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Aortic Arch Calcification in Predicting Timi and Killip Scores Based on Chest X Ray Examination in Patients With St-Elevation Myocardial Infarction (Stemi) at Adam Malik Hospital

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Abstract:
ST-Elevation Myocardial Infarction (STEMI) is a cardiovascular emergency that requires rapid and accurate risk stratification. Aortic Arch Calcification (AAC), detected through a simple and inexpensive chest X-ray examination, has the potential to serve as a prognostic predictor in STEMI patients. This study aims to analyze whether AAC can predict TIMI and Killip scores based on chest X-ray examinations in patients with STEMI. This study is an observational analytical research with a diagnostic test design involving 100 STEMI patients who underwent chest X-ray examinations at Adam Malik Hospital and were evaluated for Aortic Arch Calcification (AAC) scores semi-quantitatively. The analysis assessed the predictive ability of AAC for TIMI and Killip scores. Based on the results, AAC in predicting TIMI scores showed a sensitivity of 48.6% and a specificity of 72.3% (AUC: 0.644). The Killip score demonstrated a sensitivity of 37.1% and a specificity of 78.5% (AUC: 0.562). The Positive Predictive Values (PPV) of TIMI and Killip were 64.6% and 64.2%, respectively, while the Negative Predictive Values (NPV) were 57.5% and 54.5%. These findings indicate that AAC is inadequate in predicting TIMI and Killip scores in STEMI patients. Although it demonstrates relatively good specificity, its low sensitivity suggests that AAC cannot be recommended as a standalone predictive tool for risk stratification in STEMI patients.
Keywords: ST-Elevation Myocardial Infarction (STEMI); Aortic Arch Calcification; TIMI; Killip; Coronary Artery Disease.

INTRODUCTION

Cardiovascular diseases are the leading cause of death worldwide (Naveed et al., 2024). According to the World Health Organization (WHO, 2023), heart and blood vessel diseases remain the primary causes of death globally. In 2016, an estimated 17.9 million people died due to cardiovascular diseases—accounting for approximately 32% of all global deaths—with 85% of those deaths attributed to heart attacks and strokes (Vaduganathan et al., 2022). Coronary Artery Disease (CAD) is caused by the formation of atherosclerotic plaques in the coronary artery lumen, leading to reduced blood flow and oxygen delivery to the myocardium, which can result in angina or myocardial infarction (Młynarska et al., 2024). Based on data from the American Heart Association (AHA) between 2009 and 2012, approximately 15.5 million people in the United States suffered from CAD, with prevalence rates of 7.6% in men and 5% in women, increasing with age. According to the Non-Communicable Disease (NCD) Indonesian Surveillance Information System (2016), 4,920 individuals were diagnosed with Cardiovascular Disease (CVD), most of whom were aged ≥60 years. The number of inpatient CVD cases in Indonesian hospitals was highest in Central Java and West Java provinces, reaching approximately 7,500–7,700 cases, while North Sumatra reported fewer than 2,000 cases (Harmadha et al., 2023; Sujarwoto et al., 2025).

CAD can be classified into Stable Angina Pectoris (SAP) and Acute Coronary Syndrome (ACS) (Huang et al., 2020; Kimura et al., 2018; Mihajlović et al., 2020). ACS comprises three clinical spectrums: Unstable Angina Pectoris (UAP), Non-ST-Elevation Myocardial Infarction (NSTEMI), and ST-Elevation Myocardial Infarction (STEMI) (Mihajlović et al., 2020; Polat et al., 2025; Winiger & Rodgers, 2023). STEMI occurs due to total occlusion or embolism of a coronary artery, resulting in ST-segment elevation on the electrocardiogram (ECG) (Popovic et al., 2018; Wiśniewski et al., 2019). According to the AHA, of 5–8 million patients presenting with chest pain, 60% are STEMI cases. Furthermore, data from the Euro Heart Survey involving 21,872 ACS patients showed that 40.5% were diagnosed with STEMI.

Prognosis determination for patients with STEMI can be assessed using the Thrombolysis in Myocardial Infarction (TIMI) and Killip stratifications, which are based on patient history and physical examination findings (Andhale et al., 2021; Del Buono et al., 2021). The TIMI IMAEST score, ranging from 0–14, estimates 30-day mortality risk, while the Killip classification, ranging from Class I–IV, is determined by physical findings, with higher classes corresponding to significantly increased mortality rates of up to 60–80%.

Aortic Arch Calcification (AAC) can be easily detected using chest X-ray examination, and numerous studies have reported that AAC is strongly associated with the incidence of CAD (Ma et al., 2019; Watanabe et al., 2022). Although Coronary Artery Calcification (CAC) is an established predictor of Coronary Heart Disease (CHD), AAC has also been shown to correlate with CAC scores (Kimani et al., 2019; van der Toorn et al., 2021). Hence, AAC may serve as a useful predictor for the occurrence of CAD.

Several previous studies have examined the relationship between Aortic Arch Calcification and cardiovascular outcomes (Tian et al., 2022; Yang et al., 2019). Qureshi (2021), in a study involving 225 Acute Coronary Syndrome (ACS) patients, found that AAC was identified in 127 patients, with a higher prevalence among males (71% vs. 29%) and a mean age of 81±29 years. The study demonstrated a significant association between AAC and elevated TIMI and Killip scores, indicating a worse prognosis compared with the non-calcification group ($p < 0.001$). Patients with AAC also had significantly higher 30-day mortality (17.3% vs. 7.1%, log-rank $p = 0.02$), greater cardiovascular mortality (27.6% vs. 11.2%, log-rank $p = 0.002$), and higher overall mortality (28.3% vs. 11.2%, log-rank $p = 0.001$) than those without calcification. Yamaguchi (2017) analyzed the relationship between AAC detected on chest radiography and CAC, finding that the assessment of AAC on X-rays was reliable and linearly correlated with CAC. AAC grades 2 and 3 had a specificity of 96.4% for CAC >400, supporting screening in asymptomatic patients. However, given its relatively low sensitivity of 38.6%, AAC was not recommended for confirming CAD in symptomatic patients (Ghoshhajra et al., 2021). Similarly, Watanabe (2022) demonstrated that AAC, as detected on chest X-ray, is a strong independent predictor of cardiovascular events beyond traditional risk factors, and an independent risk factor for morbidity and mortality due to cardiovascular disease in the general population and various patient groups. These findings collectively suggest that AAC may serve as a useful predictor for CAD

events, although its utility in specific risk stratification for STEMI patients warrants further research.

The purpose of this study is to analyze whether Aortic Arch Calcification (AAC) can predict TIMI and Killip scores in STEMI patients based on chest X-ray examinations. This study is expected to provide several key contributions. Theoretically, it enhances understanding of the relationship between AAC and risk stratification in STEMI patients, particularly within the Indonesian population. Clinically, the findings may assist physicians in evaluating the potential utility and limitations of AAC detected on routine chest X-rays as a simple, inexpensive tool for predicting TIMI and Killip scores—facilitating rapid risk assessment in healthcare facilities with limited resources. For future researchers, the results provide a foundation for exploring alternative imaging markers for risk stratification in STEMI patients. In addition, policymakers may use these findings to inform guidelines regarding the implementation of routine chest X-ray examinations in the initial assessment of STEMI patients.

METHOD

This study is an observational analytical research with a diagnostic test design on patients diagnosed with STEMI. The research was conducted at Adam Malik Hospital after obtaining Ethical Clearance. The population of this study consists of all patients diagnosed with STEMI who had chest X-rays at Adam Malik Hospital in 2023-2024, which included TIMI scores, Killip scores, and risk factors such as hypertension, diabetes, triglyceride levels, HDL, LDL, and blood pressure in the medical records. Aortic arch calcification was assessed semi- quantitatively by determining the calcification score: level 0, no visible calcification; level 1,<50% calcification in the aortic knob; level 2, >50% calcification; level 3, circumferential calcification in the aortic arch. Calcification was assessed by two readers (a Radiologist and a radiology resident, Kappa value >80%). Data will be analyzed descriptively to determine the frequency distribution of each demographic characteristic variable and risk factor. Then, the analysis will continue by examining the sensitivity and specificity values using a 2x2 table, where the cut-off values will be determined from the ROC curve.

RESULTS AND DISCUSSION

Characteristics of Subject

Table 1. Characteristics of Subject

Characteristics	Total (n=100)	AAC (+) (n=49)	AAC (-) (n=51)
Gender (n,%)			
- Men	76	31 (63.3)	45 (88.2)
- Women	24	18 (36.7)	6 (11.8)
Age (μ ± SD, year)	56.67 ± 8.98	59.22 ± 9.09	54.22 ± 8.22
- 20-39	3	0 (0)	3 (5.9)
- 40-59	60	26 (53.1)	34 (66.7)
- 60-80	37	23 (46.9)	14 (27.5)

Hypertension (n,%)			
- Yes	52	25 (51)	27 (52.9)
- No	48	24 (49)	24 (47.1)
Diabetes			
- Yes	39	21 (42.9)	18 (35.3)
- No	61	28 (57.1)	33 (64.7)
Triglyceride (μ ± SD, mg/dL)	136.33 ± 54.06	132.67 ± 47.93	139.84 ± 59.63
HDL (μ ± SD, mg/dL)	39.84 ± 11.30	40.31 ± 12.57	39.39 ± 10.02
LDL (μ ± SD, mg/dL)	112.86 ± 39.71	116.96 ± 41.21	108.93 ± 38.20
Total Cholesterol (μ ± SD, mg/dL)	178.81 ± 45.28	184.53 ± 41.80	173.31 ± 48.16
TIMI (μ ± SD)	4.08 ± 2.36	5.39 ± 2.38	2.82 ± 1.52
- Rendah 0-4 (n,%)	65	19 (38.8)	46 (90.2)
- Sedang 5-8 (n,%)	27	23 (46.9)	4 (7.8)
- Berat 9-14 (n,%)	8	7 (14.3)	1 (2)
Killip (μ ± SD)	1.4 ± 0.752	1.76 ± 0.92	1.06 ± 0.24
- I (n,%)	73	25 (51)	48 (94.1)
- II (n,%)	17	14 (28.6)	3 (5.9)
- III (n,%)	7	7 (14.3)	0 (0)
- IV (n,%)	3	3 (6.1)	0 (0)
Calcification Grade			
- 0	51	0	51
- 1	35	35	0
- 2	13	13	0
- 3	1	1	0

Source: Primary research data, processed by researcher (2025)

The total of 100 patients were included in the study, with 76 (76%) men patients and 24 women patient (24%). The largest proportions of participants were within the 40-59 years old, with 60 patients (60%), and the mean age was 56.67 ± 8.98 years. 65 patients (65%) were included in the low-risk group TIMI scores, 27 patients (27%) in the moderate-risk group, and 8 patients (8%) in high-risk group. A total of 49 [35 (35%) AAC grade 1, 13 (13%) AAC grade 2 and 1 (1%) AAC grade 3)] had AAC and 51 (51%) (AAC grade 0) did not. The mean age patients had KAA was 59.22 ± 9.09 and it starts to appear in the age range of 40-59 years, with 26 patients (53.1%). Compared with non-calcification grup (AAC grade 0), patients in the calcification group had higher TIMI and Killip scores. Killip I was more commonly found in patients with AAC grade 0, with 48 patients (94.1%), Killip III and IV were only found in calcification grup, with 7 individuals (14.3%) and 3 individuals (6.1%), respectively.

Diagnostic Test Analysis

A Kappa test was performed previously to the diagnostic test analysis, to ensure the similarity of the reading results. The measurement of the grade of AAC was conducted directly by the researcher and Supervisor I, with a Kappa test result of 83%. From 100 samples in this study, an analysis was conducted on the predictive of TIMI and Killip scores

based on the grade of AAC. The analysis results used the Receiver Operating Characteristic (ROC) curve method and the Area Under The Curve (AUC). The determination of the cut-off value is done by creating a table of sensitivity and specificity and evaluating which number is the most balanced. From the table, it was found that the cut-off for TIMI score is 4.5 with a sensitivity of 48.6% and a specificity of 72.3%. The cut-off score for the Killip score is 1.5 with a sensitivity of 37.1% and a specificity of 78.5%.

Table 2. Cut-off Point of TIMI Score and Killip Score with Sensitivity and Specificity

	Cut-off point	Sensitivity (%)	Specificity (%)
TIMI	4.50	48.6	72.3
Killip	1.50	37.1	78.5

Source: Primary research data, processed by researcher (2025)

The Receiver Operating Characteristic (ROC) curve was created to determine the cut-off point (figures 4.1 and 4.2). Based on statistical calculations, the cut-off point for TIMI score with the best balance has an Area Under The Curve (AUC) value of 0.644 and the cut-off point for the Killip has an Area Under The Curve (AUC) value of 0.562.

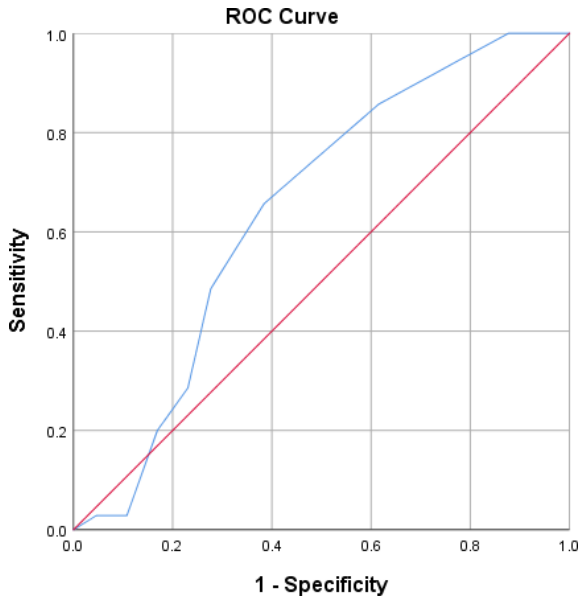


Figure 1. ROC Curve Analysis of AAC with TIMI score
Source: Results of data analysis using statistical software, processed by researcher (2025)

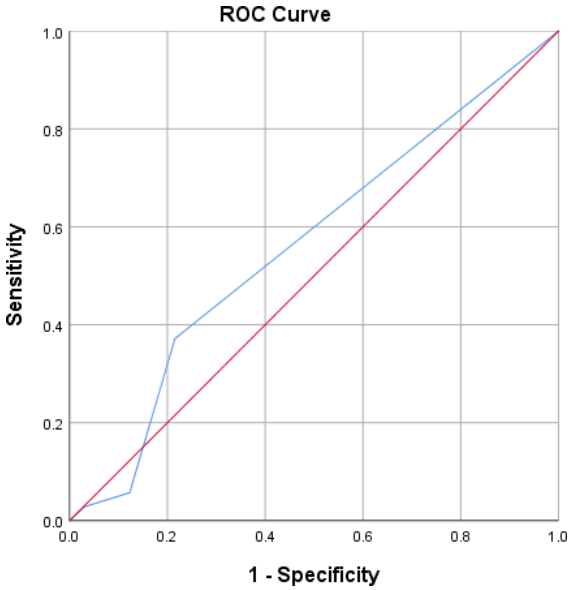


Figure 2. ROC Curve Analysis of AAC with Killip.
Source: Results of data analysis using statistical software, processed by researcher (2025)

After obtaining the sensitivity and specificity values, the Positive Predictive Value (PPV) and Negative Predictive Value (NPV) can be determined as shown in Table 3.

Table 3. Sensitivity, Specificity, Positive Prediction Value, Negative Prediction Value

Diagnostic Tests	TIMI	Killip
Sensitivity	48.6	37.1
Specificity	72.3	78.5
Positive Prediction Value (PPV)	64.6	64.2
Negative Prediction Value (NPV)	57.5	54.5

Source: Primary research data, processed by researcher (2025)

Analysis Bivariate

The results of the analysis using the Chi Square comparison test and Fisher's test show that there is a significant relationship ($p<0.05$) between gender, age, HDL levels, TIMI score, and Killip score with occurrence AAC.

Table 4. Comparison Analysis between characteristics with AAC

Characteristics	KAA (+) (n=49)	KAA (-) (n=51)	p-value
Gender (n,%)			
- Men	31 (63.3)	45 (88.2)	0.005[a]
- Women	18 (36.7)	6 (11.8)	
Age (μ ± SD, year)	59.22 ± 9.09	54.22 ± 8.22	0.020[b]
Hypertension (n,%)			
- Yes	25 (51)	27 (52.9)	1.000[a]
- No	24 (49)	24 (47.1)	

Diabetes			
- Yes	21 (42.9)	18 (35.3)	0.539[a]
- No	28 (57.1)	33 (64.7)	
Triglyceride (μ ± SD, mg/dL)	132.67 ± 47.93	139.84 ± 59.63	0.244[b]
HDL (μ ± SD, mg/dL)	40.31 ± 12.57	39.39 ± 10.02	0.032[b]
LDL (μ ± SD, mg/dL)	116.96 ± 41.21	108.93 ± 38.20	0.177[b]
Total Cholesterol (μ ± SD, mg/dL)	184.53 ± 41.80	173.31 ± 48.16	0.315[b]
TIMI (μ ± SD)	5.39 ± 2.38	2.82 ± 1.52	0.000[b]
Killip (μ ± SD)	1.76 ± 0.92	1.06 ± 0.24	0.000[b]

a: Fisher's Exact Test
b: Pearson Chi-Aquare

Source: Primary research data, processed by researcher (2025)

Coronary Artery Disease (CAD) is a condition in which there is an inadequate supply of blood and oxygen to the myocardium, caused by occlusion of the coronary arteries due to plaque formation in the coronary artery lumen that obstructs blood flow. CAD is multifactorial and categorized into non-modifiable factors such as age, gender, family history, and genetics, and modifiable factors including hypertension, diabetes mellitus, smoking, obesity, and lipid levels. In ST-Elevation Myocardial Infarction (STEMI), a transmural myocardial ischemic event occurs, leading to myocardial injury or necrosis.

This study aimed to determine the frequency distribution based on gender, age, and STEMI risk factors. It was found that there were 76 (76%) male patients and 24 (24%) female patients. This is consistent with the theory that atherosclerosis-related diseases occur more frequently in men. This may be due to the protective effects of estrogen. The incidence of CAD increases rapidly after menopause and approaches that of men. Hypertension and diabetes mellitus remain major risk factors for CAD due to oxidative and mechanical stress on arterial walls. In this study, 52 patients (52%) had hypertension. The mean systolic blood pressure was 136.91 ± 27.03 mmHg, and mean diastolic blood pressure was 82.07 ± 17.47 mmHg. Hakim and Muhani reported that among 100 Acute Coronary Syndrome (ACS) patients, 65% had hypertension, with no significant relationship between hypertension and ACS ($p = 0.191$). Tomizawa's research indicated that diabetes plays a greater role in the severity of CAD compared to hypertension. In this study, 39 patients (39%) had diabetes—29 men (38.2%) and 10 women (41.7%). The incidence of heart disease is approximately 2.5 times higher in men and 2.4 times higher in women with diabetes compared to those without.

Dyslipidemia, characterized by abnormal lipid levels in the bloodstream, is another significant risk factor for cardiovascular disease. The main components influencing this condition are total cholesterol, low-density lipoprotein (LDL) cholesterol, triglycerides, and high-density lipoprotein (HDL). This study found no increase in lipid profile levels among STEMI patients, possibly because many were already receiving dyslipidemia therapy. The TIMI STEMI score is a straightforward risk stratification system comprising parameters

available upon patient admission. This score was validated in Indonesia by Setiawan, who confirmed its calibration accuracy for predicting 30-day mortality. According to Khan R, TIMI scores are categorized into risk groups: low (0–4), moderate (5–8), and high (9–14). Khan's study found that 55.6% of STEMI patients were in the low-risk group. In this study, 65% of STEMI patients were classified as low risk, with a mean TIMI score of 4.08 ± 2.36. The mean TIMI score was higher in females (4.67 ± 2.33) compared to males (3.89 ± 2.36). In the study by Yang, the mean TIMI score among ACS patients was 4.2 ± 2.3. Another study involving 572 STEMI patients reported a predictive c-statistic value of 0.80 ($p = 0.0001$) for the TIMI risk score in predicting mortality. In that study, 32% of patients categorized as high risk (TIMI ≥ 5) had higher adverse event rates than the low-risk group: mortality 14.8% vs. 2.1% ($p = 0.0001$); heart failure 15.3% vs. 4.1% ($p = 0.0001$); cardiogenic shock 10.9% vs. 1.5% ($p = 0.0001$); ventricular arrhythmias 14.8% vs. 5.9% ($p = 0.001$); and the no-reflow phenomenon 22.4% vs. 13.6% ($p = 0.01$).

The Killip classification system is used to clinically assess STEMI patients based on the severity of post-myocardial infarction heart failure. In this study, the frequencies of Killip classes I–IV were 73%, 17%, 7%, and 3%, respectively. Hashmi demonstrated that the Killip classification is a valid tool for risk stratification in post-STEMI patients, particularly in resource-limited settings. The proportions of STEMI patients by Killip class were 395 (81.4%), 46 (9.5%), 27 (5.6%), and 17 (3.5%), respectively, with corresponding hospital mortality rates of 39 (9.9%), 4 (8.7%), 25 (92.6%), and 17 (100%).

A study by Ginanjar at Cipto Mangunkusumo Hospital found that Killip classes II–IV were associated with a 3.5-fold higher risk of 30-day mortality among STEMI patients. The Killip classification correlates with Left Ventricular Ejection Fraction (LVEF) function following infarction. Post-infarction myocardial dysfunction reduces cardiac pump function, which clinically resembles heart failure. This dysfunction increases the mortality rate in STEMI patients by three to four times compared to those without myocardial impairment.

Coronary Artery Calcification (CAC) is a strong predictor of CAD events; however, Aortic Arch Calcification (AAC) has also been shown to correlate with CAC scores. AAC can be easily detected through chest X-ray examination, and many studies have reported a strong association between AAC and CAD, making AAC a valuable predictor for CAD events. AAC detected by chest X-ray has been validated as an independent risk factor for morbidity and mortality due to cardiovascular disease within the general population and specific patient groups. Furthermore, AAC grading on chest X-rays has been identified as an independent predictor of Major Adverse Cardiovascular Events (MACE) in ACS patients.

Only a few studies have evaluated TIMI and Killip scores based on AAC in STEMI patients. In the study by Yang, AAC was observed in 127 out of 225 ACS patients, with a higher prevalence among males (71% vs. 29%) and a mean age of 81 ± 29 years. This correlation is attributed to the cumulative effects of oxidative stress in the pathogenesis of vascular calcification. Patients with AAC had significantly higher TIMI and Killip scores and exhibited markedly higher 30-day mortality (17.3% vs. 7.1%, log-rank $p = 0.02$), cardiovascular death (27.6% vs. 11.2%, log-rank $p = 0.002$), and overall mortality (28.3% vs. 11.2%, log-rank $p = 0.001$) compared to the non-calcification group.

Chest X-ray remains a fundamental diagnostic imaging tool for patients with suspected CAD. Bannas et al. found that AAC assessment on chest X-rays is reliable and linearly correlated with CAC. Additionally, AAC grades 2 and 3 demonstrated 96.4% specificity for CAC > 400, supporting screening in asymptomatic patients. However, the low sensitivity of 38.6% indicates that AAC is not recommended for confirming CAD in symptomatic patients. Nonetheless, acceptable PPV and NPV values of 85.0% and 75.0%, respectively, suggest that reporting the presence and semi-quantitative level of AAC can aid in predicting Coronary Artery Calcification. In this study, the TIMI score cut-off value showed an AUC of 0.644, while the Killip score cut-off value had an AUC of 0.562. The sensitivity and specificity of TIMI were 48.6% and 72.3%, respectively, while for Killip they were 37.1% and 78.5%, with PPVs of 64.6% and 64.2%, and NPVs of 57.5% and 54.5%, respectively.

CONCLUSION

AAC assessed from chest X-ray is inadequate to predicting TIMI and Killip scores for patients with STEMI. Although AAC demonstrated fairly good specificity (72.3% for TIMI and 78.5% for Killip), the low sensitivity values (48.6% for TIMI and 37.1% for Killip) indicate that AAC cannot reliably identify patients with high-risk scores. The Area Under the Curve (AUC) values of 0.644 for TIMI and 0.562 for Killip further confirm the low diagnostic accuracy, suggesting that AAC should not be used as a single predictive tool for risk stratification in STEMI patients.

Based on these findings, it is recommended that clinicians continue to use established risk stratification tools such as TIMI and Killip scores based on clinical parameters rather than relying on AAC as a predictor. Future research should explore alternative imaging markers or combinations of multiple non-invasive parameters to improve risk prediction in STEMI patients. Additionally, larger multicenter studies are needed to validate these findings across different populations and healthcare settings. For clinical practice, chest X-ray remains valuable for its traditional purposes in STEMI patients, such as detecting pulmonary edema or other complications, but not specifically for predicting TIMI or Killip scores based on AAC.

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