

# Advantages and Limitations of Killip and Kimball Class A at Admission in Early Discharge Decision-Making in ST-Segment Elevation Acute Myocardial Infarction. ARGEN-IAM-ST Registry

*Ventajas y limitaciones de la condición Killip y Kimball A de ingreso en la decisión de alta precoz en el infarto agudo de miocardio con elevación del segmento ST. Registro Argen-IAM-ST*

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## ABSTRACT

**Background:** Patients admitted to the coronary care unit with ST-segment elevation myocardial infarction (STEMI) without heart failure (HF) are classified as Killip and Kimball class A (KK A). They usually have a favourable prognosis and are often considered for early discharge. However, this initial assessment may be insufficient, as not all patients experience an uncomplicated clinical course. From a practical perspective, progressive HF is often used as a risk marker for mortality.

**Objectives:** 1. To determine the incidence of KK class A at admission in patients with STEMI and its role in overall mortality. 2. To establish the incidence of HF during the clinical course of patients classified as KK A at admission and its characterization. To analyze the negative predictive value of the absence of HF during the clinical course on mortality.

**Methods:** Retrospective analysis of the ARGEN-IAM-ST registry. This prospective observational study was conducted from March 2015 to October 2024. All patients enrolled in the registry were analyzed. HF was considered a complication and defined according to the treating physician's criteria.

**Results:** From March 2015 to October 2024, 7304 patients were enrolled, with a median age of 60 years (interquartile range, IQR, 52-67); 80% were male. According to the Killip and Kimball classification, 77.6% of patients were class A, 14% class B, 1.4% class C, and 7% class D. The overall mortality rate was 7.3%. For KK A patients, in-hospital mortality was 2.6%, representing 28% of the overall in-hospital mortality rate.

During hospitalization 5.4 % of KK A patients developed progressive HF, and 21% of these patients died. In contrast, among patients who did not develop HF, only 1.5% died (OR 17.77, 95% CI, 12.09-24.35;  $p < 0.001$ ). The absence of progressive HF in KK A patients had a high negative predictive value for mortality (98.5%). Independent variables related to progressive HF in KK A patients were age >70 years, female sex, diabetes, left anterior descending artery involvement, longer symptom-to-door time, and failed primary percutaneous coronary intervention.

**Conclusions:** Although mortality in KK A patients at admission is low, its contribution to overall mortality is elevated due to its high prevalence at presentation. The absence of HF during the clinical course identifies a group at a very low risk for mortality, supporting safe early discharge.

**Keywords:** ST-segment elevation acute myocardial infarction - Killip and Kimball - Early discharge

## RESUMEN

**Introducción:** Los pacientes que ingresan a la unidad coronaria con un infarto agudo de miocardio con elevación del segmento ST (IAMCEST) sin insuficiencia cardíaca (IC) constituyen la subcategoría A de la clasificación de Killip y Kimball (KK A). Suelen presentar un excelente pronóstico, y se considera en ellos el alta temprana. Sin embargo, la evaluación inicial puede ser insuficiente, ya que no todos los pacientes evolucionan de manera benigna. Desde un punto de vista práctico frecuentemente se utiliza a la IC evolutiva como un marcador de riesgo para mortalidad.

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**Objetivos:** 1. Determinar la incidencia de la subcategoría KK A al ingreso en pacientes con IAMCEST, y su participación en la mortalidad global. 2. Establecer la incidencia de IC durante la evolución de los pacientes clasificados como KK A al ingreso y su caracterización. Analizar el valor predictivo negativo de la ausencia de IC durante la evolución sobre la mortalidad.

**Material y métodos:** Análisis retrospectivo del registro ARGEN-IAM-ST, un estudio prospectivo y observacional, en el periodo comprendido entre marzo de 2015 y octubre de 2024. Se incluyó el total de los pacientes ingresados al registro. La IC fue considerada como complicación y definida según criterios del médico tratante.

**Resultados:** Desde marzo de 2015 a octubre de 2024 se registraron 7304 pacientes con una mediana de edad de 60 años (rango intercuartílico, RIC, 52-67), el 80 % de sexo masculino. La distribución de acuerdo a la clasificación de Killip y Kimball fue 77,6%, 14%, 1,4% y 7% para las categorías A, B, C, D respectivamente. La mortalidad total fue de 7,3%. La mortalidad intrahospitalaria de los pacientes con KK A fue de 2,6%, un 28% de la mortalidad global.

El 5,4% de los pacientes KK A desarrollaron IC evolutiva, de los cuales el 21% falleció; de aquellos que no desarrollaron IC durante la internación, falleció solo el 1,5 % (OR 17,77 IC 95%, 12,09-24,35;  $p < 0,001$ ). La ausencia de desarrollo de IC evolutiva en los pacientes KK A tuvo un elevado valor predictivo negativo para mortalidad: 98,5%. Las variables independientemente asociadas a IC evolutiva en los pacientes con KK A fueron: edad mayor de 70 años, el sexo femenino, la diabetes, el compromiso de la arteria descendente anterior, un mayor tiempo desde el dolor a la consulta, y la angioplastia coronaria (ATC) primaria fallida.

**Conclusiones:** Si bien la mortalidad de los pacientes que ingresan en KK A es baja, su contribución nominal a la mortalidad total es elevada debido a que es la forma de presentación más frecuente. La ausencia de IC en la evolución selecciona un grupo de muy bajo riesgo de mortalidad que permite asegurar un alta temprana.

**Palabras clave:** Infarto agudo de miocardio con elevación del segmento ST - Killip y Kimball - Alta precoz

## INTRODUCTION

Patients suffering from acute myocardial infarction with ST-segment elevation (STEMI) have a high hospital mortality rate, which, according to various records, ranges from 7% to 9%, (1-3), is higher in patients with heart failure (HF) at admission, (4) and depends on the treatment received. (5-7)

Since the 1967 work by Thomas Killip and John Kimball (KK), who described the clinical characteristics of patients with STEMI, prognosis has improved thanks to coronary reperfusion strategies. As a result, the percentage of patients classified as Killip and Kimball class A (KK A) has increased dramatically from 33% to 78%, making it the most common clinical presentation at hospital admission in patients with STEMI. However, few studies have analyzed complications or hospital mortality specifically in this patient subgroup.

In the era of reperfusion therapy, a decrease in complications in patients with STEMI has been observed, enabling earlier hospital discharge. (10,11) In countries such as the United States, the average length of hospitalization is three days, International guidelines recommend early discharge (on the third day) in low-risk patients, with conditions such as age  $< 70$ , left ventricular ejection fraction (LVEF)  $> 45\%$ , 1- or 2-vessel disease, successful coronary angioplasty, and absence of arrhythmias. (12) Despite this, early discharge is not always implemented, even in eligible patients.

Objectives:

1. To determine the incidence of the KK class A at admission in patients with STEMI and its role in overall mortality.
2. To establish the incidence of HF during the clinical course of patients classified as KK A at admission and its characterization. To analyze the negative predictive value of the absence of HF during the clinical course on mortality.

## METHODS

This study was conducted as a retrospective analysis of the ARGEN-IAM-ST continuous registry, a prospective and observational registry of hospitalized STEMI patients. The study was performed from March 2015 to October 2024, and its design focused on assessing the hospital clinical course of patients with KK A admitted to the coronary care unit.

The inclusion criteria were patients classified as Killip and Kimball classes A, B, C, or D, according to the original Killip and Kimball classification. A total of 264 patients were excluded: 174 due to missing data, and 90 because of mechanical complications. HF was classified as a hospital complication. The diagnosis of HF was based on the treating physician's criteria according to the Killip and Kimball classification. Bleeding was defined as follows: minimal: non-intracranial, with a decrease in hemoglobin (Hb)  $< 3$  mg/dL; minor: non-intracranial with a decrease in Hb between 3 and 5 mg/dL; major: intracranial bleeding or a decrease in Hb  $> 5$  mg/dL.

## Statistical analysis

Quantitative variables with normal distribution were expressed as mean and standard deviation (SD), while those with non-normal distribution were reported as median and interquartile range (IQR). To perform the statistical analysis of these variables, the Student's t-test, Mann-Whitney U test, or analysis of variance (ANOVA) were used as appropriate.

Qualitative variables were expressed as frequencies and percentages, and the statistical analysis was performed using the chi-square test or Fisher's exact test, as appropriate.

A contingency table was created to explore an association between the presence or absence of HF and the clinical course in patients with KK A at admission.

The search for independent predictors of progressive HF and the assessment of the incidence of progressive HF on the occurrence of events were conducted using multiple logistic regression analysis, including variables that were statistically significant in the univariate analysis. The association with events was expressed as odds ratio (OR) with its 95% confidence interval (95% CI). A p value  $< 0.05$  was considered statistically significant. To assess the usefulness of the overall model (Table 2), the omnibus test was used,

**Table 1.** Baseline characteristics of patients according Killip and Kimball classification at admission

Variable	KK A (n=5666)	KK B (n=1020)	KK C (n=107)	KK D (n=511)	p
Age, years	60 (52-68)	63 (55-72)	64 (56-74)	64 (57-74)	<0.001
Female sex	20	23	29	29	<0.001
Diabetes mellitus	26	31	34	34	<0.001
Hypertension	52	58	66	65	<0.001
Dyslipidemia	37	38	43	36	0.601
Smoking	31	34	35	35	0.061
Prior AMI	37	54	59	39	<0.001
Symptom-to-door time, min	119 (55-240)	129 (60-300)	152 (60-323)	120 (53-300)	0.004
Reperfusion therapy	91	88	84	87	<0.001
Ischemic total time (PCI), min	305 (185-573)	345 (198-660)	524 (271-901)	400 (212-722)	<0.001
Ischemic total time (FBL), min	180 (105-290)	220 (120-327)	170 (112-266)	180 (104-329)	0.399
Reperfusion therapy:	80		74	77	<0.001
Primary PCI	13	76	16	11	
Fibrinolytics	7	13	9	12	
Both		11			
Door-to-balloon time, min	77 (44-135)	80 (43-130)	102 (60-198)	85 (50-141)	0.004
Multivessel disease	32	41	46	52	<0.001
Successful PCI	98	95	90	84	<0.001
Bleeding:					
Minimal	2	3	7.5	6	
Minor	0.7	0.9	5	3	<0.001
Major	0.5	0.8	0.9	1.4	

AMI: acute myocardial infarction; FBL: fibrinolytics; KK: Killip and Kimball; PCI: percutaneous coronary intervention.

Qualitative variables are expressed as percentage rounded to the nearest whole number. Quantitative variables are expressed as median and interquartile range.

and a ROC curve was generated. The statistical analysis was performed using the statistical software JAMOVI (version 2.3.28.0).

### Ethical considerations

The protocol was reviewed and approved by the Bioethics Committee of the Argentine Society of Cardiology. This registry does not require signed informed consent. This decision is left to each participating institution.

### RESULTS

From March 2015 to October 2024, 7304 patients were admitted for STEMI, with a median age of 60 years (IQR 52-67), 80% were male. According to Killip and Kimball classification, 77.6% of patients were class A (n=5666), 14% class B (n=1020), 1.4% class C (n=107), and 7% class D (n=511).

Table 1 shows the baseline characteristics of patients according to KK classification at admission. KK A patients were significantly younger, less likely to be female, had lower prevalence of diabetes, hypertension, prior acute myocardial infarction (AMI) location, and shorter symptom-to-door time. They also had a lower prevalence of multivessel disease but a higher use of primary percutaneous coronary intervention (PCI) as their revascularization method. The rate of

successful primary PCI was higher in this group.

Among KK A patients, 311 (5.4%) developed progressive HF during hospitalization. Their baseline characteristics resembled those of patients with KK class >A (Table 2). In a multiple logistic regression model, the independent variables associated with progressive HF were age >70 years, female sex, diabetes, anterior descending artery involvement, symptom-to-door time, and failed primary PCI (area under the ROC curve 0.68, 95% CI 0.61-0.74) (Table 3).

Total in-hospital mortality was 7.3% (n=532). Among patients with KK A, in-hospital mortality was 2.6%, accounting for 28% of total deaths (Figure 1). Among the 311 KK A patients who developed progressive HF, in-hospital mortality was 20.9% (n=65), while it was only 1.5% (n=82) among the 5355 patients who did not (OR 17.77, 95% CI 12.09-24.35;  $p<0.001$ ). In the multivariate analysis in KK A patients, the development of HF was an independent predictor of hospital mortality (OR 4.79; 95% CI 2.74-8.36  $p<0.001$ ).

### DISCUSSION

The Killip and Kimball (KK) classification, proposed in 1967, (8) continues to be a valid and widely used tool for risk stratification in STEMI patients. Despite the time elapsed and therapeutic advances, its simplicity, reproducibility, and prognostic value have preserved

**Table 2.** Baseline characteristics of Killip and Kimball class A patients according to the presence or absence of progressive heart failure

Variable	HF (n=311)	Non-HF (n=5355)	p
Age, years	64 (56-74)	60 (52-67)	<0.001
Female sex	28	19	< 0.001
Diabetes mellitus	32	25	<0.001
Hypertension	59	52	0.001
Dyslipidemia	41	37	0.101
Smoking	31	34	0.551
Prior AMI	47	36	<0.001
Symptom-to-door time, min	120 (60-300)	116 (55-240)	<0.001
Reperfusion therapy	91	91	0.991
Ischemic total time (PCI), min	377 (203-818)	300 (183-568)	<0.001
Ischemic total time (FBL), min	200 (110-324)	180 (105-285)	0.512
Reperfusion therapy:			
Primary PCI	75	81	
Fibrinolytics	17	12	0.033
Both	8	7	
Door-to-balloon time, min	83 (48-150)	77 (44-135)	0.255
Culprit vessel: LADA	60	43	<0.001
Successful PCI	91	98	< 0.001
Bleeding			
Minimal	4	2	
Minor	3	0.5	<0.001
Major	2	0.4	

AMI: acute myocardial infarction; FBL: fibrinolytics; HF: heart failure; LADA: left anterior descending artery; min: minutes; PCI: percutaneous coronary intervention.

Qualitative variables are expressed as percentage rounded to the nearest whole number. Quantitative variables are expressed as median and interquartile range.

its clinical utility. However, the patient profile has changed considerably since its original publication. (9) In particular, there is now a higher proportion of patients admitted to KK class A, a phenomenon attributable to the positive impact of adjuvant therapies, especially early reperfusion treatment. (13,14)

In our study, we observed that the vast majority of STEMI patients were admitted to KK class A. This subcategory, despite its low individual mortality, represents a significant proportion of AMI-related deaths: approximately one in three occurs in this group. This finding, in line with our first objective, highlights that initial classification in KK class A does not guarantee an event-free hospital course. In fact, the high prevalence of this subcategory has a significant impact on overall AMI mortality, a fact that, although little explored in previous studies, is essential for an adequate understanding of population risk.

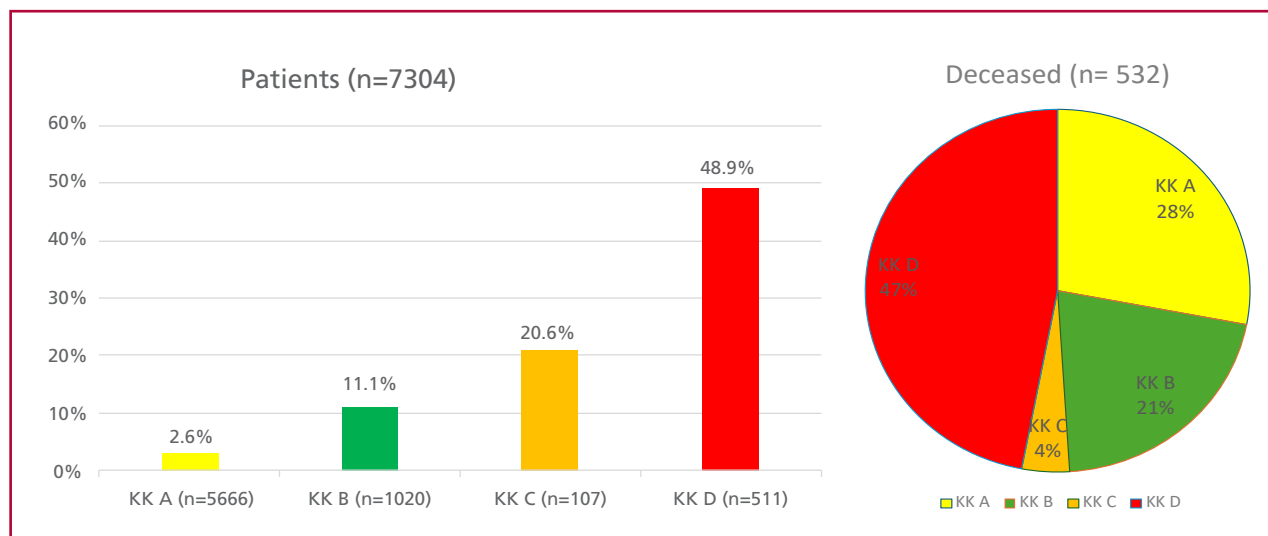
Likewise, in addressing our second objective, we identified that approximately 5% of patients admitted to KK class A developed HF during hospitalization. Among them, 21% died before discharge, underscoring the adverse prognostic impact of HF as a hospital complication. (15) The progression to HF in this subgroup, initially considered low risk, highlights

the need for continuous clinical monitoring and more sensitive risk stratification strategies. (16,17) In this regard, multivariate analysis allowed us to identify independent predictors for the development of HF, which are similar to those in the PAMI II study and the Zwolle score. (18-23) However, the model discriminatory power was moderate, with a C-statistic of 0.68, indicating the need to optimize predictive tools for this population.

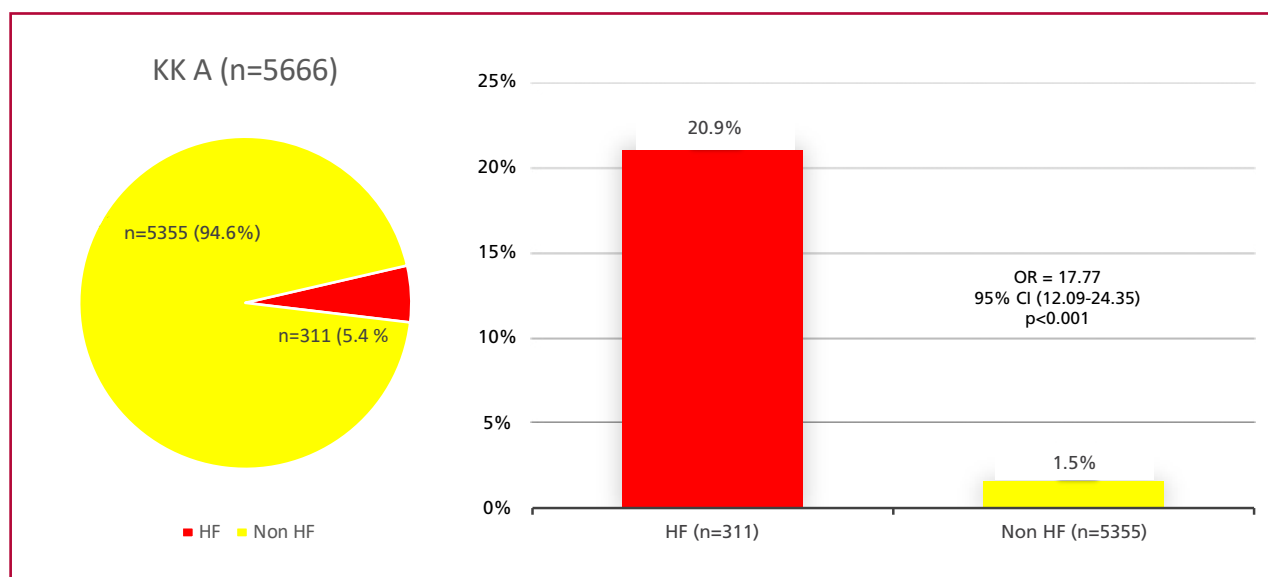
On the other hand, patients who did not develop HF during hospitalization had a very favorable outcome, with a low event rate, which translates into a high negative predictive value. This observation supports the consideration of this subgroup for early discharge strategies, (24-28) in line with international guidelines (Class IIa recommendation). (29,30) Additionally, clinical detection of HF may be complemented by B-type natriuretic peptide (BNP) testing, (31) which has proven useful for early identification of ventricular dysfunction even in the absence of overt clinical signs, as shown by the GREAD NETWORK registry. (32)

Multiple studies have confirmed that HF at admission is associated with a worse prognosis in the context of acute coronary syndrome. (4,15) However, our

**Fig. 1.** Mortality rate according to Killip and Kimball classification at admission (bar chart). Percentage impact of deaths according to Killip and Kimball classification on overall mortality for myocardial infarction (pie chart).



**Fig. 2.** Incidence (A) and mortality (B) of heart failure (HF) complicating patients with KK A at admission



study offers a different perspective, shifting the focus to HF as a progressive event in patients classified as KK A at admission. This view contrasts with previous studies from the ARGEN-IAM-ST registry, which focused exclusively on patients with KK class B, C, or D at admission, (33–36) leaving a gap in understanding the clinical course of those initially considered low risk.

Finally, our findings allow us to assess the epidemiological burden of KK A patients on overall STEMI mortality and highlight that HF onset during hospitalization is a critical event with significant prognostic implications. Conversely, the absence of HF is asso-

ciated with a favorable outcome, which has important clinical implications for decision-making regarding early discharge and outpatient follow-up. This information emphasizes the importance of a dynamic approach to risk stratification that considers both the initial clinical presentation and the hospital clinical course.

#### Limitations

Due to the design of the ARGEN-IAM-ST registry, we were unable to determine the exact timing of HF onset. However, we can estimate this indirectly, as most complications in our local clinical context occur within

**Table 3.** Multivariate analysis of the development of progressive heart failure

Variable	OR	95% CI	p
Age >70	2.06	1.51-2.81	<0.001
Female sex	1.65	1.20-2.26	0.001
Diabetes mellitus	1.71	1.27-2.31	<0.001
Culprit vessel: LADA	1.88	1.26-2.81	0.001
Symptom-to-door time, min	1.04	1.03-1.06	0.022
Failed PCI	4.20	2.42-7.28	<0.001

HF: heart failure; LADA: left anterior descending artery; PCI: percutaneous coronary intervention; OR: odds ratio

**Table 4.** Multivariate analysis of mortality

Variable	OR	95% CI	p
Age >70	1.71	1.01-2.88	0.043
Progressive HF	4.79	2.74-8.36	0.001
Major bleeding	9.21	2.60-32.62	<0.001
Failed PCI	3.99	1.73-9.21	<0.001
LVEF <35%	4.93	2.43-9.99	<0.001
Dyslipidemia	2.12	1.30-3.44	0.002

HF: heart failure; LVEF: left ventricular ejection fraction; PCI: percutaneous coronary intervention; OR: odds ratio

the first three days. A study conducted at Hospital Argerich showed that all complications, without exceptions, occurred within the first 48 hours. (37,38)

### CONCLUSIONS

KK A at admission remains a valid criterion for identifying patients who will have a favorable hospital course following STEMI. However, close monitoring in the coronary care unit is essential to detect patients who will develop heart failure, as they constitute a high-risk group for early discharge.

### Conflicts of interest

None declared.

(See authors' conflict of interests forms on the web).

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