

COVID-19 and changes in activity and treatment of ST elevation MI from a UK cardiac centre



Yang Chen^{a,b}, Krishnaraj S. Rathod^{b,c}, Stephen Hamshere^{b,c}, Fizzah Choudry^{b,c}, Mohammed M. Akhtar^{b,c}, Miles Curtis^b, Rajiv Amersey^b, Oliver Guttman^b, Constantinos O'Mahony^{a,b}, Ajay Jain^{b,c}, Andrew Wragg^{b,c}, Andreas Baumbach^{b,c}, Anthony Mathur^{b,c}, Daniel A. Jones^{b,c,*}

^aInstitute of Cardiovascular Science, University College London, UK

^bSt Bartholomew's Hospital, Barts Health NHS Trust, London, UK

^cCentre for Cardiovascular Medicines and Devices, Queen Mary University London, UK

ARTICLE INFO

Article history:

Received 3 July 2020

Received in revised form 29 January 2021

Accepted 3 February 2021

Available online 23 February 2021

Keywords:

STEMI

COVID-19

Thrombolysis

Indirect morbidity and mortality

ABSTRACT

Background: The international healthcare response to COVID-19 has been driven by epidemiological data related to case numbers and case fatality rate. Second order effects have been less well studied. This study aimed to characterise the changes in emergency activity of a high-volume cardiac catheterisation centre and to cautiously model any excess indirect morbidity and mortality.

Method: Retrospective cohort study of patients admitted with acute coronary syndrome fulfilling criteria for the heart attack centre (HAC) pathway at St. Bartholomew's hospital, UK. Electronic data were collected for the study period March 16th – May 16th 2020 inclusive and stored on a dedicated research server. Standard governance procedures were observed in line with the British Cardiovascular Intervention Society audit.

Results: There was a 28% fall in the number of primary percutaneous coronary interventions (PCIs) for ST elevation myocardial infarction (STEMI) during the study period (111 vs. 154) and 36% fewer activations of the HAC pathway (312 vs. 485), compared to the same time period averaged across three preceding years. In the context of 'missing STEMIs', the excess harm attributable to COVID-19 could result in an absolute increase of 1.3% in mortality, 1.9% in nonfatal MI and 4.5% in recurrent ischemia.

Conclusions: The emergency activity of a high-volume PCI centre was significantly reduced for STEMI during the peak of the first wave of COVID-19. Our data can be used as an exemplar to help future modelling within cardiovascular workstreams to refine aggregate estimates of the impact of COVID-19 and inform targeted policy action.

© 2021 Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

As of June 18th 2020 there have been over 400,000 deaths and >8 million cases of COVID-19 worldwide.[1] Healthcare policy has varied considerably and many unknowns remain regarding the virus – an accurate measure of its prevalence; the size, scale and timing of a second peak of infections; and the efficacy of treatments currently being tested, including a vaccine.

As COVID-19 becomes an increasing economic and societal problem, communication of its wider effects – including indirect consequences to healthcare – will have a growing impact on setting both national and international policy. A recent model pub-

lished in the UK sought to estimate the excess 1 year mortality under a number of assumptions.[2] The use of granular data from specific disease and treatment pathways has been an underutilised resource so far in helping to shape aggregate models which policy makers use to determine the pandemic response.

We report the changes in emergency activity at our high-volume cardiac centre, examining the number of primary percutaneous coronary interventions (primary PCIs) for ST-segment elevation myocardial infarction (STEMI) and the total number of activations of our heart attack centre (HAC) pathway. Relevant characteristics of STEMI cases, including measures of system activity such as number of patients thrombolysed and door to balloon (DTB) time were also analysed. We additionally model the excess indirect morbidity and mortality of service reconfigurations under a number of pragmatic assumptions.

* Corresponding author at: Consultant Cardiologist & Clinical Senior Lecturer, UK.
E-mail address: Dan.jones8@nhs.net (D.A. Jones).

2. Methods

A service evaluation of catheter lab activity at St Bartholomew's Hospital (SBH) was registered with the Clinical Effectiveness Unit on May 1st, 2020, (Project ID 11152). Anonymous data were retrospectively extracted as part of the usual governance processes observed for the British Cardiovascular Intervention Society national angioplasty audit [3], and quality assurance processes were followed according to protocols used by the audit department at SBH. The number of activations of the HAC pathway was examined and the characteristics of patients coded as having a STEMI were analysed. MI was defined according to the Fourth Universal Definition of Acute [4]. Data was collected during a two month period – March 16th- May 16th 2020, which covered the peak of cases in the UK during the first wave of the COVID19 pandemic.

All patients who were admitted as a suspected STEMI to St. Bartholomew's hospital under the HAC pathway were eligible for inclusion [Box 1]. Admissions were compared with the average number of STEMIs and HAC activations over the same time period in the previous three years. There was no data loss. Estimation of the excess indirect morbidity and mortality of different strategies was based on absolute risk increases from pooled RCT data [5] – for example, in terms of mortality, this was 7% after PPCI versus 9% after thrombolysis ($p = 0.0002$) and this method has been independently used by another group [6].

Clinical, demographic, and procedural characteristics are summarised using percentages or means and standard deviations as appropriate and compared using one-way analysis of variance (ANOVA) for continuous variables (expressed as mean \pm standard deviation) and the χ^2 tests or the Fisher's exact tests for categorical variables (expressed as count and percentage). The statistical software programme SPSS version 24 was used. The manuscript has been prepared according to The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement [7].

2.1. Patient and public involvement

There was no patient or public involvement during the course of this study.

3. Results

During the study period, 111 STEMIs were treated with primary PCI and 135 angiograms were performed in total. Over an average of the same time period across the preceding three years, there were 154 STEMIs treated with primary PCI and 243 angiograms performed. This represents a 28% fall in primary PCI activity for STEMI. The total number HAC activations was 312, compared to 485 activations across the same time period over the preceding three years, representing a 36% fall in activity, highlighted in Fig. 1. The ratio of primary PCI for STEMI as a proportion of total HAC activations is shown in Fig. 2. The average number of HAC activations a week in 2020 was 26 with 11 undergoing primary PCI per week. In comparison to the same period in 2019, there were 42 activations on average per week with 13 undergoing primary PCI per week.

When evaluating the characteristics of the STEMI cases, 2020 data was compared directly to 2019.

The baseline characteristics of the patients treated were similar and both mean Door To Balloon (DTB) time (50mins vs. 51mins ($p = 0.32$)), and call to balloon time (241mins vs. 194mins ($p = 0.08$)) were not statistically different (Table 1). There was a trend toward poorer outcomes with respect to left ventricular function – the proportion of patients coded as severe LV impairment (EF < 35%) was 12.6% during the study period vs. 7.7%

($p = 0.8$) in the same period in 2019. The rate of LV thrombus in patients with STEMI was 7.2% during the study period, compared to 4.5% ($p = 0.1$). The total number of patients thrombolysed during the study period was two (0.6%), compared to none in the previous year. Table 2.

3.1. Estimated excess indirect morbidity and mortality

Over the study period, we have cautiously modelled for the following indirect effects of COVID-19 using a series of pragmatic assumptions:

Scenario A: assume 43 missing STEMI patients were treated with fibrinolysis rather than primary PCI. Using the meta-analysis by Keeley et al. [5], this would cause an additional harm at 30 days of one extra death, three non-fatal MIs, seven episodes of recurrent ischemia, and up to one extra stroke.

Scenario B: same as Scenario A but assume treatment was with medical therapy only, rather than primary PCI. One extra death in addition to Scenario A would be incurred – using data from the original fibrinolysis versus medical care RCTs.[8] For our sample, this would represent an absolute increase of 1.3% in mortality, 1.9% in nonfatal MI, 4.5% in recurrent ischemia, and 0.6% increase in stroke.

Scenario C: assume Scenario A or B plus an additional burden of an absolute increase of 5% of STEMI patients presenting with severe LV impairment and 2.5% absolute increase in patients with LV thrombus.

4. Discussion

This report examines the changes in activity and experiences at a high volume cardiac centre and the possible downstream consequences for patients. We highlight three key messages:

1. The overall number of patients treated with primary PCI for STEMI was significantly reduced over a two-month period, with a larger associated fall in activations of our HAC pathway.
2. Very few patients were treated with thrombolysis during this study period, in spite of pragmatic advice recommended by many internationally respected sources.
3. The indirect excess harm is difficult to approximate and extrapolate to a national setting. The annual UK number of STEMI cases is approximately 35,000[9] – allowing for small monthly variations, a reasonable estimate of 6000 STEMIs would occur in two months in non-COVID times. If the reduction of activity was similar across all primary PCI centres – and evidence supports this from other UK centres [10] – then almost 1700 STEMI cases would be missing, which may represent 80 extra deaths, 120 non-fatal MIs and 280 episodes of recurrent ischaemia and 40 S. There may also be an additional 255 patients who have severe LV impairment and 162 patients with LV thrombus.

5. Comparison with other studies

Another UK centre has examined the possible delays to primary PCI over a one month period, using a surrogate of time to first medical contact (FMC) to approximate any changes in patient behaviour. The delay in symptom-to-FMC was significantly longer (227 [65–790] vs.119 [27–203] min, $P = 0.01$) and in 26.1% of the cohort the time from symptom to FMC was >12 h [10]. Nationally, recent summary level data published after the first wave of the pandemic demonstrated a 43% decline in primary PCI rates for STEMI, an increased median call to arrival time of 15 min with a non-statistically significant difference in in-hospital mortality of those who were admitted [11]. Our own data also highlighted an

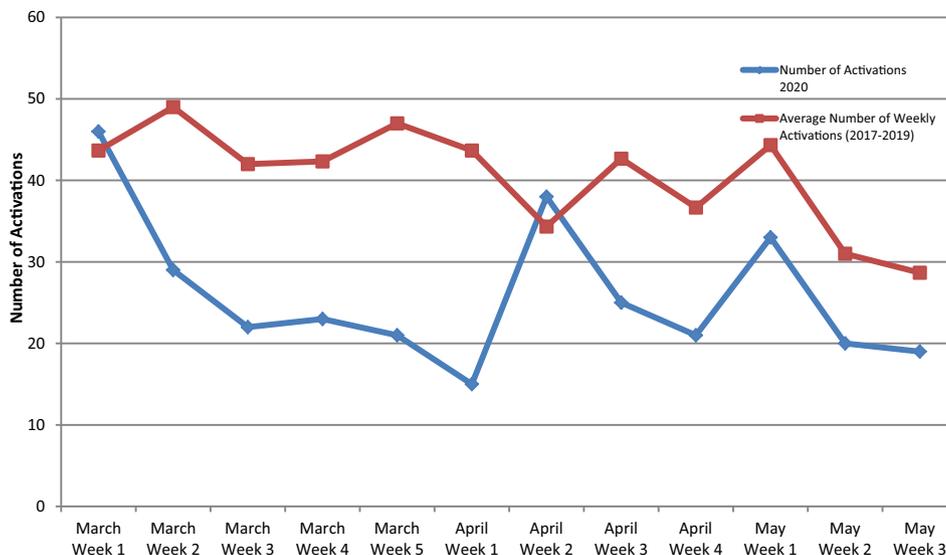


Fig. 1. Weekly trend of HAC activations over study period (Blue line) versus trend across three year average between 2017 and 2019. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

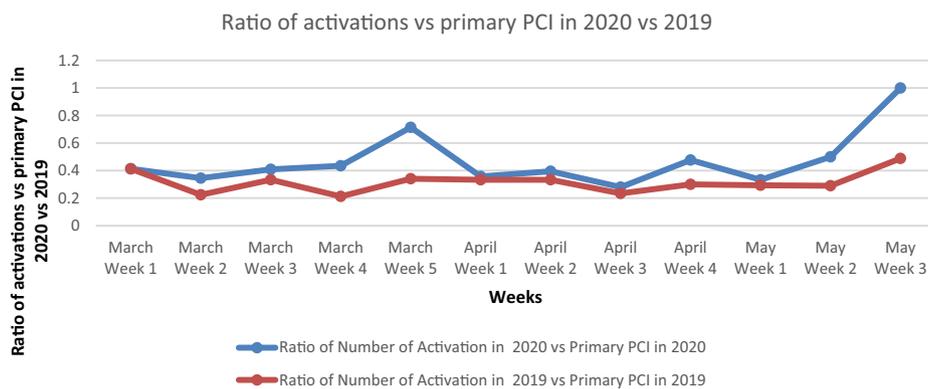


Fig. 2. Ratio of HAC activations versus primary PCI in 2019 and 2020.

Table 1

Baseline Characteristics of STEMI patients who underwent primary PCI. Abbreviations: ACS = Acute Coronary Syndrome, MI = Myocardial Infarction, CABG = Coronary Artery bypass grafting, MV = Multi-vessel, PVD = Peripheral Vascular disease, CKD = Chronic Kidney disease, LV = Left ventricular, CVA = Cerebrovascular accident, OOHA = Out of hospital cardiac arrest.

	2019 (n = 155)	2020 (n = 111)	p Value
Age (yrs)	61.33 ± 14.22	61.35 ± 13.20	0.361
Ethnicity (Asian)	51 (32.9%)	32 (28.8%)	0.284
Gender (Male)	110 (71.0%)	82 (73.9%)	0.352
Previous MI	23 (14.8%)	13 (11.7%)	0.292
Previous PCI	22 (14.2%)	15 (13.5%)	0.511
Previous CABG	5 (3.2%)	1 (0.9%)	0.204
Hypercholesterolaemia	67 (43.2%)	46 (41.4%)	0.435
Diabetes mellitus	44 (28.4%)	34 (30.6%)	0.396
Hypertension	70 (45.1%)	56 (50.5%)	0.233
Smoking History	69 (44.5%)	49 (44.1%)	0.526
PVD	1 (0.6%)	3 (2.7%)	0.198
CKD (Creatinine > 200)	2 (1.3%)	1 (0.9%)	0.623
Previous CVA	3 (1.9%)	2 (1.8%)	0.653
Poor LV function	12 (7.7%)	14 (12.6%)	0.822
Cardiogenic Shock	9 (5.8%)	10 (9%)	0.223
OOHA	11 (7.1%)	2 (1.8%)	0.041

increase in the mean call to balloon time of 47 min though this was not statistically significant. Internationally, a multicentre, nationwide survey in Italy [12] observed a 48.4% reduction in admissions

Table 2

Procedural Characteristics of 2019 and 2020 primary PCI for STEMI cases.

	2019 (n = 155)	2020 (n = 111)	p Value
Access for PCI			
Radial	133 (85.8%)	102 (91.9%)	0.090
Median Door to Balloon Times	51 mins ± 54 (SD)	50 mins ± 100 (SD)	0.318
Median Call to Balloon Times	194 mins ± 228 (SD)	241 mins ± 282 (SD)	0.081
LV thrombus rates	7 (4.5%)	8 (7.2%)	0.107
GP IIb/IIIa inhibitor	48 (31.0%)	51 (45.9%)	0.009
TIMI Flow Pre-Procedure (0)	65 (41.9%)	51 (45.9%)	0.300
Procedural Success	94 (60.6%)	75 (67.6%)	0.152

for acute myocardial infarction (AMI) throughout a 1 week period during the COVID-19 outbreak, compared with the equivalent week in 2019, of which STEMI was reduced by 26.5%.

Other research groups have attempted modelling of the possible increased mortality and bed occupancy incurred by a thrombolysis-only strategy, though caution should be exercised in direct comparisons. For instance, a time horizon of one year rather than thirty days was employed and the numbers of patients thrombolysed in real world clinical practice have been negligible [12]. In addition, the breadth of different subgroups is important

to consider. A separate UK analysis examining only the subset of out of hospital cardiac arrest (OHCA) admissions at a national level revealed an increased proportion of OHCA during the pandemic period of 2%. Across a 3 month period, this translated to approximately 400 extra OHCA admissions undergoing PCI [13].

5.1. Comparison with professional guidelines

A consensus statement from the American College of Cardiology [14] and guidance from the European Society of Cardiology [15] both emphasise the importance of maintaining primary PCI as standard of care. This is reflected in the UK BCIS position and advice from NHS England which additionally emphasised caution in reflex decisions particularly around the implications of thrombolysis and downstream effects – this is reflected in our own numbers [16,17].

6. Limitations

This is a single centre, retrospective study with a modest sample size. No causal inferences may be drawn as to why the levels of primary PCI for STEMI decreased. Our assumptions regarding the excess indirect morbidity and mortality are based on significant caveats, primarily around

- i) Assuming that there would have been an extra 43 patients in non-COVID times and attributing excess indirect harm solely to not receiving primary PCI
- ii) Using historical data that has a different baseline event rate to current practice
- iii) Attributing trends in left ventricular function to COVID-19 and delayed treatment with primary PCI
- iv) Assuming that our single centre is representative of the entire UK population.

We have also focused our analysis on STEMIs in this paper and further work examining the activity and characteristics of patients coded as NSTEMIs represent an important patient group to evaluate. Other recently published work examined this at a national level in the UK, demonstrating an increased mortality for NSTEMI patients at 30 days [18]. Additionally, at our own centre, we have published data on ancillary cardiovascular harms due to COVID-19, including higher multivessel thrombus burden and longer length of stay in the subset of STEMI patients who were COVID-19 positive [19]. Therefore consideration of this and other factors will allow more precise modelling of the totality of second order harms related to the COVID-19 pandemic and its impact on patients with acute coronary syndromes.

6.1. Implications for clinicians and policymakers

Although our hospital is one of Europe's largest cardiovascular centres, covering a population of around six million people, pooling of data internationally will be important to accurately determine changes in emergency primary PCI activity and thus model for excess indirect harms due to COVID. A global survey [20] has reported the perception of substantially reduced STEMI activity and delays to treatment amongst those who responded, however it will be critical to marry perceptions with actual changes. A careful balance is needed to manage cardiac patients and those with other specialised conditions, in the next phase of the COVID-19 pandemic. Whilst they are at an increased risk of severe disease due to COVID-19 itself, it is also the case that they are at elevated risk of mortality and morbidity from their underlying conditions,

particularly if they do not seek or receive care in a timely manner or even at all.

The design of any prediction model benefits from the use of rich, high quality data. When this can be directed to offer bespoke modelling relevant to individual patient groups, better decisions can be made by our profession and our patients alike, using nuanced analyses of the risk–benefit ratio of emergency and urgent elective treatments.

7. Conclusion

The emergency activity of a high-volume centre in the UK was significantly reduced for primary PCI in STEMI during the peak of the first wave of COVID-19. We cautiously modelled the excess indirect cardiovascular morbidity and mortality related to acute coronary syndromes. Our data can be used as an exemplar to help future modelling within cardiovascular and broader workstreams to refine aggregate and population level estimates of the impact of COVID-19.

Transparency Declaration

The first author (YC) and corresponding author (DJ) affirm that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted.

Ethics

The data collected in this study was part of a mandatory national cardiac audit, and all patient identifiable fields were removed prior to merging of the data sets and analysis. The local ethics committee had advised on previous studies with the same methodology that formal ethical approval was not required.

Data Sharing

Raw data is available on request from the corresponding author.

Funding and sponsorship: YC and KR were funded by the National Institute for Health Research Academic Clinical Fellowship and Academic Clinical Lectureship programmes respectively, during the course of this work.

No competing interests: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf AB has received research grants and honorariums from Microport, Sinamed, Abbott Vascular and Astra Zeneca, AM receives support from Barts NIHR Biomedical Research Centre. All other authors declare: no support from any organisation for the submitted work.

References

- [1] Johns Hopkins University. Coronavirus Resource Centre 2020. (Online). Accessed on: May 18th, 2020. Available at: <https://coronavirus.jhu.edu/map.html>.
- [2] Banerjee A, Pasea L, Harris S et al. Estimating excess 1-year mortality associated with the COVID-19 pandemic according to underlying conditions and age: a population-based cohort study Lancet. 2020 May 12. doi: 10.1016/S0140-6736(20)30854-0.
- [3] P.F. Ludman, British Cardiovascular Intervention Society Registry for audit and quality assessment of percutaneous coronary interventions in the United Kingdom, *Heart* 97 (2011) 1293–1299.
- [4] K. Thygesen, J.S. Alpert, A.S. Jaffe, et al., Fourth Universal Definition of Myocardial Infarction (2018), *Circulation* 138 (20) (2018) e618–e651, <https://doi.org/10.1161/CIR.0000000000000617>.
- [5] E.C. Keeley, J.A. Boura, C.L. Grines, Primary angioplasty versus intravenous thrombolytic therapy for acute myocardial infarction: a quantitative review of 23 randomised trials, *Lancet* 361 (9351) (2003) 13–20, [https://doi.org/10.1016/S0140-6736\(03\)12113-7](https://doi.org/10.1016/S0140-6736(03)12113-7).
- [6] L. Dancy, K. O'Gallagher, M. Ryan, P.A. MacCarthy, A.M. Shah, Predictive model of increased mortality and bed occupancy if thrombolysis becomes the initial treatment strategy for STEMI during the SARS-CoV-2 pandemic, *Clin Med (Lond)*. 20 (5) (2020) e170–e172, <https://doi.org/10.7861/clinmed.2020-0293>.
- [7] von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening of Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.
- [8] Fibrinolytic Therapy Trialists' (FTT) Collaborative Group. Indications for Fibrinolytic Therapy in Suspected Acute Myocardial Infarction: Collaborative

- Overview of Early Mortality and Major Morbidity Results From All Randomised Trials of More Than 1000 Patients. *Lancet*. 1994 Feb 5;343(8893):311-22.
- [9] NICOR. Adult Percutaneous Coronary Interventions (Angioplasty audit) 2019 (Online). Accessed on May 25th 2020. Available at: <https://www.nicor.org.uk/adult-percutaneous-coronary-interventions-angioplasty-audit/>.
- [10] Abdelaziz HK, Abdelrahman A, Nabi A et al. Impact of COVID-19 pandemic on patients with ST-segment elevation myocardial infarction: Insights from a British cardiac center *Am Heart J*. 2020 May 11 doi: 10.1016/j.ahj.2020.04.022.
- [11] Kwok CS, Gale CP, Kinnaird T, et al Impact of COVID-19 on percutaneous coronary intervention for ST-elevation myocardial infarction *Heart* Published Online First: 31 August 2020. doi: 10.1136/heartjnl-2020-317650.
- [12] De Rosa S, Spaccarotella C, Basso C, et al. Reduction of hospitalizations for myocardial infarction in Italy in the COVID-19 era, *European Heart Journal*, , ehaa409, <https://doi.org/10.1093/eurheartj/ehaa409>.
- [13] Rashid M, Gale CP, Curzen N et al. Impact of COVID19 Pandemic on the Incidence and Management of Out of Hospital Cardiac Arrest in Patients Presenting with Acute Myocardial Infarction in England. *J Am Heart Assoc*. 2020 Oct 7:e018379. doi: 10.1161/JAHA.120.018379. Epub ahead of print. PMID: 33023348.
- [14] E. MahmudE, H.L. Dauerman, F.G. Welt, et al., Management of Acute Myocardial Infarction During the COVID-19 Pandemic, *J. Am. Coll. Cardiol*. S0735-1097 (20) (2020) 35026-35029, <https://doi.org/10.1016/j.jacc.2020.04.039>.
- [15] European Society of Cardiology. ESC COVID 19 Guidance 2020 (Online). Accessed on 24 May 2020. Available at: <https://www.escardio.org/Education/COVID-19-and-Cardiology/ESC-COVID-19-Guidance#p08>.
- [16] British Cardiovascular Intervention Society. Statement by BCIS regarding the COVID19 pandemic 2020 (Online). Accessed on 24 May 2020. Available at: <https://www.bcis.org.uk/news/statement-by-bcis-regarding-the-covid-19-pandemic/>.
- [17] NHS England. Clinical guide for the management of cardiology patients during the coronavirus pandemic 20 March 2020 Version 1 (Online). Accessed on 24 May 2020. Available at: <https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/03/specialty-guide-cardiology-coronavirus-v1-20-march.pdf>.
- [18] Wu J, Mamas M, Rashid M et al. Patient response, treatments, and mortality for acute myocardial infarction during the COVID-19 pandemic, *European Heart Journal - Quality of Care and Clinical Outcomes*, , qcaa062, <https://doi.org/10.1093/ehjqcco/qcaa062>.
- [19] F.A. Choudry, S.M. Hamshere, K.S. Rathod, et al., High Thrombus Burden in Patients With COVID-19 Presenting With ST-Segment Elevation Myocardial Infarction, *J. Am. Coll. Cardiol*. 76 (10) (2020) 1168-1176.
- [20] Pessoa-Amorim G, Camm CF, Gajendragadkar P et al. Admission of patients with STEMI since the outbreak of the COVID-19 pandemic. A survey by the European Society of Cardiology, *European Heart Journal - Quality of Care and Clinical Outcomes*, qcaa046, <https://doi.org/10.1093/ehjqcco/qcaa046>.