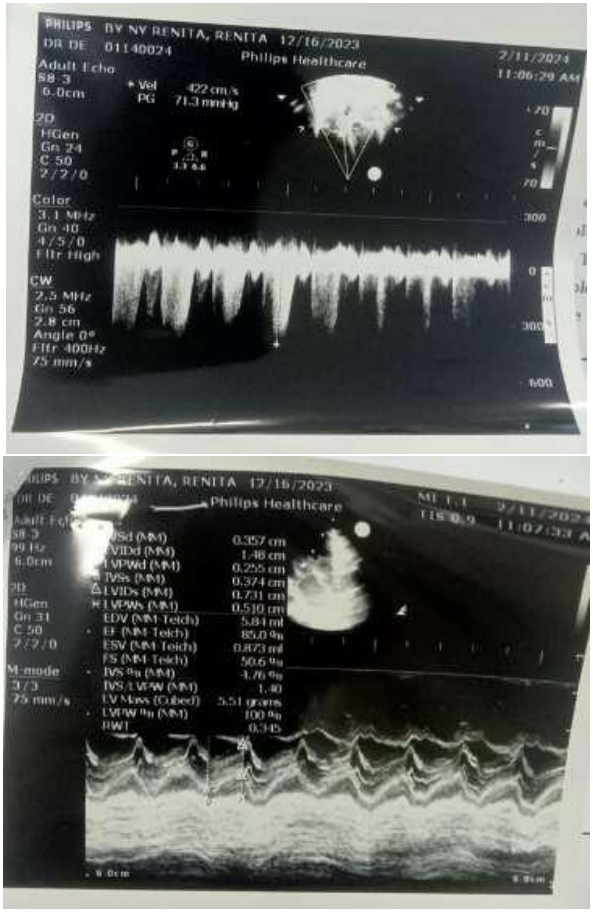

Figure 2. Echocardiographic

The surgery was performed after 1 month of pediatric cardiology therapy. Before surgery, the patient was fasted for 6 hours, and the therapy from cardiology was continued during perioperative. The operating room was fitted with monitoring devices for oxygen saturation (SpO2), heart rate (HR), echocardiogram (ECG), blood pressure (BP), and end tidal CO2 (ETCO2). The patient was preoxygenated for 3 minutes, then induced with 5 mcg fentanyl.

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The patient was sedated with 3.5 vol% sevoflurane and the patient were cuffed for 2 minutes. After deep sleep and apnea the patient was intubated with an ETT no. 3 uncuff.

Table 2. Post-operative Laboratory (14/02/2024)

Parameter	Value
HB	9.5 g/dL
WBC	22.440 /uL
Platelet	389.000 /uL
HCT	29.4 %
pH	7.18
pCO2	88.5 mmhg
pO2	172 mmhg
HCO3	32.9 mmol/L
TCO2	36 mmol/L
BE	4 mmol/L
SaO2	99%
CRP	74 mg/L

After intubation, the patient was desaturated to 50% and had blue lips. The patient was placed in knee-deep position and oxygenated with hyperventilation, then administered milrinoneat a dose of 1 mcg/min. During intraoperative ventilation control with manual bagging, maintenance anesthesia with sevoflurane 3.2 vol%, oxygen 60%, water 40%, and a flow rate of 4 liters per minute. The operation lasted 75 minutes with stable hemodynamics during surgery without the need for vasopressors or inotropic agents. After the surgery was completely finished, one was sent into pediatric intensive care unit (PICU) with ETT retention. The patient was monitored for 2 days and evaluated for a thoracic X-ray (Figure 3), laboratory, and postoperative blood gas analysis (Table 2). While in thePICU, the patient was alert and underwent gradual ventilator weaning, periodic suctioning due to sputum retention causing hypercarbia, and a 40 cc PRC transfusion to correct anemia. On the 3rd postoperative day, extubation was performed and observed for 24 hours, the patient stabilized and moved to the regular room.

Table 3. Post Transfusion Laboratory (16/02/2024)

Parameter	Value
HB	11.7 g/dL
WBC	15.640 /uL
Platelet	393.000 /uL
HCT	37.3 %
pH	7.24
pCO2	80.5 mmhg
pO2	150 mmhg
HCO3	34.8 mmol/L
TCO2	37 mmol/L
BE	7 mmol/L
SaO2	99%

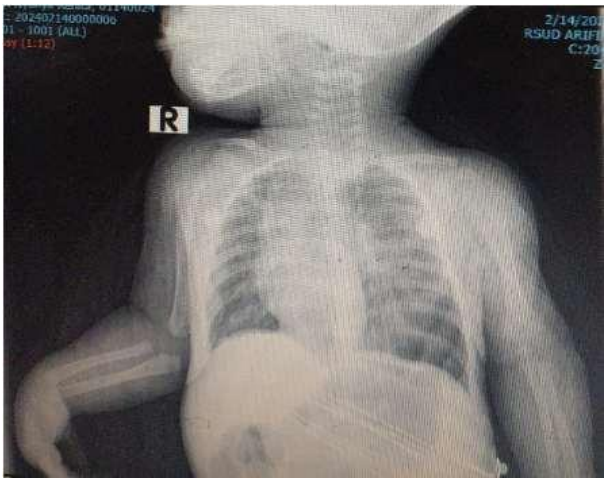

Figure 3. Post-operative Chest X-ray

Table 3 shows improvement in laboratory values; Hb increased and leukocytes decreased, and blood gas analysis seemed to have improved even though it was not significant. Figure 4 shows hemodynamic monitoring during surgery. There was a decrease in blood pressure and saturation at the beginning of the operation, but after management, blood pressure and oxygen saturation stabilized, and there was no significant decrease until the operation was completed.

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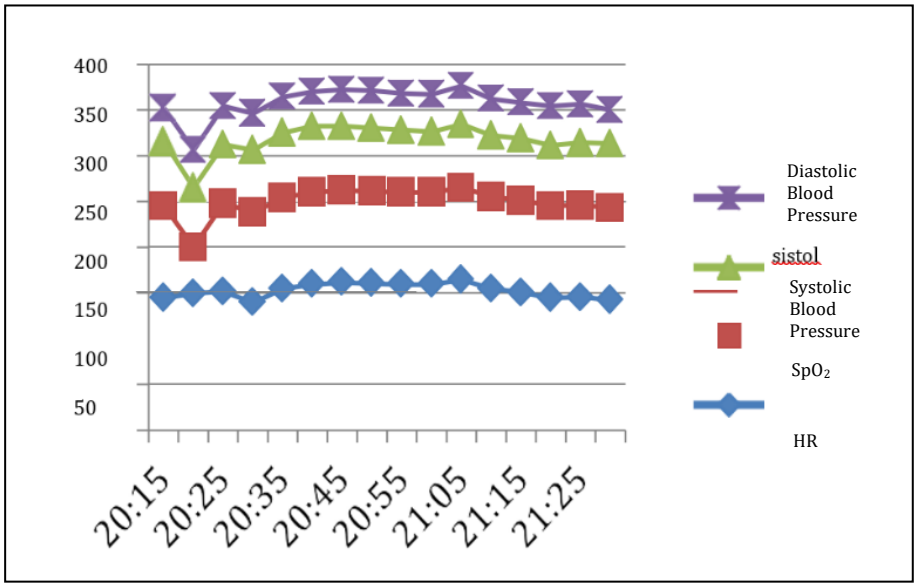

Figure 4. Intraoperative Hemodynamics

DISCUSSION

Congenital diaphragmatic hernia occurs in about 1 in 2500 to 5000 births. The male to female ratio is 2:1, and it is more common in the left diaphragm than the right. The diaphragm may develop defects during development because embryologically, it consists of the union or fusion of multiple tissues (1,2). According to current guidelines, hernia repair is customized according to expertise, resources, and elements related to the patient's condition, including comorbidities such as heart disease (3). In the case of non-cardiac surgery patients, comorbid heart disease is the most significant factor in severity and mortality (4). Patients with PH often undergo non-cardiac surgical procedures. In a study in the US, PH was admitted in a range of 0.81% of cases that had a prevalence improving from 0.4% in 2004 to 1.2% in 2014 (5). Perioperative complicationsthat occur include respiratory failure (28%), cardiac arrhythmias (12%), failure of congestive heart (11%), failure of acute renal (7%), septic shock (7%), and also postoperative death (7%) (6).

Optimization of PH Patients for Surgery

Two to four weeks before the surgery process becomes such areasonable moment for a patient visit in order to help determine therisk stratification components that are related to the surgery process. This can include an assessment of diagnostics as well as functional status. PH management in patients who will undergo surgery is necessary before the procedure in order to minimize the risk of perioperative complications. To address the pulmonary vascular abnormalities found in pH, many therapies have been developed, often referred to as pulmonary vasodilators. However, their mechanism of action is complex, including antiproliferative effects (7).

There are three classes of drugs for specific therapy of PH: (1) Nitric oxide (NO) pathway mediators: phosphodiesterase 5 (PDE5) inhibitors: tadalafil and also sildenafil; soluble guanylate cyclase stimulators: riociguat. (2) Endothelin receptor antagonists include ambrisentan, bosentan, and macitentan. (3) Prostacyclin pathway prostacyclins: agonists: treprostinil (subcutaneous, oral, inhaled, or even intravenous), epoprostenol (intravenous

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or inhaled); iloprost (inhaled), and also prostaglandin I2 receptor agonists: selexipag (oral). Every patient who had PH had to get alarmed in order to take diuretics prior to surgery to prevent acute cardiac decompensation during the perioperative period. In this case, the patient received selective therapy consisting of sildenafil taken orally for 20 days and furosemide taken twice a day at a dose of 1 mg. (8).

Intraoperative Anesthetic Management Hemodynamic Targets

Intraoperative hemodynamic targets in PH patients lead on purpose to help anticipating the acute dysfunction of RV and also keeping the cardiac index in order to make sure the process of perfusion of adequate end-organs. These are general guiding principles we are able to get to prevent systemic hypotension. Avoid using pulmonary vasoconstrictive agents not inotropic to the RV, such as phenylephrine when hypotension occurs. Maintain sinus rhythm. β-blocker and calcium canal blocker therapy should be continued preoperatively, but intraoperative initiation should generally be avoided due to negative inotropic effects (9). Reduce or avoid factorsto help improve PVR as like acidosis, hypoxia, hypothermia, hypercarbia, and pain. Avoid increasing the airway pressure and positive end expiratory pressure (PEEP). These are able to get titrated for maximal exchange of gas, hemodynamics, and also function of RV. Recommended ventilator settings are tidal volume 6 to 8 mL/kg ideal body weight, PEEP 5 to 10 mmHg, respiratory rate that is titrated to Paco2 30 to 35 mmHg, pH > 7.4, and also inhaled oxygen fraction that is titrated to Spo2 > 92% (10). It is important to maintain the baseline condition of RV filling. Hypovolaemia is going to emerge from the decrease inside MAP and also perfusion of RV, while hypervolemia makes overloading of RV and wall tension, making the function of RV get worse. RV hypertrophy may lead to a narrowing of preload volume, and volume overload becomes hardly tolerated (11). Optimize pressure of the central venous, preload, and RV through diuretics and also PAH targeted therapy. In an ideal way, optimization is made in the preoperative setting, but acute transformations of the intraoperative moment could need titration of those processes of therapy. In the intraoperative setting, inhaled (NO or prostacyclin) or even parenteral (subcutaneous or intravenous prostacyclin) therapy for PH is able to be done to acutely minimize the overload of RV. Immediate hemodynamic effects are able to be filled by changing the position of the body (e.g., the Trendelenburg position and also the elevation of the leg are going to improve the preload, while the reverse position of the Trendelenburg is going to make such an acute decrease in the preload).

General Anesthesia

Significant hemodynamic changes that contribute to acute RHF may be associated with the use of anesthetic agents in induction. Etomidate (0.15-0.3 mg/kg) has no significant influence on contractility, heart rate, or systemic PVR in patients with PH; there has been no comparative research or studies about the maximal induction agent (12). Nevertheless, the continuous process of infusion or repeatedetomidate administration is able to reduce morbidity and mortality. Ketamine is related to improved PVR in adults and is also best anticipated if monitoring of PVR or vasodilation of the pulmonarydid not get concurrent. Propofol may directly or indirectly influence the contractility of RV and could be applied with caution as it tends to require concurrent administration from

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vasopressor agents or even inotropes (13,14). Opioids, when reported alone, give minimal influence toward the circulation of the pulmonary and minimize the response to stimulation of sympathetic, but they also cause unfavorable bradycardia in larger and higher doses. Premedication that has been done through benzodiazepines and also opioids are going to be judiciously done; their co-administration will lead to an acute hypoxia-induced improvement in PA pressure and also hypercarbia. A general option to be done is to gain such an induction in rapid sequence through ventilation of the mask in order to reduce the hypercarbiaand hypoxia periods that lead to such a significant improvement in the afterload of RV. It matters to be done in order tomake a sufficient breathing moment while having ventilation of the mask, as high intrathoracic pressures cause such an acute drop in preload through the severe process of hypotension. Any inhaled agent is able to be applied for anesthesia care unless for nitrous oxide because of its influence on the impact of improving the PVR (15–18). There is a lack of comparative data about the influence of other generally used inhaled agents on PVR. If total intravenous anesthesia is chosen, a propofol infusion (50- 150 μg·kg-1·min-1) with or with no opioidscan be used. In accordance with the theory, this patient was induced with 5 mcg of opioid fentanyl and the patient was sedated with the inhalation agent sevoflurane with prior preoxygenation.

Selective Pulmonary Vasodilators

NO and also epoprostenol become such vasodilators in selective pulmonary surgery, most generally done in the non-cardiac process of surgery (19). NO is able to be given at doses of 1 to 80 ppm,even though most centers have a maximum dose of 20 to 40 ppm. Inhaled epoprostenol (iEPO) can be such as an aerosol recipe of epoprostenol and also be given in doses in the range of 10 and 50 ng/kg/min of NO and iEPO has efficacy and safety profiles in various small observational research, but procuring the cost, NO can be known to be higher than iEPO. Both tend to exhibit short half-lives, that let these agents attractive in the perioperative moment at hemodynamic objectives can changerapidly (20,21).

Vasopressors and inotropes

There are no found any comparative research and studies of inotropes and also vasopressors in those who suffered in PH cases. Norepinephrine and also vasopressin are commonly recommended over phenylephrine because they are able to help anticipate vasoconstriction of pulmonary, improvement of PVR, and also reflex bradycardia (22). Animal data reported that vasopressin has a more minimal influence on PVR than another vasopressor. Vasopressin in high doses (>0.08-0.1 U/min) is not recommended because it may exest an influence between coronary arteries that is brought to RV ischemia (23). The inodilator subclass of inotropes, like milrinone (25-50 μg/kg bolus over 15 minutes,0.25-0.75 μg/kg/min infusion) and also dobutamine (2.5-10 μg/kg/min), is able to be given in order to help increase the contractility of RV and minimize overloading RV. Both milrinone and dobutamine have systemic inotropic effects, and pulmonary vasodilator impacts that can cause severe hypotension of the systemic vascular system, thus sometimes needing more vasopressors, such as norepinephrine or terlipressin, to help maintain adequate MAP. Milrinone boluses are able to make significant systemic hypotension and thus have to be reduced in those who suffer from hypotension or hypovolemia. Both inodilators are also able to cause arrhythmias (24). In this patient,

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milrinone was used intraoperatively at a dose of 1 mcg/min, with stable hemodynamics during surgery. After surgery, milrinone was stopped, and the patient resumed preoperative therapy.

Congenital Heart Disease

Patients who have been corrected and also have uncorrected congenital heart disease are able to pose unique challenges in anesthetic management. This management will be given to every patient that has congenital heart disease which is still based on certain factors of physiology. Patients that have ventricular or atrialdefects can be given such a passive venous return, so it matters to help maintain preload and prevent improving PVR through high PEEP and intrathoracic pressure avoidance. For patients that had shunts it matters to anticipate an improvement in right-to-left shunts, that is able to be found even in those who had shunts of baseline left-to- right, as such shunts can lead to hypoxemia, acidosis, and systemic hypotension. In these patients, maintaining a low PVR:SVR ratio by avoiding increased PVR and decreased SVR, as well as maintaining contractility, preload, and cardiac output, is crucial (23, 24). The main limitation of this study is that we only included one patient, making our findings difficult to generalize to a broader population. In addition, the absence of a comparator also makes it impossible to compare outcomes between those exposed and unexposed.

CONCLUSION

Anesthetic management in pediatric patients with pulmonary hypertension and congenital heart disease requires special and more stringent attention, especially on PVRand SVR. During perioperative care, prevention of increased PVR and decreased SVR will provide a better outcome for the patient. The choice of anesthetic technique, anesthetic drugs, and pulmonary vasodilators, systemic vasopressors or inotropic drugs during perioperative care should also be considered individually depending on the patient'scondition. This case report only describes anesthesia management in one patient with comorbid pulmonary hypertension. It is hoped that further research can compare 2 or 3 cases with different anesthesia management techniques in patients with similar cases and comorbidities.

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Conflict of Interest

The authors declare that there is no conflict ofinterest.

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Authors' Contribution

M Irvan Noorrahman contributed in conceptualization, data collection, data analysis and interpretation, and manuscript preparation;

Pratama Ananda and Novita Anggraeni contributed in supervision, critical review, and final approval of the manuscript.

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Systematic Review

THE USE OF DEXMEDETOMIDINE, MIDAZOLAM, AND KETAMINE IN THE PREVENTION OF EMERGENCE AGITATION IN PEDIATRIC PATIENTS UNDERGOING SURGERY UNDER GENERAL ANESTHESIA

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ABSTRACT

Introduction: Emergence agitation (EA) is a problem that often occurs in pediatric patients during recovery from anesthesia. The cause of EA remained unclear, but the combination of etiologies increases the risk of postoperative agitation. The researchers use various drugs such as ketamine, midazolam, and dexmedetomidine to prevent and treat EA. **Objective:** This review aims to determine the effectiveness of dexmedetomidine, midazolam, and ketamine in preventing emergence agitation in pediatric patients undergoing surgery under general anesthesia. **Method:** This is a systematic review that looks at the outcomes of randomized controlled trials (RCT) studies that tested how well dexmedetomidine, midazolam, and ketamine worked at keeping pediatric patients from becoming agitated during emergence. Literature was collected through Google Scholar and PubMed using the keywords Pediatric, Children, Dexmedetomidine, Ketamine, Midazolam, Emergence Agitation, Emergence Delirium, Postoperative Agitation, and Postoperative Delirium and published within the last ten years (2011–2021) in English or Indonesian. The researchers excluded articles that were not available in full, as well as literature reviews. **Results:** Based on the specified database and keywords identified, there were 695 articles. This literature study included thirteen articles that met the inclusion criteria. Ten articles examined the effectiveness of dexmedetomidine, four reviewed the effectiveness of midazolam, and three examined the effectiveness of ketamine. **Conclusion:** According to the ten reviewed articles, administering dexmedetomidine or ketamine reduced the incidence of emergence agitation in children. However, the administration of midazolam yielded inconsistent results. To evaluate the optimal dosage, route, and timing of dexmedetomidine, midazolam, and ketamine in preventing EA, further studies are necessary.

Keywords: Dexmedetomidine; Emergence Agitation; Ketamine; Medicine; Midazolam; Pediatric

ABSTRAK

Latar belakang: *Emergence agitation* (EA) menjadi salah satu masalah yang sering terjadi pada pasien anak-anak saat pemulihan dari anestesi. Penyebab terjadinya EA belum dapat diketahui dengan pasti, namun kombinasi dari etiologi diduga meningkatkan risiko untuk terjadi agitasi pasca operasi. Berbagai obat digunakan untuk untuk pencegahan maupun pengobatan EA di antaranya ketamine, midazolam, dan dexmedetomidine. **Tujuan:** Tinjauan ini bertujuan untuk mengetahui efektivitas Dexmedetomidine, Midazolam, dan Ketamin pada pencegahan *Emergence Agitation* pada pasien anak yang menjalani pembedahan dengan anestesi umum. **Metode:** Studi ini merupakan tinjauan sistematis yang menelaah hasil penelitian *randomized controlled trial* RCT mengenai efektivitas dexmedetomidine, midazolam, dan ketamin terhadap pencegahan Emergence Agitation pada pasien anak. Pencarian literatur dilakukan melalui basis data Google Scholar dan PubMed dengan kata kunci *Pediatric*, *Children*, Dexmedetomidine, Ketamine, Midazolam, *Emergence Agitation*, *Emergence Delirium*, *Postoperative Agitation*, dan *Postoperative Delirium* yang diterbitkan dalam kurun waktu 10 tahun terakhir (2011 – 2021), menggunakan Bahasa Inggris atau Bahasa Indonesia. Artikel yang tidak bisa didapatkan secara lengkap dan merupakan studi literature review akan dieksklusi. **Hasil:** Berdasarkan database dan keyword yang telah ditetapkan, teridentifikasi 695 artikel. Tiga belas artikel yang memenuhi kriteria inklusi dan dimasukkan dalam studi

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literatur ini. Sepuluh artikel meneliti efektivitas dexmedetomidine, empat artikel menilai efektivitas midazolam, serta tiga artikel meneliti tentang efektivitas ketamin. **Kesimpulan:** Berdasarkan sepuluh jurnal yang telah ditelaah, pemberian dexmedetomidine maupun ketamin dapat menurunkan angka kejadian emergence agitation pada anak, namun hasil yang tidak konsisten dilaporkan pada pemberian midazolam. Studi lebih lanjut diperlukan untuk mengevaluasi dosis, rute, dan waktu pemberian yang optimal dari pemberian dexmedetomidine, midazolam, dam ketamin dalam pencegahan EA.

Kata kunci : *Dexmedetomidine*; *Emergence Agitation*; Ketamin; Midazolam; Obat; Pasien Anak

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INTRODUCTION

Recovery from general anesthesia is a time of physiological stress for many patients. Perioperative morbidity and mortality are higher in children than in adults. One of the complications after anesthesia in pediatric patients is Emergence Agitation (EA), which has been described as the most observed complex of psychomotor perceptual disturbances and agitation in the early post-anesthesia period (1). This is a common problem in pediatric patients recovering from anesthesia. The incident began to appear since the discovery of inhalation agents, and it is estimated to occur around 10–80% globally in the children's population, with the highest range occurring at preschool age (2).

Agitation appears within the first 30 minutes of recovery, lasts about 5–15 minutes, and can go away independently. However, if it is not handled correctly, it can cause various problems for the patient or medical personnel, including the release of the catheter or endotracheal tube, re-bleeding at the operating site, increasing recovery time in the recovery room, and increasing parental concern and anxiety regarding the clinical condition of their children (3).

The cause of EA remains unclear, but a combination of etiologies increases the risk of postoperative agitation. Three major categories present risk factors associated with EA: patient-related, anesthesia-related, and surgery-related. Patient-related risk factors include preschool age and preoperative anxiety (4). Risk factors for EA associated with anesthesia include anesthetic agents and a rapid recovery time. EA risk factors for surgery include ear, nose, throat (ENT), and eye surgical procedures. Patients with high postoperative pain scores frequently report EA events (5). Dysregulation of the dopaminergic, serotonergic, noradrenergic, and GABAergic systems mediates the pathophysiological abnormalities that underlie EA (6).

The majority of nonpharmacological EA prevention focuses on reducing preoperative anxiety. Nonpharmacological intervention is to create an environment with temperature, lighting, a comfortable atmosphere, hypnosis, and music therapy (7). Parents' presence during induction is constantly effective in reducing children's anxiety (8). Ketamine, midazolam, and dexmedetomidine are among the drugs used to prevent and treat EA. Dexmedetomidine is an α2-adrenergic receptor agonist with sedation, anxiolytic, analgesic, and amnesiac effects and does not depress the respiratory system. Various prospective studies have shown that dexmedetomidine can significantly reduce the incidence of EA in pediatric patients after the use of inhalation anesthetics (9). Administration of dexmedetomidine may be accompanied by hemodynamic changes, including a decreased heart rate and decreased blood pressure. The

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sympatholytic effect of dexmedetomidine may be responsible for this (10).

Midazolam is a widely used benzodiazepine premedication agent, particularly in pediatric anesthesia. People believe that midazolam can lower the incidence of EA by lowering the level of pre-operative anxiety (11). There is ongoing debate about the effectiveness of midazolam in reducing risk (12). Ketamine, an N-methyl-D-aspartate (NMDA) receptor antagonist, provides analgesia and sedation with minimal respiratory depression and prevents central sensitization to painful stimulation. Ketamine also works by inhibiting glutamate release (13). This is what makes the authors interested in conducting a study of the effectiveness of dexmedetomidine, midazolam, and ketamine in preventing emergence agitation in pediatric patients undergoing surgery under general anesthesia (14).

METHOD

The research protocol for this literature review uses the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) Method. While PRISMA includes flow diagrams for both systematic review and meta-analysis, it's important to note that this study's analysis is exclusively focused on a systematic review approach. The decision to refrain from meta-analysis was due to heterogeneity among included studies in terms of study designs, outcome measures, and population characteristics. Furthermore, the researchers observed limitations in data availability and quality across studies, which made a quantitative synthesis through meta-analysis impractical. Therefore, the researchers performed a narrative synthesis of the findings from the included studies to provide a comprehensive overview and qualitative synthesis of the evidence.The study began with participants, interventions, comparators, outcomes (PICO), research questions (RQ), and criteria used to develop this script. The PubMed and Google Scholar databases were comprehensively reviewed to identify relevant research published between 2011 and 2021 using the keywords that have been determined.

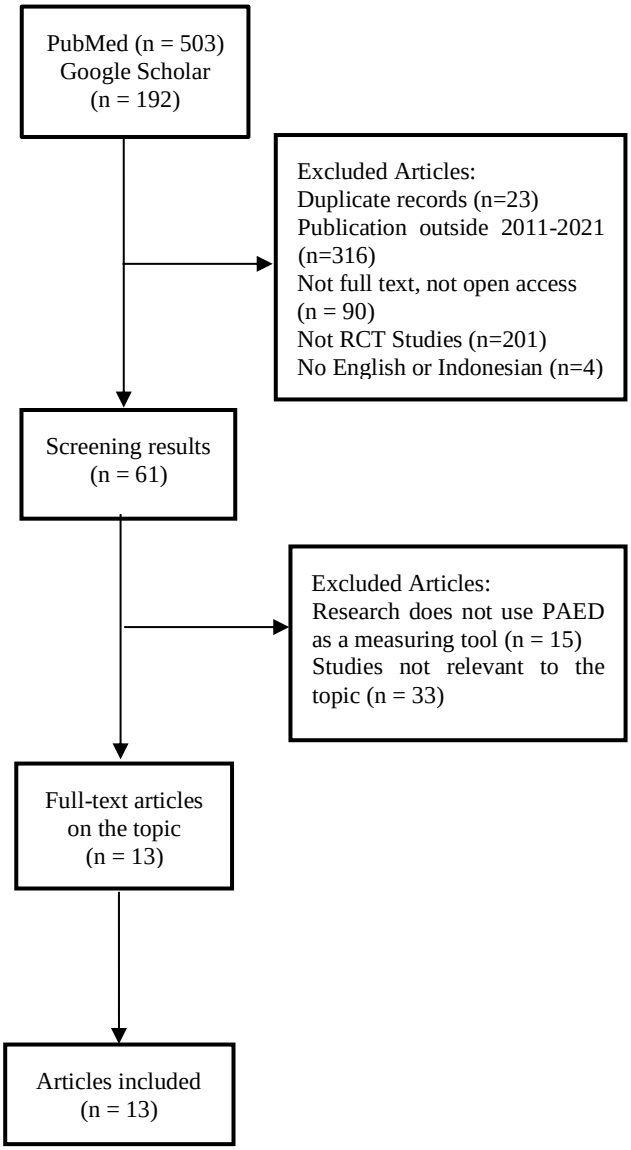

Figure 1. PRISMA flow diagram

Articles were searched with the following keywords: "pediatric," "children," "dexmedetomidine," "ketamine," "midazolam," "emergence agitation," "emergence delirium," "postoperative agitation," "postoperative

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delirium." Studies restricted to randomized controlled trials (RCTs), articles published in English or in Bahasa Indonesia, assessing the effectivity of dexmedetomidine, midazolam, or ketamine compared with placebo or other anesthetic drugs on the incidence of emergence agitation, and involving EA assessment using Pediatric Anesthesia Emergence Delirium (PAED) scales.

Studies without full-text content, observational studies, case series, case reports, correspondence, reviews, and animal studies were excluded. Furthermore, the researchers will screen the obtained articles based on their title and abstract.

Data extraction tools guide the extraction of information from records according to research objectives. The data extracted in each piece if literature includes the primary author, year of publication, sample, number of pieces, surgical procedure, anesthetic drug intervention (time of administration, dose, route of administration), and outcomes of EA.

RESULT AND DISCUSSION

Literature or article searches were carried out through the Pubmed and Google Scholar databases using the keywords 'Pediatric,' 'Children,' 'Dexmedetomidine,' 'Ketamine,' 'Midazolam,' 'Emergence Agitation,' 'Emergence Delirium,' 'Postoperative Agitation,' 'Postoperative Delirium' and found out 695 articles. Then the elimination of articles was carried out using the inclusion and exclusion criteria. The inclusion criteria include the date of publication of the article in the last ten years, starting from 2011 to 2021, in English or Indonesian; the article is primary literature in complete text form; articles discussing the effectiveness of dexmedetomidine, midazolam, and ketamine on preventing the emergence of agitation have been included after reviewing through the titles and abstracts; and there remain 13 articles.

Ten articles discuss the effectiveness of dexmedetomidine in preventing EA.Four articles examined the efficacy of midazolam, and three articles investigated the efficacy of ketamine against EA.

Table 1. Main Characteristics of the Included Studies

Author	Participants	Age	Type of Surgery
Abdelaziz, et al (2016)(15)	105	1 – 7 years	Strabismus
Chen et al. (2013)(16)	78	2 – 7 years	Strabismus
Chen et al. (2018)(17)	100	3-7 years	Inguinal hernia
Hauber, et al (2015)(18)	382	4 – 10 years	Tonsillectomy
Lin et al. (2016)(19)	90	1 – 8 years	Cataract
Makkar, et al (2015)(20)	100	2-8 years	Infra-umbilical
Soliman, et al (2015)(21)	150	4-14 years	Adenotonsillectomy
Begum et al. (2019)(22)	48	2 – 12 years	Abdomen
Bilgen, et al (2014)(23)	78	1 – 8 years	Urology
Ozcan, et al (2014)(24)	62	2 – 7 years	Inguinal hernia repair
Yao et al. (2020)(25)	153	2 – 6 years	Strabismus
Hanna, et al (2018)(26)	80	2 – 9 years	Elective surgery with a minimum duration of 2 hours
Yi et al. (2021)(27)	120	3 – 10 years	Adenotonsillectomy

Dexmedetomidine can reduce the incidence of EA, based on the ten articles reviewed. Previous studies support this. Research conducted by Hendrawan et al. in 2013 showed that dexmedetomidine at a dose

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of 0.2 µg/kgBW could reduce the incidence of delirium while recovering from general anesthesia in pediatric patients. The incidence of agitation was observed in 4.8% of patients receiving an intravenous dexmedetomidine dose of 1 µg/kg, compared to 47.6% in the placebo group (28). One potential explanation is that dexmedetomidine is an α(2)-adrenoceptor agonist with several analgesic, anxiolytic, and sedative properties. Binding to postsynaptic 2 adrenergic receptors at the locus ceruleus mediates its soothing and analgetic effects (29). The mechanism by which dexmedetomidine prevents the occurrence of EA is because dexmedetomidine decreases the secretion of noradrenaline from the locus ceruleus and facilitates the release of inhibitory neurotransmitters, namely GABA.

Table 2. Outcomes of Emergence Agitation

Author	Group	Dosage	Route	Time Administration	Outcomes
Abdelaziz, et al (2016)	DEX Midazolam Placebo	1 mcg/kg 0,1 mg/kg NS	Intranasal Intranasal Infusion	After induction After induction	The incidence of EA DEX (12%)* Midazolam (21%)* Placebo (47%)
Chen et al. (2013)	DEX Ketamine Placebo	1 mcg/kg 1 mg/kg NS	Intravenous Intravenous Infusion	After induction After induction	The incidence of EA DEX (11%)* Ketamine (22%)* Placebo (46%)
Chen et al. (2018)	DEX (D1) DEX (D2) DEX (D3) DEX (D4) Placebo	0.25 mcg/kg 0.5 mcg/kg 0.75 mcg/kg 1 mcg/kg NS	Bolus injection Bolus injection Bolus injection Bolus injection Infusion	After induction After induction After induction After induction	The incidence of EA D1 (5%) D2 (5%) D3 (0%)* D4 (0%)* Placebo (30%)
Hauber, et al (2015)	DEX Placebo	0.5 mcg/kg NS	Bolus injection Infusion	5 min. Before the end of the surgery	The incidence of EA DEX (36%)* Placebo (66%)
Lin et al. (2016)	DEX (D1) DEX (D2) Placebo	1 mcg/kg 2 mcg/kg NS	Intranasal Intranasal Infusion	45 min. before induction 45 min. before induction	The incidence of EA D1 (23,3%)* D2 (10%)* Placebo (80%)
Makkar, et al (2015)	DEX Propofol Placebo	0.3 mcg/kg 1 mg/kg NS	Intravenous Bolus Injection	15 min. before the end of surgery 5 min. Before the end of the surgery	The incidence of EA DEX (9.4%)* Propofol (13.9%) Placebo (40.6%)
Soliman, et al (2015)	DEX Placebo	0.5 mcg/kg + 0,1-0,3 mcg/kg/h NS	Intravenous for 10 min. Infusion	after induction	The incidence of EA DEX (8%)* Placebo (38,66%)
Begum et al. (2019)	DEX (D1) DEX (D2)	0.4 mcg/kg 0.4 mcg/kg/h	Bolus for 10 min. Intravenous	after intubation during surgery	The incidence of EA D1 (20%) D2 (50%)
Bilgen et al. (2014)	Ketamine Alfentanil Placebo	2 mg/kg 10 mcg/kg NS	Intranasal Intranasal Infusion	before induction before induction	The incidence of EA Ketamine (3,8%)* Alfentanil (36%) Placebo (40%)
Ozcan, et al (2014)	Ketamine Midazolam Placebo	0.25 mg/kg 0.03 mg/kg NS	Intravenous Intravenous Infusion	10 min. before the end of surgery 10 min. Before the end of the surgery	PAED scores were similar between the ketamine, midazolam, and control groups

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Continuation of Table 2. Outcomes of Emergence Agitation

Author	Group	Dosage	Route	Time Administration	Outcomes
Yao, et al (2020)	DEX	2 mcg/kg	Intranasal	45 min. before induction	The incidence of EA DEX (11,5%)*
	Midazolam	0.5 mg/kg	Oral	30 min. before induction	Midazolam (44%)
	Placebo	NS	Infusion		Placebo (49%)
Hanna, et al (2018)	Midazolam	0.5 mg/kg	Oral	Premedication	The incidence of EA Midazolam (31.58%)
	Zolpidem	0.25 mg/kg	Oral	Premedication	Zolpidem (23.81%)
Yi et al. (2021)	DEX (D1)	0.5 mcg/kg	Intravenous	after intubation	There was no significant difference in the incidence of EA between groups D1 and D2.
	DEX (D2)	1 mcg/kg	Intravenous	after intubation	

A Abbreviation: DEX: dexmedetomidine; NS: normal saline

**p<0,005*

Dexmedetomidine may cause bradycardia or hypotension in some patients, especially when given rapidly by the intravenous route, but intranasal dexmedetomidine has a slower and more gradual onset than intravenous administration (30).

Adults and children commonly use midazolam as a premedication agent to provide anxiolysis, sedation, and amnesia. However, this study's effect on EA was inconsistent. This is in line with previous research. In a study conducted by Cho et al. in 2014, it was reported that intravenous administration of 0.03 mg/kg and 0.05 mg/kg midazolam before the end of surgery can reduce the incidence compared to placebo (31).

In addition, the results of research conducted by Kawai et al. in 2019 stated that giving Midazolam 0,1 mg/kg 30 minutes before the end of the surgical procedure significantly reduces the incidence (12). In contrast, preoperative administration of oral midazolam at a dose of 0.5–1 mg/kg does not reduce the risk of EA because the duration of effective sedation does not last until the postoperative period (11). One explanation is that the fast action of midazolam premedication wears off before the end of the lengthy procedure (13).

Ketamine is an N-methyl-D-aspartate (NMDA) receptor antagonist that provides analgesia and sedation with minimal respiratory depression and prevents central sensitization to painful stimulation (13). Providing analgesia and sedation during recovery may be essential factors in reducing the incidence of EA after sevoflurane anesthesia. Ketamine has sedative and amnestic properties, and it exhibits vigorous analgesic activity at subanaesthetic doses (32). This study's results demonstrate that ketamine can lower the incidence of EA, with the exception of surgery, where a caudal block reduces pain (24). Demir et al.'s 2018 research revealed that patients undergoing rhinoplasty surgery who received intravenous 0.5 mg/kg ketamine had a lower EA incidence rate of 8.6% compared to the placebo group's 54.3% (33).

The results of this study have limitations due to factors inherent in the research methodology and the number of articles that specifically address this topic.

SUMMARY

Dexmedetomidine reduces the incidence of post-anesthesia agitation. Intranasal administration is an effective and noninvasive route for administering dexmedetomidine to pediatric patients. Studies of midazolam's effectiveness on the incidence of EA have reported inconsistent findings. One explanation is that the fast action of midazolam

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premedication wears off before the end of the lengthy procedure. Further studies are needed to evaluate the optimal dosage, route, and timing of administration of midazolam for preventing EA. Ketamine significantly reduced the incidence of EA, but adding ketamine to the caudal block under sevoflurane anesthesia showed no further effect on EA.

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Conflict of Interest
There is no conflict of interest.

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Authors' Contributors
All authors have contributed to all processes in this research.

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Literature Review

RECENT ADVANCES IN INTERVENTIONAL PAIN MANAGEMENT

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ABSTRACT

Introduction: Due to limited access to therapy, 60 million individuals worldwide suffer from chronic pain, with a frequency of 20–25% in some nations. Low- and middle-income countries (LMICs) are disproportionately affected by this condition. The yearly cost of diabetes, cancer, and heart disease—including medical expenses, lost productivity, and disability programs—is less than that of pain complaints. Pain management techniques, the most recent discoveries in pain research, and the most recent advancements in pain therapy technology can work together to reduce the prevalence of chronic pain and lessen the financial burden that comes with pain syndrome. **Objective**: To determine the extent to which the latest technological developments in interventional pain management to personalized treatment techniques according to patient complaints and conditions. The scope of technological development here is not only pain intervention techniques but also advances in understanding the pathophysiology of pain, nerve and tissue regeneration, as well as the modalities of technology used for pain interventions. **Review:** By conducting literature searches including journals, systematic reviews, library surveys, and case reports from the last 10 years on the latest interventional pain management techniques and serial cases. **Summary:** Many new minimally invasive pain intervention techniques have been developed and used in the treatment of chronic pain within the past 10 years. The necessity for standardization of processes, safety, efficacy, cost, and accessibility to new technology and techniques are among the issues and debates surrounding technical advancements and strategies for managing chronic pain. Intervention pain management techniques have grown in importance as a less intrusive method of treating chronic pain. For optimal outcomes, used in conjunction with other pain management modalities such as medication, physical therapy, cognitive behavioral change therapy, and others.

Keywords: Access and Essential Health Care Services; Chronic Pain; Coblation; Cryoneurolysis; Interventional Pain Management

ABSTRAK

Pendahuluan: Secara global, ada 60 juta orang yang menderita nyeri kronis, dengan prevalensi berkisar antara 20 dan 25 persen di beberapa negara. Karena keterbatasan akses ke perawatan medis, penyakit ini berdampak secara tidak proporsional pada negara-negara berpenghasilan rendah dan menengah (LMIC). Biaya tahunan untuk penyakit jantung, kanker, dan diabetes, termasuk biaya medis, program disabilitas, dan penurunan produktivitas, lebih rendah daripada biaya untuk keluhan nyeri. Kemajuan dalam penelitian fisiologi nyeri dan teknologi terapi nyeri terbaru dapat membantu mengurangi jumlah kasus nyeri kronis dan biaya yang disebabkan oleh sindrom nyeri. Kombinasi dari berbagai metode penanganan nyeri dapat membantu mengurangi jumlah uang yang dihabiskan karena sindrom nyeri. **Tujuan:** Untuk menentukan sejauh mana perkembangan teknologi terbaru dalam manajemen nyeri intervensional untuk mencapai teknik pengobatan yang dipersonalisasi sesuai dengan keluhan dan kondisi pasien. Menggunakan teknologi tidak hanya untuk mengatur nyeri, tetapi juga untuk mengerti nyeri patofisiologi, regenerasi saraf dan jaringan, serta modalitas teknologi yang digunakan untuk mengatur nyeri. **Review**: Dilakukan dengan cara melakukan pencarian literatur termasuk jurnal, tinjauan sistematis, tinjaun Pustaka dan laporan kasus dari 10 tahun terakhir tentang teknik dan manajemen nyeri intervensional yang terbaru, baik yang sudah teruji maupun yang masih dalam tahap serial kasus. **Kesimpulan**: Dalam sepuluh tahun

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terakhir, sejumlah teknik intervensi nyeri yang minimal invasif telah ditemukan dan digunakan dalam pengobatan nyeri kronis. Teknik manajemen nyeri intervensi telah menjadi bagian penting dari pengobatan nyeri kronis dengan cara yang minimal invasif. Untuk mencapai hasil terbaik, teknik ini harus digunakan bersama dengan modalitas nyeri tambahan seperti obat-obatan, fisioterapi, terapi perubahan, dan terapi lain. Namun, ada tantangan dan kontroversi terkait standarisasi prosedur, keamanan, efektivitas, dan biaya.

Kata kunci: Akses dan Layanan Perawatan Kesehatan Penting; Nyeri Kronis; Koblasi; Krioneurolisis; Manajemen Nyeri Intervensional

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INTRODUCTION

Pain is a reflexivity that encompasses sensory, affective, and cognitive components, making it challenging to define, characterize, and understand (1). Pain is often seen as a failure of healthcare efforts to address the underlying cause, which frequently worsens and evolves into chronic pain. The 2010 Global Burden of Disease (GBD) study revealed that 1-4% of the global population suffers from chronic back pain, which is associated with both somatic and psychological disorders. On a global scale, disability is the primary cause of this condition, which is largely unknown (2). Arthritis and cancer cases continue to rise year after year, putting a strain on the healthcare system in terms of addressing the causes. Resulting in rising medical costs and decreased productivity (3,4).

According to the 2008 Medical Expenditure Panel Survey (MEPS), heart disease ($309 billion), cancer ($243 billion), and diabetes ($188 billion) are less expensive than pain-related healthcare in the US. These expenses, which include lost productivity, disability programs, and medical bills, vary from $299 to $335 billion (5,6). The opioid crisis in the US and Canada, the side effects of opioid usage, and the failure of non-pharmacological therapies to reduce pain and lower maintenance expenses are some of the additional difficulties associated with managing persistent pain (7,8).

Combining new pain management methods with the latest advances in pain physiology research and pain therapy technology will create new opportunities for reducing the incidence of chronic pain and lowering the financial burden due to pain syndrome (9). By better understanding the concept of multifaceted pain, existing technologies, and methods can be applied in parallel. Healthcare providers can provide individualized care that is tailored to each patient's condition through internal and external technologies, pharmacotherapy, and evolving surgical and percutaneous techniques with a variety of patient management options, including medications, non-pharmacological approaches, and interventional techniques (10). Treating patients with compassion and precision can lessen the toll that chronic pain has on individuals, their families, and the healthcare system as a whole.

REVIEW

History of Pain Management

Pain management has been practiced since ancient times. The Code of Hammurabi, which consists of 282 ancient Mesopotamian laws, includes provisions for pain treatment. The Edwin Smith Papyrus, a medical manuscript from around 1500 BC, describes techniques for pain management, reflecting the Egyptians' evolving understanding of pain control. Galen, a Greek physician, developed a method of pain

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management based on the concept of balance. Both the Greeks and Romans had a thorough understanding of how to manage pain (11).

Subsequently, there was an increase in the use of the opium plant as a medication, willow bark, and leaves as natural sources of salicylic acid, pain pathways, ether and chloroform for anesthesia, cocaine, morphine, and heroin, as well as minimally invasive methods for pain intervention such as radiofrequency and vertebral augmentation (vertebroplasty and kyphoplasty) in later stages (12). The least invasive nerve interventions can utilize ultrasonography and fluoroscopy. This study focuses on techniques that use fluoroscopy. Literature searches include journal articles, original research, systematic reviews, and case studies on the application of new technologies for health interventions and the need for such advancements in the coming years.

Advancement in Pain Intervention Techniques

1. Regenerative Medicine

The growth of healthcare has led to a shift in the paradigm, moving away from viewing illness solely as a threat and preventing its spread (13). Inflammatory conditions, matrix-degrading enzymes and their upstream effectors, vascular and nerve ingrowth, and cellular aging are all examples of catabolic processes that could be stopped by regenerative therapy. Moreover, boosting cell division and the availability of anabolic growth hormones and antioxidants might improve anabolic processes. In regenerative medicine, viscosupplementation, prolotherapy, platelet-rich plasma, and mesenchymal stem cells are the main techniques for managing pain.

A. Viscosupplementation

The viscosity and flexibility of osteoarthritic synovial fluid can be restored by injecting hyaluronic acid (HA) into the intra-articular region. HA is essential for lubrication, stress absorption, and the viscoelastic characteristics of synovial fluid (14).

B. Proloterapy

The injection of a remedy known as proloterapy encourages sclerosis at the injection site and restores an inadequate structure. Unlike other regenerative medicine procedures, plurithерapy uses an injectate that is devoid of any biological component. Hypertonic dextrose is the most often utilized prolotherapy solution because it triggers the body's inflammatory cascade (15).

C. Platelet-rich plasma

Because platelet-rich plasma (PRP) has regenerative, analgesic, and anti-inflammatory properties, it produces bioactive proteins that promote the body's ability to repair (16).

D. Mesenchymal Stem Cells (MSC)

Adipose tissue and bone marrow MSCs can develop into adipogenic, chondrogenic, and osteogenic lineages. By repairing disc tissue and regulating nociceptive pain, MSCs can lessen lower back discomfort. However, a constraint on long-term results is MSC survival (12,15).

2. Neuromodulation Techniques

Techniques that use chemicals or electrical stimulation to change the activity of neurons. Neuromodulation modifies the activity of neurons and neural circuits to influence a range

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of physiological and psychological processes. Neuromodulation modifies the excitability or responsiveness of neurons to other stimuli, as opposed to direct stimulation, which elicits a response. Chemical, electrical, and bioelectrical neuromodulation are some of the classes into which neuromodulation methods are divided into several classes (16).

Table 1. Mechanisms of Neuromodulation (16).

No	Mechanism	Groups	Mode of Action
1	Chemical Neuromodulation	Neurotransmitter	Chemicals such as dopamine, serotonin, and norepinephrine modulate neuronal activity. Imbalances can affect mood, cognition, and behavior.
		Neuromodulator	Substances such as acetylcholine and neuropeptides modulate neurotransmitter release or receptor sensitivity.
2	Neuromodulasi of electrics	Deep Brain Stimulation	Involves implanting electrodes in specific areas of the brain to treat disorders such as Parkinson's disease and depression.
		Transcranial Magnetic Stimulation	Non-invasive methods that use magnetic fields to stimulate nerve cells in the brain, are often used in the treatment of depression.
		Transcranial Direct Current Stimulation	Uses low electrical currents applied to the scalp to modulate brain activity.
3	Bioelectronics	Vagus Nerve Stimulation	Implantation of a device to stimulate the vagus nerve, used for epilepsy and depression.
		Sacral Nerve Stimulation	To treat bladder control issues and chronic pain by stimulating the sacral nerve.
4	Gene therapy	Genetic modulation	Modifying gene expression to affect neuron function or repair damaged neural circuits.

Table 2. Various Invasive Neuromodulation Technologies for Pain Intervention and Their Major Indications (12) (16) (17)

No	Invasive Neuromodulation Technology	Major Indications
1	Stimulation of the Spinal Cord (SCS)	Complex regional pain syndrome (CRPS), the syndrome of failed back surgery, neuropathic pain, such as diabetic neuropathy, Peripheral vascular disease, and vascular discomfort
2	Stimulation of the Dorsal Root Ganglion (DRG)	Neural discomfort for the hands, chest, abdomen, foot, knee, or groin associated with focal CRPS
3	The stimulation of peripheral nerves (PNS)	Discrete neuropathies, headache acute pain, neuropathic pain, and chronic pain
4	DBS, or deep brain stimulation	Phantom limb pain (CRPS), discrete neuropathies neurodegenerative conditions such as Parkinson's disease
5	Neurostimulation for Restorative	Persistent low back ache caused by machinery
6	Pump-Based Intrathecal Drug Delivery	Pain associated with cancer Incongruity

Pain-transmitting sensory neurons are destroyed using radiofrequency (RF). Over 70 years, this method has improved to reduce tissue damage and regulate lesion size. Nociceptive pain, including facet joint arthralgia, sacroiliac joint pain, and discogenic low back pain, responds better to radiofrequency (RF) treatment. Novel approaches, such as pulsed RF and bipolar RF, expand pain treatment options. To stimulate peripheral nerves and lessen pain, a procedure known as peripheral neurostimulation (PNS) entails implanting electrodes close to peripheral nerves (16).

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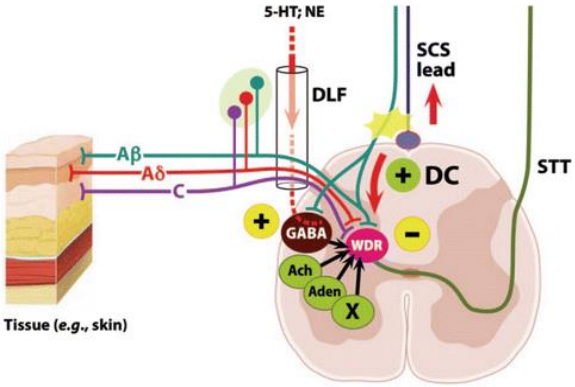

Figure 1. Segmental Spinal and Supraspinal Regulation using Neurotransmitters including GABA, Acetylcholine, and Adenosine is Required for SCS-Mediated Pain Alleviation (18).

3. Neuroablative Procedures

Techniques in medicine include removing or destroying a section of the nerve tissue to cure a range of neurological illnesses. The main goal of these procedures is to manage nerve anomalies that are difficult to treat with other means or to reduce pain. Well-established neuroablative techniques include chemical neurolysis, pulsed radiofrequency, radiofrequency ablation (RFA), and electrothermal therapy.

Table 3. Long-established Neuroablative Procedures (16).

No	Procedure of Neuroablation	Technique	Indication
1	Radiofrequency Ablation (RFA)	This technique uses radiofrequency waves to heat and destroy nerve tissue that causes pain. Electrodes are placed near the target nerve, and radiofrequency energy is used to heat and destroy portion of the nerve.	The treatment targets hronic pain, including lower back, neck, and joint pain.
2	Chemical Neurolysis	Injection of chemicals, such as phenol or alcohol, into nerve tissue to destroy the nerve. These chemicals cause nerve cell death and reduce pain.	Used to manage chronic pain, especially when other methods are ineffective.
3	Pulsed Radiofrequency	This technique involves using pulsed radiofrequency waves to stimulate nerves without causing permanent damage. It can reduce pain differently compared to RFA.	Neuropathic pain and chronic pain that is difficult to treat
4	Electrothermal Therapy	This procedure uses electrical energy to generate heat that destroys nerve tissue. Electrodes are inserted into the target area, and heat is produced to destroy the painful tissue.	Joint pain and lower back pain.

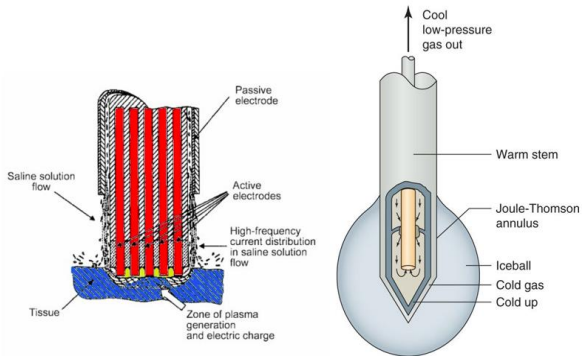

Figure 2. The Mechanism of Coblation and Cryoneurolysis (22).

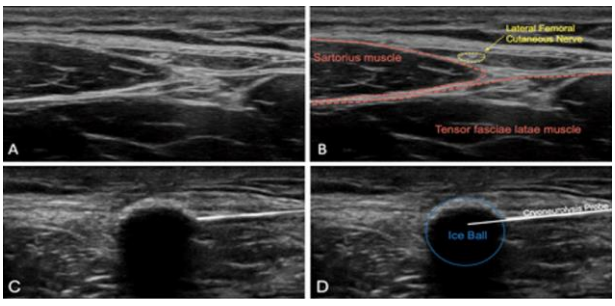

Figure 3. Cryoneurolisis to the Lateral Femoral Cutaneous Nerve (23).

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Table 4. Recent Neuroablative Procedure (16).

No	Procedure of Neuroablation	Technique	Indication
1	Coblation	Non-heat-driven process of tissue dissolution. Plasma generates hydrogen (H) and hydroxyl (OH) ions. The OH radicals cause protein degradation. This technique works by using low-pressure plasma energy to cut or destroy tissue. The energy is produced from ionized gas (usually argon) flowing through electrodes and directed to the target tissue. This process generates relatively low temperatures, reducing the risk of damage to surrounding tissues.	Phantom limb and stump discomfort. Peripheral nerve treatments may be more successful than neuroma, orthopedic surgery for trigeminal neuralgia, disc herniation, cervical discogenic pain, and tendinitis (19–22).
2	Cryoneurolysis	The procedure involves cooling the nerve to cause damage to the vasa nervorum (the blood vessels supplying the nerve). This results in endoneurial edema (swelling within the nerve sheath), increased pressure, and subsequent axonal destruction (damage to the nerve fibers). The target temperature is between -20 and -100^{0}C.	It is effective in treating acute pain such as chest wall pain after surgery or trauma, chronic pain in knee osteoarthritis, chronic head pain et causa occipital neuralgia, and specific nerves such as lateral femoral cutaneous, and neuropathic pain (23,24).
3	Basivertebral nerve (BVN) ablation	Methods that injure the spinal nerve. Disc degeneration is one possible cause of chronic low back pain and has been consistently linked to it. The vertebral endplates next to each disk play a crucial role in the pathologic disease presentations and increase the vulnerability to inflammation and damage. They maintain the balance between providing structural support for the spine and serving as the main blood and nutrient supply pathway for the disc.	Vertebrogenic pain. The following patient requirements apply to basivertebral nerve ablation: type 1 or type 2 modic alterations at one or more levels from L3-S1, as well as chronic low back pain for whom conservative treatment has been tried for more than six months (16).

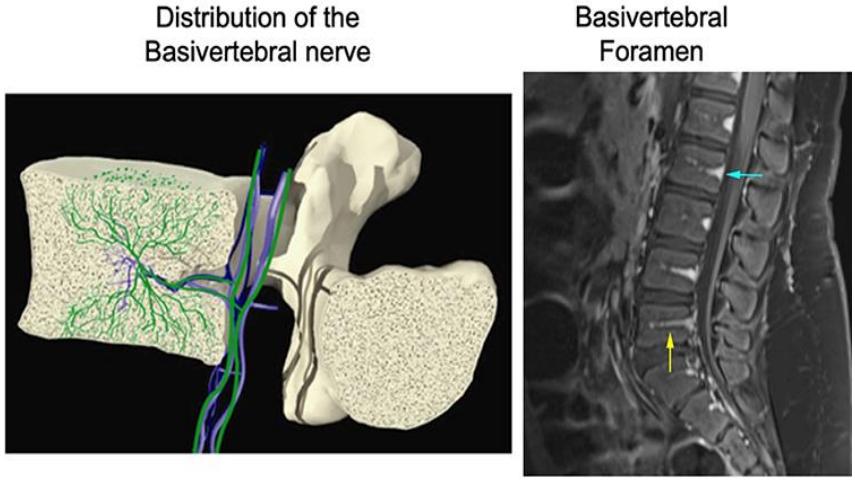

Figure 4. Distribution of Basivertebral Nerve dan Foramen (16).

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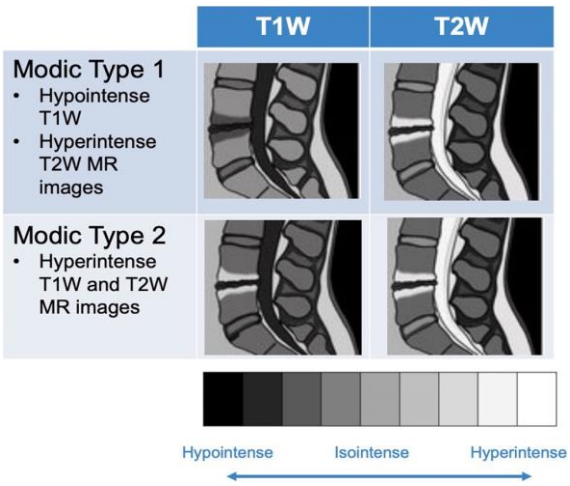

Figure 5. Modic Changes. (Photo credit: Relievant Medsystems. All rights reserved. 2021) (16).

The first human subjects BVN ablation pilot experiment was carried out in 2017 by Becker et al. The study included 17 patients with MC1 or MC2 abnormalities and chronic low back pain (CLBP) who had either received conservative treatment or had been treated for six months. For this cohort, the baseline values of the Oswestry Disability Index (ODI) were 52 and the Visual Analog Scale (VAS) was 61. During the 3-month follow-up after surgery, both the VAS and the ODI showed statistically significant improvement; the ODI dropped by 29 points to an average of 23. Sustained improvement was also seen in the 12-month follow-up (12).

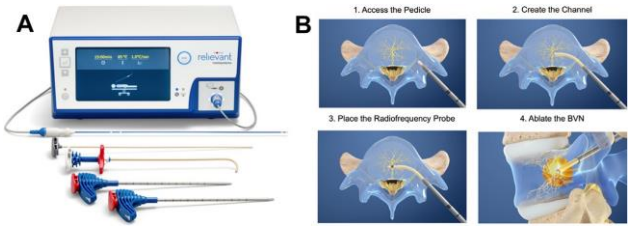

Figure 6. Intraceptive Technique. (A): Intracept apparatus. The Intracept Steps (B). (Photos by Relievant Medsystems. All rights reserved. a2021) (16).

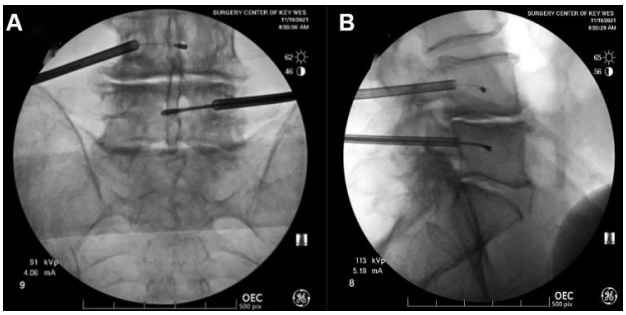

Figure 7. The X-ray View in AP and Lateral for Basivertebral Nerveablation (16).

Table 5. MILD technique (16, 25–28)

Major options	Advantages	Disadvantages	Technique and procedures	Indication
Direct decompression	Minimum of invasive. Quick recovery, and Minimum of risk	Limited access	Percutaneous Discectomy Percutaneous Laser Discectomy Microscopic Decompression	Patients who are not likely to have favorable surgical results or who would choose a less invasive operation include those with central spinal stenosis, hypertrophy of the ligamentum flavum measuring more than 2.5 cm, and diseases with or without instability.
Indirect decompression	Less invasive reversible	Variable outcome Device complication	Interspinous spacer	Patients who are adults with moderate spinal stenosis who have attained skeletal maturity and are exhibiting symptoms.

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The procedure is performed unilaterally with the patient in a prone position; either general or conscious sedation is administered. Using standard anatomic landmarks, the location of the entry pedicle at each level to be treated is determined and marked. Under fluoroscopic guidance, an introducer cannula is advanced through the pedicle until the trocar just breaches the posterior vertebral wall. The introducer trocar is exchanged with a smaller plastic cannula/curved nitinol stylet assembly, which facilitates the creation of a curved path from the posterior wall to the pre-determined target located at the terminus of the BVN, located near the center of the vertebral body. Finally, the curved nitinol stylet is removed and an RF probe is introduced and positioned at the terminus of the BVN. The bipolar RF probe is activated and the temperature at the tip is maintained at a constant 85 °C for 15 min (Figure. 7)

4. Minimally Invasive Lumbar

A less intrusive method than standard surgical approaches, lumbar decompression (MILD) is a minimally invasive surgical technique intended to minimize scarring in the lower back. The most common ailments this surgery is used to treat include disc herniation, spinal stenosis, and posterior back discomfort. Neurogenic claudication, a severe condition, can result from degenerative constriction of the spinal canal, nerve roots, or foramen in individuals with symptomatic lumbar spinal stenosis (LSS) (29).

Ligamentum flavum or facet hypertrophy, osteophyte development, and intervertebral disc bulging are the three potential pathophysiologies for LSS. Functional disability, claudication, and compressive discomfort can result from any of these disorders. As of right now, there are primarily two methods available: direct decompression, which is frequently accomplished via a percutaneous method, and indirect decompression, which is accomplished with percutaneous interspinous spacers (16).

Percutaneous interspinous spacers can only be implanted at two consecutive levels in adult patients with up to symptomatic moderate spinal stenosis who satisfy the following requirements for placement: they must have been on conservative treatment for a minimum of six months.

Individuals with spinal stenosis extending from the L1-L2 level to the L4-L5, ligamentum flavum hypertrophy more than 2.5 cm, and central or lateral stenosis in particular. Using the percutaneus, do lumbar decompression. The main goal of percutaneous lumbar decompression is to debulk the ligamentum flavum and lamina using an epidurogram and image-guided dissection (16)

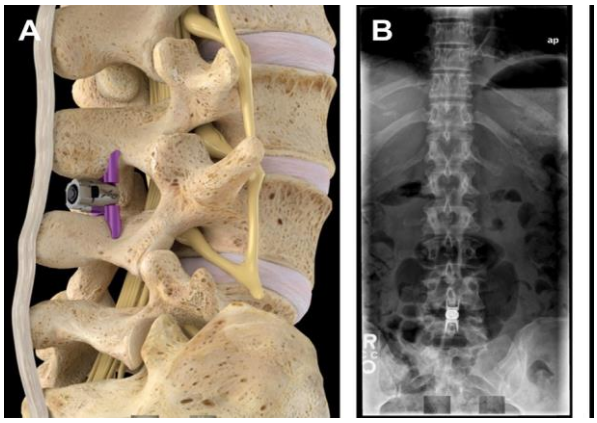

Figure 8. A. Percutaneous Interspinous Spacers Seen Laterally. B. Anteroposterior (AP) Radiography Image of the Interspinous Spacer's Final Location. (Figure supplied by Boston Scientific with permission) (16)

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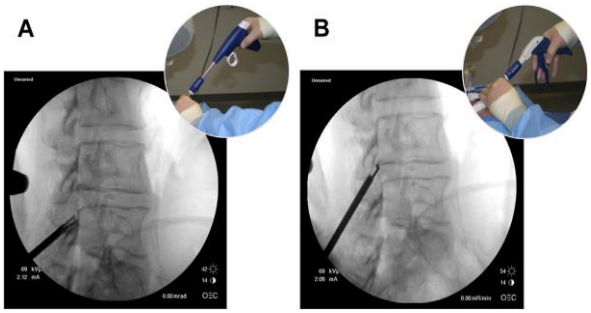

Figure 9. (A): Bone Rongeur: The Bone Rongeur is Introduced, and Lamina Pieces are Removed from the Superior and Inferior Lamina. **(B): Tissue Sculpter**: After Adequate Removal of the Lamina, the Tissue Sculpter is Introduced to Reduce the Ligamentum Flavum(16).

Pain management is a crucial component of healthcare to lessen suffering and improve the quality of life for patients with both acute and chronic pain. The best methods for managing pain effectively are as follows:

1. Through evaluation of history, physical examination, and psychosocial assessment.
2. Pain management through multiple modalities
   A. Pharmacologic treatments: When necessary, combine non-opioid analgesics (such as acetaminophen and NSAIDs), adjuvant drugs (such as antidepressants and anticonvulsants), and opioids.
   B. Non-medical interventions: For comprehensive pain management, combine chiropractic adjustments, acupuncture, physical therapy, and other non-pharmaceutical methods.
   C. Pain interventions: adjust the availability of human resources and technologies.
3. The patient-centred method consists of individualized care plans, patient education, and stewardship of opioids to avoid addiction and overdose. Adapt pain management techniques to the unique requirements and medical circumstances of the patient. Educate patients on the nature of their pain, available treatments, and the significance of following the recommended course of action.
4. Managing chronic pain with behavioural therapies and functional objectives.
5. Research and Education:
   A. Ongoing Training: Educate and train healthcare professionals on the most recent methods and best practices for managing pain.
   B. Clinical Research: Encourage and participate in research to create fresh approaches to pain management.

The challenges and controversy surrounding the use of technology and chronic nail art are as follows: there is a need for standardization in intervention techniques, patient identification, and the type of agent used to enhance treatment outcomes and consistency. Both efficiency and safety are critical, as all new techniques require extensive research to ensure their effectiveness and safety. Lastly, cost and accessibility are concerns because integrating new technology involves adjusting costs, accessibility, and training requirements for clinical practice (30).

When it comes to the future of pain management interventions, new technologies are continuously being developed, including more advanced stimulation systems and more precise pain assessment tools. It is expected that these innovations will enhance patient outcomes. However, further research is required to evaluate and optimize these new techniques and to establish more evidence-based practices.

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SUMMARY

Techniques for interventional pain treatment have grown in importance as a minimally invasive approach to managing chronic pain. While radiofrequency ablation, spinal cord stimulation, and nerve blocks are still common practices today, other methods including targeted drugs and regenerative medicine are now being used.

Technologies and approaches that make use of our growing understanding of the intricate details of human biology are developing at the same time. A pain management specialist of the future will be able to accurately evaluate each patient's condition with the use of internal and external technology, medications, and sophisticated surgical and percutaneous methods. Physicians may assist lower the risk of chronic illness for patients, their families, and the whole healthcare system by thoroughly and precisely examining their patients.

All things considered, the development of new technology and minimally invasive treatment approaches has given patients who struggle to control their pain new hope. These patients now have safer, more accurate solutions available to them.

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Conflict of Interest

The authors declare that there are no conflicts of interest related to this study.

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Authors' Contributions

1. Ratri Dwi Indriani: Contributed to the study design, data analysis, and manuscript writing.
2. Abdurrahman: Supervised the research and provided funding support.
3. Dedi Susila: Conducted the research and manuscript.
4. Muzaiwirin: Data collection.
5. Muhammad Ainur Rosyid Ridho: Assisted with data interpretation and provided critical revisions to the manuscript.

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- 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.

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