



Admission reasons, procedures, and mortality of elderly patients in CICU: the SAGE-CICU study (study on acute gaps in the elderly - cardiac intensive care unit)

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Abstract

Background The growing proportion of elderly patients admitted to cardiac intensive care units (CICUs) presents specific challenges, including complex comorbidity profiles, divergent diagnostic patterns, and reduced access to invasive therapies. Current guidelines, derived predominantly from younger cohorts, offer limited guidance for managing these high-risk patients. A better understanding of their acute cardiovascular care needs is crucial to support tailored clinical decision-making and effective resource allocation.

Methods We conducted a retrospective, single-center observational study including all CICU admissions at Fondazione Policlinico Universitario A. Gemelli IRCCS (Rome, Italy) from November 2020 to April 2024. Patients were stratified by age (<75 and ≥75 years). Primary outcomes included admission diagnoses, in-hospital interventions, and CICU mortality. Secondary outcomes were length of stay (LOS) and survival at follow-up.

Results Among 2,541 patients (mean age 69.3 ± 14.7 years), 41.4% were aged ≥75 years. Compared to younger patients, elderly individuals were more frequently admitted for atrioventricular block, valvular disease, atrial fibrillation and Takotsubo syndrome (TTS), and less often for STEMI, myocarditis and pulmonary embolism. The procedural approach also differed between groups: elderly patients underwent fewer coronary angiographies, percutaneous coronary interventions, Impella CP use, and transcatheter arrhythmia ablations, while receiving more frequent pacemaker implantations, transcatheter aortic valve replacement (TAVR), and aortic valvuloplasty. Length of stay was similar between the two groups, while it was significantly reduced in patients aged >85 and >90 years. CICU mortality was higher in patients over 75 years (9.7% vs. 4.1%, $p < 0.001$), particularly in the context of acute heart failure (13% vs. 5.6%, $p < 0.001$), STEMI (14.9% vs. 2.4%, $p < 0.001$), NSTEMI (10.2% vs. 2.6%, $p < 0.001$), and cardiogenic shock (53.8% vs. 32.6%, $p < 0.001$). Survival times at follow-up were significantly reduced in older patients across most diagnoses, with the most adverse outcomes observed in patients with cardiogenic shock.

Conclusions Elderly patients admitted to CICU display distinct clinical characteristics, procedural patterns, and outcomes compared to younger individuals. These findings enhance our understanding of the acute cardiovascular care needs in older adults and provide a data-driven foundation to inform resource allocation, priority setting, and the development of age-specific management strategies in CICU practice.

Keywords Elderly · CICU · Cardiovascular outcomes · Invasive cardiac procedures · Mortality and survival analysis

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Background

The aging of the global population has significant implications for healthcare systems, particularly in cardiovascular care. As life expectancy increases, more elderly patients present with acute cardiovascular conditions that may require admission to cardiac intensive care units (CICUs). This demographic shift introduces unique challenges, as managing elderly patients in CICUs is complicated by multiple comorbidities, varying degrees of frailty, heterogeneous clinical presentations, and different responses to treatment, all contributing to poorer prognoses [1, 2]. Current clinical guidelines are often based on studies excluding older adults and those with significant comorbidities, limiting their relevance for this population. Additionally, the definition of “elderly” is not consistent, and biological age doesn’t always align with chronological age. A recent statement from the American Heart Association (AHA) uses 75 years as the cutoff to describe the complexities of geriatric patients in the CICU [3].

Moreover, patient-centered outcomes for the elderly may differ from those of younger patients, extending beyond survival to include quality of life, functional independence, and return to pre-admission activity levels [4]. There is a pressing need for personalized approaches to managing elderly patients in CICUs. The success of such strategies depends on understanding the specific acute cardiovascular healthcare needs of this group, which are poorly characterized [5, 6]. This study aims to address this gap by characterizing the reasons for CICU admission, the spectrum of invasive management, and the mortality of elderly patients.

Methods

Study objectives

This study aimed to examine age-related differences in clinical presentation, management strategies, and outcomes among patients admitted to a cardiac intensive care unit (CICU). The analysis focused on comparing the distribution of cardiovascular admission diagnoses between patients aged 18–74 and those aged 75 years or older, evaluating differential patterns in the use of diagnostic and therapeutic interventions according to presenting condition, and assessing age-stratified in-CICU mortality, length of stay, and long-term survival.

The chosen age cutoff of 75 years, although arbitrary, aligns with thresholds reported in other published studies [7, 8], and has been endorsed by a recent AHA statement addressing the complexity of geriatric patients in the CICU [3].

Study design and setting

This was a retrospective, single-center observational study conducted at the CICU of IRCCS Fondazione Policlinico Universitario A. Gemelli, Rome, Italy. The study included all adult patients (aged ≥ 18 years) admitted to the CICU between November 1, 2020, and April 30, 2024, with follow-up extended until October 30, 2024. Patients aged < 18 years were excluded. The study hospital is a large surgical/interventional tertiary care center without active heart transplant or long-term ventricular assist device (LVAD) programs. The CICU is among the largest in Italy and provides 24/7 access to advanced mechanical circulatory support [9]. Admission criteria for the CICU, which do not include age as an exclusion criterion, are detailed in Supplementary Material. Notably, the CICU exclusively admits patients with acute cardiovascular conditions and does not include postoperative patients after cardiac surgery.

Outcomes

Primary outcomes

- *Admission diagnoses:* Proportion of patients aged 18–74 and ≥ 75 years diagnosed with specific cardiovascular conditions (e.g., ST-elevation myocardial infarction [STEMI], acute heart failure, cardiogenic shock) at CICU admission.
- *Utilization of diagnostic and therapeutic interventions:* Frequency of diagnostic procedures (e.g., coronary angiography) and therapeutic interventions (e.g., percutaneous coronary intervention [PCI], mechanical circulatory support) stratified by age group and diagnosis.
- *In-CICU mortality rates:* Mortality rates for patients aged 18–74 and ≥ 75 years, according to specific admission reason. Analysis also evaluated differences in overall mortality at age cutoffs of 80, 85, and 90 years.

Secondary outcomes

- *Length of CICU stay:* Average length of stay for patients aged 18–74 and ≥ 75 years. Analysis also evaluated stay duration at age cutoffs of 80, 85, and 90 years.
- *Long-term survival:* Survival time (in days) from admission to CICU until either death or end of follow-up (October 30, 2024), for patients aged 18–74 and ≥ 75 years, by specific admission diagnosis.

Data collection

Clinical data were extracted from the institutional Patient Data Management System (Digistat, GE Healthcare). Collected variables included age, sex, cardiovascular risk factors, admission diagnosis (classified by ICD-9 codes), performed diagnostic and therapeutic procedures, and CICU length of stay, using the Gemelli GENERATOR Real World Data (G2 RWD) Facility, which also provided pseudonymized follow-up data up to October 30, 2024. The study protocol was approved by the Ethics Committee of Lazio Area 3 (approval ID 7293, December 19, 2024).

Statistical analysis

Descriptive statistics summarized baseline patient characteristics. Continuous variables were tested for normality using the Shapiro-Wilk test and expressed as means \pm standard deviations (SD) or medians with interquartile ranges (IQR), as appropriate. Categorical variables were presented as frequencies and percentages. Comparisons between age groups were made using the independent samples t-test (or Mann-Whitney U test) for continuous variables and chi-square test (or Fisher's exact test) for categorical variables. The Mantel-Haenszel common odds ratio (OR) estimate was used to assess associations between age groups and specific clinical conditions or interventions. The OR were calculated with corresponding standard errors to evaluate statistical significance. Relative risks (RR) were also calculated to provide complementary measures of association between age groups and specific outcomes or interventions, where appropriate (highly prevalent conditions). Survival time was analyzed using the Kaplan-Meier method,

with Log-rank tests for comparisons. All analyses were two-tailed, and a p-value of less than 0.05 was considered statistically significant. All statistical analyses were conducted using IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA).

Results

A total of 2,541 patients (mean age 69.3 ± 14.7 years, males 1,710 [67.3%]) were included in our analysis. Among these patients, 1,052 (41.4%) were over 75 years old, 670 (26.4%) over 80, 300 (11.8%) over 85, and 49 (1.9%) over 90. The baseline demographic characteristics and risk factors of the population, stratified by an age cutoff of 75 years, are reported in Table 1. Although the male population was predominant in both age groups, the percentage of women is significantly higher in the over-75 population (41.7% vs. 26.3%, $p < 0.001$).

Admission reasons to CICU

The most frequent diagnoses leading to CICU admission in the overall population were acute heart failure (AHF) (48.6%), ST-elevation myocardial infarction (STEMI) (23.2%), non-ST-elevation myocardial infarction (NSTEMI) (19.6%), valvular disease (15.9%), and atrial fibrillation (AF) (15.9%).

Compared to younger patients, those over 75 years were significantly more likely to have valvular disease (24.4% vs. 9.8%, $p < 0.001$), AF (21.8% vs. 11.8%, $p < 0.001$), atrio-ventricular block (AVB) (18.3% vs. 5.6%, $p < 0.001$), and Tako-Tsubo syndrome (TTS) (4.3% vs. 2.1%, $p = 0.003$). Conversely, patients over 75 years were significantly less likely to be admitted for STEMI (16.0% vs. 28.3%, $p < 0.001$), myocarditis (0.2% vs. 3.6%, $p < 0.001$), and high-risk pulmonary embolism (1.1% vs. 3.3%, $p < 0.001$).

The distribution of other CICU admission reasons did not differ significantly between patients under and over 75 years in our cohort (Table 2).

Comparisons of cardiovascular conditions leading to CICU admission based on age cutoffs of 80, 85, and 90 years are provided in the Supplementary Material (Tables 9, 10 and 11).

Procedures performed during the CICU stay

Table 3 presents the comparison of procedures performed during CICU hospitalization in patients under and over 75 years of age, stratified by admission diagnosis. Among patients admitted with cardiogenic shock, those aged ≥ 75 years were significantly less likely to receive Impella

Table 1 Baseline characteristics stratified by age cutoff of 75 years

	Overall	Under 75	Over 75	p-value**
Age (mean \pm SD)	69.3 \pm 14.7	60.2 \pm 12.4	82.3 \pm 4.7	NA
Sex, male (n, %)	1710 (67.3%)	1097 (73.7%)	613 (58.3%)	<0.001
Diabetes* (n, %)	642 (28.5%)	326 (25.2%)	316 (32.8%)	<0.001
Hypertension* (n, %)	1683 (74.6%)	848 (65.6%)	835 (86.6%)	<0.001
Obesity* (n, %)	211 (9.6%)	147 (11.4%)	64 (6.6%)	<0.001
Hypercholesterolemia* (n, %)	1149 (50.9%)	590 (45.7%)	559 (58.0%)	<0.001
Active Smoker* (n, %)	572 (25.4%)	459 (35.5%)	113 (11.7%)	<0.001
Previous Smoker* (n, %)	662 (29.3%)	348 (26.9%)	314 (32.6%)	0.004

* Available data for 2256 patients out of 2541 (88.8%). % refers to total of 2256 pts

** p-value refers to comparison between under 75 and over 75 subgroups

Table 2 Admission reasons to CICU– under/over 75

Admission reason (ICD9 Diagnosis)	Over 75 (n)	Over 75 (%)	Under 75 (n)	Under 75 (%)	Total (n)	Total (%)	p-value
Acute heart failure	509	48.4	726	48.8	1235	48.6	0.872
STEMI	168	16.0	421	28.3	589	23.2	<0.001
NSTEMI	196	18.6	302	20.3	498	19.6	0.311
Atrial fibrillation	229	21.8	176	11.8	405	15.9	<0.001
Valvular disease	257	24.4	146	9.8	403	15.9	<0.001
Atrio-ventricular block	193	18.3	83	5.6	276	10.9	<0.001
Device complication	73	6.9	90	6.0	163	6.4	0.367
Cardiogenic shock	65	6.2	89	6.0	154	6.1	0.866
Pericardial disease	59	5.6	94	6.3	153	6.0	0.499
Ventricular tachycardia	45	4.3	85	5.7	130	5.1	0.120
Endocarditis	52	4.9	73	4.9	125	4.9	1.000
Cardiac arrest	46	4.4	55	3.7	101	4.0	0.410
Septic shock	35	3.3	43	2.9	78	3.1	0.560
Takotsubo syndrome	45	4.3	32	2.1	77	3.0	0.003
Acute aortic syndrome	23	2.2	44	3.0	67	2.6	0.259
Unstable angina	23	2.2	44	3.0	67	2.6	0.259
High risk pulmonary embolism	12	1.1	49	3.3	61	2.4	<0.001
Myocarditis	2	0.2	54	3.6	56	2.2	<0.001
Mechanical complication of AMI	8	0.8	11	0.7	19	0.7	1.000
Other types of shock	4	0.4	6	0.4	10	0.4	1.000

Table 3 ICD9 specific procedures comparison under/over 75

Condition (ICD9 Diagnosis)	Procedure	Over 75 (% procedures/ total ICD9)	Under 75 (% procedures/ total ICD9)	p- value	Odds ratio [CI 95%]
AHF	IABP	4.9	3.8	0.394	1.29 [0.74–2.24]
AHF	Dialysis	3.1	1.9	0.191	1.65 [0.80–3.41]
Atrial fibrillation	Ablation	0.9	4.5	0.023	0.18 [0.03–0.88]
AVB	PM implantation	72	53	0.003	2.28 [1.34–3.89]
Cardiac arrest	Coronary angiography	54.3	65.4	0.309	0.63 [0.28–1.40]
Cardiac arrest	Invasive mechanical ventilation	32.6	25.4	0.510	1.41 [0.59–3.36]
Cardiogenic shock	IABP	15.4	10.1	0.335	1.61 [0.61–4.23]
Cardiogenic shock	Impella	6.1	19.1	0.031	0.27 [0.09–0.87]
Cardiogenic shock	ECMO	0	2.2	0.509	Not Computable
Cardiogenic shock	Invasive mechanical ventilation	16.9	15.7	1.000	1.09 [0.46–2.58]
Mechanical complication of AMI	IABP	50	54.5	1.000	0.83 [0.13–5.14]
Myocarditis	EMB	50	5.5	0.139	17.00 [0.84–343.66]
NSTEMI	Coronary angiography	72.4	79.8	0.064	0.67 [0.44–1.01]
NSTEMI	CABG	4.6	10.6	0.019	0.41 [0.18–0.87]
NSTEMI	PCI	46.4	44.7	0.713	1.07 [0.74–1.54]
Pericardial disease	Pericardiocentesis	69.5	65.6	0.725	1.17 [0.58–2.36]
STEMI	Coronary angiography	82.1	93.3	<0.001	0.33 [0.18–0.59]
STEMI	PCI	79.2	86.4	0.033	0.59 [0.37–0.94]
STEMI	CABG	0	0.9	0.113	Not Computable
Valvular disease	Balloon aortic valvuloplasty	5.4	0.7	0.013	8.35 [1.08–64.19]
Valvular disease	(T)AVR	33.9	16.4	<0.001	2.60 [1.56–4.32]
Valvular disease	MVR	8.6	13.7	0.127	0.59 [0.31–1.12]
Valvular disease	TVR	0.8	1.4	0.623	0.56 [0.08–4.05]
Ventricular tachycardia	Ablation	4.4	18.8	0.031	0.20 [0.04–0.91]

Table 4 Length of stay (LOS)

	Age Group	N	Mean LOS	Std. Deviation	p-value (Two-Sided)	Mean Difference	Cohen's d
Split 75	≤75	1489	5,39	8,11	0,472	0,23	0,029
	>75	1052	5,62	7,27			
Split 80	≤80	1871	5,60	8,01	0,237	0,41	0,053
	>80	670	5,18	7,06			
Split 85	≤85	2241	5,63	8,10	<0,001	1,19	0,15
	>85	300	4,43	4,51			
Split 90	≤90	2492	5,52	7,82	0,002	1,82	0,23
	>90	49	3,69	3,70			

Table 5 Mortality rates in CICU by age groups

	Age Group	N	Deaths	Death Rate (%)	p-value	Odds ratio [95% CI]
Split 75	≤75	1489	61	4.1	<0.001	2.51 [1.81–3.49]
	>75	1052	102	9.7		
Split 80	≤80	1871	89	4.8	<0.001	2.48 [1.80–3.43]
	>80	670	74	11.0		
Split 85	≤85	2241	129	5.8	<0.001	2.09 [1.40–3.12]
	>85	300	34	11.3		
Split 90	≤90	2492	155	6.2	0.004	2.94 [1.36–6.38]
	>90	49	8	16.3		

support compared to younger patients (6.1% vs. 19.1%; $p=0.03$, OR 0.27 [95% CI 0.09–0.87]). In the same diagnostic group, the use of intra-aortic balloon pump (IABP) was similar between age groups (15.4% vs. 10.1%; $p=0.33$). For patients admitted with acute heart failure, no significant difference in IABP utilization was observed (4.9% vs. 3.8%; $p=0.39$). Notably, no patient aged ≥ 75 years underwent extracorporeal membrane oxygenation (ECMO). (Table 3)

In patients with STEMI, both coronary angiography and PCI were performed less frequently in those over 75 years (82.1% vs. 93.3%, $p<0.001$, OR 0.33 [95% CI 0.18–0.59], RR 0.88 for coronary angiography; 79.2% vs. 86.5%, $p=0.03$, OR 0.59 [95% CI 0.37–0.94], RR 0.92 for PCI). Similarly, older patients with NSTEMI exhibited lower rates of CABG (4.6% vs. 10.6%, $p=0.019$, OR 0.41 [95% CI 0.18–0.87]).

Among patients admitted with AF, ablation procedures were performed significantly less frequently in those aged ≥ 75 years compared to younger patients (0.9% vs. 4.5%; $p=0.023$, OR 0.18 [95% CI 0.03–0.88]). A similar age-related disparity was observed in patients with ventricular tachycardia, where ablation was performed in 4.4% of older patients versus 18.8% of those under 75 years ($p=0.031$, OR 0.20 [95% CI 0.04–0.91]).

Conversely, patients over 75 years with valvular disease were more likely to undergo balloon aortic valvuloplasty (BAV) (5.4% vs. 0.7%, $p=0.013$, OR 8.35 [95% CI 1.08–64.19]) and transcatheter aortic valve replacement (TAVR) (33.9% vs. 16.4%, $p<0.001$, OR 2.60 [95% CI 1.56–4.32]). A significant difference was also observed for atrioventricular block (AVB), with pacemaker implantation being more

frequent in the older group (72% vs. 53%, $p=0.003$, OR 2.28 [95% CI 1.34–3.89]).

No other significant differences in the execution of procedures for specific conditions were observed, as detailed in Table 3. A comparison of all procedures performed during CICU hospitalization between patients under and over 75 years, regardless of admission reasons, is provided in Table 12, Supplementary Material.

Length of hospital stay (LOS)

The overall mean length of hospital stay was 5.48 ± 7.76 days. For patients over 75 years, the LOS was 5.62 ± 7.27 days, compared to 5.39 ± 8.11 days for younger patients ($p=0.47$). In the prespecified age-stratified analysis, CICU length of stay was significantly shorter in patients over 85 years (4.43 ± 4.51 vs. 5.63 ± 8.10 days; $p<0.001$), with a similar reduction observed beyond 90 years of age (3.69 ± 3.70 vs. 5.52 ± 7.82 days; $p=0.002$) (Table 4).

Mortality rates in the CICU

The overall mortality rate in CICU was 6.4% (163/2541). Patients over 75 years had a significantly higher mortality rate of 9.7%, compared to 4.1% for those under 75 ($p<0.001$, OR 2.51 [95% CI 1.81–3.48]) (Table 5).

Several conditions were associated with a significantly higher mortality rate in patients over 75 years of age compared to their younger counterparts (Table 6). These conditions include AHF (13% vs. 5.6%, $p<0.001$), NSTEMI (10.2 vs. 2.6%, $p<0.001$), STEMI (14.9% vs. 2.4%

Table 6 ICD9 specific mortality rate in CICU comparison under/over 75

Condition– ICD9 Diagnosis	Over 75 death (%)	Under 75 death (%)	<i>p</i> -value	Odds ratio [CI 95%]	Relative Risk
Acute aortic syndrome	8.7	9.1	1.000	0.95 [0.16–5.63]	0.95
Cardiac arrest	32.6	25.5	0.510	1.42 [0.60–3.37]	1.27
Acute heart failure	13	5.6	<0.001	2.49 [1.66–3.74]	2.32
Atrial fibrillation	12.7	6.8	0.067	1.98 [0.98–4.01]	1.86
Atrio-ventricular block	5.7	2.4	0.356	2.45 [0.53–11.30]	2.37
Endocarditis	9.6	13.7	0.584	0.67 [0.22–2.09]	0.7
Myocarditis	0	0	Not Applicable	Not Computable	Not Computable
NSTEMI	10.2	2.6	<0.001	4.18 [1.80–9.68]	3.92
High risk pulmonary embolism	16.7	16.3	1.000	1.02 [0.18–5.59]	1.02
Pericardial disease	13.6	4.3	0.060	3.52 [1.00–12.30]	3.16
Cardiogenic shock	53.8	32.6	0.013	2.41 [1.25–4.67]	1.65
Septic shock	40	30.2	0.474	1.53 [0.60–3.93]	1.32
STEMI	14.9	2.4	<0.001	7.19 [3.37–15.33]	6.2
Takotsubo syndrome	6.7	3.1	0.637	2.21 [0.22–22.31]	2.16
Unstable angina	0	2.3	1.000	Not Computable	Not Computable
Valvular disease	10.1	6.8	0.364	1.53 [0.71–3.27]	1.48
Ventricular tachycardia	8.9	5.9	0.718	1.56 [0.40–6.13]	1.5

$p < 0.001$), cardiogenic shock (53.8% vs. 32.6%, $p = 0.013$). No significant differences in CICU mortality were observed for the remaining conditions in our cohort (Table 6).

Stratification by increasing age thresholds showed a progressive rise in in-CICU mortality among the oldest patients. Mortality was significantly higher in those aged ≥ 80 years compared to those under 80 (11.0% vs. 4.8%; $p < 0.001$, OR 2.48 [95% CI 1.80–3.43]). This pattern was confirmed at the ≥ 85 years cutoff (11.3% vs. 5.8%; $p < 0.001$, OR 2.09 [95% CI 1.40–3.11]) and became even more pronounced among patients aged ≥ 90 years, where mortality reached 16.3% compared to 6.2% in those under 90 ($p = 0.004$, OR 2.94 [95% CI 1.35–6.38]) (Table 5).

Survival analysis

Patients younger than 75 years had a significantly longer mean survival of 1352.7 days (95% CI: 1320.0–1385.4), compared to 891.9 days (95% CI: 853.7–930.1) in those aged 75 years or older (Log-Rank $p < 0.001$; Fig. 1).

The Kaplan-Meier analysis stratified by primary admission reason to CICU (AVB, STEMI, NSTEMI, Cardiac Arrest, AHF, Cardiogenic Shock and TTS) and age groups (under and over 75 years) revealed significant differences in survival times across various cardiac diagnoses (Table 7; Fig. 2).

For patients under 75 years, the longest mean survival times were observed in STEMI (1292.0 days) and TTS (1232.6 days). Cardiogenic shock had the shortest mean survival time at 687.4 days.

For patients over 75 years, the highest mean survival times were observed for AVB (1081.6 days), while

cardiogenic shock exhibited the poorest outcomes with a mean survival of 281.0 days.

Statistical comparisons revealed significant differences in survival between the under 75 group and the over 75 group for each condition ($p < 0.01$ for all comparisons), except for AVB ($p = 0.091$).

Pairwise comparisons between various admission reasons in the older cohort (over 75) revealed no significant difference in survival between STEMI, NSTEMI and TTS patients. Cardiogenic shock had a significantly worse survival compared to each other diagnosis (Table 8, see Figs. 3 and 4 in Supplementary material for the other survival analysis plots).

Discussion

In this study of 2,541 CICU admissions, including more than 1,000 elderly patients, we provide age-stratified data on admission diagnoses, procedural management, length of stay, and both short- and long-term mortality.

Older patients were more frequently admitted for conditions reflecting chronic or degenerative cardiovascular pathology, such as AHF, valvular heart disease, AF and AVB (Table 2). Notably, AHF emerged as the leading reason for CICU admission in the elderly. The overrepresentation of these conditions underscores the distinct epidemiological profile of critical cardiovascular illness in older adults. CICUs should implement rapid geriatric assessment pathways for patients admitted with AHF or valvular disease to identify frailty and comorbidities early, facilitating tailored

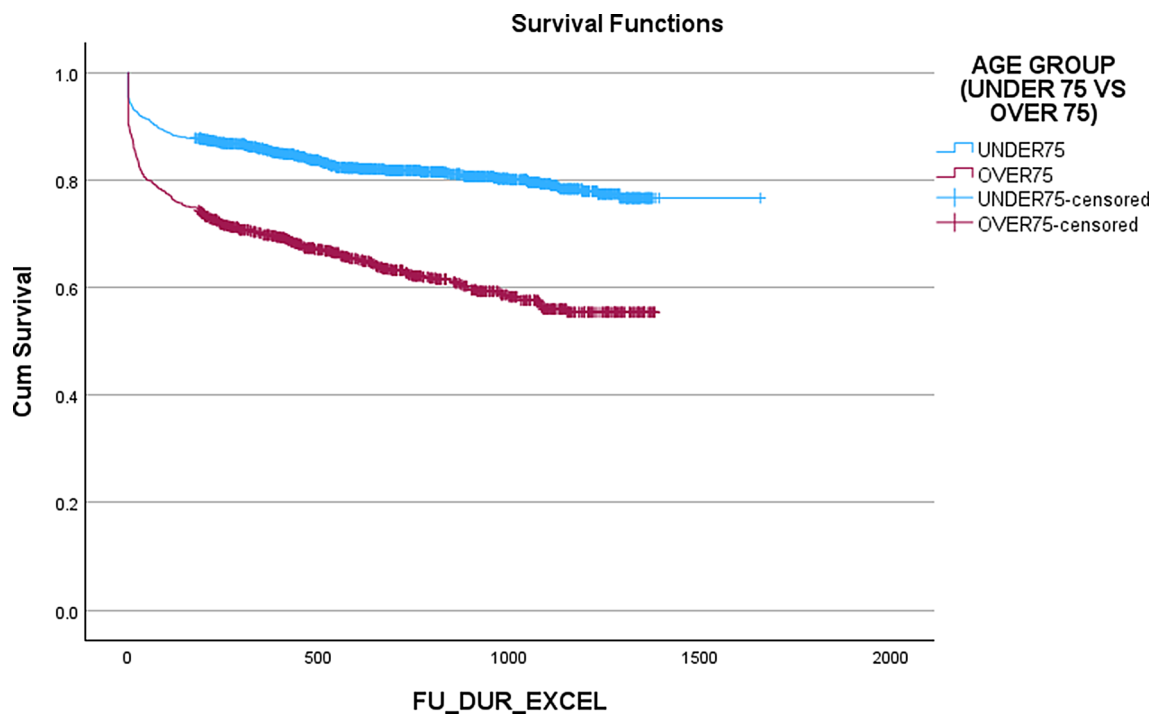


Fig. 1 Kaplan Meier curves, according to 75 years age cutoff

Table 7 Mean survival time according to cardiac diagnosis and age group

Primary reason for hospitalization	Mean Survival (days)	95% CI	Mean Survival (days)	95% CI	<i>p</i> -value
	Under 75		Over 75		
AVB	1142.3	1029.8–1254.9	1081.6	1000.7–1162.4	0.091
STEMI	1292.0	1261.0–1323.0	905.1	807.9–1002.3	<0.001
NSTEMI	1192.2	1138.1–1246.4	951.0	861.4–1040.6	<0.001
Cardiac arrest	935.5	745.8–1125.3	547.5	359.4–735.6	<0.001
Cardiogenic shock	687.4	483.8–891.0	281.0	107.4–454.6	<0.001
AHF	979.8	884.6–1075.0	663.6	544.7–782.4	<0.001
TTS	1232.6	1086.8–1378.4	820.2	646.9–993.5	0.004

care plans that align with patient preferences and anticipated outcomes.

Interestingly, our finding of a higher rate of TTS in elderly patients (Table 2) contrasts with previous large-scale registries [10], potentially indicating regional variations or improved diagnostic sensitivity.

The frequency of STEMI was significantly lower in patients over 75 years compared to those under 75 (16% vs. 28.3% of CICU admissions), whereas NSTEMI rates were similar across age groups. This pattern likely reflects age-related changes in plaque morphology and instability mechanisms, as demonstrated in prior intracoronary imaging and non-invasive diagnostic studies [11, 12].

Elderly patients with acute coronary syndromes (ACS) underwent fewer invasive procedures than their younger counterparts. While the lower rate of CABG in older adults with NSTEMI is expected—due to higher perioperative

risk and prolonged recovery—the reduced use of invasive strategies in STEMI patients is more surprising, though consistent with prior registries [13, 14]. Both coronary angiography and PCI were significantly less frequent in elderly STEMI patients (Table 3), despite the well-established mortality benefit of timely revascularization. This discrepancy is concerning, especially given the elevated ischemic risk in older individuals, who might stand to benefit the most from such interventions [15].

Several factors may underlie this pattern, including delayed presentation leading to ineligibility for revascularization, heightened concerns over bleeding or contrast nephropathy, or patient/family preferences for conservative management. In many cases, invasive procedures may have been deferred due to inadequate hemodynamic stabilization.

A contributing factor may have been the lower use of temporary Mechanical Circulatory Support (tMCS), such as

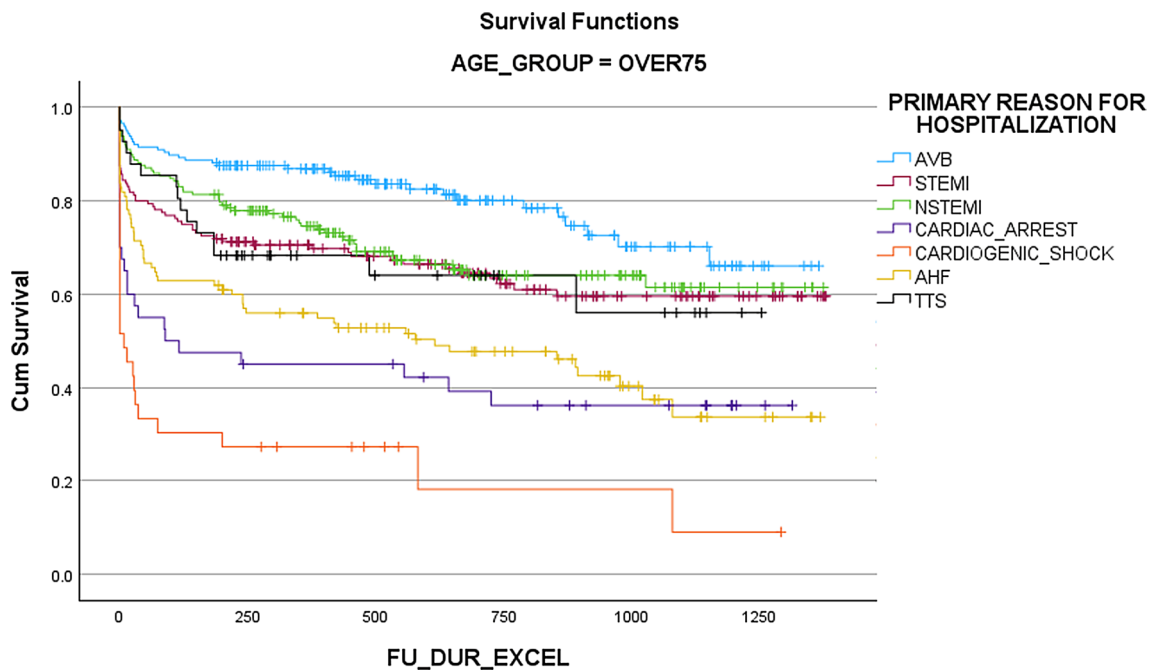


Fig. 2 Kaplan Meier curves in patients over 75 according to primary admission reason to CICU

Table 8 Pairwise log rank comparisons for primary admission reasons in over 75 group

Diagnosis 1	Diagnosis 2	Chi-Square	p-value
AVB (1)	STEMI (2)	3.577	0.059
AVB (1)	NSTEMI (3)	4.318	0.038
AVB (1)	Cardiac arrest (4)	30.304	<0.001
AVB (1)	Cardiogenic shock (5)	82.650	<0.001
AVB (1)	AHF (6)	35.756	<0.001
AVB (1)	TTS (7)	2.760	0.097
STEMI (2)	NSTEMI (3)	2.219	0.136
STEMI (2)	Cardiac arrest (4)	27.378	<0.001
STEMI (2)	Cardiogenic shock (5)	108.047	<0.001
STEMI (2)	AHF (6)	41.398	<0.001
STEMI (2)	TTS (7)	0.320	0.572
NSTEMI (3)	Cardiac arrest (4)	22.951	<0.001
NSTEMI (3)	Cardiogenic shock (5)	95.176	<0.001
NSTEMI (3)	AHF (6)	27.170	<0.001
NSTEMI (3)	TTS (7)	0.134	0.714
Cardiac arrest (4)	Cardiogenic shock (5)	7.177	0.007
Cardiac arrest (4)	AHF (6)	0.812	0.368
Cardiac arrest (4)	TTS (7)	9.483	0.002
Cardiogenic shock (5)	AHF (6)	22.857	<0.001
Cardiogenic shock (5)	TTS (7)	31.843	<0.001
AHF (6)	TTS (7)	6.774	0.009

Impella CP, in elderly patients presenting with cardiogenic shock (Table 3). No patient over 75 years was supported with ECMO, while no significant differences were observed in the use of IABP between the two groups (Table 3). These trends likely reflect a combination of perceived procedural risk, comorbidity burden, and concerns about clinical futility. Additionally, older patients are underrepresented in

cardiogenic shock trials, resulting in a significant evidence gap for this population [16]. The decision to employ tMCS requires a careful discussion of goals, potential benefits, and exit strategies, ideally by a multidisciplinary team.

Our findings underscore the need to improve access to evidence-based therapies through enhanced risk stratification tools and shared decision-making frameworks that balance procedural risks with potential benefits in older adults.

Device-based interventions, such as pacemaker implantation and cardiac implantable electronic device (CIED) revision or extraction, were significantly more common in elderly patients (Tables 3 and 12 of Supplementary Material), aligning with the increased prevalence of conduction disease and device-related complications in this population [17].

In contrast, catheter ablation procedures for AF and ventricular tachycardia (VT) were significantly underutilized (Table 3). Although concerns about procedural risk and limited long-term efficacy may explain this trend, the data suggest a potential opportunity to reassess the threshold for offering rhythm control strategies in well-selected elderly patients [18]. Prospective trials focusing on procedural outcomes and quality-of-life metrics following ablation in older adults are needed to refine current decision-making paradigms.

The significantly higher rates of TAVR and BAV observed among elderly patients underscore the burden of degenerative valvular disease in this population (Tables 2 and 3), with severe aortic stenosis affecting approximately 3.4% of individuals over 75 years of age [19]. In older patients, TAVR

has emerged as the preferred option, given its minimally invasive approach, particularly in those with high surgical risk profiles [20]. Furthermore, recent evidence has demonstrated the efficacy of TAVR even in individuals with low to intermediate surgical risk, supporting its increasing use as a therapeutic option in the elderly [21]. BAV, on the other hand, can serve as an effective tool to achieve hemodynamic stabilization in patients with cardiogenic shock, acting as a bridge to further definitive interventions [22]. Future studies should evaluate whether earlier referral and expedited work-up for TAVR among elderly CICU patients lead to improved clinical outcomes and reduced readmission rates.

Length of stay (LOS) analyses showed no difference between patients above and below 75 years; however, significantly shorter LOS was observed in patients over 85 and over 90 years (Table 4). This reduction may reflect various factors, including early limitations of care, palliative management decisions, or rapid resolution of conditions such as AVB following pacemaker implantation. Notably, mortality rates increased significantly with advancing age, peaking in nonagenarians (Table 5). These findings raise questions about the balance between intensive care resource use and clinical benefit in the very elderly. Research is needed to determine whether shorter LOS in this population is associated with improved efficiency or reflects early de-escalation of care in the context of limited prognosis.

Our study also identified specific conditions associated with significantly higher mortality in the CICU among patients over 75 years compared to younger individuals, including AHF, NSTEMI, STEMI and cardiogenic shock (Table 6). These findings underscore the vulnerability of older adults to poor in-hospital outcomes and highlight the need for proactive risk stratification tools that incorporate geriatric parameters [23]. The extent to which access to invasive procedures may have influenced these outcomes is beyond the scope of this study.

Survival analyses confirmed the heightened long-term mortality risk in older patients compared to their younger counterparts (Fig. 1), consistent with well-documented trends in aging populations [24]. Notably, this trend varied according to specific diagnoses (Table 7; Fig. 2). For patients with AVB, no significant difference in CICU mortality or follow-up mortality was observed between those under and over 75 years. However, a markedly different scenario was noted for acute coronary syndromes, AHF, and cardiogenic shock, with cardiogenic shock being clearly associated with the poorest survival in patients over 75 years.

Interestingly, elderly patients with TTS did not demonstrate higher mortality during CICU stay compared to younger patients (Table 6), but exhibited reduced survival at follow-up (Table 7), comparable to patients with STEMI and NSTEMI (Table 8). Previous studies have already

highlighted consistent findings, with comparable in-hospital mortality and increased follow-up mortality in elderly TTS patients [25, 26], suggesting that TTS is far from a benign condition in the elderly population.

Clinical programs should ensure robust outpatient follow-up and disease-specific care pathways for elderly survivors of CICU hospitalization. In parallel, comparative effectiveness studies evaluating interventions that extend beyond the CICU stay—including transitional care, rehabilitation, and telemonitoring—are essential to improve long-term outcomes in this expanding population.

Study limitations

This study has several limitations. Its retrospective, single-center design may limit external generalizability, and reliance on ICD-9 coding may introduce classification bias. Key variables such as frailty, functional status, and comprehensive comorbidity indices were unavailable, limiting adjustment for baseline vulnerability. Sex and racial representation were imbalanced, with a predominance of male and Caucasian patients. Lastly, all data were collected within the context of a publicly funded healthcare system, which may influence procedural access and decision-making dynamics.

Conclusions

This study provides a comprehensive, age-stratified analysis of over 2,500 CICU admissions, offering additional insights into the acute cardiovascular care needs of elderly patients. Older adults were more frequently admitted for chronic-degenerative conditions and experienced higher in-hospital and long-term mortality, particularly in the presence of acute heart failure, ACS, and cardiogenic shock. Invasive procedures were less frequently performed in older patients, especially in high-risk clinical settings, raising concerns about potential under-treatment and highlighting the need for individualized decision-making.

These findings underscore the importance of aligning clinical strategies with the specific risk profiles and goals of care of older adults. They also provide real-world evidence to inform health system planning, including resource allocation, priority setting, and the development of geriatric-focused CICU protocols. Further prospective, multicenter studies incorporating comprehensive geriatric assessment and patient-centered outcomes - such as quality of life, level of autonomy, and rehospitalizations - are essential to improve care quality and prognosis in this growing patient population.

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Data availability All data used in this study derive from our existing CICU database and are reported within the manuscript and supplementary materials.

Declarations

Competing interests The authors declare no competing interests.

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References

- Kim DH, Rockwood K (2024) Title of the Article. *N Engl J Med* 391(6):538–548
- Rich MW, Chyun DA, Skolnick AH et al (2016) Knowledge gaps in cardiovascular care of the older adult population: A scientific statement from the American heart association, American college of cardiology, and American geriatrics society. *J Am Coll Cardiol* 67(20):2419–2440
- Damluji AA, Forman DE, van Diepen S et al (2020) Older adults in the cardiac intensive care unit: factoring geriatric syndromes in the management, prognosis, and process of care: A scientific statement from the American heart association. *Circulation* 141(2):e6–e13
- Ferrucci L, Kuchel GA (2021) Heterogeneity of aging: individual risk factors, mechanisms, patient priorities, and outcomes. *J Am Geriatr Soc* 69(3):610–612
- Bohula EA, Katz JN, van Diepen S et al (2019) Demographics, care patterns, and outcomes of patients admitted to cardiac intensive care units: the critical care cardiology trials network prospective North American multicenter registry of cardiac critical illness. *JAMA Cardiol* 4(9):928–935
- Casella G, Scorcu G, Cassin M et al (2012) Elderly patients with acute coronary syndromes admitted to Italian intensive cardiac care units: A Blitz-3 registry Sub-analysis. *J Cardiovasc Med (Hagerstown)* 13(3):165–174
- Kunadian V, Mossop H, Shields C et al (2024) Invasive treatment strategy for older patients with myocardial infarction. *N Engl J Med* 391(18):1673–1684
- Biscaglia S, Guiducci V, Escaned J et al (2023) Complete or Culprit-Only PCI in older patients with myocardial infarction. *N Engl J Med* 389(10):889–898
- Del Buono MG, La Vecchia G, D'Aiello A et al (2024) Clinical characteristics, management, and outcomes in cardiogenic shock: insights from a High-Volume Italian cardiac intensive care unit. *J Cardiovasc Pharmacol* 84(2):210–219
- Cammann VL, Szawan KA, Stähli BE et al (2020) Age-related variations in Takotsubo syndrome. *J Am Coll Cardiol* 75:1869–1877
- Ruiz-García J, Lerman A, Weisz G, Maehara A, Mintz GS, Fahy M, Xu K, Lansky AJ, Cristea E, Farah TG, Teles R, Botker HE, Templin B, Zhang Z, de Bruyne B, Serruys PW, Stone GW (2012) Age- and gender-related changes in plaque composition in patients with acute coronary syndrome: the PROSPECT study. *EuroIntervention* 8(8):929–938
- Tzimas G, Gulsin GS, Everett RJ, Akodad M, Meier D, Sewnarain K, Ally Z, Alnamasy R, Ng N, Mullen S, Rotzinger D, Sathananthan J, Sellers SL, Blanke P, Leipsic JA (2024) Age- and Sex-Specific nomographic CT quantitative plaque data from a large international cohort. *JACC Cardiovasc Imaging* 17(2):165–175
- Ariza-Solé A, Alegre O, Elola FJ, Fernández C, Formiga F, Martínez-Sellés M, Bernal JL, Segura JV, Iñiguez A, Bertomeu V, Salazar-Mendiguchía J, Sánchez Salado JC, Lorente V, Cequier A (2019) Management of myocardial infarction in the elderly. Insights from Spanish minimum basic data set. *Eur Heart J Acute Cardiovasc Care* 8(3):242–251
- Turk J, Fourny M, Yayehd K et al (2018) Age-Related differences in reperfusion therapy and outcomes for ST-Segment elevation myocardial infarction. *J Am Geriatr Soc* 66(7):1325–1331
- Damluji AA, Forman DE, Wang TY et al (2023) Management of acute coronary syndrome in the older adult population: A scientific statement from the American heart association. *Circulation* 147(3):e32–e62
- Martillo M, Olarte N, Ebner B et al (2023) Survival of elderly patients using temporary mechanical circulatory support. *J Am Coll Cardiol* 81(8 Suppl):675
- Lambert CT, Tarakji KG (2017) Cardiac implantable electronic device infection. *Cleve Clin J Med* 84(12 Suppl 3):47–53
- Volgman AS, Nair G, Lyubarova R et al (2022) Management of atrial fibrillation in patients 75 years and older: JACC State-of-the-Art review. *J Am Coll Cardiol* 79(2):166–179
- Osnabrugge RL, Mylotte D, Head SJ et al (2013) Aortic stenosis in the elderly: disease prevalence and number of candidates for transcatheter aortic valve replacement: A Meta-analysis and modeling study. *J Am Coll Cardiol* 62(11):1002–1012
- Damluji AA, Bernacki G, Afilalo J et al (2024) TAVR in older adults: moving toward a comprehensive geriatric assessment and away from chronological age: JACC family series. *JACC Adv* 3(4):100877
- Mack MJ, Leon MB, Thourani VH et al (2023) Transcatheter Aortic-Valve replacement in Low-Risk patients at five years. *N Engl J Med* 389(21):1949–1960
- Zhong J, Kamp N, Bansal A et al (2023) Balloon aortic valvuloplasty in the modern era: A review of outcomes, indications, and technical advances. *J Soc Cardiovasc Angiography Interventions* 2(4):101002
- Blumer V, Kanwar MK, Barnett CF et al (2024) Cardiogenic shock in older adults: A focus on Age-Associated risks and approach to management: A scientific statement from the American heart association. *Circulation* 149(14):e1051–e1065
- Velders MA, James SK, Libungan B et al (2014) Prognosis of elderly patients with ST-elevation myocardial infarction treated

- with primary percutaneous coronary intervention in 2001 to 2011: A report from the Swedish coronary angiography and angioplasty registry (SCAAR). *Am Heart J* 167(5):666–673
25. El-Battrawy I, Santoro F, Núñez-Gil IJ et al (2024) Age-Related differences in Takotsubo syndrome: results from the multicenter GEIST registry. *J Am Heart Association* 13(4):e030623
 26. Núñez-Gil IJ, Sionis A, Andrés M et al (2015) Takotsubo cardiomyopathy and elderly adults: still a benign condition? *J Am Geriatr Soc* 63(2):404–407

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