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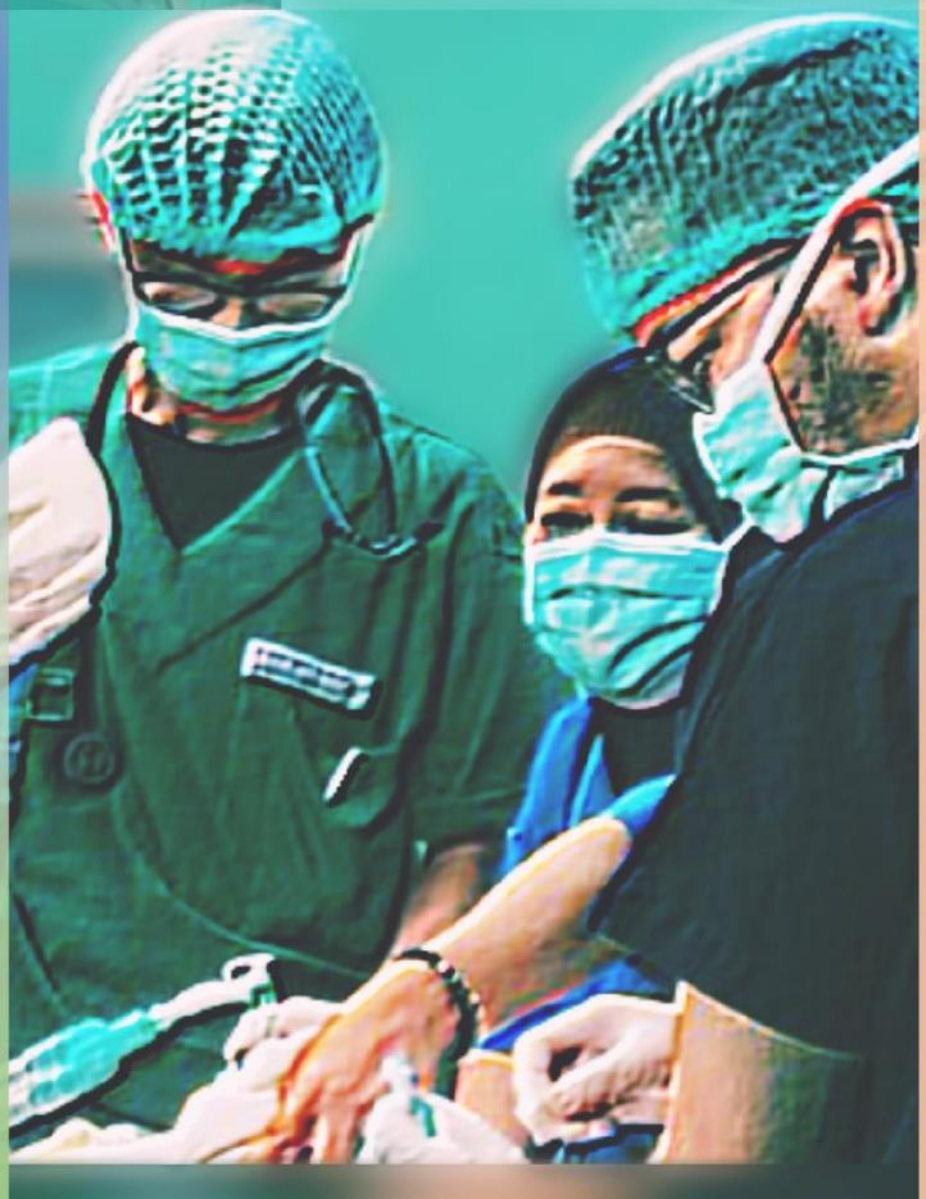

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INDONESIAN JOURNAL OF ANESTHESIOLOGY AND REANIMATION
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Original Article

PROFILE OF PATIENTS WITH RESPIRATORY FAILURE AT PEDIATRIC INTENSIVE CARE UNIT (PICU) DR. SOETOMO GENERAL HOSPITAL

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ABSTRACT

Introduction: Respiratory failure is the *respiratory system's inability* to maintain its gas exchange functions, oxygenation and carbon dioxide elimination. Infant and children are more susceptible to develop respiratory failure. Respiratory failure can also be caused by several diseases/conditions, which is a common reason for pediatrics to be admitted to the intensive care unit. **Objective:** This study aims to describe *patients'* demographic and clinical profile with respiratory failure at the PICU of Dr. Soetomo General Hospital, Surabaya. **Materials and Methods:** This is a prospective study with the descriptive method using the medical records of patients with respiratory failure who were admitted to the PICU from September 2019 to February 2020 and had arterial BGA data ($PaCO_2$, PaO_2), which were examined in the PICU or resuscitation room before the patients were admitted to the PICU. **Results:** This study showed that out of 35 patients, 24 (68.6%) were female, 19 (54.3%) were <1 year old, and 20 (57.1%) had normal nutritional status. Type I (hypoxemic) and type II (hypercapnic) respiratory failures were found in 13 patients (37.1%), respectively. The most common clinical signs were fever in 26 patients (74.3%), shortness of breath in 24 patients (68.6%), and chest retraction in 24 patients (68.6%). The primary diagnosis that commonly occurred was respiratory system disorders in 15 patients (42.9%). The *other* diagnosis that *mainly* occurred was nutrition and metabolic disorders of 19 patients (54.3%). The *patients' outcome* was that 24 patients were survived (68.6%), and *ten* patients died (28.6%). **Conclusions:** Various clinical signs and diagnoses can be found in patients with respiratory failure at PICU. The most common *respiratory failure types* are type I (hypoxemic) and type II (hypercapnic) respiratory failure.

Keywords: Chronic Respiratory Disease; Hypoxemia; Hypercapnic; PICU; Profile; Respiratory Failure

ABSTRAK

Pendahuluan: Gagal napas merupakan kondisi kegagalan sistem pernapasan dalam melakukan fungsi pertukaran gas yaitu oksigenasi dan eliminasi karbondioksida. Gagal napas lebih rentan terjadi pada bayi dan anak, dan dapat disebabkan oleh beberapa penyakit/kondisi yang mendasari, sehingga gagal napas menjadi alasan umum pasien pediatri dirawat di unit perawatan intensif. **Tujuan:** Penelitian ini bertujuan untuk menggambarkan profil demografi dan klinis pasien dengan gagal napas di PICU RSUD Dr. Soetomo. **Metode dan Bahan:** Penelitian ini merupakan studi prospektif dengan metode deskriptif menggunakan rekam medis pasien dengan gagal napas yang masuk PICU pada September 2019 hingga Februari 2020 dan memiliki data BGA arteri ($PaCO_2$, PaO_2) yang diperiksa di PICU atau ruang resusitasi sebelum pasien masuk PICU. **Hasil:** Penelitian ini menunjukkan bahwa dari 35 pasien, 24 pasien (68,6%) berjenis kelamin perempuan, 19 pasien (54,3%) berusia <1 tahun, dan 20 pasien (57,1%) memiliki status gizi normal. Gagal napas tipe I (hipoksemia) dan gagal napas tipe II (hiperkapnia) ditemukan pada masing-masing 13 pasien (37,1%). Tanda klinis yang paling sering ditemukan adalah demam pada 26 pasien (74,3%), sesak napas pada 24 pasien (68,6%), dan retraksi dada pada 24 pasien (68,6%). Diagnosis utama terbanyak adalah gangguan sistem respirasi yaitu pada 15 (42,9%) pasien, dan diagnosis tambahan terbanyak adalah gangguan nutrisi dan metabolik yaitu pada 19 (54,3%) pasien. Hasil luaran pasien yaitu hidup sebanyak 24 pasien (68,6%), dan meninggal sebanyak 10 pasien (28,6%). **Kesimpulan:** Pada pasien dengan gagal napas di PICU, ditemukan tanda klinis dan diagnosis yang bervariasi. Tipe gagal napas yang paling banyak ditemukan yaitu gagal napas tipe I (hipoksemia) dan tipe II (hipercapnia).

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Kata kunci: Penyakit Pernapasan Kronis; Hipoksemia; Hipercapnia; PICU; Profil; Gagal napas
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INTRODUCTION

The respiratory system's primary function is to carry out the gas exchange that helps maintain cellular homeostasis (1). Respiratory failure is when the respiratory system fails to maintain gas exchange functions, namely oxygenation and/or carbon dioxide elimination, to meet the body's metabolic needs. Respiratory failure based on blood gas abnormalities is classified into hypoxemic (PaO_2<60 mmHg), hypercapnic ($PaCO_2$>50 mmHg), and mixed (2,3).

Respiratory failure can be caused by various conditions, namely lung disease, airway disorders, respiratory pump problems, central nervous system disorders, and inability to meet increased metabolic demands, such as hypovolemia, septic shock, cardiac insufficiency, metabolic disease, or intoxication (4). In pediatric patients, respiratory failure is often initiated by acute respiratory distress syndrome (ARDS), with the incidence of ARDS in the population of 3.5 cases per 100,000 people in one year, while in the Pediatric Intensive Care Unit (PICU), it was 2.3% (5).

Acute respiratory failure is a medical emergency that is more susceptible to occur in infants and children. High susceptibility and clinical manifestations that develop more severely and rapidly in pediatrics cause acute respiratory failure to be a common reason for pediatric patients to be admitted to the PICU (4). Respiratory failure can be the cause of high morbidity and mortality rates in intensive care units (6). The mortality rate for pediatric due to ARDS in the previous study was approximately 24-34% (5,7).

Currently, there has not been much research on the profile of pediatric patients with respiratory failure in the intensive care unit, especially Dr. Soetomo General Hospital, Surabaya. This study is expected to provide information regarding pediatric patients' demographic and clinical profile with respiratory failure admitted to the PICU at Dr. Soetomo General Hospital, Surabaya.

MATERIALS AND METHODS

This study used the descriptive method prospectively conducted at the Pediatric Intensive Care Unit (PICU) Dr. Soetomo General Hospital Surabaya. This study period was September 2019 to July 2020. Thirty-five patients met the inclusion criteria, namely patients aged >28 days to 18 years old with respiratory failure admitted to the PICU from September 2019 to February 2020. They had arterial BGA data ($PaCO_2$, PaO_2) examined in the PICU or resuscitation room before the patient was admitted to the PICU.

Data were collected from the patient's medical record, including gender, age, nutritional status based on body weight and length/height, type of respiratory failure based on the data of arterial BGA ($PaCO_2$, PaO_2), clinical signs, primary diagnosis, additional diagnosis, and patient outcomes. Assessment of children's nutritional status based on body weight according to length/height refers to WHO 2006 chart for children <5 years and the CDC 2000 chart for children >5 years. Furthermore, children <5 years can use the weight index according to age refers to WHO 2006 chart to assess children with underweight and severely underweight (8,9). Types of respiratory failure in patients were classified based on arterial BGA data, namely type I or hypoxemic respiratory failure (PaO_2<60 mmHg), type II or hypercapnic respiratory

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failure ($PaCO_2$>50 mmHg), and type III respiratory failure (a combination of hypoxemic and hypercapnic)(3). The data were analyzed using Statistical Program for Social Sciences (SPSS) v26.0 software to show the frequency, percentage, and data distribution. The Ethics Committee of Dr. Soetomo General Hospital, Surabaya, has approved this research (1335/KEPK/VII/2019).

RESULTS AND DISCUSSION

The total number of patients with respiratory failure who met the inclusion criteria was 35 patients. Females dominated the patient's characteristics based on gender as many as 24 patients (68.6%). The ratio between males and females was 1:2.18. The characteristics of the patient based on age group were dominated by the infant age group (<1 year) of 19 patients (54.3%). The patient had a median age of 9 months, with the youngest being one month and the oldest being 17 years.

Table 1. Demographic Characteristics of Patients

Characteristics	N (%)
Gender	
Male	11 (31.4)
Female	24 (68.6)
Age group	
Infants (<1 year)	19 (54.3)
Children (1-10 years)	10 (28.6)
Adolescents (11-18 years)	6 (17.1)
Nutritional status	
Obese	3 (8.6)
Overweight	1 (2.9)
Normal	20 (57.1)
Wasted	5 (14.3)
Severely wasted	4 (11.4)
Severely underweight	2 (5.7)

The number of research samples that had complete data in the form of body weight and body length/height were 33 patients from a total of 35 patients, and thereby the nutritional status assessment of 33 patients was conducted based on Ikatan Dokter Anak Indonesia recommendations, namely using the weight index according to length/height(8). While two patients aged <5 years only had data in the form of body weight using the weight index according to age. The results showed that most patients who had a normal nutritional status were 20 patients (57.1%). The demographic profiles of the patients are shown in Table 1.

Type I (hypoxemic) respiratory failure and type II (hypercapnic) respiratory failure of 13 patients (37.1%), respectively, dominated the types of respiratory failure in patients. The distribution of the types of respiratory failure in the research subjects is shown in Table 2.

Table 2. Type of Respiratory Failure

Type	N (%)
Type I (hypoxemia)	13 (37.1)
Type II (hypercapnic)	13 (37.1)
Type III (mixed)	9 (25.7)

Clinical signs and symptoms primarily found in patients with respiratory failure were fever in 26 patients (74.3%). Moreover, the most frequent signs of respiratory distress were shortness of breath and chest retraction in 24 patients (68.6%), respectively. The distribution of clinical signs found in research subjects is shown in Table 3.

Table 3. Clinical Signs of Patients

Clinical Sign*	N (%)
Fever	26 (74.3)
Cough	14 (40)
Shortness of breath	24 (68.6)
Chest retraction	24 (68.6)
Wheezing	11 (31.4)
Pale	20 (57.1)
Cyanosis	4 (11.4)

*each patient could experience more than one clinical signs

The primary diagnosis primarily found in patients with respiratory failure was respiratory system disorders in 15 patients (42.9%), followed by central nervous system disorders in 7 patients (20%). Patients with respiratory failure in the PICU also experience conditions or problems other than the primary

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diagnosis. The other diagnoses mostly occurred to the research subjects were nutrition and metabolic disorders of 19 patients (54.3%). The distribution of the primary and additional diagnoses among the research subjects is shown in Table 4.

Table 4. The Primary and Additional Diagnosis of Patients

Diagnosis	N (%)
Primary diagnosis	
Respiratory system	15 (42.9)
Central nerve system	7 (20)
Gastrointestinal system	4 (11.4)
Renal system	4 (11.4)
Cardiovascular system	2 (5.7)
Hematologic system	2 (5.7)
Nutrition and metabolic	1 (2.9)
Additional diagnosis*	
Nutrition and metabolic	19 (54.3)
Cardiovascular system	15 (42.9)
Respiratory system	14 (40)
Renal system	12 (34.3)
Sepsis	11 (31.4)
Gastrointestinal system	7 (20)
Hematologic system	7 (20)
Central nerve system	5 (14.3)

* each patient could have more than one additional diagnosis

The patient's outcome is the condition of the patient with respiratory failure in the PICU. This study found that 24 patients (68.6%) were survived, 10 patients (28.6%) died in the PICU, and 1 patient (2.9%) was still undergoing treatment in the PICU at the end of this study. The patient outcomes are shown in Table 5.

Table 5. The Outcome of Patients in PICU

Outcome	N (%)
Survived	24 (68.6)
Died	10 (28.6)
Others	1 (2.9)

This study found that the characteristics of patients with respiratory failure in the Pediatric Intensive Care Unit Dr. Soetomo General Hospital were dominated by the female of 68.6% compared to the male of 31.4%. This is different from previous studies in Indian general hospitals: Lokmanya Tilak Municipal Medical College and Dayanand Medical College, where most pediatric patients with respiratory failure were male (10,11). This difference may be caused by a more extended study time and several other rooms as the research location.

The characteristics of patients with respiratory failure based on age were dominated by the infant age group (<1 year), with a percentage of 54.3%. The infant age group is more susceptible to develop respiratory failure because physiologically, there are several deficiencies, such as the smaller diameter of the infant respiratory tract so that resistance to airflow increases rapidly when there is secretion, edema, or bronchoconstriction, immaturity of the chest wall and diaphragm, a more horizontal orientation of the ribs and diaphragm, more oxygen consumption than adults in normal circumstances, and immaturity of respiratory control centers (1,12). Other studies at Lokmanya Tilak Municipal Medical College and Dayanand Medical College General Hospital showed the same results that the majority of pediatric patients with respiratory failure were in the 1 month to 1 year age group (10,11).

Furthermore, the characteristics of patients with respiratory failure based on nutritional status were dominated by the normal nutritional status of 57.1%, followed by wasted of 14.3%, and severely wasted by 11.4%. In pediatric patients ventilated in the PICU, nutritional status was significantly associated with clinical outcomes. Assessment of nutritional status is conducted on patients who are treated at the PICU so that patients who are malnourished are considered in the optimal nutrition strategy aimed at preventing further nutritional deterioration (13).

The types of respiratory failure in patients were categorized based on arterial BGA data

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($PaCO_2$, PaO_2). The majority of patients in the PICU who developed type I (hypoxemic) respiratory failure and type II (hypercapnic) respiratory failure were 13 patients (37.1%), respectively, followed by type III (mixed) respiratory failure as many as 25.7%. Another study at Lokmanya Tilak Municipal Medical College general hospital revealed that respiratory failure in pediatric patients was dominated by type I and type III (38%, respectively) (10). While research conducted at the Dayanand Medical College General Hospital reported that hypoxemic respiratory failure (type I) was the most common type in pediatric patients (74.78%) (11).

The clinical signs and symptoms of respiratory failure are often not specific to a particular respiratory disease, but it depends on the underlying disease and the hypoxemic and hypercapnic levels (4,14). This study showed that the clinical sign that most commonly found in patients with respiratory failure in PICU was fever, with a percentage of 74.3%. These results are consistent with the Dayanand Medical College General Hospital research, which states that fever was found in many pediatric patients with respiratory failure of 68.7% (11). Fever often occurs in patients during their treatment at the PICU and is found in more than 40% of critically ill children at the PICU (15). Moreover, the most common signs of respiratory distress found were shortness of breath and chest retraction of 68.6%, respectively. Changes in breathing depth and pattern and chest retraction can be seen in pediatric patients with respiratory failure as a sign of increased work of breathing (4)(10). Other clinical signs found in patients with respiratory failure in the PICU were cough by 40%, wheezing by 31.4%, pale by 57.1%, and cyanosis by 11.4%.

The primary diagnosis in pediatric patients with respiratory failure may vary. The research results found that the most common primary diagnosis in patients with respiratory failure at the PICU Dr. Soetomo Surabaya General Hospital is a respiratory system disorder (42.9%), followed by a central nervous system disorder (20%). These results are consistent with other studies at Lokmanya Tilak Municipal Medical College and Dayanand Medical College general hospitals, which reported that the majority of underlying diseases in pediatric patients with respiratory failure were respiratory system disorders, followed by nervous system disorders (10,11).

Also, patients with respiratory failure at the PICU of Dr. Soetomo Surabaya General Hospital are experiencing conditions or problems but the primary diagnosis. The additional diagnosis primarily found in the research subjects was nutrition and metabolic disorder (54.3%). The nutrition and metabolic disorders found in the patients were malnutrition, acid-base balance disorders, electrolyte disturbances, and hypoalbuminemia. Disturbances of acid-base and electrolyte balance are often found in critically ill children. It may occur due to underlying pathophysiologies, such as kidney failure, respiratory failure, and shock. This disorder can be severe and is often associated with poor outcomes (16). Hypoalbuminemia is also a condition that is not uncommon in critically ill children. In the adult patient literature, hypoalbuminemia is a marker of disease severity, also associated with prolonged mechanical ventilation and length of stay in intensive care unit (17).

This study found that most patients with respiratory failure who were being discharged from the PICU were alive as many as 68.6%, while the death outcome was 28.6%, and patients who were still undergoing treatment at the end of the study period was 2.9%. The relation between the outcome of patients and respiratory failure types found that the highest patient mortality rate was in patients with type

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III (mixed) respiratory failure by 33.3%, followed by type I (hypoxemic) respiratory failure by 30.8%, and type II (hypercapnic) respiratory failure by 25%.

CONCLUSION

Patients with respiratory failure in PICU were dominated by female, infant age group (<1 year), and normal nutritional status. Patients with respiratory failure may experience clinical signs and may have a variety of diagnoses. The types of respiratory failure mostly found were type I (hypoxemic) respiratory failure and type II (hypercapnic) respiratory failure.

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Fever During Pediatric Intensive Care Unit Admission Is Independently Associated With Increased Morbidity. J Intensive Care Med. 2009 Sep;24(5):317–22.
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Original Article

EFFECTIVENESS COMPARISON OF USING *MACINTOSH BLADE* AND *McCoy BLADE* FOR ENDOTRACHEAL INTUBATION IN ANESTHESIA RESIDENTS

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ABSTRACT

Introduction: Laryngoscopy is one of the critical points in the intubation process and a mechanical trauma that provides noxious stimulation, affecting cardiovascular, respiratory, and intracranial changes. Practitioner competence is a significant factor that supports laryngoscope intubation procedures. That can influence the intubation duration and amount of mechanical trauma besides caused by laryngoscope type. **Objective**: To analyze the effectiveness of using *Macintosh blade* compared to *McCoy blade* in intubation laryngoscopy by Anesthesia Residents. **Materials and Methods:** This research is an experimental study in adult patients who underwent elective surgery at GBPT Dr. Soetomo Hospital. Intubation did by Anesthesia Residents at levels 5-9 using Macintosh or McCoy Laryngoscope and chosen randomly. The data of laryngeal visualization (Cormack Lehane), hemodynamics (blood pressure, pulse), pain scale (qNOX), intubation time length, and pain scale data (VAS) after extubation were taken during intubation laryngoscope. **Result and Discussion:** The study was conducted on 28 samples that met the criteria. Anesthesia Resident's competence levels based on the semester in both groups laryngoscopes were not different (p 0.868). Based on laryngeal visualization data laryngoscopy, the *McCoy*'s *blade* had better visualization with CL 1 at 85.7% of the samples and p-value 0.020. This good visualization makes it possible to speed up the laryngoscope-intubation in the McCoy *blade* group with a significant difference of time compared to the *Macintosh blade* group. Hemodynamic parameters, there were significant differences for hemodynamics increase. In the *Macintosh blade* group, the blood pressure and pulse were significantly increased after laryngoscopy intubation. The pain scale during the intubation procedure, which was rated based on the qNOx score, showed a significant increase in the *Macintosh blade* group with a p-value of 0.003. The postoperative pain scale (VAS) was smaller in the McCoy blade group compared to the Macintosh group (p-value <0.001). **Conclusion:** The ability to use both laryngoscopes at some levels of Anesthesia residents was equally good, and the use of *McCoy Blade* is more effective than *Macintosh Blade* in the intubation laryngoscopy procedure.

Keywords: Anesthesia Residents; Effectiveness; *Macintosh Blade; McCoy Blade;* Medicine; Laryngoscopy; Intubation

ABSTRAK

Pendahuluan: Laringoskopi menjadi salah satu titik kritis dalam proses intubasi dan merupakan suatu trauma mekanik yang memberikan stimulus *noksius* dan dapat mempengaruhi perubahan respon kardiovaskuler, respirasi, dan intrakranial. Kompetensi praktisi merupakan faktor terbesar dalam mendukung tindakan laringoskopi intubasi karena mempengaruhi durasi dan besar trauma mekanik tindakan selain akibat jenis laringoskop yang digunakan. **Tujuan**: Penelitian ini menganalisis efektivitas penggunaan *blade Macintosh* dibandingkan *blade McCoy* pada tindakan laringoskopi intubasi yang dilakukan oleh PPDS Anestesi **Bahan dan Metode:** Penelitian eksperimental pada pasien dewasa yang menjalani operasi elektif di GBPT RSUD Dr.Soetomo. Intubasi dilakukan oleh PPDS Anestesi semester 5-9 menggunakan blade Macintosh atau McCoy yang dipilih acak. Data penelitian yang diambil saat tindakan laringoskopi intubasi, yaitu visualisasi laring (*Cormack Lehane*), hemodinamik (tekanan darah, nadi), skala nyeri (*qNOX*), lama waktu intubasi, dan data skala nyeri (VAS) pasca ekstubasi. **Hasil dan Pembahasan:** Penelitian dilakukan pada 28 sampel yang memenuhi kriteria. Level kompetensi PPDS Anestesi berdasarkan semeter, tidak didapatkan perbedaan yang bermakna pada kedua kelompok laringoskop (p 0.868). Berdasarkan data visualisasi laring (*Cormack Lehane / CL*) saat laringoskopi, didapatkan bahwa *blade McCoy* memiliki CL yang lebih baik, yaitu CL 1 pada 85.7% sampel dan nilai p

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0.020. Melalui visualisasi yang baik , maka kecepatan waktu laringoskopi intubasi kelompok *blade McCoy* lebih singkat secara signifikan dibandingkan kelompok *blade Macintosh*. Terdapat perbedaan bermakna dalam kenaikan hemodinamik, yaitu penigkatan tekanan darah dan nadi pada kelompok *blade Macintosh* setelah tindakan laringoskopi intubasi. Skala nyeri selama prosedur intubasi, dinilai berdasarkan nilai qNOX. dan menunjukkan peningkatan yang signifikan pada kelompok *blade Macintosh* dengan nilai p 0.003. Pada skala nyeri pasca operasi juga menunjukkan perbedaan yang bermakna, dimana angka VAS lebih kecil pada pengguna *blade McCoy* (nilai p <0.001). **Kesimpulan:** Kemampuan penggunaan kedua laringoskop pada beberapa level PPDS Anestesi sama baiknya dan penggunaan *Blade McCoy* lebih efektif dibandingkan *Blade Macintosh* pada tindakan laringoskopi intubasi.

Kata Kunci: PPDS Anestesi; Efektivitas; *Blade Macintosh; Blade McCoy;* Kedokteran; Laringoskopi; Intubasi

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INTRODUCTION

Intubation is the gold standard to secure the airway (1). Laryngoscopy for intubation aims to visualize the anatomy of the larynx and provide illumination of the larynx (2).

Practitioner competence is a significant factor that supports laryngoscope intubation procedures. That can influence the intubation duration and amount of mechanical trauma (3,4).

Some research states that the laryngoscope intubation procedure was done by an experienced anesthetist (5). In experienced hands, 82% of laryngoscopy revealed easy viewing, 16% revealed limited viewing, and 2% revealed complex presentation (1).

The laryngoscopy procedure is one of the critical points in the intubation process because there is a non-oxygenation period during the procedure. This action is a mechanical trauma that provides a noxious stimulation to mechanoreceptors and nociceptors. Then, through the pain pathway, it integrates with the sympathetic system in the spinal cord, brain stem, and center of the brain, providing a neuroendocrine response through reflex responses that affect cardiovascular changes. These changes include hemodynamic responses (increasing blood pressure and pulse, to dysrhythmias) and changes in respiration (laryngospasm and bronchospasm) (6). In addition, this noxious stimulus perceives as pain at the center of the brain (prefrontal cerebral cortex) called sore throat (7).

The author is the anesthesia residents with mid to high competency level, researched to analyze and compare the effectiveness of *Macintosh* and *McCoy blade*s in their use for orotracheal intubation. The comparison of effectiveness assessed was based on visualization, hemodynamic response (changes in blood pressure and pulse), laryngoscopic intubation time, pain scale during laryngoscope intubation, and postoperation sore throat complications.

MATERIALS AND METHODS

Research Design and Sample

This research is an experimental study with Single-Blind Randomized, in the operating room of GBPT Dr. Soetomo Hospital Surabaya. It was held from October 2020 to November 2020, and has received approval from the Hospital Ethics Committee (number 0085 / KEPK / X / 2020). The sample collection technique based on the study population that met the inclusion and exclusion criteria. Twenty-eight subjects were randomly grouped and received the same treatment.

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The inclusion criteria in this research were adult patients (age 18-65 years), PS ASA 1-2, no sign of difficulty airway, 1-2 mallampati score, and 1-5 hours operation time. The research method was explained to the patient's guardian, and if they were willing to sign the informed consent, the patient would be included as the research subject. The exclusion criteria in this study were patients with anatomical defects in the face, neck, and upper airway; difficult airway signs, limited neck movement, cervical spine abnormalities history and injuries, BMI ≥ 30, and surgical procedures in the airway area.

Data Collecting Methods

The datasheets recorded initial data such as gender, age, BMI, operation time length, PPDS competence . Researched parameters such as laryngeal visualization, duration of intubation, laryngoscopy, blood pressure, pulse, qNOX, and pain scale (VAS) then be recorded in the datasheet for further analysis.

Statistical Analysis

The research distribution data was carried out by data normality test using the Shapiro-Wilk test. Data with normal distribution were analyzed by independent t-test, and data with abnormal distribution were analyzed using Mann-Whitney test, while categorical data were analyzed using chi-square test. Statistical analysis was performed by using the Statistical Package for Social Sciences (SPSS) v19 software.

RESULTS AND DISCUSSION

The study involved 28 adult patients with more men than the number of women, which is 18 samples (64.3%) and ten samples (35.7%). The predominant patients age group is 36-45 years (39.3%). Both groups had normal BMI, and the distribution was almost even in the two groups, namely 21.9 in the *Macintosh* user group and 22.05 in the *McCoy* user group. The distribution of the research population and their demographic characteristics are in table 1.

Table 1. Research Subject Demography

Demography Data	*Macintosh*	*Mc Coy*	Percentage	P-Value
Gender				
Male	9	9	64.3 %	1.000*
Female	5	5	35.7 %	
Age (years)				
18-25	1	2	10.7 %	
26-35	4	1	17.9 %	0.170*
36-45	6	5	39.3 %	
46-55	3	2	17.9 %	
56-65	0	4	14.3 %	
BMI	21.9	22	-	0.882**

* Analyzes by *Chi-Square* Test
** Analyzes by *Independent Sample* Test

Practitioner competence is a factor that supports the procedure, which can influence the intubation duration and amount of mechanical trauma. This research was done by anesthesia residents in mid and high-level competence. There wasn't a significant difference in the ratio of residents' semesters in the two groups (p-value 0.868). These factors are shown in Table 2.

Table 2. Factors of Mechanical Trauma in Laryngoscope Intubation

Supporting Factors	*Macintosh*	*Mc Coy*	Percentage	P-Value
Anesthesia Resident Competence (semester)				
5	4	1	17.9	
6	2	4	21.4	
7	1	2	10.7	
8	3	7	35.7	0.868*
9	4	0	14.3	
Length of Operation (second)	232.5	205.00	-	0.158

* Analyzes by *Man-Whitney* Test

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Hemodynamic data (blood pressure and pulse) is the cardiovascular response after mechanical trauma due to laryngoscope intubation. Moreover, The CONOX tool also monitored the changes in consciousness degree (qCON) and pain scale (qNOX) during the procedure. The data presented in table 3.

Table 3. Hemodynamic Parameters, qCON, and qNOX After Intubation

Parameters	Group Mean Value		P-value
	McCoy	*Macintosh*	
SBP (mmHg)	107.86	116.86	0.002**
DBP (mmHg)	63.14 ± 5.112	70.21 ± 7.224	0.006**
▲N (x/minute)	3.86 ± 4.538	10.36 ± 3.992	< 0.001**
qCON	47.14 ± 3.959	50.07 ± 3.772	0.056*
qNOX	48.57 ± 3.322	53.07 ± 3.970	0.003*
▲qCON	10.21	18.79	0.006*
▲qNOX	8.99	20.11	< 0.001*

* Analyzes by *Mann-Whitney* Test
** Analyzes by *Independent Sample* Test

The laryngeal visualization during laryngoscope intubation greatly influences the research process and the data result. In the *McCoy blade* user group, the laryngeal visualization was mostly in CL 1 with 85.7% samples, while in *Macintosh blade* users, the most laryngeal visualization was CL 2 with 64.3% samples. The data presented in table 4.

Table 4. Laryngeal Visualization (Cormack Lehane)

Laryngeal Visualization	Group		Total	P-Value
	McCoy (n=14)	*Macintosh* (n=14)		
CL 1	12 85.7%	5 35.7%	17 60.7%	0.020*
CL2	2 14.3%	9 64.3%	11 39.3%	
Total	14 100%	14 100%	28 100%	

* Analyzes by *Chi-Square* Test

This research also assessed the other parameters such as duration of intubation and pain scale after extubation. The group differences significantly in intubation duration between *McCoy blade* users and *Macintosh blade*s with a p-value <0.001. In addition,post-extubation pain, which is considered a sore throat, is measured using a scale named VAS (Visual Analogue Scale). The details of the data are shown in table 5.

Table 5. Duration of Intubation and VAS

Parameters	Group		P-Value
	McCoy (n=14)	*Macintosh* (n=14)	
Intubation Duration	8.14 seconds	20.86 seconds	< 0.001
VAS	2	9	< 0.001*

* Analyzes by *Mann-Whitney T*est

Intubation is widely used in daily practice (surgery under general anesthesia), emergencies, intensive care, and trauma (1). It is performed at all ages by medical personnel or paramedics who have the skills to perform these procedures.

In this research, the distribution of gender between the two study groups was evenly distributed (p-value > 0.05). There were more men than women in this study because significantly more men underwent surgery. Then, the age characteristics of the two study groups were evenly distributed, with an average age of 41 years old and still in the productive period with high mobility.

The laryngoscope procedure is a critical point because it is a mechanical trauma that becomes a noxious stimulus. That contributes to changes in cardiovascular and respiration, primarily through the reflex response that occurs (6).

Practitioner competence is a significant factor that supports laryngoscope intubation

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procedures. The competence can influence the intubation duration and amount of mechanical trauma. Several studies suggest that laryngoscope intubation procedures are performed by experienced anesthesiologists (6).

Hamonangan (8) states that one point of intubation management is the preparation of doctors who have the skill and ability to perform intubation. This intubation management is also necessary because it can affect all parameters in the study related to the noxious stimulation of laryngoscope intubation procedures. Noxious stimuli will produce a neuroendocrine response. This can affect hemodynamic responses, such as blood pressure and pulse increased, to dysrhythmias (6,9). This response can cause fatal conditions in some cases, i.e., patients with the age level of children or the elderly, and patients with the severe comorbid disease, such as heart and blood vessel disorders patients (10).

From the research result, the *Macintosh blade* group has significant hemodynamic changes. This result showed a similar outcome from the previous study by Aggarwal *et al*., (11). The hemodynamic increases are more significant in the *Macintosh blade* user group than the *McCoy blade* user group.

According to Dorsey *et al*., (6), the competency of executing the intubation will affect the laryngeal visualization and make it easier for intubation so that the duration of intubation is shorter and side effects from mechanical trauma lesser. Based on the anasthesia resident competency test on performing intubation laryngoscopy, there is no significant difference. We can assume that the trauma that can affect the hemodynamic response in the two-*blade* groups is not different significantly.

There was a significant difference between the two *blade* groups that showed in laryngeal visualization based on Cormack Lehane (CL), where the *McCoy blade* group had more CL 1 (85.7%) than the *Macintosh blade* group with CL 2 (64.3%). This result was also obtained in Nadkarni *et al*., (4) where the laryngeal visualization of the *McCoy blade* group was better. The study of Tewari et al., (12) in 2019,showed an increase in epiglottis removal by 70°, making visualization more accessible, and head-neck manipulation not required during laryngoscope intubation.

Furthermore, in the research of Bharti et al., (13), it was found that there was a decrease in visualization based on CL by one degree. Thus, better visualization of the larynx is obtained and can facilitate the laryngoscope intubation procedure in patients with cervical spine abnormalities (limited neck mobilization).

The duration of intubation can also be related to good visualization of the larynx that is present. In a study conducted by Yildirim *et al*., (14) in three patient group models, the first group is patients with the normal airway. The second is patients with manual cervical stabilization.The third is patients with a normal airway that uses a neck collar. From these experiments, the study gave significantly different results. These results indicate that the *McCoy blade* user group had a shorter incubation time.

However, this result is different from the research Akbarzadeh *et al*., (15) that found that the intubation time was shorter in the *Macintosh blade* group, 11.18 ± 28.44 compared to the *McCoy blade* group, namely 14.3 ± 34.47. Then, the research of Aggarwal *et al*., (11) also obtained a shorter intubation duration in the *Macintosh blade* user group which was influenced by the tool's user experience.

Hemodynamic changes are also influenced by the laryngoscope intubation

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length due to the mechanical trauma duration. Yildirim *et al*., (14) and Altun *et al*., (16) research also explained that the intervention period of laryngoscope intubation could affect the changes in hemodynamic response. Therefore, a shorter intubation time is expected to minimize the risk of desaturation. This research also found that the intubation duration of the *McCoy blade* group was faster, with the fastest was 12 seconds and the longest was 20 seconds (mean time 16.43 seconds). Meanwhile, Haidry *et al*., (17) and Buhari *et al*., (18) stated that there is no evidence of hemodynamic changes in patients using *Macintosh blade*s and *McCoy blade*s due to short-lived procedures.

The duration of the procedure is also influences the patient's pain scale because it is related to mechanical trauma duration exposure / noxious stimulus. Dorsey *et al*., (6) further explained that ischemia in the tissue attached to the ETT could happen due to the cuff pressure in the area. The longer the pressure occurs, the broader / heavier the ischemic degree. Based post mortem studies conducted on laryngeal and tracheal specimens, there were pathological cell changes after intubation, including epithelial damage, glottic hematoma, glottic edema, submucosal damage, and granuloma ulcers at the contact site (19).

Moreover, ischemia, cell damage, and stimulation by mechanical trauma can cause the release of inflammatory mediators. The inflammatory mediator will then become a noxious stimulus which is transmitted to the central nerve to the brain and is perceived as pain by Thalamus (7,20).

Significant differences also showed in pain scale data (qNOX) during the laryngoscope intubation. The *McCoy blade* has a hinged tip that is useful to lift the glossoepiglottic higher to make a better laryngeal visualization and ease the intubation procedure. As such, less mechanical trauma and noxious stimulation are generated. This will reduce the effect of the hemodynamic response and minimize the pain scale (21).

Another pain scale is VAS, which estimated sore throat in this research. The research data obtained showed that the VAS of the *McCoy blade* group was lower (8.75 mm) than the *Macintosh blade* group (20.25 mm). Similar to the research by Altun *et al*., (16), where the VAS value of the *Macintosh blade* group was higher than the *McCoy blade* group. However, the patient's throat discomforts did not last long. The pain only occurs for few hours to < 24 hours and is usually limited to mild-moderate pain, which disappears without any specific therapy.

In this research, the length of operation was evenly distributed with a value of p = 0.158. The mean of the surgery in both groups was about 218 minutes. So it is hard to assume that the length of operation influenced the postoperative sore throat differences within two *blade* groups.

Another factor that also affects the duration of intubation is BMI (obesity degree). BMI is related to the changes in airway visualization due to the flab (fat deposit) on the face and neck. It can also affect study parameters changes, such as hemodynamics, length of intubation time, visualization, and pain scale (12).

From this study, there was no significant difference in BMI score between the two *blade* groups with a p-value>0.05 = 0.882. Obesity can affect the length of intubation time because it is associated with manipulation during laryngoscopy.

CONCLUSION

The competence of mid and high-level anesthesia residents in intubation using *McCoy*

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blade and Macintosh blade is equal. The other result of this research is that the use of the *McCoy blade* is more effective than the *Macintosh blade*. *McCoy blades* can provide better laryngeal visualization, less hemodynamic fluctuation (blood pressure and pulse), pain scale (qNOx) during laryngoscope intubation, and minimize sore throat pain postoperative.

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Original Article

ACCURACY COMPARISON OF ENDOTRACHEAL TUBE (ETT) PLACEMENT USING CHULA FORMULA WITH MANUBRIUM STERNAL JOINT (MSJ) FORMULA

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ABSTRACT

Introduction: Intubation mistakes, such as ETT malposition, will result in serious complications. Endobronchial intubation can cause pneumothorax and contralateral lung collapse (atelectasis). On the contrary, superficial ETT could increase the risk of being released easily, leading to desaturation or even cardiac arrest. A shallow ETT position could cause the compression of the vocal cord and laryngeal nerve by ETT's cuff. An optimal position can be reached if the cuff position is 1.5-2.5 cm under the vocal cord and the tip is 3-5 cm above the carina. Several methods of ETT depth measurement based on airway length data can be an alternative, especially during the COVID-19 era, where the use of a stethoscope to check ETT depth is limited. **Objectives:** To analyze the accuracy of ETT depth placement using Chula and MSJ formula. **Methods and Material:** We conducted the prospective comparative analytic research on 50 patients who had elective surgery in GBPT operating room at Dr. Soetomo Hospital Surabaya. The research data during the intubation and FOL (Fyber Optic Laryngoscope) from each patient were height, MSJ length, initial ETT length, the distance of carina-ETT tip, the distance of cuff-vocal cord, and final ETT length. **Result and Discussion:** In the Chula formula group, the average patients' height was 160.60cm ± 9.738 for men and 157.76 cm ± 8.604 for women. The average MSJ length was 20.28 cm. The application of the Chula formula is more accurate because ETT revision was carried out in only 8.0% of the samples, with an average revision is 0.04. On the other hand, the ETT revision with an average of 0.868 on the MSJ formula group was conducted in 84% of the samples. This research also found a linear correlation between increasing ETT depth and body height. **Conclusion:** Applying the Chula formula to measure the ETT depth for Indonesian (Javanese) people is more appropriate than the MSJ formula.

Keywords: *Chula* formula; ETT depth accuracy; FOL (Fyber Optic Laryngoscope); *MSJ* Formula; Medicine

ABSTRAK

Introduksi: Kesalahan dalam intubasi, seperti malposisi ETT, akan mengakibatkan komplikasi yang serius. Intubasi endobronkial dapat menyebabkan pneumothoraks dan kolaps paru kontralateral (atelektasis). Sebaliknya, ETT yang terlalu dangkal meningkatkan risiko mudah terlepas, sehingga menyebabkan desaturasi sampai dengan *cardiac arrest*. Posisi ETT yang dangkal dapat menyebabkan kompresi pita suara dan saraf laringeus rekuren oleh balon ETT. Posisi optimal jika balon berada 1.5-2.5 cm di bawah pita suara dan ujung distal berada 3–5 cm di atas *carina*. Beberapa cara pengukuran kedalaman ETT berdasarkan data panjang jalan napas dapat menjadi alternatif terutama di era covid karena penggunaan stetoskop untuk pemeriksaan ETT menjadi terbatas. **Tujuan**: Penelitian ini menganalisis ketepatan penempatan kedalaman ETT menggunakan formula *Chula* dengan formula *MSJ*. **Bahan dan Metode:** Kami melakukan penelitian analitik komparatif prospektif pada 50 pasien yang mengikuti operasi elektif di kamar operasi GBPT RSUD Dr. Soetomo Surabaya. Data penelitian yang diambil pada masing-masing sampel saat tindakan intubasi dan FOL (*Fyber Optic Laryngoscope*), yaitu tinggi badan, panjang *MSJ*, panjang ETT awal, jarak *carina*-ujung ETT, jarak *cuff-vocal cord*, dan panjang ETT akhir. **Hasil dan Pembahasan:** Didapatkan rerata tinggi badan kelompok formula *Chula*, yaitu 160.60 cm ± 9.738 (laki-laki) dan 157.76 cm ± 8.604 (perempuan), serta rerata panjang *MSJ* 20.28 cm. Aplikasi formula *Chula* lebih akurat karena revisi ETT hanya dilakukan pada 8.0% sampel dengan rerata revisi 0.04. Sedangkan formula *MSJ*, revisi ETT dilakukan pada 84% sampel, dengan rerata revisi 0.868. Dalam penelitian ini juga ditemukan korelasi

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linier penambahan kedalaman ETT dengan penambahan tinggi badan. **Kesimpulan:** Penggunaan formula *Chula* untuk mengukur kedalaman ETT pada orang Indonesia (suku Jawa) lebih tepat dibandingkan formula *MSJ*.

Kata Kunci: Formula *Chula*; Ketepatan Kedalaman ETT; FOL (*Fyber Optic Laryngoscope*); Formula *MSJ*; Kedokteran

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INTRODUCTION

Intubation is the gold standard to secure the airway. Endotracheal tube (ETT) ideal depth is the concern in securing the position of ETT. The malposition of ETT could cause serious complications. ASA research project reported that ETT malposition incidents are related to respiratory disorders in 2% of the adult population, and 85% of them suffered brain damage (1,2).

Deep ETT will touch the carina and stimulate sympathetic response and lead to tachycardia, hypertension, or bronchial spams. Endobronchial intubation also causes pneumothorax and contralateral lung collapse (atelectasis). In reverse, shallow ETT can increase the risk of ETT being detached, leading to desaturation to cardiac arrest. The superficial position of ETT can result in compression and trauma of vocal cords and laryngeal nerves by ETT's cuff (2,3). Ideal ETT position of the ETT cuff is 1.5-2.5 cm below the vocal cords, and the distal end of ETT is 3-5 cm above the carina (4).

Objectively, there are several methods of measuring the ETT depth based on airway length data. Research by Lee *et al*., (5) on population in Korea used the data to measure the upper incisor-MSJ distance with the head extension position. This study found a significant linear correlation with airway length that can be used to determine the ideal ETT depth. The correlation formula is {0.868 x (incisor-MSJ distance, head extension position) + 4.26}. While the ETT length was obtained by subtracting 3 cm from the MSJ formula (6).

Meanwhile, another measurement method, found in a study in Thailand in 2005, showed that body height correlates with the optimal depth of ETT. Based on this connection, the Chula formula was found ((height in cm: 10) + 4)). The study mentioned that the result of tip location was at least 3cm above the carina, which was confirmed by using FOB (4,7).

Examination by using FOB can provide a direct visualization to measure the accuracy of ETT depth (8,9). In this study, the use of FOB was also utilized to measure the actual ETT position, to determine the ETT's depth using the Chula formula compared to the MSJ formula (measuring the incisor-MSJ distance). These two measurements formula are alternative ways of determining the ETT depth individually (10).

MATERIALS AND METHODS

Research Design and Sample

This research is a prospective comparative analytic research on patients who had elective surgery in the GBPT operating room of Dr. Soetomo Academic Hospital, Surabaya, in November-December 2020. The Hospital Ethics Committee has approved this study. The sample collection technique was obtained from the study population that met the inclusion and exclusion criteria. In a total of 50 samples, all research subjects were randomly allocated into groups and received the same treatment.

This research's inclusion criteria are adult patients (age 18-65 years old) and PS ASA 1-2. The research method was explained to the

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guardian, and should they were willing to sign the informed consent, and the patient would be included as a research subject. The exclusion criteria are patients with anatomical defects in the face, neck, and upper airway; difficult airway sign, Mallampati 3-4, limited neck movement, history of cervical bone abnormalities and injuries, Trendelenburg position, BMI ≥ 30, abdominal distension, comorbid pulmonary disorders, and surgery in the airway area.

Data Collecting Methods

Initial data such as gender, age, height, MSJ length, BMI, and PPDS competency were recorded in datasheets. Then, parameters of ETT length, cuff-vocal cord distance, carina-ETT tip distance, and ETT revision will be recorded in datasheets for further analysis.

Statistical Analysis

The research distribution data was carried out by data normality test using the Shapiro-Wilk test. Normally distributed data were analyzed using an independent t-test, and abnormal distribution data were analyzed using the Mann-Whitney test. In contrast, the categorical data were analyzed by using the Chi-square test. Statistical analyses were performed by using the Statistical Package for the Social Science (SPSS) v19 software

RESULTS AND DISCUSSION

The research involved 50 adult patients with the same number of men and women, 25 samples (50%), and 25 samples (50%) perspectively. On age characteristics, the distribution was even in both research groups with an average age of 40. The two groups had normal BMI, and the distribution of the two groups was almost average, with the value of the Chula formula group was 23.15 ± 3.849, and the MSJ formula group was 23.09 ± 3.283.

Moreover, the height included in the Chula formula component was evenly distributed in both groups. The average height of both groups was 160.60 cm ± 9.738 for Chula and 157.76 cm ± 8.604 for the MSJ formula group. Besides, the average length of the MSJ group was 20.28 cm. The distribution of the study population and their demographic characteristic are detailed in table 1.

Table 1. Research Subject Demography

Demographic Data	Chula	MSJ	Percentage	P-value
Gender				
Male	13	12	50 %	0.777
Female	12	13	50 %	
Age				
18-25 yo	3	6	18.0 %	
26-35 yo	4	7	22.0 %	0.539
36-45 yo	7	4	22.0 %	
46-55 yo	7	5	24.0 %	
56-65 yo	3	3	14.0 %	
BMI	23.15± 3.849	23.09± 3.283	-	0.882
Height				
140-150 cm	5	4	18	
151-160 cm	8	12	20	0.720
161-170 cm	8	6	14	
> 170 cm	4	3	7	

Next, the initial ETT length difference was ± 1.18 cm shorter in the MSJ formula group. ETT revision that was carried out to the Chula formula group was 0.04, while the MSJ group was 0.868. By this result, it can be concluded that the ETT revision score between both groups was significantly different ($p<0.001$). The ETT analysis data will be displayed in table 2.

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Table 2. ETT Analysis Result

ETT length (cm)	Group		P-Value
	Chula (n=25)	MSJ (n=25)	
Initial ETT Median (Min-Max)	20.0 (18 – 21.5)	19.0 (17.5 – 21.5)	< 0.001
Final ETT Median (Min-Max)	20.0 (18.5 – 21.5)	19.5 (18.0 – 21.5)	0.088
ETT Revision Score Median (Min-Max)	0.0 (0.0 - 0.5)	1.0 (0.0 – 1.5)	< 0.001
ETT Average Length Mean ± Standard Deviation	20.16 ± 0.921	19.72 ± 0.867	0.084

Dominant height in this study was group height of 151-160 cm and 161-170 cm. There was a correlation between ETT depth and height that the increase in ETT length was in line with the increase of height. The analysis data will be shown in table 3.

Table 3. ETT Depth Analysis and Its Comparison with Height

Height (cm)	ETT Length Mean Median ± Standard Deviation	P-Value	r-Value
140 – 150 (n=9)	19.0 ± 0.546	<0.001	0.805
151 – 160 (n=20)	19.5 ± 0.343		
161 – 170 (n=14)	20.5 ± 0.385		
> 170 (n=7)	21.36 ± 0.244		
Total (n=50)	20.0 ± 0.913		

ETT position was confirmed by using FOB. The direct measurement from the carina-ETT tip and cuff-vocal cord distance were measured precisely. In both groups, we found the same problem occurred: the shallow ETT position with the distance of CF-VC < 1.5 cm. Only two samples needed revision in the Chula formula group, while the MSJ formula group had 21 samples that needed to be corrected because the ETT position was shallow. The analysis data of the ETT position will be shown in table 4.

Table 4. ETT Optimal Position Analysis

ETT Position	Chula (%)	MSJ (%)	P-Value
C-T Distance			
Shallow (< 3cm)	0 (0.0%)	2 (8.0%)	0.490
Precise (3-5 cm)	25 (100%)	23 (92%)	
Deep (>5 cm)	0 (0.0%)	0 (0.0%)	
CF-VC Distance			
Shallow (<1.5 cm)	2 (8%)	19 (76%)	
Precise (1.5-2.5 cm)	23 (92%)	5 (20%)	<0.001
Deep (>2.5 cm)	0 (0.0%)	1 (4%)	
Combined Distance			
Shallow C-T & Deep CF-VC	0 (0.0%)	1 (4%)	
Shallow C-T & Preicse CF-VC	0 (0%)	1 (4%)	
Precise C-T & Shallow CF-VC	2 (8%)	19 (76%)	<0.001
Precise C-T & Precise CF-VC	23 (92%)	4 (16%)	
ETT Revision	2 (8%)	21 (84%)	<0.001

The ETT cuff that we utilized in this research was 7.5 for men and 7.0 for women. The gender between the two study groups was evenly distributed with a p-value > 0.05; this is a coincidence because the samples were the population that met the inclusion and exclusion criteria regardless of their gender.

In the study of Mukherjee *et al.*, (9), the number of men was higher than women; however, this was not significant in the parameter test. Then, Lal *et al.*, (11)'s study found a correlation between ETT depth and

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height related to gender, yet it was not significant except in some extreme cases. Herway *et al*., (12) found a length difference of trachea, namely 0.7 cm longer for men. Research conducted by Fatma, (13) on body anthropometry found that men have a higher body posture than women.

The comparison of age characteristics between the two groups in this study was not significant. The average age was 40 years in this study, with the range of age was 18-65 years old. This study was conducted in patients age > 18 years old because airway anatomical structure involves the size of the head, nose, tongue, epiglottis, larynx, trachea, bronchus (14).

In addition, with that range of age, the criteria of mild-to-moderate- health condition (PS ASA 1 and 2) was easy to find. While in old age, the usually found condition are patients with severe illness (PS ASA > 2) or with the lung problem due to the lung physiology changes with age. PS ASA >2, thus it can shorten the apnea time when the ETT depth examination is carried out using FOL.

Based on geriatric anthropometry, men and women decreased by 2.7 cm and 4.22 respectively, usually associated with body posture, osteoporosis, spinal damage, and spinal abnormalities (kyphosis, scoliosis, and lordosis), affecting the height factor in measurement (13).

Another characteristic, which is obesity, can be a problem that complicates the laryngoscope intubation procedure because of huge anatomical changes in the face and neck due to the fat accumulation in that area. It is determined by body mass index (BMI). BMI value was evenly distributed between two formula groups ($p > 0.05$).

The research conducted by Busetto *et al*., (15) explained that there was no correlation between length changes in the pharyngeal area with BMI increase. However, in research by Lin et al., (16), a strong correlation was found between the increase of BMI and the increasing length of the hyoid area, which will explain that BMI affects the upper airway length. However, in the study by Varshney *et al*., (4), there was no correlation between BMI airway length.

This research uses a comparison of two formulas in determining ETT optimal depth. The first formula, the MSJ formula, introduced by Lee *et al*., (5), measures airway length based on the distance between incisors-MSJ (head extension). This formula is not correlated with height but with the airway size, which is based on the distance between the incisor-carina (head in neutral position) that was measured by using the FOB.

The other formula is the Chula formula, proposed by Techanivate *et al*., (7). This formula correlates the length of the airway with the height to determine the length of ETT to acquire precise depth according to the criteria, namely 3-5 cm above the carina and 1.5-2.5 cm below the vocal cords. Research by Lal *et al*., (11) also mentioned that the ETT depth would linearly increase with the individual height. Likewise, this study also found that the addition of ETT depth correlates with body height.

In the study, the height was evenly distributed between the two formula groups. The average height of men was 166.4 cm, and the average height of women was 151 cm. This result is similar to the study conducted by Techanivate *et al*., (7) in the Thai population. The average height of the men and women population was 166.1 cm and 156.1 cm,

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respectively; this is similar because both populations are Asian populations.

Further, both in these two studies, it was found that men are taller than women. This result can be due to the differences in posture and activity between them. According to the study by Fatma, (13), the body posture anthropometric measurement of adult men consistently higher than adult women, influenced by the hormonal and the stature of each gender.

Ronen *et al*., (17) stated that the height in those two genders is not much different before puberty, and it will be different after that. It affects the development of the upper airway, where men's will be longer than women's.

The fatal complications can result from the malposition of the ETT. Shallow ETT can result in spontaneous extubation of the head movements and cause irritation or trauma to the vocal cords, leading to irritation, inflammation, or vocal cord ischemia. Deep ETT can cause ETT to enter one lung, occurring oxygenation disorder, leading to atelectasis and pneumothorax (14,18).

Introduced by Lee *et al*., (5), the MSJ formula is based on the measurements between incisor-MSJ (head extension position), which is one way to measure ETT depth. This formula is formulated based on its correlation with the airway length (incisor-carina. Mukherjee *et al*., (9) conducted a study on the Indian population to support Lee's findings that the incisor-MSJ distance describes the airway length, although the correlation is not as strong as in Lee's study. Cherng *et al.,* (19) also found a correlation between sternal length and tracheal length, but not the incisor-carina length.

MSJ formula was found based on the calculation in the Korean population, which includes Asia as well, but when applied in this study, there was a significant difference, p< 0.001 (5). In this group, many ETT positions were found to be not ideal; there were 21 samples (84%) shallower in ETT depth, thus needed revision to obtain the right distance, ETT tip-carina 3-5 cm and cuff-vocal cord 1.5-2.5 cm (4,20).

In Lee *et al*., (5) research data, the Korean population's average height was higher than the Indonesian population, namely 171 cm for men and 158 cm for women. However, in this study, more shallow ETT positions were found.

On the other hand, the Chula formula was formulated using the height anatomical markers. Several studies also support the correlation between height and airway length, researched by Varshney *et al*., (4) with the Indian population and Gomez *et al*., (2) study in the Colombian population. They found the correlation of height with the airway length.

This research uses the Chula formula as the second formula to measure ETT depth, with mean ETT depth found was 20.62 cm for men and 19.2 cm for women. The result of this study are close with the results of Techanivate *et al*., (7) study in Thailand population with the mean length of men and women ware 20.8 cm and 19.6 cm. However, this result is much different from European ethnicity, which is in several studies found that the length of the ETT to be greater than the Asian population, namely 23 cm for men and 21 cm for women, which affected by the posture of Europeans, which is bigger and taller (11).

Inferencing the Chula and MSJ formula, which are both used in the Asian population, it can be concluded that the Chula formula by Techanivate *et al*., (7) is more relevant to the Indonesian population. The ideal ETT position was found more in the Chula formula group, namely 23 samples (92%) with precise C-T

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and CF-VC distance, while two samples (8%) with shallow CF-VC distances (< 1.5 cm) that require ETT revision. This research also found a correlation between body height and ETT depth, as in the Techanivate study.

CONCLUSION

The Chula formula is more accurate in determining the accuracy of the ETT depth for the Indonesian population than the MSJ formula. This research also found a correlation between the addition of ETT depth and the increase in body height.

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Original Article

VALIDITY OF URINE SYNDECAN-1 AS A PREDICTOR OF ACUTE KIDNEY INJURY IN PEDIATRIC SEPSIS PATIENTS

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ABSTRACT

Introduction: AKI (Acute Kidney Injury) complications in sepsis patients generally occur 24 hours after admission to ICU. Creatine Serum Concentration is a standard parameter to diagnose AKI. Unfortunately, the changes in creatine serum concentration will only be seen several days after the decrease of renal function to 50%. The low detection ability has been linked with time loss before preventive therapy is commenced. Furthermore, this instigates the need for biomarkers to ensure early detection. **Objective:** This study aimed to identify cut-off points of urine syndecan-1 and to measure the prediction ability of urine syndecan-1 towards the AKI occurrence in pediatric sepsis patients. **Materials and methods:** This study was a prospective cohort study performed at a single center in Dr. Soetomo General Hospital, Surabaya. The inclusion criterion was all children admitted to the resuscitation room from October until December 2019. Furthermore, urine sampling is carried out at 0, 6, 12, and 24 hours for a syndecan-1 urine examination, and every procedure performed on the patient will be recorded. This action were continued up to the third day and aimed to evaluate some factors related to AKI at 48-72 hours of admission. **Result and Discussion:** Out of 41 pediatric sepsis patients, 30 patients fulfilled the inclusion criteria and 57% had AKI. The value of urine syndecan-1 at hour-0 and hour-6 was significantly featured a cut-off point. **Conclusion:** The value of urine syndecan-1 at hour-0 and hour-6 are valid parameter to predict the occurrence of AKI grade 1, 2, and 3 in pediatric septic patients at 48-72 hours after their hospital admission. The best cut-off value of urine syndecan-1 at the 0th hour was 0.67 ng/ml.

Keywords: Acute Kidney Injury; Creatinine Serum; Medicine; Pediatric Septic Patient; Predictor of AKI; Urine Syndecan-1

ABSTRAK

Pendahuluan: Komplikasi acute kidney injury (AKI) pada pasien sepsis umumnya terjadi 24 jam setelah masuk ICU. Konsentrasi kreatinin serum merupakan parameter yang umum digunakan untuk mendiagnosis AKI. Sayangnya, perubahan konsentrasi kreatinin serum ini akan terlihat setelah beberapa hari saat sudah terjadi penurunan 50% fungsi ginjal. Kemampuan deteksi yang rendah ini mengakibatkan upaya pencegahan AKI lebih dini tidak dapat dilakukan. Oleh sebab itu perlu dicari biomarker yang memiliki kemampuan deteksi AKI lebih dini. **Tujuan:** Penelitian ini bertujuan untuk mencari *cut off point* kadar syndecan-1 dalam urine (urine syndecan-1) dan mengukur kemampuan sebagai prediktor kejadian AKI pada pasien sepsis anak. **Bahan dan Metode:** Penelitian ini merupakan studi kohort prospektif yang dilakukan di RSUD Dr. Seotomo Surabaya. Kriteria inklusi adalah semua anak yang dirawat di ruang resusitasi mulai Oktober hingga Desember 2019. Selanjutnya pengambilan sampel urin dilakukan pada jam 0, 6, 12, dan 24 jam untuk pemeriksaan urin sindekan-1, dan setiap prosedur yang dilakukan pada pasien akan dicatat. Kegiatan Ini dilanjutkan sampai dengan hari ketiga dan bertujuan untuk mengevaluasi faktor-faktor yang berhubungan dengan AKI pada 48-72 jam setelah masuk rumah sakit. **Hasil dan Pembahasan:** Dari total 41 pasien anak sepsis, 30 memenuhi kriteria inklusi, dan 57% mengalami AKI. Kadar syndecan-1 dalam urin pada jam-0 dan jam-6 secara signifikan menggambarkan *cut off point*. **Kesimpulan:** Kadar syndecan-1 dalam urine pada jam-0 dan jam-6 merupakan parameter yang valid untuk memprediksi kejadian AKI grade 1, 2, dan 3 pada pasien sepsis anak dalam kurun 48-72 jam setelah masuk rumah sakit. Nilai *cut-off* terbaik kadar syndecan-1 dalam urine pada jam ke-0 adalah 0,67 ng /ml

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Kata kunci: *Acute Kidney Injury*; Serum Kreatinin; Kedokteran; Pasien Sepsis Anak; Prediksi AKI; Urin Sindekan-1

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INTRODUCTION

AKI (Acute Kidney Injury) is one of the complications reported in sepsis patients, often related to poor outcomes and mortality. Based on a global study, this challenge occurs in a fifth of pediatric cases (1), and sepsis generally appears within 24 hours of admission to the ICU (2). In current clinical practice, AKI diagnosis involves the measurement of creatinine serum concentration. However, this parameter barely changes until several days, when about 50% of kidney function has lost. Therefore, the time to perform preventive therapy is not available due to low detection ability (3); hence biomarkers for early recognition are needed.

Sepsis disturbs oxygen delivery within the microcirculation that leads to a possible decline inflow, and other diffusion disorders, resulting from edema and organ inflammation. Despite the poor understanding of the exact consequences from this modifications, sepsis increases the expression of inflammatory cytokines and leukocyte activity, subsequently causing a capillary and micro-thrombus blockage. This leads to reactive oxygen species production and induction of nitric oxide synthase which responsible for further damages in the endothelium and glycocalyx, affiliated with structural and functional changes (4–6). The presence of glycocalyx in the kidney is an early indicator of microcirculation disorders during sepsis, and the degradation process further contributes to the reported symptoms (7).

The endothelial cell surface is coated with a carbohydrate-rich layer, featuring an average thickness of 0.1 to 2 mm. The endothelial cell surface consists of hyaluronic acid (HA) string, heparan sulfate (HS) chain, and about 50-90% endothelial glycosaminoglycans, consists of two proteoglycan families of syndecan and glypican. Furthermore, the unique structural location provides a passive barrier to water and solute transport (regulation of vascular permeability) and interactions between circulatory and endothelial cells (regulation of leukocyte trade). The site also functioned as a sensor of mechanical strength in terms of voltage and pressure, protects cell surface receptors, and prevents receptor hyperactivation. However, this structure is vulnerable, with a tendency to degrade under the influence of various stressors, including endotoxins, ischemia/hypoxia/reperfusion, and oxidative stress. Some studies detect the change in 20 minutes to 6 hours post-insult (8,9).

Syndecan-1 is the main constituent of endothelial glycocalyx (a protective layer luminally covering the endothelium) measured in plasma as a biomarker of possible damage. However, the compound is also expressed in renal tubular cells. Studies have shown the ability to limit kidney damage after ischemia-reperfusion injury and promote tubular damage recovery; hence extensive expression is implicated in kidney injury (10–12). Subsequently, there is a damage in glomerular endothelium, known to perform filtration functions. This barrier destruction caused the release of syndecan-1, which will be detected in urine (12).

The mechanism of kidney damage reported in sepsis patients is related to changes in renal tubular epithelial cells. Besides, the initiation phase is characterized by a decline in renal blood flow to levels that are affiliated

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with cellular ATP depletion, followed by injury and acute tubular epithelial cell dysfunction. Moreover, renal ischemia in vivo rapidly induces several structural and functional changes in renal proximal tubular epithelial cells, and the extent depends on the severity and duration of ischemic injury. These changes usually fail to kill cells but interfere with renal tubular epithelial and endothelial blood vessel cells' ability to maintain normal kidney function (5,6).

MATERIALS AND METHODS

Study Design, Setting, and Patient Selection

This research was a prospective cohort study performed at a single center in Dr. Soetomo General Hospital, Surabaya. The inclusion criterion was all children admitted to the resuscitation room from October to December 2019. Therefore, the consented patients were enrolled into the study protocol: pediatric patients aged over three months - 18 years with a suspected sepsis and septic shock diagnosis, assessed according to the PELOD-2 score criteria by Consensus on Sepsis Management in Pediatrics. However, the exclusion criteria were patients with 1) pre-existing kidney disease, 2) pre-existing heart disease, 3) malignancy, intoxication history, infection, 4) sepsis diagnosed by a previous hospital. 4) PELOD-2 score < 7.

Data Collection and Procedures

The patient's demographic data and medical history were evaluated on admission into the resuscitation room. According to the guidelines for sepsis treatment, a standard protocol for proper handling was carried out(13). The amount of fluid entering and leaving was observed, and the researcher quantitatively evaluated the urine every hour. Furthermore, vasopressors, inotropic drugs, and ventilator applications were noted. This procedures were followed by standard laboratory tests and repeated daily laboratory examinations to determine the occurrence of AKI up to the third day. Also, PELOD-2 and PRISM scores were assessed to stratify the disease severity.

Biomarker Measurement

Urine syndecan-1 examination uses an ELISA kit produced by ELABSCIENCE® with catalog number E-EL-H1298. In addition, the detection distance was 0.16-10 ng / ml, with sensitivity of 0.1 ng / mL, and variation coefficient of <10%. The assessment process was performed four times, from admission into the resuscitation room, the 3rd, 6th, 9th, 12th, 15th, 24th, to 27th hours. Also, 2 ml of new urine was collected from the catheter to obtain the appropriate sample.

Outcome

The primary study output includes the occurrence of AKI in 48 to 72 hours after hospital admission, based on the Kidney Disease Improving Outcomes (KDIGO) definition (4). The primary study output inferred this result because of the increased of serum creatinine levels, and stage 1 AKI has defined as 1.5-1.9 times the initial value, or 0.3 mg / dL increase in 48 hours. Furthermore, stage 2 is characterized by up to 2-2.9 times upsurge from the primary value and three times for stage 3. Based on the urine output, the respective values were <0.5 ml / KgBB / hour for 6-12 hours, <0.5 ml / KgBB / hour for >12 hours, and <0.3 ml / kg / hour for 24 hours or anuria for 12 hours (4).

Statistical Analysis

Continuous variables were compared using the t-test or the Mann-Whitney test, while the categorical variables were evaluated using the Chi-Square or Fisher's exact test. Subsequently, this study performed descriptive analysis, and the cut-off determination used the ROC curve, where the AUC ascertains validity and Younden's Index verifies the best cut-off from

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others. Furthermore, sensitivity, specificity, positive and negative predictive values, and positive and negative likelihood ratios were calculated. This was followed by the Kappa association test and the Mc Nemar comparison test.

RESULTS AND DISCUSSION

This research included forty-one participants, and 11 excluded because death was reported in less than the first 24 hours. Based on the final analysis results, 30 patients were selected after fulfilling the inclusion criteria, and AKI was prevalent, implicated in 57% of all pediatric sepsis cases. This data was evidenced by the data of demographics, disease origin, characteristics of therapy, and outcome, as shown in Table 1. The data recorded showed no significant differences between patients with and without AKI.

Table 1. The demographic, origin of the disease, therapy, and outcome

Parameter	(n = 13) Non-AKI	(n = 17) AKI gr. 1-3	*p*-value
Demographic Parameter			
Age (months), median (range)	22 (8 – 67)	11 (3 – 86)	0.232*
Male, n (%)	9 (69.2)	12 (70.6)	1.000*
PELOD-2 score, median (range)	11 (7 – 17)	12 (7 – 17)	
Lactate when entering, median (range)	1.71 (0.64 – 7.14)	2.2 (0.7 – 7.6)	0.32* 0.983*
PRISM-3 score, mean±SD	18.08±6.47	20.18±5.2	0.333****
IL-6, median (range)	175.02 (15,1-1280,4)	298.18 (12,39-5919)	0.250*
Origin of Disease			
Respiration, n (%)	4 (30.8)	7 (41.2)	0.708**
Cardiovascular and shock, n (%)	5 (38.5)	11 (64.7)	0.269**
neurology, n (%)	7 (53.8)	9 (52.9)	1.000**
Gastrointestinal, (%)	9 (69.2)	12(70.6)	1.000**
Therapy Characteristics			
Ventilator, n (%)	11 (84.6)	17 (100)	0.179**
Vassopressor and Inotropic agents, n (%)	5 (38.5)	8 (47.1)	0.721**
Diuretic, n (%)	0 (-)	2 (11.8)	0.492**
Outcome			
Ventilator (days), median (range)	4 (0 – 16)	4 (1 – 34)	0.445*
PICU LOS (days), median (range)	4 (2 – 16)	6 (1,5 – 34)	0.487*
Mortality, n (%)	4 (30.8)	8 (47.1)	0.465**

*Mann-Whitney test **Fisher-exact test ***Chi-square test ****2 sample *t*-test

Table 2 showed the median value of each Urine syndecan-1 collected and compared between participants with and without AKI. The result identified higher values in patients with AKI.

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Table 2. Comparison of Urine Syndecan-1 value and AUC between group 'No AKI' and 'AKI' to the incidence of acute kidney injury

Syndecan-1 (hour)	Non-AKI (n=13)	AKI gr. 1-3 (n = 17)	p-value
0^{th}	0,55 (0,11-3,44)	1,31 (0,17 – 2,91)	**0.021**
6^{th}	0,46 (0,08 – 2,26)	1,18 (0,08 – 6,81)	**0.034**
12^{th}	0,98 (0,06 – 2,4)	1,07 (0,13 – 5,72)	0.451
24^{th}	1,16 (0,16 – 6,17)	1,29 (0,1 – 7,91)	0.786
0^{th} + 6^{th}	0,5 (0,08-3,44)	1,255 (0,08-6,81)	**0.003**
All	0,73 (0,06-6,17)	1,19 (0,08-7,91)	**0.005**

*Mann-Whitney test

A urine assessment of syndecan-1 was performed. The significant values recorded at the 0th and 6th hours, and all outcomes were combined into one considerable value. Figure 1 shows the significant amount of Syndecan-1 in the urine, based on the comparison made with AUC-ROC, which differentiate the occurrence of AKI into grade 1, 2, or 3.

The urine syndecan-1 value recorded at the 0th hour has a balanced sensitivity and specificity value at 0.67 ng/ml. In comparison, 0.78 ng/ml was reported on the 6th hour, with the sensitivity and specificity values shown in Table 3. Furthermore, the cut-offs have equality and association with AKI occurrence in the next 48 to 72 hours, thus validating syndecan-1 urine as a valid predictor of AKI in pediatric sepsis patients.

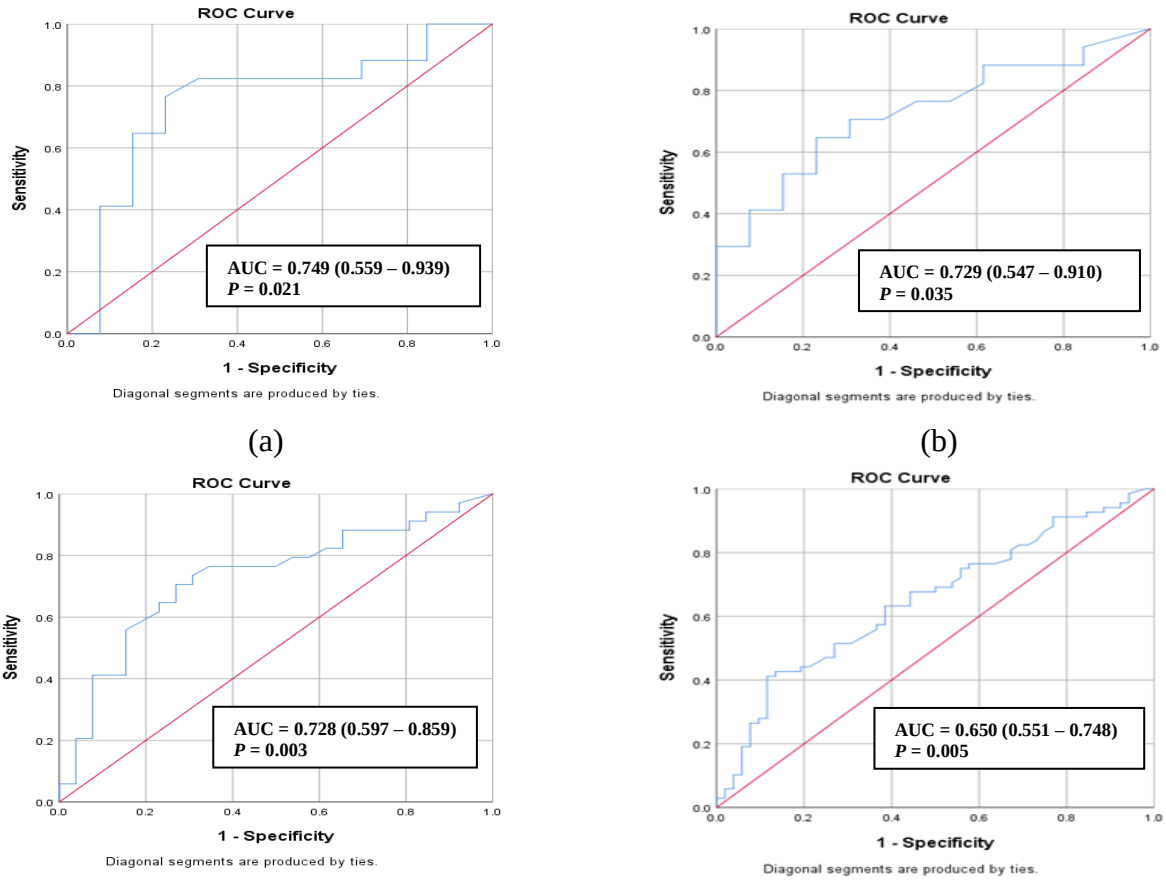

Figure 1. Ability to diagnose Urine syndecan-1 at the 0th hour (a); 6th hour (b); 0th+6th hours (c); and all results (d) to detect AKI

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Therefore, it was essential to derive a cut-off value for both the 0th and 6th hours because of the significant differences achieved by combining both values. The cut-off value was estimated at 0.71 ng/ml, with varied sensitivity and specificity. Therefore, a ROC curve is made because the overall syndecan-1 ratio between AKI and no AKI was significant. A cut-off value of 1 ng/ml was obtained, characterized by similarities in sensitivity and specificity in both the 0th and 6th hours (Table 3). A cut-off value of 1 ng/ml was obtained, characterized by similarities in sensitivity and specificity in both the 0th and 6th hours (Table 3).

Table 3. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), likelihood ratio (LR), McNemar, Kappa, and AUC on Urine Syndecan-1 *cut-off*

Parameter	Results					
	Syndecan-1 (hour)					
	0th	0th	0th	6th	6th	6th
Cut-off	0.67 ng/ml	0.71 ng/ml	1 ng/ml	0.78 ng/ml	0.71 ng/ml	1 ng/ml
Sensitivity (%)	76	71	65	71	71	65
Specificity (%)	77	77	77	69	69	77
Positive predictive value (%)	81	80	79	75	75	79
Negative predictive value (%)	71	67	63	64	64	63
Likelihood ratio (+)	3.31	3.06	2.8	2.29	2.29	2,8
Likelihood ratio (-)	0.31	0.38	0.46	0.42	0.42	0,46
Prevalence	57	57	57	57	57	57
Likelihood ratio (*p*)	8.86 (0.004)	6.946 (0.008)	5.336 (0.021)	4.81 (0.028)	4.81 (0.028)	5.336 (0.021)
Mc Nemar test (*p*)	1.000	0.727	0.508	1.000	1.000	0.508
Kappa (*p*)	0.529 (0.004)	0.467 (0.024)	0.405 (0.024)	0.395 (0.03)	0.395 (0.03)	0.405 (0.024)
Relative risk	2.84 (1.202-6.727)	2.4 (1123-5.127)	2.095 (1.052-4.174)	2.1 (0.984-4.48)	2.1 (0.984-4.48)	2.095 (1.052-4.174)
Youden's Index	0.53	0.48	0.42	0.4	0.4	0.42

The endothelial glycocalyx functioned as an excellent permeability barrier and a binding deterrent against blood. Furthermore, a disorder in this structure has known to increase capillary permeability, instigate the attachment of leukocytes and platelets, alongside tissue edema and inflammation, leading to an increase in the procoagulant state (14). The extent of damage is indicated by syndecan-1, which serves as a biomarker, characterized by an increase after cardiac surgery (14,15) or heart failure (16). Despite not being a kidney-specific indicator, there is an evidence of endothelial injury playing an essential role in the pathophysiology of AKI, especially the sepsis-related form (17).

Another thing is that syndecan-1 is inversely proportional to kidney function. The

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renal vascular endothelium is a significant target in several disease processes. Those processes are including glomerular nephritis, vasculitis, lupus nephritis, preeclampsia, hemolytic uremic syndrome, ischemic acute renal failure, renal transplant rejection, and chronic progressive kidney disease. During sepsis, the immune system is first activated and becomes hyperactive, leading to uncontrolled excessive immune reactions, with a tendency to harm rather than protect. The hyperactive phase features the presence of proinflammatory cytokines, structural and functional modification. This is assumed to support the septic process in leukocyte adhesion with endothelial cells, which then switch from anticoagulant to procoagulant state, subsequently changing the barrier function, increasing permeability, and vasomotor tone disorders.

Furthermore, an upsurge in renal vascular resistance results from sepsis induced vasoconstriction, endothelium leakage, tissue edema, leukocyte adhesion to endothelial cells, and micro thrombosis. The kidney is a unique organ with two layers of capillaries, glomerulus and peritubular, linked with the arterioles. The structure is observed as different vascular compartments connected in series with separate circuits for each, with the inherent microcirculation and macrocirculation appearing connected and dependent on one another (14–17). This series connection explains why syndecan-1 is detected in urine, regardless of tubular injury (14).

Following experimental ischemic injuries, the upsurge in Syndecan-1 expression influenced survival and tubular repair in mice (10). However, syndecan-1 in human is identified in the renal allografts, with terms associated with functional improvement (11). The concentration was evaluated at the beginning of the hospital admission, with the assumption of kidney injury on hospitalization and reflecting severity. This application is due to the ability of syndecan-1 as a biomarker during kidney regeneration (18).

Other studies revealed that the mean urine ACR was 10.5 (3-88) mg/g, and the mean syndecan-1 level was 27.7 (SD 2.24) ng/mL (19).

This study is expected to bring about significant changes, since based on the research, 56.7% of patients suffered from AKI septic disease (20).

CONCLUSION

In conclusion, the urine syndecan-1 evaluated at the 0th and 6th hours was established as a valid predictor of AKI within 48-72 hours in pediatric sepsis patients. The best outcome was observed at the 0th hour, featuring a cut-off of 0.67 ng/ml and the highest Younden's index.

Research Limitations

This study had several limitations, including the use of one center, a relatively low number of patients included, and flawed cost analysis. Therefore, it was difficult to derive definitive conclusions about the use of urine syndecan-1 to predict AKI occurrence. However, the technique was estimated to function as a potential non-invasive biomarker. The ELISA syndecan-1 test is only available for research use and not for diagnostic or therapeutic purposes. Hence, there is a need to develop analytical tests for proper validation and support in clinical practice.

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Case Report

IN PURSUIT OF PHRENIC NERVE-SPARING REGIONAL ANESTHESIA FOR AWAKE SHOULDER MANIPULATION IN PATIENTS WITH ADHESIVE CAPSULITIS

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ABSTRACT

Introduction. While interscalene brachial plexus block remains the gold standard of any shoulder procedure, including shoulder manipulation in patients with adhesive capsulitis, anesthesiologists are reluctant to face the risk of phrenic nerve paresis, especially in patients with preexisting pulmonary conditions. Hence, many studies have targeted specific regional anesthesia of the shoulder low enough by the blockade level, leaving phrenic nerve function intact but still providing satisfying anesthesia for shoulder procedures. Until recently, no comparison between these regional anesthesia techniques focusing on shoulder manipulation for adhesive capsulitis has been published. **Case Report.** We compared the profiles between suprascapular nerve block, shoulder interfascial plane block, and superior trunk block as the sole anesthesia technique in patients with adhesive capsulitis undergoing awake shoulder manipulation. **Conclusion.** This report descriptively signifies superior trunk block excellence among other regional anesthesia techniques in achieving complete anesthesia for awake shoulder manipulation in patients with adhesive capsulitis while sparing the phrenic-nerve function.

Keywords: Adhesive Capsulitis; Brachial Plexus; Nerve Block; Neglected Disease; Phrenic Nerve.

ABSTRAK

Pendahuluan. Blok pleksus brakhialis interskalenus merupakan standar emas anestesi regional untuk prosedur daerah bahu, termasuk manipulasi bahu pada pasien dengan adhesive capsulitis. Namun sayangnya banyak dokter anestesi enggan melakukan teknik anestesi regional ini mengingat resiko paresis *phrenic nerve* yang tidak diharapkan terjadi pada pasien dengan riwayat penyakit paru. Terkait hal ini, banyak studi dilakukan dalam usaha menemukan anestesi regional yang ideal untuk daerah bahu namun cukup distal sehingga *phrenic nerve* tidak ikut terblok oleh anestesi lokal. Hingga saat ini belum ada studi yang membandingkan beberapa alternatif teknik anestesi regional selain blok pleksus brakhialis interskalen terutama untuk anestesi prosedur manipulasi bahu pada pasien dengan adhesive capsulitis. **Laporan Kasus.** Penulis membandingkan profil tiga teknik anestesi regional, diantaranya blok saraf suprascapularis, blok shoulder interfascial plane dan blok trunkus superior, sebagai teknik anestesi tunggal pada pasien dengan adhesive capsulitis yang menjalani prosedur manipulasi bahu. **Kesimpulan.** Laporan kasus ini mendeskripsikan keunggulan blok trunkus superior sebagai anestesi tunggal pada pasien yang menjalani prosedur manipulasi bahu dibanding dua teknik anestesi regional lain, berikut dengan fungsi *phrenic nerve* yang masih utuh.

Kata Kunci: Adhesive Capsulitis; Plexus *Brachialis*; Blok Saraf; Penyakit Terabaikan; *Phrenic Nerve*.

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INTRODUCTION

Adhesive capsulitis is the most prevalent pathological condition of the shoulder, with a 2-5% lifetime incidence in the general population (1). Albeit it is a limited number of occurrences, this inflammatory, painful joint disease may leave the shoulder joint contracted, leading to long-term disability in 35% of the subjects (2). Hence, early interventions are paramount in improving functional outcomes; one of them is the manipulation of the shoulder (3).

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The fact that severe pain in this population may lead to low adherence to active and passive voluntary shoulder exercise puts the anesthesiologists in an essential role during its therapeutic activity, including manipulating the shoulders(4). Manipulation of the shoulders under anesthesia can be accomplished both by general or regional anesthesia, with the primary concerns being the patients' preference and underlying medical conditions.

While avoiding potential cardiopulmonary side effects from procedural sedation and analgesia, regional anesthesia has still opted with caution with phrenic nerve paresis as its complication (5). The typical approach for complete shoulder anesthesia is interscalene brachial plexus block (6).

Lately, however, some literature has offered superior trunk block, suprascapular nerve block, and shoulder interfascial plane block each as the sole anesthetic technique for shoulder procedures while sparing the phrenic nerve function (7,8). Yet, none of the comparisons between them has focused on shoulder manipulation for adhesive capsulitis.

We performed superior trunk block, shoulder interfascial plane block, and suprascapular nerve block each on three patients with adhesive capsulitis requiring awake manipulation of the shoulders. The objectives were to compare each technique's profile, effectiveness, and review the corresponding literature on the subject.

CASE REPORT

Technical Descriptions

Under strict aseptic technique, the author commenced nerve blocks in a supine (shoulder interfascial plane and superior trunk block) and sitting position (suprascapular nerve block posterior approach) with a 4-12 MHz high-frequency linear array probe (Mindray M7, Shenzhen, China) and a non-stimulating 100-mm-long, 21-gauge, short-beveled needle (Locoplex®, Vygon, Padova, Italy). All procedures commenced after local skin infiltration.

The local anesthetic administered was 1.5% Lidocaine with epinephrine (5 µg.mL-1). The illustrative probe positions and needle directions for each block are shown in Figure 2-4.

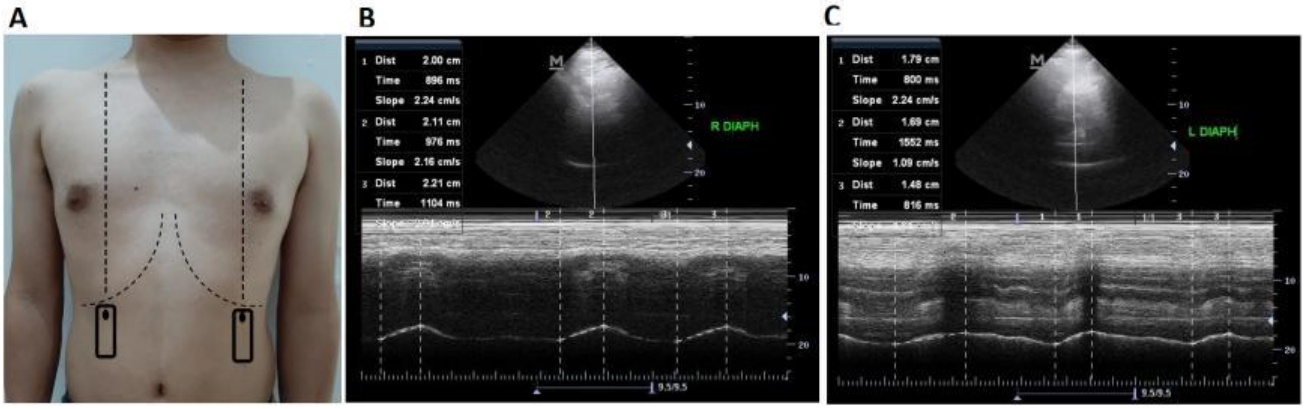

Figure 1. A. Illustration of probe positions for ultrasonographic measurement of ipsilateral diaphragmatic excursion in M-Mode. **B**. Right diaphragm. **C**. Left diaphragm.

The diaphragmatic excursion (DE) measurement was carried out with a 2-4 MHz phased-array probe (Mindray M7, Shenzhen,

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China) placed at the junction of the ipsilateral midclavicular line and the subcostal margin, where the probe tilted postero-cephalad, parallel to the diaphragmatic movement.

The diaphragmatic movement toward the probe during inspiration and expiration was recorded in the M-mode tracing, where the amplitude of DE was the maximum vertical point downward to the lowest point in M-mode tracing (Figure 1) (9). The average DE was acquired from three consecutive breaths during a single period measurement.

Case Illustrations

Case 1 – Suprascapular nerve block

A 57-year-old male patient of 50 kg weight and 148 cm height was scheduled for elective awake frozen shoulder manipulation under regional anesthesia. The patient had chronic right shoulder pain for almost a year despite undergoing routine physical rehabilitation and received shoulder joint injections. He denied general anesthesia and interscalene brachial plexus block but instead consented for suprascapular nerve block to no definite reason.

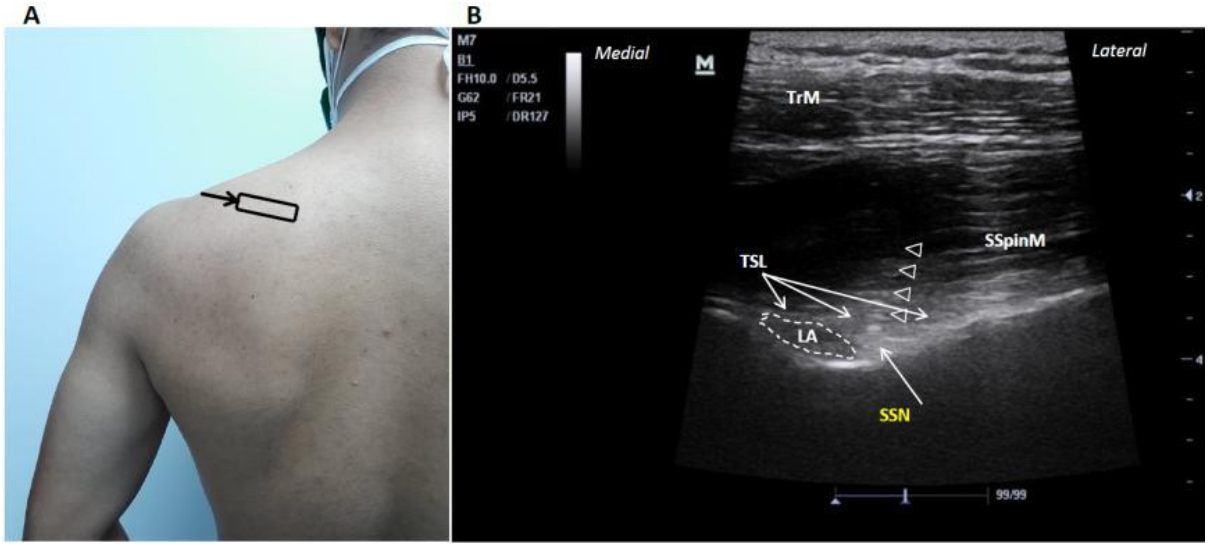

Figure 2. A. Illustration of probe positions and needle directions for suprascapular block (SSB) **B**. Ultrasound image of the needle entering suprascapular notch, where local anesthetic (LA) is injected beneath transverse scapular ligament (TSM), overlaid by the supraspinatus (SSpinM) and the trapezius muscle (TrM).

For the suprascapular nerve block posterior approach, the probe was placed parallel to the scapular spine and then moved just superior to it, with clear identification of suprascapular fossa, then slid laterally to locate the suprascapular notch. The suprascapular nerve was visible as a hyperechoic round shape beneath the transverse scapular ligament. The needle was inserted in-plane to the ultrasound beam with the endpoint of the needle tip located within the suprascapular notch, where a 10 ml local anesthetic was deposited (Figure 2B).

Despite complete pre-procedural pain relief (Table 1), there was significant pain in the shoulder's frontal area elicited by an external rotation procedure, followed by the administration of rescue analgesia (intravenous 50 mcg Fentanyl). During a visit before hospital discharge, the patient did not mention any subsequent problems related to the procedure. Still, he would prefer another

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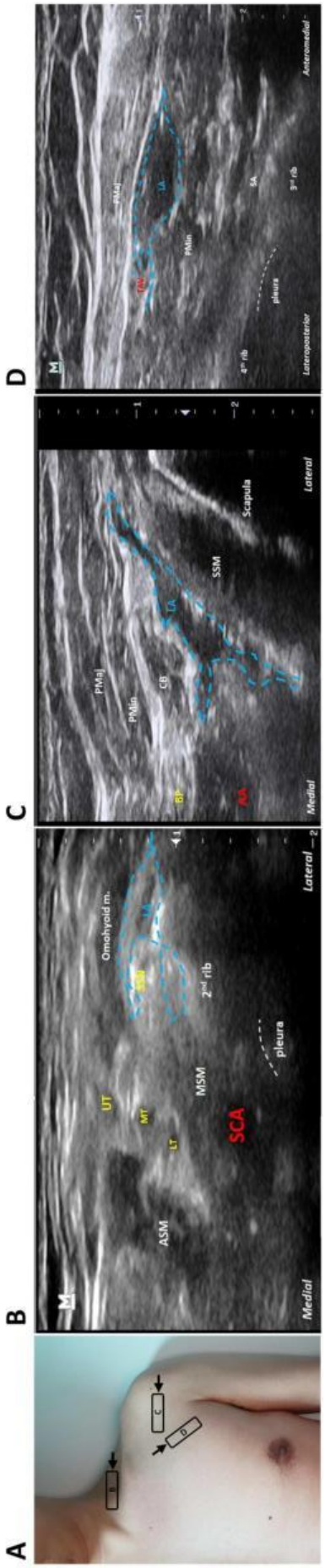

Figure 3. A. Illustration of probe position and needle direction for submomohyoid plane block (B), subscapular plane block (C) and PECS-1 block (D). B. Ultrasound image of local anesthetic (LA) deposited under omohyoid muscle inferior belly. Suprascapular nerve (SSN) is seen immediately deep to omohyoid muscle, separating from brachial plexus: upper trunk (UT), middle trunk (MT) and lower trunk (LT) laterally when probe swipes caudad. C. Ultrasound image of local anesthetic (LA) deposited anteriorly from the surface of subscapular muscle (SSM). The three layers of muscle at the anterior border of subscapular plane are coracobrachialis (CB), pectoralis minor (PMin), and pectoralis major (P.Maj) muscle. D. Ultrasound image of the fascial

option of regional anesthesia that may offer complete pain reduction for the next session of shoulder manipulation.

Case 2 – Shoulder interfascial plane block

A 75-year-old female patient of 50 kg weight and 150 cm height was scheduled to undergo awake frozen shoulder manipulation for her left shoulder's painful adhesive capsulitis. The patient had persistent shoulder pain for four weeks despite frequent physical rehabilitation visits. The patient refused an interscalene brachial plexus block due to her history of recurrent asthma attacks.

For the sub-omohyoid plane block, the probe was placed just superior to the clavicle with clear identification of brachial plexus, subclavian artery, and omohyoid muscle inferior belly, below which a 5 ml local anesthetic was deposited (Figure 3B). Subsequently, the probe was moved to the axial plane of the shoulder, where a lesser trochanter of the humerus and subscapularis muscle was well identified. Later, a 15 ml local anesthetic was deposited at the ventral surface of the subscapularis muscle (Figure 3C). The last one was the PECS-1 block with the probe positioned at midclavicular level, aligned, and moved inferolaterally until the thoracoacromial artery was seen sandwiched between the pectoralis major and minor muscle, within which a 10 ml local anesthetic was deposited (Figure 3D).

The post-block sensory evaluation resulted in complete anesthesia of axillary and suprascapular nerve dermatome with no anterior shoulder pain during voluntary movement. However, the surgeon sensed muscle resistance during external rotation at zero degrees abduction of the shoulder, originating from subscapularis muscle, with significant palpable trigger points on the subscapularis muscle belly. No rescue analgesia was required, and the procedure

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went uneventful. Within the first two days' follow-up evaluation by phone, the patient did not mention any subsequent problems related to the procedure and was satisfied with the regional anesthesia technique.

Case 3 – Superior trunk block

A 74-year-old male patient of 52 kg weight and 151 cm height was scheduled for awake frozen shoulder manipulation for adhesive capsulitis on the left shoulder. The patient experienced moderate shoulder pain and stiffness for two years with a history of physical rehabilitation non-adherence. The patient refused interscalene brachial plexus block and general anesthesia due to the previous two events of myocardial infarction requiring stent placement with subsequent cardiac decompensation.

For the superior trunk block, the probe was placed at the level of the C5 nerve root first, then slid caudally until C5 and C6 nerve roots merged, but right before the suprascapular nerve left bundle (Figure 4C). Color Doppler evaluation is paramount to identify the transverse cervical artery and dorsal scapular artery, which may cross over the brachial plexus. The needle was inserted in-plane to the beam in a lateral-to-medial direction, superficial to middle scalene muscle with the needle tip's endpoint just lateral to the superior trunk where a 10 ml local anesthetic was deposited circumferentially (Figure 4B).

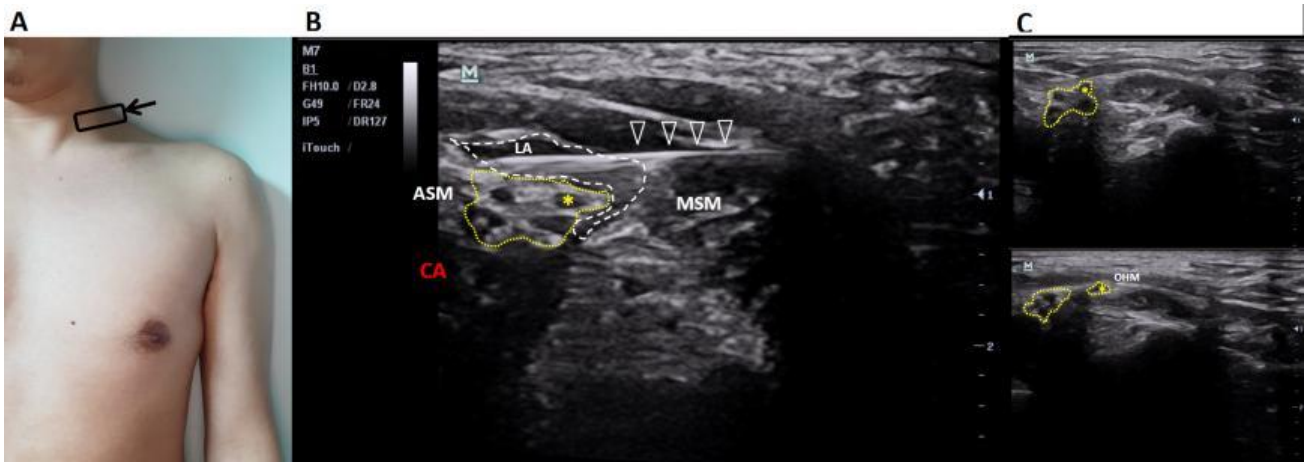

Figure 4: **A**. Illustration of probe positions and needle directions for superior trunk block (STB) **B**. White asterisk mark suprascapular nerve (SSN). Triangles correspond to the needle shaft. The level of injection is determined to right before the suprascapular nerve leaving off the superior trunk laterally beneath the omohyoid muscle (OHM), while the suprascapular nerve (SSN) still within the same nerve bundle (yellow dashed line) with C5 and C5. The needle tip is placed anteriorly to the superior trunk as local anesthesia (LA) is injected (local anesthetic spread in white dashed line). **C**. Ultrasonography depicted suprascapular nerve (SSN) leaving superior trunk nerve bundle.

Complete anesthesia at the level of C5 and C6 was achieved while sparing the motor function of the hand. There were no signs of dyspnea nor decreased diaphragmatic excursion following complete anesthesia of superior trunk block until post-anesthesia care unit (PACU) discharge. The procedure went uneventful without any need for rescue analgesia. Within the first-day follow-up evaluation by phone, no problems related to the nerve block were found, and the patient was satisfied with the regional anesthesia technique.

DISCUSSION

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Achieving complete anesthesia for shoulder procedures requires specific knowledge of its structure and related sensory innervation. A better understanding of the glenohumeral and acromioclavicular joint capsules neuroanatomy and related sensory implication for anesthesiologists' intervention was just recently revealed by Tran et al., (10) in , leaving the simple concept of cutaneous and osteotome sensory mapping apart toward more specific nerves targeting during regional anesthesia. His study answered the previous dogma of brachial plexus block at the level of interscalene compulsory as the sole anesthesia of shoulder procedures, with evidence of nerves originating only from C5 and C6. The only nerve derived not from C5-6 is the lateral thoracic nerve (C5-C7) in only one from 15 cadavers. Regarding this finding, we have to reconsider routine interscalene brachial plexus block for shoulder anesthesia as C7 and C8 nerve roots blockade is unnecessary and weighs the almost 100% risk of phrenic nerve paralysis from this level of block.

Until recently, apart from interscalene brachial plexus block, studies on complete shoulder regional anesthesia approaches have been mainly focusing on superior trunk (C5-6) block, suprascapular nerve block, and selective nerves block (7,11,12). While superior trunk and suprascapular nerve blocks' sensory coverage are self-explanatory, the selective nerves block covers three different nerves and/or plane blocks; subscapular plane block targeting subscapular and axillary nerves, suprascapular nerve block, and PECS-1 block for the lateral pectoral nerve (7).

Despite limited evidence, in this case report, the author demonstrated that both superior trunk and selective nerve block approach provided complete shoulder anesthesia, which allowed for awake manipulation of the shoulder for patients with adhesive capsulitis without any rescue analgesia and hemidiaphragmatic paralysis. Although many authors have published its utility, the suprascapular nerve block technique covers only 70% of shoulder girdle sensory innervation, rendering patients' resistance from pain elicited during shoulder manipulation (13).

Previous studies did not mention complaints following shoulder manipulation under the suprascapular nerve block alone (12). However, the author found that passive shoulder external rotation with the arm at the side raised significant pain at the anterior portion of the shoulder, with subsequent resistance from the patient. This condition is plausible as theoretically, this specific maneuver during shoulder manipulation is aimed at complete tearing of the anterior capsule of the shoulder, where the sensory innervations are from the axillary and subscapular nerves, instead of the suprascapular nerve (10).

Any shortcoming of the previous approach was discovered by incorporating additional axillary and subscapular nerve blockade, first described in correspondence by Sondekoppam et al., who applied the shoulder interfascial plane block technique with or without PECS-1 (for the lateral pectoral nerve) for analgesia of shoulder surgeries in high-risk patients. Taking advantage of the relevant anatomical position of both nerves that lie in the common potential plane, subscapularis plane, Sondekoppam et al. deposited local anesthetic at the said plane, directly beneath the epimysium of the subscapularis muscle (7).

The clinical finding from Sondekoppam et al., (7) precisely explained in the cadaveric study of Drake et al., (14) showed that a

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specific volume of dye being injected at the subscapularis plane might stain axillary and subscapular nerves. A similar result was also achieved by injecting dye deep to subscapularis muscle, staining more distal branches of nerves in the vicinity of the shoulder capsule (15). However, considering the anatomical variation of nerve branches and no clinical studies following said publication has recommended such practice on living subjects, the author did not utilize this approach.

While the technique of shoulder interfascial plane block has been proven effective as part of analgesia in shoulder surgeries, the author still found that the patient frowned during external rotation at zero degree abduction of the shoulder and sensed muscle resistance, both originating from the subscapularis muscle, with significant palpable trigger points at the superior and inferior lateral aspects on the ventral surface of the subscapularis muscle belly (7).

A similar condition was not found in the patient that was given superior trunk block, in addition, to complete analgesia of the shoulder, and all muscles relevant to the pectoral girdle were also wholly relaxed, making manipulation of the shoulder tension-free. The possible mechanism of this subscapularis muscle-spared relaxation is unblocked lower subscapular nerve by subscapularis plane block. As the injected volume of local anesthetic was probably staining the upper subscapular nerve only, sparing the lower subscapular nerve, the subscapularis muscle relaxation did not occur.

The superior trunk block is comparably superior to the previous two regional anesthesia techniques for its nature of a proximal blockade at the trunk level immediately after C5, and C5 roots merged right before the suprascapular nerve left it. With sufficient volume, local anesthetic may cover all sensory and motor nerves related to the shoulder and the pectoral girdle; the suprascapular, subclavian, lateral pectoral nerves (partial) and axillary, and lower and upper subscapular nerves.

The author found that both superior trunk block and shoulder interfascial plane block provided complete analgesia of the shoulder in a static condition, hence considered adequate for shoulder joint surgeries. However, one distinctive feature from the manipulation of frozen shoulder that anesthesiologists must be concerned about is its requirement of rotator cuff muscles relaxation during passive movement, which could only be achieved with the superior trunk block technique.

Apart from that, one also needs to consider the risk-benefit ratio of local anesthetic systemic toxicity with the transient phrenic nerve paralysis for the given high dose of the local anesthetic in the shoulder interfascial plane block. While it has apparent advantages over shoulder interfascial plane block in terms of potentially lesser risk of LAST, the superior trunk block's certainty in sparing the phrenic nerve remains questionable as anatomically, its needle end-point is within the same deep prevertebral fascia compartment, separated from the phrenic nerve only by anterior scalene muscle (16).

Despite a sonoanatomy study conducted by Kessler et al. having found that the phrenic nerve was 1.8 to 2.0 mm away from the C5 nerve root in adults at the level of the cricoid cartilage, with the additional distance of 3 mm for every centimeter distal scanning, there is 30-35% variation of individuals whose C5 root travels with or over the anterior scalene muscle in adjacent with the phrenic nerve(17).

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Table 1 : Individual peri-procedural events, rescue analgesia and adverse events.

Case Study	Pre-procedural Pre-block pain NRS (out of 10)	Pre-procedural Post-block pain NRS (out of 10)	Post-block Cutaneous Sensory Blockade Evaluation	Ipsilateral Diaphragmatic Excursion (cm)		Patient-reported intra-procedural pain or muscle spasm events	Location of intra-procedural shoulder pain	Rescue Analgesia	Adverse Events	
				Pre-block	Post-block				Nerve injury	LAST
1	5	1	Suprascapular nerve dermatome	2.1	1.96	+ (pain)	Anterior	Intravenous Fentanyl 50mcg	-	-
2	4	1	Suprascapular and axillary nerves dermatome	1.65	1.61	+ (muscle spasm)	Subscapularis muscle belly	-	-	-
3	5	1	C5 and C6 dermatome	1.78	1.68	-	-	-	-	-

NRS : Numerical Rating Scale
LAST : Local Anesthetics Systemic Toxicity

This anatomically relevant evidence regarding the higher chances of complete or partial phrenic nerve paresis after superior trunk block appeared unlikely to occur in the clinical scenario as the author did not find any diaphragmatic excursion decrease following the block, and parallel with the result of a randomized controlled trial (RCT) from Kang et al., superior trunk block saw lower decrease in the diaphragmatic excursion and respiratory function compared with interscalene brachial plexus block (8).

However, lower does not necessarily mean none, as in Kang et al. (8)'s RCT, there was one subject experiencing complete hemidiaphraghmatic paresis. Therefore, anesthesiologists have to deliver adequate information regarding the potential risks and benefits of superior trunk block or shoulder interfascial block found during pre-anesthesia visits and earn patients' consent. The 29% incidence of hemidiaphragmatic paresis found in the mentioned RCT might be related to administering a 15 ml volume of local anesthetic, 5ml higher than what Kim et al. (18) administered in his RCT. A smaller volume of LA may translate into a lower risk of phrenic nerve staining; hence Kim et al. (18) found only a 3% incidence of hemidiaphragmatic paresis. Considering the result of these two RCTs, the author opted for the administration of a 10 ml local anesthetic with no decrease in the diaphragmatic excursion.

Despite convincing results supporting superior trunk block as the sole anesthesia technique for shoulder procedures, there are limitations in this case report. As a single-subject study, the author could not provide the differences and efficacy of each regional anesthesia technique statistically other than descriptive clinical experiences. Consequently,

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further generalization of the result to routine practice should be carefully weighed. There has yet to be firm evidence regarding the technique's potencies and adverse effects and the indeterminacy of the minimum adequate volume for the lower incidence of hemidiaphragmatic paresis. With a single anesthesiologist performing nerve block, it cannot be interpreted as increasing performance bias; instead, it may limit the generalizability of the finding. Finally, the absence of a standard technique in performing the superior trunk block approach and its anatomical endpoint may result in the varying incidence of phrenic nerve involvement during daily clinical practices.

CONCLUSION

In conclusion, this case report exhibits that, compared to suprascapular nerve block and shoulder interfascial plane block, the superior trunk block provides complete sensory and motor blockade required during shoulder manipulation for adhesive capsulitis cases, with the absence of hemidiaphragmatic paresis. Therefore, one may appraise the superior trunk block's potential feasibility in patients at high risk of respiratory complications. Nonetheless, future studies are required to confirm this finding further.

Declaration of Patient Consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published, and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Case Report

THE USE OF MODIFIED HIGH FLOW NASAL CANNULA (HFNC) IN PRETERM INFANTS WITH NEONATAL RESPIRATORY DISTRESS SYNDROME (NRSD) IN PRIMARY ICU SERVICES

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ABSTRACT

Introduction: NRSD (Neonatal Respiratory Distress Syndrome) is one of the most frequent causes of newborns in intensive care (NICU). Several NICU centers are now using the High Flow Nasal Cannula (HFNC) recent years. With the use of HFNC as a breath aid in preterm infants, HFNC had the same efficacy ratio as nasal Continuous Positive Airway Pressure (CPAP) (continuous or intermittent). **Case Report:** A three-day-old baby boy was admitted to anesthesia with respiratory failure due to grade II HMD with suspicion of congenital heart failure. The initial condition showed that a respiratory rate of 70-80x / minute, breathing of the nostrils and retractions in the intercostals and abdomen with 85% post ductal SpO2 with the help of a CPAP mask (Pinsp 10, Fio2 70%). There was a Ronchi sound in the right and left basal lungs, and hemodynamics obtained a pulse of 180-195x / minute, non-invasive blood pressure 95/34 mmHg (54), heart murmurs were not found. During day 1 - day three, the patient uses a CPAP mask until the patient vomits and being consulted to an Anesthesiologist. On day 3 - day seven, the patient uses HFNC; after day seven until day 10, the patient uses neonatal nasal canularis oxygen. Until day 10, the patient is still being treated at the NICU by administering oxygen 0.5 liters/minute with SpO2 ranging from 93-96% with stable conditions but still needing oxygen. **Conclusion:** The use of Modified High Flow Nasal Cannula (HFNC) in preterm infants with Neonatal Respiratory Distress Syndrome (NRSD) is more effective and efficient than CPAP. The use of HFNC was associated with a lower incidence of nasal trauma and pneumothorax than nasal CPAP.

Keywords: Continous Positive Airway Pressure (CPAP); Childbirth Complications; Modified High Flow Nasal Cannula (HFNC); Neonatal Respiratory Distress Syndrome (NRSD); Preterm infants

ABSTRAK

Pendahuluan: NRSD (Neonatal Respiratory Distress Syndrome) merupakan salah satu penyebab bayi baru lahir yang paling sering dirawat di ruang perawatan intensif (NICU) hingga saat ini. Beberapa pusat NICU sekarang mulai menggunakan *High Flow Nasal Canula* (HFNC) dalam beberapa tahun terakhir. Dengan penggunaan HFNC sebagai alat bantu napas pada bayi prematur, ditemukan bahwa HFNC memiliki rasio efikasi yang sama dengan CPAP *(Continuous Positive Airway Pressure)* nasal (kontinu atau intermiten). **Laporan Kasus:** Bayi laki-laki usia tiga hari dirawat di anestesi dengan gagal napas karena HMD *grade* II dengan kecurigaan gagal jantung bawaan. Kondisi awal menunjukkan *respiratory rate* 70-80x/menit, pernafasan dari lubang hidung dan retraksi pada interkostal dan abdomen dengan 85% post ductal SpO2 dengan bantuan CPAP *mask* (Pinsp 10, Fio2 70%). Pada pemeriksaan fisik didapatkan suara ronchi pada basal paru kanan dan kiri, hemodinamik didapatkan *heart rate* 180-195x/menit, tekanan darah non invasif 95/34 mmHg (54), tidak ditemukan bising jantung. Selama hari ke-1 hingga hari ke-3 pasien menggunakan masker CPAP sampai pasien muntah dan dikonsultasikan ke Dokter Spesialis Anestesi, pada hari ke-3 hingga hari ke-7 pasien menggunakan HFNC, setelah hari ke-7 hingga hari ke-10 pasien menggunakan oksigen nasal canular neonatus. Sampai hari ke 10 pasien masih dirawat di NICU dengan pemberian oksigen 0,5 liter/menit dengan SpO2 berkisar 93-96% dengan kondisi stabil namun masih membutuhkan oksigen. **Kesimpulan:** Penggunaan *Modified High Flow Nasal Cannula* (HFNC) pada bayi prematur dengan *Neonatal Respiratory Distress Syndrome* (NRSD) lebih efektif dan efisien

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dibandingkan penggunaan CPAP. Penggunaan HFNC dikaitkan dengan insiden trauma hidung dan pneumotoraks yang lebih rendah daripada masker CPAP.

Keywords: *Continous Positive Airway Pressure* (CPAP); Komplikasi Bayi Baru Lahir; *Modified High Flow Nasal Cannula* (HFNC); *Neonatal Respiratory Distress Syndrome* (NRSD); Bayi Prematur

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INTRODUCTION

NRSD (Neonatal Respiratory Distress Syndrome) is one of the most common causes of the newborns in intensive care (NICU). Until now, the NRSD is one of the causes of mortality in newborns (especially in preterm infants) (1,2). The incidence of NSRD frequently in preterm infants and Low Birth Weight (LBW). Premature babies are prone to shunting and hypoventilation, often due to lack of surfactant and bad lungs. This can lead to pulmonary vasoconstriction and lead to NSRD in premature infants (3). HMD (*Hyaline Membrane Disease*) is one of the most common causes of NSRD in preterm infants and has a reasonably high Case Fatality Ratio (CFR) (4). HMD can be treated by administering artificial surfactants, using a breath aid machine, or administering CPAP (Continuous Positive Airway Pressure). The administration of CPAP proved to reduce the risk of BPD (Bronchopulmonary Dysplasia) and decrease the mortality rate in preterm infants (5).

CPAP as a non-invasive breath aid is the first line of breath assistance in premature infants with respiratory distress. During the last few years, nasal CPAP has been one of the most frequent methods of non-invasive ventilation aid (5,6). The administration of nasal CPAP has several disadvantages, such as there are various modes of CPAP, to work effectively, it must be used by trained nurses, providing discomfort to the baby. The use of nasal CPAP is associated with side effects such as trauma to the nose and pneumothorax. Several NICU centers are now using the High Flow Nasal Cannula (HFNC) in recent years. However, several studies have doubted the efficacy and efficiency of HFNC (6,7). HFNC is a method of supplying high-volume oxygen (flow> 1 liter/minute) with warm air (37ºC) and humidified air (humidification>96%) through the nasal cannula (7). Based on a systematic review, the use of HFNC as a breath aid in preterm infants, HFNC had the same efficacy ratio as nasal CPAP (continuous or intermittent), even though it was associated with a lower incidence of nasal trauma and pneumothorax than nasal CPAP (8).

The case in this journal is the use of HFNC (modification) in premature infants with NRND due to grade II HMD with a suspected congenital heart defect which we treated at Kuala Pembuang Hospital, Seruyan, Central Kalimantan (Type C Hospital in a remote area).

CASE REPORT

A three-day-old baby boy was admitted to anesthesia with respiratory failure due to grade II HMD with suspicion of congenital heart failure. The initial condition of the baby showed signs of respiratory distress, a respiratory rate of 70-80x / minute, breathing of the nostrils, and retractions in the intercostals and

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abdomen with 85% post ductal SpO2 with the help of a CPAP mask (Pinsp 10, Fio2 70%). There was a Ronchi sound in the right and left basal lungs, and hemodynamics obtained a pulse of 180-195x / minute, non-invasive blood pressure 95/34 mmHg (54), heart murmurs were not found. The baby was restless and vomiting (though he had an OGT installed) in black. The initial action we give is oxygen assistance with HFNC-modified (as in Figure 1) with a flow of 4 lpm, and the temperature is warmed 30^{o} - 34^{o}C. After 15-20 minutes after the giving of HFNC, the evaluation obtained that the Respiratory rate decrease to 70-75x/minutes, retraction still obtained SpO2 preductal 99%, Non-invasive Blood Pressure was 75/40 mmHg, clinically the baby was calmed down.

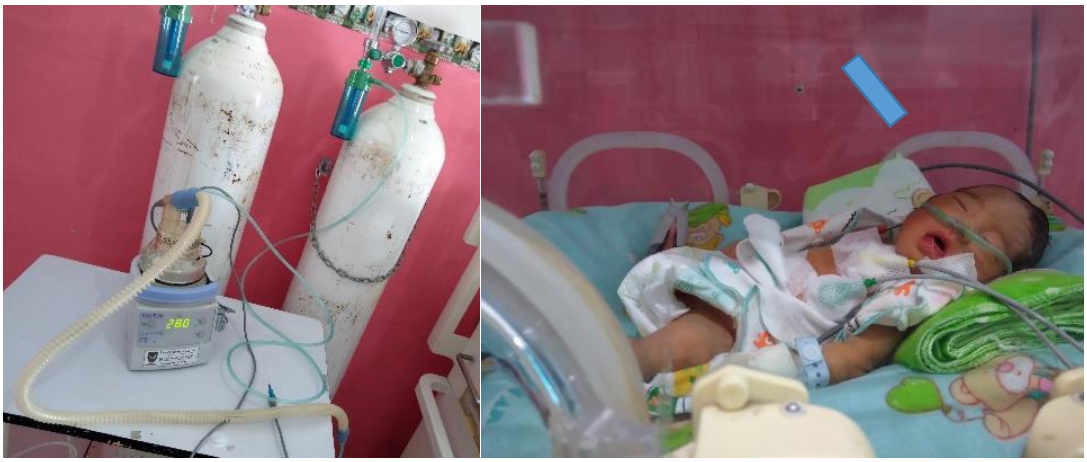

Figure 1. Modified HFNC Device (Using A Ventilator Humidifier With Neonatal Nasal Cannula)

From the baby's birth history, it was found that the patient was born immediately on the indication of antepartum bleeding due to placenta previa totalis with signs of pregnancy with 31/32 weeks of gestation; there was no comorbidity in the mother. When the baby was born, it was obtained with an APGAR (Appearance, Pulse, Grimace, Activity, and Respiration) Score of 6-7-7, with a Downe Score of 7. Due to ongoing antepartum inflammation with signs of labor, the mother had no time to get steroids during pregnancy, so immediate termination was performed. In the evaluation of complete physical examination, it was found that there was a sign of breath distress that was better than before, 25ml of urine production was obtained in 8 hours with an excess fluid balance of 220 ml for 72 hours, and there was a hematin of approximately 5ml from OGT. Investigations revealed the presence of leukocytosis 18. 240 and albumin 3,2 on other complete blood counts showed no abnormalities. The results of the baby gram showed that there was white intercourse in both lung fields. Our patient was treated with the antibiotic ceftriaxone 50mg / Kg BW / 24 hours intravenously. We added furosemide and proton pump inhibitor intravenously.

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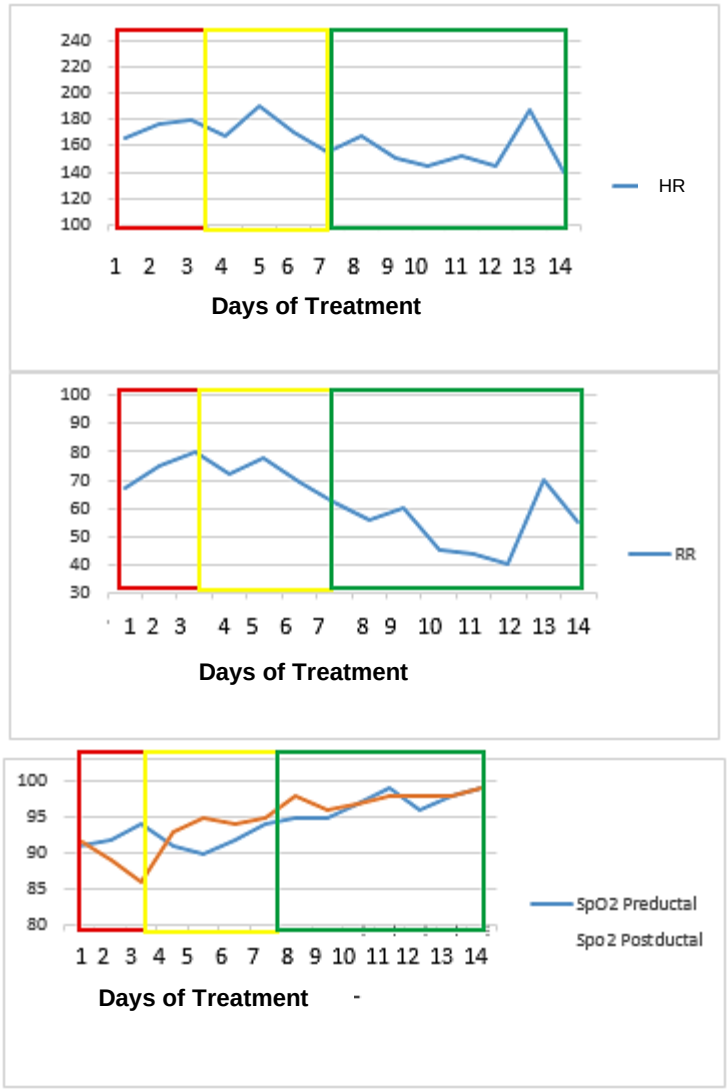

Figure 2. The Patient's Vital Sign During Treatment, Red Box: Using CPAP Mask, Yellow Box: Using HFNC, Green Box Using Neonatal Nasal Cannula Oxygen

On the 5th day of treatment, the patient's body began to turn yellow, so it was decided to do phototherapy (even though without the bilirubin examination because the examination reagent was run out) for 48 hours. Ten hours after the patient was photographed, the patient became restless, and the pulse rose to 190-200 with non-invasive systolic blood pressure ranging from 85 to 95 with a Mean Arterial Pressure (MAP) 65-70, preductal SpO2 decreased 85% and postductal SpO2 88%. At night the patient became increasingly restless until the patient's umbilical infusion was released. Our patient was sedated using ketamine at the time of re-umbilical insertion. If the patient was restless, we sedated the patient using midazolam and fentanyl while observing signs of respiratory depression. On the 7th day of treatment, there was an improvement in clinical and chest X-rays. Patients can be given nasal oxygen 1 liter/minute without giving HFNC, and we stop giving antibiotics after seven days. Figure 2 shows the graph of the patient's vital signs during treatment. During day 1 - day three, the patient uses a CPAP mask until the patient

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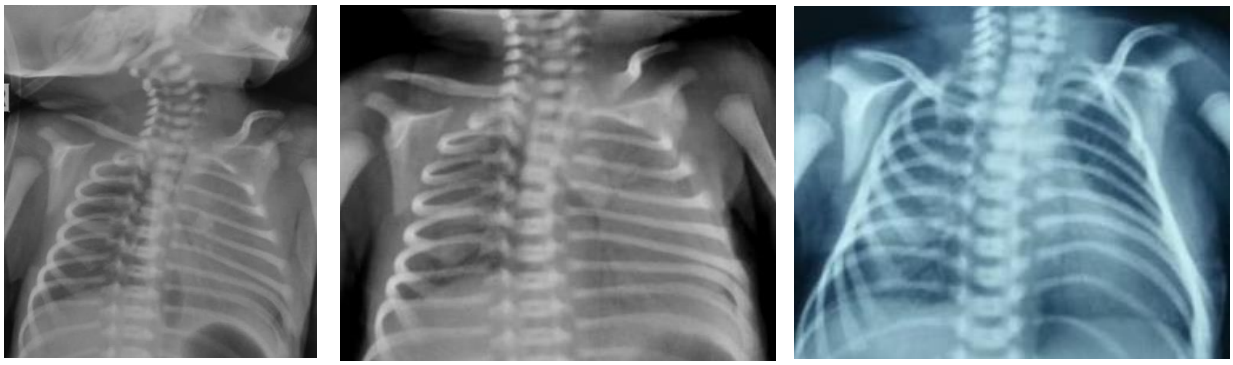
vomits and being consulted to an Anesthesiologist. On day 3 - day seven, the patient uses HFNC; after day seven until day 10, the patient uses neonatal nasal canularis oxygen. Until day 10, the patient is still being treated at the NICU by administering oxygen 0.5 liters/minute with SpO2 ranging from 93-96% with stable conditions but still needing oxygen. On the 13th day of treatment, there was an increase in pulse and breath rate. The patient also started febrile (with axilla temperature 37.4 - 38.0). The patient was suspected of starting a secondary infection, possibly due to the use of umbilical infusion for more than seven days and due to the difficulty of finding peripheral venous access despite attempts. After removing the umbilical infusion and administration of paracetamol, clinical improvement was obtained. The patient, on the 14th day of treatment, decided to be referred to another health facility. Changes in the thorax photo can be seen in Figure 3.



(a) **(b)** **(c)**

Figure 3. Chest photo during patient treatment
(a) Chest Photo After Birth, (b) Chest Photo After 3 Days of HFNC Use, (c) Chest Photo After 5 Days of HFNC Use

DISCUSSION

NSRD in premature infants is often caused by Hyaline Membrane Disease (HMD). HMD is caused by a lack of surfactant from the alveoli, which causes an increase in pressure on the alveoli surface, resulting in microatelectation and a decrease in lung volume. Clinically newborn babies will experience an increase in respiratory frequency which usually gets worse on the 3rd day. Worsening of the condition is due to decreased pulmonary compliance, decreased functional residual capacity, decreased alveolar ventilation, presence of R to L shunting, decreased capillary perfusion to a decrease. Oxygen supply (1,5). Figure 2 shows that on the first day of treatment, the patient has shown an increase in the frequency of breaths to get signs of respiratory distress (increased breathing rate and pulse) on the 3rd day.

Management of infants with HMD can be divided into the prenatal and postnatal periods. Steroid administration in the prenatal period has been shown to aid maturation at 24-33 weeks of gestation (5). Giving betamethasone to women at 34-35 weeks of gestation can improve neonates better than a placebo. Betamethasone administration has a Relative Risk (RR) of 0.77 (95% CI 0.63 - 0.95) to infants who are given CPAP or given HFNC (9). Betamethasone 12 mg intramuscular (IM)

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every 12 hours for 24 hours with an alternative dexamethasone 6 mg intravascular (IV) every 6 hours for 48 hours is recommended for pregnant women at 34 weeks of gestation (10). Our patient did not have time to be given prenatal steroids because the termination process had to be done immediately because there was an indication of antepartum hemorrhage with signs of labor (inpartum). The postnatal management given is breath support (from CPAP, HFNC to mechanical ventilation) and administration of exogenous surfactants (5). The provision of surfactants as prophylactic or therapeutic has been shown to reduce the risk of pneumothorax and neonatal death in infant patients at risk of HMD. Surfactants that can be given are synthetic or natural. Synthetic surfactants without protein are less effective than natural surfactants with SP-B and SP-C. Early surfactant administration in the first 2 hours of a newborn significantly reduces the need for mechanical ventilation compared to therapy (11).

The provision of breath assistance to patients with HMD can be differentiated based on non-invasive ventilation support (CPAP, NIPPV, HFNC) and invasive (mechanical ventilation) (5). Based on the results of a meta-analysis on the use of non-invasive ventilation in RDS (Respiratory Distress Syndrome) patients, CPAP is preferred for infants who still have spontaneous breathing, with a recommended pressure of at least six cmH_2O to 9 cmH_2O. Apply higher pressure to PIP (Peak Inspiratory Pressure) of 20-25 cmH_2O in infants with persistent apnea or bradycardia. NIPPV is a non-invasive breath support method that provides intermittent mandatory ventilation at continuous distending pressure. The advantages of giving NIPPV are reducing the risk of asynchronous breathing, increasing TV (Tidal Volume) and MV (Minute Volume), and reduce the effort on patient's inspiration (12). Based on an RCT (Randomized Clinical Trial) in Los Angeles County (LAC), it was found that the use of NIPPV in LBW infants after extubation proved to be more effective in preventing respiratory failure at 48 hours after extubation than nasal CPAP (5% vs. 37%). Complications of using NIPPV and nasal CPAP were found in both cases but were not statistically significant (13). The use of HFNC as a therapy for non-invasive ventilation support is now often carried out in several health centers. Based on a survey in Australia and the United Kingdom (UK), it was noted that there are several advantages to using HFNC, such as fewer incidences of trauma to the nose, more comfort in infants, easier if want to provide enteral nutrition, and make it easier to prepare and use (6). Based on a meta-analysis of the use of HFNC in preterm infants as a means of breath support, it shows that there is no significant difference in the use of HFNC to mortality (with a Risk Ratio (RR) of 0.36 95% CI 0.01 - 8.73) and the possibility of chronic occurrence. Lung Disease (CLD) (with RR 2.07 95% CI 0.64 - 6.64) (8). A study found that there was no significant difference between the use of HFNC and nasal CPAP on the success of therapy at less than 72 hours (nasal CPAP 18% vs. HFNC 20%) and more than 72 hours (nasal CPAP 2% vs. HFNC 6%). Still, on nasal complications, trauma on day 3 showed a significant difference (nasal CPAP 14% vs. HFNC 0%) (7).

HFNC therapy in infants is the provision of high flow air (more than 1 liter/minute) that is heated, warmed, and mixed (air and oxygen) through a special nasal cannula. The components of HFNC (can be seen in Figure 4) consist of (a) flow meters, (b) sterile water to be warmed, (c) humidifier chamber and heater, (d) tubing, and (e) specific nasal

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canula6 (14). The recommended airflow for newborns is 4 - 6 liters/minute, depending on the patient's weight. For patients with a bodyweight of 1000 - 1999 grams, the recommended initial flow of 3 liters/minute, bodyweight of 2000-2999 grams, 4 liters/minute, and more than 3000 grams is recommended 5 liters/minute.

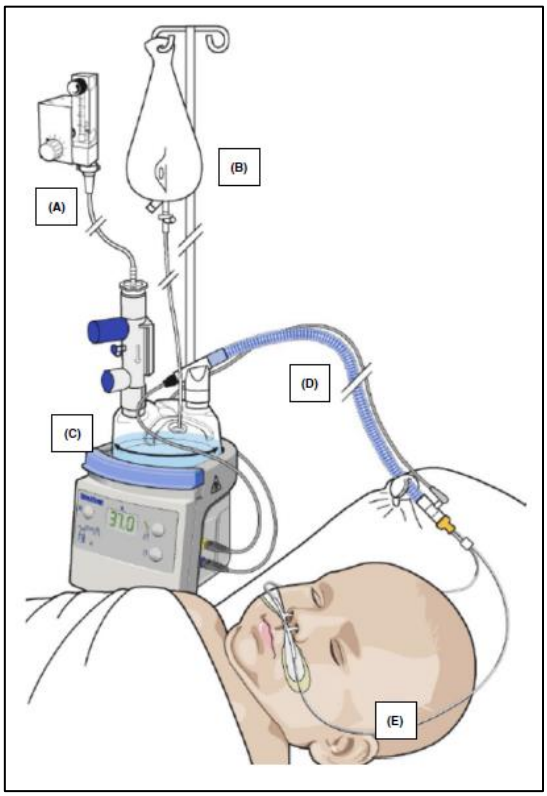

Figure 4. Component Overview of HFNC(14)

The respiratory assist mechanisms provided by HFNC were found to create distending pressure, remove dead space from the nasopharynx, provide sufficient airflow to reduce holding during inspiration, and Work Of Breathing (WOB) and provide adequate hot and humid gas for the baby (15). Physiologically, giving HFNC to preterm infants will increase the pressure from the airway and help wash out from dead space in the airway. Giving HFNC 2 to 8 liters/minute to preterm infants will increase the CO2 pressure in the airway (nasopharyngeal) to decrease the minute volume and reduce breathing effort during inspiration. The baby's weight influences the pressure produced by HFNC, airflow was given, the position of the mouth, and the baby's gestational age when measured. The pressure can be estimated by the formula obtained from Liew's research, HFNC airway pressure = -6,373 + (0.525 x Flow rate (liters/minute) + 1,454 x mouth position (0 when open, 1 when closed) – 1,856 x body weight (kg) + 0.307 x current gestational age (week). The resulting pressure does not differ significantly when compared to the pressure produced by CPAP (16). We use the modified HFNC using heaters and humidifiers used by ventilators to connect using pediatric tubing (as seen in figure 1). We keep the temperature from heater 30^{o} to 34^{o}C; if a lot of steam is obtained, the heater will be turned off 5-10 minutes and restarted. The use of HFNC in these cases can improve SpO2 as

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well as decrease the patient's breath rate and pulse (showing clinical improvement of respiratory distress) as can be seen in figure 2, can be compared at the time of use of CPAP (red box) with HFNC (yellow box).

Table 1. Criteria for N-PASS (National Pain, Agitation & Sedation Scale)(20)

Assessment criteria	Sedation		Normal	Pain / Agitation	
	- 2	- 1	0	1	2
Cry	Do not cry with pain stimulation	Groaning or crying with pain stimulation	- Cry naturally - No-fuss	- Often fuss or cry - It can be calmed down	- Crying loudly or crying softly but continuously - Fussiness cannot be soothed
Behavior	- Not bothered by any stimulation - No spontaneous movements	- At least disturbed by stimulation - Minimal spontaneous movement	By gestational age	Restless, often wake up when it's time to rest	Likes to kick, gets up during rest or there is no movement (without sedation)
Facial expressions	No expression Saggy mouth	Minimal expression with stimuli	Quiet according to conditions	Frequent expression of pain	Always shows an expression of pain
Extremity tone	- There is no reflex grasp (grasp) - Flaccid tone	- Reflex holding (grasp) is weak - Weak muscle tone	- Hands and feet calm - Normal muscle tone	- Often clenched fists, feet or often spread fingers - Increased muscle tone but not tense	Always clench your fists, feet and spread your fingers - tense body muscle tone
Vital sign	- There is no variation with stimuli - Apnea or hypoventilation	More than 10% of baseline with stimuli	By the baseline or normal according to gestational age	- Increase 10 - 20% from baseline - SaO2 76 - 85% with stimulation	- Increase more than 20% from baseline - SaO2 less than 76% with stimulation

The use of HFNC has the same efficacy as CPAP in providing infant outcomes when used in preterm infants and providing less frequent complications (8). Our patient had gastric distension, which caused reflux of gastric contents when wearing the CPAP mask. CPAP masks make the baby uncomfortable, causing agitation, which will increase Systemic Vascular Resistance (SVR). The patient we treated was suspected of having a Patent Ductus Arteriosus (PDA). An increase in SVR would exacerbate the L to R shunt, leading to increased volume overload from the ventricles and pulmonary pressure (17). According to Figure 2, it can be seen that we use modified HFNC for five days with initial flows ranging from 4 liters/minute to 2 liters/minute.

On the 5th day of treatment, clinically, it was found that the body looked yellowing, possibly due to hyperbilirubinemia. Still, the bilirubin test could not be done because the examination reagent was running out at the hospital, so it was decided to do phototherapy. Icterus in patients may be due to disruption of bilirubin excretion due to neonatal sepsis or because preterm patients may develop neonatal icterus (18). Figure 2 also shows an increase in pulse and breath rate caused by the patient being restless at the time of phototherapy. When the baby was crying and restless, there was a lump in the groin of the thigh, which was suspected of having an inguinal hernia. Agitation and pain in neonatal patients are rarely detected and well treated,

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and in some conditions, the agitation has adverse clinical effects on patients. Patients are suspected of having PDA in their heart defects, so agitation and pain will adversely affect the patient, as previously described (17,19). We use the N-PASS (Neonatal Pain Agitation and Sedation Scale) to determine the use of sedation or analgesia. We provide a clinical combination of midazolam, ketamine, and fentanyl if the N-PASS is more than 219 (20). The N-PASS assessment criteria can be seen in table 1.

On the 13th day of treatment, the patient got an increase in pulse and respiratory rate. The patient also had a fever of up to 38^{o}C. The patient was suspected of having a secondary infection and, after being observed, the use of an umbilical infusion for more than seven days due to difficulty finding venous access. The use of umbilical infusions for more than seven days is at risk of developing CLABSI (Central Line-Associated Bloodstream Infection) (21). After removal, there is a clinical improvement of pulse, breath rate, and decrease in temperature. Due to limited facilities and difficulty collecting blood samples, the patient did not have time to be evaluated in the laboratory for infection markers. The patient was referred to another health facility on day 14.

CONCLUSION

Modified High Flow Nasal Cannula (HFNC) in preterm infants with Neonatal Respiratory Distress Syndrome (NRSD) is more effective and efficient than CPAP. The use of HFNC was associated with a lower incidence of nasal trauma and pneumothorax than nasal CPAP.

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