RENAL RESISTIVE INDEX (RRI) GUIDED BY ULTRASOUND (USG) AS A DIAGNOSTIC PREDICTOR OF ACUTE KIDNEY INJURY IN SEPSIS PATIENTS

Satria Pinanditas S[1*], Putu Agus Surya Panji[2], I Made Gede Widnyana[3], Tjahya Aryasa EM[4], I Made Agus Kresna Sucandra[5], Made Wiryana[6], Tjokorda Gde Agung Senapathi[7]

Department of Anesthesiology, Pain Management, and Intensive Care, Udayana University, Sanglah General Hospital Bali[1,2,3,4,5,6,7]

**Corresponding Author :* satbius2020@gmail.com

ABSTRAK

Penelitian ini merupakan studi observasional analitik dengan desain potong lintang yang dilakukan di unit perawatan intensif RSUP Prof. Dr. I.G.N.G. Ngoerah dari bulan Januari 2024 hingga selesai. Populasi penelitian terdiri dari pasien berusia 18-65 tahun yang memenuhi kriteria diagnosis sepsis tanpa penyakit ginjal kronis. Analisis data dilakukan menggunakan SPSS versi 26, termasuk analisis deskriptif, kurva ROC, tes diagnostik, dan analisis korelasi. Rata-rata RRI pada 0 jam adalah ±SB 0,78±0,68 cm/s untuk kelompok AKI dan ±SB 0,60±0,08 cm/s untuk kelompok non-AKI. Rata-rata RRI pada 6 jam adalah ±SB 0,77±0,65 cm/s untuk kelompok AKI dan ±SB 0,60±0,08 cm/s untuk kelompok non-AKI. Titik potong untuk RRI pada 0 jam adalah ≥0,70 cm/s, dengan sensitivitas 84,6%, spesifisitas 88,9%, akurasi 86,4%, nilai prediktif positif (PPV) 91,7%, dan nilai prediktif negatif (NPV) 80%, dengan risiko relatif AKI sebesar 4,58 kali (95% CI 1,89-11,10; P<0,001). Sementara itu, untuk RRI pada 6 jam, titik potongnya juga ≥0,70 cm/s, dengan sensitivitas 88,5%, spesifisitas 88,9%, akurasi 88,6%, PPV 92%, NPV 84,2%, dan risiko relatif AKI sebesar 5,83 kali (95% CI 2,05-16,56; P<0,001). Koefisien korelasi antara RRI pada 0 jam dan kreatinin serum adalah r=0,380, p=0,011, sedangkan untuk RRI pada 6 jam, adalah r=0,393, p=0,008. RRI pada 0 jam menunjukkan korelasi dengan produksi urin dengan r=-0,428, p=0,004, sedangkan untuk RRI pada 6 jam, adalah r=-0,540, p<0,001. Dapat disimpulkan bahwa RRI yang dipandu oleh ultrasonografi adalah prediktor diagnostik yang baik untuk cedera ginjal akut pada sepsis.

Kata kunci **:** cedera ginjal akut (AKI), diagnostik, indeks resistensi renal (RRI), sepsis, ultrasonografi

ABSTRACT

This study is an observational analytical study with a cross-sectional design conducted in the intensive care unit of RSUP Prof. Dr. I.G.N.G. Ngoerah from January 2024 until completion. The study population consisted of patients aged 18-65 years who met the criteria for sepsis diagnosis without chronic kidney disease. Data analysis was performed using SPSS version 26, including descriptive analysis, ROC curve, diagnostic test, and correlation analysis. The mean RRI at 0 hours was ±SB 0.78±0.68 cm/s for the AKI group and ±SB 0.60±0.08 cm/s for the non-AKI group. The mean RRI at 6 hours was ±SB 0.77±0.65 cm/s for the AKI group and ±SB 0.60±0.08 cm/s for the non-AKI group. The cut-off point for RRI at 0 hours was ≥0.70 cm/s, with a sensitivity of 84.6%, specificity of 88.9%, accuracy of 86.4%, PPV of 91.7%, and NPV of 80%, with a relative risk of AKI of 4.58 times (95% CI 1.89-11.10; P<0.001). Meanwhile, for RRI at 6 hours, the cut-off point was also ≥0.70 cm/s, with a sensitivity of 88.5%, specificity of 88.9%, accuracy of 88.6%, PPV of 92%, NPV of 84.2%, and a relative risk of AKI of 5.83 times (95% CI 2.05-16.56; P<0.001). The correlation coefficient between RRI at 0 hours and serum creatinine was r=0.380, p=0.011, while for RRI at 6 hours, it was r=0.393, p=0.008. RRI at 0 hours showed a correlation with urine production with r=-0.428, p=0.004, while for RRI at 6 hours, it was r=-0.540, p<0.001. In conclusion, RRI guided by ultrasound is a good diagnostic predictor for acute kidney injury in sepsis.

Keywords ***:*** *acute kidney injury (AKI), diagnostic, renal resistive index (RRI), sepsis, ultrasound*

INTRODUCTION

The advancement in Acute Kidney Injury (AKI) diagnosis is centered on prevention and early detection. The ability to predict AKI as a complication enables clinicians to devise preventive strategies; hence, early sensitive and easily implementable AKI diagnostic methods are necessary. Current AKI diagnosis relies on functional criteria (serum creatinine and urine output). Oliguria symptoms manifest prior to the rise in serum creatinine, making it more sensitive in predicting AKI but with lower specificity. The increase in serum creatinine typically occurs several hours after kidney damage onset and a decline in Glomerular Filtration Rate (GFR) exceeding 30%. Acute kidney injury, according to the Kidney Disease Improving Global Outcome (KDIGO), is a sudden decrease in kidney function characterized by structural and/or functional damage. AKI encompasses an increase in serum creatinine of ≥0.3 mg/dl (≥26.5 μmol/l) within 48 hours or a serum creatinine increase to ≥1.5 times the known or presumed baseline within the preceding 7 days, and urine volume <0.5 ml/kg/hour for 6 hours (KDIGO, 2012). The KDIGO criteria have a sensitivity of 83.5% and specificity of 55.6% for early-stage AKI (Luo et al., 2014).

The current confirmation of AKI diagnosis relies on increased serum creatinine levels and oliguria. Oliguria is considered less specific for renal dysfunction, whereas an elevation in serum creatinine typically occurs several hours after renal dysfunction due to increased volume distribution, liver function abnormalities, and malnutrition (Hotchkiss et al., 2016). The delay in diagnosing AKI often leads to pharmacological interventions in clinical trials failing to prevent AKI occurrences (Endre et al., 2011). Detecting and characterizing kidney function in the early phase of AKI are advancements needed in secondary prevention. Secondary prevention efforts focus on improving kidney perfusion, fluid therapy restriction, and avoiding nephrotoxic agents.

Sepsis is a life-threatening medical condition characterized by organ dysfunction due to dysregulated immune response to infection. It occurs when the immune system overreacts by releasing chemicals into the bloodstream to combat the infectious microorganisms. Vascular dysfunction plays a major role in AKI during sepsis. Exposure to inflammatory mediators in the kidneys can cause damage to the renal tubular epithelium. Sepsis is the leading cause of AKI cases in the ICU (45-70%) (Liu et al., 2020). Research findings (Anggara, 2021) also indicate that out of 41 sepsis patients, the majority were diagnosed with AKI (32 patients or 78%). This suggests that sepsis patients have a higher risk of developing AKI compared to non-sepsis patients.

A new non-invasive method using ultrasound (USG) has recently been utilized to early detect AKI. Several studies describe renal resistive index (RRI) examination as a non-invasive bedside test for early AKI detection. A decrease in renal blood flow occurs due to uncontrolled decrease in mean arterial pressure (MAP) leading to intrarenal vasoconstriction. Renal resistive index (RRI) used to assess pulsatility of arteries has been shown to correlate with renal vascular resistance. High perioperative RRI values are associated with increased risk of AKI (Bellos et al., 2019). Ultrasound Doppler examination of the kidneys not only provides morphological images but also qualitative and quantitative data on renal vasculature (Mulier et al., 2018). RRI examination with USG is non-invasive and can be performed in intensive care units to assess renal blood flow; moreover, it can predict persistent AKI occurrence, with RRI sensitivity for AKI being higher compared to changes in serum creatinine (Beloncle et al., 2019).

Therefore, researchers conducted a study on Renal Resistive Index (RRI) guided by ultrasound (USG) as a diagnostic predictor for acute kidney injury in sepsis and septic shock patients at Prof. Dr. I.G.N.G Ngoerah Hospital in Denpasar. The aim of this study is to assess the validity of Renal Resistive Index guided by ultrasound as a predictor for diagnosing Acute Kidney Injury in sepsis patients at Prof. Dr. I.G.N.G. Ngoerah Hospital.

METHOD

This study is an observational analytical study with a cross-sectional design aimed at identifying diagnostic predictors of acute kidney injury in sepsis patients by confirming through the gold standard examination for AKI, which includes serum creatinine levels and urine output post-admission, alongside Renal Resistive Index examination guided by ultrasound. The study was conducted in the intensive care unit of Prof. Dr. I.G.N.G. Ngoerah Hospital from January 2024 until its completion. The study population consists of patients aged 18-65 years who meet the criteria for sepsis diagnosis without chronic kidney disease at Prof. Dr. I.G.N.G Ngoerah Hospital. The study population comprises patients aged 18-65 years who meet the criteria for sepsis or septic shock diagnosis without chronic kidney disease at Prof. Dr. I.G.N.G Ngoerah Hospital from January 2024 until the required sample size is reached and they fulfill the inclusion and exclusion criteria.

Sampling in this study is conducted using consecutive sampling, where every adult patient experiencing sepsis and meeting the eligibility criteria within a specific timeframe is included until the minimum required sample size is reached. The study sample consists of a subset of the research population that meets the subject eligibility criteria. Inclusion criteria include patients aged 18-65 years who have developed sepsis with a SOFA score of ≥2 and have signed informed consent forms. Exclusion criteria comprise patients with a history of chronic kidney disease and hemodialysis, anatomical structural abnormalities of the kidneys, kidney transplant history, severe vascular diseases, increased intra-abdominal pressure, arrhythmia, obesity with a BMI ≥30 kg/m2, and gestation. The calculation of the sample size resulted in 37 samples. To account for potential dropouts, the researcher added 20 percent, bringing the minimum required sample size to 44 samples.

Descriptive statistical analysis is conducted to describe the characteristics of subjects and research variables overall. Numeric data variables are presented in terms of mean and standard deviation, while categorical data variables are presented in terms of relative frequency. The results of descriptive statistical analysis are presented in distribution tables. The ROC Analysis aims to determine the optimal cutoff point for elevated Renal Resistive Index in diagnosing Acute Kidney Injury in sepsis patients. This analysis involves constructing an ROC curve. The ability of Renal Resistive Index to diagnose Acute Kidney Injury in sepsis patients is assessed based on the area under the curve. The optimal cutoff point for Renal Resistive Index is determined based on the coordinates furthest from the diagonal line. The Diagnostic Test aims to assess the validity, including sensitivity, specificity, accuracy, and efficacy of RRI in diagnosing AKI in sepsis patients, comprising positive predictive value and negative predictive value. The Correlation Test aims to determine the correlation between the use of Renal Resistive Index (RRI) with serum creatinine and urine production, which are numerical scale variables, using Pearson correlation. The direction of correlation is considered positive if the r value is positive. Correlation is evaluated by examining the correlation coefficient (r) value to determine whether the correlation is very weak, weak, strong, or very strong.

RESULTS

Characteristics of the Study Data

Overall, the study included 44 subjects, with characteristics detailed in Table 5.1. The results indicate that age did not differ significantly between the two groups, with a p-value of 0.140. The AKI group had an average age of 51.38±13.20 years, while the non-AKI group had an average age of 45.27±13.29 years.

The results showed that the majority of patients were male, with no significant difference observed between the two groups (p=0.911). In the AKI group, there were 12 (46.2%) female subjects and 14 (53.8%) male subjects, while in the non-AKI group, there were 8 (44.4%) female subjects and 10 (55.6%) male subjects. Body Mass Index (BMI) did not significantly differ between the two groups (p=0.183). The AKI group had an average BMI of 25.28±3.51 kg/m2, while the non-AKI group had an average BMI of 23.84±3.36 kg/m2. Mean Arterial Pressure (MAP) also did not significantly differ between the two groups (p=0.835). The AKI group had an average MAP of 87.03±15.17 mmHg, while the non-AKI group had an average MAP of 86.05±15.45 mmHg. Significant differences were observed in the SOFA score (p=0.001) and VIS score (p=0.014) between the two groups, with higher scores observed in the AKI group. The AKI group had an average SOFA score of 9.87±1.15 compared to 8.16±0.38 in the non-AKI group, and an average VIS score of 27.88±24.25 compared to 11.11±16.31 in the non-AKI group. Serum creatinine levels differed significantly between the two groups (p<0.001), with higher levels observed in the AKI group. The AKI group had an average serum creatinine level of 3.73±2.46 mg/dL, while the non-AKI group had an average serum creatinine level of 1.00±0.62 mg/dL. Total urine production over 6 hours also differed significantly between the two groups (p<0.001), with lower production observed in the AKI group. The AKI group had an average total urine production of 0.45±0.42 mL/kgBW/hour, while the non-AKI group had an average total urine production of 1.24±0.70 mL/kgBW/hour. Similarly, Renal Resistive Index values at both 0 hours and 6 hours differed significantly between the two groups (p<0.001), with higher values observed in the AKI group. The AKI group had an average Renal Resistive Index value of 0.78±0.68 cm/s at 0 hours and 0.77±0.65 cm/s at 6 hours, while the non-AKI group had average values of 0.60±0.08 cm/s at both time points.

Table 1. Characteristics of Research Data

Variable	Group	p-value
	AKI (n=26)	Non-AKI (n=18)
Age (years)	51.38±13.20	45.27±13.29
Gender		
Male	14 (53.8%)	10 (55.6%)
Female	12 (46.2%)	8 (44.4%)
Body Mass Index (kg/m2)	25.28±3.51	23.84±3.36
Mean Arterial Pressure (MAP) (mmHg)	87.03±15.17	86.05±15.45
SOFA Score	9.87±1.15	8.16±0.38
VIS Score	27.88±24.25	11.11±16.31
Serum Creatinine Level (mg/dL)	3.73±2.46	1.00±0.62
Total Urine Production over 6 hours (mL/kgBW/hour)	0.45±0.42	1.24±0.70
Renal Resistive Index Value at 0 hours (cm/s)	0.78±0.68	0.60±0.08
Renal Resistive Index Value at 6 hours (cm/s)	0.77±0.65	0.60±0.08

ROC Analysis Results of RRI

The ROC curve was conducted to determine the optimal cutoff point for high Renal Resistive Index in diagnosing Acute Kidney Injury (AKI) in sepsis patients, as presented in Table 5.2, based on AKI and non-AKI categorization. The ROC curve analysis resulted in the following values: for RRI-0 hours, sensitivity of 84.6% and specificity of 88.9% with a cutoff value of 0.70 cm/s (Figure 5.1), and for RRI-6 hours, sensitivity of 88.5% and specificity of 88.9% with a cutoff value of 0.70 cm/s (Figure 5.2). In this study, the optimal cutoff point for RRI was ≥0.70 cm/s, categorized as indicative of AKI.

Table 2. Sensitivity, Specificity and Cutoff Point of RRI Threshold For AKI

Variable	AUC	Sensitivity	Specificity	Cutoff Point	95% CI	p-value
RRI 0 hours	94.4%	84.6%	88.9%	0.70	0.873 – 1.000	<0.001
RRI 6 hours	91.1%	88.5%	83.3%	0.70	0.813 – 1.000	<0.001

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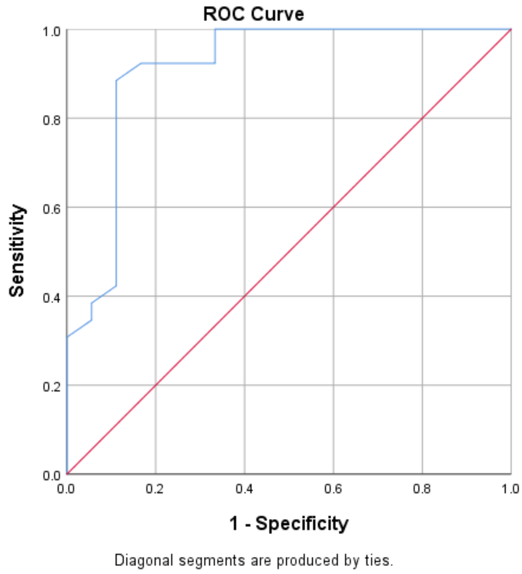

Figure 1. ROC Curve of RRI at 0 Hours

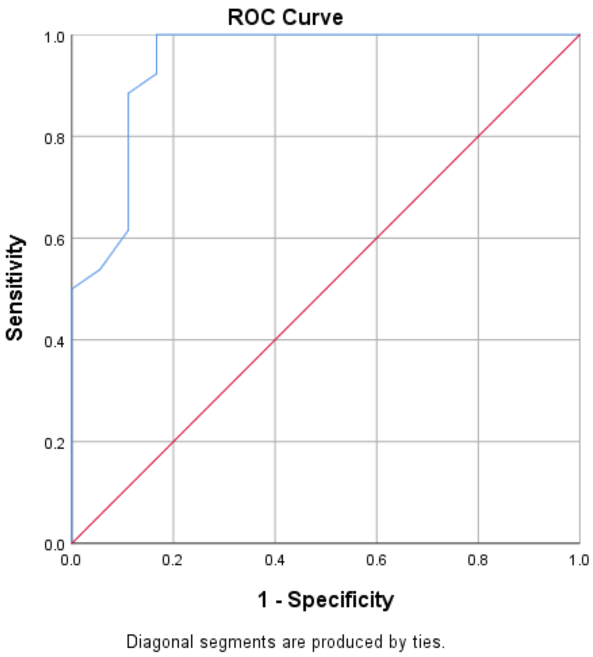

Figure 2. ROC Curve of RRI at 6 Hours

Diagnostic Test of RRI for AKI

The diagnostic test was conducted to assess the validity, comprising sensitivity, specificity, accuracy, and efficacy of RRI-0 hours and RRI-6 hours in diagnosing AKI in sepsis patients, including positive and negative predictive values, as presented in Table 3. and Table 4.

Table 3. Diagnostic Test Of RRI-0 Hours with Serum Creatinine and Urine Output Examination

RRI-0 hours Result	Septic Diagnosis	AKI	Total	RR	95% CI	p-value
	AKI (+)		AKI (-)			
High ≥0.70	22 (84.6%)		2 (11.1%)	24 (54.5%)	4.58	1.89-11.10
Low <0.70	4 (15.4%)		16 (88.9%)	20 (45.5%)		
Total	**26 (59.1%)**		**18 (40.9%)**	**44 (100%)**		

Table 4. Diagnostic Test Of RRI-6 Hours with Serum Creatinine and Urine Output Examination

RRI-6 hours Result	Septic AKI Diagnosis	Total	RR	95% CI	p-value
	AKI (+)	AKI (-)			
High ≥0.70	23 (88.5%)	2 (11.1%)	25 (56.8%)	5.83	2.05-16.56
Low <0.70	3 (11.5%)	16 (88.9%)	19 (43.2%)		
Total	**26 (59.1%)**	**18 (40.9%)**	**44 (100%)**		

The validity was determined based on the following parameters for RRI-0 hours: Sensitivity = 84.6%, calculated as 22/(22+4) X 100%; Specificity = 88.9%, calculated as 16/(2+16) X 100%; Accuracy = 86.4%, calculated as (22+16)/(22+2+4+16) X 100%; Positive Predictive Value = 91.7%, calculated as 22/(22+2) X 100%; Negative Predictive Value = 80%, calculated as 16/(4+16) X 100%. Similarly, for RRI-6 hours, the parameters were as follows: Sensitivity = 88.5%, calculated as 23/(23+3) X 100%; Specificity = 88.9%, calculated as 16/(2+16) X 100%; Accuracy = 88.6%, calculated as (23+16)/(23+2+3+16) X 100%; Positive Predictive Value = 92%, calculated as 23/(23+2) X 100%; Negative Predictive Value = 84.2%, calculated as 16/(3+16) X 100%.

The cutoff point for RRI-0 hours was determined to be ≥0.70 cm/s, with a sensitivity of 84.6%, specificity of 88.9%, accuracy of 86.4%, PPV of 91.7%, and NPV of 80%, indicating a relative risk of AKI occurrence at 4.58 times higher (95% CI 1.89-11.10; P<0.001). Similarly, for RRI-6 hours, a cutoff point of ≥0.70 cm/s was established, with a sensitivity of 88.5%, specificity of 88.9%, accuracy of 88.6%, PPV of 92%, and NPV of 84.2%, indicating a relative risk of AKI occurrence at 5.83 times higher (95% CI 2.05-16.56; P<0.001).

Correlation Analysis

The correlation analysis was conducted to determine the relationship between the use of Renal Resistive Index (RRI) at 0 hours and 6 hours with serum creatinine levels and urine production, both of which are numeric variables, using Pearson correlation, as presented in Table 5.5. The results of the test revealed a weak positive correlation, with a coefficient (r) of 0.380 and a p-value of 0.011 between RRI at 0 hours and serum creatinine, while for RRI at 6 hours, a weak positive correlation with a coefficient (r) of 0.393 and a p-value of 0.008 were obtained. This suggests that as RRI increases, serum creatinine levels also increase significantly.

Table 5. Correlation between RRI and Serum Creatinine and Urine Production

Variable	Serum Creatinine	Urine Production
RRI-0 hours	Correlation (r)	0.380
	p-value	0.011*
	Count (n)	44
RRI-6 hours	Correlation (r)	0.393
	p-value	0.008*
	Count (n)	44

The correlation analysis between RRI and urine production revealed a moderate negative correlation, with a coefficient (r) of -0.428 and a p-value of 0.004 for RRI at 0 hours, and a moderate negative correlation, with a coefficient (r) of -0.540 and a p-value of less than 0.001 for RRI at 6 hours. This indicates that as RRI increases, urine production decreases significantly.

DISCUSSION

Acute Kidney Injury (AKI) represents a complex clinical disorder characterized by a sudden decrease in Glomerular Filtration Rate (GFR) over ≤7 days. It is diagnosed according to Kidney Disease Improving Global Outcome (KDIGO) criteria, which include an increase in serum creatinine ≥0.3 mg/dL (≥26.5 μmol/L) within 48 hours or an increase in serum creatinine ≥1.5 times from baseline within 7 days, along with urine volume <0.5 mL/kg/hour for 6 hours. In this study, 26 (59%) subjects with sepsis experienced AKI. This finding aligns with prior research, such as the study by Ninet et al. (2015), which reported that 83% of sepsis patients suffered from persistent AKI. The incidence of AKI in critically ill patients with sepsis or septic shock is estimated to be between 25%-75% (Liu et al., 2020; Zhou et al., 2019). However, there is currently a lack of research reporting AKI incidence among sepsis patients in Indonesia.

Various risk factors for sepsis-associated AKI (S-AKI) have been identified in previous studies. (Liu et al., 2020) identified septic shock as the most common risk factor for S-AKI, followed by comorbid conditions such as hypertension and diabetes, abdominal infections, smoking history, positive blood culture, use of vasopressors, and mechanical ventilation. Similarly, (Zhou et al., 2019) identified several independent predictors of S-AKI, including age, comorbidities such as hypertension/coronary artery disease, diabetes, Chronic Kidney Disease (CKD), heart failure, Chronic Obstructive Pulmonary Disease (COPD), acute pancreatitis, hypotension, hypoalbuminemia, lactic acidosis, duration of ICU stay, hemoglobin levels, and the number of organs affected.

The average age of AKI patients with sepsis in this study was around 50 years, consistent with findings by (Kellum et al., 2021). However, this differs from the majority of epidemiological studies where the average age of AKI patients was in their 60s (Srisawat et al., 2020). Male patients were predominantly affected by AKI in sepsis, which is consistent with some meta-analyses indicating a slightly higher risk of AKI in males (Liu et al., 2020).

Body mass index (BMI) did not significantly differ between AKI and non-AKI groups in this study. However, obesity, defined as BMI ≥27, was associated with increased AKI incidence in sepsis patients (Peerapornratana et al., 2019; Srisawat et al., 2020). Additionally, obesity was associated with a 3.5-fold increase in mortality among sepsis patients with AKI (Manrique-Caballero et al., 2021). Mean Arterial Pressure (MAP) did not significantly differ between AKI and non-AKI groups in this study. However, Maheshwari et al. (2018) found that lower TWA-MAP (<65 mmHg) was associated with increased mortality, AKI, and myocardial injury in sepsis patients. The risk of mortality and AKI increased as the MAP threshold decreased from 85 to 55 mmHg.

Significant differences were observed in Sequential Organ Failure Assessment (SOFA) scores between AKI and non-AKI groups in this study. Higher SOFA scores were consistently associated with sepsis patients who developed AKI in previous studies (Jonny et al., 2020; Manrique-Caballero et al., 2021; Peerapornratana et al., 2019; Srisawat et al., 2020). SOFA scores ≥8 indicate organ dysfunction or failure in sepsis patients (Srzić et al., 2022). Similarly, significant differences were observed in Vasoactive Inotropic Score (VIS) between AKI and non-AKI groups in this study. Higher VIS scores were associated with increased RRI values, indicating a correlation between hemodynamic instability and renal perfusion. VIS is crucial for assessing the severity of hemodynamic instability in septic patients and guiding the use of vasoactive medications, although its use is also associated with adverse cardiovascular effects (Hendra et al., 2023). Serum creatinine levels significantly differed between AKI and non-AKI groups in this study, consistent with findings by (Srisawat et al., 2020), who reported higher serum creatinine levels in sepsis patients with AKI.

Total urine production at 6 hours significantly differed between AKI and non-AKI groups in this study, with AKI patients exhibiting lower urine production. (Gameiro et al., 2018) similarly found that sepsis patients with AKI had urine production <0.5 mL/kg/hour. Although serum creatinine testing is the basis for AKI diagnosis, it has limitations. Pre-renal kidney hypoperfusion can lead to increased serum creatinine levels without renal parenchymal damage, and more than 50% of kidney damage can occur without increased creatinine.

Additionally, not all patients have baseline serum creatinine data, making it less sensitive for diagnosing sepsis-associated AKI. Biomarkers such as Neutrophil Gelatinase-Associated Lipocalin (NGAL), cystatin C, Kidney Injury Molecule-1 (KIM-1), and interleukin-18 have been proposed for early AKI detection in sepsis patients (Setiawan et al., 2018).

Bedside ultrasound Doppler examination is a rapid, non-invasive, and relatively inexpensive tool for assessing renal perfusion in critically ill patients. Renal Resistive Index (RRI) measured by ultrasound Doppler can change before serum creatinine levels during AKI progression. RRI is determined by pulse pressure, intra-renal vessel compliance, and a combination of venous and interstitial pressures (Cherry et al., 2020)). RRI values >0.75 cm/s can identify renal and pre-renal causes, while RRI <0.7 indicates better reversibility and prognosis. However, the superiority of RRI in determining AKI causes remains unclear due to its dependence on pre-renal, renal, and obstructive factors (Spatola & Andrulli, 2016).

This study has limitations, including its single-center design and limited sample size. Additionally, RRI is influenced by intra-renal vessel compliance, venous pressure, and renal interstitial pressure, which were not measured by the researchers. Nevertheless, the researchers applied exclusion criteria to minimize the involvement of these factors. In conclusion, Renal Resistive Index (RRI) shows promise as a diagnostic tool for early AKI detection in sepsis patients. Its correlation with serum creatinine levels and urine production highlights its potential utility in assessing renal.

CONCLUSION

Renal Resistive Index (RRI) guided by ultrasound demonstrates excellent sensitivity as a predictor for diagnosing Acute Kidney Failure in sepsis patients at RSUP Prof. Dr. I.G.N.G. Ngoerah. The utilization of RRI in ultrasound imaging offers a reliable method for early detection of AKI in sepsis patients, given its rapid and non-invasive nature. Moreover, RRI guided by ultrasound exhibits outstanding specificity as a predictor for diagnosing Acute Kidney Failure in sepsis patients at RSUP Prof. Dr. I.G.N.G. Ngoerah. This specificity underscores the accuracy of RRI in identifying AKI, facilitating prompt intervention and management. Furthermore, RRI guided by ultrasound demonstrates high accuracy as a predictor for diagnosing Acute Kidney Failure in sepsis patients at RSUP Prof. Dr. I.G.N.G. Ngoerah. Its accuracy ensures reliable diagnostic outcomes, aiding clinicians in making informed decisions regarding patient care. Additionally, RRI guided by ultrasound shows excellent positive predictive value as a predictor for diagnosing Acute Kidney Failure in sepsis patients at RSUP Prof. Dr. I.G.N.G. Ngoerah. This positive predictive value indicates the effectiveness of RRI in identifying AKI cases accurately, minimizing false-positive diagnoses. Furthermore, RRI guided by ultrasound exhibits excellent negative predictive value as a predictor for diagnosing Acute Kidney Failure in sepsis patients at RSUP Prof. Dr. I.G.N.G. Ngoerah. The high negative predictive value ensures the reliability of RRI in ruling out AKI cases, reducing the risk of false-negative results. Overall, RRI guided by ultrasound has been validated as a valuable tool for predicting Acute Kidney Failure diagnosis in sepsis patients. Its utilization enhances the early detection of AKI in sepsis, offering clinicians timely alerts regarding AKI occurrence.

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