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Original Article

Epidemiology and management of acute coronary syndrome in remote and resource-limited settings: Insights from a rural Indonesian hospital

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Abstract

Acute coronary syndrome (ACS) remains a major global health and economic burden. In Indonesia, North Kalimantan reports the highest prevalence of heart disease (2.2%), exceeding the national average of 1.5%. Nunukan, the province's northernmost and predominantly archipelagic region, is served by a single general hospital, reflecting the healthcare challenges faced by many rural Indonesian areas. This study aimed to provide epidemiological insights into ACS cases in this region to inform improved management strategies in similar resource-limited settings. A retrospective cross-sectional study was conducted among ACS patients admitted to Nunukan Regency General Hospital, Nunukan, Indonesia, between January 1 and August 31, 2023. Data on demographics, risk factors, clinical presentation, vital signs, diagnostic findings, treatments, and outcomes were collected from paper-based medical records. Of the 241 patients admitted, 4.56% were diagnosed with ST-elevation myocardial infarction (STEMI), 35.68% with very high-risk non-ST-elevation ACS (VHR NSTE-ACS), and 59.75% with non-very high-risk NSTE-ACS (NVHR NSTE-ACS). The mean age was 55.4±12.26 years, with a predominance of males (51.5%) and obesity (35.7%). The median number of risk factors was 2 (IQR: 1–2.5), with hypertension being the most prevalent (72.6%). Late presentation was common, and only 36.4% of STEMI patients received fibrinolytic therapy. The overall in-hospital mortality rate was 3.3%, and the median length of stay was 6 days (IQR: 5–7). ACS patients in Nunukan exhibited distinct clinical and demographic profiles, characterized by younger age, obesity, multiple risk factors, and delayed presentation. These findings highlight the urgent need to strengthen cardiovascular care capacity and early intervention strategies in remote and resource-limited regions of Indonesia.

Keywords: Acute coronary syndrome, STEMI, NSTE-ACS, epidemiology, rural region

Introduction

Coronary artery disease (CAD) refers to the condition in which the coronary arteries become narrowed or blocked, resulting in a reduced blood supply to the cardiac muscle [1]. Acute coronary syndrome (ACS) is an umbrella term for conditions that encompass a broad spectrum of clinical manifestations, including acute myocardial infarction (AMI) or unstable angina, varying from being asymptomatic at presentation to experiencing persistent chest discomfort, hemodynamic instability, or even cardiac arrest [2]. No single risk factor has been recognized as being solely responsible for the development of CAD; rather, there is a combination of modifiable and unmodifiable risk factors [3].

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Globally, CAD is the primary cause of death and reduction of disability-adjusted life years (DALYs). Even while CAD-related mortality has decreased over the previous forty years, the condition still accounts for more than one-third of fatalities among people over 35 years old [4]. In Indonesia, CAD was the primary cause of death, contributing to 89.82 fatalities per 100,000 population in 2021 [5]. Among noncommunicable diseases, cardiovascular diseases also contribute the most to gross domestic product (GDP) loss, with an estimated loss of USD 1.77 trillion from 2012 to 2030 [6].

According to the 2018 Riset Kesehatan Dasar (RISKESDAS) statistics, North Kalimantan has the greatest prevalence of CAD in Indonesia, with a rate of 2.2%, surpassing the national prevalence of 1.5% [7]. The northernmost region of North Kalimantan is the Nunukan Regency, a district that is an archipelagic area with a direct border with Sabah, Malaysia. The regency has a population of 208,303 people in 2023 and occupies a total area of 14,247.50 square meters [8]. Access to medical care in Nunukan is quite challenging, with only one general hospital serving as a referral center [8]. This situation reflects healthcare conditions in rural Indonesia, highlighting challenges in managing ACS patients. Early diagnosis and risk modification are crucial due to ACS's impact on morbidity, mortality, and financial burden in such resource-limited settings. This study aimed to provide insights into ACS patient characteristics, management, and outcomes at Nunukan Regency General Hospital to aid ACS management strategies in rural areas. Understanding these aspects is critical for creating deliberate treatments to improve care for patients and prognosis. Furthermore, the results could provide a basis for further investigation and policy enhancements in similar underserved regions.

Methods

Study design

A retrospective study was conducted among patients diagnosed with ACS who presented to Nunukan Regency General Hospital, Nunukan, North Kalimantan, Indonesia. All patients with confirmed ACS between January 1, 2023 and August 31, 2023 were consecutively recruited. A cardiologist made the diagnosis according to the European Society of Cardiology (ESC) Guidelines for ST-elevation myocardial infarction (STEMI) [9] and ESC guidelines for non-ST-elevation acute coronary syndrome (NSTE-ACS) [10].

Patients criteria

Patients aged 18 years and older who presented during the study period with a confirmed diagnosis of ACS were included. The diagnosis of ACS, comprising STEMI and NSTE-ACS, was determined by the attending cardiologist based on clinical presentation and electrocardiographic findings in accordance with ESC guidelines. Patients were excluded if the final diagnosis was non-cardiac chest pain or another condition mimicking ACS, if they were admitted electively for evaluation of stable coronary disease, or if their medical records were incomplete, duplicated, or lacked essential diagnostic or outcome information. Records with missing data exceeding 5% for key variables were excluded from the analysis to maintain data completeness and reliability.

Case criteria and classification

The diagnosis of ACS was initially made based on symptoms of acute chest discomfort, defined as chest pain lasting more than 20 minutes at rest, Class II or III de-novo angina (less than three months) of the Canadian Cardiovascular Society (CCS) classification, post-myocardial infarction (MI) angina, recent worsening angina with at least Class III CCS criteria, or atypical symptoms such as epigastric pain, abdominal discomfort, or isolated shortness of breath and fatigue [10]. The diagnosis was then classified into: (a) STEMI, characterized by persistent ST-segment elevation or its equivalents on electrocardiography (ECG), and (b) NSTE-ACS, identified by the absence of persistent ST-segment elevation or its equivalents on ECG [9,10]. Since cardiac biomarker data were not available at the hospital, a differential diagnosis between unstable angina and non-ST-elevation myocardial infarction (NSTEMI) could not be made; therefore, the diagnosis of NSTE-ACS was categorized by risk stratification into (a) very high risk (VHR), if any of the following conditions were met: life-threatening arrhythmias, mechanical complications of

MI, acute heart failure associated with NSTE-ACS, unstable hemodynamic or cardiogenic shock (CS), recurring or refractory chest pain despite medical treatment, or ST-segment depression >1 mm/6 leads plus ST-segment elevation aVR and/or V1; and (b) non-very high risk (NVHR), if the patient lacked any VHR criteria [10].

Data collection and extraction

The medical records of patients with ACS were retrieved from the hospital admission database. Because electronic medical records were unavailable, data were manually extracted from paper-based files. The variables collected included patient demographics (age, sex, and ethnicity), body mass index (BMI) according to Asia-Pacific World Health Organization (WHO) classification [11], symptom onset and presentation of ACS, cardiovascular risk factors, previous atherosclerotic cardiovascular disease (ASCVD), vital signs at presentation, ECG results at presentation, echocardiography results, medical treatment during hospitalization, and clinical outcomes. Therapeutic decisions were based on the attending physician's discretion and drug availability. Outcome measures included in-hospital mortality and length of stay (LOS).

Statistical analysis

All extracted data were coded and entered into a Microsoft Excel spreadsheet (Microsoft Corp., Redmond, WA, USA) and subsequently analyzed using SPSS software version 26 (IBM Corp., Armonk, NY, USA). Categorical variables were summarized as frequencies and percentages, while continuous variables were presented as mean ± standard deviation or median with interquartile range (Q1–Q3), as appropriate. Comparisons of means were performed using one-way analysis of variance (ANOVA), and comparisons of medians used the Kruskal–Wallis test. Proportional differences were evaluated using either the chi-squared test or Fisher's exact test. When statistically significant differences were observed in bivariate analyses, post-hoc pairwise comparisons were conducted using unpaired t-tests, Mann–Whitney U tests, chi-squared tests, or Fisher's exact tests, as appropriate. Odds ratios (ORs) for risk factors were calculated and compared between the STEMI and NSTE-ACS groups. Missing data were included in the analysis if they accounted for less than 5% of a given variable within each group and in the overall dataset; if more than 5% of data were missing, this was reported in the Results section and excluded from further analysis. Statistical significance was set at $p<0.05$. Graphs were created using GraphPad Prism version 8.0.1 (GraphPad Software, San Diego, CA, USA).

Results

Patient demographics

A total of 241 patients diagnosed with ACS out of a total of 10,007 hospital admissions were included in this study (4.56% STEMI, 35.68% VHR NSTE-ACS, and 59.75% NVHR NSTE-ACS). The summary of the demographics, risk factors, presentations, diagnostics, management, and outcomes is presented in **Table 1**. The mean age of the patients was 55.4 years, with the STEMI group being the youngest and the VHR NSTE-ACS group being the oldest. Most patients in the STEMI and VHR NSTE-ACS groups were male, while females predominated in the NVHR NSTE-ACS group. Most of the patients were of Buginese ethnicity. Overall, 35.7% of the patients were obese. Compared with males, females had a significantly higher BMI (25.84±5.51 kg/m² vs 24.04±5.32 kg/m², $p=0.030$) (**Figure 1**).

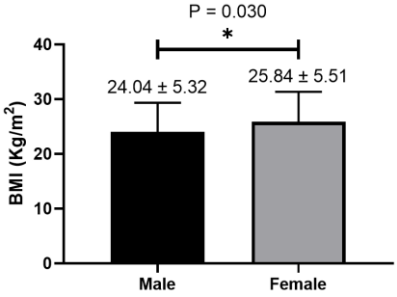

Figure 1. Body mass index (BMI) differences between sexes.

Table 1. Summary of patients' demographics, risk factors, presentations, diagnostics, management, and outcomes (n=241)

Variable	Frequency (percentage)				*p*-value
	All patients (n=241)	STEMI (n=11)	VHR NSTE-ACS (n=86)	NVHR NSTE-ACS (n=144)	
Age (year), mean ± standard deviation (SD)	55.4±12.26	49.64±14.12*	59.79±10.99*‡	53.22±12.15‡	0.000
<40	25 (10.4)	3 (27.3)	4 (4.7)	18 (12.5)	
40–49.9	49 (20.3)	2 (18.2)	8 (9.3)	39 (27.1)	
50–59.9	76 (31.5)	3 (27.3)	27 (31.4)	46 (31.9)	
≥60	91 (37.8)	3 (27.3)	47 (54.7)	41 (28.5)	
Sex					
Male	124 (51.5)	10 (90.9)*†	47 (54.7)*	67 (46.5)†	0.014
Female	117 (48.5)	1 (9.1)	39 (45.3)	77 (53.5)	
Ethnicity					0.972
Bugis	144 (59.8)	7 (63.6)	54 (62.8)	83 (57.6)	
Toraja	23 (9.5)	1 (9.1)	8 (9.3)	14 (9.7)	
Tidung	15 (6.2)	0 (0)	6 (7)	9 (6.3)	
Timur	12 (5)	1 (9.1)	4 (4.7)	7 (4.9)	
Others	47 (19.5)	2 (18.2)	14 (16.3)	31 (21.5)	
Body mass index (BMI) (kg/m^2), mean±SD	24.88±5.47	25.44±5.02	24.10±6.25	25.34±4.95	0.352
Underweight	23 (9.5)	1 (9.1)	13 (15.1)	9 (6.3)	
Normal	40 (16.6)	2 (18.2)	16 (18.6)	22 (15.3)	
Overweight	24 (10)	1 (9.1)	6 (7)	17 (11.8)	
Obese	86 (35.7)	5 (45.5)	29 (33.7)	52 (36.1)	
Missing data	68 (28.2)	2 (18.2)	22 (25.6)	44 (30.6)	
Risk factor, median (interquartile range Q1-Q3 (IQR))	2 (1–2.5)	2 (2–3)	2(1–3)	2 (1–2)	0.063
Hypertension	175 (72.6)	8 (72.7)	71 (82.6)‡	96 (66.7)‡	0.033
Diabetes	81 (33.6)	3 (27.3)	39 (45.3)‡	39 (27.1)‡	0.016
Dyslipidemia	74 (30.7)	6 (54.5)*	18 (20.9)*‡	50 (34.7)‡	0.019
Smoker	109 (45.2)	8 (72.7)	40 (46.5)	61 (42.4)	0.143
Previous atherosclerotic cardiovascular disease, median (IQR)	1 (0–1)	0 (0–1)	1 (0–1)	0 (0–1)	0.128
Coronary artery disease	108 (44.8)	4 (36.4)	39 (45.3)	65 (45.1)	0.846
Peripheral artery disease	3 (1.2)	0 (0)	1 (1.2)	2 (1.4)	1
Stroke	23 (9.5)	0 (0)	15 (17.4)‡	8 (5.6)‡	0.007
Onset (hours), median (IQR)	13.5 (4–48)	9 (6–24)	12 (4–48)	20.5 (4–72)	0.426
Missing data	13 (5.39)	0 (0)	7 (8.1)	6 (4.2)	
Symptoms, median (IQR)	2 (1–2)	1 (1–2)	2 (1–2)	2 (2–3)	0.347
Chest discomfort	175 (72.6)	7 (63.6)	59 (68.6)	109 (75.7)	0.401
Epigastric/abdominal	83 (34.4)	4 (36.4)	26 (30.2)	53 (36.8)	0.592
Shortness of breath	136 (56.4)	5 (46.6)	59 (68.6)‡	72 (50)‡	0.017
Palpitation	10 (4.1)	0 (0)	2 (2.3)	8 (5.6)	0.583
Unconscious	3 (1.2)	0 (0)	3 (3.5)	0 (0)	0.067
Vital sign					
Systolic blood pressure (mmHg), median (IQR)	140 (120–160)	170 (120–180)	150 (120–180)‡	140 (120–150)‡	0.011
Diastolic blood pressure (mmHg), median (IQR)	90 (80–100)	100 (70–110)	90 (80–100)	90 (80–92.25)	0.145
Heart rate (bpm), median (IQR)	88 (75–104)	100 (78–112)	92.5 (81.5–109.25)‡	85 (72.25–102)‡	0.006

Variable	Frequency (percentage)				*p*-value
	All patients (n=241)	STEMI (n=11)	VHR NSTE-ACS (n=86)	NVHR NSTE-ACS (n=144)	
Respiratory rate (tpm), median (IQR)	24 (22–26)	26 (22–36)†	24 (22–30)‡	22 (20–25)†‡	0.000
SpO_2 (%), median (IQR)	97 (96–98)	96 (85–98)	97 (94–98)‡	98 (97–98)‡	0.005
Temperature (°C), median (IQR)	36.5 (36–36.65)	36.5 (36.2)	36.4 (36–36.625)	36.5 (36–36.6)	0.613
Cardiogenic Shock	7 (2.9)	1 (9.1)†	6 (7)‡	0 (0)†‡	0.002
ECG findings					
Wall territory ischemia					
Anterior	136 (56.4)	9 (81.8)†	66 (76.7)‡	61 (42.4)†‡	0.000
Lateral	86 (35.7)	5 (45.5)	46 (53.5)‡	35 (24.3)‡	0.000
Inferior	83 (34.4)	2 (18.2)	34 (39.5)	47 (32.6)	0.289
Right	0 (0)	0 (0)	0 (0)	0 (0)	n/a
Posterior	1 (0.4)	1 (9.1)*†	0 (0)*	0 (0)†	0.046
Arrhythmia	17 (7.1)	0 (0)	11 (12.8)‡	6 (4.2)‡	0.030
Normal	43 (17.8)	0 (0)	5 (5.8)‡	38 (26.4)‡	0.000
Echocardiography					
Reduced left ventricular ejection fraction	77 (36)	9 (81.8)*†	34 (47.2)*‡	34 (26)†‡	0.000
Reduced right ventricular tricuspid annular plane systolic excursion	15 (7)	0 (0)	6 (8.3)	9 (6.9)	0.598
Enlarged left ventricular dimension	51 (23.8)	4 (36.4)	22 (30.6)	25 (19.1)	0.112
Wall motion abnormality	77 (36)	10 (90.9)*†	34 (47.2)*‡	33 (25.2)†‡	0.000
Mitral valve regurgitation	43 (20.1)	0 (0)*	22 (30.6)*‡	21 (16)‡	0.011
Missing data	27 (11.2)	0 (0)	14 (16.28)	13 (9.03)	
Medical Treatment					
Fibrinolytic	n/a	4 (36.4)	n/a	n/a	n/a
Heparin	124 (51.5)	6 (54.5)	45 (52.3)	73 (50.7)	0.951
Fondaparinux	65 (27)	5 (45.5)	18 (20.9)	42 (29.2)	0.146
Single antiplatelet therapy (acetylsalicylic acid or clopidogrel)	24 (10)	0 (0)	8 (9.3)	16 (11.1)	0.479
Dual antiplatelet therapy (acetylsalicylic acid + clopidogrel)	184 (76.3)	11 (100)	61 (70.9)	112 (77.8)	0.083
Nitrate	207 (85.9)	10 (90.9)	77 (89.5)	120 (83.8)	0.378
Diuretic	151 (62.7)	7 (63.6)	67 (77.9)‡	77 (53.5)‡	0.001
β–blocker	61 (25.3)	2 (18.2)	14 (16.3)‡	45 (31.3)‡	0.035
Calcium channel blocker	19 (7.9)	0 (0)	6 (7)	13 (9)	0.522
Angiotensin converting enzyme inhibitor/angiotensin receptor blocker	115 (47.7)	7 (63.6)	48 (55.8)	60 (41.7)	0.064
Statin	210 (87.1)	11 (100)	74 (86)	125 (86.6)	0.421
Outcome					
Length of stay (days), medians (IQR)	6 (5–7)	6 (4–9)	6 (5–7)‡	5 (5–6)‡	0.015
Mortality	8 (3.3)	1 (9.1)†	7 (8.1)‡	0 (0)†‡	0.001

NVHR NSTE-ACS: non-very high-risk non-ST-elevation acute coronary syndrome; STEMI: ST-elevation myocardial infarction; VHR NSTE-ACS: very high non-ST-elevation acute coronary syndrome

* STEMI vs VHR NSTE-ACS statistically significant at $p<0.05$

† STEMI vs NVHR NSTE-ACS statistically significant at $p<0.05$

‡ VHR NSTE-ACS vs NVHR NSTE-ACS statistically significant at $p<0.05$

Cardiovascular risk factors

The median number of risk factors among the patients was 2 (interquartile range: 1–2.5) (**Table 1**). The prevalence of hypertension, diabetes, dyslipidemia, and smoking was 72.6%, 33.6%, 30.7%, and 45.2%, respectively. The proportion of patients with hypertension was significantly higher in the VHR NSTE-ACS group than in the NVHR NSTE-ACS group (82.6% vs 66.7%, $p<0.05$), and the prevalence of diabetes was also greater in the VHR NSTE-ACS group compared with the NVHR NSTE-ACS group (45.3% vs 27.1%, $p<0.05$). The STEMI group had a higher prevalence of dyslipidemia than the VHR NSTE-ACS group (54.5% vs 20.9%, $p<0.05$). In comparison, the VHR NSTE-ACS group had a considerably lower prevalence of dyslipidemia than the NVHR NSTE-ACS group (20.9% vs 34.7%, $p<0.05$) (**Table 1**).

Previous ASCVD was observed with a median of 1, and the most prevalent previous ASCVD was CAD, with a rate of 44.8% (**Table 1**). The prevalence of stroke was significantly greater in the VHR NSTE-ACS group than in the NVHR NSTE-ACS group (17.4% vs 5.6%, $p<0.05$) (**Table 1**).

Risk factors associated with STEMI compared to NSTE-ACS

The ORs for potential risk factors were compared between the STEMI and NSTE-ACS groups (both VHR NSTE-ACS and NVHR NSTE-ACS). Male sex was significantly associated with STEMI (OR=10.175, 95%CI: 1.282–80.785, $p=0.028$) (**Figure 2**). No significant associations were found for hypertension (OR=1.001, 95%CI: 0.259–3.912, $p=0.993$), diabetes (OR=0.731, 95%CI: 0.189–2.832, $p=0.650$), dyslipidemia (OR=2.859, 95%CI: 0.844–9.685, $p=0.092$), or smoking (OR=3.406, 95%CI: 0.881–13.167, $p=0.076$) (**Figure 2**).

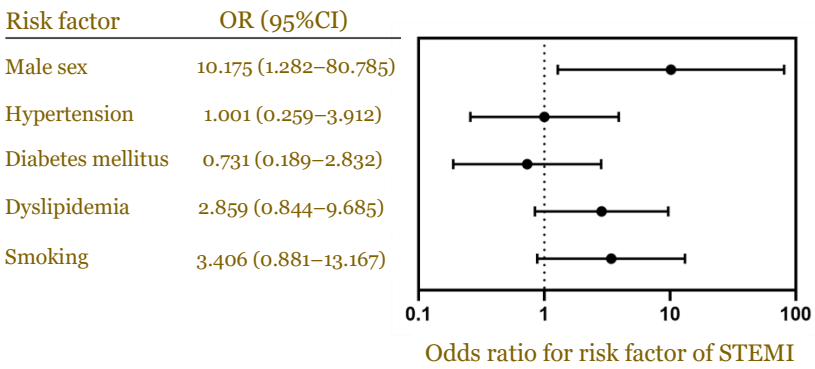

Figure 2. Forest plot presenting the odds ratio for the risk factor of STEMI compared to both VHR and NVHR NSTE-ACS groups.

ACS presentations and diagnostics

The patients presented to the hospital with a median onset of 13.5 (4–48) hours (**Table 1**). STEMI patients presented the earliest, with a median onset of 9 (6–24) hours, followed by VHR NSTE-ACS at 12 (4–48) h and NVHR NSTE-ACS at 20.5 (4–72) h. Compared with males, females presented a significantly later onset (24 (5.5–72) h vs 8 (3.5–48) h, $p=0.014$) (**Figure 3A**). Compared with non-referred patients (those presented directly to the hospital), referred patients (those transferred from another facility) presented earlier, with a nonsignificant difference in median of the onset (9.5 (4–48) vs 24 (5–48) hours, $p=0.417$) (**Figure 3B**).

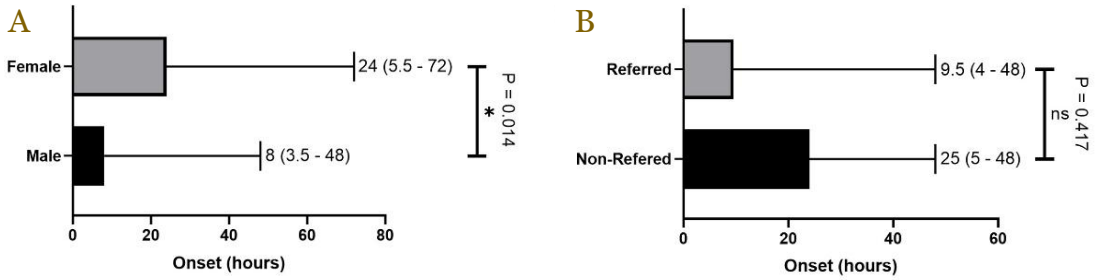

Figure 3. Differences in the onset of presentation between sexes (A) and between referred and non-referred patients (B).

Patients were presented with a median of 2 (1–2) symptoms (**Table 1**). Chest discomfort was the most common symptom experienced by 72.6% patients. Epigastric/abdominal symptoms, shortness of breath, palpitations, and unconsciousness were experienced by 34.4%, 56.4%, 4.1%, and 1.2% of patients, respectively. Shortness of breath was significantly greater in the VHR NSTE-ACS group than in the NVHR NSTE-ACS group (68.6% vs 50%, $p<0.05$) (**Table 1**).

The STEMI group had the highest systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), and respiratory rate (RR), and the lowest SpO_2 (**Table 1**). A statistically significant difference in the median SBP was found between the VHR and the NVHR NSTE-ACS groups (150 vs 140 mmHg, $p<0.05$), HR between the VHR and the NVHR NSTE-ACS groups (92.5 vs 85 bpm, $p<0.05$), RR between the STEMI group and the NVHR NSTE-ACS group (26 tpm vs 22 tpm, $p<0.05$), RR between the VHR and NVHR NSTE-ACS groups (24 tpm vs 22 tpm, $p<0.05$), and SpO_2 between the VHR and NVHR NSTE-ACS groups (97% vs 98%, $p<0.05$) (**Table 1**). Six out of 86 patients in the VHR NSTE-ACS group (7%), and one out of eleven patients in the STEMI group (9.1%) had cardiogenic shock (**Table 1**).

ECG revealed greater anterior wall ischemia in the STEMI and VHR NSTE-ACS groups (81.8% and 76.7%, respectively) (**Table 1**). In the VHR NSTE-ACS group, lateral wall ischemia was considerably higher than in the NVHR NSTE-ACS group (53.5% vs 24.3%, $p<0.05$). Posterior wall ischemia was found in only one STEMI patient. The prevalence of arrhythmia was considerably higher in the VHR NSTE-ACS group (12.8%) compared to the NVHR NSTE-ACS group (4.2%). Normal ECG findings were found in 17.8% of patients, with the highest percentage in the NVHR NSTE-ACS group (38 of 144 patients) (**Table 1**).

A reduced left ventricular ejection fraction (LVEF) was found in 9 (81.8%) STEMI patients, 34 (47.2%) VHR NSTE-ACS patients, and 34 (26%) NVHR NSTE-ACS patients, with significant differences between groups (**Table 1**). Wall motion abnormalities also showed significant variations across groups, with 10 (90.9%) STEMI patients, 34 (47.2%) VHR NSTE-ACS patients, and 33 (25.2%) NVHR NSTE-ACS patients. The VHR NSTE-ACS group had considerably higher mitral valve (MV) regurgitation (30.6%) compared to the STEMI and NVHR NSTE-ACS groups. A total of 7% of patients had a reduced right ventricular (RV) tricuspid annular plane systolic excursion (TAPSE). In comparison, 23.8% had larger left ventricular (LV) dimensions, with no significant difference between the groups (**Table 1**).

Treatments

A total of 36.4% of STEMI patients received fibrinolytic therapy (**Table 1**). Door-to-needle time was available in those four patients with a median of 35.5 minutes (25 minutes – 140 minutes). Heparin was used in 51.5% of patients, and fondaparinux was used in 27% of patients. Dual antiplatelet therapy was used in 76.3% of patients, and 10% of patients received only single antiplatelet therapy. Nitrate was used in 85.9% of patients. Diuretics were used more in the VHR NSTE-ACS group than in the NVHR NSTE-ACS group (77.9% vs 53.5%, $p<0.05$). The percentage use of antihypertensive medication was 25.3% Beta-blockers (β-blockers), 7.9% calcium channel blockers, and 47.7% angiotensin converting enzyme inhibitors/angiotensin receptor blockers. β-blockers were used more in the NVHR NSTE-ACS group than in the VHR NSTE-ACS group (31.3% vs 16.3%, $p<0.05$). The use of statins was 87.1% in all groups.

Outcomes

The median LOS of the 241 patients was 6 (5–7). Significant differences in the LOS were found between the VHR NSTE-ACS group and the NVHR NSTE-ACS group (6 (5–7) vs 5 (5–6)). Mortality occurred in one patient (9.1%) in the STEMI group and seven patients (8.1%) in the VHR NSTE-ACS group, while no deaths were recorded among NVHR NSTE-ACS patients. The fatality in the STEMI group occurred in a patient who did not undergo fibrinolytic therapy.

Discussion

Our study found that the proportion of ACS patients admitted to Nunukan Regency General Hospital was 2.41%, which is slightly higher than the prevalence of cardiac disease reported by RISKESDAS 2018 for North Kalimantan (2.2%) and the national prevalence (1.5%) [7]. Among these patients, 4.56% were classified as STEMI, 35.68% as VHR NSTE-ACS, and 59.75% as NVHR

NSTE-ACS. These proportions differ markedly from reports in Germany [12] (24.37% STEMI), Sri Lanka [4] (25.7%), Malaysia [13] (47.59%), and East Nusa Tenggara [14] (41%). A reduction in STEMI cases could reflect advances in CAD prevention, diagnosis, and treatment, but might also be due to undiagnosed cases [12].

Patients with STEMI in this study were more than five years younger than those reported in other studies from developing countries and over ten years younger than those from developed countries [4,12,15]. Nearly half of the STEMI patients were classified as young STEMI (<50 years), and more than one-quarter were under 40 years of age, twice the rate reported in Singapore [16]. In contrast, patients with VHR NSTE-ACS were the oldest group, consistent with the increasing cardiovascular risk associated with advancing age [17]. Male patients predominated in both the STEMI and VHR NSTE-ACS groups, whereas females were more common in the NVHR NSTE-ACS group. This pattern aligns with previous evidence showing a strong association between male sex and a higher risk of major adverse cardiovascular events (MACEs). In contrast, female sex hormones are thought to confer protective effects in premenopausal women [17,18]. Most patients in this study were of Bugis ethnicity, reflecting the demographic composition of Nunukan Regency. The predominance of Bugis participants may also be related to certain lifestyle factors associated with cardiovascular risk. Traditional Bugis and Makassar cuisines—such as *coto* and *konro*—are typically rich in meat, offal, and broth prepared with substantial amounts of animal fat and salt. These energy-dense foods remain popular in Nunukan. Furthermore, rapid urbanization and the ongoing nutrition transition in the region have led to greater availability and consumption of ultra-processed and high-fat foods, contributing to excessive caloric and sodium intake [19].

Obesity was prevalent across all groups, with females exhibiting significantly higher BMIs. Obesity increases the risk of premature MI and may explain younger ACS presentations [20,21]. Although it is still controversial, the "obesity paradox," where overweight patients exhibit lower death rates, might be explained due to earlier disease development [22]. In line with the INTERHEART study's findings, traditional cardiovascular risk factors—such as smoking, dyslipidemia, hypertension, and diabetes—had a substantial effect on the severity of ACS [23]. The two most significant risk factors according to the INTERHEART study were abnormal lipid levels and smoking, which represent almost two-thirds of the risk attributable to AMI [23]. This could account for the increased OR and greater prevalence of smokers and dyslipidemia in the STEMI group. Cigarette smoking remains highly prevalent among Indonesian men. It is common in many rural and coastal communities, which likely contributes to the male predominance in STEMI cases observed in our sample [24].

Atherosclerosis is a systemic disease, and many ACS patients share comorbidities like peripheral artery disease (PAD) or cerebrovascular disease [25,26]. Interestingly, every group had a relatively high rate of prior CAD. Recurrent cardiovascular events remain a very high risk for patients with ACS, with a 5-year event rate of 33.4% for nonfatal MI, nonfatal ischemic stroke, and cardiovascular mortality (95%CI 33.1%-33.7%; $p<0.001$) [27]. The fact that most of our patients did not have revascularization explains why this outcome was worse than that of our patients. Patients who do not receive revascularization therapy are five times more likely to experience recurrent cardiovascular incidents than those who receive revascularization [27]. PAD was not common in every group since both have different pathophysiologies [25]. In addition, this might also be due to the low level of PAD screening in our hospital. A previous study showed that approximately 16.9% of CAD patients have a history of stroke, which is similar to what we found in the VHR NSTE-ACS group [26].

Delayed presentation was a significant issue, with a median delay similar to other low- and middle-income countries (12.7 hours) [28]. We can conclude that patient-related delay was the main cause since referred patients presented earlier in the hospital than non-referred patients. Females had longer delays, potentially due to atypical symptoms and misattributed causes [29]. Longer delays were associated with older age, female sex, gradual onset, and atypical symptoms [28,30,31]. Other factors, such as low education level, rural residence, financial limitations, transportation difficulty, and lack of communication and coordination between healthcare centers, also have implications for delays, which are the conditions that we face in Nunukan [28]. Patients are more likely to present earlier if their symptoms are more acute [32].

Patients presented with a median of two symptoms, with NVHR NSTE-ACS cases showing the most, likely due to the higher proportion of females, who experience more non-chest pain symptoms [29]. Chest pain was reported in 72.6% of cases, while 20–30% had atypical symptoms, similar to other studies where older, female patients with comorbidities were more affected [14,33,34]. Atypical presentations led to delayed diagnoses and worse outcomes [33]. VHR NSTE-ACS patients commonly had shortness of breath due to acute heart failure [35]. SBP, HR, and RR increased with ACS severity, while SpO2 declined. Higher SBP did not worsen short-term outcomes, but CS with SBP <80 mmHg led to worse outcomes [36,37]. HR >80 bpm predicted in-hospital mortality [38], and RR and SpO2 correlated with a higher Killip class and increased mortality [39].

Anterior wall involvement was most common in all groups and was significantly greater in the STEMI and VHR NSTE-ACS groups. Inferior wall involvement was greatest in the VHR NSTE-ACS group. Anterior wall MI is associated with more severe CAD, and inferior wall MI involves more coronary vessels [40]. Posterior wall involvement was found in only one STEMI patient. Despite being extremely uncommon, posterior MI is frequently misdiagnosed and, if left untreated, can result in a bigger infarct and a higher risk of sequelae [41]. Patients with ACS rarely experience life-threatening arrhythmias, and a prolonged LOS is independently linked to ≥ 50 premature ventricular contractions per hour, which primarily affects patients over 65 [42]. This might explain why the VHR NSTE-ACS group experienced a noticeably higher incidence of arrhythmia. A previous study found that approximately 43%–60% of ACS patients exhibited neither ST deviation nor T wave inversion upon presentation [43]. In our study, 17.8% of the patients had a normal ECG, which was significantly higher in NVHR NSTE-ACS patients (26.4%). Transthoracic echocardiography plays a crucial role in evaluating patients with acute chest pain by aiding in ACS diagnosis—assessing ventricular function and detecting regional wall motion abnormalities—while also helping to identify other potential causes of acute chest pain or dyspnea [44]. A reduced LVEF and wall motion abnormalities were found to gradually increase significantly as the more severe degree of the disease, with MV regurgitation, was found to be significantly greater in the VHR NSTE-ACS group. Significant ischemic MV regurgitation and highly diseased coronary arteries were identified as independent predictors of significant LV dysfunction (LVEF ≤40%), which was correlated to a higher 1-year mortality and hospitalization rates in ACS patients [45].

Nunukan and North Kalimantan lack percutaneous coronary intervention (PCI) facilities, requiring patient referrals to other provinces via limited-speed boats and flights. Many patients refuse referrals due to social and economic barriers, preventing us from implementing guideline-recommended invasive strategies [9,10]. Fibrinolysis was the only reperfusion option, administered in the emergency department. Still, its use was low (36.4%) compared to other studies [13,46,47], mainly due to contraindications, late presentations (≥12 hours), and limited drug availability. The median door-to-needle time was 35.5 minutes (range: 25–140 minutes), with delays caused by consent processes and atypical presentations like epigastric pain. Other treatments followed standard hospital practice, with higher diuretic and lower β-blocker use in VHR NSTE-ACS due to more patients presenting with a higher Killip class and experiencing acute heart failure.

Health-system limitations may also influence the high incidence of ACS observed in our study. During the study period, only one cardiologist served the entire regency, and reperfusion options were restricted to pharmacological thrombolysis due to the absence of a catheterization laboratory. These resource constraints, compounded by long travel times, limited transportation infrastructure, and delayed patient presentation, likely contributed to the overall ACS burden in this remote border district [48].

Overall, the LOS and mortality rates in our study were similar to those in other studies [13,14,46,49]. As expected, patients with more severe forms of ACS experienced poorer outcomes. Data from the Jakarta ACS Registry indicate that reperfusion therapy markedly improved survival outcomes [46]. In that registry, non-reperfused STEMI patients had a significantly higher in-hospital mortality rate (9.1%) compared with those who underwent primary percutaneous coronary intervention (PCI) (3.2%) or received fibrinolytic therapy [46]. Our findings also indicated that mortality in the STEMI group occurred among patients who did not

receive reperfusion therapy. However, due to the small sample size within this subgroup, definitive conclusions cannot be drawn.

ACS patients in Nunukan exhibit a unique profile which are typically younger, obese, have multiple risk factors, and present late. To improve cardiovascular care in Nunukan and similar rural areas, short-term efforts should focus on cost-effective health promotion targeting risk factors, including obesity and ACS symptoms, to prevent severe cases. Healthcare providers must recognize both typical and atypical ACS symptoms and perform early ECGs, especially in younger at-risk patients, to reduce diagnostic delays. Long-term strategies should enhance coordination, referral systems, and access to ACS management facilities, medications, cardiac biomarkers, and activation of PCI centers for timely reperfusion. Future studies with larger samples and longer follow-ups are required.

There are several limitations in the current study. The study period was limited to January–August 2023 because data collection was conducted during a defined institutional period when access to complete medical records and direct data verification were feasible. As the hospital still uses paper-based medical records, all information had to be manually extracted and cross-checked, which restricted the achievable duration of data collection. Electronic medical records were not yet available, increasing the potential for documentation inconsistencies and data-entry errors. Some variables, including cardiac biomarker results, could not be analyzed because the relevant examinations were unavailable at the hospital during the study period. Additionally, nonuniformity in history-taking and incomplete documentation may have led to minor data gaps. Despite these limitations, this study consecutively included all ACS patients admitted to the only referral hospital in Nunukan Regency, providing valuable real-world insights into the epidemiology and management of ACS in a remote Indonesian setting.

Conclusion

ACS patients at Nunukan Regency General Hospital demonstrated distinct characteristics, including younger age, obesity, multiple risk factors, and delayed presentation. Both short-term and long-term efforts are necessary to enhance cardiovascular care in this region, and further comprehensive studies should be conducted in the future.

Ethics approval

The ethical committee of Nunukan Regency General Hospital approved the study protocol (No: 445/II/RSUD-NNK). The ethical committee waived the requirement for informed consent because of the study's retrospective design.

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Competing interests

All the authors declare that there are no conflicts of interest.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

We hereby confirm that no artificial intelligence (AI) tools or methodologies were utilized at any stage of this study, including during data collection, analysis, visualization, or manuscript

preparation. All work presented in this study was conducted manually by the authors without the assistance of AI-based tools or systems.

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