Intensive care unit readmissions following isolated coronary artery surgery

Keywords
postoperative complications, coronary artery surgery, in-hospital mortality, ICU readmission

Abstract
Introduction
According to single institution studies, patients readmitted to the ICU (Intensive Care Unit) following cardiac surgery are at high risk of death. In our study, we primarily aimed to assess the impact of ICU readmission on postoperative results and to identify the independent risk factors of this complication among patients undergoing isolated coronary artery surgery.

Material and methods
Following exclusions, we analyzed 89,958 consecutive patients in the Polish National Registry of Cardiac Surgical Procedures (KROK Registry), scheduled for isolated coronary artery surgery between January 2010 and December 2019. Variables that independently influenced ICU readmission were identified by means of the multivariable logistic regression. Data of survivors and non-survivors among patients readmitted to the ICU were compared.

Results
In the analyzed group, 1,003 patients underwent ICU readmission (1.1%). In-hospital mortality among patients readmitted and not readmitted to the ICU was 29.6% and 2.1%, respectively ($p<0.001$). All postoperative complications were more frequent among patients readmitted to the ICU. Overall, 15 independent predictors of ICU readmission were identified, and conversion to on-pump procedure, age>65 years and preoperative NYHA class III or IV were located on the top of this list. Patients who died following ICU readmission were older, more frequently classified NYHA IV, more frequently underwent non-elective surgery or MIDCAB (Minimally Invasive Coronary Artery Bypass).

Conclusions
ICU readmission following coronary artery surgery is associated with increased in-hospital mortality and the development of postoperative complications. There are many predictors of ICU readmission. Non-survivors of this complication were older, with more advanced heart failure and more frequently underwent non-elective surgery.

Explanation letter
Editor's suggestions:
The authors need to clearly indicate the novel aspects of their results and clear differences with those already available in the literature.
Answer:
This issues have been raised in the text of our study. We have indicated the novel aspects of our results and clear differences with those already available in the literature, in numerous places in the text.
In the Introduction section of our paper, we stated:
“Data regarding ICU readmissions following cardiac surgery come exclusively from single-center studies. In addition, all these studies were based on heterogenous material, as they usually aimed to analyze all procedures performed in a certain department, within a specified time period. This issue is important, as various cardiac surgical procedures are associated with different outcomes. Moreover, there are currently no data on this topic from the area of Central and Eastern Europe, where a rapid increase in the number of cardiac surgery procedures has recently been observed”.

In the Discussion section, such information is given in the following sentences:
“Population of patients readmitted to the ICU following isolated coronary artery surgery, analyzed in our study, is probably the largest described to date in the medical literature”.
“It is very difficult to find comparative data for our results in the medical literature. Most of the available studies refer to ICU readmissions following various cardiac surgical procedures, and therefore involve an extremely heterogeneous population. Only two relatively small studies recently analyzed ICU readmissions in patients undergoing isolated coronary artery surgery”.
“The results of our multivariable analysis are unique, because there are no comparative data of this size in the medical literature”.

Review 1

1) Some abbreviations are used for the first time, without explanation (e.g. ICU even in the abstract)
Answer:
Agree.
Action:
We added explanations to abbreviations in the abstract: ICU (Intensive Care Unit), NYHA (New York Heart Association), MIDCAB (Minimally Invasive Coronary Artery Bypass Procedure) and in the discussion: COPD (Chronic Obstructive Pulmonary Disease), MI (Myocardial Infarction), ERAS (Enhanced Recovery After Surgery).

2) “The primary aim” and “the secondary aim” should be changed to “the primary outcome” and “the secondary outcome”; it is a bit odd with this terminology;
Answer:
Agree.
Action:
The phrases „the primary aim” and „the secondary aim”
have been changed to:
„the primary outcome” and „the secondary outcome”.

3) I believe that the clinical / paraclinical criteria applied for admission / readmission to the ICU should be specified in the section on methods
Answer:
We fully agree with this comment, but unfortunately KROK Registry has its limitations. Information on the direct reason for ICU readmission is not available in this Registry. This is clearly indicated in the paragraph describing the limitations of our study in the Discussion section:
“In spite of the fact that the analyzed population of patients readmitted to the ICU following isolated coronary artery surgery in our study was very large, our study is not without drawbacks. One obvious limitation is in the retrospective nature of our study. In our analysis, we were strictly limited to the data available in the KROK Registry. Also, we did not know, what was the timing and the direct reason for ICU readmission, as this information is not available in the KROK database.”
However, in our results it may be clearly seen that ICU readmissions have been primarily linked to postoperative complications, and these are well defined in the Methods section in the following paragraph:
„Patients who developed postoperative complications in the analyzed cohort were identified. Neurological complications were defined to include patients who developed a new neurological deficit in the postoperative period with persistent symptoms still present at the time of the hospital discharge. Respiratory complications included patients who required prolonged mechanical ventilation for more than 24 hours, and/or patients who developed pneumonia in the postoperative period. Renal complications included patients who required any form of renal replacement therapy in the postoperative period. Gastrointestinal complications included patients with gastrointestinal bleeding, pancreatitis, cholecystitis, and/or mesenteric ischemia – with or without a surgical intervention. Sternal, mediastinal or wound infection included all types of surgical site infections of the sternum. Perioperative myocardial infarction was recognized according to the criteria used by the Society of Thoracic Surgeons adult cardiac surgery database. In the initial period (<24 hours following the procedure) this included CK-MB serum values exceeding 5 times the upper limit of norm, with or

without new Q waves present in two or more leads (clinical signs were not required). In the later period (> 24 hours), it was necessary to determine at least one of the following criteria: progressive reduction in ST, appearance of new Q waves, appearance of a new left bundle branch block in the ECG, at least 3 times the CK-MB serum values.
Mechanical circulatory support was broadly defined to include the use any of the available options in this field. Finally, ICU readmission was identified if a patient was transferred to the ICU again following a previous discharge from this unit, during the same hospital admission."

4) It is not understood why perioperative myocardial infarction was defined using CK-MB and Q-waves, but not according to the 4th universal definition of myocardial infarction (CABG myocardial infarction): "Coronary artery bypass grafting (CABG) -related MI is arbitrarily defined as elevation of cTn values> 10 times the 99th percentile URL in patients with normal baseline cTn values. In patients with elevated pre-procedure cTn in whom cTn levels are stable (≤20% variation) or falling, the post-procedure cTn must rise by> 20%. However, the absolute post-procedural value still must be> 10 times the 99th percentile URL "- doi: 10.1093 / eurheartj / ehy462

Answer:
Thank for this comment. The 4th universal definition of myocardial infarction was created recently (in 2018), and KROK Registry was lauched many years ago. Polish Club of Cardiac Surgeons (owner of the KROK Registry) used the criteria adopted by the Society of Thoracic Surgeons to establish the KROK Registry and no changes in the nomenclature have been made since then. The authors of this publication have no influence on the definitions used in the Registry, but we will inform Polish Club of Cardiac Surgeons to redefine the definition of myocardial infarction in the KROK-Registry.

5) We did not find anything specified about the impact of AKI after CABG on ICU readmission as well as mortality.
Answer:
We are grateful for this comment. We are perfectly aware that AKI increases the risk of both ICU readmission and mortality. In our study, however, we did not aim to assess the impact of AKI on ICU readmissions and mortality. Instead, we aimed to assess the incidence of postoperative AKI and mortality among patients readmitted and not readmitted to the ICI and this makes an important difference.
Among patients readmitted to the ICU, renal complications were found to be 10 times higher in comparison to the remaining patients. According to the definition used in the KROK Registry: „renal complications included patients who required any form of renal replacement therapy in the postoperative period". It means, that the percentage of patients requiring any form of renal replacement therapy in the postoperative period was 11.5% among patients readmitted to the ICU and 1.3% in the remaining population.
The same is also valid for ICU mortality. In-hospital mortality among patients readmitted and not readmitted to the ICU was 29.6% and 2.1%, respectively ($p<0.001$).

6) The conclusions should be written as a separate chapter, not as part of the discussion
Answer:
Agree.
Action:
We deleted the conclusions from discussion and added a new chapter „Conclusions", as suggested.

poprawka KROK 2.doc

Intensive care unit readmissions following isolated coronary artery surgery

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Running head: ICU readmitted after coronary artery surgery

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Declarations of interest: none

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Abstract

Objectives: According to single institution studies, patients readmitted to the ICU (Intensive Care Unit) following cardiac surgery are at high risk of death. In our study, we primarily aimed to assess the impact of ICU readmission on postoperative results and to identify the independent risk factors of this complication among patients undergoing isolated coronary artery surgery.

Methods: Following exclusions, we analyzed 89,958 consecutive patients in the Polish National Registry of Cardiac Surgical Procedures (KROK Registry), scheduled for isolated coronary artery surgery between January 2010 and December 2019 (10 years). Variables that independently influenced ICU readmission were identified by means of the multivariable logistic regression. Data of survivors and non-survivors among patients readmitted to the ICU were compared.

Results: In the analyzed group, 1,003 patients underwent ICU readmission (1.1%) In-hospital mortality among patients readmitted and not readmitted to the ICU was 29.6% and 2.1%, respectively ($p<0.001$). All postoperative complications were more frequent among patients readmitted to the ICU. Overall, 15 independent predictors of ICU readmission were identified, and conversion to on-pump procedure, age>65 years and preoperative NYHA (New York Heart Association) class III or IV were located on the top of this list. Patients who died following ICU readmission were older, more frequently classified NYHA IV, more frequently underwent non-elective surgery or MIDCAB (Minimally Invasive Coronary Artery Bypass).

Conclusion: ICU readmission following coronary artery surgery is associated with increased in-hospital mortality and the development of postoperative complications. There are many predictors of ICU readmission. Non-survivors of this complication were older, with more advanced heart failure and more frequently underwent non-elective surgery.

Keywords: coronary artery surgery, ICU readmission, in-hospital mortality, postoperative complications.

Introduction

Intensive care unit (ICU) readmission rate in the entire cardiac surgical population is relatively constant and is maintained between 2% and 4% [1, 2, 3, 4]. The exact percentage of patients readmitted to the ICU after coronary revascularization is currently unknown. The only truly comparative study on this subject, published by Bardell et al., reports a readmission rate of 3.6%, but describes a population operated on nearly 20 years ago [5].

Cardiothoracic patients are usually readmitted to the ICU due to sternal instability, late tamponade, bleeding, mediastinitis or other postoperative complications. It has been confirmed that this population have a much higher in-hospital mortality (6 - 7 fold) and a longer hospital stay [1, 2, 6, 7, 8].

Data regarding ICU readmissions following cardiac surgery come exclusively from single-center studies. In addition, all these studies were based on heterogenous material, as they usually aimed to analyze all procedures performed in a certain department, within a specified time period. This issue is important, as various cardiac surgical procedures are associated with different outcomes. Moreover, there are currently no data on this topic from the area of Central and Eastern Europe, where a

rapid increase in the number of cardiac surgery procedures has recently been observed [9].

Therefore, in our study we analyzed patients readmitted to the ICU following isolated coronary artery surgery on a basis of nationwide, registry data, aiming to identify independent risk factors of ICU readmission. We also aimed to compare survivors and non-survivors of hospital stay among patients readmitted to the ICU.

Materials and methods

This analysis is based on data extracted from the Polish National Registry of Cardiac Surgical Operations (KROK Registry), a joint initiative of the Polish Society of Cardiothoracic Surgeons and the Polish Ministry of Health. The personal data of patients were protected in accordance with the Polish law. The sophisticated personal data protection system provided by the National Center for Healthcare Information Systems was used during data processing. Details regarding the KROK Registry have been previously described [9].

The primary outcome of our study was a comparison of preoperative variables, procedure-related variables and the postoperative course between patients readmitted and not readmitted to the ICU following isolated coronary artery surgery and to identify independent risk factors

for ICU readmission. The secondary outcome was a comparison of data of survivors and non-survivors of hospital stay among patients readmitted to the ICU in this population.

Our study included all patients who underwent isolated coronary artery bypass grafting (CABG) in Poland between January 2010 and December 2019 (10 years). ICU readmission was recorded if a patient was transferred to the ICU again following a previous discharge from this unit, during the same hospital stay.

Overall, 125.575 patients underwent isolated coronary artery surgery in Poland in the analyzed period. Patients coming from the centers where a field "ICU readmission" contained missing data, were excluded (n=34.347). Excluded were also patients with missing or confusing data on key variables (n=1.270). Finally, 89.958 patients (71.6% of the total population who underwent coronary surgery in the previously defined timeframe) were analyzed. In this group, 1.003 patients (1.1%) who were discharged from the ICU and subsequently readmitted to the ICU, were identified.

EuroSCORE II and the variable "poor mobility" was introduced to the KROK Registry in January 2012, and therefore these two variables were assessed in only 70.616 patients (78.5% of the analyzed population - 78.5% patients not requiring readmission and 81.2% patients requiring

readmission). Therefore, a variable “poor mobility” was not included later in a multivariable analysis.

The scope of data obtained from the KROK Registry allowed for the assessment of each patient in the following domains: baseline demographic data, circulatory function, individual risk factors, general condition directly before the procedure, and procedure-related variables (Table I and II). As previously mentioned, patients with missing or confusing data on key variables were excluded. The remaining categorical binary variables with missing data (<5%) were defaulted to the most common value present in the majority of cases.

Patients who developed postoperative complications in the analyzed cohort were identified. Neurological complications were defined to include patients who developed a new neurological deficit in the postoperative period with persistent symptoms still present at the time of the hospital discharge. Respiratory complications included patients who required prolonged mechanical ventilation for more than 24 hours, and/or patients who developed pneumonia in the postoperative period. Renal complications included patients who required any form of renal replacement therapy in the postoperative period. Gastrointestinal complications included patients with gastrointestinal bleeding, pancreatitis, cholecystitis, and/or mesenteric ischemia – with or without a surgical intervention.

Sternal, mediastinal or wound infection included all types of surgical site infections of the sternum. Perioperative myocardial infarction was recognized according to the criteria used by the Society of Thoracic Surgeons adult cardiac surgery database. In the initial period (<24 hours following the procedure) this included CK-MB serum values exceeding 5 times the upper limit of norm, with or without new Q waves present in two or more leads (clinical signs were not required). In the later period (> 24 hours), it was necessary to determine at least one of the following criteria: progressive reduction in ST, appearance of new Q waves, appearance of a new left bundle branch block in the ECG, at least 3 times the CK-MB serum values.

Mechanical circulatory support was broadly defined to include the use any of the available options in this field. Finally, ICU readmission was identified if a patient was transferred to the ICU again following a previous discharge from this unit, during the same hospital admission.

Statistical analysis

Initially, patients readmitted to the ICU were compared to the remaining population. Continuous variables were presented as mean and standard deviation, while categorical variables were presented as percentages.

Chi-squared test, Mann-Whitney U test and Student's t-test were used to test for statistical significance, where appropriate.

The independent demographic, preoperative and procedure-related variables (listed in table I) were compared between patients not readmitted and readmitted to the ICU. The effect of independent variables on ICU readmission was calculated by means of univariable logistic regression. Variables with a p-value <0.05 were then included in the multivariable logistic regression analysis, where p <0.05 was considered as significant. Finally, survivors and non-survivors of hospital stay were compared among patients readmitted to the ICU.

For all analyses, a two-tailed p-value <0.05 was considered statistically significant. The analyses and graphs were performed with the use of Dell Inc. (2016). Dell Statistica (data analysis software system), version 13.

Results

In the analyzed population of 89.958 patients who underwent isolated coronary artery surgery, 1,003 ICU readmissions were identified (1.1%).

Patients requiring ICU readmission had a mean EuroSCORE II of 4.48±6.38%, while patients not requiring ICU readmission had a mean EuroSCORE II of 2.15.±.3.43% (p<0.001). Patients readmitted to the ICU

were older (69.3 ± 8.5 vs 65.6 ± 8.8 years, p<0.001), and had significantly more comorbidities. Characteristics of patients who required or did not require ICU readmission is presented in table I. The percentage of patients who underwent their operation on pump, was similar among patients readmitted or not readmitted to the ICU (51.1% vs 51.7%, p=0.743), however there the percentage of patients who underwent conversion from off-pump to on-pump surgery was more than three times higher among patients readmitted to the ICU (1.7% vs 0.5%, p<0.001).

Overall, among 89,958 patients who underwent isolated coronary artery bypass surgery, there were 2,165 in-hospital deaths (2.4%). Among 1,003 patients requiring readmission to the ICU, there were 297 in-hospital deaths (29.6%). In the remaining group of 88,955 patients 1,868 deaths were noted (2.1%). Therefore, patients requiring readmission had a significantly higher in-hospital mortality in comparison to the remaining patients (29.6% and 2.1%, respectively, p<0.001). Patients readmitted to the ICU also had a strikingly higher incidence of all postoperative complications in comparison to the remaining population (table II).

Patients readmitted to the ICU had a longer overall ICU and hospital stay in comparison to the remaining patients (22.2 · 17.5 days and 10.5 · 6.5 days, respectively, p<0.001).

Multivariable analysis, carried out on the basis of data presented in table I (with the use of variables known at ICU readmission), indicated that ICU readmission following coronary artery surgery was independently associated with 15 preoperative and procedure-related variables. Three independent predictors for ICU readmission located on the top of this list, were conversion to on-pump procedure (OR 2.03; 95% CI: 1.23 - 3.34), age>65 years (OR 1.89, ; 95% CI: 1.63 - 2.18) and preoperative NYHA class III or IV (OR 1.80; 95% CI: 1.55 - 2.10). Complete list of independent predictors is presented in figure 1.

Patients who died following ICU readmission were older, more frequently classified NYHA IV and previously more frequently underwent either non-elective surgery or MIDCAB procedure (table III).

Discussion

Population of patients readmitted to the ICU following isolated coronary artery surgery, analyzed in our study, is probably the largest described to date in the medical literature. We proved, that ICU readmission following isolated coronary surgery was associated with a dramatic increase in mortality. The majority of these patients were readmitted to the ICU, because they developed serious postoperative complications. Additionally, ICU readmission had a significant impact on the duration of

hospital stay. Therefore, ICU readmissions must have had a profound and negative impact on the cost of hospital treatment. It has been already proved, that after adjusting for preoperative patient risk, ICU readmission has been shown to result in a $68,030 increase to a patient's total hospital charges in the United States [10].

Fortunately, ICU readmissions of cardiac surgical patients are relatively rare [1, 2, 3, 4]. ICU readmission made at the right time may have a preventive effect and usually prevents further serious events. Therefore, a clinician working at the bedside should be aware of the risk factors of ICU readmission, but also aware of the differences between survivors and non-survivors of hospital stay, if ICU readmission is actually taking place.

In our study, in-hospital mortality among patients readmitted to the ICU after isolated coronary revascularization was nearly 30%. The reasons for such high mortality need to be explained. The KROK database does not contain any data describing clinical situations and circumstances that led to ICU readmission. It is a serious limitation of our study, because various centers may have different local indications for ICU readmission: in some of them, it may be a relatively minor medical problem (e.g. the requirement for more advanced monitoring, without the need for mechanical ventilation or inotropic support), while in the others ICU readmission

may be only justified when serious postoperative complications occur. The trigger for ICU readmission may be therefore highly dependent on quality of a step-down unit operating within a local cardiac surgical department. In Poland, cardiac surgical step-down units are usually well developed, and generally a trigger for ICU admission might be set on a higher level, when compared to other countries, lowering the ICU readmission rate. That might have a profound impact on ICU mortality, when it comes to ICU admission [11, 12].

It is very difficult to find comparative data for our results in the medical literature. Most of the available studies refer to ICU readmissions following various cardiac surgical procedures, and therefore involve an extremely heterogeneous population. Only two relatively small studies recently analyzed ICU readmissions in patients undergoing isolated coronary artery surgery. The only larger study (containing 2,117 patients) was published by Bardell et al. nearly 20 years ago (in 2003) [5].

In a small case-control study conducted by Benetis et al., the case group contained 54 patients readmitted to the ICU, and the control group contained 115 randomly selected patients who did not require ICU readmission over a period of two consecutive years. In-hospital mortality among readmitted patients was 17%, and the readmission rate was 5% [13].

Another study published by Gümüş et al., presented only 36 patients readmitted to the ICU in a population of 679 coronary revascularizations. The results were basically identical, because in-hospital mortality in this group was 16.7% and the readmission rate was 5.3% [14]. These two studies were preceded by a larger single-center study carried out by Bardell et al., where the in-hospital mortality was 16.7%, and ICU readmission rate was 3.6% [5]. It may be easily observed, that the results obtained in our study are characterized by a lower ICU readmission rate and a higher mortality among the readmitted patients. This confirms our assumption, that the ICUs in Poland are generally characterized by a higher trigger for ICU admission, with a direct impact on the higher ICU mortality and the lower ICU readmission rates.

It would be very difficult to relate our results to the studies analyzing ICU readmissions following other types of cardiac surgical procedures, or to compare our data to the studies that analyze heterogeneous material where all cardiac surgical procedures performed in a given center were taken into account. Among the papers published in the last decade, the literature includes, for example, an analysis of patients readmitted to the ICU after valvular surgery [4], or following isolated valvular and coronary procedures only [1]. Other authors publishing on this topic over the past decade also analyzed the entire heterogeneous population

operated in their centers [2, 3, 6, 7, 15]. Among these studies, the largest material so far was presented by Litwinowicz et al., Van Diepen et al., and Kolat et al. [2, 3, 15]. In each study, ICU readmissions were analyzed in populations of approximately 10,000 patients each. In-hospital mortality in patients readmitted to ICU was 14%, 24% and 21%, while the proportions of patients requiring ICU readmission were 1.8%, 4.4% and 3.5%, respectively [2, 3, 15].

It should be pointed out, that patients readmitted to the ICU stay had a strikingly higher incidence of all postoperative complications in comparison to the remaining population undergoing coronary artery surgery. There is no doubt, that in the majority of cases the occurrence of these complications primarily led to ICU readmission. A similar picture emerges from a large study performed by Van Diepen et al., where almost 50% of patients in the group readmitted to the ICU underwent reintubation and repeat mechanical ventilation (versus 2.7% of such patients in the remaining population) and the incidence of neurological, renal and infectious complications were five times, six times and over 16 times higher, respectively [3].

The results of our multivariable analysis are unique, because there are no comparative data of this size in the medical literature. With the use of our large sample size, we were able to prove, that ICU readmission

following coronary artery surgery was independently associated with as many as 15 preoperative and procedure-related variables. Three most prominent independent predictors for ICU readmission from this list were: conversion to on-pump procedure, age>65 years and preoperative NYHA class III or IV, however it has to be taken into account that among the independent risk factors there were also such preoperative comorbidities as: *COPD* (Chronic obstructive pulmonary disease), chronic or persistent atrial fibrillation, peripheral vascular disease, obesity, low left ventricular ejection fraction, recent MI (Myocardial Infarction), non-elective surgery and many others (figure 1).

In our study, conversion from off-pump to on-pump coronary surgery is located in the beginning of the long list of independent risk factors for ICU readmission. This is logical in terms of the available evidence. Conversion from off-pump to on pump surgery is known to significantly increase in-hospital mortality, the frequence of reoperation due to bleeding and deep sternal wound infection (when compared both with off-pump and on-pump surgery) and is also associated with increased 30-day hospital readmission rate [16]. Moreover, hospital readmission following previous conversion in this particular study was often due to postoperative infection [16]. It should be recalled that in a previously cited study published by van Diepen et al., the incidence of infectious

complications was over 16 times higher among patients readmitted to the ICU [3].

Advanced age and non-elective surgery could have been expected among the risk factors of in-hospital death as these variables are already well-known to increase surgical risk in the EuroSCORE II [17]. Advanced age is associated with frailty and the presence of comorbidities, which in turn, are associated with an increased mortality among octogenarians admitted to the ICUs in Poland [18]. According to the data from a KROK Registry, there is a considerable number of octogenarians undergoing isolated coronary artery bypass surgery in Poland [19]. These factors are also important, because patients with advanced age and patients following non-elective surgery were not only more prone to ICU readmissions but also more prone to death when they were actually readmitted to the ICU (table 3).

In spite of the fact that the analyzed population of patients readmitted to the ICU following isolated coronary artery surgery in our study was very large, our study is not without drawbacks. One obvious limitation is in the retrospective nature of our study. In our analysis, we were strictly limited to the data available in the KROK Registry. Also, we did not know, what was the timing and the direct reason for ICU readmission, as this information is not available in the KROK database. In view of

such a long observation time, it should be also remembered that patient's hospital safety in the analyzed timeframe could not be considered constant - in Poland, for example, early response teams and ERAS (Enhanced Recovery After Surgery) protocols have been recently introduced and this fact may also have an influence on the ICU readmission rates [20, 21]. The strength of the study, however, was a very large sample size and exceptionally long observation period, which ensures the reliability of the results.

Conclusions

ICU readmission following isolated coronary surgery in Poland is associated with increased in-hospital mortality and the development of postoperative complications. There is a large group of independent risk factors for ICU readmission. In a subgroup of ICU readmissions, non-survivors were older, with more advanced heart failure and more frequently underwent non-elective surgery.

Table and figure legends

Table 1. Comparison of preoperative variables among patients who required or did not require ICU readmission following coronary artery surgery.

Table 2. The incidence of postoperative complications among patients who required or did not require ICU readmission following coronary artery surgery.

Table 3. Comparison of preoperative variables among survivors and non-survivors in patients readmitted to the ICU following coronary artery surgery.

Figure 1. Multivariable analysis – independent risk factors of ICU readmission after isolated coronary artery surgery.

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Table 1. Comparison of preoperative variables among patients who required or did not require ICU readmission following coronary artery surgery.

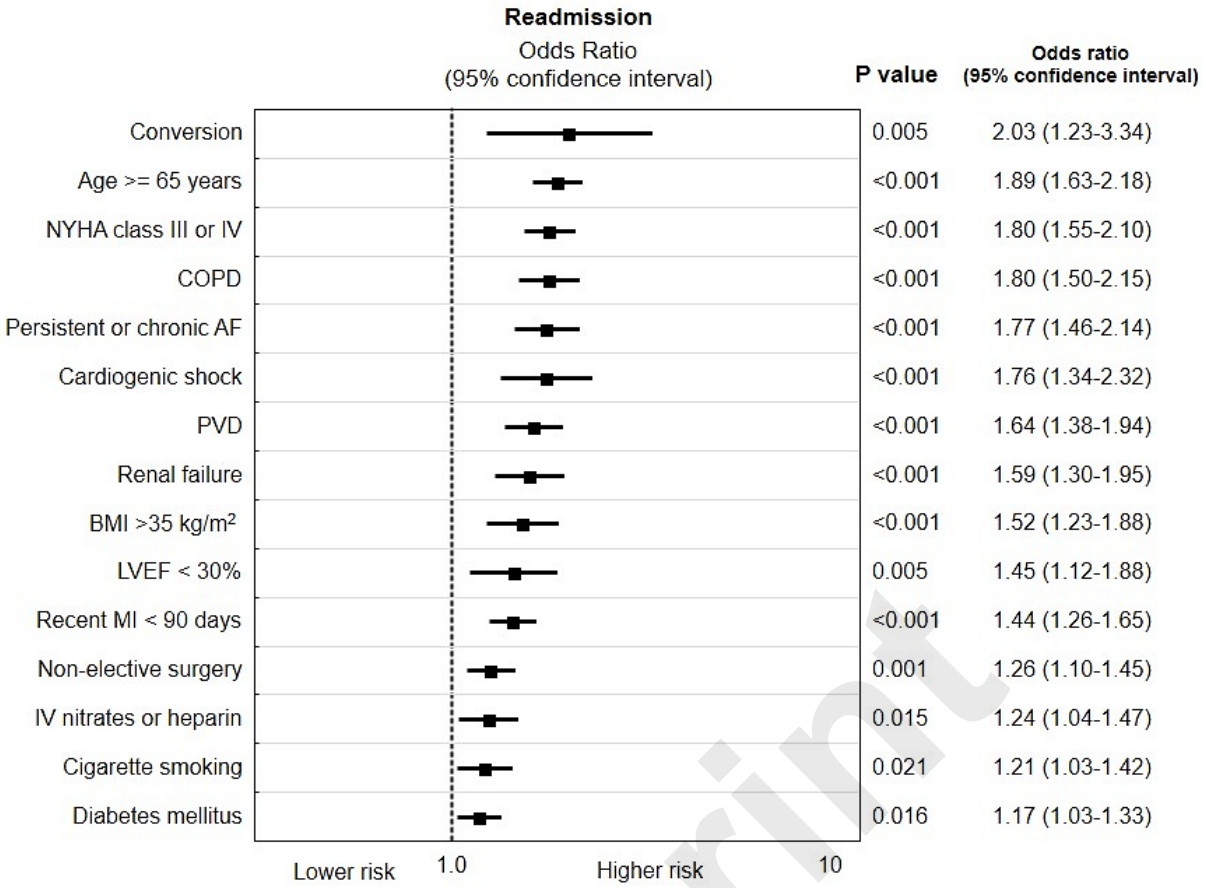
Group of variables	Variable	All (n=89 958)		Not readmitted (n=88 955)		Readmitted (n=1 003)		p Yates
	Age ≥ 65 years	48 764	54.2%	48 044	54.0%	720	71.8%	**<0.001**
	Female gender	22 138	24.6%	21 858	24.6%	280	27.9%	**0.016**
Circulatory function	CCS class IV	13 304	14.8%	13 068	14.7%	236	23.5%	**<0.001**
	NYHA class III or IV	10 550	11.7%	10 298	11.6%	252	25.1%	**<0.001**
	Recent MI < 90 days	25 414	28.3%	24 988	28.1%	426	42.5%	**<0.001**
	Pulmonary hypertension	287	0.3%	276	0.3%	11	1.1%	**<0.001**
	LVEF < 30%	2 619	2.9%	2 550	2.9%	69	6.9%	**<0.001**
	Previous PCA/stent	28 498	31.7%	28 174	31.7%	324	32.3%	0.694
	Persistent or chronic AF	5 225	5.8%	5 098	5.7%	127	12.7%	**<0.001**
	Left main stem lesion	27 750	30.8%	27 387	30.8%	363	36.2%	**<0.001**
	Triple vessel disease	51 129	56.8%	50 553	56.8%	576	57.4%	0.728
Individual risk factors	Cigarette smoking	16 361	18.2%	16 154	18.2%	207	20.6%	**0.047**
	Hypercholesterolemia	54 899	61.0%	54 310	61.1%	589	58.7%	0.141
	Diabetes mellitus	31 815	35.4%	31 394	35.3%	421	42.0%	**<0.001**
	Arterial hypertension	78 946	87.8%	78 050	87.7%	896	89.3%	0.139
	BMI >35 kg/m^2	6 316	7.0%	6 216	7.0%	100	10.0%	**<0.001**
	Renal failure	4 714	5.2%	4 597	5.2%	117	11.7%	**<0.001**
	COPD	6 967	7.7%	6 822	7.7%	145	14.5%	**<0.001**
	Past TIA, RIND, stroke	3 575	4.0%	3 509	3.9%	66	6.6%	**<0.001**
	Past treatment of CAD	1 104	1.2%	1 082	1.2%	22	2.2%	**0.008**
	PVD	8 255	9.2%	8 082	9.1%	173	17.2%	**<0.001**
	Poor mobility*	4 389	4.9%	4 291	4.8%	98	9.8%	**<0.001**
Condition before the procedure	Cardiogenic shock	1 919	2.1%	1 845	2.1%	74	7.4%	**<0.001**
	Use of IABP	948	1.1%	918	1.0%	30	3.0%	**<0.001**
	IV nitrates or heparin	11 882	13.2%	11 660	13.1%	222	22.1%	**<0.001**
Procedure-related variables	Previous cardiac surgery	1 478	1.6%	1 454	1.6%	24	2.4%	0.079
	Non-elective surgery	33 093	36.8%	32 588	36.6%	505	50.3%	**<0.001**
	CABG	46 518	51.7%	46 005	51.7%	513	51.1%	0.743
	OPCAB	40 879	45.4%	40 410	45.4%	469	46.8%	0.418
	MIDCAB	2 561	2.8%	2 540	2.9%	21	2.1%	0.178
	Conversion	497	0.6%	480	0.5%	17	1.7%	**<0.001**

Table 2. The incidence of postoperative complications among patients who required or did not require ICU readmission following coronary artery surgery.

Postoperative complications	All (n=89 958)		Not readmitted (n=88 955)		Readmitted (n=1 003)		p Yates
Neurological complications	1 324	1.5%	1 184	1.3%	140	14.0%	**<0.001**
Respiratory complications	3 085	3.4%	2 687	3.0%	398	39.7%	**<0.001**
Gastrointestinal complications	601	0.7%	513	0.6%	88	8.8%	**<0.001**
Renal complications	1 209	1.3%	1 094	1.2%	115	11.5%	**<0.001**
Sternal, mediastinal or wound infection	2 127	2.4%	1 977	2.2%	150	15.0%	**<0.001**
Perioperative myocardial infarction	1 343	1.5%	1 243	1.4%	100	10.0%	**<0.001**
Mechanical circulatory support	1 905	2.1%	1 764	2.0%	141	14.1%	**<0.001**
Reoperation due to bleeding	3 300	3.7%	3 079	3.5%	221	22.0%	**<0.001**

Table 3. Comparison of preoperative variables among survivors and non-survivors in patients readmitted to the ICU following coronary artery surgery.

Group of variables	Variable	All (n=1,003)		Survivors (n=706)		Non-survivors (n=297)		p Yates
	Age ≥ 65 years	720	71.8%	485	68.7%	235	79.1%	**0.001**
	Female gender	280	27.9%	187	26.5%	93	31.3%	0.139
Circulatory function	CCS class IV	236	23.5%	152	21.5%	84	28.3%	**0.026**
	NYHA class III or IV	252	25.1%	165	23.4%	87	29.3%	0.058
	Recent MI < 90 days	426	42.5%	295	41.8%	131	44.1%	0.542
	Pulmonary hypertension	11	1.1%	5	0.7%	6	2.0%	0.136
	LVEF < 30%	69	6.9%	46	6.5%	23	7.7%	0.572
	Previous PCA/stent	324	32.3%	219	31.0%	105	35.4%	0.206
	Persistent or chronic AF	127	12.7%	83	11.8%	44	14.8%	0.220
	Left main stem lesion	363	36.2%	261	37.0%	102	34.3%	0.473
	Triple vessel disease	576	57.4%	404	57.2%	172	57.9%	0.895
Individual risk factors	Cigarette smoking	207	20.6%	151	21.4%	56	18.9%	0.413
	Hypercholesterolemia	589	58.7%	425	60.2%	164	55.2%	0.164
	Diabetes mellitus	421	42.0%	296	41.9%	125	42.1%	0.982
	Arterial hypertension	896	89.3%	629	89.1%	267	89.9%	0.791
	BMI >35 kg/m^2	100	10.0%	67	9.5%	33	11.1%	0.505
	Renal failure	117	11.7%	78	11.0%	39	13.1%	0.406
	COPD	145	14.5%	95	13.5%	50	16.8%	0.197
	Past TIA, RIND, stroke	66	6.6%	43	6.1%	23	7.7%	0.410
	Past treatment of CAD	22	2.2%	11	1.6%	11	3.7%	0.060
	PVD	173	17.2%	116	16.4%	57	19.2%	0.334
	Poor mobility*	98	9.8%	66	9.3%	32	10.8%	0.563
Condition before the procedure	Cardiogenic shock	74	7.4%	50	7.1%	24	8.1%	0.674
	Use of IABP	30	3.0%	19	2.7%	11	3.7%	0.512
	IV nitrates or heparin	222	22.1%	156	22.1%	66	22.2%	0.969
Procedure-related variables	Previous cardiac surgery	24	2.4%	13	1.8%	11	3.7%	0.125
	Non-elective surgery	505	50.3%	336	47.6%	169	56.9%	**0.009**
	CABG	513	51.1%	374	53.0%	139	46.8%	0.086
	OPCAB	469	46.8%	323	45.8%	146	49.2%	0.359
	MIDCAB	21	2.1%	9	1.3%	12	4.0%	**0.011**
	Conversion	17	1.7%	11	1.6%	6	2.0%	0.803


Readmission
Odds Ratio
(95% confidence interval)
P value
Odds ratio
(95% confidence interval)
Conversion
0.005
2.03 (1.23-3.34)
Age >= 65 years
<0.001
1.89 (1.63-2.18)
NYHA class III or IV
<0.001
1.80 (1.55-2.10)
COPD
<0.001
1.80 (1.50-2.15)
Persistent or chronic AF
<0.001
1.77 (1.46-2.14)
Cardiogenic shock
<0.001
1.76 (1.34-2.32)
PVD
<0.001
1.64 (1.38-1.94)
Renal failure
<0.001
1.59 (1.30-1.95)
BMI >35 kg/m2
<0.001
1.52 (1.23-1.88)
LVEF < 30%
0.005
1.45 (1.12-1.88)
Recent MI < 90 days
<0.001
1.44 (1.26-1.65)
Non-elective surgery
0.001
1.26 (1.10-1.45)
IV nitrates or heparin
0.015
1.24 (1.04-1.47)
Cigarette smoking
0.021
1.21 (1.03-1.42)
Diabetes mellitus
0.016
1.17 (1.03-1.33)
Lower risk
1.0
Higher risk
10