ORIGINAL RESEARCH

The Relationship of Renal Resistive Index and Central Venous Pressure As Predictors of Acute Kidney Injury in Critically Ill Patients of Intensive Care Unit Adam Malik General Hospital Medan

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ABSTRACT

Background: Changes in the doppler-based renal resistive index (RRI) occur prior to the changes of glomerular filtration rate (GFR) during the development of acute kidney injury (AKI) and during the healing process from AKI. Central venous pressure (CVP) is not only a marker for resuscitation, but also can determine the microcirculatory perfusion pressure as outflow obstruction.

Objective: This study aims to determine the relationship between RRI and CVP as a predictor of AKI in critically ill patients admitted to the intensive care unit (ICU) of Adam Malik General Hospital.

Methods: This was an observational study with prospective cohort design and diagnostic test method. This research was conducted at the Adam Malik General Hospital Medan from June to July 2020. Forty patients aging 18-65 years old who met the diagnostic criteria of sepsis and septic shock were examined for RI and CVP when admitted to the ICU.

Results: RI had better sensitivity and specificity than CVP in predicting the incidence of AKI (sensitivity 68% vs 59%, specificity 77% vs 55.5%, Receiver operating characteristics (ROC) 0.870 vs 0.321 (95% confidence interval)).

Conclusion: Based on the results of this study, the renal resistive index has better sensitivity and specificity than central venous pressure in predicting the incidence of AKI in critical patients in the ICU.

Keywords: Sepsis; AKI; creatinine; central venous pressure; renal resistive index; ICU

Muhammad Aripandi Wira, Achsanuddin Hanafie, Asmin Lubis, Bastian Lubis
The Relationship of Renal Resistive Index and Central Venous Pressure As Predictors of Acute Kidney
Injury in Critically Ill Patients of Intensive Care Unit Adam Malik General Hospital Medan

INTRODUCTION

Based on a study of more than 75,000 critically ill adults, acute kidney injury (AKI) is more severe in 4% - 25% of patients admitted to the ICU, while sepsis is the most common cause of AKI in intensive care unit (ICU) [1]. AKI occurs in about 7% of all hospitalized patients and up to 36% - 67% of critically ill patients.[2] According to the 11th Annual Report of Indonesia Renal Registry in 2018, AKI occurred in 3,822 patients[3].

A biologic marker with high sensitivity and specificity that can detect AKI early before creatinine increases is needed so that therapeutic interventions can be carried out more quickly.[1] Currently there are several biological markers that have been used for early detection of AKI such as cystatin C, neutrophil gelatinase-associated lipocalin (NGAL), kidney injury molecule-1 (KIM-1), interleukin-18 (IL-18) and others, but these biological markers cannot be verified to prove a diagnosis and the management of sepsis caused by AKI[4].

Doppler ultrasonography, which is fast, noninvasive, and can be repeated to assess renal perfusion, is widely used in critically ill patients. Changes in the renal resistive index (RRI) occur before there are changes in creatinine level during the development and healing process of AKI, making RRI one of predictors for AKI.[5] However, several physiological factors such as vascular compliance and intra-abdominal pressure can affect RRI[5]. Central venous pressure (CVP) is not just a marker for resuscitation, but can also determine perfusion pressure microcirculatory as outflow of obstruction.[6] A high CVP value is closely related to the occurrence of disruption of blood circulation in the microcirculation and against the development of AKI.[6] Therefore, we conducted a study of the relationship between RRI and CVP as predictors of AKI in critically ill patients.

METHODS

This was an observational study with a prospective cohort design and diagnostic test method to compare the sensitivity and specificity between RRI and CVP as a predictor of AKI in critical patients of the ICU of Adam Malik General Hospital, Medan, from June to July 2020. The sampling technique used was consecutive sampling, with a total of 40 subjects. The population in this study were all critical and septic patients who were treated in the ICU of Adam Malik General Hospital, Medan. Inclusion

Solo Journal of Anesthesi, Pain and Critical Care | Vol 2, No 1, October 2022
Medical Faculty of Universitas Sebelas Maret - PERDATIN Solo

81

Muhammad Aripandi Wira, Achsanuddin Hanafie, Asmin Lubis, Bastian Lubis
The Relationship of Renal Resistive Index and Central Venous Pressure As Predictors of Acute Kidney
Injury in Critically Ill Patients of Intensive Care Unit Adam Malik General Hospital Medan

criteria were patients aging 18-65 years who met the diagnostic criteria of sepsis and septic shock. Exclusion criteria were patients with acute and chronic renal failure, thyroid disease, or those receiving nephrotoxic drug therapy. Dropout criteria were patients who were admitted to the ICU and died less than 24 hours from the start of the examination, or those who moved from the hospital at their own request in less than 24 hours from the start of the examination.

This research was conducted after obtaining informed consent and approval by the Health Research Ethics Commission of the Faculty of Medicine of North Sumatra University. The data collected were gender, age, diagnosis on admission, laboratory results (especially urea and creatinine levels), and urine output monitored by volunteers. A renal doppler ultrasound examination was then carried out within a span of 3 hours from admission to assess RRI. CVP assessment was also conducted by the researcher and confirmed by the ICU consultant doctor. After that, urine output was monitored and creatinine clearance was checked to assess whether AKI occurs or not according to the RIFLE criteria. Urea and creatinine levels were checked daily. Patients were observed for up to 28 days of treatment, discharge from hospital, or died.

First, normality test was carried out using Shappiro Wilk test, then the data were analyzed descriptively to see the characteristics and frequency distribution of the subjects. Numerical data was presented in mean±SD (standard deviation) and median (minimum-maximum) values. Meanwhile, categorical data were shown in number (percentage). Sensitivity and specificity assessments were based on the area under the curve (AUC). Parametric data uses the T-test while non-parametric data uses Chi-Square. 95% confidence interval was used and p value <0.05 was considered significant.

RESULTS

Table 1 shows the distribution of the research subjects' characteristics. Of the 40 samples, the number of male and female was the same, each consisted of 20 (50%) subjects. The mean of subjects' age was 47.25 ± 15.19 (p = 0.497), the mean of BMI was 24.48 ± 2.25 (p = 0.218) and both were statistically normally distributed, while the mean of GFR was 73.2 ± 50.2 (p = 0.035) and statistically not normally distributed.

Solo Journal of Anesthesi, Pain and Critical Care | Vol 2, No 2 October 2022
Medical Faculty of Universitas Sebelas Maret - PERDATIN Solo

82

Muhammad Aripandi Wira, Achsanuddin Hanafie, Asmin Lubis, Bastian Lubis
The Relationship of Renal Resistive Index and Central Venous Pressure As Predictors of Acute Kidney
Injury in Critically Ill Patients of Intensive Care Unit Adam Malik General Hospital Medan

Table 1. Characteristics of the research subjects

Characteristics	Subjects (n = 40)	p value*
Age (year, mean ± SD)	47.25 ± 15.19	0.497
Gender (n, %)		
Male	20 (50%)	
Female	20 (50%)	0.992
BMI (mean ± SD)	24.48 ± 2.25	0.218
GFR	73.2 ± 50.2	0.035
Hemodynamic		
Heart rate, bpm	101.87 ± 13.1	0.794
Systolic BP, mmHg	111.8 ± 19.9	0.078
Diastolic BP, mmHg	64.13 ± 14.35	0.126
MAP, mmHg	81.15 ± 13.31	0.023

*)Shappiro-Wilk

Table 1 also describes the hemodynamic characteristics of samples. The mean of mean arterial pressure (MAP) value was 81.15 ± 13.31 mmHg (p = 0.023), while mean of systolic and diastolic blood pressures, respectively were 111.8 ± 19.9 and 64.13 ± 14.35 mmHg (p = 0.078 and p = 0.126). Both parameters were normally distributed. In this study, incidence of AKI occurred in 22 (55%) samples.

Table 2. RI and CVP measurements

Variables	AKI (22)	Non-AKI (18)	p value*
RRI	0.72 ± 0.07	0.58 ± 0.1	0.001
CVP	10.7 ± 2.83	10.3 ± 2.22	0.11

*) Dependent T-test

Based on table 2, there were significant differences both statistically and clinically on the mean value of RRI between the AKI and non-AKI group (0.72 ± 0.07 versus 0.58 ± 0.1) with p value = 0.001. Meanwhile, there was no significant difference on the mean of CVP between the two groups (p = 0.11).

Table 3 AKI incident according to RRI and CVP

| | AKI (RIFLE) (n, %) | | |
	Non-AKI	AKI	p value
RRI			
0.5-0.7	14 (35)	7 (17.5)	0.038*
>0.7	4 (10)	15 (37.5)	
CVP, mmHg			
<11.5	10 (25)	9 (22.5)	0.174*
>11.5	8 (20)	13 (32.5)	
Total	18 (45)	22 (5)	

Solo Journal of Anesthesi, Pain and Critical Care | Vol 2, No 1, October 2022
Medical Faculty of Universitas Sebelas Maret - PERDATIN Solo

83

Muhammad Aripandi Wira, Achsanuddin Hanafie, Asmin Lubis, Bastian Lubis
The Relationship of Renal Resistive Index and Central Venous Pressure As Predictors of Acute Kidney
Injury in Critically Ill Patients of Intensive Care Unit Adam Malik General Hospital Medan

*) Chi-square

Table 3 shows the incidence of AKI based on RRI and CVP values, in which assessments were performed when the patient was admitted to the ICU. The minimum GFR values of patients were first measured and diagnosis of AKI was then made based on the RIFLE criteria. In the normal RRI range (0.5-0.7), there were 7 (17.5%) subjects with AKI and 14 (35%) subjects did not have AKI. Meanwhile, with RI value > 0.7, there were 15 (37.5%) subjects with AKI (p-value = 0.038), which was considered statistically significant.

Table 3 also shows the incidence of AKI based on the CVP assessment. Normal CVP value ranges from 8 - 11.5 mmHg. In the sample group with normal CVP values, with a cut-off of 11.5 mmHg, AKI occurred in 9 (22.5%) subjects, while 10 (25%) subjects in the CVP normal group did not have AKI. Meanwhile, in the range of CVP > 11.5 mmHg, AKI occurred in 13 (32.5%) subjects with p value of 0.174.

Table 4. Prediction value of renal resistive index

(%)	TP	TN	FP	FN	Sensitivity	Specificity	Accuracy	NPV	PPV
RRI	15 (37.5)	14 (35)	4 (10)	7 (17.5)	68	77	72.5	78.9	66.6

TP: true positive; TN: true negative; FP: false positive; FN: false negative; NPP: negative predictive value; PPV: positive predictive value
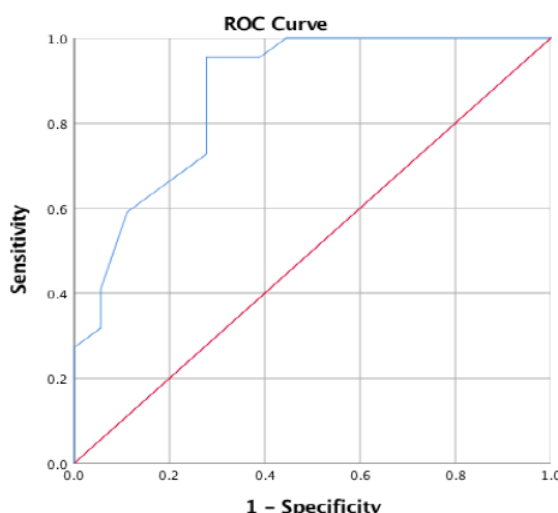

Figure 1. Receiver operating characteristics (ROC) curve of RRI and AKI

Table 4 describes the predicted value of RRI for the incidence of AKI in ICU patients. In this study, the true positive value was 37.5%, true negative

Solo Journal of Anesthesi, Pain and Critical Care | Vol 2, No 2 October 2022
Medical Faculty of Universitas Sebelas Maret - PERDATIN Solo

84

Muhammad Aripandi Wira, Achsanuddin Hanafie, Asmin Lubis, Bastian Lubis
The Relationship of Renal Resistive Index and Central Venous Pressure As Predictors of Acute Kidney
Injury in Critically Ill Patients of Intensive Care Unit Adam Malik General Hospital Medan

35%, false positive 10%, and false negative 17.5%. Thus, from this study it was found that the RI has a sensitivity of 68%, a specificity of 77%, and an accuracy of 72.5% in predicting the incidence of AKI in critical patients undergoing ICU care, with a positive predictive value of 78.9% and a negative predictive value of 66.6%. Figure 1 shows that RI has AUC value of 0.870 with 95% confidence interval.

Table 5. Prediction value of central venous pressure

(%)	TP	TN	FP	FN	Sensitivity	Specificity	Accuracy	NPV	PPV
CVP	13 (32.5)	10 (25)	8 (20)	9 (22.5)	59	55.5	57.5	61.9	52.6

TP: true positive; TN: true negative; FP: false positive; FN: false negative; NPP: negative predictive value; PPV: positive predictive value
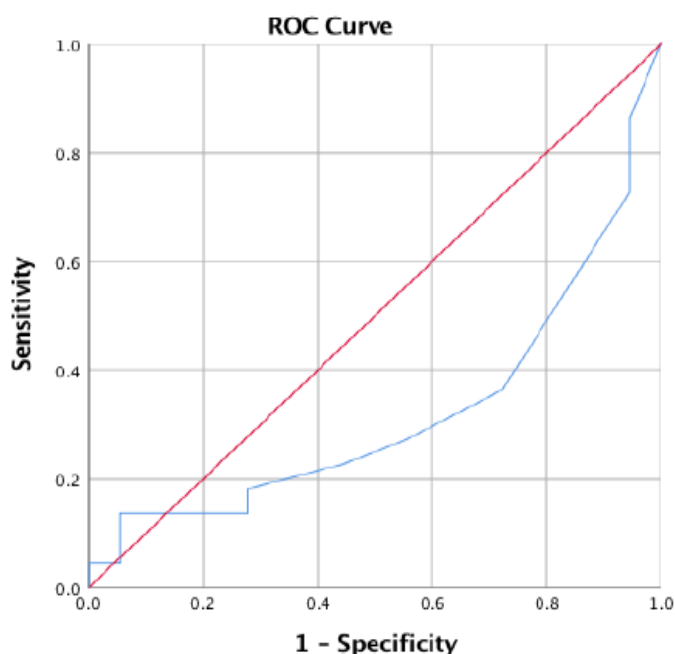

Figure 2. ROC curve of CVP and AKI

Table 5 shows the predictive value of CVP for the incidence of AKI and we obtained a true positive value of 32.5%, 25% true negative, 20% false positive, and 22.5% false negative. Thus, from this study it was found that CVP had a sensitivity of 59%, a specificity of 55.5% and an accuracy of 57.5% in predicting the incidence of AKI in critical patients undergoing ICU care, with a positive predictive value of 61.9% and a negative predictive value of 52.6%. Figure 2 shows the CVP has AUC value of 0.321, with 95% confidence interval.

Solo Journal of Anesthesi, Pain and Critical Care | Vol 2, No 1, October 2022
Medical Faculty of Universitas Sebelas Maret - PERDATIN Solo

85

Muhammad Aripandi Wira, Achsanuddin Hanafie, Asmin Lubis, Bastian Lubis
The Relationship of Renal Resistive Index and Central Venous Pressure As Predictors of Acute Kidney
Injury in Critically Ill Patients of Intensive Care Unit Adam Malik General Hospital Medan

CONCLUSION

Renal resistive index has better sensitivity and specificity than central venous pressure in predicting the incidence of AKI. The renal resistive index has a sensitivity of 68% and specificity of 77%, with an AUC of 0.870 (95% confidence interval), while central venous pressure has a sensitivity of 59% and specificity of 55.5%, with an AUC of 0.321 (95% confidence interval).

CONFLICT OF INTEREST

The Authors declare that have no conflict of interest.

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Solo Journal of Anesthesi, Pain and Critical Care | Vol 2, No 2 October 2022
Medical Faculty of Universitas Sebelas Maret - PERDATIN Solo

86