ISSN No:-2456-2165

Hypoperfusion that found using Transcranial Doppler in Intracranial Hemorrhage Patients have Corelation with Glasgow Outcome Scale after an Emergency Surgery

Akhyar Nur Uhud
Departmen of Anesthesiology and Intensive Care – Doctor Soetomo General Hospital
Faculty of Medicine University Airlangga – Doctor Soetomo General Hospital
Surabaya, Indonesia

Nancy Margaretta Rehatta
Departmen of Anesthesiology and Intensive Care – Doctor Soetomo General Hospital
Faculty of Medicine University Airlangga – Doctor Soetomo General Hospital
Surabaya, Indonesia

Teguh Sylvantoro
Departmen of Anesthesiology and Intensive Care – Doctor Soetomo General Hospital
Faculty of Medicine University Airlangga -Doctor Soetomo General Hospital
Surabaya, Indonesia

Abstract

➢ ***Background:***

Intracranial Haemorrage is a life-threatening condition which has high mortality and morbidity, but with a good intensive care the outcome can be improved. GCS is an objective grading system for measuring the degree of brain dysfunction and neurological status after damage to the brain. GCS has been used for several years to asess neurological status of patient with decreassed consciousness but there are some conditions where GCS cannot be measured. An examination of hypoperfusion (using TCD) shows a worse prognosis in patients with intracranial haemorrage. Brain hypoperfuision has been shown to cause poor neurological status and can cause damage to the brain.

➢ ***Method:***

Correlational observational analytic study was conducted on 30 intracranial hemorrhage patients who underwent surgery in the emergency ward of Dr. Soetomo General Hospital. The primary survey was conducted in patients with intracranial hemorrhage after that in patients who will undergo surgery seen hypoperfusion (using TCD) preoperatively. The patient is operated according to indications, after surgery the patient will be sedated and a postoperative CT scan is performed. After free of sedation the patient was tested for postoperative TCD.

➢ ***Results:***

Preoperative hypoperfusion was found in 77% of patients, with 65% of patients having GCS≤8. According to statistical analysis there was no relationship between the incidence of preoperative hypoperfusion with preoperative GCS (p 0.211). Postoperatively, 60% of patients experienced hypoperfusion with 77% of patients having GCS≤8. In the statistical analysis examination found there was a relationship between the incidence of postoperative hypoperfusion with postoperative GCS (p 0.002).

➢ ***Conclusion:***

Postoperative hypoperfusion is related to postoperative GCS, so it can be used as an evaluation of neurological status in patients with intracranial hemorrhage.

Keyworld:- *Hipoperfusion cerebral, TCD, GCS, Intracranial Haemorrage.*

I. INTRODUCTION

Intracranial bleeding is a haematoma inside cranium vault including brain parenchym and its surroundings such as meningeal space. Intracranial bleeding can be classified based on the location of the bleeding that is Intracerebral hematoma (ICH), Epidural hematoma (EDH), Subdural hematoma (SDH), Subarachnoid haemorrage (SAH) and intraventrikel haemorrage (IVH)[1]. Intracranial hemorrhage is a life-threatening condition with high mortality and morbidity but with an intensive care the outcome can be improved. Intracranial hemorrhage can occur spontaneously (due to vascular malformations), due to trauma, or due to coagulation therapy. The mechanism of brain damage in trauma patients and bleeding stroke patients have in common, the difference if the trauma damage is caused by external forces (external barotrauma) while ICH hemorrhage strokes are debated the existence of internal power (internal barotrauma)[2,3].

ISSN No:-2456-2165

Non-traumatic intracranial hemorrhage is a very adverse event because it has a high morbidity and mortality. About 10-15% of strokes are ICH with an incidence of 24.6 every 100,000 people every year, in the United States there were 40,000 to 67,000 cases in 2007. Mortality rate for 30 days spontaneous ICH ranges from 35% - 52% and only 20% survivors can experience a good recovery function for 6 months[4,5]. The mortality rate in brain injury (Traumatic Brain Injury) varies in various studies, in studies of tieves et all in North America found 19.7 out of 100,000 patients per year, in studies of Mauritz et all in Europe found 11 out of 100,000 patients per year, and in based on studies from Aghkani et all, a TBI mortality rate of 0.5%[6]. The target of management of intracranial hemorrhage is to assess and minimize the direct effects of the bleeding by controlling blood pressure, correcting coagulation abnormalities and removing vascular lesions that are at high risk of rebleeding. Recently, there is no study that show specific therapy can improve the final outcome after ICH, focused treatment in a special neurocrictical unit can improve the final outcome[6,7].

In patients with intracranial hemorrhage an autoregulation mechanism is disrupted so that brain perfusion can occur, brain hypoperfusion is shown to cause poor neurological status and can cause damage to the brain. Brain hypoperfusion is obtained if Cerebral Blood Flow (CBF) is less than 35ml / 100g / min[8]. CBF if less than 30 ml / 100g / min can cause neurological symptoms, CBF 15-20 ml / 100g / min can cause reversible damage or disturbance of electrical activity of the brain and CBF less than 15ml / 100g / min will cause irreversible nerve damage[9]. One of the targets in the care of patients with TBI is to maintain secondary brain damage that can cause pathological conditions such as hypoperfusion which causes brain ischemia, intracranial hypertension and energy dysfunction that arise after primary brain damage which will worsen the final condition later[10].

There are several techniques for measuring CBF, some methods have their advantages and disadvantages. One of the CBF direct measurement techniques that can be done by bedside is Transcranial Doppler (TCD)[9]. TCD is a non-invasive, inexpensive, portable and safe technique for assessing intracerebral blood flow based on the Doppler effect. The Doppler effect is a transducer effect that emits waves and then receives reflections from the surface of red blood cells in intracranial blood vessels, this provides numerical and visual information that is useful for inferring flow characteristics in blood vessels[11]. The use of TCD in cases of traumatic brain injury has been shown to detect hypoperfusion in traumatic brain injury patients associated with mortality. Based on Chan et all hypoperfusion is one of the poor prognostic factors, where in patients if there are three of the following two categories initial Vmean <28 cm / s, diastolic flow velocity <25 cm / s and Pulsatility index (PI)> 1.31 (showing increased cerebral vascular resistance). In TBI there is an increased metabolic need of the brain and a lack of energy reserves which causes the risk of damage to the CBF[12].

The Glasgow Coma Scale (GCS), first introduced since 1974, is an objective method for determining the degree of brain dysfunction and coma after brain damage. GCS measures 3 categories of eye response (eye), speech response (verbal) and motor response (motoric)[13]. For several years GCS has always been used as a predictor of trauma patients and patients with decreased consciousness at Dr. Seotemo General Hospital. However, there are several conditions where GCS cannot be measured such as patients in sedation, patients with a history of alcohol consumption, patients with swollen eyes, tube in patients and other conditions[14]. Based on study conducted by Ziegler by performing TCD in brain injury patients, patients with measurements on normal TCD have a better chance of survival than others, whereas patients with hypoperfusion have a worse prognosis[12]. Through this study, we will determine corellation between brain hypoperfussion (inspected with TCD) and neurological status (using GCS) in Intracranial hemorrhage patient undergo Emergency Surgery. In addition, we will investigated whether there are correlation between TCD parameter (Mean velocity (Vm), Diastolyc velocity (Vd) adn pulsatility index) with GCS.

II. METHODS

This study is a prospective longitudinal analytic observational study and conducted at october 2019 until september 2019. Data were taken in operathing theather emergency unit in Dr Soetomo general hospital. Inclussion criteria in this study was patients with intracranial hemorrage cause by stroke or trauma that undergone emergency operation and patients with PaCO2 between 20-80 mmHg. Patients with unstable hemodynamic (characterized by SBP < 80mmHg), Hipoksia (SpO2 < 90%) were excluded in this study because it can altered the examination of CBF. Patients rellative who refuse to included for this study was also excluded, and patienst where its *Media Cerebri Artery* (MCA) cannot be obtained with TCD also excluded.

The primary survey will be performed in intracranial hemorrage patienst when in comes to emergency ward Dr Soetomo general hospital. Primary survey consisting of keeping the airway free if necessary definitive airway with intubation, breathing make sure oxigenation is maintained properly so as not to occur hypoxia, circulation keep the hemodynamics stable and disability control intracranial pressure with medical or non medical treatment. Intracranial hemorrhage patients can be done primary survey in the resuscitation room (RES) or in the surgical ward or medical ward Dr Soetomo Hospital depending on patients condition. After the primary survey is conducted, it is continued with the secondary survey by looking for any abnormalities from head to toe. One of them is by conducting blood gas investigations to check $PaCO_2$ levels and CT scans to see any abnormalities in intracranial. After the primary survey and secondary survey if there any indication to undergone emergency operation (depends on the neurosurgical team) the patient than evaluated by GCS and TCD measurement. We measured mean velocity (Vm),

ISSN No:-2456-2165

diastolic velocity (Vd) and pulsatility index (PI) MCA ipsilateral with the lession. Surgery that can be performed was craniotomy evacuation of the bleeding, craniectomy decompression, insersiton extraventricular draniage (EVD) or any combination depends its condition. The surgery was performed at operathing theater emergency ward Dr Soetomo general hospital. During surgery, anesthesia and surgery management is adjusted to the patienst condition and depends on the anesthesia and neurosurgeon team. Post-operative patients will be moved to the intensive observation room (ROI) of Dr. Soetomo General Hospital and will be evaluated post-operative CT scans. The patient will be re-evaluated GCS after the patient is free from the necessary sedation. After the GCS is evaluated, postoperative TCD is reassessed. We once again measured mean velocity (Vm), diastolic velocity (Vd) and pulsatility index (PI) MCA ipsilateral with the lession.

After that data will be collected on research data collection sheet and then analyzed using SPSS. Data that obtained was patient identity (sex,age), physical profile (body weight, height, BMI), causes of intracranial hemorrage (trauma or stroke), blood pressure (SBP, DBP and MAP), from CT scan we know the location of the bleeding and sign of brain edema, from the TCD measurement we know Vm MCA, Vd MCA and PI MCA. We could know the estimated *Cerebral Perfusion Pressure* (CPP) with formula : CPP = MAP – ICP, estimated ICP we can get by using formula : ICP = (10,93 x PI) – 1,28. Data was analyzed using SPSS 23, we first perform normality test using kolmogorov-smirnov, if we got a normal distribution we use pearson corelation test but if the data wasn't distributed normally we use non parametric corelation test. This study has been aproved by the ethical review comitte of Dr Soetomo general hospital, refference number 1554/KEPK/X/2019.

III. RESULTS

We conducted this study during october until november 2019 and get 30 samples that met inclusion and exclusion criteria. Majority causes of the intracranial bleeding in this study was stroke with 53% and the rest caused by TBI. Neurological outcome was measured using GCS. Majority GCS preoperative and postoperative was lower than 8 (57% preoperative and 53% postoperative). Other characteristic can be found in **Table 1**.

Variable	n (%)
Gender	
Male	15 (50%)
Female	15 (50%)
Age	
11- 20 y.o	5 (17%)
21 – 30 y.o	1 (3%)
31 – 40 y.o	3 (10%)
41 – 50 y.o	9 (30%)
51 – 65 y.o	8 (27%)
More than 65 y.o	4 (13%)
Type of surgery	
Craniotomy evacuation	5 (17%)
Craniectomy decompresion	
Extraventricular drainage (EVD)	6 (20%)
More than one procedur	
	7 (23%)
	12 (40%)

Table 1:- General characteristic intracranial bleeding in this study

Hypoperfusion that was detected using TCD was found in 76% preoperatively and 60% postoperative. Relationship between hypoperfusion and GCS preoperative and postoperative can be found in **Table 2**.

Hypoperfusion postoperative gave significant results (p = 0,002) while preoperative were not significant. TCD parameter (Vm, Vd and PI) postoperative was also found have significant relationship with GCS, but preoperative found not significant.

ISSN No:-2456-2165

Variabel	Mean (SD)	*p* value
Preoperative		
Hypoperfusion		0,211
Vm MCA	35,66 (±15,72)	0,131
Vd MCA	19,9 (±14,71)	0,115
PI MCA	1,5 (±0,55)	0,115
Estimated CPP	81 (±18,05)	0,453
Postoperative		
Hypoperfusion		0,002*
Vm MCA	35,66 (±15,72)	0,000*
Vd MCA	19,9 (±14,71)	0,000*
PI MCA	1,5 (±0,55)	0,000*
Estimated CPP	73 (±13,63)	0,042*
Difference in preop and postop		
dVm MCA	+4,47 (±13,66)	
dVd MCA	+6,81 (±14,04)	
dPI MCA	-0,4 (±0,76)	
dEstimated CPP	-8 (±18,42)	
*Significant if p < 0,05 [d] difference postoperative and preoperative [-] decreased ; [+] increased		

Table 2:- The relationship between Hypoperfusion that was detected using TCD and GCS preoperative and postoperative

IV. DISCUSSION

Hypoperfusion is associated with long term poor outcome in TBI or in stroke. Hypoperfusion than happens less than 72 hours in stroke patients is associated with a low barthel index and canadian neurological score[15], as well as in TBI hypoperfusion can occur in first 24 hour and its associated with a poor prognosis[16]. As mentioned above assesment CBF is essential in neurocrictical care and there are a lot of method can be used, TCD is one of tools to measure the CBF that non invasive and bedside. Previous study found that hypoperfusion in TCD can be defined if found two of three criteria mentioned. Theses three criteria was Vm of the MCA less than 35 cm/sec, Vd of the MCA less than 2 cm/sec and PI greater than 1,4. Those criteria was associated with poor prognosis in severe TBI[12].

In our study was found 76% intracranial bleeding patients was having hypoperfusion preoperative and 60% postoperative, these found was higher than previous study (24% - 46%[12,17,18]). Hypoperfusion was assosiated with low neurological status that measured by GCS, 56% patients with hypoperfusion was having low GCS (4-5)[18]. In our study we found that 88% patients with GCS less than 8 have hypoperfusion preoperative and 87% postoperative.

The difference in the statistical results (preoperative and postoperative) in our study can be due to brain metabolic disturbance in acute conditions, apparently have more influential than CBF disorder. In previous study it's found that hypoperfusion didn't have a significant effect with GCS in acute conditions. Decrease in $CMRO_2$ showed a significant corelation with GCS in patients with a poor outcome (GOS 1-3). Although hypoperfusion didn't have significant corelation with GCS, a hypoperfusion with metabolic failure was a good predictor for poor neurological outcome in severe traumatic brain injury[18]. In our study, preoperative patients come avaraged 24 – 72 hours post brain injury and postoperative patients was sedated using sedative agent. In an animal studies, it's found that there is a significant decrease of NAA (N-Acetylaspartate) after brain injury and increased of brain lactate in first hour until 48 hours. NAA was a marker of neuron viability and lactate was a metabolic product of anaerobic metabolism (that show a mitocondrial dysfunction)[19]. The use of sedative agent in neurocrictical care was to decreased the metabolic demand of the brain to compensate for the decrease in suply due to hypoperfusion[20]. In our study sedative agent that have been used was propofol. Propofol was a nonbenzodiazepin sedative agent that can caused decreased in $CMRO_2$ and CBF in order to decreased ICP[21].

Hypoperfusion as mentioned above was defined using Vm, Vd and PI MCA. In our study showed that both postoperative TCD parameter (Vm,Vd and PI MCA) and difference between preoperative and postoperative have significant corelation with GCS. Vm and Vd on doppler examination depend on the diameter, length and degree of stenosis of the blood vessels. If there were pathological condition occur inside intracranial vault (intracranial hemorrage or brain edema), there will be compensation with autoregulation. In the first phase it will caused vasodilation which causes an increase in cerebral blood volume and will further increase ICP. A continuous increase in ICP will cause a decrease in MAP and CPP. Hypertension intracranial causes CBF disorders that begin at the level of microcirculation and dilate to large blood vessels. The level of microcirculation can be seen from the MCA, where at the beginning there will be a picture of stenosis at the distal of the MCA and in conditions of increased ICP the stenosis can develop up to the MCA[22]. In previous study found that changes waves and values on doppler TCD can predict, differentiate and help

prognostication of clinical outcomes in patients with increased ICP, according to that study changes in Peak Systolic Velocity (PSV), End Diastolic Velocity (EDV), systolic and diastolic doppler ratios, PI and RI are associated with pathological symptoms of increased ICP[23].

V. CONCLUSION

Postoperative hypoperfusion that examined using TCD has a significant corelation with GCS postoperative. TCD parameter (Vm, Vd and PI MCA) postoperative also has a significant corelation with GCS postoperative. TCD can be used to examine neurological status postoperative in intracranial hemorrage patients undergone an emergency surgery.

REFFERENCE

[1]. Caceres, J. A., & Goldstein, J. N. "Intracranial Haemorrhage". *Emerg Med Clin North Am* , 30(3), 2012, pp 771-794.
[2]. Rymer, M. M. "Hemorrhagic Stroke: Intracerebral Hemorrhage". *Science of Medicine*, 108(1), 2011, pp 50-54
[3]. Powers, W. J. "Intracerebral Hemorrhage and Head Trauma: Common Effects and Common Mechanisms of Injury". *Stroke*, 41, 2010, S107-S110
[4]. Naidech, A. M. "Intracranial Hemorrhage". *American Journal Of Respiratory and Crictical Care Medicine*, 184, 2011, pp 998-1006
[5]. Li, M., Zhao, Z., Yu, G., & Zhang, J. "Epidemiology of Traumatic Brain Injury over the World: A Systematic Review" . *Austin Neurology & Neurosciences*, 1(2), 2016, pp 1-14
[6]. Elliott, J., & Smith, M. "The Acute Management of Intracerebral Hemorrhage: A Clinical Review". *Anesthesia & Analgesia*, 110(5), 2010, pp 1419-1427
[7]. Sahni, R., & Weinberger , J. "Management of intracerebral hemorrhage". *Vascular Health and Risk Management* , 3(5), 2007, pp 701-709
[8]. Bouzat, P., Vidal, P. M., Zerlauth, J. B., Sala, N., Suys, T., Schoettker, P., . . . Oddo, M. "Accuracy of Brain Multimodal Monitoring to Detect Cerebral Hypoperfusion After Traumatic Brain Injury". *Critical Care Medicine* , 43(2), 2015, pp 445-452
[9]. Malkoff, M. Cerebral Blood Flow Physiology and Metabolism. In M. T. Torbey (Ed.), Neurocrictical Care . United States of America : Cambridge University Press, 2010, pp 1-10
[10]. Sharath, B., & Reddy, C. "Traumatic Brain Injury Induced Cerebral Blood Flow Changes - A potential Role For Caffeine". *Wayne State University Thesis*, 2012, 201.
[11]. Purkayastha, S., & Sorond, F. "Transcranial Doppler Ultrasound: Technique and Application". *Semin Neurol*, 32(4), 2012, pp 411-420
[12]. Ziegler, D., Cravens, G., Poche, G., Gandhi, R., & Tellez, M. "Use of Transcranial Doppler in Patients with Severe Traumatic Brain Injuries". *Journal of Neurotrauma* , 2015, pp 1-25
[13]. Matis, G., & Theodossios. "The Glasgow Coma Scale – a brief review Past, present, future". *Acta neurol. belg*, 108, 2008, pp 75-89
[14]. Lu, J., Murray, G. D., Steyerberg, E.W., Butcherm I., Mchugh G.S, Lingsma,H., . . . Marmarou, A. "Effects of Glasgow Outcome Scale Misclassification on Traumatic Brain Injury Clinical Trials". *Journal Of Neurotrauma* , 25, 2008, pp641-651
[15]. Davis, SM. Chua, MF. Lichenstein, M. Rossiter, SC. Binns D & Hopper, JL. "Cerebral Hypoperfusion in Stroke Prognosis and Brain Recovery". *Stroke*, 24(11), 1993, pp 1691-1696
[16]. Avelino,AM. Lam,AM & Winn,HR. Management of Acute Head Injury in SM Albin (Ed.), Textbook of Neuroanesthesia with Neurosurgical and Neuroscience Prespective. Iowa: McHraw Hill, 1997, pp 1137-1176
[17]. Prasad BKD, Madhavi Chamarthi, Pravallika Isireddy. "Role of transcranial doppler as a predictor of prognosis in patients with traumatic brain injury". *International Journal of Contemporary Medicine Surgery and Radiology* 2 (4), 2017, pp 139-142
[18]. Zaaroor Menashe., Mahamid Eugenia., Shik Venyamin, Soustiel Jean F. "Course of cerebral blood flow and metabolism following severe brain injury. Correlation with neurological function and outcome". *Indian Journal of Neurotrauma (IJNT)* Vol. 4(1). 2007, pp 25-29
[19]. Stovell MG, Yan JL, Sleigh A, Mada MO, Carpenter TA, Hutchinson PJA and Carpenter KLH. "Assessing Metabolism and Injury in Acute Human Traumatic Brain Injury with Magnetic Resonance Spectroscopy" *Current and Future Applications. Front. Neurol*. 8:426, 2017. doi: 10.3389/fneur.2017.00426
[20]. Stutz, Helen R. Charchafileh, Jean. Postoperative and Intensive Care Including Head Injury and Multisystem Sequele in Cottrell, James E and Young,William L, *Cottrell and Young's Neuroanesthesia*. Philadelphia : Mosby Elsevier, 2010, pp 400-415.
[21]. Rivas, Elizabeth R. Wedel and Denise J. Neurophysiology and Anesthesia in Buterworth, John F. Mackey, David C and Wasnick, John D, *Morgan & Mikhail's Clinical Anesthesiology sixth edition*. United States : McGraw-Hill Education, 2018, pp 942 - 973.
[22]. Naqvi, J., Yap, K. H., Ahmad, G., & Gosh, J. "Transcranial Doppler Ultrasound: A Review of the Physical Principles and Major Applications in Critical Care". *International Journal of Vascular Medicine*, 13, 2013.
[23]. Mangalore Sandhya., Kotresh., Srinivasa Rakshith., Hedge S Alangar., Srinivasa Rangeshetty. "Can Transcranial Color Doppler Spectral Signatures be a Novel Biomarker for Monitoring Cerebrovascular Autoregulation and Intracranial Pressure? A Speculative Synthesis". *Annals of Indian Academy of Neurology* 20(3), 2017, pp 252-262 DOI:10.4103/Aian.AIAN_80_17