Bolnišnične krvavitve med zdravljenjem akutnih miokardnih infarktov z dvigom veznice ST med pandemijo COVID-19
STEMI bolniki med pandemijo COVID-19
In-hospital bleeding occurring while treating ST-segment elevation myocardial infarction during the COVID-19 pandemic
STEMI during the COVID-19 pandemic

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Izvleček

Namen: *Namen je ocena vpliva krvavitev na preživetje STEMI bolnikov po primarni perkutani koronarni intervenciji (PKI) s spremljajočo antitrombotično terapijo med pandemijo COVID-19.*

Metode: *V retrospektivni raziskavi smo opazovali prevalenco in dejavnike bolnišničnih krvavitev pri 317 STEMI bolnikih (74,8 % moških, povprečna starost 65,7 ± 11,9 leta) ter vpliv krvavitev na šestmesečno preživetje STEMI bolnikov med pandemijo COVID-19, in sicer od januarja do oktobra 2021. Vodilna reperfuzijska strategija je bila primarna PKI. Registrirali smo vse pomembne krvavitve.*

Rezultati: *Spremljajoči COVID-19 smo ugotovili pri 3,2 % STEMI bol-*

Abstract

Purpose: *The purpose of the current study was to determine the impact of bleeding on survival in patients with ST-segment elevation myocardial infarction (STEMI) after primary percutaneous intervention (PCI) and concomitant anti-thrombotic therapy during the COVID-19 pandemic.*

Methods: *This was a retrospective, observational study involving the prevalence and factors observed in hospital bleeding among 317 STEMI patients (74.8% males; mean age, 65.7 ± 11.9 years) and the impact of bleeding on 6-month survival in STEMI patients during the COVID-19 pandemic from January-October 2021. The leading reperfusion strategy was prima-*

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nikov. Primarna PKI je bila opravljena pri 94,3 % bolnikov, a le pri 17 % v prvih 3 urah od začetka prsne bolečine. Krvavitve smo opazovali pri 11,4 % STEMI bolnikov, ki so imeli pomembno več zunajbolnišničnih srčnih zastojev, bolnišničnih zapletov in umrljivosti. Samo bakterijska bolnišnična okužba je bila pomembno povezana s krvavitvami (OR 4,467; 95% CI 1,819 do 10,973; p = 0,001). Bolniki z in brez krvavitev so imeli podobno povprečno starost, podobno prevalenco spola, spremljajočih bolezni, COVID-19 ter uporabo in začetek primarne PKI.

Zaključki: *Prevalenca bolnišničnih krvavitev med zdravljenjem STEMI bolnikov med epidemijo COVID-19 je bila 11,4-%. STEMI bolniki s krvavitvami so imeli pomembno več zunajbolnišničnih srčnih zastojev, bolnišničnih zapletov in večjo umrljivost. Samo bakterijska bolnišnična okužba je bila pomembno povezana s krvavitvami.*

ry PCI. All significant bleeding events were recorded.

Results: *Concomitant COVID-19 infections occurred in 3.2% of the STEMI patients. Primary PCI was performed in 94.3% of all patients, with 17% of STEMI patients undergoing PCI within the first 3 hours of chest pain. Bleeding occurred in 11.4% of all STEMI patients. STEMI patients with in-hospital bleeding were significantly more likely to have an out-of-hospital cardiac arrest, in-hospital complications, and mortality. Only hospital-acquired bacterial infections were significantly associated with in-hospital bleeding (OR, 4.467; 95% CI, 1.819 to 10.973; p = 0,001). Age, gender, co-morbidities, concomitant COVID-19 infections, and the use and start of primary PCI were similar between STEMI patients with and without in-hospital bleeding.*

Conclusions: *The prevalence of in-hospital bleeding while treating STEMI patients during the COVID-19 pandemic was 11.4%. Out-of-hospital cardiac arrest, hospital complications, and mortality were significantly more likely among STEMI patients with in-hospital bleeding, but only hospital-acquired bacterial infections were associated with bleeding.*

INTRODUCTION

The worldwide spread of the highly contagious SARS-CoV-2 virus resulted in a worldwide COVID-19 pandemic in 2020, leading to substantial healthcare reorganization aimed exclusively toward COVID-19 cases (1-4). COVID-19 became the leading cause of deaths globally as COVID-19 extended into 2021 (1). Social distancing and restricted access to emergency services persisted (1,4). In 2021 more reliable and rapid tests for COVID-19 became available, many infected individuals recovered from and/or were vaccinated against COVID-19, and protective equipment was of better quality and easier to use (4). Among ST-segment elevated myocardial infarction (STEMI) patients, primary percutaneous coronary intervention (PCI) remained the major reperfusion strategy during the COVID-19 pandemic in the majority of developed countries combined with potent antiplatelet agents, such as prasugrel and ticagrelor (2,3,5).

Bleeding in STEMI patients with dual antiplatelet therapy, including prasugrel or ticagrelor in the pre-COVID-19 era was reported to be approximately 11% in randomized control trials and 10% in observational studies (7). Bleeding was directly associated with increased mortality and indirectly linked with recurrent ischemic events, especially in the 5% of STEMI patients with major bleeding episodes, such as intracranial bleeding, bleeding requiring transfusion or surgery, or a decrease in the hemoglobin concentration ≥ 3 g/dl with or without an overt source of bleeding (8-11).

The role of bleeding in STEMI patients during the pandemic has not been established. Therefore, the purpose of the current study was to determine the prevalence of, factors associated with, and mortality rate associated with in-hospital bleeding in consecutive STEMI patients during the COVID-19 pandemic in 2021.

PATIENTS AND METHODS

We conducted a retrospective single center observational study involving 317 consecutive STEMI patients (74.8% men, mean age 65.71 ± 11.9 years) who were admitted to the University Medical Centre Maribor (Maribor, Slovenia) from January–October 2021. The University Medical Centre Maribor is a tertiary clinical institution in the northeastern part of Slovenia and the 24/7 regional referral center for primary PCI in STEMI patients in an area with a population of 850,000. The University Medical Centre Maribor was also the designated COVID-19 regional hospital with a 24/7 dedicated COVID-19 catheter suite (12).

We extracted and reviewed the patient electronic medical records based on the International Classification of Diseases, Tenth Revision (ICD-10). STEMI was defined according to well-established criteria (12,13). The baseline data included co-morbidities, an out-of-hospital cardiac arrest (OHCA) before admission, the time that elapsed until primary PCI was performed, and creatinine and cardiac troponin I levels. Treatment of STEMI patients in 2021 was in accordance with ESC guidelines and recommendations for the invasive management of acute coronary syndrome during the COVID-19 pandemic (12,13). Primary PCI was the main reperfusion strategy. Treatment data included the use of primary PCI, thrombolysis in myocardial infarction (TIMI) III flow after primary PCI, radial and femoral access data, and dual antithrombotic therapy.

We monitored the patients in the coronary care unit or medical ICU for up to 24 h after primary PCI and > 24 hours in case of complications until the patient was transferred to the cardiology ward or a local hospital in stable condition (13). We recorded any acute bleeding event, which was defined as category 3–5 by the Bleeding Academic Research Consortium (BARC), and the bleeding sites (14), concomitant and preexisting COVID-19 infection, and other complications during the hospital stay. Acute heart failure was classified as Killip classes II–IV, arrhythmias were classified as ventricular and/or atrial, and acute kidney injury was defined as an increase in the serum creatinine level by at least 50% from the baseline within the first 48 h (13,15). A hospital-acquired bacterial infection was defined as the presence of microorganisms in otherwise sterile body tissues or fluids with or without clinical symptoms (fever and increased inflammatory markers) or as initiation of antibiotic therapy due to a high clinical suspicion of infection (16). We recorded all standard pharmacologic treatments [acetylsalicylic acid (ASA) with clopidogrel, ticagrelor, or prasugrel; heparin; norepinephrine; dobutamine; levosimendan; a loop diuretic; and a glycoprotein receptor (GP) IIb/IIIa antagonist and treatment of complications [insertion of an intra-aortic balloon pump (IABP) and mechanical ventilation, blood transfusions] (13).

2.1. Data analysis and endpoints

We compared the baseline, treatment, hospital complication, hospital mortality data and 6-month survival rates between STEMI patients with and without in-hospital bleeding.

2.2. Ethical approval

The Institutional Medical Ethics Committee (University Clinical Center Maribor Medical Ethics Committee [KME]) approved the retrospective observational study (approval no. UKC-MB KME-26/22). Informed consent of the patients was waived due to the retrospective nature of the study. The study was conducted in accordance with the 1996 Declaration of Helsinki and its subsequent amendments. We protected the personal data of the patients according to the Law on Personal Data Protection.

2.3. Statistical analysis

We used the SPSS Statistical package (version 19 for Windows; IBM Corp., Armonk, NY, USA) to perform statistical analysis. We present the data as

means ± standard deviations or percentages. We tested the differences between the groups using the two-sided Student's t-test for means ± standard deviations and Fisher's exact test for percentages. A p value < 0.05 was considered statistically significant. We used a logistic regression model to adjust for the influence of confounders on in-hospital bleeding in STEMI patients. Variables adjusted in the model were as follows: age > 65 years; OHCA; admission and in-hospital cardiogenic shock; arterial hypertension (AH); hospital-acquired infection; femoral access; acute kidney injury; and gender.

Cumulative survival was estimated using the Kaplan-Meier method and the difference between the groups (bleeding vs. non-bleeding patients) was tested with a log-rank test.

RESULTS

The baseline characteristics of the STEMI patients are presented in Table 1. Among co-morbidities, AH was most prevalent. Treatment by primary PCI was started within the first 3 h of chest pain in only 17% of patients.

In-hospital bleeding occurred in 36 patients (11.4%). We did not note any significant differences in baseline characteristics between bleeding and non-bleeding STEMI patients with the exception of OHCA, which was significantly more prevalent in bleeding STEMI patients.

Treatment of STEMI patients was as follows (Table 2): coronary angiography (98.4%); primary PCI (94.3%); radial access (42.6%); femoral access (48.9%); TIMI III flow (86.5%); and stent deployment (87.7%). The majority of STEMI patients (45%) received dual antiplatelet therapy, statin therapy, and bail-out therapy with a GP IIb/IIIa antagonist. Femoral access, clopidogrel, dobutamine, levosimentan, antibiotic treatment, mechanical ventilation, IABP, transfusion, and emergency surgery were used significantly more frequently in bleeding than non-bleeding STEMI patients, while the use of ticagrelor and a statin were used significantly less frequently.

The hospital complications are presented in Table 3. We recorded concomitant COVID-19 infections in 10 patients (3.2%), arrhythmias in 78 patients (24.6%), Killip classes II-IV in 71 patients (22.4%), cardiogenic shock in 48 patients (15.1% of all STEMI patients), mitral

Table 1. Baseline characteristics of STEMI patients

Baseline characteristics	All patients (n = 317)	Nonbleeding patients (n = 281)	Bleeding patients (n = 36)	p
Men (n; %)	237; 74.8	215; 76.5	22; 61.1	0.065
Mean age ± SD, years	65.71 ± 11.9	65.41 ± 11.9	68.11 ± 11.9	0.200
Age ≥ 65 years (n; %)	175; 55.2	150; 53.4	25; 69.4	0.076
Anterior STEMI (n; %)	151; 47.6	131; 46.6	20; 55.6	0.376
AH (n; %)	187; 59.0	164; 58.4	23; 63.9	0.592
Prior MI (n; %)	41; 12.9	38; 13.5	3; 8.3	0.597
Diabetes (n; %)	60; 18.9	52; 18.5	8; 22.2	0.651
OHCA (n; %)	29; 9.1	22; 7.8	7; 19.4	0.033
Pain to PPCI ≤12h (n; %)	189; 78.4	169; 79.0	20; 74.1	0.620
Pain to PPCI ≤6h (n; %)	136; 63.0	120; 62.2	16; 69.6	0.649
Pain to PPCI ≤3h (n; %)	54; 17.0	48; 17.1	6; 16.7	0.999
hsTnI ≥ 1000 ng/L (n; %)	185; 58.4	161; 57.3	24; 66.7	0.370
Serum creatinin (mean ± SD, µg/L	91.0 ± 45.0	92.3 ± 46.9	80.83 ± 24.4	0.075
Killip classes ≥ II (n; %)	55; 17.4	281; 16	10; 27.8	0.100
Cardigenic shock (n; %)	31; 9.8	22; 7.8	9; 25%	0.004

Legend: SD = standard deviation; MI = myocardial infarction; AH = arterial hypertension; STEMI = ST-elevation myocardial infarction; OHCA = out-of-hospital cardiac arrest; PPCI = primary percutaneous coronary intervention

Table 2. Treatment of STEMI patients (n; %)

Table 2. Treatments of STEMI patients Treatments (n; %)	All patients (n = 317)	Nonbleeding patients (n = 281)	Bleeding patients (n = 36)	p
Coronary angiography	312; 98.4	276; 98.2	36; 100	0.999
PPCI	299; 94.3	263; 93.6	36; 100.0	0.241
TIMI III after PPCI	274; 86.5	245; 87.4	29; 80.0	0.287
Radial access	135; 42.6	125; 44.5	10; 27.8	0.073
Femoral access	155; 48.9	131; 46.6	24; 66.7	0.033
Stent	278; 87.7	248; 88.3	30; 83.3	0.418
Thrombus aspiration	41; 12.9	34; 12.1	7; 19.4	0.287
ASA	313; 98.7	279; 99.3	34; 94.4	0.065
Ticagrelor	226; 71.3	208; 74.0	18; 50.0	0.005
Prasugrel	32; 10.1	30; 10.7	2; 5.6	0.555
Clopidogrel	51; 16.1	39; 13.9	12; 33.3	0.006
Statin	278; 87.7	255; 90.7	23; 63.9	< 0.001
Heparins	242; 76.3	212; 75.4	30; 83.3	0.405
GP IIb/IIIa antagonist	143; 45.1	124; 44.1	19; 52.8	0.375
Noradrenalin	41; 12.9	33; 11.7	8; 22.2	0.108
Dobutamin	26; 8.2	18; 6.4	8; 22.2	0.004
Levosimendan	20; 6.3	14; 5.0	8; 16.7	0.017
Antibiotic	59; 18.6	41; 14.6	18; 50.0	<0.001
Diuretic	43; 13.6	36; 12.8	7; 19.4	0.299
Mechanical ventilation	36; 11.4	24; 8.5	12; 33.3	<0.001
IABP	2; 0.6	1; 0.4	1; 2.8	0.215
Urgent surgery	7; 2.2	4; 1.4	3; 8.3	0.034
Blood transfusion	11; 3.5	5; 1.8	6; 16.7	<0.001

Legend: PPCI = primary percutaneous coronary intervention; TIMI = thrombolysis in myocardial infarction; GP = glycoprotein receptor; ASA = acetylsalicylic acid

Table 3. Hospital complications and data in STEMI patients

Hospital complications and data	All patients (n = 317)	Nonbleeding patients (n = 281)	Bleeding patients (n = 36)	p
Peak hs-TnI ≥ 10.000 ng/L (n; %)	233; 73.5	202; 71.9	31; 86.1	0.074
EF ≤ 40 (n; %)	74; 43.5	59; 40.7	15; 60.0	0.083
HF (Killip classes ≥ II) (n; %)	71; 22.4	55; 19.6	16; 44.4	0.002
Cardiogenic shock (n; %)	48; 15.1	37; 13.2	11; 30.6	0.012
Arrhythmias (n; %)	78; 24.6	61; 21.7	17; 47.2	0.002
Bacterial infection (n; %)	57; 18.0	39; 13.9	18; 51.4	<0.001
In-stent trombosis (n; %)	5; 1.6	3; 1.1	2; 5.6	0.101
Acute kidney injury (n; %)	26; 8.3	17; 6.1	9; 25.0	<0.001
Mitral regurgitation (n; %)	59; 18.6	48; 17.1	11; 30.6	0.067
VSD (n; %)	4; 1.3	3; 1.1	1; 2.8	0.384
Covid-19 (n; %)	10; 3.2	8; 2.8	2; 5.6	0.317
Mortality (n; %)	26; 8.2	17; 6	9; 25	<0.001
Peak serum creatinin (mean ± SD, µmol/L)	112.5 ± 86.5	78.8 ± 4.7	129.1 ± 21.5	< 0.001

Legend: Hs-TnI = high-sensitivity troponin I; HF = heart failure; EF = ejection fraction; VSD = ventricular septum defect

Table 4. Independent factors associated with in-hospital bleeding in STEMI patients

variables	OR	p	95% CI
Age ≥ 65 years	1.383	0.453	0.593 to 3.227
Arterial hypertension	0.885	0.769	0.390 to 2.005
Admission cardiogenic shock	1.329	0.575	0.492 to 3.585
OHCA	0.944	0.930	0.260 to 3.427
Acute kidney injury	1,296	0.651	0.421 to 3.989
Femoral access	1.498	0.329	0.666 to 3.367
Hospital infection	4.467	0.001	1.819 to 10.973
Male vs female gender	1.487	0.338	0.660 to 3.348
Hospital cardiogenic shock	1.324	0.638	0.411 to 4.261

Legend: OHCA = out-of-hospital cardiac arrest

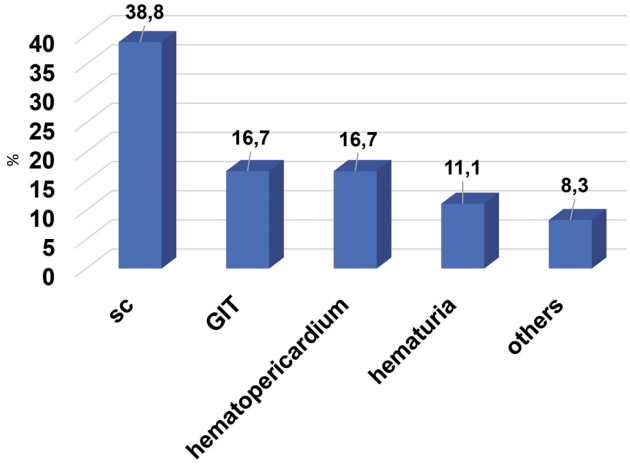

***Figure 1.** Bleeding sites in STEMI patients.*

Figure Legends: Figure 1. GIT = gastrointestinal

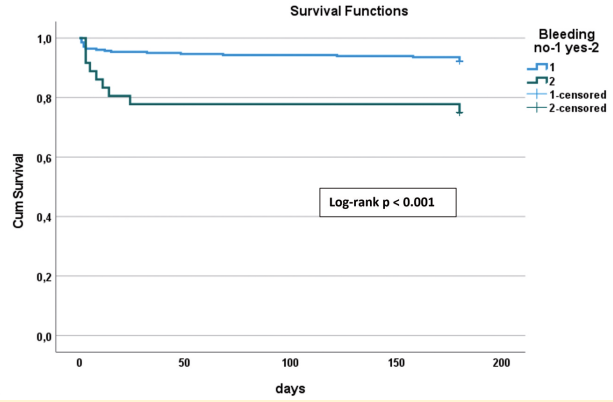

***Figure 2.** Survival within 6 months in bleeding and non-bleeding STEMI patients.*

regurgitation in 59 patients (18.6%), a bacterial infection in 57 patients (18%), acute kidney injury in 26 patients (8.3%), and hospital mortality in 26 patients (8.2%). Hospital heart failure, cardiogenic shock, arrhythmias, bacterial infections, acute kidney injury, and hospital mortality were significantly more likely in bleeding than non-bleeding STEMI patients. Concomitant COVID-19 infections were observed in eight non-bleeding and two bleeding STEMI patients, respectively (2.8% vs. 5.6%, p = 0.317). Stent thrombosis occurred in five patients (three cases of stent thrombosis in non-COVID-19 patients and two cases in COVID-19 patients [1% vs. 20%, p = 0.009]).

The only independent variable associated with in-hospital bleeding was hospital bacterial infections (Table 4).

In-hospital bleeding sites are shown in Figure 1. Bleeding at the puncture site was most common, followed by gastrointestinal bleeding, hemopericardium, hematuria, and bleeding in other locations (thoracic, vaginal, and tracheal). We did not observe any cerebral bleeding.

The 6-month survival rate for all STEMI patients was 90.2% (92.2% in non-bleeding and 75% in bleeding patients [log rank, p < 0.001]), as shown in Figure 2.

DISCUSSION

Primary PCI was the only reperfusion strategy in STEMI patients in our institution during the COVID-19 pandemic in 2021. Specifically, primary

PCI was performed in 93.4% of non-bleeding and 100% of bleeding patients. In-hospital bleeding occurred in 11.4% of STEMI patients. Among bleeding compared to non-bleeding STEMI patients, we noted that the following occurred significantly more frequently: OHCA; admission cardiogenic shock; femoral access for primary PCI; hospital heart failure; hospital cardiogenic shock; acute kidney injury; arrhythmias; hospital mortality; and use of dobutamine, levosimendan, clopidogrel, and an antibiotic. Among hospital complications, hospital-acquired bacterial infection was most significantly associated with hospital bleeding. Within 6 months of treatment, 92.2% of the non-bleeding and 75% of the bleeding STEMI patients survived (log-rank, $p < 0.001$).

Several clinical trials have reported high prevalence of thrombosis in COVID-19 patients (2,3). In our retrospective analysis of STEMI patients from 2021, the prevalence of in-stent thrombosis was significantly increased in COVID-19 patients compared to non-COVID-19 patients as well. However, none of the patients with in-stent thrombosis had re-infarction due to prompt recognition and treatment. The small number of all COVID-19 patients (n = 10) and in-stent thrombosis (n = 5) are not representative of a larger population and may lead to potential interpretation bias.

The time delay to primary PCI in 2021 persisted as <20% of STEMI patients received primary PCI within the first 3 hours of symptom onset (17). The time delay to primary PCI and the use of primary PCI was similar in non-bleeding and bleeding patients.

The prevalence of in-hospital bleeding among our STEMI patients with potent dual antiplatelet therapy during the COVID-19 pandemic in 2021 was similar to other real-world data from the pre-pandemic period (7,11). Greater than 50% of our bleeding STEMI patients experienced major bleeds, such as hemopericardium or bleeding with a significant decrease in the hemoglobin concentration, some of whom required blood transfusions. Recent studies identified older age, a lower baseline hemoglobin concentration, pre-existing hypertension, previous heart failure, and femoral access site as predictors of severe bleeding events (11,18). Gender, older age, and co-morbidities were not shown to significantly influence bleeding in our STEMI patients, unlike OHCA. According to studies, OHCA or mechanical complications increased considerably during the COVID-19 pandemic compared to the pre-COVID-19 era (19,20). Based on our experience in 2020, the prevalence of OHCA in 2021 returned to the pre-pandemic values (17). One study concluded that the increased risk of major bleeding in STEMI patients after OHCA was mainly the consequence of combined use of GP IIb/IIIa antagonists and post-PCI anticoagulants, as well as traumatic resuscitation, post-resuscitation global myocardial dysfunction, coagulation disturbances, and invasive procedures with the inherent risks of vascular complications (21). Among all the clinical variables, only hospital-acquired infection was more significantly associated with bleeding. The high prevalence of infection in bleeding patients was most often associated with severe pulmonary congestion in patients with pulmonary edema, respiratory failure following an OHCA, infection at the vessel puncture site, and the use of invasive procedures, such as intubation and mechanical ventilation, which are important predisposing factors for hospital-acquired infections and sepsis.

Paradoxically, clopidogrel was used more often in our bleeding STEMI patients even though clopidogrel decreases the risk of bleeding in STEMI patients. This finding confirms the multifactorial risk of bleeding in STEMI patients, including admission heart failure, OHCA, older age, female gender, and low body weight. All these parameters were considered in selection of a P2Y2 inhibitor before admission to the catheter suite.

Femoral access for primary PCI is more likely associated with bleeding than radial access (18, 22, 23). The same finding was noted in our STEMI patients. The vascular access site was individually chosen by the attending cardiologist. The reasons to use femoral access included hemodynamic deterioration due to cardiogenic shock or pulmonary edema, OHCA, cardiologist experience and skill, and in some cases time-consuming use of personal protective equipment against COVID-19 by the medical staff.

Clinical trials conducted during the pre-pandemic period documented that the risk of bleeding exceeded that of ischemia during the days after primary PCI, both of which markedly decreased over time (18, 23, 24). The bleeding rate exceeded the hospital in-stent thrombosis rate in our patients (11.4% vs. 1.6%); however, in-stent thrombosis was more likely observed in bleeding than non-bleeding patients (5.6% vs. 1.1%, $p > 0.05$). This observation confirms prior findings that bleeding risk often overlaps with ischemic risk (10,11,21). Severe bleeding can induce hemodynamic compromise, hypoxemia, and temporary interruption of anti-thrombotics, all of which can exacerbate re-infarction (23, 24). Monitoring systems to assess efficacy and safety of anti-thrombotic therapies are limited. Indeed, most of the time it is unknown whether the patient will or will not bleed until bleeding occurs (24).

Bleeding in our patients was significantly more often associated with hospital complications and mortality. The hospital mortality rate was 25% in bleeding STEMI patients compared to 8% in non-bleeding patients; however, the 6-month survival rate in bleeding patients was similar to hospital survival. This finding confirms prior data that bleeding is associated with higher mortality in the acute STEMI phase (24).

Subcutaneous bleeding at the vascular puncture site was the most prevalent bleeding site in our patients and this observation was similar to other studies from the pre-pandemic period, especially in patients who had a femoral artery puncture (18, 22).

Gastrointestinal bleeding was observed in 16.7% of all bleeding complications. Usually, proton pump inhibition is recommended in addition to judicious anti-platelet therapy in high-risk patients (17). Hemopericardium was as frequent as gastrointestinal bleeding and was an important cause of morbidity and mortality in our STEMI patients. The use of dual antiplatelet agents in patients with pericardial bleeding was temporarily interrupted and tests of hemostasis were performed during and after pericardiocentesis or surgery if necessary.

CONCLUSIONS

Bleeding events in STEMI patients during the COVID-19 pandemic were as devastating as before the pandemic. Balancing the risk of bleeding and thrombosis was particularly challenging for clinicians during the COVID-19 pandemic due to the prothrombotic effect of COVID-19 in infected STEMI patients. The prevalence of bleeding during the second year of the COVID-19 pandemic was similar to the pre-pandemic period and associated with a worse prognosis in STEMI patients.

LIMITATIONS OF THE STUDY

The study was retrospective and observational with all the inherent drawbacks. As this was a single center study, a limited number of patients was included within a limited time interval and the results were not necessarily representative of a larger population. However, the data provide insight into the prevalence, bleeding sites, and the outcome in bleeding and non-bleeding STEMI patients during the COVID-19 pandemic in 2021.

There are no conflicts of interests.

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