

Hospitalizations and in-hospital outcomes in patients with ST-elevation myocardial infarction during the coronavirus disease 2019 pandemic: The Albanian experience

ORIGINAL INVESTIGATION

ABSTRACT

Objective: Global studies report a significant decline in ST-elevation myocardial infarction (STEMI) related hospitalization rates during the coronavirus disease 2019 (COVID-19) pandemic outbreak. However, there have been several divergent reports on hospital outcomes. In this study, we aim to investigate the impact of the COVID 19 outbreak on hospitalizations because of STEMI and in-hospital outcomes in Albania.

Methods: This was a retrograde study, collecting data for hospitalizations because of STEMI from March 9, (first COVID 19 case in our country) to April 30, 2020, (period of total lockdown) compared with the same period in 2019 at our center. The incidence rate ratio (IRR) was used to compare admissions because of STEMI and procedures and the risk ratio (RR) to compare mortality and other complication rates.

Results: Admissions for STEMI declined during the COVID-19 period from a total of 217 in 2019 to 156 in 2020 (-28.1%) representing IRR 0.719 ($p=0.033$). PCIs also reduced from 168 procedures in 2019 to 113 in 2020 (-33%), representing an IRR of 0.67, $p=0.021$. The time from symptom onset to arrival at our intensive care unit was significantly higher in 2020 compared to 2019 (925.6 ± 1097 vs. 438.7 ± 385 minutes, $p<0.001$). The STEMI death rate during the pandemic compared to the control period was significantly increased to 14.1% vs. 7.8% (RR=1.91 $p=0.037$, but with no significant increase in primary PCI-STEMI death rate (8.9% vs. 4.8% RR=1.85 $p=0.217$). Cardiogenic shock also increased during the pandemic to 21.2% from 12.4% in 2019 (RR=1.70 $p=0.025$).

Conclusion: Hospitalizations and revascularization procedures for STEMI significantly reduced during the COVID-19 pandemic. We identified a substantial increase in the STEMI mortality rate and cardiogenic shock during the pandemic outbreak. Delayed timely reperfusion intervention might be responsible for the increased risk for complications.

Keywords: ST-elevation myocardial infarction, coronavirus disease 2019 pandemic, hospitalizations, in-hospital outcomes, coronary interventions

INTRODUCTION

In December 2019, a case of pneumonia of unknown cause was reported in Wuhan, China (1). The infection caused by a newly identified coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) spread all over the world, causing the current pandemic of coronavirus 2019 disease (COVID-19) (2).

The Albanian government, progressively since March 09, 2020, (3) (the first case declared) urged and ordered physical distancing and strict movement restriction measures. Total containment measures; closure of all activities and restriction of movement except for healthcare workers and other vital services, began on March 16, 2020 (4). At the end of April 2020, Albania had a low COVID-19 incidence rate of 27/100,000 and a low mortality rate of 1.08/100,000 inhabitants (5). The COVID-19 outbreak did not affect the structure and organization of hospital cardiac services in Albania. Patients suffering from COVID-19 have been treated in specialized hospital facilities.

The SARS-CoV-2 infection is associated with an increase in thrombotic complications and an inflammatory impact on atherosclerotic plaque progression (6, 7).

Leonard Simoni 

Ilir Alimehmeti¹ 

Mirald Gina 

Astrit Ceka 

Ermir Tafaj 

Alban Dibra 

Artan Goda 

Department of Cardiology, University Hospital Center "Mother Teresa"; Tirana-Albania

¹Department of Occupational Health, Faculty of Medicine, University of Medicine; Tirana-Albania

Corresponding Author:

Leonard Simoni
✉ leonardsimoni@yahoo.com

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Therefore, an increase in the incidence of ST-segment elevation myocardial infarction (STEMI) was expected. Global surveys and reports have shown a significant decrease in admissions (STEMI) (8-14) and associated invasive procedures (15-17), showing the collateral effect of the COVID-19 pandemic on patients with acute myocardial infarction and suggesting a variety of possible contributing factors. However, thus far, there have been several divergent reports on hospital outcomes, particularly mortality and cardiogenic shock (8, 18-21).

Therefore, in this study, we aimed to assess the impact of the COVID-19 pandemic outbreak on STEMI hospitalizations and in-hospital management and outcomes in Albania.

METHODS

We conducted a single-center, observational, and retrospective study, including all the consecutive patients hospitalized for STEMI in the Department of Cardiology from March 9, 2020, (first day of application of social distance measures) to April 30, 2020, (a period of total lockdown with first release measures beginning in the last week of April (22) and continuing through May and June). This same period in 2019 was used as a control. All information was collected using the patients' medical files. STEMI was diagnosed using the 4th Universal Definition of Myocardial Infarction criteria (23). The study complies with the Declaration of Helsinki and was approved by the Local Ethics Committee of the hospital. Informed consents were waived because of the retrospective nature of the study.

Demographic data, cardiovascular risk factors, previous comorbidities, and outcomes were collected. Coronary angiography was performed as per standard practice. Angiographic data regarding angiographic obstructive coronary artery disease (CAD), critical stenosis, number of affected vessels, and treated vessels and data obtained from revascularization procedures, such as percutaneous coronary intervention (PCI) or coronary artery bypass surgery (CABG) were analyzed.

Admission, procedural, and in-hospital outcomes

The primary outcome of this analysis was the overall rate and weekly incidence of admissions for STEMI during the study and control periods. Other outcomes analyzed and compared between the two periods included overall admissions

for STEMI, proportion of patients undergoing coronary angiography and revascularization procedures (PCI or CABG), cardiac troponin I (cTnI) on admission (normal values 0.00–1.00 ng/mL), time from symptom onset to intensive care unit (ICU), time from arrival in ICU to sheath insertion, left ventricular ejection fraction (at discharge), in-hospital all-cause mortality, cardiogenic shock, life-threatening arrhythmias, mechanical complications, stroke, stent thrombosis, and reinfarction. Changes in the rate of admissions for STEMI and related procedures were calculated by comparing the total admission/procedure number for the period 9th of March to 30 April 2020 with the number during 2019 and expressed as a percentage. Percentage changes in weekly STEMI admission and related procedures were calculated similarly by comparing the admission/procedure numbers of each week (starting with the first week from March 09 and the following 6 weeks until April 26, 2020) with the weekly number during 2019.

The rate ratio of STEMI admissions/procedures between the study period and the control period are shown as incidence rate ratios (IRR), which were calculated by comparing the incidence ratios of STEMI admissions or procedure/day during both periods. IRR is presented with 95% confidence intervals (95% CI). The ratio of STEMI deaths and complication rate (in percentage) between the study and control period are shown in the risk ratio (RR) with 95% CIs.

Statistical analysis

The continuous data (demographic characteristics and angiographic, procedural, and hospital outcomes) are presented as mean \pm SD and compared using the t-test. Discrete data are shown as counts and proportions and risk ratio (RR) with 95% CI and compared using the chi-squared (χ^2) test. Poisson regression (STEMI admissions per day model) was used to calculate the IRR for events including admissions, procedures, between the study and control periods. IRR between the groups is presented with 95% CI. A two-sided p value of <0.05 is considered to indicate statistical significance. The statistical analysis was performed using the Statistical Package for the Social Sciences released 2012 (IBM Corp, SPSS Statistics for Windows, Version 21.0, Armonk, NY, USA).

RESULTS

Patient characteristics

Overall, 373 patients admitted with the diagnosis of STEMI were included in this analysis. Of them, 156 (41.8%) were admitted during the study period and 217 (58.2%) during the control period. Baseline data are shown in Table 1. There were no differences between the patients admitted in the study and control periods in terms of sex, age, and cardiovascular risk factors (arterial hypertension, dyslipidemia, diabetes mellitus, and smoking) and previous comorbidities.

Admission and procedural findings for STEMI during the COVID-19 and control periods

The admissions for STEMI in the study period reduced by 28.1% compared with the control period representing IRR=0.719 (95% CI 0.51–0.95), p=0.033. A typical U curve was observed for STEMI admissions from similar numbers during the first week to an important reduction by around 59% throughout

HIGHLIGHTS

- Containment measures and the fear of contracting the virus in healthcare settings during the coronavirus disease 2019 pandemic affected admissions and invasive interventions in patients with ST-elevated myocardial infarctions.
- The patients who were admitted showed worse conditions (later from the onset of symptoms, a higher level of troponin I, and a lower left ventricular ejection fraction), which explains the potential increase in mortality and cardiogenic shock.
- Public education and health service safety are the major challenges.

Table 1. Baseline demographic, clinical, and procedural characteristics of the study population

Variables	Control period n=217 (%)	Study period n=156 (%)	P-value*
Male	153 (73%)	121 (78%)	0.160
Age, years (SD)	66.56 (11.46)	65.22 (11.73)	0.271
Diabetes mellitus	104 (47.9%)	68 (43.8%)	0.469
Hypertension	189 (87.1%)	139 (89.7%)	0.670
Dyslipidemia	119 (54.8%)	86 (55.5%)	0.955
Familiar history for CAD	51 (23.5%)	21 (13.5%)	0.022
Smoking	88 (40.6%)	56 (36.1%)	0.422
Previous MI	29 (13.4%)	15 (9.7%)	0.345
Previous PCI	17 (7.8%)	7 (4.5%)	0.278
Previous CABG	3 (1.4%)	4 (2.6%)	0.658
Previous CAD	27 (12.4%)	12 (7.7%)	0.191
Dilated CMP	10 (4.6%)	2 (1.3%)	0.134
Impaired renal function	31 (14.3%)	21 (13.5%)	0.940
Previous stroke	12 (5.5%)	12 (7.7%)	0.531
Anterior infarction (n, STEMI%)	102 (47%)	85 (54.5%)	0.187
Inferior (lateral posterior) infarction (n, STEMI%)	115 (53%)	71 (45.5%)	0.187
Symptom onset to ICU time (SD)	438.73 (385)	925.65 (1097)	<0.001
Symptom onset <6 h (early)	126 (58.1%)	69 (44.2%)	0.011
Symptom onset 6–12 h (delayed)	58 (26.7%)	34 (21.8%)	
Symptom onset >12 h (late)	33 (15.2%)	53 (34%)	
Coronary angiography	199 (91.7%)	140 (89.7%)	0.641
Refused coronary angiography	13 (6%)	11 (7.1%)	0.825
Died before consent for coronary angiography	5 (2.3%)	5 (3.2%)	0.836
CAD (n, angiography%)	196 (98.5%)	138 (98.6%)	0.950
1 vessel CAD (n, angiography%)	53 (26.3%)	41 (29.3%)	0.678
2 vessel CAD (n, angiography%)	80 (40.2%)	42 (30%)	0.070
3 vessel CAD (n, angiography%)	62 (31.2%)	56 (40%)	0.117
LM disease (n, angiography%)	15 (7.5%)	24 (17.1%)	0.011
No critical stenoses (n, angiography%)	3 (1.5%)	2 (1.4%)	0.950
PCI (n, %)	168 (77.4%)	113 (72.4%)	0.327
PPCI (n, %)	146 (67.3%)	90 (57.7%)	0.074
PPCI (<12h)	146 (79.3%)	90 (87.4%)	0.122
PCI of LAD (n, %)	110 (65.5%)	71 (62.8%)	0.740
PCI of LCX (n, %)	41 (24.4%)	22 (19.5)	0.408
PCI of RCA (n, %)	80 (47.6%)	49 (43.4%)	0.500
CABG recommended (n, %)	30 (13.8%)	29 (18.6%)	0.271
CABG performed (n, %)	5 (2.3%)	13 (8.3%)	0.043
CAD with medical treatment (n, %)	6 (2.7%)	5 (3.2%)	0.804

*To determine the statistical significance for comparison regarding each of the demographic characteristics, angiographic and procedure-related variables were summarized using mean \pm SD for continuous variables compared using t-tests and frequency and percentage for categorical variables compared using chi-squared (χ^2) tests.
SD - standard deviation; STEMI - ST-segment elevation myocardial infarction; CAD - coronary artery disease; PCI - percutaneous coronary intervention; CABG - coronary artery bypass grafting; CMP - cardiomyopathy; LM - left main; LAD - left anterior descending; LCx - left circumflex; RCA - right coronary artery

the third to the fifth weeks and returning to a similar range on the seventh week of the study (Fig. 1a and Table 2).

The number of patients undergoing coronary angiography during the study period reduced by 31% when compared with that in the control period, representing an IRR=0.69 (0.47–0.95), $p=0.039$. The number of patients undergoing PCI was also reduced by 33% during the COVID-19 period, compared with the control period representing an IRR=0.67 (0.43–0.89) $p=0.021$ (Fig. 1b, Table 2). During both study and control periods, there were no significant differences in the propor-

tion of patients undergoing coronary angiography (89.7% vs. 91.7%) and PCI (72.4% vs. 77.4%); however, there was a trend in which the proportion of patients undergoing primary PCI was smaller during the COVID-19 period (57.7% vs. 67.3%, $p=0.074$) but not quite significant. There were no differences in the proportion of patients recommended for CABG (20.7% vs. 15.1%) but with a significant increase of patients undergoing CABG during the COVID-19 period (9.3% vs. 2.5% $p=0.013$). The frequency of left main involvement (17.1% vs 7.5%, $p=0.011$) was higher among the patients in the study

period than in the control period. In both the study groups, the left anterior descending artery (LAD) was the most commonly treated vessel, but without any significant differences between the groups (Table 1).

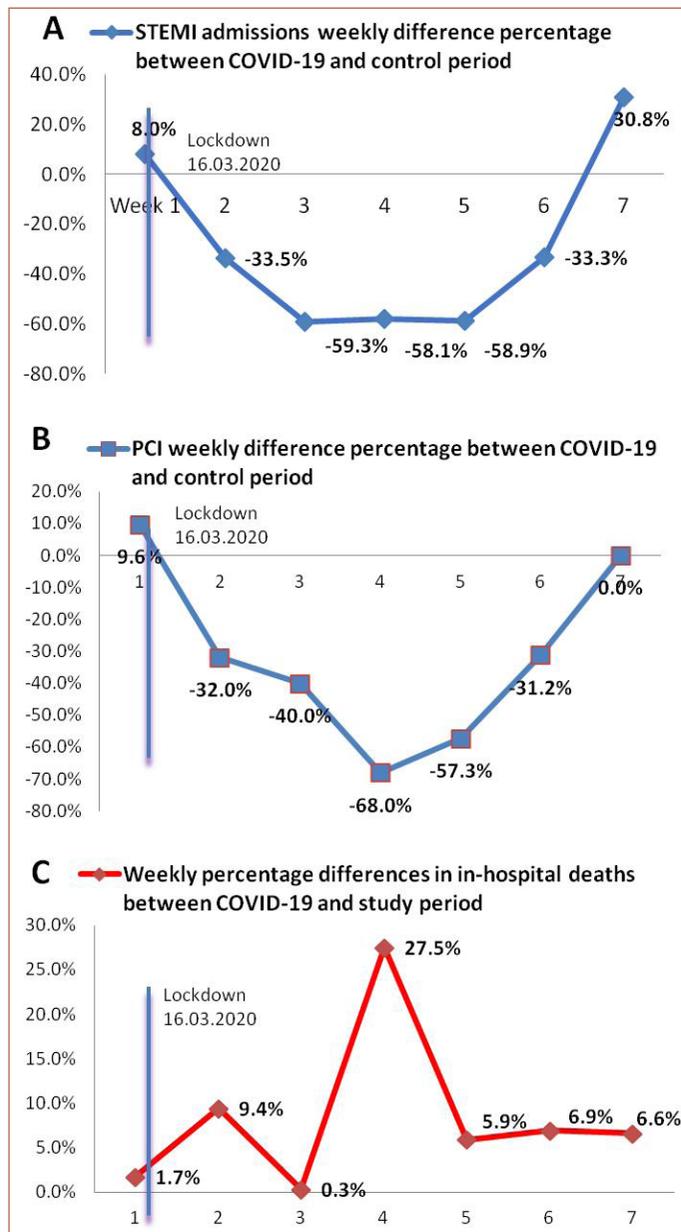


Figure 1. a) Weekly admission difference in percentage (percentage change during COVID-19 compared with the control period) assessed for ST-segment elevation myocardial infarction showing an important reduction in all admissions during the third to fifth weeks of the study compared with that in the control period. b) Weekly difference in percutaneous coronary interventions percentage (percentage change during COVID-19 and control periods) showing an important reduction during the third to fifth weeks of the study compared to that in the control period. c) Weekly difference in in-hospital mortality percentage (percentage change during COVID-19 and control periods) showing an important increase during the fourth week of the study compared to that in the control period.

Symptom onset to the intensive care unit time

During the study period compared with the control period, not only was there a reduction in admissions, but also the patients presented later from symptom onset to our ICU, (925.6 ± 1097 vs. 438.7 ± 385 minutes, $p < 0.001$). A significant reduction in the number of patients presenting less than 6 hours from symptom onset (44.2% vs. 58.1%, $p = 0.011$) and a significant increase in the number of patients presenting over 12 hours from symptom onset (34% vs. 15.2%, $p < 0.001$) was observed during the COVID-19 pandemic period (Table 1 and Fig. 2a).

In-hospital outcomes

In-hospital outcomes are shown in Tables 3 and 4 and Figures 1c, 2b, and 2c. The death rate owing to STEMI during the pandemic period was significantly increased to 14.1% from 7.8% during the control period [RR=1.91 (95% CI 1.039–3.52), $p = 0.037$]. The incidence of cardiogenic shock also increased during the pandemic at 21.2% versus 12.4% in 2019 [RR=1.70 (95% CI 1.07–2.71), $p = 0.025$]. There is a trend of greater death rate in patients undergoing primary PCI during 2020 than in 2019, but without reaching significance [8.9% vs. 4.8%, RR=1.85 (95% CI 0.69–4.94), $p = 0.217$]. The increase in death rates owing to STEMI is associated as mentioned above with longer time from symptom onset to ICU with higher cTnI on admission (36 ± 55.1 vs. 21.96 ± 49.9 ng/mL, $p = 0.014$) and lower ejection fraction (42.3 ± 9.59 vs. 44.9 ± 8.90 ; $p = 0.007$) among patients admitted during the study period compared with those in the control period. However, the time between ICU arrival and sheath insertion in patients with STEMI was shorter (48.3 ± 24.9 vs. 57.2 ± 33.2 , $p = 0.04$), and the length of hospital stay was shorter (4.63 ± 2.58 vs. 5.98 ± 3.17 , $p < 0.001$).

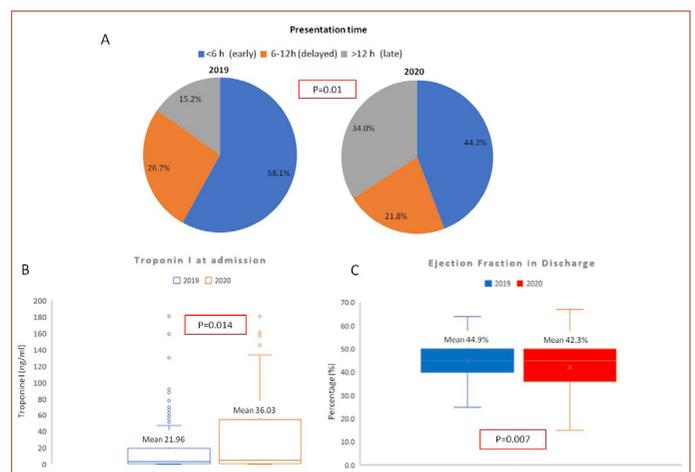


Figure 2. a) Time from symptom onset to ICU presentation showed in percentage according to the presentation time; <6 h (early) in blue, 6–12 h (delayed) in orange, and >12 h (late) in gray. b) Cardiac troponin I at admission and c) ejection fraction at discharge. In b and c, the mean values are reported, whereas the central line indicates the 50th percentile (median value). The box contains values between the 25th and 75th percentiles, the whiskers denote the values between the 5th and 95th percentiles, whereas the dots beyond the whiskers are outlier values.

Table 2. Incidence rate ratio of admissions and invasive procedures

Admission presentation and procedures	COVID-19	Control	Incidence rate ratio (IRR) (95% CI) [†]	P-value*
STEMI (n)	156	217	0.719 (0.51-0.95)	0.033
Angiography (n, patients %)	140 (89.7%)	199 (91.7%)	0.69 (0.47-0.95)	0.039
PCI (n, patients %)	113 (77.4%)	168 (72.4%)	0.67 (0.43-0.89)	0.021

[†]Incidence rate ratio (IRR) for STEMI admissions, angiography, PCI obtained from the analyses of 7 weeks in COVID-19 and control period is expressed in IRR and 95% CI.

* To determine statistical significance for the comparison regarding STEMI admissions and each procedure, the Poisson regression (STEMI admissions/procedure per day model) was used.

STEMI - ST-segment elevation myocardial infarction; PCI - percutaneous coronary intervention

Table 3. In-hospital outcomes

Variables	Control period 217 pts n (%)	Study period 156 pts n (%)	P-value*
Death	16 (7.4%)	22 (14.1%)	0.049
PPCI death n (PPCI %)	7 (4.8%)	8 (8.9%)	0.328
Cardiogenic shock	27 (12.4%)	33 (21.2%)	0.034
ICU- sheath time (SD)	57.2±33.2	48.3 (24.9)	0.012
cTn I (SD)	21.96 (49.91)	36.03 (55.16)	0.014
Ejection fraction (SD)	44.90 (8.90)	42.27 (9.59)	0.007
Length of stay (SD)	5.98 (3.17)	4.63 (2.58)	<0.001
Ventricular fibrillation	9 (4.1%)	12 (7.7%)	0.220
Ventricular tachycardia	15 (6.9%)	11(7.1%)	0.780
AV block	12 (5.5%)	17 (10.9%)	0.090
Atrial fibrillation	24 (11.4%)	23 (14.7%)	0.540
Thrombosis	9 (4.1%)	7 (4.5%)	0.890
Reinfarction	9 (4.1%)	7 (4.5%)	0.890
Mechanic complications	4 (1.8%)	2 (1.3%)	0.590
Stroke	7 (3.2%)	4 (2.6%)	0.530

*To determine statistical significance for the comparison regarding each of the in-hospital characteristics, angiographic and procedure-related variables were summarized using mean ± SD for continuous variables compared using t-tests and frequency and percentage for categorical variables compared using chi-squared (χ^2) tests.

ACS - acute coronary syndrome; ICU - intensive care unit; cTnI - cardiac troponin I; VF - ventricular fibrillation; VT - ventricular tachycardia; AV - atrioventricular; AF - atrial fibrillation

Table 4. Risk ratios for major complications

Complications	COVID-19 (n=156)	Control (n=217)	Risk ratio (RR) (95% CI) [†]	P-value*
Death n (patients %)	22 (14.1%)	16 (7.4%)	1.91 (1.04-3.52)	0.037
PPCI death n (PPCI %)	8 (8.9%)	7 (4.8%)	1.85 (0.69-4.94)	0.217
CSH n (patients %)	33 (21.2%)	27 (12.4%)	1.70 (1.07-2.70)	0.025

[†]Risk ratio (RR) for death, PPCI death, and cardiogenic shock STEMI obtained from the comparison of event rate (death/CSH) between the COVID-19 and control periods and expressed in RR and 95% CI.

PPCI - primary percutaneous coronary intervention, CSH - cardiogenic shock

DISCUSSION

Our study investigated the impact of the COVID-19 pandemic outbreak on STEMI admissions, related invasive procedures, and in-hospital outcomes. We documented a significant reduction in patients with STEMI in COVID-19 compared with those in the control period associated with a significant reduction in the number of patients undergoing coronary angiography and PCI; late presentation and delayed reperfusion therapy associated with greater myocardial damage; and a significant increase in in-hospital mortality and other complication rates.

Hospitalization and in-hospital management of patients with STEMI

The decline in admissions because of STEMI (28.1%) during COVID-19 compared with those during the control period

at our center is consistent with other contemporary reports published worldwide. In studies conducted in Turkey, Kundu et al. (24) found a 58.3% decrease in admissions for acute myocardial infarction at the Ankara City Hospital (24); and Erol et al. (11) in a nationwide study found a 31.2% reduction in STEMI comparing the non-pandemic period (TURKMI 1) with the pandemic period (TURKMI 2) (11). In Italy, De Rosa et al. (9) found a 26.5% reduction in STEMI, 24% reduction was reported in Greece (14), and a 24% reduction was reported from the French Cohort of Myocardial Infarction Evaluation (FRENCHIE) registry (13), along with a similar reduction in England at 23% (12).

Congruent to other studies, we documented a reduction of coronary angiography (31%) and PCI (33%) in patients with STEMI. Reports from the US cardiac catheterization labora-

tories estimated a 38% reduction in STEMI activations (16), whereas a 40% reduction was observed in Spain (17), 31% reduction in primary PCI in Greece (14), and 21% reduction in PCI for STEMI in England (12).

The greatest reduction of admissions and procedures happened during the third to the fifth week of lockdown, with 59.3% reduction in admissions in the third week and 68% reduction in PCI during the fourth week. The increasing trend of numbers started in the sixth week; and in the seventh week, the numbers were similar to the first week of the study, which might reflect a restoration of the normal trend in STEMI compared with the same period of time in 2019.

In Albania, where there was little spread of the virus (5) and no change in the structural and personnel organization of hospital cardiology services, there were no significant differences in the proportion of patients undergoing coronary angiography (89.7% vs. 91.7%) and PCI (72.4% vs. 77.4%) during both the study and control periods.

There was a trend to a greater number of patients recommended for CABG (20.7% vs. 15.1%, $p=0.271$) even though it was not statistically significant; however, there was a significant increase in patients undergoing CABG during the COVID-19 period (9.3% vs. 2.5%, $p=0.013$). One explanation for this could be a possible increase in urgent CABG related to a greater percentage of patients who presented with high-risk coronary anatomy (LM disease) during the COVID-19 pandemic. The late presentation of patients with STEMI (>12 h) possibly shifted the revascularization recommendation toward CABG for full revascularization versus treating the culprit lesion as it was not considered a primary PCI anymore. The planned interventions were canceled in the cardiosurgery service during the pandemic period, and only emergent or urgent interventions were performed creating greater availability of free operating rooms and staff during the weeks of lockdown.

There are several suggested reasons for the reduction in STEMI admissions during the COVID-19 pandemic. In Albania, the pandemic did not affect the cardiology hospital services; therefore, we strongly believe that the fear of catching the virus was the most important factor which led to ignoring or postponing the seeking of medical care and therefore in the reduction of STEMI admissions and delayed presentation. The call of STAY AT HOME from the authorities and all restrictive measures also led to a probable avoidance of seeking medical care. Another reason could be a lack of physical activity converted into fewer physical triggers for ischemic heart disease.

The first measure mitigation (relaxation of movement restriction and police hour) (22) which began during the seventh week of lockdown and consequent increase in physical activity might have impacted the reverse and increase in STEMI admissions. Possible psychosocial factors (25) such as stressful situations, lost jobs, and so forth accumulating during the weeks of lockdown might have influenced the admissions to increase during the last weeks of the study period.

Late presentation and delayed reperfusion therapy associated with greater myocardial damage

Our study documented that the time from symptom onset to presentation to our ICU for patients with STEMI was higher (including first medical contact (FMC) time and all urban and regional transportation time taken together). The percentage of patients presenting earlier than 6 hours was lower, and the percentage presenting over 12 hours was significantly greater during the pandemic period, partly explaining why a smaller proportion of patients underwent primary PCI during COVID-19 compared with that in the control period (57.7% vs. 67.3%, $p=0.074$). The longer presentation time could be because of the late presentation of the patients in emergency services or regional hospitals because of fear of contagion, lockdown, and restriction of movements and also as a function of delayed transportation in Tirana and other regions of Albania to our center as the unique reference center for primary PCI. All these factors may have resulted in a longer time of presentation, and more importantly a longer time of reperfusion through primary PCI, reducing the possible benefits obtained from early reperfusion. During the pandemic period, because of reduced admissions and work volumes in the catheterization laboratory, the ICU sheath time was reduced; however, its effect was neutralized by longer symptom onset to ICU time, consequently without having an impact on the total ischemic time. The later presentation of patients with STEMI is also documented in other studies. Erol et al. (11) showed a significant delay in the treatment of patients presenting with STEMI (*an increase in the time from symptom onset to hospital arrival*) (185 min vs. 150 min $p<0.001$). British investigators (26) documented a significant increase in symptom onset time to FMC during COVID-19 compared to that in the pre-COVID group [227 min (65–790) vs. 119 min (27–203), $p=0.01$]. A significant increase in symptom onset to FMC time was also reported in Ireland (27), France (28), the Lombardy region in Italy (29, 30), and Hubei Region in China (31). The increase in the FMC time in Northern Italy (29, 30), and in China (31) (specific region as mentioned above) is also attributed to the severity of the COVID-19 pandemic during the first months of the outbreak along with the influence of different factors related to possible healthcare system deficits and the fear of catching the virus in healthcare structures.

Contrary to our findings, a multicentric study (FITT-STEMI) conducted in Germany documented no differences in symptom onset to FMC time and emergency and transportation time showing that the STEMI network and all structures overcame the pandemic challenge successfully (21).

Our patients admitted with STEMI during the COVID-19 outbreak presented with worsening conditions, such as longer time from symptom onset to ICU, higher troponin I levels (a marker of delayed presentation), and lower left ventricular ejection fraction (an indicator of greater myocardial injury). Our findings are congruent to other single-center studies conducted in the UK (32) and Germany (33, 34) regarding high cTnI on presentation and studies conducted in Turkey (11), Greece (14), Ireland (24), Germany (33), and UK (32) regarding lower LVEF at hospital discharge.

The effect of deferred or late presentation of patients with STEMI during the COVID-19 pandemic associated with a greater myocardial injury (lower left ventricular ejection fraction) conceivably will be observed in the future in terms of morbidity and mortality.

Mortality and complications

In our study, we observed a significant increase in the rates of mortality (RR=1.91, $p=0.037$) and cardiogenic shock (RR=1.7, $p=0.025$) during COVID-19 compared with those in the control period. We believe this is explained by the late presentation and greater myocardial injury. The delayed and late MI presentation are the possible reasons for increased in-hospital mortality, explained also by the fact that during both periods there were no differences in the percentage of patients undergoing coronary angiography and PCI. There is no significant increase in the STEMI mortality of patients undergoing primary PCI [RR=1.85 (95% CI 0.69–4.94), $p=0.217$] and a decrease as mentioned in the ICU sheath time during the pandemic period at our center. The benefits of perfusion therapy (PCI) would be greater if performed in time, reducing myocardial damage, and consequently heart failure and mortality in our patients.

Relevant discrepancies in mortality and complication rates are found between studies in different countries and centers. Several studies, mainly from COVID-19 epicenters, have reported that patients with STEMI had higher in-hospital mortality and complication rate. In Italy, the study conducted by De Rosa et al. (9) showed that STEMI case fatality rate during the pandemic was substantially increased compared with that in 2019 (RR=3.3, $p<0.001$). Similarly in a study by Trabattoni et al. (29), the in-hospital mortality in patients admitted late with AMI increased to 38% from 10%. Increase in mortality rates was also observed in the Hubei province, China, from 4.6% to 7.3% during the outbreak period (24), in the USA (18), and Hong Kong (20).

Results from a multicentric study conducted in Germany (21) demonstrated that the in-hospital mortality was similar (9.2% vs. 8.5%, $p=0.074$). In Denmark (19), the adjusted STEMI mortality (OR 1.04, 0.68–1.59) and the incidence of AMI-cardiogenic shock [5.8% (2015-19) vs. 5.9% (2020 lockdown)] was comparable between periods showing that the resources of the healthcare systems and logistic structures, especially the intensive care units preserved a high quality of standards even in the challenging pandemic period. In Turkey, the results from the abovementioned nationwide study (11) showed similar in-hospital mortality for STEMI comparing the pre-pandemic and pandemic periods (5.3% vs. 4.7%, $p=0.642$); however, in-hospital major adverse cardiac events (in-hospital mortality, heart failure, and cardiogenic shock) were significantly increased during the pandemic period [OR=2.08 (1.38–3.13), $p<0.001$].

In a recent systematic review and meta-analysis, Rattka et al. (35) demonstrated globally that in-hospital mortality of the post-COVID-19 group was not significantly higher than the pre-pandemic group, although in some pandemic epicenters, included in the analysis, there was an increase in mortality.

We found a reduction of STEMI admissions, related invasive revascularization procedures, and an increase in STEMI in-hospital mortality and complications, creating a full view of all the collateral damage caused by the COVID-19 pandemic in Albania. We demonstrated a delayed admission of patients with STEMI and as a consequence greater myocardial damage, an increase in cardiac troponin I, and lower LVEF leading to greater, but avoidable in-hospital mortality and complications. This collateral damage owing to the pandemic (patients with STEMI not presenting or presenting late to the hospital) will create further pressure on the public health system in terms of morbidity, disability, and mortality.

Public information encouraging people not to avoid necessary medical care and COVID-19 safe healthcare services are the key challenges in dealing with the situation created by the pandemic.

Strength and limitations

This study included all the consecutive patients admitted with STEMI to our center in two different periods [pre-pandemic and pandemic (lockdown)] presenting the entire view of management, invasive treatment, and complications; however, ours was a retrospective study, and all data were taken from medical files with possible known biases (36).

As a reference center, the largest tertiary public center, all the patients with STEMI throughout Albania (regional hospitals) are normally transferred here. The proportion of patients transferred versus those treated in hospitals in the local counties during the pandemic remains unknown. Our study did not include patients diagnosed (or suspected) with COVID-19 because these patients were hospitalized in COVID-19 hospitals equipped with a catheterization laboratory.

CONCLUSION

Hospitalizations and related invasive revascularization procedures for STEMI significantly reduced during the COVID-19 pandemic. A significant increase in STEMI mortality and cardiogenic shock was observed during the pandemic outbreak. Delayed timely reperfusion by primary PCI might be responsible for the increased risk for complications. Public information encouraging people not to avoid required medical care and safe and COVID-19 free healthcare services are the key challenges in this pandemic.

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