ORIGINAL RESEARCH

Impact of Coronavirus Disease 2019 Pandemic on the Incidence and Management of Out-of-Hospital Cardiac Arrest in Patients Presenting With Acute Myocardial Infarction in England

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BACKGROUND: Studies have reported significant reduction in acute myocardial infarction–related hospitalizations during the coronavirus disease 2019 (COVID-19) pandemic. However, whether these trends are associated with increased incidence of out-of-hospital cardiac arrest (OHCA) in this population is unknown.

METHODS AND RESULTS: Acute myocardial infarction hospitalizations with OHCA during the COVID-19 period (February 1–May 14, 2020) from the Myocardial Ischaemia National Audit Project and British Cardiovascular Intervention Society data sets were analyzed. Temporal trends were assessed using Poisson models with equivalent pre–COVID-19 period (February 1–May 14, 2019) as reference. Acute myocardial infarction hospitalizations during COVID-19 period were reduced by >50% (n=20 310 versus n=9325). OHCA was more prevalent during the COVID-19 period compared with the pre–COVID-19 period (5.6% versus 3.6%), with a 56% increase in the incidence of OHCA (incidence rate ratio, 1.56; 95% CI, 1.39–1.74). Patients experiencing OHCA during COVID-19 period were likely to be older, likely to be women, likely to be of Asian ethnicity, and more likely to present with ST-segment–elevation myocardial infarction. The overall rates of invasive coronary angiography (58.4% versus 71.6%; P<0.001) were significantly lower among the OHCA group during COVID-19 period with increased time to reperfusion (mean, 2.1 versus 1.1 hours; P=0.05) in those with ST-segment–elevation myocardial infarction. The adjusted in-hospital mortality probability increased from 27.7% in February 2020 to 35.8% in May 2020 in the COVID-19 group (P<.001).

CONCLUSIONS: In this national cohort of hospitalized patients with acute myocardial infarction, we observed a significant increase in incidence of OHCA during COVID-19 period paralleled with reduced access to guideline-recommended care and increased in-hospital mortality.

Key Words: acute myocardial infarction ■ coronavirus disease 2019 ■ incidence ■ mortality ■ out-of-hospital cardiac arrest

During the global pandemic of coronavirus disease 2019 (COVID-19), caused by the novel severe acute respiratory syndrome coronavirus 2, a significant reduction in acute myocardial infarction (AMI)–related hospitalizations has been observed.1–4 It has been postulated that patients with AMI are not

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seeking medical attention because of their concerns about the risk of nosocomial-acquired COVID-19 infection, as well as limitations to social movement attributable to government lockdowns.3,5,6 Delays to timely reperfusion are associated with an increased risk of life-threatening arrhythmias, out-of-hospital cardiac arrest (OHCA), heart failure, and death among patients presenting with AMI.7–9

A recent multicenter observational report from Italy found that AMI-related hospitalizations were reduced by almost 50% during the COVID-19 period and accompanied by a 3-fold increase in mortality compared with the pre–COVID-19 period.7–9 Data from the Lombardia CARe (Lombardia Cardiac Arrest Registry) reported a 58% increase in OHCA during the first 40 days of the COVID-19 outbreak.12 It was thought that this may be related to the spread of the COVID-19 infection as there was no information about the incidence of AMI in this cohort. Similar observations were made by Lai et al from New York City emergency medical services system, where a 3-fold increase in incidence of OHCA was noted in those undergoing emergency medical services resuscitation during the COVID-19 period.13 It remains unclear, however, whether reduced hospitalizations with AMI are associated with changes in incident OHCA. Equally, it is not known if the changes in service structure and delivery of healthcare emergency response during the COVID-19 pandemic have influenced the management of patients presenting with OHCA in the context of AMI. Using multisource nationwide data derived from UK national acute coronary syndrome and percutaneous coronary intervention (PCI) data sets, we studied the characteristics, care, and outcomes of admissions to hospital with AMI complicated by OHCA during the first wave of the COVID-19 outbreak in England.

METHODS

Study Data
Because of the sensitive nature of the data collected for this study, requests to access the data set from qualified researchers trained in human subject confidentiality protocols may be sent to National Institute of Cardiovascular Outcomes Research. Data for this study were drawn from 2 nationwide cardiovascular registries of National Institute of Cardiovascular Outcomes Research (namely, the MINAP [Myocardial Ischaemia National Audit Project] registry and the BCIS [British Cardiovascular Intervention Society] registry PCI data set).14,15 Full details on the framework of these data sets and their utility in conducting research have been described previously.16–18 Briefly, the MINAP registry is one of the largest single health system heart attack registries and collects information about baseline demographics, reperfusion treatment, and pharmacological and invasive management of patients admitted with AMI to 1 of the 195 acute National Health System hospitals in England.19–21 The BCIS registry PCI database contains high-resolution information about the procedural aspects, periprocedural pharmacology, and in-hospital PCI-related complications of patients admitted with AMI.16,22,23

Ethics
The National Institute of Cardiovascular Outcomes Research databases, including MINAP and BCIS registries, are collected and used for research purposes without requiring informed patient consent, which fell under section 251 of National Health Service Act
sets.26,27 Variables with complete information, such as age, sex, OHCA, month, and year, were registered as regular, whereas all other variables with missing information were imputed using logistic regression for binary, multinomial for nominal, and linear regression for continuous variables (Table S1). We used multivariable logistic regression with an interaction term between OHCA and the month variable to study the association between OHCA and in-hospital mortality in the pre–COVID-19 and COVID-19 periods. The margins command was using following the regression models, to obtain adjusted probability for in-hospital mortality.

To investigate whether the lag in the data uploads may be associated with inflated incidence of OHCA because of different hospital reporting pre–COVID-19 and post–COVID-19 period, we performed a sensitivity analysis. We only included the 88 “rapid reporting” hospitals that have consistently provided data on a weekly basis during the COVID-19 and pre–COVID-19 period across 2019 and 2020. All analyses were performed using Stata v16.0.

RESULTS

Clinical Characteristics
Five hundred twenty-four patients (5.6%) were admitted with OHCA from a total of 9325 AMI admissions during the COVID-19 period from February 1, 2020, to May 14, 2020, compared with 731 (3.6%) patients of 20,310 during the equivalent pre–COVID-19 period from February 1, 2019, to May 14, 2019. Patients presenting with OHCA during the COVID-19 period were older (mean age, 67.1 versus 63.1 years; \( P < 0.001 \)), were more often women (28.8% versus 20.5%; \( P < 0.001 \)), and were more often of Asian ethnicity (10.0% versus 4.6%; \( P < 0.001 \)). There was an increased prevalence of insulin-treated diabetes mellitus (6.4% versus 3.0%; \( P < 0.001 \)) and hypertension (47.9% versus 41.2%; \( P < 0.001 \)) in the COVID-19 OHCA group compared with the pre–COVID-19 OHCA group. In-hospital pharmacological treatments were comparable between the pre–COVID-19 and COVID-19 groups, with similar use of glycoprotein IIb/IIIa inhibitors, P2Y12 inhibitors, and dual antiplatelet therapy (Table 1). An increasing proportion of patients with OHCA during the COVID-19 period had ST-segment–elevation myocardial infarction compared with patients experiencing OHCA in the pre–COVID-19 period (Figure S3).

Trends in Incidence of OHCA
During the COVID-19 period, the monthly proportions of OHCA increased from 5.4% in February 2020 to 6.9% in May 2020 (Figure 1), whereas there was a significant decrease in the total number of patients presenting with AMI. There was a 56% increase in the overall incidence of OHCA during the COVID-19 period (5.6% versus 3.6%; IRR, 1.56; 95% CI, 1.39–1.74) compared with pre–COVID-19 period (Figure 2). The IRR of OHCA also increased from 1.55 (95% CI, 1.29–1.87) in February 2020 to 1.96 (95% CI, 1.31–2.86) in May 2020 compared with equivalent monthly periods in 2019 (Figure 2). In the sensitivity analysis...
### Table 1. Baseline Characteristics of All Patients Presenting With OHCA Admitted With AMI Before and During the COVID-19 Pandemic in England

| Variables                                      | Total Admissions With AMI (N=29,635) | Pre–COVID-19 OHCA Group (N=731) | COVID-19 Period Group (N=524) | P Value* |
|------------------------------------------------|-------------------------------------|---------------------------------|-------------------------------|----------|
| Age, mean (SD), y                              | 68.2 (13.6)                         | 63.1 (12.2)                     | 67.1 (13.2)                   | <0.001   |
| Men, n (%)                                      | 19,295 (68.0)                       | 581 (79.5)                      | 373 (71.2)                    | <0.001   |
| Race, n (%)                                     |                                     |                                 |                               | 0.008    |
| White                                          | 20,039 (86.7)                       | 530 (89.4)                      | 350 (83.7)                    |          |
| Black                                          | 368 (1.4)                           | 7 (1.2)                         | 5 (1.2)                       |          |
| Asian                                           | 1,930 (8.3)                         | 27 (4.6)                        | 42 (10.0)                     |          |
| Mixed                                          | 787 (3.4)                           | 29 (4.9)                        | 21 (5.0)                      |          |
| **Presenting characteristics**                  |                                     |                                 |                               |          |
| BMI, mean (SD), kg/m²                           | 28.2 (5.9)                          | 27.6 (4.9)                      | 28.1 (5.7)                    | 0.15     |
| Heart rate, mean (SD), bpm                      | 78.8 (19.4)                         | 86.3 (24.2)                     | 84.6 (24.2)                   | 0.22     |
| Systolic blood pressure, mean (SD), mm Hg       | 140.2 (27.5)                        | 124.5 (30.4)                    | 125.7 (29.4)                  | 0.51     |
| **Clinical syndrome**                           |                                     |                                 |                               | 0.62     |
| STEMI, n (%)                                    | 8,867 (31.2)                        | 538 (73.6)                      | 379 (72.3)                    |          |
| NSTEMI, n (%)                                   | 19,513 (68.8)                       | 193 (26.4)                      | 145 (27.7)                    |          |
| Creatinine (μmol/L), mean (SD)                  | 97.1 (64.9)                         | 102.5 (49.3)                    | 107.8 (69.9)                  | 0.13     |
| Peak troponin level (ng/l), median (IQR)        | 266 (43–1771)                       | 596 (40–4722)                   | 380 (23–4081)                 | <0.001   |
| Killip class, n (%)                             |                                     | 116 (18.6)                      | 77 (16.9)                     | 0.007    |
| No heart failure                                | 21,946 (84.6)                       | 410 (65.8)                      | 301 (66.2)                    |          |
| Basal crepitation                               | 2,599 (10.0)                        | 70 (11.2)                       | 44 (9.7)                      |          |
| Pulmonary edema                                 | 1,037 (4.0)                         | 27 (4.3)                        | 33 (7.3)                      |          |
| Cardiogenic shock                               | 371 (1.4)                           | 116 (18.6)                      | 77 (16.9)                     |          |
| LV systolic function, n (%)                     |                                     |                                 |                               |          |
| Good                                            | 10,499 (45.7)                       | 182 (30.1)                      | 121 (28.9)                    |          |
| Moderate                                        | 5,785 (25.2)                        | 233 (38.5)                      | 141 (33.7)                    |          |
| Poor                                            | 1,795 (7.8)                         | 108 (17.9)                      | 66 (15.8)                     |          |
| Not assessed                                    | 4,894 (21.3)                        | 82 (13.6)                       | 91 (21.7)                     |          |
| **Medical history, n (%)**                      |                                     |                                 |                               |          |
| Percutaneous coronary intervention              | 4,187 (16.8)                        | 66 (10.6)                       | 49 (11.4)                     | 0.68     |
| Coronary artery bypass grafting                 | 1,740 (7.0)                         | 28 (4.5)                        | 29 (6.7)                      | 0.12     |
| Heart failure                                   | 1,833 (7.3)                         | 34 (5.5)                        | 30 (7.0)                      | 0.33     |
| Hypercholesterolemia                            | 8,147 (32.6)                        | 151 (24.6)                      | 107 (24.9)                    | 0.90     |
| Angina                                          | 5,193 (20.8)                        | 53 (8.6)                        | 55 (12.9)                     | 0.02     |
| Cerebrovascular disease                         | 2,042 (8.4)                         | 86 (7.8)                        | 25 (6.1)                      | 0.14     |
| Myocardial infarction                           | 6,015 (23.8)                        | 94 (15.1)                       | 83 (19.2)                     | 0.07     |
| Peripheral vascular disease                     | 1,100 (4.4)                         | 16 (2.6)                        | 14 (3.2)                      | 0.54     |
| Chronic kidney disease                          | 3,027 (11.9)                        | 91 (14.4)                       | 73 (16.4)                     | 0.37     |
| Diabetes mellitus, n (%)                        |                                     |                                 |                               | <0.001   |
| Not diabetic                                    | 20,019 (72.6)                       | 575 (85.3)                      | 361 (76.6)                    |          |
| Diet controlled                                 | 12,08 (4.4)                         | 12 (1.8)                        | 26 (5.5)                      |          |
| Oral medications                                | 4,112 (14.9)                        | 67 (9.9)                        | 54 (11.5)                     |          |
| Insulin therapy                                 | 2,234 (8.1)                         | 20 (3.0)                        | 30 (6.4)                      |          |
| Hypertension                                    | 13,850 (54.5)                       | 254 (41.2)                      | 209 (47.9)                    | 0.02     |
| Smoking status, n (%)                           |                                     |                                 |                               | 0.25     |
| Never smoked                                    | 8,264 (35.6)                        | 156 (31.1)                      | 130 (36.4)                    |          |
| Previous smoker                                 | 8,475 (36.5)                        | 148 (29.5)                      | 94 (26.3)                     |          |

(Continued)
of “rapid reporting,” hospitals that consistently reported data in all months during pre–COVID-19 and COVID-19 periods, we found a similar increase in the incidence of OHCA in patients presenting with AMI during the COVID-19 period (IRR, 1.36 [95% CI, 1.08–1.72] in February 2020, increasing to IRR, 1.80 [95% CI, 1.20–2.99] in May 2020) compared with the pre–COVID-19 period (Figures S4 and S5).

The COVID-19 period was from February 1, 2020, to May 14, 2020; and the pre–COVID-19 period was from February 1, 2019, to May 14, 2019. The UK lockdown was on March 22, 2020. ACE indicates angiotensin-converting enzyme; AMI, acute myocardial infarction; BMI, body mass index; bpm, beats per minute; CHD, coronary heart disease; COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease 2019; IQR, interquartile range; LV, left ventricle; NSTEMI, non–ST-segment–elevation myocardial infarction; OHCA, out-of-hospital cardiac arrest; and STEMI, ST-segment–elevation myocardial infarction.

*All statistical comparisons were made between pre–COVID-19 period and COVID-19 period groups only.

### Table 1. Continued

| Variables                              | Total Admissions With AMI (N=29 635) | Pre–COVID-19 OHCA Group (N=731) | COVID-19 Period Group (N=524) | P Value* |
|----------------------------------------|-------------------------------------|---------------------------------|-------------------------------|----------|
| Current smoker                         | 6503 (28.0)                         | 198 (39.4)                      | 133 (37.3)                    |          |
| Asthma/COPD                            | 4444 (17.8)                         | 88 (14.3)                       | 71 (16.6)                     | 0.31     |
| Family history of CHD, n (%)           | 6067 (28.5)                         | 87 (16.6)                       | 60 (17.0)                     | 0.87     |
| In-hospital pharmacology, n (%)        |                                    |                                 |                               |          |
| Low-molecular-weight heparin           | 9130 (42.4)                         | 340 (60.7)                      | 184 (50.8)                    | 0.003    |
| Unfractionated heparin                 | 7001 (32.3)                         | 286 (50.9)                      | 153 (41.5)                    | 0.005    |
| Warfarin                               | 718 (3.3)                           | 20 (3.6)                        | 11 (3.0)                      | 0.63     |
| Loop diuretic                          | 5054 (23.4)                         | 162 (29.2)                      | 118 (32.2)                    | 0.35     |
| Glycoprotein lib/llia inhibitor use    | 1435 (6.6)                          | 93 (16.5)                       | 69 (18.7)                     | 0.38     |
| Processes of care                      |                                    |                                 |                               |          |
| Seen by cardiologist, n (%)            | 27 381 (97.7)                       | 690 (96.8)                      | 457 (91.0)                    | <0.001   |
| Coronary angiography, n (%)            | 16 918 (77.9)                       | 305 (71.6)                      | 177 (58.4)                    | <0.001   |
| Percutaneous coronary intervention, n (%) | 9635 (56.3)                     | 176 (43.7)                      | 102 (42.9)                    | 0.84     |
| Time to reperfusion, mean (SD), h      | 3.0 (14.6)                          | 1.1 (1.4)                       | 2.1 (11.5)                    | 0.05     |
| P2Y12 use, n (%)                       | 25 629 (90.3)                       | 553 (75.6)                      | 378 (72.1)                    | 0.16     |
| Dual-antiplatelet therapy, n (%)       | 24 936 (87.9)                       | 525 (71.8)                      | 364 (69.5)                    | 0.37     |
| ACE inhibitors, n (%)                  | 15 702 (70.7)                       | 338 (58.8)                      | 197 (52.4)                    | 0.26     |
| In-hospital mortality, n (%)           | 778 (2.8)                           | 201 (27.8)                      | 192 (37.7)                    | <0.001   |

Figure 1. Temporal trends of monthly proportions of patients with acute myocardial infarction presenting with out-of-hospital cardiac arrest (OHCA) before and during coronavirus disease 2019 (COVID-19) pandemic in England. COVID-19 period indicates February 1, 2020, to May 14, 2020; pre–COVID-19 period, February 1, 2019, to May 14, 2019; and UK lockdown, March 22, 2020.
Processes of Care

Patients admitted with OHCA during the COVID-19 period were slightly less likely to be seen by a cardiologist (91.0% versus 96.8%; P<0.001), less likely to be investigated with invasive coronary angiography (58.4% versus 71.6%; P<0.001), and, for those with ST-segment–elevation myocardial infarction, had increased time to reperfusion treatment (mean, 2.1 versus 1.1 hour; P=0.05) (Table 1). Temporal analysis of use of invasive coronary angiography revealed a consistent lower use of an invasive strategy across all months in the COVID-19 period, with almost a 50% reduction in May 2020 compared with May 2019 (Figure 3). The use of PCI was also lower across COVID-19 months in 2020 compared with pre–COVID-19 months in 2019 (Figure S6). In-hospital mortality was higher in the OHCA group during the COVID-19 period compared with pre–COVID-19 period (37.7% versus 27.8%; P<0.001). In the multivariable analysis, the adjusted probability of mortality also increased from 27.7% to 35.8% in the COVID-19 cohort compared with 16.9% to 29.8% in the pre–COVID-19 cohort (P<0.001) (Figure S7).

Clinical and Angiographic Characteristics From BCIS Registry

In the BCIS registry, of 15 114 PCI procedures, 674 (4.5%) were undertaken for OHCA in the pre–COVID-19 period compared with 270 (3.4%) of 7856 during the COVID-19 period. The baseline demographics and clinical characteristics were similar between the pre–COVID-19 and COVID-19 periods (Table 2). Patients with OHCA who received PCI during the COVID-19 period more frequently had complex coronary disease, such as left main stem (3.8% versus 1.2%; P<0.001) and multivessel PCI (21.2% versus 12.6%; P<0.001). There was similar use of periprocedural pharmacology, hemodynamic support in the form of pharmacological inotropes, intra-aortic balloon pump, and Impella device across the pre–COVID-19 and COVID-19 groups (Table S2). The procedural success was similar in both groups, with no difference in the in-hospital mortality, major adverse cerebrovascular events, bleeding, and other periprocedural complications (Table S2).

DISCUSSION

In this national prospective cohort of patients hospitalized with AMI during the COVID-19 outbreak, there was an increase in the incidence of OHCA accompanied with a substantial decline in AMI-related hospitalizations during the same time period. In fact, following announcement of lockdown and implementation of social distancing measures in England, the incidence of OHCA among those presenting with AMI almost
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doubled in the late phase of COVID-19 pandemic compared with an equivalent period in the previous year. More frequently, patients presenting with OHCA during the COVID-19 period were older, women, and of Asian ethnicity. Although the pharmacological management strategies were not changed, during the COVID-19 pandemic, patients hospitalized with AMI after OHCA had longer delays to emergency reperfusion, less frequently received invasive coronary angiography, were less likely to receive specialist care, and had a higher risk of in-hospital death.

Many studies have noticed a decrease in AMI-related admissions during COVID-19 pandemic. Data from 15 hospitals in the northern Italy revealed >30% reduction in the incidence of AMI-related hospitalizations during the COVID-19 pandemic. Similar observations were made by Mafham et al from England, reporting 40% reduction in AMI-related hospitalizations during the COVID-19 pandemic. The slight difference between the incidence of AMI-related hospitalizations in this study may be related to differences in data sets and coding differences in the Secondary Uses Service Admitted Patient Care data set that was used. These findings have raised concerns that the decrease in AMI admissions may have resulted in an increased risk of OHCA, mortality, or both. Our study substantiates these concerns by showing reduced AMI admissions paralleled an increased incidence of OHCA among those presenting with AMI during the COVID-19 pandemic in England. These results are consistent with those of Baldi et al, who reported a 58% increase in the incidence of OHCA among COVID-19–positive patients in Italy. However, there were no data about the concurrent history of coronary heart disease or AMI diagnosis in these patients, and the authors concluded that these findings may be related to actual viral infection.

Our data provide important information about the characteristics and in-hospital management of patients experiencing OHCA during the COVID-19 pandemic. The demographic differences in the prepandemic and during COVID-19 period are of particular interest. It is possible that older patients with increased comorbidities may have refrained from seeking early help because of fears of being exposed to infection, breaking their shielding and social confinement. Our observation about the ethnic origin of patients experiencing OHCA may be linked to increased risk of COVID-19–related mortality in ethnic minorities, such as south Asians, that has been widely reported. It is probable that media coverage, cultural and social beliefs, and a lack of awareness may have prompted many to delay contact with the emergency medical services, thus presenting with OHCA.

There were also differences in in-hospital management and outcomes of patients experiencing OHCA during the COVID-19 period. Patients with OHCA during the COVID-19 period experienced an increase in time to reperfusion therapy and slightly

Figure 3. Temporal trends in rates of coronary angiography use in management of patients with out-of-hospital cardiac arrest (OHCA) before and during coronavirus disease 2019 (COVID-19) pandemic in England.

COVID-19 period indicates February 1, 2020, to May 14, 2020; pre–COVID-19 period, February 1, 2019, to May 14, 2019; and UK lockdown, March 22, 2020.
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less specialist care and use of invasive coronary strategy, whereas the demographics of those selected for PCI seem to have been unchanged. Following government directives and a declaration of a healthcare emergency in the United Kingdom, hospitals undertook major reconfigurations of their services in preparation for COVID-19–related admissions. It is possible that the restructuring of emergency services, redeployment of specialist physicians to COVID-19 wards to focus on the care of COVID-19–positive patients, and conflicting and evolving guidance on how and when to resuscitate in the context of OHCA, specifically with concerns about the aerosol generation, may have contributed to these differences.

Table 2. Baseline Characteristics of All Patients Presenting With OHCA Undergoing PCI Before and During the COVID-19 Pandemic in England

| Variables                  | Total Patients With AMI (N=22,026) | Pre–COVID-19 OHCA (N=674) | COVID-19 OHCA (N=270) | P Value* |
|----------------------------|------------------------------------|---------------------------|-----------------------|----------|
| Age, mean (SD), y          | 65.3 (12.2)                        | 62.3 (12.2)               | 63.0 (11.7)           | 0.41     |
| Men, n (%)                 | 16,273 (73.9)                      | 534 (79.2)                | 212 (78.5)            | 0.81     |
| White                      | 14,849 (83.9)                      | 471 (69.0)                | 201 (71.0)            |          |
| Black                      | 235 (1.3)                          | 6 (0.9)                   | 0 (0.0)               |          |
| Asian                      | 1,767 (10.0)                       | 26 (4.9)                  | 9 (4.1)               |          |
| Others                     | 854 (4.8)                          | 27 (5.1)                  | 11 (4.0)              | 0.49     |
| BMI, mean (SD), kg/m²      | 28.4 (5.4)                         | 27.9 (4.9)                | 27.7 (5.3)            | 0.61     |
| Previous PCI, n (%)        | 5150 (23.7)                        | 90 (13.7)                 | 35 (13.5)             | 0.95     |
| Previous CABG, n (%)       | 1,134 (5.2)                        | 18 (2.7)                  | 5 (1.9)               | 0.47     |
| Previous AMI, n (%)        | 5032 (23.1)                        | 96 (15.1)                 | 36 (14.0)             |          |
| CVA, n (%)                 | 887 (4.2)                          | 27 (4.5)                  | 0 (0.0)               | <0.001   |
| Renal disease, n (%)       | 4,711 (21.7)                       | 163 (25.3)                | 114 (43.2)            | <0.001   |
| Hypercholesterolemia, n (%)| 9,403 (44.6)                       | 207 (34.3)                | 48 (20.8)             | <0.001   |
| PVD, n (%)                 | 754 (3.6)                          | 23 (3.8)                  | 9 (3.9)               | 0.96     |
| Smoking history, n (%)     | 8,118 (40.4)                       | 208 (40.5)                | 92 (47.9)             |          |
| Never smoked               | 6,823 (33.9)                       | 135 (26.3)                | 42 (21.9)             |          |
| Ex-smoker                  | 5,163 (25.7)                       | 171 (33.3)                | 58 (30.2)             |          |
| Diabetes mellitus, n (%)   | 5,292 (24.4)                       | 91 (14.6)                 | 29 (11.8)             | 0.28     |
| Hypertension, n (%)        | 11,527 (54.7)                      | 230 (38.1)                | 85 (36.8)             | 0.72     |
| LV systolic function, n (%)| Good                               |                           |                       | 0.12     |
|                            | 18,188 (82.6)                      | 452 (87.1)                | 196 (72.2)            |          |
|                            | Moderate                           | 3073 (14.0)               | 145 (21.5)            | 42 (16.6) |
|                            | Severe                             | 746 (3.4)                 | 77 (11.4)             | 33 (12.2) |
| Indication for intervention, n (%)| STEMI                       | 13,257 (63.4)              | 122 (18.3)            | 52 (19.7) |
|                            | NSTE/ACS                           | 7,647 (36.6)              | 543 (81.7)            | 212 (80.3) |
|                            | Arterial blood gas PH, mean (SD)   | 7.22 (0.16)               | 7.19 (0.15)           | 7.23 (0.13) |
|                            | Base excess, mean (SD)             | −3.72 (7.8)               | −3.74 (8.0)           | −3.45 (8.3) |
|                            | Cardiogenic shock, n (%)           | 1475 (6.7)                | 233 (34.6)            | 89 (33.0) |
|                            | Glasgow Come Scale score, n (%)    | 0.55                      |                       |          |
|                            | T5                                 | 1011 (95.1)               | 148 (36.7)            | 70 (39.3) |
|                            | <8                                 | 52 (4.9)                  | 255 (63.3)            | 108 (60.7) |
|                            | Mechanical ventilation, n (%)      | 26 (1.3)                  | 338 (56.6)            | 132 (55.5) |

The COVID-19 period was from February 1, 2020, to May 14, 2020; and the pre–COVID-19 period was from February 1, 2019, to May 14, 2019. The UK lockdown was on March 23, 2020. ACS indicates acute coronary syndrome; AMI, acute myocardial infarction; BMI, body mass index; CABG, coronary artery bypass grafting; COVID-19, coronavirus disease 2019; CVA, cerebrovascular accident; LV, left ventricle; NSTE/ACS, non–ST-segment–elevation myocardial infarction; OHCA, out-of-hospital cardiac arrest; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease; and STEMI, ST-segment–elevation myocardial infarction.

*All statistical comparisons were made between pre–COVID-19 period and COVID-19 period groups only.
in management.\textsuperscript{32,33} Indeed, we noted a significant reduction in invasive coronary strategy for OHCA in this study, which is associated with improved survival and more favorable neurological outcomes, particularly in those presenting with ST-segment elevation on the ECG.\textsuperscript{34} Reassuringly, we observed no substantial differences in procedural characteristics and outcomes for patients with OHCA who received PCI during the COVID-19 period.

To the best of our knowledge, this is first national report of impact of COVID-19 pandemic on the care and outcomes of patients with OHCA presenting to hospitals in the setting of AMI. We acknowledge the limitation of our study. The MINAP registry collects data only for hospitalized cases of acute coronary syndrome, and we were therefore unable to investigate the incidence, care, and outcomes of those with OHCA occurring in patients in whom OHCA was not related to an acute coronary syndrome or who did not survive to hospital admission. Therefore, our data are likely to have underestimated the overall incidence of OHCA. Nevertheless, a recent report from a community cardiac arrest registry suggested a similar increase in OHCA incidence, reaffirming our findings.\textsuperscript{12} Finally, the observational nature of our study precludes inferences about causation.

**CONCLUSIONS**

Our study provides important insight into admissions, care, and outcomes for patients with AMI complicated by OHCA during the COVID-19 pandemic. These data suggest that a decline in AMI-related hospitalization in England was accompanied by an increase in the number of cases of OHCA, particularly after the implementation of social confinement measures during the COVID-19 outbreak in England. It appears that elderly people, women, and ethnic minorities may have refrained from seeking early help after developing cardiac symptoms of AMI. The reorganization of hospital services and staff in preparation for the COVID-19 pandemic may inadvertently have affected the care of this high-risk group. Urgent interventions to improve public awareness and treatment pathway to allow timely access to specialist care will be required to minimize the collateral cardiac damage of COVID-19 for patients with AMI.

**ARTICLE INFORMATION**

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**Disclosures**

None.

**Supplementary Material**

Tables S1–S2

Figures S1–S7

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SUPPLEMENTAL MATERIAL
Table S1. Percentage of missing information for each variable from MINAP registry.

| Variables                              | Number (percentage) |
|----------------------------------------|---------------------|
| Age                                    | 0                   |
| Sex                                    | 0                   |
| Race                                   | 5,500 (18.5%)       |
| BMI                                    | 0                   |
| Heart rate                             | 0                   |
| Systolic blood pressure                | 0                   |
| Clinical syndrome                      | 0                   |
| Creatinine                             | 0                   |
| Kilip Class                            | 2,604 (8.8%)        |
| LV systolic function                   | 5,638 (19.0%)       |
| Percutaneous coronary intervention     | 3,702 (12.5%)       |
| Coronary artery bypass graft           | 3,705 (12.5%)       |
| Heart failure                          | 3,568 (12.0%)       |
| Hypercholesterolemia                   | 3,574 (12.0%)       |
| Angina                                 | 3,641 (12.3%)       |
| Cerebrovascular disease                | 3,643 (12.3%)       |
| Myocardial infarction                  | 3,333 (11.3%)       |
| Peripheral vascular disease            | 3,692 (12.5%)       |
| Chronic kidney disease                 | 3,204 (10.8%)       |
| Diabetes                               | 917 (3.0%)          |
| Hypertension                           | 3,168 (10.7%)       |
| Smoking status                         | 5,534 (18.7%)       |
| Asthma / COPD                          | 3,557 (12.0%)       |
| Family history of CHD                  | 7,462 (25.2%)       |
| Low molecular weight heparin           | 7,177 (24.2%)       |
| Unfractionated heparin                 | 7,045 (23.8%)       |
| Warfarin                               | 7,270 (24.5%)       |
| Loop Diuretic                          | 7,085 (23.9%)       |
| Glycoprotein use                       | 6,891 (23.2%)       |
| Seen by cardiologist                   | 381 (1.3%)          |
| Coronary angiography                   | 3,523 (11.9%)       |
| Percutaneous coronary intervention     | 9,677 (32.6%)       |
| P2Y12 use                              | 0                   |
| Dual antiplatelet therapy              | 0                   |
| ACE inhibitors                         | 6,480 (21.9%)       |
| In-hospital mortality                  | 0                   |

CHD= coronary heart disease, COPD= chronic obstructive pulmonary disease, LV= left ventricle, bpm= beats per minute, BMI= body mass index, OHCA= out of hospital cardiac arrest, UK lockdown= 22nd March 2020, COVID19 = Corona virus infection. Pre-COVID19 period= 1st February 2019 to 14th May 2019, COVID19 period= 1st February 2020 to 14th May 2020
Table S2. Procedural characteristic of patients presenting with OHCA undergoing PCI before and during COVID-19 pandemic.

| Variables                        | Total AMI patients N=22,026 | Pre-COVID-19 OHCA N= 674 | COVID-19 OHCA N=270 | P value* |
|----------------------------------|-----------------------------|---------------------------|----------------------|----------|
| Lesion attempted                 |                             |                           |                      | 0.26     |
| 1                                | 14,965 (68.9%)              | 480 (71.8%)               | 216 (81.2%)          |          |
| 2                                | 4171 (19.2%)                | 129 (19.3%)               | 31 (11.6%)           |          |
| 3 or more                        | 1442 (6.6%)                 | 50 (7.5%)                 | 16 (6.2%)            |          |
| Call to Balloon time             | 8.8 (18.9)                  | 2.5 (4.5)                 | 3.2 (5.9)            | 0.12     |
| Vessel attempted                 |                             |                           |                      | 0.05     |
| Grafts                           | 357 (1.7%)                  | 7 (1.1%)                  | 2 (0.8%)             |          |
| LMS                              | 485 (2.3%)                  | 8 (1.2%)                  | 10 (3.8%)            |          |
| RCA                              | 9314 (45.0%)                | 367 (55.8%)               | 145 (54.5%)          |          |
| LAD                              | 3925 (19.0%)                | 113 (17.2%)               | 35 (13.2%)           |          |
| LCX                              | 6608 (31.9%)                | 163 (24.8%)               | 74 (27.8%)           |          |
| Multi-vessel PCI                 | 4200 (19.1%)                | 85 (12.6%)                | 44 (21.2%)           | <0.001   |
| Number of stents                 |                             |                           |                      | 0.26     |
| 0                                | 3221 (14.9%)                | 72 (10.8%)                | 37 (14.1%)           |          |
| 1                                | 11301 (52.4%)               | 376 (56.6%)               | 153 (58.4%)          |          |
| 2                                | 4755 (22.1%)                | 138 (20.8%)               | 50 (19.1%)           |          |
| 3 or more                        | 2278 (10.6%)                | 78 (11.7%)                | 22 (8.4%)            |          |
| Inotropis support                | 334 (1.6%)                  | 113 (17.4%)               | 37 (14.2%)           | 0.23     |
| Intra-aortic balloon pump        | 127 (0.6%)                  | 49 (7.6%)                 | 16 (6.1%)            | 0.45     |
| Impella                          | 16 (0.1%)                   | 1 (0.2%)                  | 1 (0.4%)             | 0.50     |
| Glycoprotein IIb/IIa inhibitor use | 3075 (16.2%)               | 243 (40.7%)               | 99 (42.1%)           | 0.71     |
| TIMI flow post PCI               |                             |                           |                      | 0.64     |
| 0                                | 431 (3.0%)                  | 34 (6.5%)                 | 15 (7.3%)            |          |
| 1                                | 120 (0.8%)                  | 5 (1.0%)                  | 3 (1.5%)             |          |
| 2                                | 419 (2.9%)                  | 25 (4.8%)                 | 6 (2.9%)             |          |
| 3                                | 13529 (93.3%)               | 460 (87.8%)               | 182 (88.3%)          |          |
| IVUS use                         | 1946 (9.8%)                 | 44 (7.4%)                 | 24 (10.0%)           | 0.22     |
| OCT use                          | 726 (3.7%)                  | 21 (3.5%)                 | 11 (4.6%)            | 0.48     |
| FFR/iFR use                      | 2236 (11.3%)                | 15 (2.5%)                 | 5 (2.1%)             | 0.71     |
| Aspirin                          | 17585 (93.6%)               | 442 (78.4%)               | 175 (76.4%)          | 0.55     |
| Clopidogrel                      | 7451 (40.9%)                | 130 (24.2%)               | 47 (21.2%)           | 0.37     |
| Ticagrelor                       | 8079 (44.3%)                | 186 (34.6%)               | 80 (36.0%)           | 0.70     |
| Heparin                          | 4502 (24.7%)                | 142 (26.4%)               | 64 (28.8%)           | 0.49     |
| Procedural outcomes              |                             |                           |                      |          |
| MACCE                            | 615 (2.9%)                  | 151 (23.2%)               | 42 (17.0%)           | <0.001   |
| In-hospital bleeding             | 92 (0.4%)                   | 10 (2.0%)                 | 2 (1.0%)             | 0.34     |
| In-hospital death                | 316 (1.4%)                  | 136 (20.2%)               | 40 (14.8%)           | 0.05     |

*All statistical comparisons were made between pre-COVID19 and COVID-19 period group only.
LMS= left main stem, RCA= Right coronary artery, LAD= left anterior descending artery, LCX= left circumflex artery, IVUS= intravascular ultrasound, OCT= optical coherence tomography, FFR= fractional flow reserve, iFR= instantaneous flow reserve, MACCE= major adverse cerebrovascular events.
Figure S1. Cohort selection from MINAP registry.

Total number of AMI admissions between 01-01-2019 - 14-05-2020
n=101,698

Patient excluded
- Admitted outside February to May period = 64,479
- Duplicate records = 3,611
- Cardiac arrest information missing = 790
- Sex missing = 22
- Final diagnosis not AMI = 1,886
- Cardiac arrest on the ward = 1,325

Total number of AMI patients
n=29,035

Final number of AMI admissions in Pre-COVID19 period
n=20,310
(OHCA=731)

Final number of AMI patients in COVID19 period
n=9,325
(OHCA=524)
Figure S2. Cohort selection from BCIS registry.

Total number of PCI procedures from 01-01-2019 - 14-05-2020
n= 101,146

Patient excluded
- Admitted outside February to May period = 52,023
- Duplicate records = 3788
- Cardiac arrest information missing = 18,100
- Sex missing = 139
- Elective PCI procedures = 3,226

Individual records of PCI procedures
n= 22,970

Final number of PCI procedure in Pre-COVID19 period
n=15,114
(OHCA=674)

Final number of PCI procedure in COVID19 period
n=7,856
(OHCA=270)
Figure S3. Temporal trends of monthly proportions of OHCA patients presenting with STEMI before and during COVID19 period.

OHCA= out of hospital cardiac arrest, UK lockdown= 22nd March 2020, COVID19 = Corona virus infection. Pre-COVID19 period= 1st February 2019 to 14th May 2019, COVID19 period= 1st February 2020 to 14th May 2020, STEMI= st elevation acute myocardial infarction.
Figure S4. Temporal trends of monthly proportion of patients presenting with OHCA before and during the COVID-19 pandemic amongst the rapid reporting hospitals.

OHCA= out of hospital cardiac arrest, UK lockdown= 22nd March 2020, COVID19 = Corona virus infection. Pre-COVID19 period= 1st February 2019 to 14th May 2019, COVID19 period= 1st February 2020 to 14th May 2020
Figure S5. Incidence rate ratio of OHCA during COVID-19 pandemic amongst the rapid response hospitals.

OHCA = out of hospital cardiac arrest, UK lockdown = 22nd March 2020, COVID19 = Corona virus infection. Pre-COVID19 period = 1st February 2019 to 14th May 2019, COVID19 period = 1st February 2020 to 14th May 2020
Figure S6. Temporal trends of use of percutaneous coronary intervention before and during COVID19 period in England.

OHCA = out of hospital cardiac arrest, UK lockdown= 22nd March 2020, COVID19 = Corona virus infection. Pre-COVID19 period= 1st February 2019 to 14th May 2019, COVID19 period= 1st February 2020 to 14th May 2020
Figure S7. Monthly adjusted probability of mortality between pre-COVID-19 and COVID-19 OHCA groups in England.

OHCA= out of hospital cardiac arrest, UK lockdown= 22nd March 2020, COVID19 = Corona virus infection. Pre-COVID19 period= 1st February 2019 to 14th May 2019, COVID19 period= 1st February 2020 to 14th May 2020