ORIGINAL ARTICLE

UDC: 616.127-005.8-08-036
https://doi.org/10.2298/VSP180128183P

# Complete percutaneous myocardial revascularization in patients with STEMI complicated by cardiogenic shock

## Kompletna perkutana revaskularizacija miokarda kod bolesnika sa STEMI komplikovanim kardiogenim šokom

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**Abstract**

**Background/Aim**. Despite considerable progress in terms of early myocardial revascularization and the use of mechanical circulatory support, cardiogenic shock continues to be the leading cause of death in acute myocardial infarction. The current recommendations of the European Society of Cardiology advocate early revascularization of all critical stenosis or highly unstable lesions in the state of cardiogenic shock, while recently published studies favour the early revascularization of the infarct related artery only, in patients with acute myocardial infarction with the ST segment elevation (STEMI) presenting with cardiogenic shock. The aim of the study was to assess the impact of the complete early percutaneous myocardial revascularization in an acute myocardial infarction complicated by cardiogenic shock on intra-hospital mortality. **Methods**. The research was conducted as a retrospective observational analysis of data obtained from the hospital registry for cardiogenic shock. The study group consisted of 235 patients treated in the period from August 2007 until October 2016 for STEMI complicated by cardiogenic shock. Three groups were formed. The first group consisted of patients with one vessel disease who underwent revascularization of infarct related artery; the second group of patients had multi-vessel disease and only culprit lesions were revascularized and the third one consisted of patients with multi-vessel disease and the complete myocardial revascularization performed. Additional subgroups were formed in reference to the intra-aortic balloon pump (IABP) implantation. Intra-hospital mortality was analyzed in all groups and subgroups. **Results.** Revascularization of the culprit lesion alone among patients with multivessel disease was performed in 142 (60.4%) patients while the complete revascularization (revascularization of "culprit" and other significant lesions) was performed in 28 (11.9%) patients with multi-vessel disease. There were 65 (27.7%) patients with single-vessel disease who underwent revascularization of infarct related artery. The lowest mortality was found in the group of patients with multi-vessel coronary disease who underwent complete myocardial revascularization and had IABP implanted (mortality was 35.7%). The difference in the mean value of the left ventricular ejection fraction (EF) between the surviving and deceased patients was statistically significant ($p < 0.005$). The average EF of survivors was 44% (35%–50%) while 30% (25%–39.5%) deceased of patients. Based on the obtained data, the mathematically predictive model was tested. The receiver operating characteristic (ROC) curve showed that our model is a good predictor of fatal outcome ($p < 0.0005$; AUROC = 0.766) with the sensitivity of 80.3%, and the specificity of 67%. **Conclusion**. STEMI complicated by cardiogenic shock is still associated with a high mortality rate. Complete myocardial revascularization independently as well as in combination with an IABP, significantly reduces mortality in patients with acute STEMI complicated by cardiogenic shock.

**Key words:**
**myocardial infarction; shock, cardiogenic; myocardial revascularization; percutaneous coronary intervention; mortality.**

**Apstrakt**

**Uvod/Cilj.** I pored značajnog napretka rane miokardne revaskularizacije i upotrebe mehaničke cirkulatorne podrške, kardiogeni šok i dalje predstavlja vodeći uzrok smrti kod akutnog infarkta miokarda. Aktuelne preporuke Evropskog udruženja kardiologa preporučuju ranu revaskularizaciju svih kritičnih stenoza ili visoko nestabilnih lezija kod stanja kardiogenog šoka, dok skorašnje studije preporučuju ranu revaskularizaciju samo infarktne koronarne arterije kod bo-

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lesnika sa akutnim infarktom miokarda sa ST segment elevacijom (STEMI) i kardiogenim šokom. Cilj studije bio je da analizira uticaj kompletne rane perkutane miokardijalne revaskularizacije u akutnom infarktu komplikovanim kardiogenim šokom na intrahospitalni mortalitet. **Metode.** Istraživanje je sprovedeno kao retrospektivna opservaciona analiza podataka dobijenih iz bolničkih registara za kardiogeni šok. Studijska grupa imala je 235 bolesnika lečenih u periodu od avgusta 2007. do oktobra 2016. godine zbog STEMI komplikovanim kardiogenim šokom. Formirane su tri grupe. Prva grupa sastojala se od bolesnika sa bolešću jednog krvnog suda podvrgnutih revaskularizaciji, arterije povezane sa infarktom. Drugu grupu činili su bolesnici sa multisudovnom bolešću, kod kojih je samo revasulizirana *culprit* lezija, a treću grupu činili su bolesnici sa multi-sudovnom bolešću i kompletnom revaskularizacijom miokarda. Dodatne subgrupe formirane su na osnovu implantaciju intraaortne balon pumpe (IABP). Intrahospitalni mortalitet analiziran je u svim grupama i subgrupama. **Rezultati.** Revaskulsrizacija samo *culprit* lezije kod bolesnika sa multisudovnom bolešću učinjena je kod 142 (60,4%) bolesnika, dok je kompletna revaskularizacija (revaskularizacija *culprit* i ostalih značajnih lezija) kod bolesnika sa multisudovnim lezijama učinjena kod 28 (11,9%) bolesnika. Šezdeset pet (27,7%) bolesnika sa jednosudovnom bolešću podvrgnuto je revaskularizaciji infarktne arterije. Najniži mortalitet bio je u grupi bolesnika sa multisudovnom koronarnom bolešću koji su podvrgnuti kompletnoj revaskularizaciji i implantaciji IABP (mortalitet 35,7%). Razlika u srednjoj vrednosti ejekcione frakcije leve komore (EF) između preživelih i umrlih bila je statistički značajna ($p < 0,005$). Prosečna vrednost EF kod preživelih bila je 44% (35%–50%), dok je kod umrlih iznosila 30% (25%–39,5%). Na osnovu korišćenih podataka, testiran je matematički prediktivni model. *Reciever operating characteristics* (ROC) kriva pokazala je da je naš model dobar pokazatelj fatalnog ishoda ($p < 0,0005$; AUROC = 0,766), uz senzitivnost od 80,3% i specifičnost 67%. **Zaključak.** STEMI komplikovan kardiogenim šokom još uvek je udružen sa visokom stopom mortaliteta. Samo kompletna revaskularizacija miokarda, kao i u kombinaciji sa IABP, značajno smanjuje mortalitet kod bolesnika sa akutnim STEMI komplikovanim kardiogenim šokom.

**Ključne reči:**
**infakrt miokarda; šok, kardiogeni; miokard, revaskularizacija; perkutana koronarna intervencija; mortalitet.**

## Introduction

Cardiogenic shock is the state of critical tissue hypoperfusion, resulting from cardiac failure which is in 75% of cases caused by acute myocardial infarction [1–3]. The incidence of cardiogenic shock in acute myocardial infarction is 5%–15% [4].

Despite the significant therapeutic progress, primarily in the sense of early myocardial revascularization strategy and aggressive inotropic and vasopressor support, cardiogenic shock continues to be the leading cause of death in acute myocardial infarction with the mortality rate of 42%–48% [5–9].

Data obtained from a limited number of studies show a possible reduction in hospital mortality related to cardiogenic shock, which is associated with the strategy of performing early myocardial revascularization in this group of patients [4].

The current European Guidelines on Myocardial Revascularization recommend early myocardial revascularization either by percutaneous coronary intervention or coronary artery bypass grafting (CABG). Also, revascularization of culprit lesion and all critical stenosis or highly unstable lesions was highly encouraged in cardiogenic shock at that time by the guideline [2].

When it comes to the use of an intra-aortic balloon pump (IABP) in cardiogenic shock caused by acute myocardial infarction, the valid recommendation of the European Society of Cardiology (ESC) and the American College of Cardiology/American Heart Association (ACC/AHA) guidelines do not recommend routine IABP implantation, except in the case of mechanical complications of acute myocardial infarction, in order to bridge to surgery [10, 11].

## Methods

The research was conducted as a retrospective observational analysis of data obtained from the hospital information system of the Institute of Cardiovascular Diseases of Vojvodina in Sremska Kamenica. The study group consisted of 235 patients with ST-elevation myocardial infarction (STEMI) complicated by cardiogenic shock who were treated in the period from August 2007 until October 2016. The inclusion criterion was the STEMI of any localization with signs of cardiogenic shock according to the current guidelines of the ESC as well as urgent coronarography and primary percutaneous coronary intervention (pPCI) [10].

Patients in whom cardiogenic shock developed before urgent coronarography were analyzed. The criteria used for the diagnosis of cardiogenic shock (Killip Class IV) were: systolic blood pressure less than 90 mmHg lasting longer than 30 minutes, or the necessity of vasopressor therapy in order to achieve systolic arterial blood pressure value $\geq 90$ mmHg; pulmonary congestion or elevated left ventricular filling pressures; signs of tissue perfusion disorder with at least one of the following criteria: altered mental status, cold, sticky skin, oliguria (< 0.5 mL/kg/h); elevated serum lactate (> 1.5 mmol/L) [10–13]. Patients who failed pPCI or had fatal outcome during intervention were not included in the analysis.

Total ischemic time could not be determined since these patients were already in a severe general condition and cardiogenic shock at admission, and the data on the onset of symptoms were unreliable or impossible to obtain.

The primary goal was to assess the impact of the complete early percutaneous myocardial revascularization in acute myocardial infarction complicated by cardiogenic shock on intra-hospital mortality, while the secondary goal

was to assess the impact of the intra-aortic balloon pump (IABP) in cardiogenic shock caused by acute myocardial infarction on intra-hospital mortality.

As part of the patient admission and preparation process for PCI, all patients were admitted to the Coronary Care Unit, where clinical examination and electrocardiography (ECG) were performed and blood was taken to determine the markers of myocardial necrosis. All patients were sedated, endotracheally intubated and placed on invasive mechanical ventilation. All patients were given the circulatory support in terms of vasopressors and/or inotropes. After an adequate preparation, urgent coronarography and pPCI were performed in all patients at the catheterization laboratory (Cath Lab). Depending on a patient's clinical condition, echocardiography was performed before or after percutaneous coronary intervention.

Complete percutaneous coronary myocardial revascularization involved not only mechanical revascularization of culprit lesions but also other critical stenoses in both the infarct and other coronary arteries. The method of revascularisation of only „culprit lesions", or complete revascularization was decided by the interventional cardiologist during the procedure depending on the form and type of a lesion, regarding its suitability and feasibility for the complete revascularization.

Implantation of the intra-aortic balloon pump (IABP Datascope, Corp Mahwah, NJ USA) was assessed and decided on by the interventional cardiologist according to clinical condition of the patient. Since this was a retrospective follow-up, there were no clearly defined criteria for the IABP implantation, so the decision on implantation was made by the interventional cardiologist.

All implantations were performed at the Cath Lab during or after the percutaneous coronary intervention PCI procedure.

Accordingly, three large groups were formed. The first group consisted of patients with one vessel disease who underwent revascularization of infarct related artery; the second group was made up of patients with multivessel disease and only culprit lesions revascularized, and the third one consisted of patients with multi-vessel disease and the complete myocardial revascularization performed. Additional subgroups were formed within these three large groups in reference to the IABP implantation. Intra-hospital mortality was analyzed in all groups and subgroups. The patients with unsuccessful revascularization of culprit lesion were excluded from the analysis.

In this paper, the following measures of the descriptive statistics were used: arithmetic mean, standard deviation, median, quartiles, frequencies, and percentages. For the comparison of the mean values of variables of two populations, the independent samples *t*-test and the Mann-Whitney test were used. The correlation of the categorical variables was examined using the Chi-square ($\chi^2$) test for the contingency tables or the Fisher test. The effects of variables on the treatment outcome were determined using the univariate and multivariate binary logistic analyses. Determining the outcome prediction markers was assisted by the recieves operating characteristic (ROC) curves. The Kaplan Meier and Cox regression analyses were used for the statistical analysis of survival.

Statistical analysis and data processing were done using the Statistical Package for Social Sciences – SPSS program for Windows, Version 17.0 (SPSS Inc. Chicago, IL), in which the significance limit was $p < 0.05$.

## Results

This study included 235 patients, 137 (58.3%) men and 98 (41.7%) women. The average age of men was 64.94 ± 10.87 years while the average age of women was 68.87 ± 11.05 years. Demographic characteristics, risk factors for ischemic heart disease, and early history of myocardial infarction of the patients included in the study are shown in Table 1. Urgent coronarography and then primary PCI were performed in all patients. Urgent coronarography found 65 (27.7%) patients with single-vessel coronary disease and 170 (72.3%) patients with multi-vessel coronary disease. One hundred and twenty-seven (54%) patients had anterior wall STEMI, while 108 (46%) patients had inferior wall STEMI. Revascularization of the culprit lesion alone among patients with multi-vessel disease was performed in 142 (60.4%) patients, while the complete revascularization (revascularization of „culprit" and other significant lesions) among patients with multi-vessel disease was performed in 28 (11.9%) patients. There were 65 (27.7%) patients with single-vessel disease who underwent revascularization of infarct related artery.

Intra-aortic balloon pump was implanted in 84 (35.7%) patients (Table 1), predominantly in patients with anterior wall STEMI (75%) and in 25% of patients with the inferior wall STEMI. IABP was significantly more often implanted in patients with the anterior wall STEMI ($p = 0.0005$). Mortality in relation to the type of coronary disease and the implantation of IABP is shown in Figure 1. There was a statistically significant difference in the mortality rate among the groups ($p = 0.046$), and the lowest mortality was found in the group of patients with multi-vessel coronary disease who underwent complete myocardial revascularization and IABP was implanted (mortality was 35.7%). However, the Kaplan-Meier survival curve and Cox regression analysis showed that there are no statistically significant difference ($p = 0.220$) in survival length between the groups (Figure 2).

The intra-hospital mortality rate of the sample was 62.6% (Table 1). Implantation of IABP ($p = 0.406$), type of infarction ($p = 0.171$) as well as whether it was single or multi-vessel coronary disease ($p = 0.341$) did not significantly affect mortality. Mechanical complications of STEMI appeared as ventricular septal defect in 5 (2.1%) patients, rupture of the papillary muscle of the mitral valve also in 5 (2.1%) patients and as the tamponade due to the rupture of the free wall of the myocardium in 1 (0.4%) patient. The total mortality of patients with mechanical complication was high (90.9%), but there was no statistically significant difference in regards to the mortality of patients without mechanical complication ($p = 0.219$).

**Table 1**

**Demographic and clinical characteristics of patients**

| Variable | All patients (n = 235) | Single-vessel (n = 65) | Multi-vessel and complete revas-cularization (n = 28) | Multi-vessel and incomplete re-vascularization (n = 142) | *p* |
|---|---|---|---|---|---|
| Sex, n (%) | | | | | |
| male | 137 (58.3) | 38 (27.7) | 25 (18.2) | 74 (54.1) | 0.001 |
| female | 98 (41.7) | 27 (27.5) | 3 (3.1) | 68 (69.4) | |
| HTA, n (%) | 137 (58.3) | 37 (27) | 14 (10.2) | 86 (62.8) | 0.425 |
| DM, n (%) | 64 (27.2) | 13 (20.3) | 8 (12.5) | 43 (67.2) | 0.333 |
| HLP, n (%) | 44 (18.7) | 7 (15.9) | 9 (20.5) | 28 (63.6) | 0.066 |
| Smoking, n (%) | 75 (31.9) | 20 (26.7) | 6 (8) | 49 (65.3) | 0.326 |
| Heredity, n (%) | 44 (18.7) | 16 (36.4) | 6 (13.6) | 22 (50) | 0.249 |
| Previous MI, n (%) | 17 (7.2) | 3 (17.6) | 1 (5.9) | 13 (76.5) | 0.202 |
| Age (years), mean (range) | 69.0 (59.0–75.0) | 68.0 (58.5–73.0) | 64.5 (55.5–73.0) | 70.0 (61.0–76.0) | 0.237 |
| EF (%), mean (range) | 36.0 (27.0–46.0) | 39.0 (30.0–48.0) | 35.0 (21.5–44.5) | 35.0 (27.0–46.0) | 0.249 |
| Localization, n (%) | | | | | |
| inferior | 108 (46.0) | 26 (24.1) | 11 (10.2) | 71 (65.7) | 0.307 |
| anterior | 127 (54.0) | 39 (30.7) | 17 (13.4) | 71 (55.9) | |
| Mechanical complications, n (%) | | | | | |
| None | 224 (95.2) | 61 (93.9) | 28 (100) | 135 (95.1) | |
| VSD | 5 (2.1) | 3 (4.6) | 0 (0) | 2 (1.4) | 0.598 |
| RPM | 5 (2.1) | 1 (1.5) | 0 (0) | 4 (2.8) | |
| Tamponade, n (%) | 1 (0.4) | 0 (0) | 0 (0) | 1 (0.7) | |
| TIMI Flow, n (%) | | | | | |
| 0 | 20 (8.5) | 4 (20) | 3 (15) | 13 (65) | |
| 1 | 9 (3.8) | 6 (66.7) | 0 (0) | 3 (33.3) | 0.215 |
| 2 | 25 (10.6) | 7 (28) | 0 (0) | 16 (64) | |
| 3 | 181 (77) | 48 (26.5) | 23 (12.7) | 110 (60.8) | |
| TIMI Code, n (%) | | | | | |
| TF < 3 | 54 (23) | 17 (31.5) | 5 (9.3) | 32 (59.3) | 0.670 |
| TF = 3 | 181 (77) | 48 (26.5) | 23 (12.7) | 110 (60.8) | |

**EX – died; IABP – intra-aortic balloon pump; HTA – arterial hypertension; DM – diabetes mellitus; HLP – hyperlipidaemia; MI – myocardial infarction; EF – ejection fraction; VSD – ventricular septal defect; RPM – rupture of papillary muscle; TIMI – thrombolysis in myocardial infarction.**

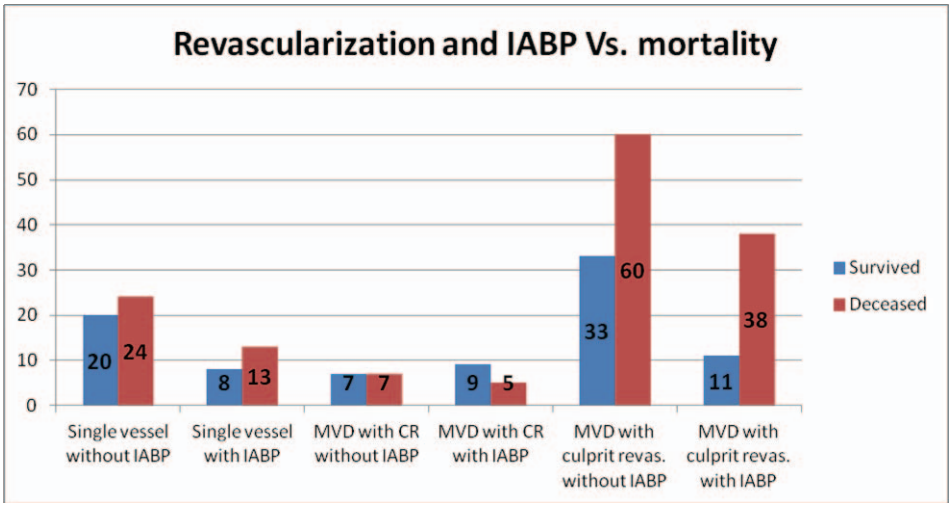


**Fig. 1 – Percutaneous myocardial revascularization, intra-aortic balloon pump (IABP) use and mortality.**
**MVD – multivessel disease; CR – complete revascularization.**

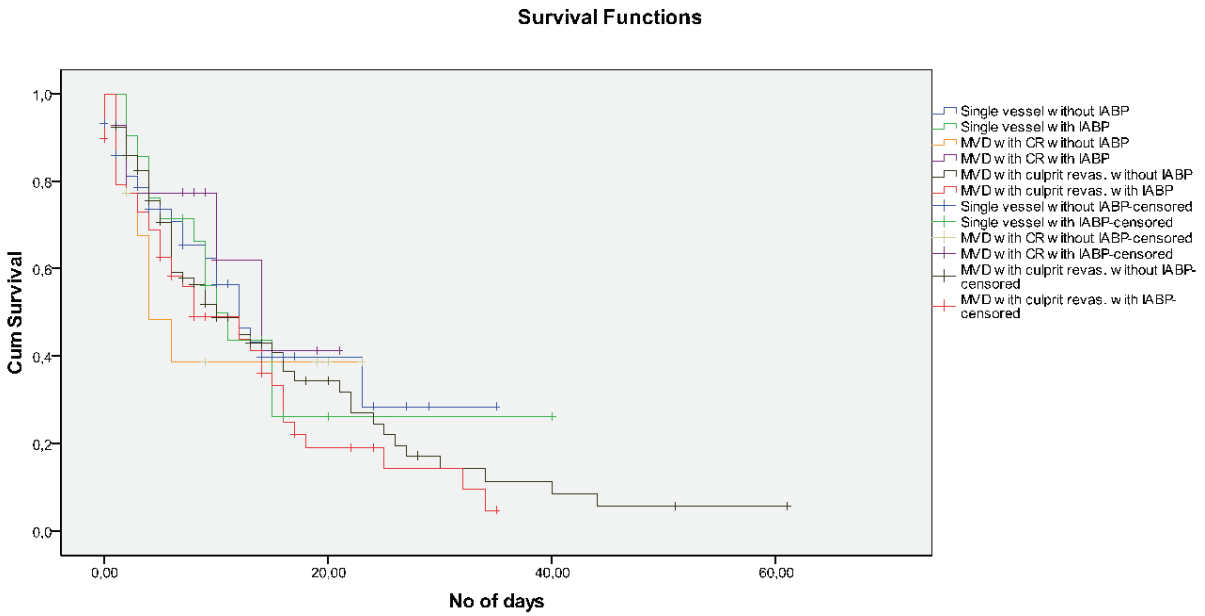


**Fig. 2 – Kaplan Meier Curve of intra-hospital survival in relation to the type of coronary disease and revascularization; MVD – multi-vessel disease; CR – coronary revascularization; ($p > 0.05$).**

**Table 2**

**Age, EF, complete percutaneous revascularization, TIMI flow and influence on mortality**

| Variable | Univariate binary logistic regression | | Multivariate binary logistic regression | |
|---|---|---|---|---|
| | OR (95%CI) | *p*-value | OR (95%CI) | *p* |
| Age (year) | 1.029 (1.005–1.054) | 0.019 | 1.035 (1.007–1.064) | 0.015 |
| EF (%) | 0.928 (0.904–0.953) | < 0.0005 | 0.924 (0.899–0.950) | < 0.0005 |
| Complete revascularization | 0.500 (0.291–0.858) | 0.012 | 0.413 (0.222–0.767) | 0.005 |
| TIMI Flow | 0.395 (0.195–0.800) | 0.010 | 0.409 (0.183–0.916) | 0.030 |

**EF – left ventricular ejection fraction, TIMI – thrombolysis in myocardial infarction.**
**OR – odds ratio; CI – confidence interval.**

**Table 3**

**ROC curve – Age and ejection fraction in the fatal outcome prediction**

| Parameters | ROC curve | | | | |
|---|---|---|---|---|---|
| | Area (95% CI) | Cut-off | Sensitivity | Specificity | *p* |
| Age (year) | 0.598 (0.523–0.672) | 65.5 | 63.3% | 51.1% | 0.012 |
| Ejection fraction (%) | 0.728 (0.660–0.796) | 38.5 | 72.1% | 68.2% | < 0.005 |

**ROC – reciever operating characteristic; CI – confidence interval.**

In the investigated group of patients, age affected the occurrence of fatal outcome ($p = 0.015$) (Table 2). The average age of the survivors was 64.5 (56–73) years and the deceased 70 (62–76) years. The odds ratio for age was 1.035 (1.007–0.064), which means that the increase of 1 year in life age increases the risk of fatal outcome by 3.5%. The ROC curve showed that age of patients was not a good marker for the prediction of fatal outcome (area = 0.598; sensitivity = 63.3%; specificity = 51.1%), (Table 3). The difference in the mean value of the left ventricular ejection fraction (EF) between the surviving and deceased patients was statistically significant ($p < 0.005$), (Table 3). The average EF of survivors was 44% (35%–50%), while it was 30% in the deceased ones (25%–39.5%). The OR for the EF was 0.924 (0.899–0.950). The increase of EF by 1 decreased the risk of death by 7.5%. The ROC curve in Table 3 shows that the EF can be a good marker for the prediction of fatal outcome (area = 0.728; sensitivity = 72.1%: specificity = 68.2%).

The incidence of complete revascularization was significantly lower in the female patients (30.6% in relation to 46% of men, $p < 0.025$) while mortality was significantly higher ($p < 0.0005$).

The quality of TIMI flow after the stent implantation on the "culprit lesion" affected the occurrence of fatal outcome ($p = 0.030$). The OR for TIMI flow was 0.409 (0.183–0.916). The patients with TIMI 3 flow had nearly 60% lower risk of fatal outcome (Table 2).

Based on the obtained data, the mathematically predictive model was tested. The Hosmer-Lemeshow test was performed proving that the model was good ($p = 0.124$). The

ROC curve showed that our model was a good predictor of fatal outcome ($p < 0.0005$; AUROC = 0.766). The cut-off value was 55.8235 while the sensitivity was 80.3%, and the specificity 67% (Figure 3).

The mortality of patients in reference to the type of coronary disease is shown in Table 4. There was a statistically significant difference in mortality rate between the groups ($p < 0.018$). The lowest mortality rate was in the group of patients who had multi-vessel coronary disease and underwent complete myocardial revascularization (42.9%). It is important to note that the sample in this group of patients was smaller than in other two groups. The Kaplan-Meier and Cox regression analyses did not show a statistically significant difference ($p = 0.226$) in the length of survival among the patient groups (Figure 4).

The mortality analysis in relation to TIMI flow after the stent implantation showed that the highest mortality rate was in the patients with TIMI 0 flow (80% of the deceased), while the lowest mortality rate was in the patients with TIMI 3 flow (58% of the deceased). However, there was no statistically significant difference in mortality between the groups ($p = 0.071$) (Table 5).

**Table 4**
**Mortality of patients in reference to the type of coronary disease**

| Type of coronary disease | Mortality [n (%) within groups] | | | |
|---|---|---|---|---|
| | No | Yes | Total | *p* |
| Singlevessel | 28 (43.1) | 37 (56.9) | 65 (27.7) | |
| Multivessel and complete revascularization | 16 (57.1) | 12 (42.9) | 28 (11.9) | 0.018 |
| Multivessel and incomplete revascularization | 44 (31.0) | 98 (69.0) | 142 (60.4) | |

**Table 5**
**Mortality in relation to TIMI flow**

| TIMI flow | Mortality, n (%) | | *p* value |
|---|---|---|---|
| | No | Yes | |
| 0 | 4 (20) | 16 (80) | 0.071 |
| 1 | 2 (22.2) | 7 (77.8) | |
| 2 | 6 (24) | 19 (76) | |
| 3 | 76 (42) | 105 (58) | |

**TIMI – thrombolysis in myocardial infarction.**

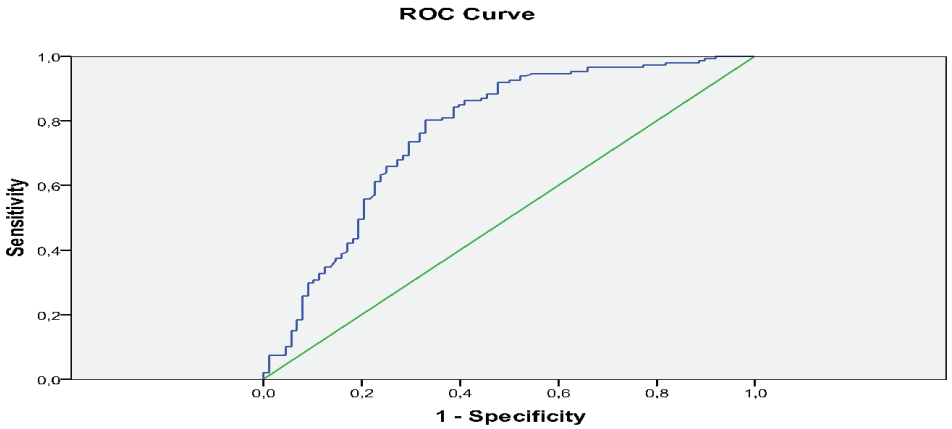


**Fig. 3 – Diagonal segments are produced by ties.**
**ROC – reciever operating characteristic**

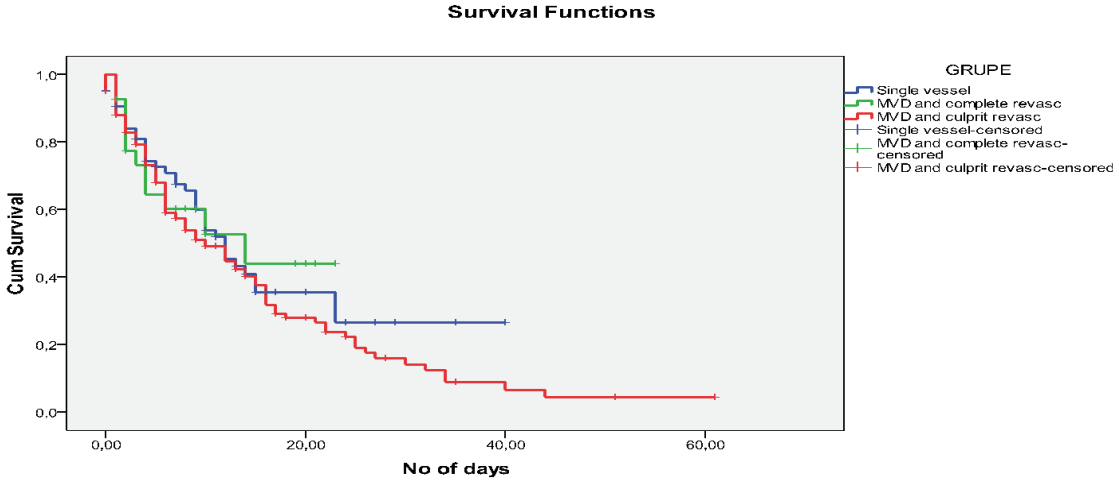


**Fig. 4 – Length of survival among the patient groups.**

**Discussion**

Our retrospective research analyzed the influence of the complete early myocardial revascularization in acute myocardial infarction with ST elevation complicated by cardiogenic shock as well as the influence of the IABP on the intra-hospital mortality.

In the research carried out by Kolte et al. [14] , based on the database of patients with STEMI complicated by cardiogenic shock in the United States (US), which included around 2 million patients from 2003 to 2010, the incidence of cardiogenic shock was 7.9% and it occurred statistically significantly more frequent in patients older than 75 years as well as in women.

The average age of the patients involved in our study, the higher proportion of anterior wall myocardial infarction as well as the average age of deceased patients included in our retrospective study were in accordance with the results of studies conducted in the US, as well as the SHOCK trial registry [14, 15].

The results of our study showed a high intra-hospital mortality in the patients with acute myocardial infarction complicated by cardiogenic shock (62.6%), despite the use of primary percutaneous coronary intervention, which are significantly higher than the results of other randomized studies and registers where the intra-hospital mortality rate was 42%–48% [5–9].

The intra-hospital mortality rate, according to the results of the SHOCK II trial, was slightly lower and amounted to 40%, with the limitation that the patients with incipient cardiogenic shock were included in the study [16, 17]. In Serbia, the intra-hospital mortality rate of patients with STEMI is 7% [18].

High intra-hospital mortality in our patient sample could be explained by the strict patient selection criteria so that all patients prior to primary percutaneous coronary intervention had clear clinical signs of the acute heart failure of the Killip IV class.

There was a statistically significant difference in the mortality among the investigated groups. The lowest mortality was in the group of patients who had multi-vessel coronary disease that was suitable for complete revascularization. However, this group of patients was the most uncommon, since more frequent were patients with multi-vessel disease that was not suitable for complete myocardial revascularization (diffuse atherosclerotic disease, chronic total occlusion, massive calcification).

The results of our research showed that the average EF on echocardiography in the patients treated for acute myocardial infarction complicated by cardiogenic shock was estimated to be 36% (27%–46%) which corresponds to the results of other studies and registers. A study by Garcia-Alvarez et al. [19] carried out in Spain showed that there was a significant decrease in systolic function in the group of patients with acute myocardial infarction in cardiogenic shock who died, which was echocardiographically estimated to be 25% ± 10%. The results of the IABP-SHOCK II trial showed that among patients with acute myocardial infarction in cardiogenic shock an average EF estimated by echocardiography was 25% [16].

According to Rasoul et al. [20] and Toma et al. [21], multivessel coronary disease was present in 40% of patients with STEMI. Patients with multi-vessel coronary disease had poorer outcomes than patients with single-vessel coronary disease, and the question of whether to revascularize culprit lesion only in acute myocardial infarction or perform complete myocardial revascularization is still subject to discussion [22].

The data from the TRANSLATE ACS observational study showed that the complete revascularization in patients with STEMI and multi-vessel coronary disease was associated with the lower risk of readmission after 6 weeks as well as the lower risk of major adverse cardiovascular events after 6 weeks and 1 year [23].

The results of SHOCK study showed that, although there was no benefit after 30 days among patients with cardiogenic shock resulting from the left ventricle failure due to STEMI, the early revascularization strategy was superior to the initial medical stabilization after 6 and 12 months of follow-up, especially among patients under 75 years of age. Based on the results of the SHOCK study, early myocardial revascularization either by the percutaneous coronary intervention or by the coronary artery bypass grafting is now the class I recommendation according to the current ESC and ACC/AHA guidelines, whereby, in the state of cardiogenic shock, the revascularization of all critical stenoses or highly unstable lesions besides the culprit lesion is encouraged. The mortality rate of surgically revascularized patients was similar in this high-risk group of patients to patients who were revascularized by the percutaneous coronary intervention [2,10,11,15].

The results of our study confirmed the results of several randomized studies and registers (PRAMI, CvlPRIT) [24, 25] along with the recommendations of the European and American Society of Cardiology [10, 11]. However, they differ from the results of the recently published CULPRIT SHOCK trial on patients with acute myocardial infarction complicated by cardiogenic shock and evidence of multi-vessel coronary disease on coronarography. It showed that the risk of fatal outcome was lower in patients who underwent culprit-lesion-only pPCI compared to patients who underwent complete revascularization [26].

In our investigation, the patients with the complete myocardial revascularization and multivessel disease had significantly lower intra-hospital mortality rate than the patients with multivessel disease and culprit lesion revascularization only, and the patients with singlevessel disease.

IABP has been the most commonly used type of mechanical circulatory support for nearly five decades [27]. It improves perfusion of coronary arteries in the diastole and by decreasing afterload leads to the reduction in myocardial oxygen demand, leading to an increase in cardiac output. As for the use of IABP in cardiogenic shock caused by acute myocardial infarction, according to the results of the IABP SHOCK II study, the use of IABP did not lead to a significant reduction in a 30-day, 6-month and 12-month mortality in patients with acute myocardial infarction complicated by cardiogenic shock who underwent pPCI [16, 17]. Today, the current European as well as American STEMI guidelines, do not recommend routine use of IABP in cardiogenic shock pa-

tients (class III recommendations), except for the mechanical complications of acute myocardial infarction in order to bridge the time to surgery [10, 11].

In the period from 2007 to 2016, during which the data for our research were collected, the only available type of mechanical circulatory support at our centre was IABP. According to the results of our study, IABP was more frequently implanted in the patients with the anterior wall STEMI complicated by cardiogenic shock. This could be explained by the commonly more severe clinical state with the development of acute heart failure in the patients with the anterior wall STEMI.

Among the patients with the IABP who underwent the complete myocardial revascularization, the total intra-hospital mortality was statistically significantly lower compared to other patient groups.

The patients with TIMI 3 flow after the stent implantation on culprit lesion had lower mortality compared to the patients with TIMI flow less then 3, although there was no statistically significant difference between the groups.

Multivariate binary logistic regression using all available variables identified 4 multivariate predictors of death: age, EF, complete revascularization and TIMI flow. A prospective validation of the predictive model was planned.

Mehta et al. [28] showed in their work that when the TIMI flow was less than 3, it represented an independent predictor of mortality. In our work TIMI flow was not an independent predictor of mortality, but its impact on mortality depended on the presence of other variables.

## Conclusion

STEMI complicated by cardiogenic shock is still associated with a high mortality rate. Complete myocardial revascularization, independently and in combination with IABP, significantly reduces mortality in patients with acute STEMI complicated by cardiogenic shock.

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Received on January 28, 2018.
Revised on September 14, 2018.
Accepted on November 16, 2018.
Online First November, 2018.