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Original Article

PROFILE OF AIRWAY PATENCY, RESPIRATORY RATE, $PaCO_2$, AND PaO_2 IN SEVERE TRAUMATIC BRAIN INJURY PATIENTS (GCS <9) IN EMERGENCY ROOM DR. SOETOMO GENERAL ACADEMIC HOSPITAL SURABAYA

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ABSTRACT

Introduction: Traumatic Brain Injury (TBI) is the most common neurotrauma with high morbidity and mortality. Many guidelines recommend the use of mechanical ventilation for severe TBI patients, but there are limited resources of procuring ventilator machine in hospitals especially in developing countries. Yet it is not comparable with the number of TBI patients. **Objective:** This study is purposed to provide the profile of ventilation and oxygenation (airway patency, RR, $PaCO_2$, and PaO_2) in severe TBI patients (GCS<9) admitted in the Emergency Room (ER) of Dr. Soetomo General Academic Hospital Surabaya. **Method and Material:** This is a retrospective study using medical records of patients with TBI who were admitted in the ER of Dr. Soetomo General Academic Hospital from January to December 2017. The patient's general characteristics, blood gas analysis ($PaCO_2$, PaO_2), airway patency were recorded and analyzed. **Results and Discussion:** Thirty-seven severe TBI patients were included in the analysis. 30 men (81.1%) and 7 women (18.9%) with an average of 37±16 years old (range: 5-65) were studied. Most of the patients (94.6%) had MAP between 60 and 160 mmHg, $PaCO_2$<35 mmHg (72.9%), PaO_2>60 mmHg (100%), RR>20 breaths per minute (70.2%), and patent airways (64.9%) with simple support of oxygen. 8.1% of all of those patients had $PaCO_2$>45 mmHg. **Conclusion:** Most of the severe TBI admitted in the ER of Dr. Soetomo General Academic Hospital had hypocapnia or respiratory rate higher than the normal range. Though one-third of the patient has partial obstruction of the airway, no significant hypoxemia is found.

Keywords: $PaCO_2$; PaO_2; RR; Airway Patency; Severe TBI; GCS; MAP

ABSTRAK

Pendahuluan: Cedera otak adalah kasus neurotrauma yang paling umum dengan morbiditas dan mortalitas yang tinggi. Banyak pedoman merekomendasikan penggunaan ventilasi mekanik pada pasien cedera otak berat. Namun di banyak rumah sakit di negara berkembang, pengadaan ventilator masih terbatas dibandingkan dengan jumlah pasien cedera otak berat. **Tujuan**: Penelitian ini bertujuan untuk memberikan profil ventilasi dan oksigenasi (patensi jalan nafas, frekuensi nafas, $PaCO_2$ dan PaO_2) pada pasien cedera otak berat (GCS <9) di ruang resusitasi Instalasi Gawat Darurat (IGD) Rumah Sakit Dr. Soetomo Surabaya. **Metode dan Bahan:** Penelitian ini merupakan studi retrospektif dengan menggunakan rekam medis pasien cedera otak berat yang dirawat di ruang resusitasi IGD Rumah Sakit Dr. Soetomo dari bulan Januari hingga Desember 2018. Data umum pasien, analisis gas darah ($PaCO_2$, PaO_2), pantensi saluran nafas dicatat dan dianalisis. **Hasil dan Pembahasan:** Tiga puluh tujuh pasien cedera otak berat dianalisis. 30 pria (81,1%) dan 7 wanita (18,9%) dengan rata-rata 37±16 tahun (rentang: 5-65) diteliti. Sebagian besar pasien memiliki MAP antara 60 dan 160 mmHg (94,6%), $PaCO_2$<35 mmHg (72,9%), PaO_2> 60 mmHg (100%), frekuensi nafas>20 napas per menit (70,2%), dan jalan nafas atas bebas (64,9%) dengan bantuan oksigen tambahan. Namun, 8.1% pasien mengalami $PaCO_2$>45 mmHg. **Kesimpulan**: Sebagian besar pasien cedera kepala berat yang dirawat di ruang resusitasi IGD Rumah Sakit Dr. Soetomo mengalami hipokapnia atau tingkat pernapasan lebih tinggi dari kisaran normal. Meskipun sepertiga dari pasien mengalami obstruksi parsial pada jalan nafas, tetapi tidak ditemukan hipoksemia yang signifikan.

Kata kunci: $PaCO_2$; PaO_2; Frekuensi Nafas; Patensi Jalan Nafas; GCS; Cedera Otak Berat; MAP

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INTRODUCTION

Traumatic Brain Injury (TBI) is the most common neurological disease with high morbidity and mortality. One of the main causes is traffic accidents, which occupy the top 10 global causes of death in 2016. (1) TBI patients in developing countries are worse than in developed countries. (2) This also explains the mortality rate due to traumatic brain injury in Indonesia is higher compared to international standards. Severe TBI is the category of brain injury that has a high mortality rate. (3)

Death in patients with severe TBI can occur due to a decrease in the quality of the patient's condition including impaired ventilation and oxygenation, such as hyperventilation or hypoventilation. Hyperventilation is a set attempt to autoregulate the brain in reducing intracranial pressure due to primary brain injury. This will result in a decrease in $PaCO_2$. (4)

On the other hand, a decrease in consciousness that occurs in severe brain injury causes upper airway obstruction so that hypoventilation occurs. The hypoventilation causes hypercarbia which is characterized by increased $PaCO_2$ and hypoxia which is characterized by decreased PaO_2. (5)

Therefore, guidelines for the management of severe TBI recommend mechanical ventilators use in patients with severe TBI. (6)(7)

However in some countries, especially developing countries like Indonesia, procuring ventilators is still a problem. This problem occurs because of the relatively high price and cost of ventilator use, the need for a good education in the installation of ventilators, and the lack of research on mechanical ventilator protocols. (8) For example, as the main referral hospital in eastern Indonesia, Dr. Soetomo General Academic Hospital, the number of ventilators is not sufficient to meet the needs of all patients who need a ventilator.

Therefore, we want to find out whether there is a tolerance in the implementation of guidelines for the management of severe TBI patients regarding the indication of mechanical ventilator installation.

METHOD AND MATERIAL

This research is an observational retrospective study using a descriptive research design. The study population is all aged>5 years patients with severe TBI (Glasgow Coma Scale/GCS<9) admitted 2017 in the Emergency Room (ER) of Dr. Soetomo General Academic Hospital from January to December 2017 and had blood gas analysis data ($PaCO_2$, PaO_2), Mean Arterial Pressure (MAP), primary survey data (respiratory rate and airway patency) before definitive airway apparatus was installed. The research used the total sampling technique.

All data was collected just after admitting to the ER of Dr. Soetomo General Academic Hospital and before definitive breathing apparatus installation as seen in the medical records as approved by the ethics committee Dr. Soetomo General Academic Hospital Surabaya.

RESULT AND DISCUSSION

The total number of available patients' medical records is 86. Among these, 37 medical records meet to study criteria. The mean (standard deviation/SD) range is 37±17 years old with the range between 5 to 65 years

old. The average GCS with an absolute number is 6±2. Grouping data is presented in Table 1.

Table 1. Distribution of Severe TBI Patients Based on Mean Arterial Pressure (MAP)

MAP	N	Percentage (%)
<60	2	5.4
≥60 and <160	35	94.6
≥160	0	0
TOTAL	**37**	**100**

This study found that most patients have MAP between 60 to 100 mmHg (94.6%). The increase of blood pressure is a result of the brain's compensation in dealing with Increased Intracranial Pressure (ICP) that occur due to brain injury. (8) Increased blood pressure is in line with the brain's efforts to keep Cerebral Pressure Perfusion (CPP) constant. (4)(9) CPP is the difference between MAP and ICP. An increase in ICP, which occurs in brain injury, can cause a decrease in CPP. Therefore the brain, through brain autoregulation, will try to improve MAP to keep CPP constant. Brain autoregulation can occur when MAP is between 60 to 160 mmHg. (4)

In this study, we found that most of the TBI patients admitted in the ER of Dr. Soetomo General Academic Hospital based on MAP were still in acceptable brain auto-regulation range.

Distribution of Severe TBI Patients Based on $PaCO_2$

The average $PaCO_2$ of the subjects was 32.6±8.4 mmHg with a range of 17.9 to 59 mmHg. Grouping data is presented in Table 2.

When ICP increases, as in the case of brain injury, compensated hyperventilation will occur to decrease $PaCO_2$. (4) This is an attempt by the brain to reduce ICP by vasoconstriction that induced the reduction of blood volume. (4)

Table 2. Distribution of Severe TBI Patients Based on $PaCO_2$

$PaCO_2$ (mmHg)	N	Percentage (%)
<30	17	45.9
≥30 and <35	10	27.0
≥35 and <45	7	18.9
≥45	3	8.1
TOTAL	**37**	**100**

But some patients had hypercarbia. According to Cranshaw and Nolan (5), hypoventilation can occur in severe TBI patients as the result of a decrease of awareness. Decreased awareness can cause the reduction of pharyngeal tones and results in airway obstruction. It is linear with the data that shows most of severe TBI patients who admitted in the ER of Dr. Soetomo General Academic Hospital with $PaCO_2$ increases also experienced airway obstruction. (10)

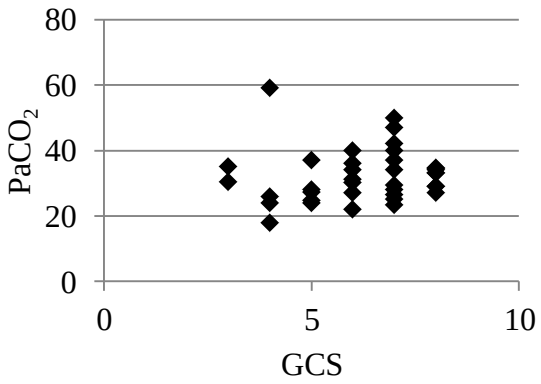

Figure 1. Distribution of Severe TBI Patients Based on $PaCO_2$ vs GCS

From Figure 1, it was found that there is a clear distribution of data between $PaCO_2$ and GCS. Severe TBI patients who come with low GCS tend to have low $PaCO_2$ and vice versa. This is quite different from a similar study conducted by Pfernninger and Linder (11) in Germany who also obtained a correlation between $PaCO_2$ and GCS of TBI patients measured at the scene and had not been intubated and ventilated. However, Pfernninger and Linder found that TBI patients who come with low GCS tend to have

high $PaCO_2$ and vice versa. But there are differences in data collection time between their study and our study. Their blood sample was taken within the first few minutes after the accident. On the other hand, Dr. Soetomo General Academic Hospital is a referral hospital. This makes many patients who admit to the ER of Dr. Soetomo General Academic Hospital had a chance to visit another hospital before a Dr. Soetomo General Academic Hospital and only a few patients had come directly after the incident.

Distribution of Severe TBI Patients Based on PaO_2

The average PaO_2 of the sample was 183.5±91.5 mmHg with a data range of 61.8 to 423.6 mmHg. Grouping data is presented in Table 3.

Table 3. Distribution of Severe TBI Patients Based on PaO_2 with simple device of oxygen support

PaO_2 (mmHg)	N	Percentage (%)
<60	0	0
≥60 and <80	5	13.5
≥80 and ≤200	18	48.6
>200	14	37.8
TOTAL	**37**	**100**

Hypoxemia is a secondary result that often occurs in patients with TBI. (5) Therefore, Guidelines for the Management of Severe TBI recommend (7) oxygenation monitoring to avoid PaO_2<60 mmHg. Table 3 shows that all of the patients with severe brain injury who admitted to the ER of Dr. Soetomo General Academic Hospital have no problems with oxygenation according to the Guidelines for the Management of Severe TBI 3rd Edition.

Dr. Soetomo General Academic Hospital has its PaO_2 standard in the treatment of severe TBI patients who admit in Dr. Soetomo General Academic Hospital (12), namely PaO_2 80-200 mmHg. Based on Dr. Soetomo General Academic Hospital standards, all of the patients with GCS <9 automatically will get the oxygen support with a simple devices. Our study shows that 84.6% patient who admitted in the ER of Dr. Soetomo General Academic Hospital did not experience hypoxia with PaO_2≤80. There was 13.5% suffered slightly hypoxia.

Distribution of Severe TBI Patients Based on Respiratory Rate

The average Respiratory Rate (RR) of the sample was 25±7.4 breaths per minute with a data range of 15 to 45 breaths per minute. Grouping data is presented in Table 4.

Table 4. Distribution of Severe TBI Patients Based on Respiratory Rate

Respiratory Rate (breaths per minute)	N	Percentage (%)
<12	0	0
≥12 and ≤ 20	11	29.7
>20 and ≤ 35	20	54
>35	6	16.2
TOTAL	**37**	**100**

According to Tülin and Nihan (13) in the discussion regarding intensive care management in TBI, there are indications based on respiration status when deciding ventilation in patients, one of which is respiratory rate>35 or <5 breaths per minute. Table 4 shows that most of the patients with severe TBI in the ER of Dr. Soetomo General Academic Hospital in 2017 did not meet one indication of ventilator use based on breath frequency.

However, based on the range of RR revealed by Yuan, Drost, and McIvor, most of severe TBI patients had RR>20 breaths per minute. (14) This means most of the patients had a severe brain injury in the ER of Dr. Soetomo General Academic Hospital experienced an increase in the RR from the normal range. Increased RR from this normal range can be an indication for mechanical ventilator instillation in patients with severe

TBI in the ER of Dr. Soetomo General Academic Hospital. If ICP increases (as in the case of brain injury), hyperventilation occurs, so that $PaCO_2$ will decrease. This reduction in $PaCO_2$ is done as an effort to vasoconstrict the blood vessels of the brain so that Cerebral Blood Fluid (CBF) remains constant. (4)

Distribution of Severe TBI Patients Based on Airway Patency

Patients' airway is classified according to their additional breath sounds and there were 4 categories of additional breath sounds, namely free upper airway (no additional breath sounds), partial obstruction (snoring), fluid obstruction (gargling), and mixed obstruction (snoring and gargling). Grouping data is presented in Table 5.

Table 5. Distribution of Severe TBI Patients Based on Additional Breath Sounds

Additional Breath Sounds	N	Percentage (%)
Nothing	24	64.9
Snoring	5	13.5
Gargling	4	10.8
Snoring dan *Gargling*	4	10.8
TOTAL	**37**	**100**

Decreased awareness of TBI can also cause upper airway obstruction due to pharyngeal tone, including the base of the tongue. The decreased pharyngeal tone will cause upper airway obstruction which causes hypoventilation. (5) However, based on the data that have been collected, shown in Table 5, it is found that most of the patients had no problems with the upper airway, or in this case, had free upper airway. This shows that most of the patients with severe TBI in the ER of Dr. Soetomo General Academic Hospital has no internal problems with the upper airway.

CONCLUSION

Most of the patients with severe brain injury (GCS <9) who admitted in the ER of Dr. Soetomo General Academic Hospital tend to experience hypocarbia ($PaCO_2$ <35 mmHg) with increasing RR, but there is no oxygenation problem that is significant with relatively good upper airway patency.

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Conflict of Interest

There is no conflict of interest to be declared.

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