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Cardiovascular Abnormalities in Critically Ill Leptospirosis Patients at UNS Hospital: A Study Over A 5-Year-Period

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ABSTRACT

Leptospirosis is a globally prevalent zoonotic disease. Cardiovascular involvement in leptospirosis patients, while reported, remains underexplored, especially in Indonesia. This study aims to characterize cardiovascular abnormalities in leptospirosis patients at UNS Hospital over a 5-year period. A descriptive analytical study with a retrospective approach was conducted on 38 patients aged ≥18 years who met the inclusion criteria of confirmed leptospirosis, electrocardiography (ECG) data, and hospitalization at the UNS Hospital. The data were analyzed based on ECG abnormalities. Of the 38 patients, 39.5% had sinus tachycardia, 31.6% sinus rhythm, and 2.6% each experienced supraventricular tachycardia, atrial flutter, or accelerated junctional rhythm. Furthermore, 15.8% had 1st degree AV block and 5.2% had paroxysmal atrial fibrillation. Hypotension was observed in 34.2%, while 92.1% of patients showed elevated urea levels, indicating renal involvement. The SPiRO score categorized 92.1% as severe leptospirosis cases. Mortality reached 42.1%, with ECG abnormalities present in 75% of deceased patients. These findings highlight the predominance of sinus tachycardia and the frequent co-occurrence of hypotension, renal impairment, and severe disease. This study emphasizes the critical role of early detection and monitoring of cardiovascular and hemodynamic parameters in leptospirosis patients. These findings provide valuable insights for improving diagnosis and management strategies, particularly in resource-limited settings.

Keywords: Leptospirosis, Cardiovascular, Electrocardiogram, Hypotension, SPiRO score.

INTRODUCTION

Leptospirosis is still a public health problem, especially in Indonesia. In 2022, it was reported that 1,419 cases of leptospirosis occurred in Indonesia with 139 deaths (Ministry of Health of the Republic of Indonesia, 2023). Leptospirosis is a zoonotic disease or can be transferred from animals to humans caused by infection with pathogenic Leptospira bacteria (Sari, 2021). Transmission of leptospirosis into the human body can be through direct contact of the reservoir animal (intermediary) with human mucous membranes or contact with water that has been contaminated by the urine of the reservoir animal (Gonçalves-de-Albuquerque et al., 2023).

Leptospirosis disease can cause various clinical manifestations involving various organs which end in organ dysfunction (Rajapakse, 2022). One of the organs involved in the clinical manifestations of leptospirosis is the heart. Clinical manifestations range from changes in blood pressure, non-specific electrocardiographic changes, arrhythmias, myocarditis, pericarditis, endocarditis, and cardiogenic shock (Jayathilaka et al., 2019). Apart from these findings, only a few studies have been conducted to determine the involvement of the heart organ in leptospirosis patients in Indonesia. Thus, this research serves to determine the characteristics of cardiovascular disorders in leptospirosis patients who are hospitalized at the UNS Hospital inpatient installation, Sukoharjo, Central Java.

RESEARCH METHODS

This research is a descriptive analytical study with a retrospective approach. The data in this study came from medical records of patients at UNS Hospital, Sukoharjo, Central Java. In this study, the study population was patients who were hospitalized at UNS Hospital for the period January 2019–December 2023. The inclusion criteria for this study were patients who had incomplete medical record data in the form of no electrocardiography examination results in the patient's medical record . The sampling technique in this research was total sampling. Thus, the sample size in this study was leptospirosis patients in the UNS Hospital inpatient installation in the

2019–2023 period aged 18 years and over with complete medical record data.

This study consisted of 29 variables whose data was taken from medical record data. These variables can be divided into 3 general categories, namely demographic data, clinical manifestations, and laboratory examination results data. The degree of patient severity was measured using the SPiRO score (Systolic blood Pressure ≤100 mmHg, Respiratory auscultation abnormalities, Oliguria), taken from the patient's clinical findings.

This study focuses more on ECG pattern variables taken from the results of examining the patient's ECG recordings during the patient's hospitalization. From this data, the presence of abnormalities in the ECG recording results read by the cardiologist and written in the medical record data will be evaluated. Patients are considered normal if they have a sinus rhythm ECG pattern. Patients with abnormal ECG patterns are generally classified into sinus tachycardia, supraventricular arrhythmias (atrial fibrillation, supraventricular tachycardia, and atrial flutter), and AV block. Patients will be categorized based on their ECG pattern and univariate analysis will be carried out later. In the table, which has been categorized based on ECG abnormalities, data on the patient's age, duration of illness, and laboratory examination results will be displayed with average values. Meanwhile, gender data will be in comparative form. Data on jaundice and mortality will be presented in percentage form in a table which has been categorized based on ECG abnormalities. After that, cardiovascular disorders in categorical form will be tested for their relationship with mortality rates using the Chi-square test, where a result of $p < 0.05$ is said to be statistically significant.

This research was declared ethically feasible on March 25, 2024 by the Research Ethics Commission of the Faculty of Medicine, Sebelas Maret University with protocol number 68/02/03/2024 and certificate number 86/UN27.06.11/KEP/EC/2024. This ethical suitability is valid for 1 year from publication. In addition, in order to collect the required data, this research has been approved by the education and research section of the Sebelas Maret University (UNS) Hospital with the issuance of a service note number 1066/UN27.46/TA.04.19/2024.

RESULTS AND DISCUSSION

After collecting data from the medical record section of UNS Hospital in May and June 2024, a total of 38 patients aged ≥18 years were obtained who met the research criteria, namely being confirmed positive for leptospirosis by IgM examination and having electrocardiography examination data who were hospitalized at UNS Hospital in the period of January 2019–December 2023. Of the 38 patients, the diagnosis of leptospirosis was divided into three based on ICD-10 codes, namely A27.0, A27.8, and 27.9. The following are the results of medical record data from the 38 patients.

Description based on age

The youngest age of a patient confirmed with leptospirosis is 34 years, while the oldest age with confirmed leptospirosis is 86 years. The age range with the highest number of confirmed patients is 46–55 years, 34.2% or 13 out of 38 patients. The average age of patients confirmed with leptospirosis was 53.89 ± 11.7 years. Meanwhile, the age of 58 years is the age with the largest number of confirmed leptospirosis patients, namely 4 patients (10.5%).

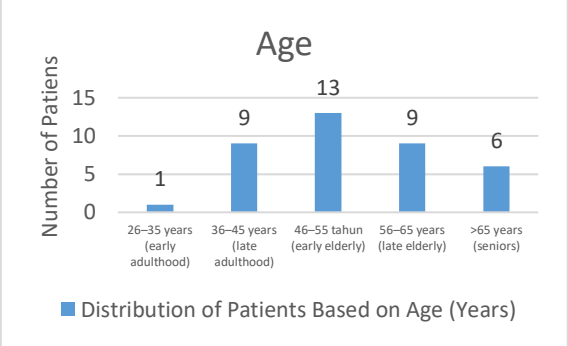

Figure 1. Distribution Of Patients Based on Age

When looking at the median age of patients, this result is different from the results of research conducted in the Philippines, where the median patient age was 33.48 ± 10.0 years (Quizon et al., 2023). These results are also different from research conducted by Sethia in 2023 where the majority of patients were ≤40 years old (Sethia et al., 2023).

Description based on gender

The majority of patients were male (28 patients (73.7%)) who had confirmed leptospirosis and were treated at the UNS Hospital inpatient ward in the period of 2019–2023.

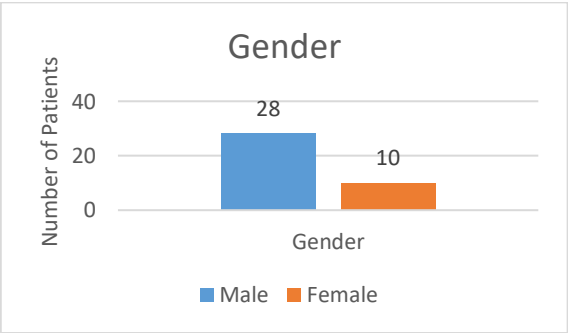

Figure 2. Distribution of Patients Based on Gender

These results are in line with the results of research conducted in Surat, India, where it was found that 80% of leptospirosis patients were male (Sethia et al., 2023). This high ratio of men compared to women can be caused by several things, one of which is the presence of work or activity risk factors that can increase the risk of exposure to Leptospira sp . bacteria. greater risk of developing leptospirosis, such as fishing, working as a mechanic in an automotive repair shop, farming and raising livestock (Yuniasih et al., 2022).

Description based on duration of hospitalization

The results showed that 37 patients (97.4%) had a hospitalization duration of <16 days, while only 1 patient (2.6%) had a hospitalization duration of >16 days. The average duration of hospitalization for these 38 patients

was 6.39 ± 3.9 days. These results are in line with research conducted in Malaysia in 2022, where the average patient stay was 6.77 ± 5.6 days (Al Hariri et al., 2022).

Description based on jaundice

Data obtained revealed that the majority of patients (21 patients (55.3%)) had a manifestation of jaundice during the course of the disease. The results of this study are slightly different from existing research where it is stated that 90% of leptospirosis patients have mild jaundice and 5-10% have severe jaundice (Ningsih & Wahid, 2022). Jaundice in leptospirosis itself is caused by the pathogenic Leptospira bacteria invading the intercellular cell junctions of the hepatocyte cells of the host body, causing damage and disruption to these junctions. As a result of this, there will be a leak of bile from the bile canaliculi so that jaundice can occur in a person (Gonçalves-de-Albuquerque et al., 2023).

Description based on lab oratory examination

When examining the white blood count, it was found that 6 patients had normal leukocyte counts (4.5–11.0 x 10^3/ul) and 32 patients had leukocytosis (>11.0 x 10^3/ul). The average white blood cell count was 16.68 ± 7.20x10^3/ul and the median was 15.96x10^3/ul. This result is different from research conducted in Kerala, India, in 2020, where the median white blood cell count was 8.8x10^3/ul (Mathew et al., 2020). The difference in results and increase in the number of white blood cells in this study could be caused by the patients experiencing severe disease (Pongpan et al., 2023). In a systematic review, it was also stated that the presence of leukocytosis showed an increase in bacterial colonies and a greater inflammatory reaction so that the presence of leukocytosis could be a predictor of death (Nagraik et al., 2021).

For total bilirubin examination, it was found that 5.3% or 2 patients had normal total bilirubin levels in their blood (0.1–1 mg/dL), 14 patients (36.8%) had hyperbilirubinemia (>1 mg/dL), and 57.9% or 22 patients did not have total bilirubin examination data in the medical records studied. Of the 16 patients who had data on total bilirubin levels, the average value was 8.64 ± 5.63 mg/dL. These results are in accordance with a case report published in 2024, where there was an increase in total bilirubin levels in patients (Lashkarbolouk & Mazandarani, 2024). An increase in total bilirubin levels occurs because leptospirosis can cause hepatocellular damage, disruption of connections between hepatocyte cells, and blockage of the bile ducts (Puca et al., 2020).

In the urea examination, the results of the patient's urea nitrogen examination were none (0%) which had a low value, 2 patients (5.4%) had normal urea levels (10–45 mg/dL), and 35 patients (92.1%) had normal high urea levels (10–45 mg/dL). urea was hig level of urea (>45 mg/dL), and 1 patient (2.6%) did not have data regarding urea levels. Of the 37 patients who had data on urea examination results, the average value was 173.94 ± 101.25 mg/dL and the median value was 148 mg/dL. This increase in urea level examination results is the same as the results of research conducted in Semarang in 2021, where an increase in urea levels was obtained with a median value of 131 mg/dL (Retnoningrum & Dharmawan, 2023).

Of the 37 patients or all patients who had data on blood creatinine level examination results in their medical records, 36 patients (94.7%) experienced an increase in keratinin levels. The average creatinine level of the 37 patients was 4.55 ± 2.09 mg/dL. Meanwhile, the mean value was 4.88 mg/dL. The results of this study are similar to those carried out in three hospitals in Central Java in 2023, where there was an increase in creatinine levels in 78 patients with an average of 2.66 ± 2.14 mg/dL (Zelindrah et al., 2023). Creatinine levels in the blood were checked because creatinine is a serum marker of acute kidney injury (AKI) which can be caused by severe leptospirosis (Osorio-Rodríguez et al., 2024). This increase in creatinine levels also correlates with a decrease in glomerular filtration rate of up to 50% and if there is an increase in creatinine levels of up to 1.5 times the baseline value, it can increase the risk of kidney failure (Nisansala et al., 2021). The median estimated glomerular filtration rate (eGFR) using the CKD-EPI creatinine formula was found to be 12.0 ml/min/1.73 m^2 with an interquartile range (IQR) of 9.0-25.50 for the 37 patients who had data. If the eGFR data is classified using the RIFLE (Risk, Injury, Failure, sustained Loss, and End-stage kidney disease) criteria, it is found that 2 patients (5.3%) are at risk of developing acute kidney disorders, 5 patients (13.2%) have acute kidney injury, and 27 patients (71.1%) are experiencing acute renal failure. The remainder, if classified outside the RIFLE criteria, were found that 1 patient (2.6%) had normal kidney function (≥90%), 2 patients (5.3%) had mild decline in kidney function (60-89%), and 1 patient (2.6%) did not have eGFR data due to the absence of creatinine level test results.

On blood potassium examination, it was found that 11 patients (28.9%) had blood potassium levels below the normal limit (<3.50 mmol/L), 21 patients (52.6%) had normal potassium levels (3.50–5.50 mmol/L), 1 patient (2.6%) had potassium levels above normal or hyperkalemia (>5.50 mmol/L), and 6 patients (15.8%) had no data regarding blood potassium examination results in the medical record. Of the 32 patients who had blood potassium examination results, the average was 3.70 ± 0.83 mmol/L. The results of this study are the same as the results of research conducted in Selangor, Malaysia in 2020, where of the 30 patients with laboratory-confirmed leptospirosis, 8 patients (26.7%) experienced hypokalemia and 22 patients had normal potassium levels (Fish-Low et al., 2020).

Of the 38 patients, 33 SGOT examination data were obtained on patients or the equivalent of 86.8%. From 33 data, 12 patients (31.6%) had normal SGOT levels and 21 patients (55.3%) had SGOT levels higher than the normal range. The average value of SGOT levels from 33 patients was found to be 77.48 ± 70.68 U/L or above the normal range of 8–37 U/L. The results of this study are in line with research conducted in Manila, Philippines in 2023, where

of 106 patients who had data on SGOT level examination results, an increase in SGOT levels was found with an average value of 102.30 ± 230.94 (Cuaño et al., 2023).

From 33 data, 13 patients (34.2%) had normal SGPT levels and 20 patients (52.6%) had SGPT levels higher than the normal range. The average value of SGPT levels from 33 patients was found to be 60.21 ± 50.12 U/L or above the normal range of 8–40 U/L. The results of this study are in line with research conducted in Manila, Philippines in 2023, where of 110 patients who had data on SGPT level examination results, an increase in SGPT levels was found with an average value of 65.80 ± 43.05 (Cuaño et al., 2023).

From 33 existing data, it was found that 32 patients (84.2%) had an SGOT/SGPT ratio ≤3, which indicated a good prognosis and only 1 patient had an SGOT/SGPT ratio >3, which indicated a poor prognosis. From 33 patients, the results showed that the average SGOT/SGPT ratio was 1.39 ± 0.81. The results of this study are the same as research conducted in Manila, Philippines in 2023, where from 105 medical record data, an average SGOT/SGPT ratio was obtained of 1.40 ± 1.23 (Cuaño et al., 2023).

Description based on blood pressure

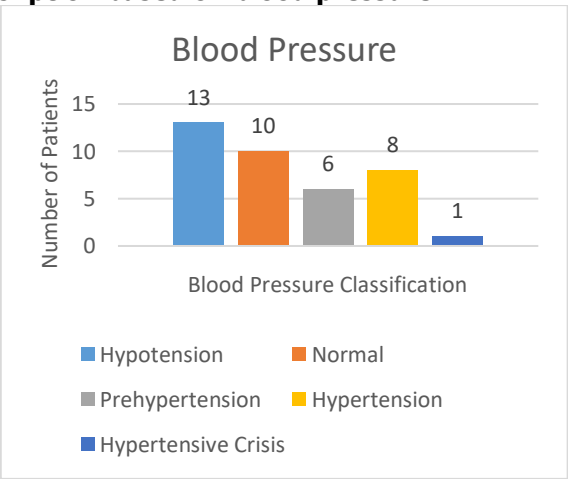

Figure 3. Distribution of Patients Based on Blood Pressure

From 38 blood pressure examination results, 13 patients (34.2%) had blood pressure <90/60 mmHg (hypotension), 10 patients (26.3%) had blood pressure 90-120/60-80 mmHg (normotension), 6 patients (15.8%) had blood pressure 120-139/80-89 mmHg (prehypertension), 8 patients (21.1%) were classified as hypertensive with 5 patients (13.2%) having blood pressure 140-159/90-99 mmHg and 3 patients (7.9%) had blood pressure ≥160/≥100 mmHg, and 1 patient (2.6%) experienced hypertensive crisis or blood pressure ≥180/≥110 mmHg. These results are quite different from research conducted in Thailand in 2023, where it was found that 60% of patients or more than half of the patients experienced hypotension. It is important to check blood pressure because, in several studies, blood pressure <90/60 mmHg or hypotension is a significant predictor of death in leptospirosis patients (Pongpan et al., 2023).

Description based on SPiRO score

From 38 medical record data, using 3 clinical manifestation points in the form of systolic blood pressure ≤100mmHg, abnormal breathing sounds when auscultated, and urine volume ≤500 mL in one day (oliguria), it was found that 3 patients had a total score of 0 indicating mild leptospirosis severity , 20 patients had a total score of 1 indicating severe leptospirosis severity, 13 patients had a total score of 2 indicating severe leptospirosis severity, and 2 patients had a total score of 3 indicating severe leptospirosis severity. The use of the SPiRO score compared to quick Sepsis Related Organ Failure Assesment (qSOFA) score to determine the severity of leptospirosis in this study is based on a study conducted in Australia in 2019, where in the study of 392 patients who were calculated using the SPiRO score, it was found that the possibility of disease severity increased gradually as the number of scores increased. Of 3%, 20%, 69%, and 100% with scores of 0, 1, 2, and 3, respectively. In addition, it was also found that a SPiRO score <1 had a negative predictive value of 97% for severe leptospirosis (Smith et al., 2019).

Table 1

Description of Patient SPiRO Score Results

Clinical Manifestations	Total score	Classification	Number of Patients
There were no clinical manifestations on the SPiRO score	0	Mild	3
Systolic blood pressure ≤100 mmHg	1	Severe	4
Abnormal breathing sounds on auscultation	1	Severe	9
Urine volume ≤500 mL in one day (oliguria)	1	Severe	7
Systolic blood pressure ≤100 mmHg and abnormal breathing sounds on auscultation	2	Severe	4
Systolic blood pressure ≤100 mmHg and urine volume ≤500 mL in one day (oliguria)	2	Severe	5
Abnormal breathing sounds on auscultation and urine volume ≤500 mL in one day (oliguria)	2	Severe	4

Systolic blood pressure ≤100 mmHg, abnormal breathing sounds when auscultated, and urine volume ≤500 mL in one day (oliguria)	3	Severe	2
Total			38

Description based on ECG results

Based on data from 38 ECG recordings, it was found that 12 patients (31.6%) had normal ECG (sinus rhythm) recording readings and the remaining 26 patients (68.4%) had abnormal ECG results

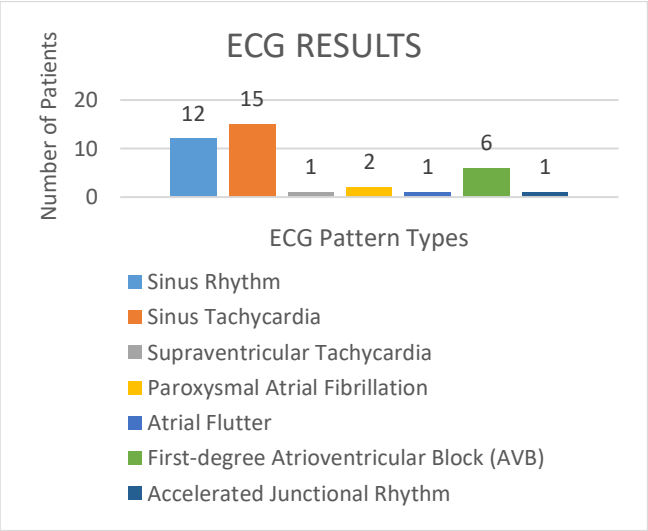

Figure 4. Distribution of Patients Based on Ecg Results

The most common ECG abnormality pattern was sinus tachycardia in 15 patients or equivalent to 39.5% of the 38 patients who were included as research subjects. This result is the same as a study conducted in 2020, where 34.2% of patients experienced a change in the ECG pattern to sinus tachycardia, making it the most common ECG pattern in the study (Mathew et al., 2020). However, these results are different from Swarath's research in 2023, which stated that atrial fibrillation along with 1st degree AV block was the most common ECG pattern change that occurred in leptospirosis patients (Swarath et al., 2023). Apart from that, an accelerated junctional rhythm (AJR), which is a rhythm that occurs when the atrioventricular (AV) junctional pacemaker rate exceeds the sinus node pulse rate, ECG pattern was also obtained in this study. Based on research conducted by Swarath in 2023, accelerated junctional rhythm was also found, which was the sixth most common ECG pattern change in leptospirosis cases, the same as in this study (Swarath et al., 2023).

From the results of the ECG reading, a table was created containing the characteristics of patient data based on the ECG results. Patients with ECG patterns of supraventricular tachycardia (SVT), atrial fibrillation (AF), and atrial flutter (AFL) were included in the supraventricular arrhythmia category. The following are patient characteristics based on categorization of ECG results:

Table 2

Patient Characteristics Based on ECG Result Category.

Characteristics	Categories Based on ECG Interpretation				
	Normal ECG	Sinus Tachycardia	Supraventricular Arrhyth-mia	AV Block	AJR
	n=12	n=15	n=4	n=6	n=1
Age (years)	53.41 ±13.15	55.40 ± 10.99	58.50± 13.32	49.0± 11.57	48.0± 0.00
Male, n(%)	7 (18.40)	11 (28.90)	3 (7.90)	6 (15.80)	1 (2.6)
Female, n(%)	5 (13.20)	4 (10.50)	1 (2.6)	0 (0)	0 (0)
Duration of hospitalization (days)	6.58± 1.92	5.46± 4.80	7.50± 4.43	6.50± 4.03	1.00± 0.00
Jaundice, n(%)	4 (10.50)	9 (23.70)	3 (7.90)	5 (13.2)	1 (2.6)
WBC *count* ($x10^3$/ul)	14.75 ±4.68	16.61 ± 6.70	15.81± 5.20	21.49± 12.19	22.50 ± 0.00
TBil (mg/dL)	2.05± 1.55	9.48± 4.55	15.16± 2.96	8.60± 0.00	-
Ureum (mg/dL)	140.67 ±68.72	175.00 ±121.64	241.33± 113.70	204.33 ±101.59	170.00 ±0.00
Creatinine(mg/dL)	4.16± 2.19	4.08± 2.07	5.67± 1.44	5.93± 2.03	4.43± 0.00
eGFR (ml/min/ 1.73m^2)	23.17 ± 20.63	28.27 ± 29.42	10.33± 1.52	13.83± 10.99	16.00 ± 0.00
Potassium (mmol/L)	3.22± 0.80	4.08± 0.80	3.91± 1.12	3.84± 0.29	-
SGOT (U/L)	66.25 ±96.38	85.87 ± 69.31	58.66± 19.03	70.50± 62.49	140.00 ± 0.00
SGPT (U/L)	45.50 ±21.59	72.13 ± 70.50	43.00± 10.58	60.16± 22.31	51.00 ± 0.00
SGOT/ SGPT Ratio	1.25± 1.01	1.46± 0.76	1.48± 0.74	1.10± 0.66	2.74± 0.00
Death, n(%)	4 (10.50)	7 (18.40)	3 (7.90)	1 (2.6)	1 (2.6)

For the average age, there is not a significant age difference in each category. For gender in each category, there were more males than females. For the duration of hospitalization, patients with results in the supraventricular arrhythmia category (supraventricular tachycardia, atrial fibrillation, atrial flutter) have the highest average duration of hospitalization compared to other categories, with a duration of 7.50 ± 4.43 days, from the start of being treated in the inpatient installation until declared cured by a doctor or died or referred to another

hospital. The category of patients with recorded AV block (AVB) results had the largest percentage of jaundice manifestations, namely 83.3% or it could be said that 5 out of 6 patients had jaundice manifestations in the course of the disease.

For white blood cell counts and total bilirubin levels, the category of patients with sinus rhythm ECG recordings had the smallest increase with an average of 14.75 ± 4.68 x 10^3/ul and 2.05 ± 1.55 mg/dL respectively. The highest average blood ureum levels belonged to the category of patients with supraventricular arrhythmia ECG recordings with an average of 241.33 ± 113.70 mg/dL. The category of patients with the highest average creatinine level results was AV block with an average of 5.93 ± 2.03 mg/dL. The patient category with the lowest average eGFR was supraventricular arrhythmia with an average of 10.33 ± 1.52 ml/min/1.73 m^2. The category of patients with sinus tachycardia ECG recordings had the highest average compared to other categories in the characteristics of blood potassium levels, SGOT levels, and SGPT levels with an average of 4.08 ± 0.80 mmol/L, 85.87 ± 101.95 U/L, and 72.13 ± 70.50 U/L, respectively. For the SGOT/SGPT ratio, it was found that all categories had a good prognosis because the value was ≤3. Lastly, the accelerated junctional rhythm category is the category with the highest patient mortality compared to other categories with as many as 1 out of 1 patients dying or it could be said that 100% of accelerated junctional rhythm patients die.

Based on the theory known to date, cardiac arrhythmia can be caused by one of the antigenic fractions on the outer membrane of *Leptospira*, namely glycoprotein (GLP). GLP will inhibit sodium-potassium adenosine triphosphatase (Na/K-ATPase), a transmembrane protein that functions to maintain the electrical potential of cells and intracellular water volume by inserting two potassium ions into cells and removing three sodium ions from cells in the heart, which causes hypokalemia, which leads to arrhythmia, but in this study there was no difference in blood potassium in patients with normal ECG or abnormal ECG, so that changes in ECG patterns in this study were not caused by potassium levels.

Description based on pharmacological management

There were 7 antibiotics used in pharmacological management in 38 patients confirmed with leptospirosis with IgM (+) results and hospitalized at the UNS Hospital inpatient installation in the 2019–2023 period. Antibiotics used include ampicillin, cefotaxime, ceftriaxone, cotrimoxazole, doxycycline, and levofloxacin. If we only look at the type without looking at the dose and therapy, 12 patients (31.6%) were given just one type of antibiotic in the form of ceftriaxone. These results are in accordance with research in 2024 where it was stated that ceftriaxone is one of the first-line antibiotic drugs for curing severe leptospirosis besides penicillin (Arbour et al., 2024). The most ceftriaxone administered in this study was at a dose of 2 g/24 hours intravenously.

In this study, it was also found that doxycycline was the second most frequently administered antibiotic for leptospirosis patients. However, in this study, doxycycline was not given as a single antibiotic therapy, but as a combination with other antibiotics. Doxycycline is given in combination form because it is considered an empiric antibiotic and for mild leptospirosis (Petakh et al., 2024).

The third most common type of antibiotic in this study was ampicillin. These results are in accordance with Parra Barrera's research where ampicillin was the third most frequently administered antibiotic for leptospirosis patients after ceftriaxone and doxycycline (Parra Barrera et al., 2023). Ampicillin itself can be used for severe leptospirosis (Petakh et al., 2024).

Table 3

Types of Antibiotics Based on Number of Patients

Antibiotic Therapy	Number of Patients	Percentage
Ampicillin	1	2.6%
Cefotaxime	1	2.6%
Ceftriaxone	12	31.6%
Ampicillin and Ceftriaxone	1	2.6%
Ampicillin and Doxycycline	4	10.5%
Ceftriaxone and Doxycycline	6	15.8%
Ceftriaxone and Levofloxacin	4	10.5%
Ampicillin, Ceftazidime, and Ceftriaxone	1	2.6%
Ampicillin, Ceftriaxone, and Doxycycline	4	10.5%
Ampicillin, Ceftriaxone, and Levofloxacin	1	2.6%
Ceftriaxone, Doxycycline, and Levofloxacin	2	5.3%
Ceftriaxone, Cotrimoxazole, Doxycycline, and Levofloxacin	1	2.6%
Total	38	100%

Description based on comorbidities

Comorbidities in this study mainly used the Charlson comorbidity index. The higher the score, the greater the influence of a disease on changes in the patient's ECG pattern. In this study, based on the Charlson comorbidity index (CCI), 32 patients (84.2%) did not have significant comorbidities, while 6 patients (15.8%) had mild comorbidities which might influence changes in ECG recording patterns.

Apart from the comorbidities that are in the Charlson comorbidity index (CCI), there are also other comorbidities that can influence the ECG recording patterns in 38 patients who do not have comorbidities

based on the CCI. There were 5 patients (13.2%) who had other comorbidities which might have an influence on the patient's ECG recording pattern. Of the 5 patients, 1 patient also had comorbidities included in the CCI. These comorbidities include: hypertension, hyperuricemia, and gastroesophageal reflux disease (GERD).

Table 4
Comorbidities in Patients

Comorbidities	Number of Patients	Percentages Based on a Total of 38 Patients
Diabetes melitus	3	7.8%
Chronic kidney disease	2	2.6%
Rheumatoid arthritis	1	5.2%
GERD	1	2.6%
Hypertension	2	5.2%
Hyperuricemia	1	2.6%
Total	10	26.3%

Of the 10 patients who had comorbidities, it was found that 1 patient had diabetes mellitus or 2.6% of the total 38 patients, 1 patient had diabetes mellitus with hypertension, 1 patient had diabetes mellitus with chronic complications, 2 patients or 5.3% of the total 38 patients had chronic kidney disease, 1 patient had rheumatoid arthritis disease, 1 patient had GERD, 2 patients had hypertension, and 1 patient had hypertension with hyperuricemia. These results are the same as the results of research conducted in India in 2024, where hypertension and diabetes were the most frequent comorbidities in leptospirosis patients where of the 12 cases, 5 patients had comorbid hypertension and 4 patients had comorbid diabetes mellitus. The same study explained that only patients with liver cirrhosis comorbidity that increased the risk of mortality in leptospirosis patients. While other comorbidities such as hypertension, diabetes mellitus, dyslipidemia, and coronary artery disease were not significantly associated with mortality in leptospirosis patients (Kumar et al., 2024).

Description based on death

Of the 38 patients, 16 patients (42.1%) died because they suffered from leptospirosis. The death rate in this study was higher than in a similar study conducted in the Philippines in 2023, where 7 patients out of 31 total patients died or it could be said that only 22.58% (Quizon et al., 2023). The high death rate in the study conducted at UNS Hospital could be caused by the average age of patients at UNS Hospital being much higher than the study in the Philippines, where in the study at UNS Hospital the average age was 53.89 ± 11. 7 years, while research in the Philippines found an average age of 33.48 ± 10.0 years. This is because based on existing research, advanced age is a predictor of a poor prognosis because the older you get, the greater the involvement of kidney disorders in the course of (Daher et al., 2019). In addition, although it did not have a statistically significant effect with p-value 0.658 (p-value>0.05), 12 of the 16 or 75% of patients who died in this UNS Hospital study had abnormal ECG results. Moreover, although 6 of the 16 patients who died had hypotension, based on statistical tests it was found that hypotension did not affect mortality, where a p-value of 0.724 or >0.05 was obtained.

CONCLUSION

Based on the results and discussion written in the previous chapter, research using descriptive methods on 38 patients with confirmed leptospirosis who were treated at the UNS Hospital inpatient ward, it can be concluded that there are cardiovascular abnormalities in leptospirosis patients treated at the UNS Hospital inpatient installation. These abnormalities include changes in the pattern of ECG recording results (26 patients) and a decrease in blood pressure (13 patients). ECG pattern changes in leptospirosis patients may indicate that *Leptospira sp.* bacteria contribute directly or indirectly to cardiac disorders during mild or severe forms of leptospirosis. ECG abnormalities such as sinus tachycardia, supraventricular arrhythmia, and accelerated junctional rhythm are common early in the disease and may be caused by the direct effects of *Leptospira* or febrile infection with a combination of metabolic and electrolyte abnormalities. Therefore, it is important for health workers to carry out ECG and blood pressure examinations on leptospirosis patients in the early phase of leptospirosis when the patient first visits a health facility.

SUGGESTION

It is hoped that the results of this study can be used as consideration for future researchers so that they can be used to examine the characteristics of cardiovascular abnormalities in leptospirosis patients with other variables such as the results of echocardiogram examinations, the results of other electrolyte examinations (sodium), and the results of chest x-rays. It is hoped that future similar research will be able to explain the mechanism or pathogenesis of cardiovascular disorders caused by leptospirosis. Other recommendation is that future research uses a prospective cohort study which can detect and completely record comorbidities that exist during the course of the study. Last recommendation is to collect data over a longer period of time or collect data in more than one place so that more data can be collected.

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