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Original Research

Predictive Value of Non-Invasive Intracranial Pressure Monitoring in Profoundly Impaired Traumatic Brain Injury Patients

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Abstract

Introduction: Trauma brain injury is an emergency condition that requires immediate precise first aid to reduce mortality rates and prevent secondary complications. Severe head injuries can lead to intracranial bleeding, thereby affecting hemodynamics. Monitoring the increase in intracranial pressure aims to mitigate the severity of head injury in patients, reducing deaths caused by brain edema. The significance of assessing the Glasgow Coma Scale (GCS) concerning increased intracranial pressure is to determine conditions that could exacerbate physiological conditions due to head injury. The objective of this study is to determine changes in intracranial pressure among severe head injury patients.
Methods: This research employed a descriptive study with a retrospective approach. Patient data were sourced from medical records of individuals treated at RS PKU Muhammadiyah Gombong, diagnosed with severe head injuries during the last year from January to December 2022. A total of 180 severe head injury patients data were collected.
Results: Research findings revealed that patients with head injuries experienced an increase in systolic blood pressure (33.3%), a decrease in pulse rate (30.5%), and a temperature within the normal range (78.9%).
Conclusion: However, not all severe head injury patients exhibited elevated blood pressure, reduced pulse rate, or decreased oxygen saturation. All head injury patients experienced a decreased level of consciousness with a GCS score of less than 8.

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INTRODUCTION

Head injury can be defined as a result of mechanical trauma to the head, either directly or indirectly, leading to neurological, physical, cognitive, and psychosocial disturbances that can be temporary or permanent in nature. Injury can be described as an event or incident that disrupts an individual's ability to continue life or maintain bodily functions [1]. Accidents can be caused by various factors, incidents, or others, such as falls, motor vehicle collisions (MVCs), sports, diving, drowning, poisoning, overdoses, violence, and natural causes. To comprehend trauma, one must become better acquainted with injury mechanisms, how traumatic injuries are classified, and evaluate field reports [2], [3].

Head injury is a condition affecting the brain that can lead to decreased consciousness and hemodynamic imbalance. Head injury is an emergency that requires immediate accurate first aid to reduce mortality rates and prevent secondary complications. Severe head injury patients with decreased consciousness experience hemodynamic disturbances such as increased blood pressure and decreased respiratory and pulse rates [4], [5]. Increased intracranial pressure disrupts blood flow to the brain, leading to cerebral ischemia. Monitoring hemodynamic status serves as an indicator of patient prognosis. Monitoring intracranial pressure in head injury prevents perfusion from reaching the brain. Hemodynamic status affects oxygen transfer to the brain [6].

In the United States, the estimated incidence rate of head injuries reaches 500,000 cases annually, with an 80% incidence rate resulting in death before reaching the hospital, 80% being mild head injuries, 10% moderate head injuries, and 10% severe head injuries. Based on 2018, head injuries in Indonesia accounted for 11.9% of cases [7]. The highest incidence of head injury cases was in Gorontalo, accounting for 17.9%, and the lowest in South Kalimantan, with 8.6%. The prevalence of head injury incidence in Central Java was 10.61% in 2018. Among these, the highest incidence was in Klaten at 20.10%, while the lowest was in Purworejo at 4.66%, and in Kebumen at 8.28% in 2018 [8], [9].

Severe head injuries lead to intracranial bleeding, which can affect the hemodynamics of severe head injury patients. Intracranial pressure influences increased blood pressure, a consequence of venous pressure in the brain [10]. From the journal article, it can be concluded that monitoring hemodynamics is an indicator of increased intracranial pressure, thus minimizing its effects in head injury patients [11].

Head injury affects the autoregulation of intracranial volume, consisting of the brain, cerebrospinal fluid, and blood vessel flow—changes in one of the intracranial volumes without compensation result in intracranial pressure. If the blood flow volume from systemic circulation required for brain metabolism exceeds 100 mmHg, increased intracranial pressure can occur. Furthermore, if cerebral perfusion pressure is less than 60 mmHg, inadequate blood flow to the brain can cause hypoxia, impaired consciousness, and even death of brain cells [12], [13].

Monitoring the increase in intracranial pressure aims to mitigate the severity of head

injury in patients, reducing deaths caused by brain edema. The importance of assessing the Glasgow Coma Scale (GCS) in relation to increased intracranial pressure is to determine conditions that could exacerbate physiological conditions due to head injury [14]. Monitoring the increase in intracranial pressure is crucial in heart rate, blood pressure, and pulse oximetry: invasive measurements of cardiac output, preload, and afterload may be indicated, including pulse oximetry to indicate oxygen saturation outcomes in the care of head injury patients. Based on preliminary study data conducted on October 26, 2021, at RS PKU Muhammadiyah Gombong, aimed to explore the incidence of traffic accidents present in the emergency department's severe head injury patients recorded from January to December 2021 amounted to 18 individuals, and from January to June 2021, it amounted to 10 patients. From the varying number of head injury patients, it can be concluded that a month-to-month increase in problems resulting from head injury with clinical signs in patients who have severe head injuries with GCS values <8, increased systolic and diastolic blood pressure, increased pulse rate, irregular breathing pattern, oxygen saturation values <90%, CRT <2 seconds, and subsequent bleeding after accidents that can increase intracranial pressure.

The researcher is interested in researching traffic accident patients because monitoring increased intracranial pressure has yet to be conducted intensively. However, severe head injury patients receive nursing interventions to minimize injury, with clinical conditions after traffic accidents being admitted to RS PKU Muhammadiyah Gombong. This study aims to determine changes in intracranial pressure non-invasively in severe head injury patients.

METHODS

This study used a descriptive quantitative research with a retrospective approach. Patient data was obtained from medical records of patients treated at RS PKU Muhammadiyah Gombong. Data from the last year, spanning January to December 2022, yielded 284 patients. Subject selection criteria included complete medical records of patients diagnosed with severe head injury and who were treated from the beginning to the end at the same hospital without being referred to another facility.

The samples were collected based on criteria using the consecutive sampling technique, resulting in 180 medical record data, followed by the subsequent phase. Data collection occurred after obtaining permission from the head of the medical records department. The data were screened and entered into observation sheets containing respondent characteristics such as age, gender, education, occupation, and distance to healthcare services. Meanwhile, the main data included systolic and diastolic blood pressure, pulse rate, temperature, and signs of increased intracranial pressure. The research team conducted data selection after reviewing 284 medical record data, and only 180 relevant data were retained for further analysis.

The collected data was coded according to the variables under investigation, such as

blood pressure, pulse rate, temperature, GCS score, and oxygen saturation. Informed consent was obtained from the medical record department head regarding patient data collection. The data was presented in tabular form, displaying frequencies and percentages. This study has received ethical clearance with No. 159.6/II.3.AU/F/KEPK/X/2022.

RESULTS

The study was conducted over a period of one month to collect medical record data from severe head injury patients. The initial step involved identifying the diagnosis of head injury patients, followed by verifying the completeness of their medical record data. A total of 180 patients with suitable medical records were obtained. Patients with head injuries exhibited varying changes in vital signs. Differences in systolic and diastolic blood pressure, pulse rate, temperature, GCS score, and oxygen saturation were observed. Not all head injury patients experienced changes and had abnormal values in all parameters used for monitoring head injury patients.

Table 1

Characteristics of Respondents

	n	%
Age (years)		
18 - 25	44	24.4
26 - 35	62	34.4
36 - 45	25	13.9
46 - 55	12	6.8
> 55	37	20.5
Gender		
Male	112	62.2
Female	68	38.8
Highest Education Attainment		
No formal education	27	15.2
Elementary School	35	19.4
Junior High School	39	21.6
Senior High School	56	31.1
College/University	23	12.7
Occupation		
Unemployed	32	17.8
Laborer/Worker	55	30.5
Farmer	57	31.7
Trader	14	7.8
Entrepreneur	22	12.2
Distance from Residence to Hospital		
0 - 5 km	23	12.8
6 - 10 km	29	16.2
11 - 15 km	53	29.4
16 - 20 km	40	22.2
> 20 km	35	19.4

Table 2

Non-Invasive Head Injury Monitoring Parameters

	n	%
Systolic Blood Pressure (mmHg)		
< 80	2	1.1
80-100	15	8.3
100-120	36	20
120-140	48	26.7
> 140	79	43.9
Diastolic Blood Pressure (mmHg)		
< 60	4	2.2
60-80	37	20.5
80-100	97	53.9
> 100	42	23.4
Pulse Rate (beats/minute)		
< 60	5	2.8
60-80	55	30.5
80-100	43	23.9
100-120	54	30
> 120	23	12.8
Temperature (°C)		
< 34	2	1.1
34.5 – 36.5	13	7.2
36.5 – 37.5	142	78.9
37.5 – 38.5	20	11.1
> 38.5	3	1.7
Signs of Increased ICP*		
Yes	152	84.4
No	28	15.6

*Signs of Increased ICP: projectile vomiting, anisocoria of pupils, and severe headache

DISCUSSION

Based on the research findings, it can be concluded that intracranial pressure was increased in 100% of the 18 respondents. According to the researcher, the increased intracranial pressure is caused by bleeding or brain edema as a response to the injury. Shim et al (2023) stated that brain damage in severe head injury patients can lead to brain edema, resulting in increased intracranial pressure. Recent clinical studies indicate that brain edema due to blood vessel swelling is a primary cause responsible for brain swelling after severe head injury, including both vasogenic and cytotoxic brain edema [3].

Increased intracranial pressure is characterized by an excessive amount of Cerebrospinal Fluid (CSF) exceeding 15 mmHg (normal range 3-15 mmHg). An increased brain volume due to intracranial lesions or cerebral edema leads to elevated pressure within the intracranial vault. Subsequently, cerebral blood flow diminishes, causing cerebral hypoxia, which eventually leads to neuronal cell death. Cell death in the brain is irreversible, resulting in edema around the necrotic tissue and gradual herniation of the brainstem, leading to death [15], [16].

The research findings are consistent with previous studies. The average

intracranial pressure of the respondents was 62 mmHg, indicating signs such as headache, papilledema, and vomiting, among others. A survey conducted by Dhanda et al. (2022) at a Level I Trauma Center in the United States found that out of 529 patients monitored with severe head trauma, 65.6% had increased intracranial pressure, mostly due to subdural hematoma [17].

A study by Dai et al. (2020) on 160 respondents with severe brain trauma, monitored for intracranial pressure several hours after the injury, showed an increase of more than 10 mmHg in 82% of cases. Among these, 62 patients had intracranial mass lesions requiring surgical decompression. Sustained increased intracranial pressure can lead to poor outcomes, even death. Patients with severe head injuries who had intracranial pressure greater than 40 mm Hg upon admission were significantly associated with poor neurological outcomes. Severe intracranial hypertension was the primary cause of death in nearly half of the 48 deceased head injury patients. Therefore, comprehensive management is necessary for head injury patients with increased intracranial pressure to improve care quality and reduce morbidity and mortality rates [12], [18].

Monitoring systolic blood pressure revealed that most respondents had normal values (55.6%). Some had poor (33.3%) or very poor (11.1%) values. This aligns with studies conducted on head injury patients, where the average systolic blood pressure was normal. Both hypotension and hypertension can worsen head injuries [19], [20]. Hypotension can lead to cerebral ischemia, while hypertension can cause cerebral abscess. Adequate cerebral perfusion pressure is crucial for reducing death rates and improving quality of life. Normal blood pressure and adequate cerebral perfusion pressure ensure brain tissue perfusion and oxygenation, preventing cerebral ischemia [15], [21]. Diastolic blood pressure monitoring showed that most respondents had normal values (88.9%). Few had poor (5.6%) or very poor (5.6%) values. Like systolic blood pressure, abnormal diastolic blood pressure can lead to brain ischemia due to reduced cerebral perfusion [22]. The highest observed pulse rate among respondents was normal (44.4%), with only two respondents (11.1%) having a very poor pulse rate. This finding corresponds with studies showing that pulse rate has a weak correlation with outcomes in head injury patients. O'Brien et al. (2020) found that the average pulse rate in head injury patients was normal at 86.2 beats per minute. Regarding temperature monitoring, most respondents had normal values (94.4%), while only one (5.6%) exhibited hyperthermia. This contrasts with other studies where elevated temperature (>37.5°C) was observed in severe head injury patients. Blood presence in cerebrospinal fluid, particularly within the intraventricular space, can stimulate the hypothalamic thermoregulation center, increasing body temperature [23].

IMPLICATIONS

In this study, most respondents were young and had normal vital signs, including blood pressure, temperature, and oxygen

saturation. This aligns with the observation that the productive age group (18-40 years) tends to have a normal pulse due to optimal systemic body function. The implications that can be made in nursing are improving monitoring measures for patients with head trauma to be able to predict the severity of the condition based on changes in intracranial pressure.

LIMITATION

This study has limitations, including reliance on secondary data and a retrospective cohort design. Future research could adopt a prospective methodology with a larger sample size to improve results and include additional observations and control variables.

CONCLUSION

Patients with severe head injuries experience an increase in intracranial pressure during their hospitalization, amounting to 84.4%. Further treatment and monitoring processes must be carried out by nurses and the medical team during their stay at the hospital to prevent the worsening of their condition.

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CONFLICT OF INTEREST

All authors involved in this research have no conflicts of interest.

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