European Heart Journal Supplements (2022) **24** (Supplement B), B3–B9
The Heart of the Matter
https://doi.org/10.1093/eurheartj/suac001

ESC
European Society
of Cardiology

Patient characteristics, treatment strategy, outcomes, and hospital costs of acute coronary syndrome: 3 years of data from a large high-volume centre in Central Europe

Petr Toušek[1]*, David Bauer[1], Marek Neuberg[2], Markéta Nováčková[1], Petr Mašek[2], Petr Tůma[2], Viktor Kočka[1], Zuzana Moťovská[1], and Petr Widimský[1]

[1]*Department of Cardiology, Third Faculty of Medicine, University Hospital Královské Vinohrady, Charles University, Prague, Czech Republic*
[2]*Medtronic Czechia, Partner of INTERCARDIS Project, Prosecká 852/66, Prague, 190 00, Czech Republic*

KEYWORDS
Acute;
coronary syndrome;
Characteristics;
Treatment strategy;
Outcome Financial costs;
Length of hospital stay

Managing patients with acute coronary syndrome (ACS) in an ageing population with comorbidities is clinically and economically challenging. Well-conducted unselected registries are essential for providing information on real-day clinical practice. The aim was to create a long term, very detail-controlled registry of unselected patients admitted with ACS to a high-volume centre in Central Europe. Consecutive patients admitted with confirmed ACS were entered into the prospective registry from 1 October 2018 to 30 September 2021. Data on 214 parameters, including clinical characteristics, angiographic findings, laboratory and therapeutic findings, financial costs, and in-hospital mortality, were obtained for all patients. Analyses were performed on the complete dataset of 1804 patients. Of these patients, 694 (38.5%) were admitted for ST-segment elevation myocardial infarction (STEMI) and 1110 (61.5%) were admitted for non-ST-elevation (NSTE)-ACS [779 with NSTE myocardial infarction (NSTE-MI) and 331 with unstable angina (UA)]. Almost all patients (99%) underwent coronary angiography. Primary percutaneous coronary intervention (PCI) was performed in 93.4% of STEMI patients and 74.5% of NSTE-ACS patients. Patients with NSTE-MI had the longest total hospital stay (8.1 ± 9.1 days) and highest financial costs (8579.5 ± 7173.2 euros). In-hospital mortality was 1.2% in UA, 6.2% in NSTE-MI, and 10.9% in STEMI patients. Age older than 75 years, pre-hospital cardiac arrest and/or mechanical ventilation, subacute STEMI, and ejection fraction below 40% were the most powerful predictors of in-hospital mortality as assessed by multivariate analyses. The in-hospital mortality of unselected NSTE-MI and STEMI patients in daily practice is not low despite very good implementation of guideline-recommended therapy with a high rate of revascularization. The highest financial costs are associated with NSTE-MI.

*Corresponding author. Tel: +420 267 162 621, Fax: +420 267 163 388,
Email: petr.tousek@fnkv.cz

Introduction

Acute coronary syndrome (ACS) is the most common clinical condition in hospitalized patients. Many therapeutic advances and new strategies have been implemented in clinical practice during the past two decades. At the same time, managing patients with ACS in an ageing population with comorbidities has brought about new clinical and economic challenges.

Well-organized real-world registries provide essential information about patient characteristics, how treatment recommendations are followed, patient outcomes, and financial costs. However, different strategies may be used to build the registry. The short duration of registries, patient selection, incomplete data collection, and missed monitoring are the main sources of discrepancies among registries and may not reflect daily clinical reality.[1–3]

We created a long term, very detail-controlled registry of unselected patients admitted with ACS to a high-volume centre in Central Europe to analyse patient characteristics, actual treatment strategies, in-hospital mortality, and financial costs connected with hospitalization.

Methods

We created a prospective registry of patients with ACS admitted to the University Hospital Královské Vinohrady Cardiocentre, Prague, Czech Republic, in September 2018. (This project was supported by the EU project INTERCARDIS–INTERventional treatment of life-threatening CARdiovascular DISeases with the cooperation of project partner Medtronic.) Consecutive patients admitted with confirmed ACS were entered into the registry from 1 October 2018 to 30 September 2021. Types of ACS were defined according to the European guidelines for acute myocardial infarction with ST-elevation (STEMI) and ACS without ST-elevation (NSTE-ACS).[4,5] Subacute STEMI was defined if the time interval from the onset of symptoms to the first medical contact (FMC) with electrocardiogram (ECG) was more than 24 h. Patients with Takotsubo syndrome (TTS) were not assigned to the STEMI or NSTE-ACS groups, and TTS was diagnosed according to international InterTAK criteria.[6] There were no exclusion criteria for patients admitted with a final diagnosis of ACS. Data on 214 parameters—including clinical characteristics; angiographic, laboratory, and therapeutic findings; financial costs; and hospital outcomes—were obtained for all patients. Clinical data and data on in-hospital outcomes were obtained from medical documentation and reports by the registry research co-ordinator. Angiographic structured data were exported from dedicated software for angiography and percutaneous coronary intervention (PCI) structured description. Laboratory results and data for calculating direct costs were exported from the universal hospital information system. Data were validated with cross-controls between data sources and with random monitoring of 100 patients by an experienced physician/researcher. The registry was approved by the local ethics committee.

The observational registry had several endpoints: (i) to describe clinical and angiographic characteristics and treatment strategies and compare them between NSTE-ACS and STEMI patients, (ii) to calculate the length of stay in the intensive/coronary care unit (ICU/CCU) and the total hospital stay, (iii) to evaluate financial costs connected with hospitalization and compare these costs between NSTE-ACS and STEMI patients, and (iv) to analyse in-hospital mortality in ACS groups.

The total cost of hospitalization was counted as the sum of direct and indirect costs. Direct costs included all medications and materials whose consumption was linked to specific patients. Department indirect costs were costs incurred by medical departments that were not directly related to patients, such as personnel costs and amortization of devices and materials. Indirect costs were allocated to patients using key cost drivers (length of stay in the CCU, standard units, catheterization laboratory, etc.) that best expressed the relationship between cost consumption and the health services provided. Costs were calculated in Czech crowns and converted into euros according to the exchange rate of the Czech National Bank on 29 October 2021.

The Kolmogorov–Smirnov test or Shapiro–Wilk test was used to test for the normality of the distribution. Continuous variables with non-normal (log-normal) distributions are expressed as box plots in which the central line indicates the median. Continuous variables with normal distributions are expressed as mean ± standard deviations. Between-groups differences were assessed with the Mann–Whitney *U* test or Kruskal–Wallis test for non-normally distributed variables and Student's *t*-test for normally distributed data. The χ^2 or Fisher's exact test was used to assess differences between categorical variables. We also compared the risk of mortality between groups expressed as odds ratios with confidence intervals. A *P*-value <0.05 was considered to indicate statistical significance. Logistic regression was performed to evaluate the effect of selected predictors on cardiovascular mortality. Predictors of mortality at univariate analysis at the level $P < 0.05$ were then entered into a backwards step-wise logistic regression model. The predictors found to be significant at the level $P < 0.05$ were retained in the final model. All statistical analyses were performed with SPSS version 26 (IBM, Armonk, NY, USA). Graphical analyses were performed in Sigmaplot version 14 (SYSTAT Software, San Jose, CA, USA).

Results

Patient characteristics

Data from 1849 patients were collected in the registry. Analyses were performed on the complete dataset of 1804 (97.6%) patients. Of these patients, 694 (38.5%) were admitted for STEMI and 1110 (61.5%) for NSTE-ACS. The NSTE-ACS patients included 779 NSTE-MI patients and 331 patients with unstable angina (UA). During the 3-year registry period, 49 patients were admitted with a diagnosis of TTS.

The characteristics of STEMI and NSTE-ACS patients are shown in *Table 1*. Except for sex, there were clear

Table 1 Clinical and angiographic characteristics of NSTE-ACS and STEMI patients

	Type of ACS		*P*
	NSTE-ACS ($n=1110$)	STEMI ($n=694$)	
Age, years ± SD	69.6 ± 11.5	65.6 ± 13.2	<0.001
≥75 years, *n* (%)	366 (33.3%)	167 (24.1%)	<0.001
Sex			0.164
Male	760 (68.5%)	459 (66.1%)	
Female	350 (31.5%)	235 (33.9%)	
History of PCI, *n* (%)	309 (27.8%)	85 (12.2%)	<0.001
History of MI, *n* (%)	314 (28.3%)	89 (12.8%)	<0.001
History of CABG, *n* (%)	130 (11.7%)	23 (3.3%)	<0.001
History of stroke *n* (%)	142 (12.8%)	52 (7.5%)	<0.001
Hypertension, *n* (%)	864 (77.8%)	419 (60.4%)	<0.001
Hyperlipidaemia, *n* (%)	543 (48.9%)	245 (35.3%)	<0.001
History of bleeding, *n* (%)	98 (8.8%)	48 (6.9%)	0.005
History of PCI, *n* (%)	309 (27.8%)	85 (12.2%)	<0.001
Diabetes			0.005
Non-insulin dependent, *n* (%)	288 (25.9%)	147 (8.2%)	
Insulin dependent, *n* (%)	112 (10.1%)	52 (7.5%)	
Peripheral artery disease, *n* (%)	157 (14.1%)	47 (6.8%)	<0.001
History of heart failure, *n* (%)	95 (8.6%)	26 (3.7%)	<0.001
ECG rhythm on admission, *n* (%)			<0.001
Sinus rhythm	926 (83.4%)	616 (88.8%)	
Atrial fibrillation/flutter	125 (11.3%)	51 (7.3%)	
Other rhythm	19 (1.7%)	10 (1.4%)	
Pacemaker	39 (3.5%)	9 (1.3%)	
Oral anticoagulation before admission, *n* (%)			<0.001
NOAC	51 (4.6%)	21 (3.0%)	
Warfarin	89 (8.0%)	28 (4.0%)	
KILLIP, *n* (%)			<0.001
I	907 (81.7%)	528 (76.1%)	
II	105 (9.5%)	66 (9.5%)	
III	58 (5.2%)	21 (3.0%)	
IV	36 (3.2%)	77 (11.1%)	
OHCA, *n* (%)	53 (4.8%)	76 (11.0%)	<0.001
Mechanical ventilation started before admission			<0.001
Invasive, *n* (%)	52 (4.7%)	64 (9.2%)	
Non-invasive, *n* (%)	2 (0.2%)	0 (0.0%)	
Mechanical ventilation started after admission			<0.001
Invasive, *n* (%)	39 (3.5%)	54 (7.8%)	
Non-invasive, *n* (%)	14 (1.3%)	2 (0.3%)	
Left main disease, *n* (%)	153 (13.8%)	50 (7.2%)	<0.001
Number of diseased vessels, *n* (%)			<0.001
One	270 (24.3%)	227 (32.7%)	
Two	312 (28.1%)	210 (30.3%)	
Three	496 (44.7%)	242 (34.9%)	
Ejection fraction (%)	49.9 ± 11.8	43.1 ± 10.9	<0.001

CABG, coronary artery bypass graft; MI, myocardial infarction; OHCA, out of hospital cardiac arrest; PCI, percutaneous myocardial infarction.

differences in clinical and angiographic characteristics between STEMI and NSTE-ACS patients. Such clear differences were not seen between UA and NSTE-MI patients. History of MI and coronary artery bypass graft had 30.5% and 12.1% UA patients that did not differ from 27.6% ($P=0.260$) and 11.6% ($P=0.801$) NSTEMI patients, respectively. However, UA patients more often had a history of PCI (36.6% vs. 24.1%, $P<0.001$), had higher EF on echocardiography (55.79% ± 8.65% vs. 47.53% ± 12.07%, $P<0.001$), and presented more frequently with KILLIP I class on admission (94.9% vs. 76.1%, $P<0.001$) compared with NSTE-MI patients.

A PRECICE-DAPT score ≥25 indicating high bleeding risk was present more often in the NSTE-MI group compared to the STEMI and UA groups (50.6% vs. 35.5% and 35.3%, $P<0.001$).

Time intervals and treatment strategies

ST-segment elevation myocardial infarction patients

The distribution of time intervals in 530 patients with acute STEMI (admitted to the hospital within 24 h of the onset of

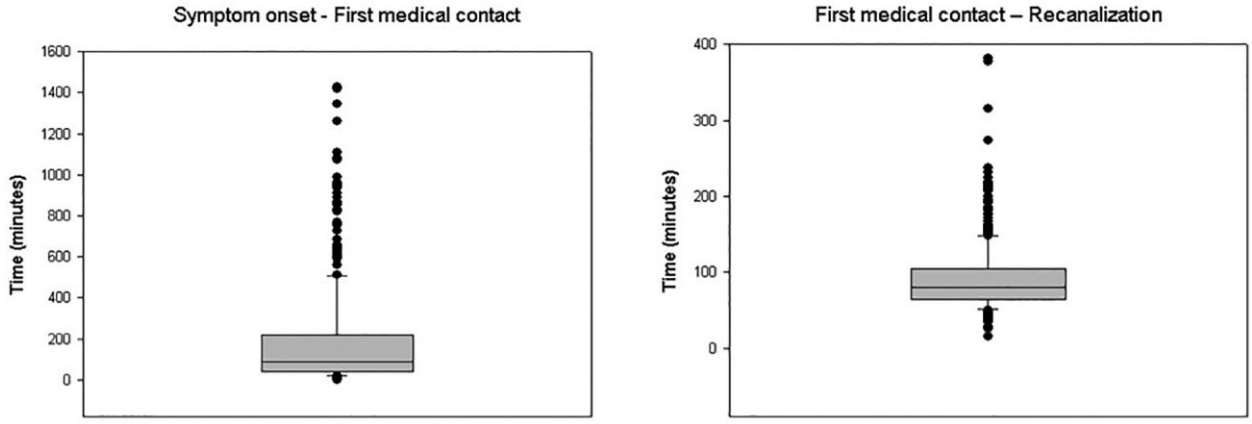

Figure 1 Time interval of symptoms onset to first medical contact (left) and first medical contact to recanalization (right).

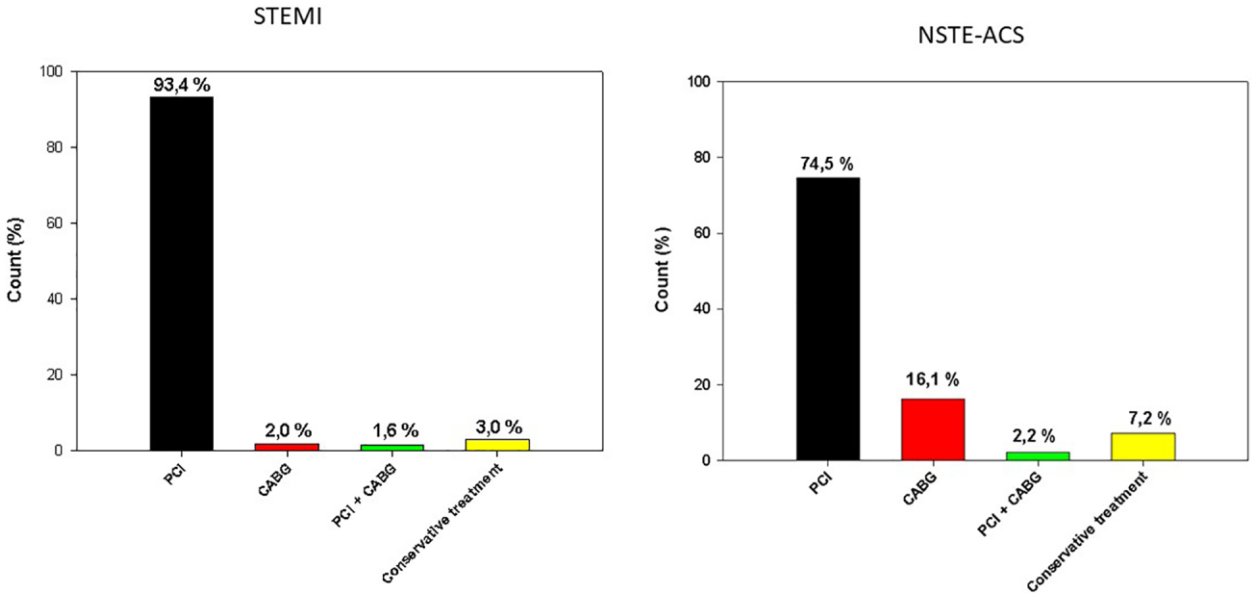

Figure 2 Type of revascularization in ST-segment elevation myocardial infarction and non-ST-elevation-acute coronary syndrome patients.

symptoms) is shown in *Figure 1*. The time interval in STEMI patients from the onset of symptoms to FMC was 191 ± 250 min, from FMC to arrival in the cathlab was 64 ± 57 min, and from arrival in the cathlab to recanalization was 31 ± 16 min. Coronary angiography was performed in 99% of patients. Of 694 STEMI patients, 164 (23.6%) presented with subacute STEMI (more than 24 h between the onset of symptoms and FMC).

Non-ST-elevation-acute coronary syndrome patients

The time from the onset of symptoms to FMC and ECG was <24 h in 46.2% of patients. Of the 1110 NSTE-ACS patients, 348 (31.1%) were referred from regional hospitals. Coronary angiography was performed in 99% of patients. In 847 (76.3%) of these patients, the procedure was performed within 24 h of admission to the cardiocentre.

Figure 2 shows the type of revascularization in STEMI and NSTE-ACS patients. Primary PCI was performed in 93.4% of STEMI patients (TIMI 3 flow was achieved in 88%) and 74.5% of NSTE-ACS patients (TIMI 3 flow was achieved in 94%).

Length of hospital stay

The ICU stays for the STEMI and NSTE-ACS patients were 5874 ± 6195 and 6243 ± 8554 min ($P < 0.001$), respectively, calculated in Days 4.1 ± 4.3 and 4.3 ± 5.9 ($P < 0.001$). The total hospital stays for the STEMI and NSTE-ACS patients were 6.3 ± 5.5 days and 7.3 ± 8.4 days ($P = 0.570$), respectively. There were differences between UA and NSTE-MI patients with respect to length of ICU stay (2.4 ± 4.2 vs. 5.2 ± 6.4 days, $P < 0.001$) as well as total hospital stay (5.3 ± 6.1 vs. 8.1 ± 9.1 days, $P < 0.001$). *Figure 3* compares the ICU and total hospital stay among all groups.

Financial costs

The mean total hospital costs for STEMI and NSTE-ACS patients were 7642.4 ± 5676.7 euros and 7838.3 ± 6541 euros ($P = 0.132$), respectively. Of these total costs,

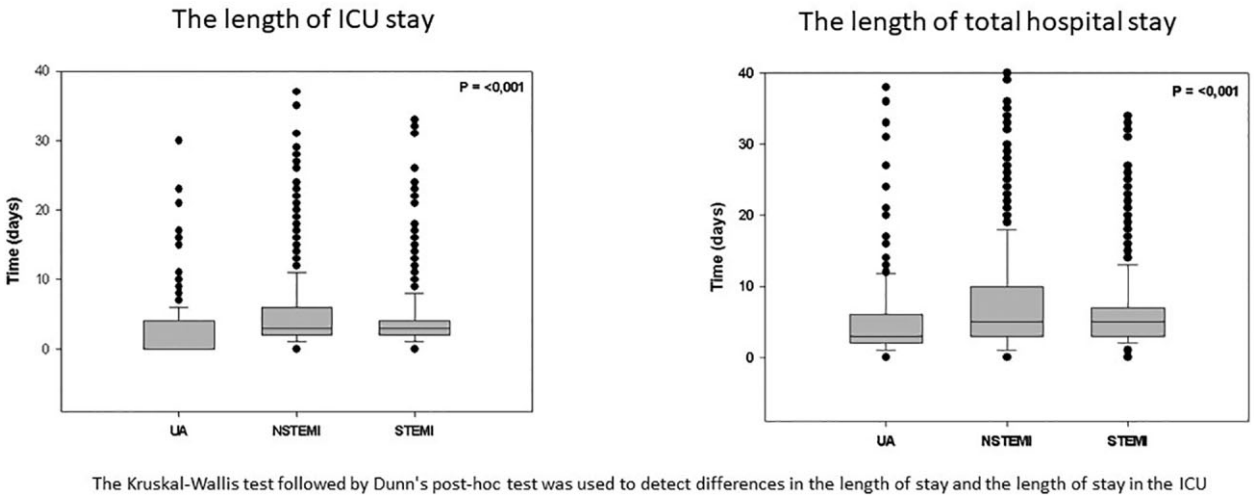

Figure 3 Length of intensive care unit stay (left) and total hospital stay (right) in UA, non-ST-segment elevation myocardial infarction, and ST-segment elevation myocardial infarction patients.

Table 2 Predictors of in-hospital mortality for STEMI and NSTE-MI patients assessed by multivariate analyses

	STEMI (*P*)	NSTE-MI (*P*)
Age older than 75 years	<0.001	0.005
OHCA and/or mechanical ventilation	0.004	<0.001
Ejection fraction <40%	<0.001	0.027
Subacute STEMI	<0.001	N/A
Non-sinus rhythm	0.004	NS

N/A, not applicable for NSTE-ACS analyses; NS, not significant; NSTE-MI, non-ST-elevation acute myocardial infarction; OHCA, out of hospital cardiac arrest; STEMI, ST-elevation acute myocardial infarction.

material costs represented 46.8% and 40.6% ($P = 0.002$). Among NSTE-ACS patients, there were differences between UA and NSTE-MI patients in total costs (6093.8 ± 4258.3 vs. 8579.5 ± 7173.2 euros, $P < 0.001$) and material costs (44.1% vs. 39.6%, $P < 0.001$).

In-hospital mortality

In-hospital mortality for STEMI patients was 10.9%. There were differences in mortality between acute and subacute STEMI patients (8.7% vs. 18.3%, $P < 0.001$). The rates of KILLIP IV on admission, out-of-hospital cardiac arrest (OHCA), and subacute STEMI without OHCA in the STEMI mortality group ($n = 76$) were 50%, 31.6%, and 51.3%, respectively.

In-hospital mortality for patients with NSTE-ACS was 4.7%. When calculated for UA and NSTE-MI, mortality was 1.2% and 6.2% ($P < 0.001$), respectively. *Table 2* shows independent variables predicting in-hospital mortality in STEMI and NSTE-MI patients assessed by multivariate analyses.

Discussion

We present the results of a large, single-centre, unselected registry of ACS patients. Our registry needs to be regarded in the context of a large-volume centre following guideline-recommended therapy, with appropriate invasive time treatment intervals, a very high rate of revascularization, and the capacity to admit and treat a high number of ACS patients with critical clinical conditions (e.g. 11% of STEMI patients after OHCA and in the KILLIP IV class).

There are several interesting observations from this unselected ACS registry. First, a UA diagnosis in ACS patients in the high-sensitivity troponin era is still not negligible and represented 18.3% of all ACS patients in the registry. Patients with UA often had a history of revascularization or MI, and thus it can be suggested that many patients with a known history of coronary artery disease and chest pain are referred and hospitalized with concerns about a new coronary event. Mortality due to UA was very low (1.2%), and financial costs in the context of the short hospitalization were significantly lower compared to costs for NSTE-MI and STEMI patients. These observations agree with the APACE and High-STEACS registries assessing incidence, characteristics, and outcomes of UA.[7] Secondary prevention is very important in UA patients because these patients have a similar risk of future non-fatal MI events as NSTE-MI patients, as these registries have shown.

Second, managing NSTE-MI patients is a clinical challenge, in particular, after the initial invasive strategy that 99% of patients undergo with a revascularization rate of 90%. Patients with NSTE-MI often have several comorbidities that lead to a long stay in the ICU and hospital. The 6.2% in-hospital mortality in this study reflects the numerous risk factors in the NSTE-MI population and agrees with rates from previously published unselected European multicentre registries.[8,9] The high financial cost of NSTE-MI is certainly associated with nonmaterial patient care during the hospital stay. Finally, half of NSTE-MI patients have high bleeding risk assessed by PRECISE-DAPT, and thus the decision to start antithrombotic treatment before discharge is often not simple. In light of this, we suggest that NSTE-ACS patients be considered two different clinical entities: UA patients and NSTE-MI patients.

Third, our registry shows that the management of STEMI patients in the acute phase is very well organized. Recommended time intervals after FMC are reached in most patients. Unfortunately, the long period of ischaemia in approximately one-quarter of STEMI patients is caused by a delay in contacting emergency health services. This certainly has an impact on the total in-hospital mortality of STEMI patients, because in this study, mortality was twice as high among patients with subacute STEMI than acute STEMI. The 10 times higher mortality in patients with OHCA is another important factor that influences mortality in STEMI.[10] In our registry, we observed a higher prevalence of OHCA compared to other studies evaluating the incidence of OHCA in STEMI patients.[10,11] Both factors can explain the higher in-hospital mortality compared with some registries.[2,3] However, in-hospital mortality in our registry was comparable to that in other large, unselected European registries.[12–15] Such differences highlight the importance of avoiding selection bias and using a unique methodology when preparing registries to get true information from daily clinical practice.

Our registry has the following limitations. First, it contains data from a single centre. The data may be specific to this high-volume centre, which is part of a large university hospital able to manage a high number of critical patients. Second, the data in our registry were collected partly during the COVID-19 pandemic, which influenced the treatment and outcomes of ACS patients in many countries.[16] However, we stated previously that COVID-19 did not have an impact on treatment strategies or mortality among ACS patients in our centre.[17] Third, there is no clear definition of subacute STEMI. We assigned to the subacute STEMI group patients who presented more than 24 h after the onset of symptoms, including patients with a time delay of more than 48 h. ESC guidelines recommend classifying patients who present 12–48 h after the onset of symptoms as subacute.[4]

Conclusion

Our registry shows higher in-hospital mortality in NSTE-MI and STEMI patients compared with registries with non-consecutive patient enrolment despite very good implementation of guideline-recommended therapy regarding invasive treatment and a high rate of revascularization. The greatest economic burden is associated with managing NSTE-MI patients, mainly because of nonmaterial costs during the long hospital stay. It is essential that future registries that intend to gain information from real-day clinical practice collect data from unselected populations with a well-defined common methodology.

Funding

Supported by project Interventional treatment of life-threatening cardiovascular diseases – INTERCARDIS, project EU Nr. CZ.02.1.01/0.0/0.0/16_026/0008388.

Conflict of interest: PT reports consultant contracts, lecture fees, and grant support from Medtronic, and BBraun. VK reports consultant contracts, lecture fees, and grant support from Medtronic, Phillips and BBraun.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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