

Twenty-Year Trends in Treatment in the Cardiac Intensive Care Unit of Sestre milosrdnice University Hospital Center

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SUMMARY

Background: The aim of this study was to determine trends over the past 20 years in the demographic characteristics of patients, frequency of main and other diagnoses, risk factors, types and numbers of admissions, used therapeutic agents and procedures, as well as to assess length of stay (LOS) and outcomes including mortality among patients hospitalized in the Cardiac Intensive Care Unit (CICU) of Sestre milosrdnice University Hospital Center in Zagreb, Croatia.

Methods: The authors retrogradely collected data from medical records and the electronic hospital information system on all patients hospitalized in CICU during March 2003, March 2013 and March 2023, and compared the three groups of patients.

Results: During the study period, a total of 304 patients were hospitalized. There was a significant increase in the number of patients during the investigated time (74, 87 and 143, respectively), including patients referred from surrounding district/community hospitals (1.4% vs 28.7% vs 34.3%; $P < 0.001$), and especially those with ST-elevation myocardial infarction (STEMI) as the first diagnosis (6.8% vs 31% vs 28.7%; $P < 0.001$). The use of echocardiography became more frequent during the investigated period (33.9 vs 56.5 vs 65.7%; $P < 0.001$), as did percutaneous coronary intervention (PCI) (35.6 vs 61.2 vs 67.8%; $P < 0.01$). Higher frequencies of antibiotic prescription (3.4 vs 18.8 vs 22.9%; $P < 0.01$) indicate an increase in the frequency of infections. The median time of stay in CICU (59 vs 43 vs 22 hours; $P < 0.01$) and in hospital (10 vs 7 vs 3 days; $P < 0.01$) showed a decreasing trend in the investigated period, as did mortality rates (9.5 vs 5.7 vs 2.8%; $P < 0.01$).

Conclusion: The results indicate an increasing trend in the number of patients hospitalized in CICU (especially those with STEMI) with a shortening of their

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stay, higher usage of echocardiography and PCI, and a decrease in mortality. For significant statistical analysis in the use of mechanical circulatory and respiratory support, as well as continuous renal replacement therapy, a larger cohort should be investigated.

KEYWORDS

Cardiac intensive care unit; Temporal trends; Acute coronary syndrome; Length of stay; In-hospital mortality

Introduction

Back in 1962, the first coronary care unit was developed with the purpose of providing better treatment to patients with acute myocardial infarction and with a special focus on arrhythmia management and resuscitation¹. In the meantime, acute cardiovascular care has progressed considerably and cardiac intensive care units (CICU) were formed with advances in diagnostic and interventional cardiac care. Multiple single- and multicenter registries have described this change in demographics, comorbidities and procedures performed in a contemporary CICU^{2,3,4}.

Acute cardiovascular care has to be delivered to a wider spectrum of different cardiovascular diseases, which is caused by changes in patient population admitted to CICU⁵. On that account, a typical CICU will presently admit patients presenting acutely with worsening heart failure symptoms and cardiogenic shock, both complicated and uncomplicated acute coronary syndromes, severe heart valve diseases like endocarditis, complicated disturbances of the conduction system, intermediate- and high-risk pulmonary embolism, aortic dissection, in-hospital and out-of-hospital cardiac arrest, complications of invasive procedures and other iatrogenic complications⁶. In addition, several studies report an increasing prevalence of non-cardiovascular comorbidities and end-organ failure requiring hemodynamic or mechanical therapeutic support,

which suggests that CICU are specialized not only for complex cardiovascular patients, but also for general medical conditions⁷.

To better describe the CICUs case mix and to define their functional organization, the acuity of care has been divided into three levels by the Acute Cardiovascular Care Association (ACVC) and is presented in Table 1⁸. The level of intensive cardiovascular care refers to both the quantity and level of expertise of medical care being provided for the management of various cardiovascular conditions.

Considering all the aforementioned facts, we performed a retrospective analysis to describe the long-term temporal trends in patient characteristics, processes of care and in-hospital outcomes among unselected admissions in the level III CICU of Sestre milosrdnice University Hospital Center in Zagreb, Croatia.

Patients and methods

We retrospectively collected data on patient characteristics, diagnoses, work-up, procedures, treatment, hospital stay and outcomes from medical records and the electronic hospital information system on all patients hospitalized in our CICU during March 2003, March 2013 and March 2023. The patients were divided into three

TABLE 1 The technical capacities and expertise of cardiac intensive care units (CICUs) (adapted from Acute Cardiovascular Care Association Position Paper on Intensive Cardiovascular Care Units)⁸

Level I CICU Basic cardiovascular intensive care	Level II CICU Advanced cardiovascular intensive care	Level III CICU Cardiovascular critical care
	<i>As in level I CICU plus</i>	<i>As in level II CICU plus</i>
All non-invasive clinical parameters monitoring	Ultrasound-guided central venous line insertion	Extracorporeal life support
24/7 Echocardiography and thoracic ultrasound	Pericardiocentesis	Mechanical circulatory support expertise (LVAD, Bi-VAD)
Direct current cardioversion	Transvenous temporary pacing	Renal replacement therapy
Non-invasive ventilation	Transoesophageal echocardiography	Mechanical ventilation
Transcutaneous temporary pacing	Pulmonary artery catheter/right heart catheterization	
Chest tubes	Percutaneous circulatory support (IABP, percutaneous axial pump)	
Nutrition support	Targeted temperature management (in many centers)	
Physiotherapy in ward		

groups based on their time of admission, giving us the opportunity to compare and investigate long-term trends.

Patients are admitted in our CICU after examination and work-up in the emergency departments of our hospital or surrounding general district hospitals when there is a need of level III intensive cardiovascular care. Diagnostic and treatment protocols are in accordance with the applicable European Society of Cardiology (ESC) guidelines and position papers. Additionally, our hospital is a primary percutaneous coronary intervention (PCI) center within the Croatian primary PCI network for a region of around 600,000 inhabitants, and patients needing this kind of intervention are primarily admitted in our CICU. The Croatian primary PCI network was established in 2005³², affecting the numbers and proportion of patients with coronary artery disease admitted in our hospital.

Our CICU is a level III cardiac intensive care unit providing critical care for the most complicated acute cardiovascular pathologies requiring advanced cardiovascular support, invasive mechanical ventilation, renal replacement therapy and/or extracorporeal life support, and is among the most developed CICUs in Croatia³³. Among other equipment, it is equipped with mechanical ventilators, a mobile echocardiography machine including a TEE probe, an X-ray system in the unit, a hemodialysis machine, a hypothermia maintenance device, percutaneous circulatory assist devices (IABP and Impella) and an ECMO machine. There are 10 beds in the unit for patients with 4 cardiology specialists and 5 nurses taking care of them during working hours, and 24/7 continuous medical service with 1 cardiology specialist and 1 cardiology resident.

After treatment and stabilization in our CICU, patients are transferred to one of the three cardi-

ology departments in our hospital or surrounding district/community hospitals for further treatment, or discharged directly to their homes.

Statistical analysis

Descriptive data are presented as medians and interquartile ranges (IQR) or counts and frequencies. The chi-square test was used for categorical variables and the Kruskal–Wallis H test for continuous variables. Two-tailed significance tests were performed, and $P < 0.05$ was considered statistically significant. Statistical analyses were performed with SPSS for Windows, version 25 (IBM, Armonk, NY, USA).

Results

In the studied period (March 2003, March 2013 and March 2023), there were 304 hospital admissions (74, 87 and 143, respectively). The main demographic characteristics are presented in Table 2.

Over time, there was a significant increase in the number of patients, including patients referred from surrounding general hospitals (1.4% vs 28.7% vs 34.3%; $P < 0.001$).

ST-elevation myocardial infarction (STEMI) as an admission diagnosis consistently increased over the years (6.8% vs 31% vs 28.7%; $P < 0.001$), while the frequency of Non-ST-Elevation Myocardial Infarction (NSTEMI) did not change significantly and there was a trend toward decline

TABLE 2 Patients' demographics, risk factors and diagnoses

	March 2003 count (%) or median (IQR)	March 2013 count (%) or median (IQR)	March 2023 count (%) or median (IQR)	<i>P</i>
Age (years)	65.0 (57.5–71.5)	65.0 (59.0–73.5)	69.0 (59.0–78.5)	0.607
Male sex	67.6%	60.9%	65.7%	/
BMI	27.2 (25.2–29.4)	28.0 (24.4–30.8)	27.5 (24.7–29.3)	0.491
Referral from other hospitals	1 (1.4%)	25 (28.7%)	49 (34.3%)	< 0.001
Hypertension	46 (79.3%)	59 (69.4%)	103 (72%)	0.292
Dyslipidemia	31 (53.4%)	40 (47.1%)	83 (58%)	0.412
Diabetes mellitus	16 (27.6%)	18 (21.2%)	35 (24.5%)	0.673
Smoking	8 (13.8%)	19 (22.4%)	41 (28.7%)	0.075
Obesity	8 (13.8%)	10 (11.8%)	5 (3.5%)	0.017
STEMI at admission	5 (6.8%)	27 (31%)	41 (28.7%)	< 0.001
NSTEMI at admission	21 (28.4%)	16 (18.4%)	34 (23.8%)	0.324
Unstable angina at admission	12 (16.2%)	13 (14.9%)	16 (11.2%)	0.528
Heart failure as admission diagnosis	4 (5.4%)	3 (3.4%)	6 (4.2%)	0.828

TABLE 3 Comparison of patient outcomes and performed procedures

	March 2003 count (%) or median (IQR)	March 2013 count (%) or median (IQR)	March 2023 count (%) or median (IQR)	P
Use of inotropes	4 (6.8%)	4 (4.7%)	12 (8.5%)	0.356
Use of vasopressors	1 (1.7%)	0	9 (6.3%)	0.072
Use of GP IIb/IIIa inhibitors	0	9 (10.6%)	10 (7%)	0.041
Use of antibiotics	2 (3.4%)	16 (18.8%)	47 (32.9%)	<0.001
Advanced respiratory support	3 (5.1%)	4 (4.7%)	15 (10.5%)	0.267
Mechanical circulatory support	0	0	1 (0.7%)	0.603
PCI	13 (22.1%)	38 (44.7%)	73 (51.1%)	<0.001
Hemodialysis	0	0	3 (2.1%)	0.538
Echo performed in CICU	20 (33.9%)	48 (56.5%)	94 (65.7%)	<0.001
Pacemaker implantation	5 (8.5%)	10 (11.9%)	13 (9.1%)	0.586
Mortality in CICU	7 (9.5%)	5 (5.7%)	4 (2.8%)	<0.001

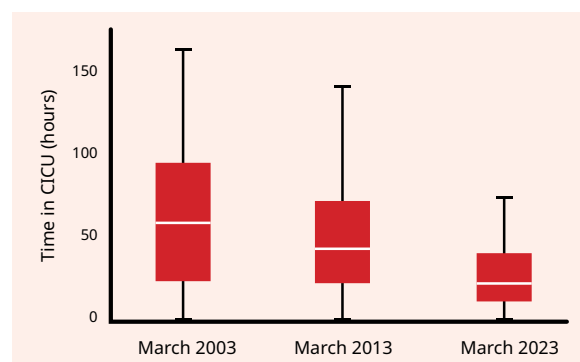
in the diagnosis of unstable angina (16.2% vs 14.9% vs 11.2%, $P=0.528$).

Inotropes prescription (6.8% vs 4.7% vs 8.5%; $P=0.356$), as well as the usage of vasopressor drugs (1.7% vs 0 vs 6.3%; $P=0.072$) and glycoprotein IIb/IIIa inhibitors (0 vs 10.6% vs 7%; $P=0.041$) increased during the study period, but without reaching statistical significance.

There was a significant increase in antibiotic prescription (3.4% vs 18.8% vs 32.9%; $P<0.001$), PCIs (22.1% vs 44.7% vs 51.1%; $P<0.001$) and bedside CICU echocardiography (33.9% vs 56.5% vs 65.7%; $P<0.001$).

On the other hand, the number of patients who received certain critical care therapies was very low in the investigated period and their proportions did not reach statistical significance, but there was an increasing trend in mechanical circulatory support (0 vs 0 vs 0.7%; $P=0.603$),

hemodialysis (0 vs 0 vs 2.1%; $P=0.538$) and advanced respiratory support (5.1% vs 4.7% vs 10.5%; $P=0.267$). A comparison of patient outcomes and performed procedures is presented in Table 3.

**FIG. 1** Trends in CICU length of stay over time

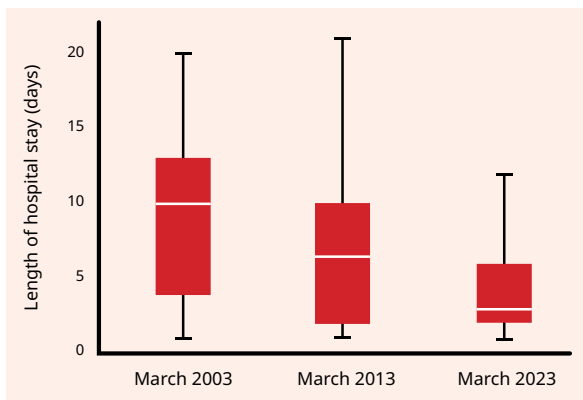


FIG. 2 Trends in hospital length of stay of CICU patients over time

During the study period, a strong decline in in-hospital mortality (9.5% vs 5.7% vs 2.8%; $P < 0.001$) was observed.

In the study population, the median CICU length of stay (LOS) decreased (59 h vs 43 h vs 22 h; $P < 0.001$), as did in-hospital LOS (10 days vs 7 days vs 3 days; $P < 0.001$) (Figure 1 and Figure 2).

Discussion

This study presents data from 304 admissions to our level III CICU that occurred in March 2003, March 2013 and March 2023. As in many other studies, the median age was 68 (59–78) years and most (64.8%) patients were male^{2,3,9,10}.

Our data showed a changing role of CICUs with an increase of traditionally non-cardiovascular patients requiring critical cardiac care, but as opposed to some other studies which reported an increasing burden of non-cardiovascular illnesses^{7,22,23}, our data showed that ACS is the predominant pathology in our CICU, as ACS patients accounted for more than half of all patients in the investigated period with an increasing trend, but without reaching statistical significance (51.4%,

64.4% and 63.6%; $P = 0.156$). On the other hand, a decreasing trend in ACS or myocardial infarction (MI) diagnoses was recently observed in several countries with annual decreasing rates — 4% in European countries²⁴ and 6% in New Zealand²⁵. However, several studies emphasized age- and sex-specific differences with an increase in the incidence of ACS in people younger than 65, especially women^{26–28}, which can also explain our data.

Cardiovascular diseases are the leading cause of mortality worldwide and ischemic heart disease remains one of the largest contributors to disease burden¹⁵. Many improvements in preventive, diagnostic and therapeutic strategies for patients with coronary artery disease¹⁶ led to a strong decrease in STEMI incidence, as first reported by Yeh and al. in 2010¹⁷ in a study on 45,000 US patients. However, our data showed a significant increase in the proportion of STEMI patients over the investigated time. Our findings are supported by Luk et al., who also reported a growing number of STEMI diagnoses on admission in their study of 373,992 patients admitted to CICU in Canada in the period of 2005–2015. In addition to an increase in STEMI diagnoses (9.4% to 24.1%; $P < 0.001$), they also reported an increase in NSTEMI diagnoses (14.6% to 16.2%; $P < 0.001$), and a decline in the diagnosis of unstable angina (4.9% to 4.0%; $P < 0.001$), which is comparable to our results²⁹.

The potential reasons for this finding may be differences between healthcare systems and differences in the use of diagnostic codes or in the distribution of hospital types¹¹, since our CICU is a referral unit with more than a third of admissions coming from surrounding district general hospitals where intensive care units (ICUs) may be mixed or multi-purpose ICUs that may admit a higher proportion of patients with non-cardiovascular diseases^{12,13,14}. Additionally, with the establishment of the Croatian primary PCI network in 2005, a large number of STEMI patients are directed to PCI centers, while some NSTEMI

patients are admitted directly to non-intensive cardiology departments leading to a decrease in the incidence of NSTEMI diagnosis.

Another prominent finding in our study was a rapid increase of invasive procedures, such as coronary angiography and PCI, in the last two decades. A similar trend was observed in a large SWEDEHEART registry^{18,19}. In their cohort, the authors reported the rate of primary PCI that reached up to 80% for patients diagnosed with STEMI in 2018. Similarly, considering all ACS patients (not just STEMI), Neumann *et al.*²⁰ reported an in-hospital PCI rate of 50.29% in 2015, which is similar to our cohort.

With regard to critical care restricted therapies and procedures, like invasive and non-invasive mechanical ventilation, acute renal replacement therapy and mechanical circulatory support, our data showed a trend of an increase in their utilization in CICU patients, but the study was underpowered to reach statistical significance. Nevertheless, it is clear that larger proportions of CICU patients require such an advanced management, as reported by Sinnha *et al.*, who showed that 11% of Medicare recipients in CICU required mechanical ventilation³¹, while Katz *et al.* reported that the prevalence of patients requiring mechanical ventilation rose to approximately 30% in 2006^{7,30}. All these data, along with our report of a notably higher usage of antibiotics and trend towards a more frequent prescription of inotropes and vasopressors over time, suggest growing patient complexity and acuity in contemporary CICU.

Regardless of the above, the in-hospital mortality of our study population decreased over time, which is consistent with various studies in the literature^{2,4,7}. The aforementioned SWEDEHEART registry analysis revealed a decrease of in-hospital mortality from 12.4% in 1995 to 3.7% in 2014¹⁸; data comparable with our results. In contrast, the outcome of STEMI patients in Germany in 2008 and 2013 was analyzed from

the German Quality Assurance database and the results showed a slight increase of in-hospital mortality in unadjusted analyses²¹. These differences may be a result of advanced age and an increased risk profile of these patients.

Along with a reduction in mortality in our study, a significant shortening of CICU and hospital LOS was observed as well. Our findings corroborated what had previously been reported in the literature: we need less time to stabilize our patients. Neumann *et al.* reported a decrease in median hospital LOS for all ACS patients from 7.79 days in 2005 to 6.53 days in 2015²⁰. However, these studies cannot clarify the reasons for the decline in mortality and improved outcomes despite more demanding patients and complex procedures. Future research should focus on examining the clinician, nursing or healthcare system factors that have contributed to these findings.

There are several limitations to this study. This was a retrospective study and it was conducted in a single center in a level III CICU. Our findings may be the result of local practice and there could be uncontrolled confounders, so these data are not necessarily applicable to other CICUs. In addition, the study population included patients admitted in the month of March in 2003, 2013 and 2023, which makes it underpowered in terms of population size for some rare and complex procedures.

Conclusion

In this retrospective single-center study of patients admitted to our CICU over a period of 20 years, we observed a quickly growing number of admissions, especially of STEMI patients, with a shortening of their stay and a decrease in mortality. There was a trend towards increasing use of

critical care restricted therapies, including mechanical ventilation and acute renal replacement therapy, and significantly increased numbers of urgent percutaneous revascularization procedures — all indicating an increase in clinical acuity and case complexity. However, the patients' LOS and mortality rates declined, highlighting the importance of adequate education, modern equipment and demanding contemporary therapeutic procedures.

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Statements and declarations

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ■

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SAŽETAK

Dvadesetogodišnji trendovi u liječenju u Zavodu za intenzivnu kardiološku skrb Kliničkog bolničkog centra Sestre milosrdnice

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Uvod: Cilj ovog istraživanja bio je utvrditi trendove u zadnjih 20 godina u demografskim karakteristikama bolesnika, učestalosti glavnih i drugih dijagnoza, čimbenicima rizika, vrstama i broju prijema, korištenim terapijskim sredstvima i postupcima te usporediti duljinu liječenja i ishode uključujući mortalitet među bolesnicima hospitaliziranim u Zavodu za intenzivnu kardiološku skrb KBC-a Sestre milosrdnice.

Metode: Autori su retrogradno prikupili podatke iz medicinske dokumentacije i elektroničkog bolničkog informacijskog sustava o svim pacijentima hospitaliziranim tijekom ožujka 2003., ožujka 2013. i ožujka 2023. te usporedili te tri skupine bolesnika.

Rezultati: Tijekom razdoblja istraživanja ukupno su hospitalizirana 304 bolesnika. Došlo je do značajnog povećanja broja pacijenata tijekom razdoblja istraživanja (74, 87 i 143), uključujući pacijente upućene iz okolnih mjesnih bolnica (1,4 % naspram 28,7 % naspram 34,3 %; $P < 0,001$), a posebno one s infarktom miokarda sa ST-elevacijom kao prvom dijagnozom (STEMI) (6,8 % prema 31% prema 28,7 %; $P < 0,001$). Korištenje ehokardiografije postalo je češće tijekom vremena (33,9 % prema 56,5 % prema 65,7 %, $P < 0,001$), kao i perkutana koronarna intervencija (PCI) (35,6 % prema 61,2 % prema 67,8 %, $P < 0,01$). Veća učestalost propisivanja antibiotika (3,4 % prema 18,8 % prema 22,9 %, $P < 0,01$) ukazuje na povećanje učestalosti infekcija. Medijan vremena boravka u jedinici intenzivnog liječenja (59 naspram 43 naspram 22 sata; $P < 0,01$) i trajanje cijele hospitalizacije (10 naspram 7 naspram 3 dana; $P < 0,01$) smanjivao se tijekom ispitivanog razdoblja, kao i stopa smrtnosti (9,5 % naspram 5,7 % naspram 2,8 %; $P < 0,01$).

Zaključak: Rezultati upućuju na trend porasta broja pacijenata hospitaliziranih u jedinici intenzivnog kardiološkog liječenja (osobito onih sa STEMI-jem) uz skraćivanje boravka, veću primjenu ehokardiografije i PCI-ja te smanjenje mortaliteta. Za značajnu statističku analizu u korištenju mehaničke cirkulacijske i respiratorne potpore, kao i kontinuirane bubrežne nadomjesne terapije, potrebno je ispitati veći broj bolesnika.

KLJUČNE RIJEČI

Intenzivna kardiološka skrb; Trendovi; Akutni koronarni sindrom; Duljina hospitalizacije; Bolnička smrtnost