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# **Profile of patients hospitalized in intensive cardiac care units in France: ADDICT-ICCU registry**

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Cardiovascular disease; Epidemiology; In-hospital major adverse outcomes; Intensive cardiac care unit; Management.

**Abbreviations**

ACS acute coronary syndromes AHF acute heart failure CPU chest pain unit ICA invasive coronary angiogram ICCU intensive cardiac care unit IQR interquartile range MAE major adverse events NSTEMI non-ST-elevation myocardial infarction PCI percutaneous coronary intervention STEMI ST-segment elevation myocardial infarction

# Abstract

## Background:

Intensive cardiac care units (ICCU) were initially developed to monitor ventricular arrhythmias after myocardial infarction. In recent decades, ICCU have diversified their activities.

## Aim:

To determine the type of patients hospitalized in ICCU in France.

## Methods:

We analysed the characteristics of patients enrolled in the ADDICT-ICCU registry ([NCT05063097](https://clinicaltrials.gov/ct2/show/study/NCT05063097)), a prospective study of consecutive patients admitted to ICCU in 39 centres throughout France from 7th-22nd April 2021. In-hospital major adverse events (MAE) (death, resuscitated cardiac arrest and cardiogenic shock) were recorded.

## Results:

Among 1499 patients (median age 65 [interquartile range 54-74] years, 69.6% male, 21.7% diabetes mellitus, 64.7% current or previous smokers), 34.9% had a history of coronary artery disease, 11.7% atrial fibrillation and 5.2% cardiomyopathy. The most frequent reason for admission to ICCU was acute coronary syndromes (ACS; 51.5%), acute heart failure (AHF; 14.1%) and unexplained chest pain (6.8%). An invasive procedure was performed in 36.2%. "Advanced" ICCU therapies were required for 19.9% of patients (intravenous diuretics 18.4%, non-invasive ventilation 6.1%, inotropic drugs 2.3%). No invasive procedures or advanced therapies were required in 44.1%. Cardiac computed tomography or magnetic resonance imaging was carried out in 12.3% of patients. The median length of ICCU hospitalization was 2.0 (interquartile range 1.0-4.0) days. The mean rate of MAE was 4.5%, and was highest in patients with AHF (10.4%).

## Conclusions:

ACS remains the main cause of admissions to ICCU, with most having a low rate of in-hospital MAE. Most patients experience a brief stay in ICCU before being discharged home. AHF is associated with highest death rate and with higher resource consumption.

# 1 Introduction

Intensive cardiac care units (ICCU) were introduced in the 1960s, initially to monitor and treat lethal ventricular arrhythmias occurring after acute myocardial infarction [1]. However, the patient population requiring acute cardiovascular care has since changed, with a wider variety of acute cardiac pathologies including the spectrum of acute coronary syndromes (ACS), acute heart failure (AHF), valvular heart disease, arrhythmias, conduction disturbances, tamponade and pulmonary embolism [2,3]. Furthermore, the population of elderly patients with acute or chronic comorbid conditions is growing and the heterogeneity of patients admitted in ICCU is increasing [4]. This substantial change in the landscape of acute cardiovascular care emphasizes the crucial need to adapt our practice and organizations [5]. However, recent reports using individual patient-level data on acute cardiovascular care in European ICCU are lacking. Furthermore, risk factors associated with a prolonged length of hospital stay and in-hospital major adverse events (MAE) in a contemporary cohort of patients admitted to intensive care are poorly understood.

The Addiction in Intensive Cardiac Care Units (ADDICT-ICCU) study is a prospective, multicentre French registry. We aimed to describe the medical profile of enrolled patients, the use of additional investigations, management, and in-hospital outcomes according to final diagnosis. As secondary objectives, we sought to identify independent predictors of in-hospital MAE and factors associated with prolonged in-hospital length of stay to enhance risk stratification and deepen comprehension of the care process in a contemporary health care landscape.

## 2. Methods

### 3.1. Study population

Data were derived from the ADDICT-ICCU Registry. Details about the study have been reported previously [6]. Briefly, the ADDICT-ICCU study is a multicentre, prospective, observational study. The population comprised all consecutive adults admitted to 39 ICCU located throughout France from 7th to 22nd April 2021 [7]. The list of participating centres is provided in Table A.1. Inclusion criteria were: male or female patients aged  $\geq 18$  years admitted to the ICCU regardless of the medical reason with written informed consent obtained at enrolment. The main exclusion criteria were hospitalization for a planned interventional procedure (to focus the analysis on patients addressed for an acute cardiovascular event and patients previously hospitalized in another place). Owing to regulatory requirements, patients aged  $> 75$  years were not admitted during the first week of the study. The management of patients was at the discretion of the treating physicians following the current European Society of Cardiology guidelines [4–8]. This study was approved by ethics committees (Committee for the Protection of Human Subjects, Île-de-France-7) and was registered on the ClinicalTrials.gov website under the number NCT05063097.

### **3.2. Variables**

All details on the collection of baseline data have been published [6]. Briefly, baseline data included clinical data, reason for hospitalization and history of cardiovascular disease. Biological data were collected systematically upon admission and included haemoglobin, N-terminal prohormone of B-type natriuretic peptide or B-type natriuretic peptide, serum potassium, creatinine and peak troponin. The main final diagnoses were recorded and were adjudicated by two independent experts at the end of the hospitalization. For each main final diagnosis, we describe all data related to in-hospital management, including non-invasive or invasive cardiac procedures. Transthoracic echocardiography was performed systematically in patients within 24 hours of admission, but the need for additional transoesophageal echocardiography, cardiac magnetic resonance imaging or coronary computed tomography angiography was recorded. Invasive procedures were defined as the requirement for invasive coronary angiogram (ICA) or percutaneous coronary intervention (PCI), an invasive rhythmological procedure or cardiovascular surgery. Invasive rhythmological procedures were defined as the requirement for permanent pacemaker implantation, implantable cardioverter-defibrillator, cardiac resynchronization or ablation. Cardiovascular surgery was defined as the requirement for in-hospital coronary artery bypass surgery, valve surgery or pericardial drainage. Advanced ICCU therapies were defined as the requirement for intravenous diuretics, need for inotropes and/or vasopressor drugs, non-invasive ventilation with continuous positive airway pressure or intubation and intra-aortic balloon pump or cardiac assistance. We also described ICCU and in-hospital length of stay and the mode of discharge from the ICCU.

### **3.3. Events**

The occurrence of in-hospital MAE was defined as a composite outcome including in-hospital death, resuscitated cardiac arrest (severe ventricular arrhythmia requiring defibrillation or intravenous antiarrhythmic drugs) or cardiogenic shock requiring medical or mechanical haemodynamic support. An independent committee of experts who reviewed anonymized medical documents according to the standardized definitions adjudicated all events, including in-hospital MAE [6].

### **3.4. Statistical analysis**

Continuous variables are expressed as medians with interquartile range, and categorical variables as number and percentages with absolute 95% confidence intervals. Data distribution was assessed with the Shapiro-Wilk test. Risk factors for in-hospital MAE and prolonged in-hospital length of stay (defined as a duration of hospitalization exceeding the third quartile [ $\geq 6$  days]) were assessed within the whole cohort using univariate and multi variable logistic regression models. Variables were included in the multivariable logistic model when their P-value was  $\leq 0.20$  in univariate analysis. Odds ratios and 95% confidence intervals were calculated. Differences were considered significant if 2-sided P was  $< 0.05$ . All analysis were performed using R software, version 4.2 (R Project for Statistical Computing).

**Table 1**  
Patient baseline characteristics at admission ( $n = 1499$ ).

Baseline characteristic	
Age (years)	65 (54–74)
Men	1043 (69.6)
Body mass index ( $\text{kg}/\text{m}^2$ )	$27.3 \pm 5.5$
Medical history of cardiovascular disease	
Known coronary artery disease	523 (34.9)
Previous percutaneous coronary intervention	482 (32.2)
Previous coronary artery bypass grafting	56 (3.4)
Stroke	3 (0.2)
Known chronic kidney disease <sup>a</sup>	157 (10.5)
History of heart failure hospitalization	88 (5.9)
Known left ventricular ejection fraction < 50%	96 (10.3)
History of atrial fibrillation	175 (11.7)
Pacemaker or implantable cardioverter-defibrillator	95 (6.4)
Known cardiomyopathy <sup>b</sup>	78 (5.2)
Medical history of non-cardiovascular disease	
Cancer (active and remission)	151 (10.1)
Active cancer	61 (4.1)
Human immunodeficiency virus	13 (0.9)
Chronic obstructive pulmonary disease or asthma	89 (5.9)
Psychiatric history	156 (10.4)
Family history of coronary artery disease	247 (16.5)
Cardiovascular risk factors	
Diabetes	326 (21.7)
Hypertension	795 (53.0)
Dyslipidaemia	582 (38.8)
Current or previous smoking	961 (64.7)
Active smoker	595 (39.7)
Family history of coronary artery disease	247 (16.5)
Chronic medications	
Anticoagulant/antiplatelet aggregation	661 (44.1)
Antihypertensive treatment	816 (54.4)
Statins	502 (33.5)
Admission diagnosis	
ST-segment elevation myocardial infarction	334 (22.3)
Non-ST-segment elevation myocardial infarction	438 (29.2)
Acute heart failure	211 (14.1)
Unexplained chest pain	102 (6.8)
Atrial rhythm arrhythmias	60 (4.0)
Ventricular arrhythmias	34 (2.3)
Myocarditis or pericarditis	73 (4.9)
Cardiac conduction abnormalities	83 (5.5)
Pulmonary embolism	46 (3.1)
Coronary spasm or coronary/aortic dissection or takotsubo	41 (2.7)
Other	77 (5.1)
Clinical data at admission	
Systolic blood pressure (mmHg)	136 (118–153)
Heart rate (beats per min)	83 (67–95)
Oxygen saturation (%)	97 (96–99)
Killip class $\geq 2$	254 (17.0)
Laboratory results at admission	
Haemoglobin (g/dL)	13.6 (12.5–14.9)
Creatinine ( $\mu\text{L}$ )	80 (67–99)
High-sensitivity cardiac troponin peak	266 (40–3,962)
NT-pro-BNP (pg/mL)	734 (169–2,675)
BNP (pg/mL)	141 (39–453)
Left ventricular ejection fraction (%)	55 (45–60)

Data are expressed as number (%), mean  $\pm$  SD or median (interquartile range). BNP: B-type natriuretic peptide; NT-pro-BNP: NT-pro-B-type natriuretic peptide.

<sup>a</sup> Estimated glomerular filtration rate < 60 mL/min.

<sup>b</sup> Defined by the European Society of Cardiology consensus, and including hypertrophic cardiomyopathy, dilated cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy and restrictive cardiomyopathy.

## 4. Results

#### **4.1. Patient characteristics**

From 7th to 22nd April 2021, 1904 patients were admitted to 39 ICCU. Among these, 1575 met the enrolment criteria and 1499 (95.2%) were recruited and constituted our study cohort. The base-line characteristics of the overall population are reported in Table 1. Among the 1499 patients recruited (69.9% male, median age 65 [interquartile range 54–74] years), 581 (38.8%) were  $\leq 60$  years of age and 200 (13.3%) were  $\geq 80$  years. Distribution according to age is shown in Fig. A.1. Regarding traditional cardiovascular risk factors, 53.0% had hypertension, 38.8% dyslipidaemia, 39.7% were current smokers and 21.7% had diabetes mellitus. The most common cardiovascular comorbidities were coronary artery disease (34.9%), history of atrial fibrillation (11.7%) and chronic heart failure (5.9%). Non-cardiac comorbidities included chronic kidney disease in 10.5% of patients (defined by estimated glomerular filtration rate  $< 60$  mL/min/1.73 m<sup>2</sup>), chronic pulmonary disease in 5.9% and active malignancy in 4.1%. Patient characteristics according to main final diagnosis are reported in Table A.2.

#### **4.2. Reason for ICCU hospitalization and main final diagnosis**

The reasons for hospitalization were chest pain (n = 954, 63.6%), dyspnoea (n = 321, 21.4%), palpitations (n = 137, 9.1%) and syncope (n = 130, 8.7%). The two most common main final diagnoses were ACS (51.5%) and AHF (14.1%). Nearly half of ACS admissions were for ST-segment elevation myocardial infarction (STEMI), accounting for 22.3% of all ICCU admissions. Other final diagnoses were severe cardiac conduction abnormalities (5.5%), myocarditis or pericarditis (4.9%), atrial rhythm disorder (4.0%), ventricular rhythm disorder (2.3%), pulmonary embolism (3.1%), takotsubo syndrome or coronary spasm or aortic dissection or spontaneous coronary dissection (2.7%), unexplained chest pain (6.8%) and other cardiovascular or non-cardiovascular diagnosis (5.1%) (Table 1 and Central Illustration).

#### **4.3. ICCU management and therapies**

The spectrum and proportion of each common ICCU-based management and therapy are shown in Fig. 1. One of the indications for ICCU-level care is justified by use of advanced ICCU therapies for cardiac or respiratory failure. These advanced ICCU therapies were used for only 19.9% patients: cardiac advanced therapies with intravenous diuretics were used for 18.4%, inotropes for 2.3%, vaso-pressor for 1.2% and intra-aortic balloon pump for 0.3%. Beyond common oxygen therapies in 12.1%, advanced respiratory management was performed in 6.9%, including non-invasive ventilation with continuous positive airway pressure in 6.1% and intubation in 0.8%.

Beyond advanced ICCU therapies for cardiac or respiratory failure, management of patients in the ICCU includes additional invasive and non-invasive explorations. Regarding invasive explorations, nearly 65.6% of the overall population admitted to the ICCU had ICA and 32.2% had PCI. Regarding ACS subgroup, PCI was performed in 59.7% of cases, including 49.5% for non-STEMI (NSTEMI) and 73.0% for STEMI. While most ICA were for ACS patients, 8.5% were performed for AHF patients and 5.2% for patients with a final diagnosis



of unexplained chest pain. Of note, half of the patients with a final diagnosis of unexplained chest pain underwent ICA. Other non-invasive cardiac exploratory procedures, such as cardiac magnetic resonance (6.1%) or coronary CT(3.3%) were performed, mostly for patients with a final diagnosis of AHF (24.3%) or myocarditis/pericarditis (18.9%).

An assessment of ICCU use according to the need for advanced ICCU therapies or invasive procedures was performed (Fig. A.2).Regarding patients who required advanced ICCU therapies, 52.6% were admitted with a final diagnosis of AHF, followed by NSTEMI(17.7%) and STEMI (13.9%). Conversely, 44% of the overall population had no invasive management or advanced ICCU therapies. Most had NSTEMI (24.3%) or unexplained chest pain as main final diagnosis (14.0%).

#### **4.4. ICCU and in-hospital outcomes**

The median length of ICCU stay was 2.0 (interquartile range [IQR] 1.0–4.0) days and in-hospital length was 4.0 (IQR 2.0–6.0) days (Table 2). Table 3 shows variables independently associated with prolonged in-hospital length of stay. Dyslipidaemia, use of intravenous diuretics, LVEF  $\leq$  40%, systolic blood pressure at admission and Killip class  $\geq$  2 at admission were independently associated with prolonged hospital stay.

The overall rate of in-hospital MAE was 4.5%, including 27 (1.8%) deaths, 13 (0.9%) cardiac arrest events and 27 (1.8%) cardiogenic shocks requiring medical or mechanical haemodynamic support. Stratified by main final diagnosis, the highest in-hospital MAE rate was for patients with AHF (10.4%), following by ACS patients (4.3%)(Table 2 and Central Illustration). None of the patients admitted to ICCU with a final diagnosis of unexplained chest pain had in-hospital MAE (Table 2). On multivariable analysis, age, LVEF  $\leq$  40% and use of intravenous diuretics were associated with a higher risk of in-hospital MAE (Table 4).

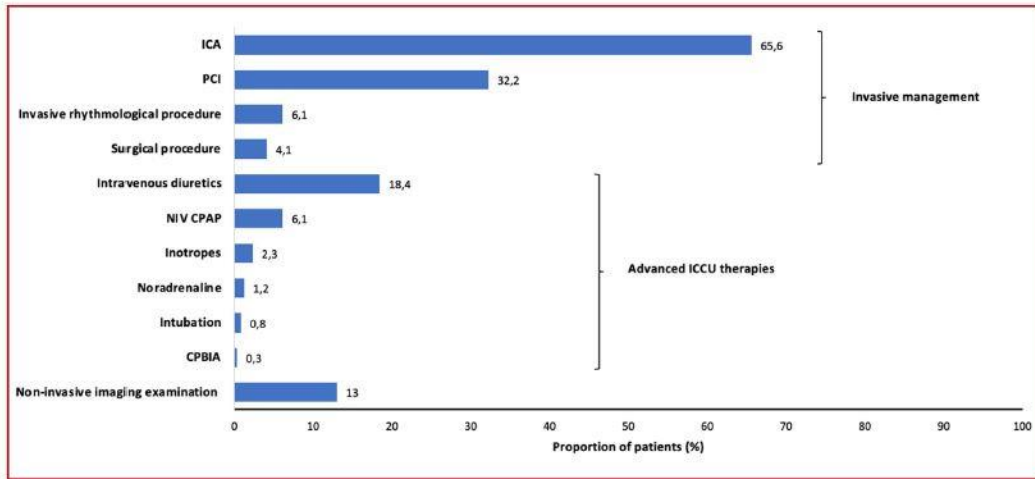
Among patients who were discharged alive, 77.2% were discharged home, 12.9% were transferred to a conventional cardiology unit, 2.4% to cardiovascular surgery and 0.5% to a general intensive care unit (Fig. 2). These results varied substantially according to main final diagnosis. While patients hospitalized with a diagnosis of AHF had a longer median duration of hospitalization(3, IQR 2–5, days) with the lowest discharge-home rate (61.6%),the ACS subset had a better prognosis with a shorter median hospitalization in ICCU (2, IQR 2–4, days) and with a higher discharge home rate (75.8%). Conversely, patients with unexplained chest pain had the shortest ICCU stay (1, IQR 0–1, days) of all subgroups, with the highest rate of discharge home (95.1%) (Table 2).

**Table 2**

Length of stay and outcomes according to primary final diagnosis.

	All (n=1499)	STEMI (n=334)	NSTEMI (n=438)	AHF (n=211)	Unexplained chest pain (n=102)	Cardiac conduction abnormality (n=83)	Myocarditis or pericarditis (n=73)	Atrial rhythm disorder (n=60)	Ventricular rhythm disorder (n=34)	Coronary spasm or coronary/aortic dissection or takotsubo (n=41)	PE (n=46)	Other (n=77)
Length of stay (days)												
ICCU stay	2.0 (1.0-4.0)	3.0 (2.0-4.0)	2.0 (1.0-3.0)	3.0 (2.0-5.0)	1.0 (0.0-1.0)	2.0 (1.0-3.0)	2.0 (1.0-3.2)	1.0 (1.0-2.0)	2.0 (1.0-3.7)	2.0 (1.0-3.0)	2.0 (2.0-3.0)	2.0 (1.0-3.0)
Hospital stay	4.0 (2.0-6.0)	4.0 (3.0-5.0)	3.0 (2.0-5.0)	7.0 (4.0-12.0)	1.0 (0.0-1.0)	4.0 (2.0-6.0)	4.0 (3.0-6.2)	2.0 (1.0-4.0)	5.5 (3.0-9.5)	5.0 (3.0-8.0)	5.0 (3.0-8.0)	4.0 (1.0-10.0)
Outcome												
MAE	67 (4.5)	17 (5.1)	16 (3.6)	22 (10.4)	0 (0)	2 (2.4)	1 (1.3)	1 (1.7)	1 (2.9)	2 (4.9)	0 (0)	5 (6.5)
Death	27 (1.8)	6 (1.8)	8 (1.8)	8 (3.8)	0 (0)	1 (1.2)	0 (0)	1 (1.7)	0 (0)	1 (2.4)	0 (0)	2 (2.6)
Death due to ventricular rhythm disorder	19 (1.3)	3 (1.0)	7 (1.6)	4 (1.9)	0 (0)	1 (1.2)	0 (0)	1 (1.7)	0 (0)	1 (2.4)	0 (0)	2 (2.6)
Resuscitated cardiac arrest	14 (0.9)	7 (2.1)	3 (0.7)	0 (0)	0 (0)	0 (0)	1 (1.3)	0 (0)	0 (0)	0 (0)	0 (0)	3 (3.9)
Cardiogenic shock	38 (2.5)	10 (3.0)	8 (1.8)	17 (8.1)	0 (0)	1 (1.2)	0 (0)	0 (0)	1 (2.9)	1 (2.4)	0 (0)	0 (0)
ICCU discharge												
Home	1127 (75.2)	251 (75.1)	334 (76.2)	131 (62.1)	97 (95.1)	64 (77.1)	59 (80.8)	53 (88.3)	25 (73.5)	29 (70.7)	34 (73.9)	49 (63.6)
Conventional cardiology service	188 (12.5)	49 (14.7)	50 (11.4)	37 (17.5)	3 (2.9)	12 (14.4)	7 (1.0)	4 (6.7)	7 (20.6)	5 (12.2)	7 (15.2)	7 (9.1)
Cardiovascular surgery	35 (2.3)	7 (2.1)	18 (4.1)	6 (2.8)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2.4)	0 (0)	3 (3.9)
Intensive care unit	10 (0.7)	3 (1.0)	3 (0.7)	1 (0.5)	0 (0)	0 (0)	1 (1.4)	0 (0)	0 (0)	2 (4.9)	0 (0)	0 (0)
Other	122 (8.1)	20 (6.0)	30 (6.8)	32 (15.2)	2 (2.0)	5 (6.0)	6 (8.2)	2 (3.3)	2 (5.9)	3 (7.3)	5 (10.9)	11 (14.3)

Data are expressed as number (%), mean  $\pm$  SD or median (interquartile range). AHF: acute heart failure; ICCU: intensive cardiac care unit; MAE: major adverse event; NSTEMI: non-ST-segment elevation myocardial infarction; STEMI: ST-segment elevation myocardial infarction; PE: pulmonary embolism.



**Fig. 1.** ICU management and therapies. CPBIA: intra-aortic balloon counterpulsation; ICA: invasive coronary angiogram; ICCU: intensive cardiac care unit; NIV CPAP: non-invasive ventilation and continuous positive airway pressure; PCI: percutaneous coronary intervention.

**Table 3**

Univariate and multivariable analysis of factors associated with prolonged in-hospital stay ( $\geq 6$  days).

Variable	Univariate		Multivariable	
	OR (95% CI)	P	OR (95% CI)	P
Age (per 1-year increase)	1.01 (1.01-1.02)	< 0.001	-	-
Body mass index (per 1 kg/m <sup>2</sup> increase)	1.02 (1.0-1.04)	0.076	-	-
Current smoker (vs. past or non-smoker)	0.71 (0.52-0.94)	0.018	-	-
Hypertension (vs. no)	1.22 (0.96-1.55)	0.10	-	-
Dyslipidaemia (vs. no)	1.56 (1.22-1.98)	< 0.001	1.71 (1.17-2.5)	0.006
Family history of coronary artery disease (vs. no)	0.47 (0.32-0.68)	< 0.001	-	-
Coronary artery disease <sup>a</sup>	0.55 (0.43-0.71)	< 0.001	-	-
Chronic kidney disease <sup>b</sup>	1.93 (1.34-2.74)	< 0.001	-	-
Intravenous diuretics (vs. no)	6.0 (4.52-7.99)	< 0.001	1.75 (1.06-2.87)	0.03
LVEF			Ref	-
$\geq 50\%$	Ref	-	Ref	-
40-50%	1.04 (0.67-1.59)	-	-	-
$\leq 40\%$	3.03 (2.29-4.01)	< 0.001	1.58 (1.04-2.37)	0.03
Systolic blood pressure at admission (per 1-mmHg increase)	1.05 (1.04-1.06)	< 0.001	1.03 (1.01-1.04)	< 0.001
Killip class $\geq 2$ (vs. 0 or 1)	5.08 (3.80-6.81)	< 0.001	1.8 (1.08-2.99)	0.02
Acute heart failure diagnosis at admission (vs. other)	5.08 (3.73-6.93)	< 0.001	-	-

CI: confidence interval; LVEF: left ventricular ejection fraction; OR: odds ratio.

<sup>a</sup> Myocardial infarction, percutaneous coronary intervention or coronary artery bypass graft.

<sup>b</sup> Estimated glomerular filtration rate < 60 mL/min.

**Table 4**  
Univariate and multivariable analysis of factors associated with prolonged in-hospital major adverse event.

Variable	Univariate		Multivariable	
	OR (95% CI)	P	OR (95% CI)	P
Age (per 1-year increase)	1.01 (1.0–1.03)	0.18	1.03 (1.0–1.06)	0.05
Current smoker (vs. past or non-smoker)	2.46 (1.49–4.04)	< 0.001	–	–
Family history of CAD (vs. no)	0.31 (0.09–0.76)	0.008	–	–
Diabetes (vs. no)	1.95 (1.10–3.20)	0.015	–	–
Chronic kidney disease <sup>a</sup>	1.94 (0.97–3.58)	0.06	–	–
Active cancer (vs. no)	1.98 (0.67–4.68)	0.16	–	–
LVEF (ref: ≥ 50%)				
40–50%	2.04 (0.85–4.4)		–	
< 40%	4.53 (2.7–7.8)	< 0.001	2.28 (1.06–4.97)	0.04
Killip class ≥ 2 (vs. 0 or 1)	4.64 (2.80–7.77)	< 0.001	–	–
Systolic blood pressure at admission (mmHg)	1.05 (1.03–1.06)	< 0.001	–	–
Intravenous diuretics (vs. no)	7.02 (4.26–11.7)	< 0.001	3.19 (1.21–8.70)	0.02
Acute heart failure diagnosis at admission (vs. other)	3.22 (1.86–5.42)	< 0.001	–	–

LVEF: left ventricular ejection fraction.

<sup>a</sup> Estimated glomerular filtration rate < 60 ml/min.

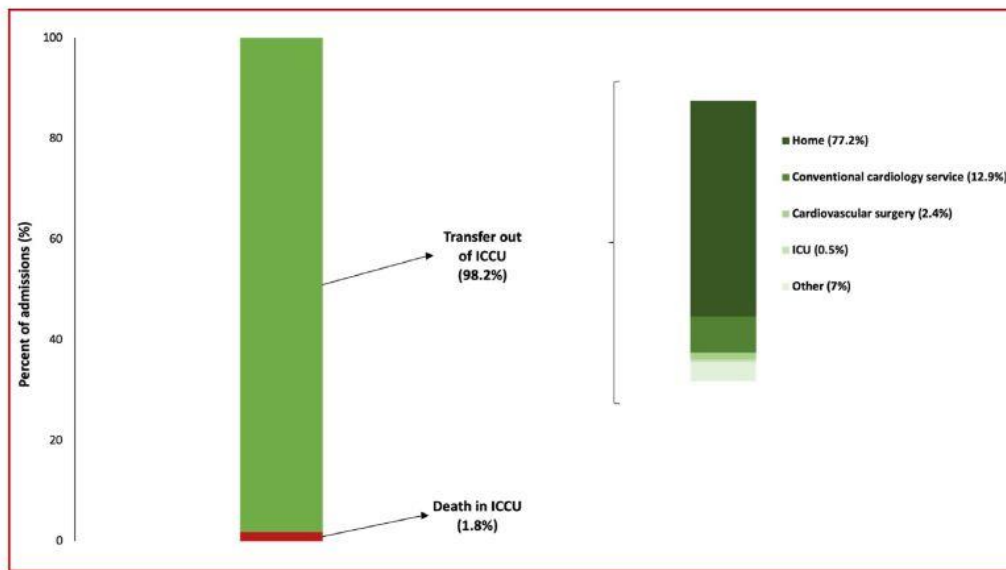


Fig. 2. ICCUs and hospital discharge. ICCU: intensive cardiac care unit; ICU: intensive care unit.

## 5. Discussion

In this prospective registry of consecutive patients hospitalized in ICCU, the main findings were:

- the main reason for admission to contemporary ICCU remains ACS, and accounted for half of admissions;

- beyond ACS patients, there was a large broader array of cardio-vascular disease with several comorbidities

- we found a low rate of in-hospital MAE, which varied considerably according to final diagnosis;

- the most important burden for ICCU in terms of resource consumption (advanced ICCU therapies, length of stay and outcomes) is patients with AHF; •we can isolate a significant subgroup of patients (44% of the cohort) with a very good in-hospital prognosis in terms of resource consumption and in-hospital outcomes.

The current study reports that the main reason for hospitalization in contemporary ICCU is still ACS, representing just over half of the overall population. This finding is consistent with previous European [[8]] and US [9] reports with, respectively, 49 and 32% of ACS among patients hospitalized in ICCU. However, this study also emphasizes an ongoing shift in the phenotypes of patients treated in ICCU towards a broader array of heterogeneous non-ACS population [7]. While ICCU were historically created for ACS [1,2,4], the decline in the proportion of admissions for ACS is concurrent with an increasing rate of non-acute coronary events and especially AHF. Indeed, the rate of patients admitted for AHF has increased in past years from 10% in 2014 [3, 8] to 15–36% in more recent registries [9], which is close to our findings. This observation could be explained by the increasing prevalence of heart failure in the European population probably related to ageing [10]. Beyond the ACS population and the emergence of AHF as the second indication for ICCU-level care, we describe the granularity of other non-ACS primary diagnoses, highlighting a strong heterogeneity in patients hospitalized in contemporary ICCU. To our knowledge, this is the first study reporting the prevalence of each cardiac primary diagnosis in a contemporary French ICCU registry through acquisition of individual patient-level data ensuring the high-fidelity capture of diagnosis, resource use and outcomes. Moreover, our findings emphasize the need to develop skills for managing AHF, acute respiratory or haemodynamic failure, handling rhythm disorders, and effectively using non-invasive cardiovascular imaging data to make accurate clinical decisions.

We reported a relatively low rate of in-hospital MAE of 4.5% and in-hospital death of 1.6%. While previous North American studies have shown a higher death rate, estimated around 8.5%, in patients hospitalized in ICCU [9,11], our results are consistent with French observational studies showing death rates closer to our findings, around 4.5% [3]. This relatively lower rate of in-hospital death in our study could be explained by the high proportion of ACS, which remains the primary reason for admission to contemporary ICCU. Indeed, death and adverse events among patients hospitalized for ACS has decreased in recent decades [3], and most are admitted to routine post myocardial infarction care with only cardiac monitoring without the requirement for advanced ICCU-based therapies [9]. Consistently, we shown in the current analysis that despite a high mean age, ACS patients exhibited a low rate of in-hospital MAE and most were discharged home directly after a short length of stay in the ICCU. These results highlight the favourable trend in recent decades for the pathway of care in ACS fields. Furthermore, in contrast to ICCU in the North America, where most cases involving out-of-hospital resuscitated cardiac arrest, cardiogenic shock or other acute cardiovascular diseases requiring advanced respiratory or haemodynamic management can be managed [9], French ICCU exhibit a lower level of commitment and intensity of care. This leads to a subsequently lower risk profile among patients admitted to these ICCU.

Our current findings suggest that AHF patients, in view of their relatively low prevalence (14%), represent one of the great-est burdens for ICCU in terms of advanced ICCU-based therapy consumption, prognosis and length of hospital stay compared with other patients admitted to ICCU. These results are consistent with previous studies using the French

nationwide administrative database for admission to ICCU [3]. Indeed, Roubille et al. described in 2014 that patients admitted with AHF were also significantly older with worse outcomes (in-hospital mortality 11%) and longer hospital stays (mean 12 days) [3]. We found similar results including an older age in our study (68 vs. 63 years for the overall population). Furthermore, in the current analysis, factors independently associated with the occurrence of MAE during hospitalization and prolonged in-hospital length of stay were mainly linked with AHF with use of intravenous diuretics, Killip class and LVEF  $\leq 40\%$ . All these data strongly suggest a critical need for global improvement in evidence-based therapies to improve AHF outcomes [12, 13].

In contrast to the high-risk subgroup with AHF, our study identified a low-risk subgroup of patients (44% of admissions) with NSTEMI or unexplained chest pain as the main final diagnosis. They had shorter hospital stays, high rates of discharge home, no need for advanced ICCU therapies and no in-hospital complications. Similar trends were observed in previous cohorts [9], with a significant proportion of patients admitted for monitoring only, associated with a low rate of in-hospital events. For these patients, alternative options such as chest pain units could be explored. Indeed, chest pain units can optimize resource use [14], reduce costs [15], and improve patient satisfaction [16]. Finally, risk stratification using more non-invasive cardiac imaging exploratory such coronary CT could be useful to manage and avoid some unnecessary ICA with inherent risks and costs. Indeed, in this subgroup of patients, half had ICA (50.0%), while only 10.8% benefitted from cross-sectional cardiac imaging, also reflecting difficulties of access to this type of non-invasive cardiac assessment in France.

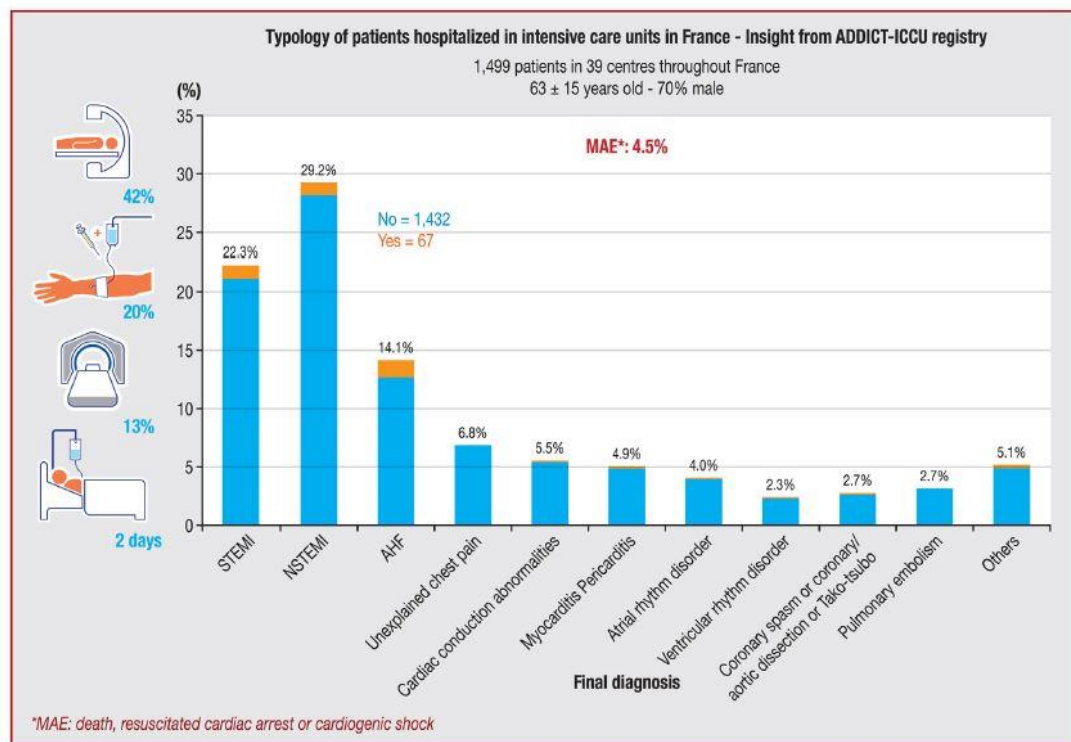
### **5.1. Study limitations**

We acknowledge some limitations. First, this is a single-country registry and caution should be taken before generalizing the results to other countries. Although the organization of ICCU and health systems vary from country to country, the findings of our study are in line with some previous European surveys in terms of the demographic features of the population and in-hospital outcomes. Second, this multicentre study was not exhaustively conducted in all French centres. Nevertheless, the 39 centres that participated included those in large metropolitan areas, medium-sized cities and overseas centres, university hospitals, non-university hospitals and private clinics, ensuring a representative sample of French ICCU. Moreover, given that data on nationwide activity in ICCU in France reports an average ICCU admission rate of 45 patients per centre over the 15-day inclusion period [8], the theoretical recruitment would have been 1755 patients over 39 centres. Therefore, our recruitment of 1904 patients is consistent with systematic and consecutive enrolment. Third, while a substantial proportion of patients is currently admitted to ICCU for planned interventional postprocedural observations or monitoring, we could not specifically investigate their in-hospital management and outcomes regarding the main exclusion criteria of this study. It is important to remember that during the first week of the study, only patients aged  $< 75$  years were admitted. If all consecutive patients had been admitted during the survey, the mean age of the population would have been 66 years instead of 63. Fourth, death occurring after transfer to a general intensive care unit is not reported. However, given the very low number

of patients transferred to general intensive care, we can assume that our rate of in-hospital MAE could be only slightly underestimated. Finally, for some final diagnoses, it is difficult to interpret the rate of MAE found when the number of patients was low.

## 6. Conclusion

In this large multicentre, prospective study of consecutive patients hospitalized in French ICCU, our study adds to the growing body of evidence demonstrating the evolving landscape of cardiac critical care. Although ACS remains the primary reason for triage to ICCU, AHF represents a significant burden in terms of resource use, length of stay and in-hospital outcomes. Heterogeneity regarding the distribution, management and in-hospital prognosis of non-ACS primary diagnosis revealed potential areas for help in redesigning the landscape of cardiac critical care (Central Illustration).



**Central Illustration.** In-hospital major adverse events according to main final diagnosis. AHF: acute heart failure; NSTEMI: non-ST-segment elevation myocardial infarction; STEMI: ST-segment elevation myocardial infarction.

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## Disclosure of interest

The authors declare that they have no competing interest.

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