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Clinical paper

In-hospital cardiac arrest outcomes among patients with COVID-19 pneumonia in Wuhan, China

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Abstract

Objective: To describe the characteristics and outcomes of patients with severe COVID-19 and in-hospital cardiac arrest (IHCA) in Wuhan, China.

Methods: The outcomes of patients with severe COVID-19 pneumonia after IHCA over a 40-day period were retrospectively evaluated. Between January 15 and February 25, 2020, data for all cardiopulmonary resuscitation (CPR) attempts for IHCA that occurred in a tertiary teaching hospital in Wuhan, China were collected according to the Utstein style. The primary outcome was restoration of spontaneous circulation (ROSC), and the secondary outcomes were 30-day survival, and neurological outcome.

Results: Data from 136 patients showed 119 (87.5%) patients had a respiratory cause for their cardiac arrest, and 113 (83.1%) were resuscitated in a general ward. The initial rhythm was asystole in 89.7%, pulseless electrical activity (PEA) in 4.4%, and shockable in 5.9%. Most patients with IHCA were monitored (93.4%) and in most resuscitation (89%) was initiated <1 min. The average length of hospital stay was 7 days and the time from illness onset to hospital admission was 10 days. The most frequent comorbidity was hypertension (30.2%), and the most frequent symptom was shortness of breath (75%). Of the patients receiving CPR, ROSC was achieved in 18 (13.2%) patients, 4 (2.9%) patients survived for at least 30 days, and one patient achieved a favourable neurological outcome at 30 days. Cardiac arrest location and initial rhythm were associated with better outcomes.

Conclusion: Survival of patients with severe COVID-19 pneumonia who had an in-hospital cardiac arrest was poor in Wuhan.

Keywords: In-hospital cardiac arrest, Cardiopulmonary resuscitation, COVID-19, ROSC, Survival

Introduction

Since the outbreak of a novel coronavirus resulting in coronavirus disease 2019 (COVID-19) in Wuhan, China at the end of 2019, there have been more than 820,000 individuals in more than 170 countries with confirmed COVID-19, of whom more than 40,000 have died by April 1, 2020.[1] Several studies have already reported the clinical course and outcomes of patients with COVID-19 pneumonia.[2–6] The mortality of critically ill patients and risk factors for a poor prognosis have been assessed; however, the identification of risk factors and assessment of outcomes of

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patients with COVID-19 after in-hospital cardiac arrest (IHCA) remain unknown.

Therefore, in this study, we aimed to present the clinical characteristics; clinical outcomes, including return of spontaneous circulation (ROSC); and 30-day survival of patients with laboratory confirmed COVID-19 pneumonia after IHCA at the west campus of Union Hospital in Wuhan. We identified factors associated with improved outcomes following IHCA in patients with COVID-19.

Methods

Study design

This was a single-centred, retrospective, observational study. We identified patients who had IHCA between January 15 and February 25, 2020 in the west campus of Union Hospital in Wuhan. The eligibility criteria were as follows: patients aged 14 years or older and patients with IHCA who were diagnosed with severe COVID-19 pneumonia according to the interim guidelines from the World Health Organisation. All enrolled inpatients had a definite outcome after IHCA, including death, ROSC, and 30-day survival. The study was approved by the Ethics Committee Boards of Beijing Chaoyang Hospital, Capital Medical University, and Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, and the requirement for informed consent was waived.

Setting

The west campus of Union Hospital, which is a teaching tertiary hospital in Wuhan, was one of the designated hospitals for patients with severe COVID-19 pneumonia. In total, 800 beds were modified as isolation wards and opened for admission to severe patients with COVID-19 pneumonia starting from January 2020. In addition to the 800-current staff (doctors nurses and others) of the hospital, over 2000 staff from 12 other provinces were employed to provide medical care on the general wards and intensive care unit (ICU) of the west campus of Union Hospital. There was a rapid response team available 24/7 to attempt resuscitation for patients with IHCA; this team was also in charge of tracheal intubation and cardiopulmonary resuscitation (CPR) in the general ward when needed. The team were alerted using a pager system. Resuscitation followed guidelines from the American Heart Association and International Liaison Committee on Resuscitation for advanced cardiac life support and post-resuscitation care. Ward staff (usually nurses) started CPR and if defibrillation prior to team arrival. All staff (clinical and non-clinical) working on the general ward, ICU and rapid response team donned personal protective equipment (PPE) at the beginning of their shift. For all settings this included protective clothing, a N95 mask and visor. Due to the exertion required of doing continuous chest compressions whilst wearing PPE, the person doing compressions was changed after at most one minute. A mechanical chest compression device was only available in ICU.

Data collection

We collected demographic, clinical, and outcome data of treated patients with severe COVID-19 pneumonia and IHCA from an electronic medical record according Utstein style guidelines during the 40 days.[7]

Cardiac arrest was defined as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation. 'Treated IHCA' refers to a patient who experienced a cardiac arrest and was treated with chest compressions and/or defibrillation. Details regarding treated cases were collected by the physicians and entered into a database. We collected information on age and sex of the patient; locations where IHCA occurred; witness and monitor status; initial ECG rhythm such as shockable rhythm (ventricular fibrillation [VF], and pulseless VT) or non-shockable rhythm (PEA and asystole); information on the response interval; and presumed aetiology of the IHCA, which was categorised as cardiac, respiratory, and other. Information regarding clinical symptoms, treatments, time from illness onset to hospital admission, comorbidity, and length of hospital stay were also recorded.

The primary outcome was immediate survival with any ROSC, which was defined by return of circulation in the absence of ongoing chest compressions (return of adequate pulse/heart rate by palpation, auscultation, Doppler, arterial blood pressure waveform, or documented systolic blood pressure $>$50 mmHg). The secondary outcome was 30-day survival and neurological outcomes at 30 days recorded by cerebral performance category (CPC) score. Survival with favourable neurological outcome was defined as CPC score of 1 or 2.

Statistical methods

Continuous variables are reported as means or median with interquartile ranges (IQRs) as appropriate. Categorical variables are reported as numbers and percentages of patients in each category. We stratified patients according to survival status. The chi-square test was used to examine baseline differences in demographics and clinical characteristics across the strata of resuscitation durations. A p-value <0.05 was considered statistically significant. The odds ratio and 95% confidence interval were accordingly calculated. All analyses were conducted using Python, version 3.6 (Python Software Foundation).

Results

Totally, we reviewed 761 records of patients with severe COVID-19 and identified 151 patients who had an IHCA during the study period of 40 days. After exclusions, a total of 136 patients were resuscitated and documented using the Utstein template (Fig. 1). The characteristics of the included patients are shown in Table 1. Of these patients, 110 (80.9%) were aged over 60 years and 46 (33.8%) were women. The most frequent comorbidity was hypertension (30.2%), followed by diabetes (19.9%) and coronary heart disease (11.0%) (Table 1).

Of 136 patients who were resuscitated, most patients had a respiratory aetiology (119 cases), whereas the remaining had cardiac aetiology (10 cases) and other causes (7 cases) (Table 1). The initial cardiac arrest rhythm was VF or pulseless VT in 8 (5.9%) cases, PEA in 6 (4.4%), and asystole in 122 (89.7%) (Table 1).

Of 136 patients resuscitated, 113 (83.1%) were in the general ward at the time of IHCA, while 23 (16.9%) of the resuscitation efforts were initiated in the ICU (Table 1). Nearly all patients had electrocardiogram (ECG) and pulse oximetry monitoring (93.4%) before their cardiac arrest and in most cases resuscitation (89%) was initiated in $<$1 min. The length of hospital stay was 7 (IQR, 4−11) days, and the time from illness onset to hospital admission was 10 (IQR, 7−14) days (Table 1).

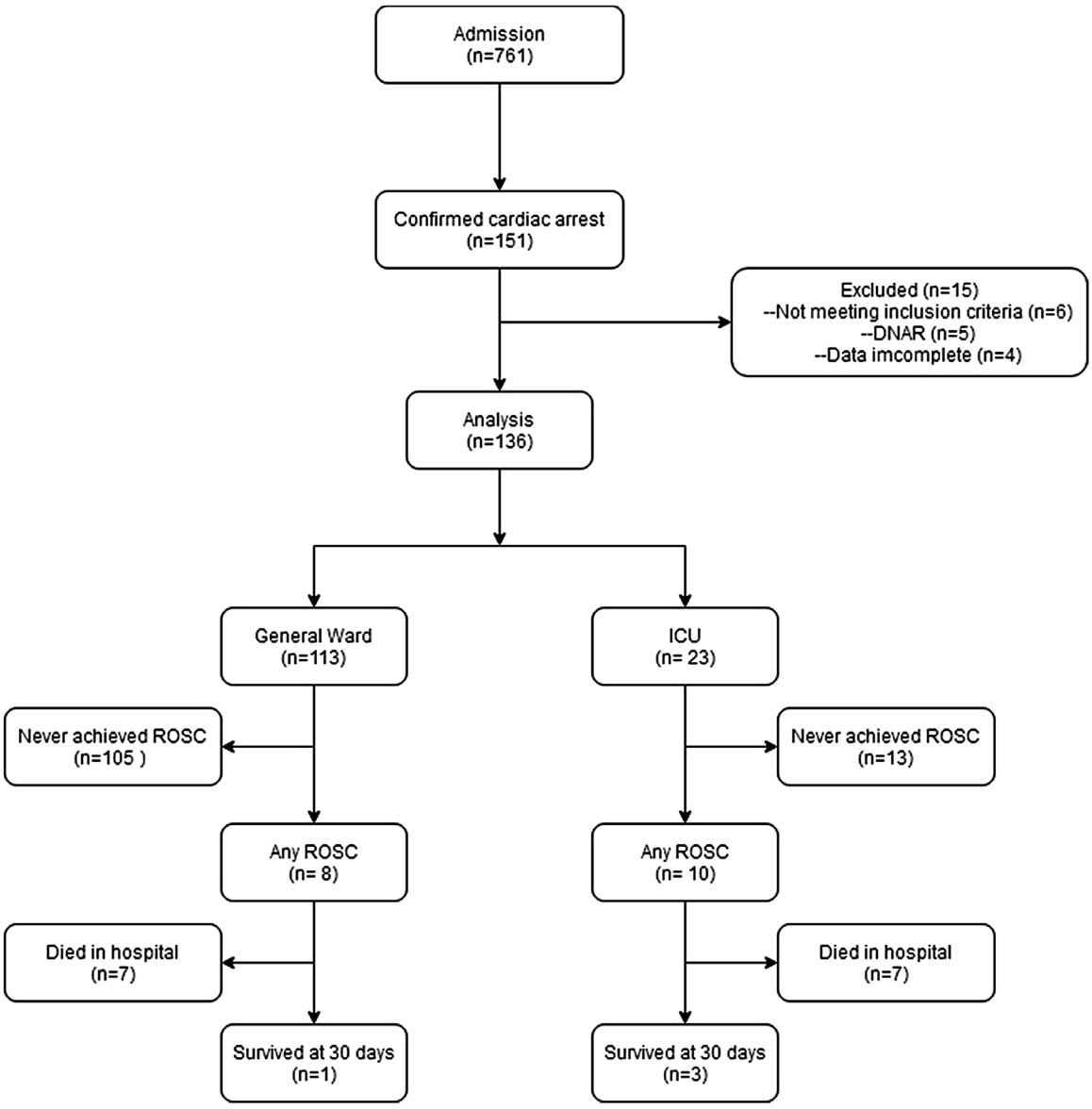

Fig. 1 – Flow diagram illustrating the number of patients during the study with respect to the location of cardiac arrests. ROSC, return of spontaneous circulation; ICU, intensive care unit; DNAR, do-not-attempt-resuscitation.

The most frequent symptom was shortness of breath (75%), followed by myalgia/arthralgia (60.3%) and cough (52.2%). Fever on admission was observed only in 52 (38.2%) cases (Table 1).

Of 136 patients who underwent resuscitation efforts, ROSC was achieved in 18 (13.2%) patients, of which four patients were still alive at 30 days.

Resuscitation in the ICU resulted in better outcome when compared with that for the general ward. Of the eight patients with an initial rhythm of VF or pulseless VT, six achieved ROSC, whereas in patients with an initial rhythm of asystole, 9% achieved ROSC. The location and initial rhythm between patients with different survival statuses were statistically significantly different (Table 2, Supplementary Table). Only one patient achieved a favourable neurological outcome at 30 days after IHCA. The overall mortality rate was 19.3% in patients with severe COVID-19 pneumonia during the 40-day study period.

Discussion

To our knowledge, this is the first study to report the clinical characteristics and outcomes of patients with severe COVID-19 pneumonia and IHCA using the Utstein style for reporting IHCA events. In our study population, most patients with IHCA (96.3%) underwent attempted resuscitation; however, there were five cases where the patients' relatives had requested no resuscitation attempt be made if cardiac arrest occurred.

The most frequent underlying comorbidity of patients in our study was hypertension followed by diabetes mellitus and coronary heart disease. This was consistent with other reports in Wuhan. The common symptoms such as fever, shortness of breath, myalgia/arthralgia, and cough were also similar to that of previous studies.

Table 1 – Characteristics of patients with severe COVID-19 pneumonia and in-hospital cardiac arrest in Wuhan.

Variables	Overall (N = 136)
Sex	
Female (%)	46 (33.8)
Male (%)	90 (66.2)
Age, years	
Mean	69
Range, IQR	61–77
Age group, years, n (%)	
14–18	1 (0.7)
19–29	2 (1.5)
30–39	2 (1.5)
40–49	3 (2.2)
50–59	18 (13.2)
60–69	46 (33.8)
70–79	39 (28.7)
≥80	25 (18.4)
Aetiology, n (%)	
Cardiac	10 (7.4)
Respiratory	119 (87.5)
Others	7 (5.1)
Location, n (%)	
ICU	23 (16.9)
General ward	113 (83.1)
Initial rhythm, n (%)	
VF/VT	8 (5.9)
PEA	6 (4.4)
Asystole	122 (89.7)
Time to initiation of CPR, n (%)	
≤1 min	121 (89.0)
2–4 min	12 (8.8)
≥5 min	3 (2.2)
Witnessed, n (%)	
Yes	132 (97.1)
No	4 (2.9)
Monitored, n (%)	
Yes	127 (93.4)
No	9 (6.6)
Comorbidity, n (%)	
Hypertension	41 (30.2)
Diabetes	27 (19.9)
Coronary heart disease	15 (11.0)
Cancer	10 (7.4)
COPD	6 (4.4)
Cerebrovascular disease	5 (3.7)
Chronic renal disease	3 (2.2)
Others	5 (3.7)
Length of hospital stay, median, days (IQR)	7 (4–11)
Time from illness onset to hospital admission, median days (IQR)	10 (7–14)
Symptom, n (%)	
Fever on admission	52 (38.2)
Shortness of breath	102 (75.0)
Myalgia/arthralgia	82 (60.3)
Cough	71 (52.2)
Fatigue	66 (48.5)
Sputum	48 (35.3)
Abnormality of mentality	45 (33.1)
Diarrhoea	27 (19.9)
Nausea/vomiting	14 (10.3)
Headache/dizziness	9 (6.6)
Abdominal pain	8 (5.9)

IQR, interquartile range; ROSC, return of spontaneous circulation; ICU, intensive care unit; CPR, cardiopulmonary resuscitation; PEA, pulseless electrical activity; VF, ventricular fibrillation; VT, ventricular tachycardia; COPD, chronic obstructive pulmonary disease.

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It is commonly accepted that the outcome after IHCA is more favourable when the initial monitored rhythm is VF/VT rather than non-VF/VT (i.e., asystole or PEA). Most of the initial monitored rhythms recorded by responders in our survey of patients who experienced an IHCA were asystole (89.7% of cases), which is more common than described in previous reports of IHCA.[8–10]. A shockable rhythm was recorded in only 5.9% of cases (2.7% of ward cases [3 patients], 22% of ICU cases [5 patients]), but the outcome among these patients was better than those with asystole or PEA.

There have been differences reported in previous studies regarding the mortality rate of patients with COVID-19. A retrospective cohort study in Wuhan reported that 54 of 191 patients died in the hospital, and older age, higher SOFA score, and elevated d-dimer at admission were risk factors for death of adults with COVID-19.[2]. In another report from Wuhan, the mortality rate was 62% among critically ill patients with COVID-19 and 81% among those requiring mechanical ventilation.[3]. Meanwhile, Washington state, USA reported a mortality rate of 67%, and 24% of the patients remained critically ill and 9.5% were discharged from the ICU.[11]. We observed an overall mortality rate of 19.3% in patients with severe COVID-19 pneumonia during the study period. The difference may be due to the severity of patients enrolled in the analysis, management of intensive care, and the capacity of hospitalisation for patients.

The overall outcome of IHCA in our study was poor, with a ROSC rate of 13.2% and 30-day survival rate of 2.9%. The shortage of medical resources and uncertain quality of CPR were key factors in the resuscitation of patients with severe COVID-19 pneumonia in Wuhan. As COVID-19 spread, the number of critically ill patients exceeded the capacity of ICUs in most hospitals in Wuhan. It was not rare for critically patients to stay in the general ward with limited advanced life-support facilities. With an improvement in recognition and protection strategies, two newly constructed hospitals and several isolation hospitals were soon brought into service. As the west campus of Union Hospital was designated for patients with severe pneumonia, the defibrillation and advanced airway interventions and mechanical ventilation could be established in the general ward with the help of a 24/7 rapid response team. Although a growing number of mechanical compression devices had been introduced in hospitals, there was still a significant lack of intensive care resources. In addition, few patients had do-not-attempt CPR (DNACPR) decision. The patients were cared for in isolation wards, and visiting by relatives was very limited.

Table 2 – Outcomes of patients with severe COVID-19 pneumonia and in-hospital cardiac arrest in Wuhan.

Group	*N*	ROSC			30-day survival		
		n (%)	*p*-Value	OR (95% CI)	*n* (%)	*p*-Value	OR (95% CI)
Age, years			0.08			0.19	
>60	105	11 (10.5)		1.00	2 (1.9)		1.00
≤60	31	7 (22.6)		0.40 (0.13–1.37)	2 (6.5)		0.28 (0.02–4.09)
Sex			0.12			0.15	
Female	46	9 (19.6)		1.00	0 (0)		1.00
Male	90	9 (10)		0.46 (0.17–1.25)	4 (4.4)		4.28 (0.22–82.71)
Location			<0.01			<0.01	
General ward	113	8 (7.1)		1.00	1 (1)		1.00
ICU	23	10 (43.5)		10.10 (3.38–30.14)	3 (13)		16.80 (1.663–169.70)
Witnessed			0.43			0.72	
No	4	0 (0)		1.000	0 (0)		1.00
Yes	132	18 (13.6)		1.26 (0.06–24.91)	4 (3)		0.25 (0.01–5.57)
Aetiology			0.48			0.36	
Cardiac	10	2 (20)		1.000	1 (10)		1.00
Respiratory	119	16 (13.4)		0.62 (0.12–3.19)	3 (2.5)		0.23 (0.02–2.47)
Others	7	0 (0)		0.29 (0.01–7.45)	0 (0)		0.64 (0.02–22.06)
Initial rhythm			<0.01			<0.01	
VF/VT	8	6 (75.0)		1.000	3 (37.5)		1.00
PEA	6	1 (16.7)		0.07 (0.01–0.97)	0 (0)		0.14 (0.01–3.48)
Asystole	122	11 (9)		0.03 (0.01–0.18)	1 (0.8)		0.01 (0.00–0.16)

ROSC, return of spontaneous circulation; OR, odds ratio; CI, confidence interval; ICU, intensive care unit; PEA, pulseless electrical activity; VF, ventricular fibrillation; VT, pulseless ventricular tachycardia.

Only five patients who had a cardiac arrest had a DNACPR decision. We did not make any DNACPR decisions without discussion with a relative.

According to recent international CPR guidelines, post-resuscitation care has been added to the 'chain of survival', and its importance to the outcome of cardiac arrests has been emphasised.[12,13]. Although the World Health Organisation and National Health Commission of China have issued preliminary guidance on infection control, screening, and diagnosis in the general population, in addition to the guidelines issued by the Surviving Sepsis Campaign COVID-19 panel who provided recommendations to support hospital clinicians managing critically ill adults with COVID-19, there is still limited guidance based on clinical research on the acute management of critically ill patients with COVID-19.[14,15]. Supportive care is the mainstay of treatment among patients with severe COVID-19 pneumonia. In our study, there were numerous patients with severe pneumonia who were resuscitated in the general ward, resulting in a poor outcome when compared with those who received intensive care in the ICU. The difficulties in managing rapid deterioration, acute respiratory failure and acute respiratory distress syndrome in a general ward setting may have also contributed to the poor outcomes.

Based on our observations, chest compressions with PPE require considerable effort, and the person doing compressions should change every minute. In addition, the PPE clothing should be loose fitting to enable compressions and movement. The use of a mechanical chest compression device should be considered if prolonged compressions are required.

This study had some limitations. First, many data points in the resuscitation process were not documented, such as duration of resuscitation efforts, time to first defibrillation, and time to first epinephrine. Second, we do not know the precise interventions that patients had prior to cardiac arrest. Third, this study involved only one centre and the results may not be generalisable to other settings and healthcare systems. The relatively few cases and survivors means that our confidence in our estimates of outcome is low. To explore the risk factors for outcome, univariable and multivariable logistic regression models were applied, but no significant difference were found. More studies are needed to better understand the incidence and outcomes of acute respiratory distress syndrome and critical illnesses caused by COVID-19, which will be important for critical care management and resource planning. Finally, a lack of data regarding CPR quality is also a limitation. It was also difficult to identify the differences between general wards that were managed by staff from different hospitals. These variations in resuscitation efforts and post-arrest care could also affect the survival outcomes and results. Finally, although we did not study this formally, we are not aware of any clinical staff involved in a resuscitation attempt becoming infected with COVID-19 as a result of their involvement.

Conclusions

The overall ROSC and 30-day survival rates of IHCA patients with severe COVID-19 pneumonia in Wuhan were poor. Factors associated with ROSC and 30-day survival were initial rhythm and location of arrest. Providing care for patients at risk of cardiac arrest in an intensive care setting, should be considered to improve the outcome of IHCA patients with severe COVID-19 pneumonia.

Conflicts of interest

None declared.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.resuscitation.2020.04.005.

REFERENCES

1. World Health Organization. Novel Coronavirus (2019-nCoV) situation reports. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/ [accessed 01.04.20].
2. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet 2020;6736:1–9.
3. Yang X, Yu Y, Xu J, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. Lancet Respir Med 2020;2600:1–7.
4. Wang D, Hu B, Hu C, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. JAMA 2020;1–9.
5. Guan W-J, Ni Z-Y, Hu Y, et al. Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med 2020;1–13.
6. Zhu N, Zhang D, Wang W, et al. A novel coronavirus from patients with pneumonia in China, 2019. N Engl J Med 2020;382:727–33.
7. Nolan JP, Berg RA, Andersen LW, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update of the Utstein Resuscitation Registry Template for in-hospital cardiac arrest. A consensus report from a Task Force of the International Liaison Committee on Resuscitation. Resuscitation 2019;1–12.
8. Benjamin EJ, Muntner P, Alonso A, et al. Heart disease and stroke statistics – 2019 update: a report from the American Heart Association. Circulation 2019;139:e28–56.
9. Bradley SM, Kaboli P, Kamphuis LA, Chan PS, Iwashyna TJ, Nallamothu BK. Temporal trends and hospital-level variation of in-hospital cardiac arrest incidence and outcomes in the Veterans Health Administration. Am Heart J 2017;193:117–23.
10. Shao F, Li CS, Liang LR, et al. Incidence and outcome of adult in-hospital cardiac arrest in Beijing, China. Resuscitation 2016;102.
11. Arentz M, Yim E, Klaff L, et al. Characteristics and outcomes of 21 critically ill patients with COVID-19 in Washington State. JAMA 2020;4720:2019–21.
12. Perkins GD, Neumar R, Monsieurs KG, et al. The International Liaison Committee on Resuscitation – review of the last 25 years and vision for the future. Resuscitation 2017;121:104–16.
13. Field JM, Hazinski MF, Sayre MR, et al. Part 1: Executive Summary 2010 American Heart Association Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2010;122:S640–56.
14. Waleed A, Morten HM, Yaseen MA, et al. Surviving sepsis campaign: guidelines on the management of critically ill adults with coronavirus disease 2019 (COVID-19). Crit Care Med 2020, doi:http://dx.doi.org/10.1097/CCM0000000000004363.
15. National Health Commission of the People's Republic of China. New diagnosis and treatment scheme for novel coronavirus infected pneumonia (trial edition 7). 2020.