


Junctional Bradycardia with Cardiorenal Syndrome

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ABSTRACT

Junctional bradycardia occurs when electrical activity at the SA node is disrupted, or there is a conduction block originating from the SA node, or its automaticity is less than the AV node or HIS bundle. A 46-year-old female was referred because of shortness of breath and swollen limbs. The patient has a long history of diabetes and hypertension. She was diagnosed with acute pulmonary edema, junctional bradycardia, stage 4 CKD, CHF, hypoalbuminemia, anemia, and T2DM. The patient was admitted to the ICCU for 7 days before being discharged. Cardiorenal syndrome can induce sinus node dysfunction or AV node dysfunction, leading to junctional bradycardia. Subsequently, the junctional bradycardia exacerbates concomitant heart failure and renal failure.

Keywords: Cardiorenal syndrome, CKD, heart failure, junctional bradycardia.

ABSTRAK

Junctional bradycardia terjadi saat aktivitas listrik pada nodus SA terganggu atau terdapat blok konduksi yang berasal dari nodus SA atau otomatisitasnya kurang dibandingkan dari nodus AV/berkas His. Seorang wanita berusia 46 tahun dirujuk dengan sesak napas dan kedua tungkai bengkak. Pasien memiliki riwayat diabetes dan hipertensi. Pasien didiagnosis dengan edema paru akut, *junctional bradycardia*, PGK stadium 4, GJK, hipoalbuminemia, anemia, dan DM tipe 2. Pasien dirawat di ICCU selama 7 hari sebelum dipulangkan. Sindrom kardiorenal bisa menginduksi disfungsi nodus SA atau nodus AV, menyebabkan *junctional bradycardia* yang berpotensi memperburuk gagal jantung dan gagal ginjal. **Yehiel Flavius Kabanga, Iman Haryana, Denny Jolanda, Alvionita Patandean. *Junctional Bradycardia* dengan Sindrom Kardiorenal.**

Kata Kunci: Sindrom kardiorenal, CKD, gagal jantung, *junctional bradycardia.*

INTRODUCTION

The initiation of a heartbeat originates from the sinoatrial (SA) node. The electrical activity thereafter propagates from the atrium to the atrioventricular (AV) node, proceeds through His bundle, and ultimately reaches the ventricle through Purkinje fibers. Interruption of the sinoatrial (SA) node electrical activity may cause a conduction block emanating from the SA node, or automaticity deficiency within the atrioventricular (AV) or His node, and may result in a junctional rhythm originating from the AV node or the proximal bundle of His[1-3] since the cells within the atrioventricular (AV) node and its Purkinje system possess intrinsic automaticity, but at a slower pace compared to the sinoatrial (SA) node; they are activated during regular sinus rhythms.[1] The defining feature of junctional rhythm is the presence of a regular, narrow QRS complex with a heart rate of 40 to 60 beats per minute. If the heart rate is specifically 40 beats per minute, it is referred to as junctional bradycardia. Notably, the preceding P wave is absent due to the origin of the electrical impulse from the region below the atrium. The presence of a retrograde P wave may be observed due to the dispersion of the pulse in divergent directions. The junctional rhythm serves as a protective mechanism aimed at preserving the heart rate and pulse in instances where the typical pulsations generated by the sinoatrial (SA) node become ineffective.[1] Various factors that can trigger a junctional rhythm include digoxin toxicity, renal failure, acidosis, infection, medication-induced causes, electrolyte imbalances, and ischemic disease.[4]

The heart plays a vital role in facilitating the circulation of blood throughout the entire body, including the kidneys.[5] On the other hand, the kidneys are responsible for the filtration of the circulating blood and the maintenance of homeostasis and electrolyte balance. The interrelationship between these two organs is of significant importance, as they are mutually reliant and essential for sustaining human life. Hence, the preservation of cardiovascular homeostasis relies on the effective interplay between the cardiac and renal systems. It is not unexpected that the malfunction of one organ has an impact on the function of another organ.[5] It is evident that heart disease and kidney disease exhibit common vascular risk factors, such as hypertension and diabetes, among others. Both renal failure and cardiac failure (HF) are linked with an unfavorable prognosis. Furthermore, the co-occurrence of renal failure and heart failure is observed due to the strong association between these two conditions and their interconnected implications, which result in more unfavorable prognoses.[5] Cardiorenal syndrome (CRS) encompasses several dysfunctions, acute or chronic dysfunction in one organ might result in the manifestation of acute or chronic dysfunction in the other organ.[5,6] Chronic kidney disease (CKD) is a progressive disease

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but asymptomatic until it approaches end-stage renal disease (ESRD). Cardiovascular (CV) pathology in CKD has specific characteristics, described as uremic cardiomyopathy. This condition is characterized by left ventricular hypertrophy (LVH), marked cardiac fibrosis, intramyocardial arteriolar wall thickening, and predominantly diastolic dysfunction, followed by systolic dysfunction in the late stages of heart failure. LVH is commonly used as a surrogate marker of uremic cardiomyopathy and a predictor of CV mortality. In addition, CKD patients tend to develop heart rhythm disturbances with an increased risk of sudden cardiac death.[7] Junctional rhythms can also occur in CKD patients due to sinus node dysfunction, accumulation of uremia causing acidosis, and may also be due to electrolyte imbalances, especially potassium levels.[2,4] A case of a potentially uncommon occurrence: the cardiorenal syndrome accompanied with junctional bradycardia in a female aged 46 years was reported.

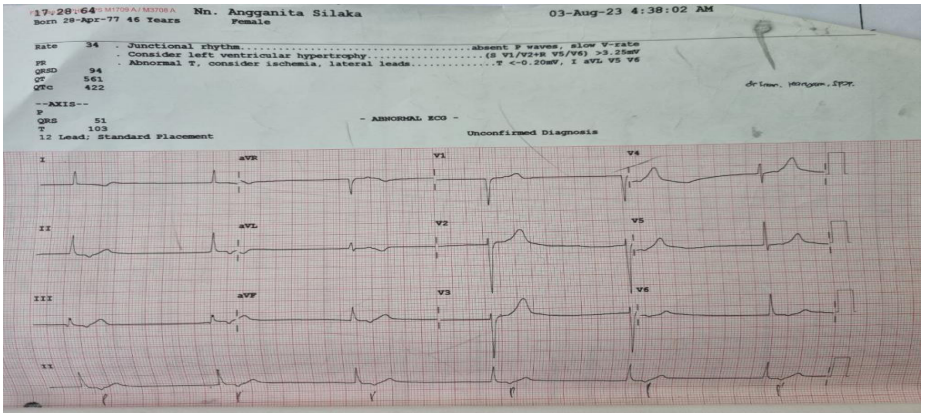

Figure 1. ECG on day 1 shows junctional bradycardia, regular, 34 x/minute.

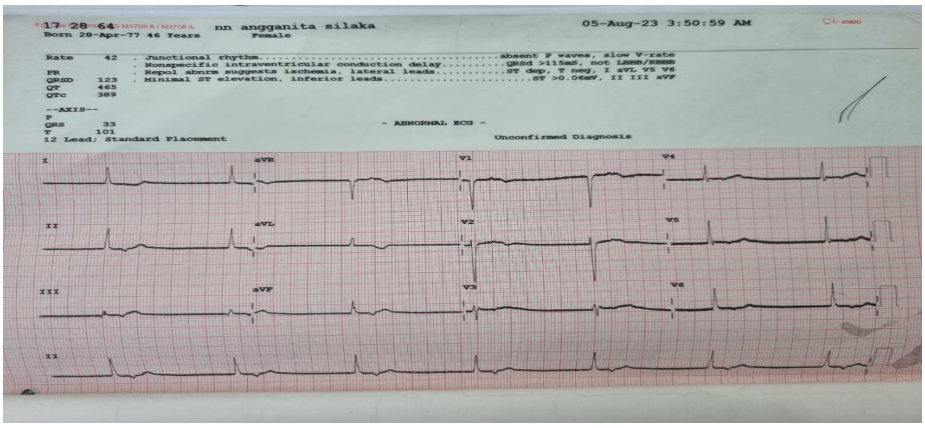

Figure 2. ECG on day 3 shows a junctional rhythm, regular, 42 x/minute.

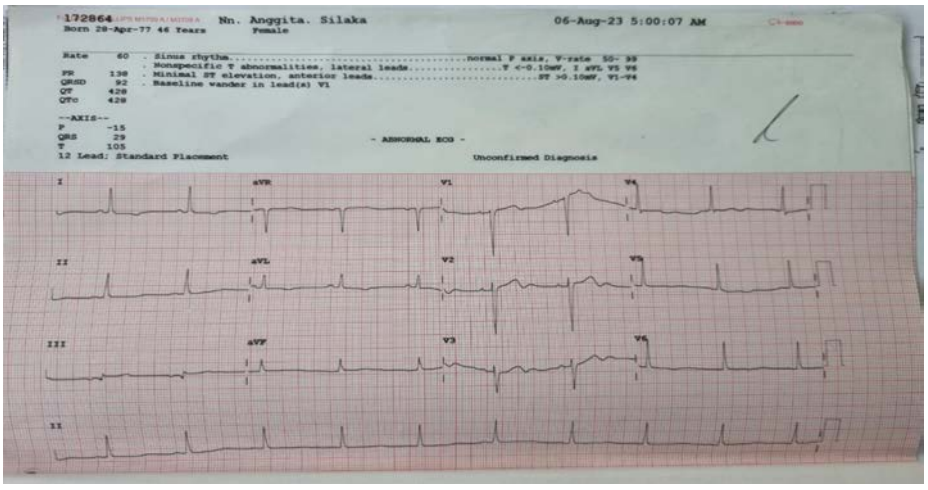

Figure 3. ECG on day 5 shows sinus rhythm, regular, 60 x/minute.

CASE

A female, aged 46, was sent to our medical facility due to the presence of third-degree atrioventricular block, congestive heart failure, and chronic renal failure. The patient presented with persisting and progressive dyspnea for three days. She also presented with bilateral lower extremity edema persisting for three days. Her urine production is decreased. She was previously diagnosed with type 2 diabetes and hypertension. The medications include amlodipine (10 mg), metformin (3 mg), and glimepiride (1 mg).

The patient's vital signs were: blood pressure of 140/90 mmHg, pulse rate of 38 beats per minute, respiratory rate of 32 breaths per minute, body temperature of 36.2ºC, oxygen saturation level of 90% on room air, and 68 kg bodyweight. The patient was alert and oriented; jugular venous pressure (JVP) at 5 ± 2cm; auscultation revealed crackles in both lung fields; heart sounds were within normal limits; pitting edema was observed in both legs; and the acral was warm. Electrocardiogram (ECG) revealed a junctional bradycardic rhythm, with a regular heart rate of 34 beats per minute. Chest x-ray indicated cardiomegaly, with a cardiothoracic ratio (CTR) of 64%, along with bilateral pulmonary edema. Laboratory test results: hemoglobin 9.5 g/dL, urea 113 mg/dL, creatinine 3.8 mg/dL, random blood glucose 119 mg/dL, albumin 3.2 g/dL, sodium 133 mmol/L, potassium 4.4 mmol/L, and chloride 101 mmol/L. Diagnoses were acute pulmonary edema, junctional bradycardia, stage 4 chronic kidney disease (CKD), hypoalbuminemia, anemia, and type 2 diabetes mellitus (T2DM).

During the first day in the Intensive Coronary Care Unit (ICCU), the patient received oxygen 10 liters per minute via a non-rebreather mask. Intravenous administration of furosemide 3 x 40 mg IV daily. A dopamine drip was initiated at a rate of 5 micrograms per kilogram per minute. Oral medications were vipalbumin 3x1 capsule, bicarbonas natricus 3x500 mg,


and candesartan 8 mg. Dosage of dopamine was escalated to 6 mcg/kg/minute and to 7 mcg/kg/minute on the third day as the blood pressure was158/62 mmHg, heart rate 40 beats per minute. Candesartan 16 mg, furosemide 3x20 mg IV, nifedipine 3x5 mg, salbutamol 3x2 mg was added. On the fifth day, the blood pressure was 165/69 mmHg, heart rate 60 beats per minute, the dose of dopamine was decreased to 5 micrograms per kilogram per minute, and oxygen was administered at a rate of 4 liters per minute using a nasal cannula. On the seventh day, the blood pressure was 168/67 mmHg, heart rate was 74 beats per minute; the patient was relocated to the general ward. Dopamine infusion was discontinued, and intravenous furosemide was switched to 40 mg orally, plus 25 mg hydrochlorothiazide. On the eighth day, his blood pressure was 158/70 mmHg, and a heart rate of 80 beats per minute. The laboratory test results were urea 75 mg/dL, creatinine 2.5 mg/dL, fasting glucose 107 mg/dL, HbA1c 6.5%, sodium 142 mmol/L, potassium 3.5 mmol/L, and chloride 106 mmol/L. The patient was discharged.

DISCUSSION

Cardiorenal syndrome (CRS) is a condition characterized by a complicated bidirectional relationship between the heart and kidneys, causing acute or chronic dysfunction in these two organs.[8] A classification of CRS was proposed at a consensus conference by the Acute Dialysis Quality Group in 2008 (**Table**).[9–11] This classification basically divides CRS into two main groups, namely cardiorenal and renocardiac CRS. Both cardiorenal and renocardiac CRS are then divided into acute and chronic types according to the onset and duration of the underlying organ dysfunction. Type 5 CRS integrates all cardiorenal involvement caused by systemic disease.[9]

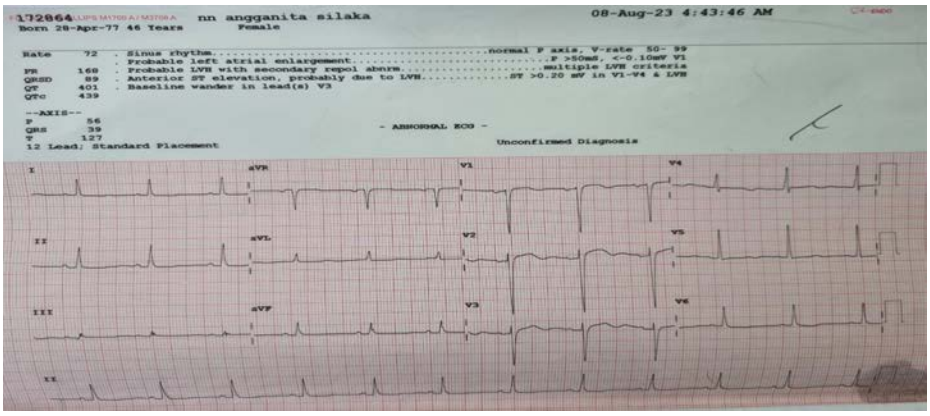

Figure 4. EKG on day 7 shows sinus rhythm, regular, 75 x/minute, poor R wave progression.

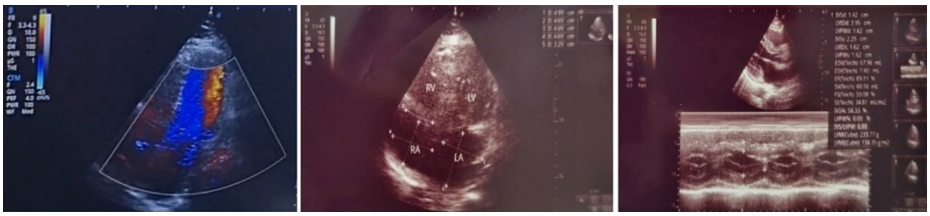

Figure 5. Transthoracic echocardiography (TTE) shows an EF of 89%, abnormally relaxed LV diastolic function, and concentric LV remodeling.

Table. CRS classification.[9–11]

CRS	Description	Example
CRS type 1	Acute HF causes AKI	Acute coronary syndrome causes acute CHF and AKI or ADHF causes AKI
CRS type 2	Chronic HF causes CKD	HF chronic
CRS type 3	AKI causes acute HF	Sudden decline in kidney function, which may be due to renal ischemia or glomerulonephritis which causes acute HF
CRS type 4	CKD causes HF	Myocardial remodelling and heart failure due to CKD-related cardiomyopathy
CRS type 5	Systemic disease that causes heart and kidney failure	Acute or chronic systemic disorders (e.g. sepsis, amyloidosis, or diabetes mellitus) that cause cardiac and renal dysfunction

The case exhibits chronic renal syndrome (CRS) type 4, marked by chronic kidney disease (CKD). This condition is characterized by elevated levels of serum creatinine, anemia, hypoalbuminemia, a prolonged history of hypertension and diabetes, as well as persistently high levels of urea and creatinine, albeit with a slight decrease following treatment. The patient's transthoracic echocardiography (TTE) confirmed the presence of impaired left ventricular (LV) diastolic function and visible concentric left ventricular remodelling, despite an ejection fraction of 89%.

Chronic Renocardiac Disease (CRD) type 4 is a medical condition characterized by the presence of cardiovascular complications in individuals with any stage of Chronic Kidney Disease (CKD).[12] Chronic kidney disease (CKD) has an indirect impact on the progression of ischemic heart disease and a direct effect on the development of pressure and volume overload, leading to left ventricular hypertrophy.[12] Hyperkalemia and hypokalemia frequently manifest in individuals with chronic kidney disease (CKD), leading to perturbations in extracellular pH, magnesium levels, and calcium concentrations.[12] The development of cardiovascular risk factors, including hypertension, volume overload, anemia, iron insufficiency, dietary deficiencies, bone disease, and buildup of uremic toxins, begins at the estimated glomerular filtration rate (eGFR) below 60 ml/min/1.73 m^2.[13] Several variables contribute to the development of cardiac and endothelial dysfunction, which then leads to inflammation and oxidative stress. These processes ultimately culminate in vascular microcalcification and myocardial fibrosis.[13] Subsequently, this sequence of events becomes evident at the macrovascular scale, characterized by a reduction in myocyte contractility, development of left ventricular

hypertrophy (LVH), and/or dilatation, ultimately leading to heart failure.[13] Consequently, chronic kidney disease (CKD) leads to a decline in cardiac performance due to left ventricular hypertrophy, diastolic dysfunction, and cardiac remodelling.[8] These factors contribute to an elevated susceptibility to acute cardiovascular events, including stroke, acute heart failure, and myocardial infarction.[8] Cardiovascular complications in individuals with first- and second-degree chronic kidney disease (CKD) can be attributed to several factors, including hypertension, dyslipidemia, chronic inflammation, primary neuropathy, and diabetes mellitus.[11,12] In stages three and four of chronic kidney disease (CKD), anemia, toxic uremia, electrolyte imbalance, and excessive volume can lead to impairments in cardiac function. In fifth-grade chronic kidney disease (CKD), the manifestation of soft tissue calcification and resistance to erythropoietin (EPO) will become evident.[11,12] Multiple studies have provided evidence indicating that structural alterations in the left ventricle start during the initial phases of chronic kidney disease (CKD), although left ventricular ejection fraction (LVEF) stays preserved.[13] Cardiac fibrosis and remodelling sinus node dysfunction can be attributed to intrinsic factors, namely structural or functional alterations in the sinoatrial (SA) node.[14] The SA node, being an intrinsic component, plays a significant role in the development of the condition.[14] Fibrosis and cardiac remodelling lead to structural alterations that diminish the transfer of tension within the cardiac tissue, hence causing a delay or obstruction of the sinoatrial (SA) node, which subsequently gives rise to sinus dysfunction.[14] In patients with end-stage renal disease, the accumulation of uremia leads to the development of acidosis. This acidosis has a significant impact on the AV node as it becomes more sensitive to lower pH levels, ultimately reducing the conduction and contractility of cardiac myocytes.[4] The result is bradycardia. In addition, electrolyte imbalances, especially potassium levels, also contribute to the occurrence of bradycardia. Normal potassium levels are essential for the generation of action potentials in cardiac myocytes.[4] The presence of acidosis causes conduction delay, resulting in prolongation of the PR interval and, in severe cases, the occurrence of AV nodal block. Interestingly, the posterior nodal extension (also known as the slow pathway) within the AV node appears to be particularly susceptible to the effects of acid.[4] This sensitivity further exacerbates the conduction delay. The mechanism underlying PR interval prolongation is most likely due to two main factors. [4] First, a decrease in sodium current plays an important role in the conduction process.[4] Second, an increase in intercellular resistance contributes to conduction disturbances.[4] Together, these two mechanisms contribute to PR interval prolongation in the presence of acidosis.[4] AV node dysfunction can also be caused by hyperkalemia, which refers to excessive levels of potassium in the blood.[4] Elevated potassium levels cause depolarization of the resting membrane potential, resulting in an acceleration of conduction velocity.[4] However, when potassium levels exceed 8 mmol/L, conduction velocity decreases.[4] Junctional bradycardia in our patient could be caused by sinus node dysfunction, or by AV node dysfunction due to acidosis. Unfortunately, there are no blood gas analysis facilities in our hospital. There were no medications, hyperkalemia, or other extrinsic factors suspected to cause bradycardia in our patient.[4,6,15] Severe bradycardia in this patient resulted in decreased cardiac output and inadequate blood flow to the kidneys, leading to hemodynamic instability especially when it occurred with pre-existing heart failure and renal failure, even if systolic blood pressure remains within the normal range.[6] While cardiac pacing serves as the primary therapeutic approach for symptomatic sinus node dysfunction (SND), the initial treatment involves the identification of transient or reversible factors contributing to SND.[15] It is advisable to explore drugs that might potentially cause sinus node dysfunction, correct any electrolyte imbalances, and address any external factors such as obstructive sleep apnea, hypothyroidism, or hypoxemia.[15] Pharmacological interventions, such as atropine or isoproterenol, are mostly employed as temporary emergency measures pending the implementation of a cardiac pacemaker.[15]

CONCLUSION

There is a reciprocal relationship between cardiorenal syndrome and junctional bradycardia. The cardiorenal syndrome can lead to sinus node dysfunction or AV node dysfunction, resulting in a junctional bradycardia rhythm. Subsequently, junctional bradycardia exacerbates the pre-existing heart and renal failure, ultimately leading to acute pulmonary edema.

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