The Impact of the COVID-19 Pandemic on the Treatment and Prognosis of AMI in Urban and Rural Areas in Developing Country

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Abstract

Background COVID-19 continues to spread globally, this study is the first to explore the impact of COVID-19 on the treatment and prognosis of rural and urban acute myocardial infarction (AMI) in developing country.

Methods A total of 128 patients with AMI in our hospital during the COVID-19 pandemic (January 25, 2020-March 24, 2020) were enrolled. As a control group, a total of 197 patients diagnosed with AMI from November 25, 2019 to January 24, 2020 were selected. A total of 1 year of follow-up was performed. In addition to basic clinical data, this study focused on the treatment time, Killip class and hospital stay, the event of interest was defined as MACE (all-cause death, reinfarction, new congestive heart failure).

Results Compared with Before COVID-19 group, the proportion of killip class ≥ 2 was significantly higher in During COVID-19 group in AMI Total. In Rural AMI, hospital stay and the proportion of killip class ≥ 2 were increased in During COVID-19 group. In STEMI Total and Rural STEMI, the treatment time in During COVID-19 group was longer than that in Before COVID-19 group, while only S to D Total and D to B were extended in Urban STEMI. The proportion of Invasive treatment time within 24 hours in NSTEMI patients was obviously lowered in During COVID-19 group. In AMI Total and Rural AMI, MACE and all-cause mortality were increased in During COVID-19 group compared with Before COVID-19 group. Through Kaplan-Meier analysis, it was found that the survival and the occurrences of MACE in AMI Total and Rural AMI were significantly higher in During COVID-19 group.

Conclusion COVID-19 pandemic can lead to delayed treatment and worse prognosis in AMI patients, and rural areas seem to be more worrying.

Background

Acute myocardial infarction (AMI) is a disease with high mortality and morbidity. Percutaneous coronary intervention (PPCI) remains the most recommended treatment [1]. More than one report has shown that reducing the reperfusion time of patients with AMI is related to improving the prognosis [2, 3]. The analysis of a prospective, multicentre trial in Germany showed that for every 10 minutes of delay in treatment, there will be an increase of 3.31 deaths in 100 patients undergoing percutaneous coronary intervention [4]. To reduce mortality and improve prognosis, the healthcare system has been working to shorten the reperfusion treatment time for the past few decades [5, 6]. Despite continuous efforts at multiple levels, delays in treatment are still a challenging factor [7]. Since December 2019, the coronavirus disease (COVID-19) that emerged in Wuhan, China, has been spreading rapidly and evolving into a pandemic [8–10], placing an enormous burden on all parts of the medical system. Although many countries are constantly trying to reduce the impact of COVID-19 on AMI treatment [11], many studies have reported that its treatment during the COVID-19 pandemic has still been affected to varying degrees, especially in the delay of treatment [12–15]. The impact of public health emergencies such as the outbreak of community infectious diseases on the treatment of AMI is poorly understood. During the COVID-19 pandemic, balancing AMI management and COVID-19 control has become a major challenge for cardiovascular doctors around the world. Many expert groups have made some recommendations for the management of AMI during the COVID-19 pandemic [16–21]. However, these recommendations lack evidence from clinical studies. During the COVID-19 pandemic in China, to limit the spread of COVID-19, the Chinese government formulated strict control measures, which successfully limited the spread of new coronary pneumonia. However, whether this management model can treat AMI during the spread of COVID-19 as well as its impact of prognosis management are worth investigating. At present, there are few studies on the long-term prognosis of patients with AMI during the COVID-19 pandemic, and the treatment of AMI is even more diverse. As a typical developing country, China still has differences in development levels between rural and urban areas. This study is the first to explore the treatment and prognosis of AMI in rural and urban areas during the COVID-19 pandemic.

Methods

Study Design and Population

The Affiliated Hospital of Xuzhou Medical University is the largest tertiary hospital in Xuzhou. It was assigned by the government as a designated hospital for COVID-19 patients during the COVID-19 pandemic. During this period of time, our hospital allocated two specialized catheterization laboratories for emergency cardiac surgery, one for fever patients, and one for nonfebrile patients. Patients were isolated immediately after the operation, and released after the investigation was completed. According to the consensus of experts at the time [18], in particular, patients with NSTEMI need to undergo stricter exclusion of COVID-19. This study included 142 patients with AMI in our hospital during the COVID-19 pandemic in the region, that is, the “first level response to pandemic situation” period of the local government (January 25, 2020-March 24, 2020). As a control group, a total of 213 patients diagnosed with AMI from November 25, 2019 to January 24, 2020 were selected, the diagnosis of AMI followed the European Society of Cardiology (ESC) definition [1]. Exclusion criteria included a history of acute myocardial infarction, outside of this control area, COVID-19 positive or suspected COVID-19 positive patient and serious diseases that limited the life expectancy of the patient. Finally, a total of 326 patients were selected. This study was approved by the local ethics committee, and all

participants were informed and signed a consent form. All methods were performed in accordance with the relevant guidelines and regulations. The clinical data of the patients are shown in Table 1.

Table 1
Baseline demographics of study population

	AMI Total			Urban AMI			Rural AMI		
	Before COVID-19 (n = 197)	During COVID-19 (n = 128)	<i>P</i>	Before COVID-19 (n = 81)	During COVID-19 (n = 56)	<i>P</i>	Before COVID-19 (n = 116)	During COVID-19 (n = 72)	<i>P</i>
Age (yr)	64.7±12.92	66.2±13.01	0.306	66.77±14.26	66.02±14.22	0.763	63.25±11.74	66.35±12.09	0.084
Male, n (%)	139(70.6%)	90(70.3%)	0.962	59(72.8%)	44(78.6%)	0.445	80(69%)	46(63.9%)	0.472
Current smoking, n (%)	80(40.6%)	54(42.2%)	0.778	36(44.4%)	23(41.1%)	0.695	44(37.9%)	31(43.1%)	0.485
Hypertension, n (%)	87(44.2%)	51(39.8%)	0.442	33(40.7%)	25(44.6%)	0.650	54(46.6%)	26(36.1%)	0.159
Diabetes, n (%)	62(31.5%)	36(28.1%)	0.521	30(37%)	14(25%)	0.138	32(27.6%)	22(30.6%)	0.662
Stroke, n (%)	43(21.8%)	27(21.1%)	0.875	20(24.7%)	9(16.1%)	0.225	23(19.8%)	18(25%)	0.404
STEMI, n (%)	111(56.3%)	76(59.4%)	0.589	43(53.1%)	27(48.2%)	0.575	68(58.6%)	49(68.1%)	0.195
Countryside, n (%)	116(58.9%)	72(56.2%)	0.639	-	-	-	-	-	-
BMI (kg/m ²)	24.95±3.79	24.91±3.55	0.925	24.95±4.00	25.65±3.94	0.315	24.95±3.65	24.34±3.12	0.240
Hospital stay (d)	5.12±2.26	5.55±3.18	0.178	4.96±2.46	4.61±2.78	0.432	5.22±2.11	6.29±3.29	0.016
Killip class≥2, n(%)	37(18.8%)	42(32.8%)	0.004	16(19.8%)	17(30.4%)	0.154	21(18.1%)	25(34.7%)	0.01
Revascularization, n(%)	129(65.5%)	75(58.6%)	0.209	58(71.6%)	34(60.7%)	0.182	71(61.2%)	41(56.9%)	0.563
AMI:Acute myocardial infarction, STEMI ST-segment elevation myocardial infarction, BMI Body Mass Index (kg/m ²)									

Variables of Interest

In addition to basic clinical data, this study also focuses on the proportion of reperfusion treatment, treatment time, Killip grade and length of hospital stay. The treatment time was extracted from the chest pain center database of the hospital. Symptom to door (S to D) time, door to balloon (D to B) time and symptom to balloon (S to B) time of STEMI patients were obtained, and the ratio of interventional treatment within 24 hours of NSTEMI patients was observed. Killip class was based on the definition and changes in patient condition during hospitalization, with the highest grade taken.

Events of Interest

The follow-up time was to the end of life or 1 year, and the event of interest was defined as MACE (all-cause death > reinfarction > new congestive heart failure). Define re-infarction according to the redefined ESC/ACC/AHA committee standard: ischemic symptoms and/or new significant ST segment changes, and at least one value of the increase and/or decrease of hs-cTnT is higher than the 99th percentile Upper limit [22]. New congestive heart failure is determined to be the first episode of cardiac decompensation and requires intravenous diuretic treatment, regardless of whether it is readmitted to the hospital [23]. The follow-up of the event was mainly completed by telephone and outpatient service, and it was completed at the 12th month of follow-up. Cardiac ultrasound examination, including whether the lost patient died and their date of death, were determined through the death registry of the region, which is a detailed mandatory official database.

Statistical Analysis

SPSS 22.0 software was used for statistical analysis. If the measurement data follows a normal distribution, it was expressed as the mean $\pm$ standard deviation and the independent sample t-test was used for comparisons between groups, non-normally distributed data was described by the median [IQR] and the Manwhitney U test was used. Count data are expressed as the number of cases and percentage (%), and the χ^2 test or Fisher's exact probability method was used for comparisons between groups. Kaplan–Meier curves of the clinical outcomes were compared using a log-rank test. A P-value <0.05 was considered statistically significant.

Results

1. Comparison of clinical data in all patients with AMI

Compared with Before COVID-19 group, the age, male, current smoking, hypertension, diabetes, stroke, Countryside, STEMI and BMI were not statistically significant in During COVID-19 group. This finding ensures the comparability of the data. In AMI Total, compared with Before COVID-19 group, the hospital stay was prolonged and the proportion of revascularization was decreased in During COVID-19 group, but them were not statistically significant, while the proportion of killip class ≥ 2 was significantly higher. In Urban AMI, the hospital stay, the proportion of killip class ≥ 2 and revascularization had no significant difference between Before COVID-19 group and During COVID-19 group. In Rural AMI, hospital stay and the proportion of killip class ≥ 2 were increased in During COVID-19 group (Table 1).

2. Treatment time of STEMI patients

The S to D Total in STEMI Total (299.0 [158.00–600.00] vs. 659.5 [242.50–1020.00] min, $P < 0.001$), Urban STEMI (179.0 [119.00–419.00] vs. 660.0 [180.00–960.00] min, $P = 0.003$) and Rural STEMI (360.0 [197.00–720.00] vs. 659.0 [298.00–1080.00] min, $P = 0.001$) were significantly prolonged in During COVID-19 group compared with Before COVID-19 group. Next, the data of patients undergoing emergency PCI were extracted and compared. The S to D, D to B and S to B in STEMI Total (189.5 [119.00–345.00] vs. 250.0 [180.00–420.00] min, $P = 0.008$; 75.0 [62.25–87.00] vs. 97.0 [82.00–120.00] min, $P < 0.001$; 266.5 [188.50–411.75] vs. 367.0 [281.00–522.00] min, $P = 0.002$) and Rural STEMI (239.0 [174.50–366.50] vs. 300.0 [240.00–450.00] min, $P = 0.04$; 75.0 [61.00–92.50] vs. 99.0 [84.50–118.00] min, $P < 0.001$; 328.0 [244.00–432.5] vs. 405.0 [334.00–537.50] min, $P = 0.017$) were longer in During COVID-19 group than those in Before COVID-19 group. In Urban STEMI, only D to B (81.0 [64.00–85.00] vs. 94.0 [80.75–127.00] min, $P = 0.003$) was extended in During COVID-19 group compared with Before COVID-19 group, although S to D (125.0 [88.00–266.00] vs. 180.0 [138.75–52.50] min, $P = 0.120$) and S to B (240.0 [169.00–331.00] vs. 272.5 [244.00–472.75] min, $P = 0.056$) become longer, they were not statistically significant (Figure 1).

3. The proportion of Invasive treatment time within 24 hours in NSTEMI patients

Compared with Before COVID-19 group, the proportion of Invasive treatment time within 24 hours in NSTEMI Total (70.9% vs. 30.8%, $P < 0.001$), Urban NSTEMI (73.7% vs. 34.5%, $P = 0.001$) and Rural NSTEMI (68.8% vs. 26.1%, $P = 0.001$) were obviously lowered in During COVID-19 group (Table 2).

Table 2
Invasive treatment time in NSTEMI patients

	NSTEMI Total			Urban NSTEMI			Rural NSTEMI		
	Before	During	<i>P</i>	Before	During	<i>P</i>	Before	During	<i>P</i>
	COVID-19 (n = 86)	COVID-19 (n = 52)		COVID-19 (n = 38)	COVID-19 (n = 29)		COVID-19 (n = 48)	COVID-19 (n = 23)	
Invasive treatment time <24 h, n (%)	61(70.9%)	16(30.8%)	<0.001	28(73.7%)	10(34.5%)	0.001	33(68.8%)	6(26.1%)	0.001
NSTEMI Non-ST-segment elevation myocardial infarction									

4. Comparison of the prognosis in all patients

In AMI Total, MACE (17.3% vs. 29.7%, $P = 0.008$) and all-cause mortality (5.6% vs. 12.5%, $P = 0.027$) were increased in During COVID-19 group compared with Before COVID-19 group, and similar results were observed in Rural AMI (19% vs. 31.9%, $P = 0.043$; 5.2% vs. 13.9%, $P = 0.037$).

Compared with Before COVID-19 group, there was no significant difference in MACE and all-cause mortality in During COVID-19 group in Urban AMI (Table 3).

Table 3
Comparison of the prognosis in all patients

	AMI Total			Urban AMI			Rural AMI		
	Before COVID-19 (n = 197)	During COVID-19 (n = 128)	<i>P</i>	Before COVID-19 (n = 81)	During COVID-19 (n = 56)	<i>P</i>	Before COVID-19 (n = 116)	During COVID-19 (n = 72)	<i>P</i>
MACE, n (%)	34(17.3%)	38(29.7%)	0.008	12(14.8%)	15(26.8%)	0.083	22(19%)	23(31.9%)	0.043
All-cause mortality, n (%)	11(5.6%)	16(12.5%)	0.027	5(6.2%)	6(10.7%)	0.521	6(5.2%)	10(13.9%)	0.037
Reinfarction, n (%)	7(3.6%)	7(5.5%)	0.406	2(2.5%)	3(5.4%)	0.672	5(4.3%)	4(5.6%)	0.909
NCHF, n (%)	16(8.1%)	15(11.7%)	0.281	5(6.2%)	6(10.7%)	0.521	11(9.5%)	9(12.5%)	0.514
AMI Acute myocardial infarction; NCHF New congestive heart failure									

5. MACE of the AMI Patients During and Before COVID-19

Through Kaplan-Meier analysis, it was found that the occurrences of MACE in AMI Total and Rural AMI were significantly higher in During COVID-19 group compared with Before COVID-19 group, there was no significant difference in Urban AMI (Figure 2).

6. Mortality of the AMI Patients During and Before COVID-19

Through Kaplan-Meier analysis, it was found that the survival in AMI Total and Rural AMI was significantly reduced in During COVID-19 group compared with Before COVID-19 group, there was no significant difference in Urban AMI (Figure 3).

Discussion

Acute myocardial infarction is still the main cause of cardiovascular death worldwide. Total ischaemic time is the main determinant of the prognosis of AMI patients. Shortening the reperfusion treatment time is essential to reducing mortality and improving prognosis [24, 25]. At present, PPCI is still the preferred method of emergency reperfusion therapy for AMI patients after admission [26]. Over the past few decades, including the construction of a chest pain centre, the reperfusion treatment time for AMI has been significantly shortened [5]. COVID-19 is a viral infection that causes respiratory diseases [27]. Its highly contagious nature requires strict infection control measures at the national level and the healthcare system to limit its spread. A large number of studies have shown that novel coronavirus pneumonia has had an unprecedented impact on the treatment of AMI in various countries and regions [28–32]. Similar to the results of these studies, the treatment of AMI in this region had also been affected by the spread of COVID-19. It was found that the proportion of killip class ≥ 2 was significantly higher in During COVID-19 group in AMI Total and Rural AMI, and hospital stay was increased in Rural AMI. But these indicators were not observed to be statistically significant in Urban AMI. A related reason may be the delay in treatment time. In STEMI Total and Rural STEMI, S to D, D to B and S to B in During COVID-19 group were longer than those in Before COVID-19 group. In Urban STEMI, only D to B were extended. This delay in treatment was also shocking in patients with NSTEMI. According to ESC guidelines for NSTEMI [33], we focused on the proportion of invasive treatment time within 24 hours. It was found that the proportion of Invasive treatment time within 24 hours in NSTEMI patients was obviously lowered in During COVID-19 group. From the above research results, we could find that both the pre-hospital visit time and the in-hospital treatment time have been significantly affected, and rural areas seem to be even more worrying. This may be due to the strict closure of villages and urban communities during the “first level response to pandemic situation” of COVID-19 in this province, and the hospitals with the ability to treat AMI are far away from rural areas, resulting in prolonged SD time. Coupled with the fear of new coronary pneumonia, choosing to stay at home may lead to a longer subjective consultation time. These factors may eventually lead to delays in all aspects of the treatment of acute myocardial infarction [15]. Finally, in addition to regional differences, it seems that treatment of NSTEMI also attracted our attention. The pathophysiological mechanisms of ST and NS are different, so the treatment procedures for the two in the guidelines are also different [33]. There are also differences in the treatment management for STEMI and NSTEMI in some countries or regions [16, 32]. During the pandemic of

COVID-19, we still regards PPCI as the main treatment for STEMI patients, which is to shorten the reperfusion time as much as possible, isolate immediately after the operation, and remove the suspicion of infection. This may be the reason why the S to B of STEMI patients in the city did not receive a significant impact. However, there are stricter screening standards for NSTEMI patients. All NSTEMI patients were excluded from the COVID-19 before being admitted to the hospital for the next step of treatment. Because of the sharp increase in the pressure of the medical system during the COVID-19 pandemic, the proportion of NSTEMI patients who received reperfusion therapy within 24 hours was significantly reduced. Next, we conducted a 1-year follow-up of all the enrolled patients. In AMI Total and Rural AMI, MACE and all-cause mortality were increased in During COVID-19 group, while there was no significant difference in MACE and all-cause mortality in Urban AMI. Through Kaplan-Meier analysis, it was found that the survival and the occurrences of MACE in AMI Total and Rural AMI were significantly higher in During COVID-19 group. In addition to the abovementioned differences in treatment and development levels, the reason may also be related to poor post-hospital management in rural areas.

Limitations

Our research has several limitations. First, the sample size we obtained is relatively small, which may cause some problems with statistical power. Secondly, this research was conducted in a centre, other medical centres may not have exactly the same strategy for dealing with COVID-19 and the treatment plan for patients with AMI may also be different. Finally, our follow-up time was 1 year, which may not be long enough.

Conclusion

COVID-19 pandemic can lead to delayed treatment and worse prognosis in AMI patients, and rural areas seem to be more worrying. During the COVID-19 pandemic, different regions should formulate appropriate AMI management plans to improve the treatment and prognosis of patients.

Abbreviations

AMI:Acute myocardial infarction, STEMI:ST-segment elevation myocardial infarction, NSTEMI:non-ST elevation myocardial infarction, COVID-19:Coronavirus disease 2019, BMI:Body mass index, ESC:European Society of Cardiology.

Declarations

Acknowledgments

Not applicable.

Consent for publication

Not applicable.

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Not applicable.

Ethics approval and consent to participate

This study has been approved by the Ethics Committee of the Affiliated Hospital of Xuzhou Medical University (Xuzhou, china), and all participants were informed and signed a consent form.

Availability of data and materials

The datasets used and/or analyzed during the present study are available from the corresponding author on reasonable request.

Authors' contributions

YL, ZW and YY performed the experiments and analyzed the data. LC, CL and MC designed the study and wrote the manuscript. All authors read and approved the manuscript and agree to be accountable for all aspects of the research in ensuring that the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Competing interests

The authors declare that they have no competing interests.

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Figures

Figure 1

Comparison of treatment time in all STEMI patients (A), STEMI patients undergoing emergency PCI (B), Urban STEMI patients undergoing emergency PCI (C) and Rural STEMI patients undergoing emergency PCI (D). * $P < 0.05$: Comparison between Before COVID-19 group and During COVID-19 group. ** $P < 0.001$: Comparison between Before COVID-19 group and During COVID-19 group.

Figure 2

Kaplan–Meier survival curves for the MACE in AMI Total (A), Urban AMI (B) and Rural AMI (C).

Figure 3

Kaplan–Meier survival curves for the all-cause mortality in AMI Total (A), Urban AMI (B) and Rural AMI (C).