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Research Article

Risk Management of Ineffective Cerebral Perfusion in Children with Hydrocephalus

Ade Haniah Sya'adah Rahmaniah[1], Ema Arum Rukmasari[2]

[1]Nurse Professional Study Program, [2]Paediatric Nursing Departement, Faculty of Nursing, Padjadjaran University, Bandung, Indonesia.
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Corresponding Author:
Ade Haniah Sya'adah Rahmaniah, Faculty of Nursing, Padjadjaran University, Bandung, Indonesia.
E-mail Id:
ade17004@mail.unpad.ac.id
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A B S T R A C T

Introduction: Hydrocephalus is the accumulation of cerebrospinal fluid in the brain ventricles caused by impaired absorption of cerebrospinal fluid or obstructions of cerebrospinal fluid flow. Ventricular Peritoneal Shunt is a treatment for hydrocephalus. The main nursing problem is the risk of ineffective cerebral perfusion. This article explains the risk management of ineffective cerebral perfusion.

Method: The subject was a baby (7 months 14 days) with acute hydrocephalus post ventriculo-peritoneal shunt post-operative day 0. The case study method with the nursing care approach starting from assessment, nursing care plan, implementation and evaluation was used. Data collection methods were observation, physical and diagnostic examination, and interviews.

Results: The results showed that risk management of ineffective cerebral perfusion included identifying the causes of increased intracranial pressure, monitoring signs and symptoms of increased intracranial pressure, monitoring mean arterial pressure, monitoring respiratory status, monitoring fluid intake and output, positioning semi-fowler 30-45°, and drug collaboration. The implementation was carried out for 3 days (30 May-1 June 2022). The evaluation results showed that for 3 days, the blood pressure and mean arterial pressure values were in the normal range and consciousness did not increase.

Conclusion: It was established that risk management of ineffective cerebral perfusion can maintain stable mean arterial pressure but cannot increase the effectiveness of cerebral perfusion.

Keywords: Cerebral, Children, Hydrocephalus, Respiration, Nursing

Introduction

Hydrocephalus is a physiological disorder of the cerebrospinal fluid (CSF) due to brain ventricular abnormalities which cause an increase in intracranial pressure (ICP).[1] Hydrocephalus occurs in 1:1000 births, but this prevalence increases in developing countries to reach 200,000 cases per year in Africa.[2] Various conditions can cause hydrocephalus such as genetic factors, brain malformations, vascular dysfunction, dysregulation of ion and fluid transport in the choroid plexus, and inflammatory processes such as meningitis.[1]

Physiologically, CSS is secreted by the choroid plexus in the ventricles of the brain then flows into the subarachnoid space, and enters the cerebral venous system through arachnoid granulations.[1] In obstructive or non-communicating hydrocephalus there is an obstruction to the flow of CSS such as brain tumours and in some cases, it is also accompanied by hypersecretion of CSS.[1,3] Meanwhile, communicating hydrocephalus occurs due to inflammation that interferes with the flow or absorption of CSS fluid in the arachnoid villi or due to blockage in the flow of CSS after exiting the ventricles, where the flow in the ventricles is still good but fluid buildup occurs in the ventricles.[3] One of the inflammations is tuberculosis meningitis (Tb), which can cause vasculitis, causing decreased cerebral perfusion which in turn causes hydrocephalus.[4]

In infants, clinical manifestations from hydrocephalus include an abnormal increase in head circumference, protrusion of the fontanel, and widening of the cranial sutures.[1] In acute hydrocephalus it can cause brain herniation, brainstem reflex death, and coma.[3]

Management of hydrocephalus is through surgery to create drainage of CSS such as endoscopic third ventriculostomy (ETV) and Ventriculo-Peritoneal shunt (VP Shunt).[1,5] ETV is a surgical procedure that is generally performed on non-communicating hydrocephalus with the aim of creating a shortcut for the flow of CSS so that it can flow unhindered, but the failure rate tends to be high,[1,6] whereas VP Shunt is a surgical procedure by implanting a catheter subcutaneously in the ventricles of the brain into the peritoneal cavity, and it has valves in the ventricular and distal catheters to regulate CSS flow.[1] In hydrocephalus patients with Tb meningitis, VP shunt action is more recommended because the results are faster than ETV and ETV tends to fail at 3 months after surgery, so ETV is recommended after giving anti-TB treatment.[6] The reason is that shunt installation carries a lifetime risk of malfunction and infection.[6] This management is carried out to prevent complications that may arise such as increased ICP, ventriculomegaly and increased intraventricular pressure.[1] These conditions can then increase pressure and stretch on the periventricular tissue (including myelin, axons and, blood vessels) causing damage such as inflammation, hypoxia, and ischaemia.[1]

Obstruction of CSF flow in hydrocephalus causes fluid accumulation and pressure to increase in the intraventricular space, then fluid is pushed into the brain parenchyma causing cerebral oedema which then reduces cerebral perfusion and increases ICP.[7] Furthermore, these conditions can cause tissue injury.[1] Based on this theory, hydrocephalus patients have nursing problems namely the risk of ineffective cerebral perfusion. In the book Indonesian Nursing Diagnosis Standards (SDKI) it is explained that the risk of ineffective cerebral perfusion is decreased blood flow to the brain with associated clinical conditions, such as hydrocephalus and meningitis.[8] Interventions that can be carried out based on the Indonesian Nursing Intervention Standards (SIKI) include the management of increased intracranial pressure.[9] This intervention was carried out because cerebral perfusion can be adequate if ICP is maintained within normal range values.[10]

This case study aims to report management to maintain cerebral perfusion that remains effective in a child with hydrocephalus and a VP shunt. Furthermore, it will explain the risk management of ineffective cerebral perfusion in children with medical diagnoses of acute hydrocephalus, suspected bacterial meningitis, bronchopneumonia, hyponatraemia, post-VP shunt Postoperative Day (POD). The main nursing diagnosis is the risk of ineffective cerebral perfusion. Nursing care carried out included assessment, data analysis, enforcement of nursing diagnoses, preparation of nursing care plans (NCP), nursing implementation and nursing evaluation. The assessment was carried out on May 29 2022 and nursing implementation was carried out on May 30 - June 1 2022.

Method

This study uses a case study method with a nursing care approach. The case study method is a research approach used to analyze in depth a phenomenon that occurs at a time.[11] The case study approach has benefits such as being able to explore a case with a focus on a predetermined space and time and being able to collect data in various ways such as observation, interviews, surveys and so on.[11] This study also uses a nursing care approach that includes assessment, enforcement of nursing diagnoses, setting goals and NCP, implementation, and evaluation.[12] The assessment included observation, interviews with families, physical examinations, and diagnostic examinations.[12] The research was conducted on 29 May 2022-1 June 2022. Assessment, enforcement of nursing diagnoses, and preparation of NCP were carried out on 29 May 2022. Then implementation and evaluation of nursing were carried out on 30 May 2022-1 June 2022. The subject of this study was a baby (Baby H) aged 7 months 14 days with a medical diagnosis of acute hydrocephalus, post VP shunt POD 0 who is being treated at the Paediatric Intensive Care Unit (PICU) in a hospital in Bandung City.

Results and Discussion

Case Presentation

Baby H (7 months 14 days) was of Sundanese ethnicity and Muslim. The client was hospitalised because she had a fever for 3 weeks before being admitted to the hospital, accompanied by frequent bowel movements (4 per day) with liquid and loose stools, frequent seizures with blinking and eye movements upwards and for a short duration, often falls asleep, is fussy, and cough with phlegm 1 week of SMRS. Previously the client was treated in the inpatient room for 4 days due to bronchopneumonia and dehydration, but the client was transferred to the PICU room because of decreased consciousness and experienced seizures.

During the prenatal period, the client's mother always visited the midwife. In the third trimester, the client's mother

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suffers from hypertension. The client's mother routinely consumed vitamins, calcium, and anti-hypertensive drugs. The client was born normally with a body weight (BB) of 2,900 grams and a body length (PB) of 48 cm. Since birth, Baby H did not get any immunisations because it was contrary to her father's belief. History of disease in the client's family included TB suffered by the client's grandparents who are often in contact with the client. During the assessment, the client's consciousness was under the influence of drugs. The client had a nasal cannula installed, IV line 1 line, and OGT. The vital signs (TTV) were: pulse 121/minute, SpO_2 100% (by nasal cannula), blood pressure (BP) 88/59 mmHg, mean arterial pressure (MAP) 69 mmHg, respiratory rate 68/minute, and temperature 39.7˚C in the axilla, weight 6.5 kg (weight/age good nutrition), PB 63cm (PB/age normal). The results of the inspection physical examination found that the head was symmetrical, looked large with a head circumference of 41cm, had a VP shunt tube attached and was bandaged with gauze, the lip mucosa was dry, chest retraction was visible, and the client's posture was decerebrate. Palpation results obtained capillary refill time (CRT) < 2 s, pulse felt strong, and skin felt warm, the body, especially the joints, was stiff and difficult to move. The results of auscultation of bowel sounds (+), found no abnormal heart sounds, and there were additional wheezing and stridor breath sounds. Then there were no abnormal findings on percussion examination. Assessment of the risk of pressure sores with the Glamorgan scale, namely a score of 30 (very high risk). Assessment of fall risk with the Humpty Dumpty Fall Scale, which is a score of 15 (high risk of falling).

The results of a CT scan are that there is an accumulation of fluid in the brain. Complete blood count results on 27 May 2022 found: Hemoglobin 10.7 g/dL (low), leukocytes 13,040/mm³ (normal), erythrocytes 4.37 million/L (normal), hematocrit 31.9% (low), platelets 780,000/mm³ (high). The results of the electrolyte examination on May 28, 2022 found: Sodium/sodium 131 mEq/L (low), potassium (potassium) 4.4 mEq/L (normal), calcium ion (Ca++) 1.18 mmol/L (normal).

Based on the results of this study, the priority nursing diagnosis for the client is the risk of ineffective cerebral perfusion as evidenced by meningitis and hydrocephalus. Supporting data are: DS (-), DO: Medical diagnosis acute hydrocephalus, suspected meningitis. Based on the guidelines from the IDHS, writing a risk diagnosis is done by writing down the risk of problems as evidenced by risk factors.[8] In addition, there are other nursing problems in patients, namely: ineffective airway clearance, electrolyte imbalance (hyponatremia), hyperthermia, risk of pressure sores and risk of falling.

Nursing Care Plan

Furthermore, the nursing goals were: after 3 x 24 hours cerebral perfusion improved with result criteria, increase consciousness, BP within the normal range (systole 65-115 mmHg, diastole 42-80 mmHg, MAP within the normal range (48-92 mmHg).[13] Cerebral perfusion, is adequate cerebral blood flow for brain functions.[13]

The risk management of ineffective cerebral perfusion was arranged based on ICP improvement management interventions which are interventions to identify and manage ICP improvements.[9] The NCP that was carried out was identifying the causes of increased ICP, monitoring signs and symptoms of increasing ICP, monitoring MAP, monitoring respiratory status (respiration rate 20-30/ minute, respiratory effort, breathing pattern, oxygen saturation), monitoring fluid intake and output, positioning semi fowler 30-45˚, collaboration Sibital 2 x 20 mg IV, Phenytoin 2 x 20 mg IV, Mannitol 3 x 16 cc IV, Dexamethasone 3 x 1.3 mg IV, Ceftriaxone 1 x 650 mg IV, Amikacin 1 x 10 mg IV, Ethambutol 1 x 125 mg PO, Prednisone 2 x 5 mg PO.

In this study, researchers took the semi-fowler's position intervention (30˚-45˚) based on evidence as presented in Table 1.

Table 1.Evidence-based Practice for NCP

Title, Author, Publication Year	Research design, Sampling Technique, Sample	Intervention	Result
Effects of different head-of-bed elevations and body positions on intracranial pressure and cerebral perfusion pressure in neurosurgical patients[14]	Design: quasi experiment Sampling technique: purposive sampling Sample: 30 subjects > 18 years old with extra ventricular drainage and/ or ICP monitoring in the neurosurgical room	Head elevation 15, 30, 45˚ in supine and left/ right lateral position	ICP increased and Cerebral Perfusion Pressure decreased in all positions with different degrees of head elevation, but the results were not significant. Patients with a GCS score of 3-8 are in 15˚ right and left lateral positions and 45˚ right lateral positions; and when a patient with a GCS score of 13-15 acts at 15˚ left lateral, ICP increases and CPP decreases significantly.

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Does prone positioning increase intracranial pressure? a retrospective analysis of patients with acute brain injury and acute respiratory failure[15]	Design: retrospective Sampling technique: purposive sampling Sample: 115 patients treated in prone position based on medical records from 2007-2013 in the Neurointensive Care Unit (NICU) with brain damage and respiratory failures	The patient is positioned supine with a head elevation of 30˚, then changed to a prone position of 135˚ for 8 hours per day, on average the patient gets 4x therapy	ICP is significantly increased < 20 mmHg in the prone position compared to supine and is accompanied by a trend toward decreased CPP. Oxygenation is significantly increased in the prone position compared to when supine.
Systematic review of decreased intracranial pressure with optimal head elevation in postcraniotomy patients: a meta-analysis[16]	Design: systematic review Sampling technique: - Sample: randomized control trial study examining the benefits of different degrees of head elevation on changes in ICP in postcraniotomy patients	Head elevation 0˚, 10˚, 15˚, 30˚, 45˚	Compared to 0˚, head elevations of 10˚, 15˚, 30˚, and 45˚ result in lower ICP. Head elevation of 30˚ and 45˚ produces a lower ICP than 0˚, 10˚. Head elevation of 30˚ and 45˚ resulted in a lower ICP but not significantly different.

Table 2.Vital Signs during Implementation

Variable	Day 1	Day 2	Day 3
Time	15.00	06.30	09.30
Level of consciousness	Coma (E1V1M2)	Coma	Coma (E1VTM1)
BP (mmHg)	93/62	111/81	99/68
MAP (mmHg)	72.3	91	78.3
Heart rate (times/min)	171	195	188
Respiratory rate (times/min)	32	63	33
SpO_2 (%)	100 (by nasal canul)	100% (by NRM 10L)	97% (by ventilator)
Temperature (˚C)	38	37.8	38.4

Then, the implementation of nursing to Baby H is carried out for 3 days (30 May 2022-1 June 2022). Nursing interventions were implemented based on nursing ethics such as autonomy, beneficence, nonmaleficence, confidentiality, veracity, and justice in order to respect research subjects as human beings.[17] In addition, researchers have also obtained written informed consent from the patient's family.

Evaluation

The evaluation results after implementing nursing for 3 days are presented in Table 2. It can be seen that the client's level of awareness did not increase despite the collaboration of 2 x 20 mg IV Sibital sedation on May 30, 2022. The client's level of awareness on June 1, 2022 was in a coma with a score of Glasgow Coma Scale (GCS) E1VTM1. For 3 days TD and MAP were within the normal value range. The value of the client's respiratory rate was always high > 30/minute, but the oxygen saturation was within the normal value range with the help of oxygen. The client's respiratory status had worsened on May 31, 2022 at 06.30 with an increasing respiratory rate (56/minute)

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and chest retraction so that the oxygen mask was replaced by using a 10 L NRM then at 10.00 it was increased to 15 L because the respiratory rate continued to be high, namely 54/minute. Then the client experienced respiratory failure and septic shock at 22.03 with BP 106/65mmHg, temperature 37.3˚C, so a collaborative endotracheal tube (ETT) intubation was carried out and afterwards a collaboration was carried out with the installation of intraosseous access. After installation of the ventilator, chest retraction decreased, respiratory rate 33/minute and SpO_2 96%. On June 1, at 06.00, collaboration of the vein section and intraosseous access was stopped. In addition, the client's body temperature tends to be high. During the 3 days of implementation, the patient was also in a semi-Fowler's position as well as right and left lateral with a head elevation of 30˚-45˚ which was changed every 8 hours to prevent decubitus. In addition, monitoring of fluid intake and output was carried out. The client's fluid intake was milk as much as 90cc/3 hours and D5 ¼ NS 500CC/24 hours infusion, while the fluid output was urine which is measured by weighing the diapers used. The results of the evaluation were that the problem was partially resolved and the intervention was continued.

Discussion

Based on the examination, baby H was diagnosed with hydrocephalus and suspected bacterial meningitis. Hydrocephalus can be caused by several things such as genetic factors, brain malformations, vascular dysfunction, dysregulation of ion and fluid transport in the choroid plexus, and inflammatory processes such as meningitis.[1] In this case, it is known that the client has not received any immunizations because of the belief of her parents and the client has also had contact with a family member who has TB. This is a risk factor for clients experiencing hydrocephalus.[18]

It is known that the risk of hydrocephalus in meningitis patients is caused by inflammation of the meninges producing exudates which then ensnare the blood vessels causing vasculitis, blocking the flow of CSF, and causing communicating or non-communicating hydrocephalus.[19] Communicating hydrocephalus occurs due to inflammation that interferes with the flow or absorption of CSF fluid in the arachnoid villi or due to blockage in the flow of CSF after exiting the ventricles, where the flow in the ventricles is still good but fluid buildup occurs in the ventricles.[3] Whereas non-communicating (obstructive) hydrocephalus occurs due to an obstacle to the flow of CSS such as a tumour.[3] Complications of communicating hydrocephalus are a more common complication in patients with bacterial meningitis, however, in younger children, acute obstructive hydrocephalus is more common.[5] Surgical procedures such as placing a VP shunt are more recommended for acute obstructive hydrocephalus.[5]

In Baby H, a VP Shunt was performed. VP shunt is a catheter placed subcutaneously from the ventricles of the brain to the peritoneal cavity which functions to drain CSS from the ventricles to the peritoneum.[1] The use of a VP shunt is more likely to provide improvement compared to an endoscopic third ventriculostomy (ETV), where ETV is more at risk for failure, especially in Tb meningitis patients who have not received treatment.[6]

Installation of a VP shunt in children is known to have a risk of failure due to obstruction that must be treated but there is still a risk of failure after treatment, the risk increases in the first 2 years after installation. Failure can be diagnosed by imaging with enlarged ventricular size, rapid head growth, chronic headaches, vomiting, irritability, decreased consciousness and a prominent fontanel. If the symptoms that appear are not significant, ICP monitoring can be done to detect obstruction. In addition, VP shunt also poses an increased risk of infection in the first 3 months after surgery with symptoms of fever, irritability, erythema, or symptoms of shunt malfunction. Another complication is shunt overdrainage which causes symptoms of shunt obstruction or chronic headaches.[1]

Data analysis shows that the main nursing diagnosis was the risk of ineffective cerebral perfusion. The emergence of this problem is caused by obstruction to the flow of CSF so that fluid accumulates and causes increased pressure in the intraventricular space, then fluid is pushed into the brain parenchyma causing cerebral oedema which then reduces cerebral perfusion and increases ICP.[7] Furthermore, these conditions can cause tissue injury.[1]

An increase in ICP occurs due to an increase in intracranial CSF volume, which is based on the theory from Monro-Kellie intracranial volume consists of 10% CSS, 10% brain blood volume, and 80% brain tissue, so if one of the three components increases, it will increase ICP.[10] Manifestations of increased ICP include anxiety, excessive drowsiness, decreased consciousness into stupor where the patient only responds to sound or pain stimuli, or even in severe conditions the patient becomes comatose with abnormal motor responses such as decortication (abnormal flexion of the upper extremities and extension of the extremities) or decerebrate (extension of the upper and lower extremities).[20] These symptoms are also experienced by the client who were consciousness and decerebration posturing.

Cerebral perfusion can be maintained adequately if MAP is at normal values, and with the MAP-ICP (Intracranial

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Pressure/ICP) equation it will produce CPP values or CPP = MAP-ICP. (Cerebral Perfusion Pressure).[10] The normal value of ICP in children is 3-7 mmHg, ICP > 20 mmHg usually results in a bad condition.[10] The normal value of MAP in children aged 6-12 months is 48-92 mmHg.[21] Calculating MAP can be done with the equation MAP = diastolic pressure (D) + (systolic pressure (S) – diastolic pressure /3) or MAP = (S+2D)/3.[22] The normal value of a baby's blood pressure is 65-115 mmHg for systolic pressure and 42-80 for diastolic pressure.[12]

Based on the theory, we know that ICP plays an important role in cerebral perfusion, besides that BP measurement is also important for determining MAP and knowing CPP values. Thus, in this study, the intervention designed for ineffective cerebral perfusion was ICP increasing management. Risk management of ineffective cerebral perfusion keeps ICP from increasing to maintain cerebral perfusion. The first implementation of nursing is to identify the causes of the increase in ICP which is carried out by identifying the aetiology that causes the increase in ICP. As previously discussed, the client is at risk for increased ICP due to Tb meningitis which causes hydrocephalus. The implementation is carried out with the collaboration of VP shunt installation and administration of drugs such as Etambutol 1 x 125 mg PO to treat infections due to Tb bacteria,[23] as well as administration of antibiotics such as Ceftriaxone 1 x 650 mg IV and Amikacin 1 x 10 mg IV to treat bacterial infections.[19]

Furthermore, other interventions were given, namely monitoring symptoms of increased ICP, monitoring BP, MAP, respiratory status, and intake and output which were carried out to determine if there was an increase in ICP, as well as to evaluate the success of the interventions that had been given. TD and MAP are used to ensure that cerebral perfusion remains adequate. Meanwhile, respiratory status needs to be monitored because carbon dioxide pressure ($PaCO_2$) and O_2 pressure (PaO_2) in the arteries play a role in the regulation of intracranial pressure. Hypercapnia or increased $PaCO_2$ causes cerebral arterial vasodilation which causes increased cerebral blood flow, decreases cerebral blood flow and then increases ICP, whereas hypocapnia or low $PaCO_2$ causes cerebral arterial vasoconstriction thereby reducing cerebral blood flow. Vasodilation of cerebral arteries due to hypercapnia causes an increase in vascular permeability so that plasma easily escapes from the intravascular space and causes cerebral oedema. In addition, the condition of low PaO_2 in the arteries causes cerebral arterial vasodilation causing cerebral edema, therefore it is important to maintain O_2 so that patients do not experience hypoxia which causes an increase in ICP. The physiology of blood vessels against $PaCO_2$ is the basis for brief hyperventilation as a management for increased ICP.[10]

Then, the next intervention is positioning the patient with semifowler 30˚-45˚. The semi-fowler position is a semi-sitting position of 30˚-45˚ when the patient is lying down which can increase the feeling of comfort when breathing. Positioning the patient in a semi-Fowler's position is recommended for ICP management.[19] The effect of the patient's body position on ICP has indeed been widely studied. A study by Roth et al. showed that the prone position (stomach) increases ICP and oxygenation in patients with brain injury and respiratory failure.[15] Altun Uğraş et al. in his research found that in neurosurgery patients the supine position at elevations of 15˚, 30˚, 45˚, left lateral position 15˚, and right lateral position 15˚ increased ICP and decreased CPP.[14] Different findings were found in a study in which head elevation positions of 10˚, 15˚, 30˚, and 45˚ produced a lower ICP than the 0˚ position, but the 30˚ position produced a lower ICP than the 10˚ and 15˚ positions, while the 30˚ has no difference in results with the 45˚ position. The position of the head elevation of 30˚ and keeping the head parallel to the midline of the body functions to increase venous return from the cerebral to the heart via the jugular vein.[10]

It has been explained that patients who had increased ICP may experience cerebral oedema leading to excessive secretion of Antidiuretic Hormone (ADH), causing fluid retention, which then leads to fluid dilution and hyponatremia.[20] The patients are given Phenytoin 2 x 20mg IV collaboration which has an impact on reducing ADH expenditure, therefore fluid monitoring is very important for evaluating the results of interventions. Preventing hyponatremia is very important so as not to worsen the client's condition.

Further more, another collaborative intervention given to clients is mannitol 3 x 16 cc IV which functions as an osmotic diuretic which reduces cerebral edema. The administration of corticosteroids, namely Dexamethasone 3 x 1.3 mg IV and Prednisone 2 x 5 mg PO also helps reduce cerebral oedema. Collaboration Sibital (phenobarbital) 2 x 20 mg IV, Phenytoin 2 x 20 mg IV is an anticonvulsant used to treat seizures in clients.[20]

The results of the nursing evaluation showed that during the 3 days of implementation, the TD and MAP values were within the normal range. As has been explained, MAP plays a role in calculating the CPP value. However, in this study, ICP was not measured so the CPP value was not known. Supposedly, in patients who are not under sedation with a GCS of 3-8, it is necessary to measure ICP using a transducer or doppler.[10] However, even so, normal MAP values are known to maintain cerebral blood flow to remain effective.[10] In addition, the client's respiratory status during implementation tends to be unfavourable. This is seen from the value of the frequency of breath

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which tends to be high, as well as clients who experience respiratory failure. On May 31, at 10:02 p.m., an intubation was performed on the client, so that the client's risk of experiencing hypoxia which could increase ICP has been handled. Then the client's level of awareness decreased from stupor with a GCS value of E1V1M2 to coma with E1VTM1. As previously explained, this indicates cerebral perfusion is a manifestation of increased ICP.

The results of the nursing evaluation are not in line with the theory, in which after the implementation of nursing the client's consciousness does not increase and the client even experiences various complications such as respiratory failure and septic shock. In this case, the client's TB meningitis condition can worsen the client's condition and it becomes difficult to achieve nursing goals. Age < 2 years is a risk factor for worse neurological manifestations in meningitis.[5] In paediatric patients, meningitis at the most severe stage can cause coma, decerebrate posturing, hypertension, and decreased vital signs, even death.[18] As many as 43% of bacterial meningitis patients died due to complications in the central nervous system (CNS) which were characterised by GCS < 9, 39% due to systemic complications such as septic shock and respiratory failure, and 4% experienced both complications.[24] Septic shock occurs due to the spread of bacterial infection through the blood vessels, this can occur in pneumonia conditions such as those experienced by patients.[23] In addition, the hyponatremic condition experienced by patients can also cause shock.[25] Then the next cause of death in patients with bacterial meningitis is respiratory failure, which in children can be caused by lung disease that causes impaired gas diffusion, airway obstruction, or neuromuscular and CNS dysfunction.[26] In this case the condition of respiratory failure can be caused by lung disease (bronchopneumonia) and CNS complications. Changes in $PaCO_2$ levels can affect the pH of CSF which can then affect the impulses conveyed by chemoreceptors in the brain to the pons and medulla which function to stimulate breathing.[26] An increase in CO_2 will lower blood pH and increase ventilation.[26]

The limitations of this study are the lack of time to implement nursing, the absence of ICP measurements, and the lack of data related to the results of laboratory tests and documentation of nursing care for clients.

Conclusion

After 3 days of implementation, it can be seen that risk management of ineffective cerebral perfusion which includes: identifying causes of increased ICP, monitoring signs and symptoms of increased ICP, monitoring MAP, monitoring respiratory status, monitoring fluid intake and output, positioning semi fowler 30-45˚, collaborative pharmacological therapy plays a role in stabilising MAP, but these interventions cannot increase the effectiveness of cerebral perfusion in children with hydrocephalus and VP shunts installed.

In future research, it is expected to conduct research related to the risk management of ineffective cerebral perfusion over a longer time.

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