Interactive CardioVascular and Thoracic Surgery (2020) 1–7
doi:10.1093/icvts/ivaa209

ORIGINAL ARTICLE

VASCULAR

Cite this article as: Hu X, Wang Y, Liu J, Qiu X, Liu X, Jiang X *et al*. Early outcomes of Stanford type A aortic dissection under the coronavirus disease 2019 (COVID-19) pandemic: a multicentre study from Hubei province. Interact CardioVasc Thorac Surg 2020; doi:10.1093/icvts/ivaa209.

Early outcomes of Stanford type A aortic dissection under the coronavirus disease 2019 (COVID-19) pandemic: a multicentre study from Hubei province

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Received 11 April 2020; received in revised form 4 August 2020; accepted 16 August 2020

Key question

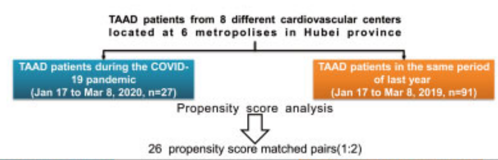
Is an emergency operation feasible for patients with Stanford type A aortic dissection (TAAD) during the COVID-19 pandemic?

Key finding(s)

Satisfactory early outcomes can be achieved after emergency operations for patients with TAAD during the COVID-19 pandemic.

Take-home message

TAAD operations during the COVID-19 pandemic had longer cross-clamp/circulatory arrest/ventilation/ICU stay times but similar in-hospital mortality/morbidity.



TAAD patients during the COVID-19 pandemic (n=26)	Operative Variables and Early Outcomes	TAAD patients in the same period of last year (n=52)	P-Value
22.9±8.3	Waiting time to operation(h)	9.7±4.0	< 0.001
135±36	Clamp time (min)	103±45	0.003
24±9	Circulatory arrest time (min)*	17±8	< 0.001
1 (3.8)	30-day or in-hospital mortality (%)	2 (3.8)	1
1 (3.8)	Stroke (%)	3 (5.8)	0.716
1 (3.8)	Neurological deficit (%)	4 (7.7)	0.513
2 (7.7)	Acute kidney injury (%)	7 (13.5)	0.187
19 (73.1)	Pulmonary infection (%)	31 (59.6)	0.243
0 (0)	Unplanned reintubation (%)	3 (5.8)	0.212
1 (3.8)	Reoperation (%)	5 (9.6)	0.367
7.4±3.8	ICU time (days)	4.5±2.7	0.002
81±71	Ventilation time (h)	45±19	< 0.001

[†] The first two authors contributed equally to this work.

Abstract

OBJECTIVES: Our goal was to compare the short-term outcomes of Stanford type A aortic dissection (TAAD), during the coronavirus disease 2019 (COVID-19) pandemic with those during normal times and summarize our perioperative management experience of patients with TAAD in the context of COVID-19.

METHODS: From 17 January 2020 to 8 March 2020, a total of 27 patients with TAAD were operated on in 8 cardiovascular surgery centres in Hubei Province (COVID-19 group). The data from 91 patients with TAAD from the same centres during the same period last year were extracted from the Hubei Cardiac Surgery Registration System (control group). A propensity score matched subgroup of 26 pairs (1:2) was identified. Perioperative data and short-term outcomes were assessed.

RESULTS: Nine patients in the COVID-19 group were categorized as suspicious for the disease (9/27, 33.3%), and others were excluded (18/27, 66.7%). No one was laboratory confirmed preoperatively. The average waiting, cross-clamp and circulatory arrest times were longer in the COVID-19 group (22.9 ± 8.3 vs 9.7 ± 4.0 h, $P < 0.001$; 135 ± 36 vs 103 ± 45 min, $P = 0.003$; 24 ± 9 vs 17 ± 8 min, $P < 0.001$, respectively). The 30-day or in-hospital deaths were 3.8% in both groups ($P = 1.0$). The COVID-19 group was associated with longer ventilation and intensive care unit times (81 ± 71 vs 45 ± 19 h, $P < 0.001$; 7.4 ± 3.8 vs 4.5 ± 2.7 days; $P < 0.001$, respectively). There were no statistical differences between the 2 groups in the incidence of complications such as stroke, neurological deficit, acute kidney injury, pulmonary infection and reoperation. Serum antibody tests for those patients showed 7 out of 9 suspected cases were Immunoglobulin G positive. No cross-infection occurred in other patients or associated medical staff.

CONCLUSIONS: With adequate preparation and appropriate protection, satisfactory early outcomes can be achieved after emergency operations for patients with TAAD during the COVID-19 pandemic.

Keywords: Coronavirus disease 2019 • Acute aortic dissection • Stanford type A aortic dissection • Emergency operation • Propensity score match

ABBREVIATIONS

COVID-19	Coronavirus disease 2019
CT	Computed tomography
ICU	Intensive care unit
qRT-PCR	Quantitative real-time polymerase chain reaction
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
TAAD	Type A aortic dissection

INTRODUCTION

Since early December 2019, when the first case of pneumonia of unknown origin was identified in Wuhan, the capital of Hubei province, a serious respiratory pandemic has spread worldwide [1–3]. As clinical data and relative knowledge accumulated, a novel beta-coronavirus named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was confirmed as the causative agent [4, 5]. SARS-CoV-2 can be transmitted person to person through respiratory droplets or by direct contact with a highly infectious person and can lead to viral pneumonia named coronavirus disease 2019 (COVID-19). As of 4 April 2020, there have been a total of 81 669 confirmed cases and 3329 confirmed deaths across China (including Hong Kong, Macao and Taiwan), with 1 051 635 confirmed cases and 56 985 confirmed deaths in more than 200 other countries [6, 7]. The World Health Organization has already declared this ongoing epidemic a global pandemic.

The pandemic broke out as winter turned to spring, which is also the time when one sees an increase in the number of cases of emergency cardiovascular diseases such as Stanford type A aortic dissection (TAAD). Some researchers suggested that SARS-CoV-2 might act on the cardiovascular system via the angiotensin-converting enzyme 2 receptor [3, 8] and lead to the deterioration or acute onset of underlying or pre-existing cardiovascular disease. Therefore, in the case of TAAD, if the patient presents with pericardial tamponade, visceral malperfusion, haemodynamic instability or any signs of aortic rupture, emergency surgery is inevitable and crucial. However, neither the World Health Organization interim guideline nor the New Coronavirus Pneumonia Prevention and Control Program (published by the National Health Commission of China) offered any specific recommendations for the management of patients with TAAD in the context of COVID-19 [9, 10]. Therefore, we designed this multicentre retrospective study to analyse the clinical characteristics and outcomes of patients with TAAD who had emergency interventions in Hubei province, the centre of the pandemic. We compared our results with the propensity score matching data extracted from the Hubei Cardiac Surgery Registration System in order to assess the early outcomes of these patients and summarize effective management experiences.

PATIENTS AND METHODS

Study design

The data of patients with TAAD during the COVID-19 pandemic (from 16 January 2020 to 8 March 2020, hereinafter referred to as the COVID-19 group) were retrospectively collected from 8 different cardiovascular centres located at 6 metropolises in Hubei province. The data of patients with TAAD from the same centres during the same period last year (from 16 January 2019 to 8 March, 2019, hereinafter referred to as the control group) were extracted from the Hubei Cardiac Surgery Registration System, the administrative database of the Hubei Cardiovascular Surgery Quality Control centre, in which all inpatient hospitalizations for cardiovascular surgery in Hubei province are recorded. All patients diagnosed with Stanford TAAD who underwent operations in this period were identified. Preoperative clinical characteristics, operative variables and early outcomes were obtained from the medical records. All data of the COVID-19 group were obtained and revised with the same customized data collection

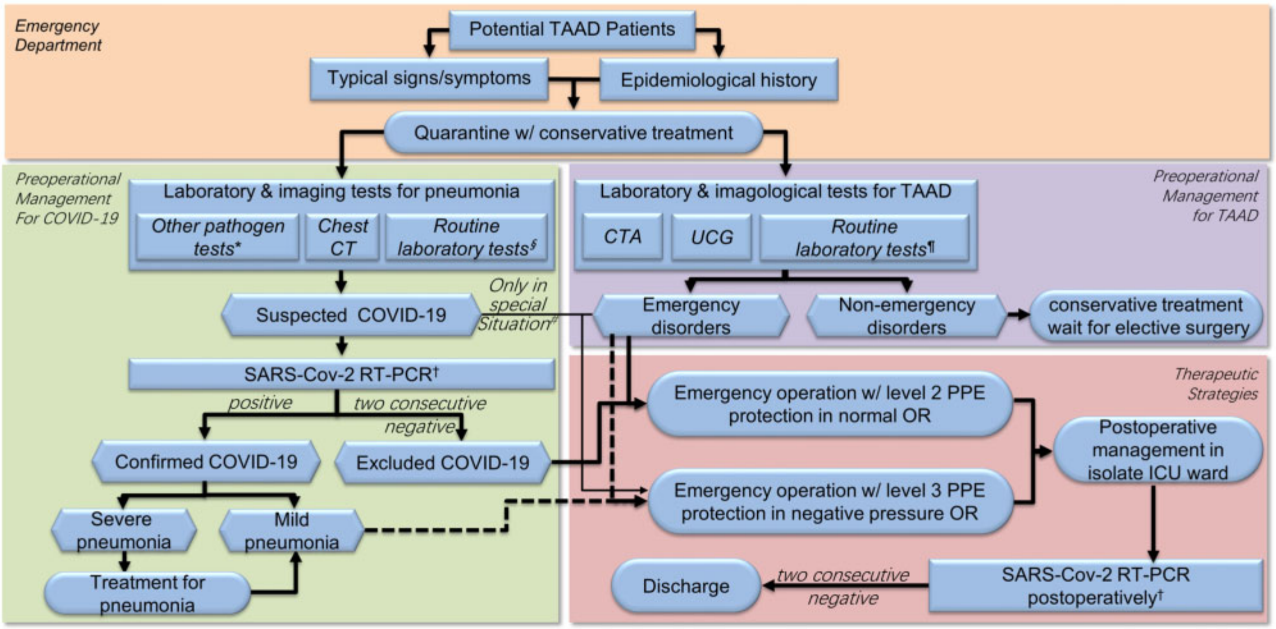


Figure 1: Flow chart of the perioperative management of patients who may have TAAD during the COVID-19 pandemic. *Including tests for influenza type A and B, respiratory syncytial virus, Coxsackie group B virus, adenovirus, *Mycoplasma pneumoniae* and *Chlamydia pneumoniae*. #For patients with rapidly deteriorating conditions who cannot wait for the qRT-PCR test results or during the early phase when the qRT-PCR kit is in short supply. §Including complete blood count, c-reactive protein test and others. ¶Including myocardial enzymology, brain natriuretic peptide analysis and others. †qRT-PCR of pharyngeal swab samples. COVID-19: coronavirus disease 2019; CT: computed tomography; CTA: computed tomography angiography; ICU: intensive care unit; OR: operating room; PPE: personal protective equipment; qRT-PCR: quantitative real-time polymerase chain reaction; RT-PCR: real-time polymerase chain reaction; SARS-Cov-2: severe acute respiratory syndrome coronavirus 2; TAAD: type A aortic dissection; UCG: ultrasonic cardiography.

form among the 8 centres. All data for the 2 groups was reviewed by 2 investigators (X.H. and Y.W.) to verify its accuracy.

The study was approved by the medical ethical committee of Wuhan Union Hospital of Huazhong University of Science and Technology. Patient anonymity was assured during the analysis.

Perioperative management

The perioperative workflow of patients in the COVID-19 group is summarized in the flowchart in Fig. 1. The patients were quarantined in specific wards and were tested immediately to clarify the diagnoses of the cardiovascular lesion and of the pneumonia. All patients had preoperative computed tomography (CT) scans and haematological examinations. Oral and pharyngeal swab samples were taken from 18 patients in the COVID-19 group for a quantitative real-time polymerase chain reaction (qRT-PCR) test using the kit (BioGerm, Shanghai, China) [11, 12].

The diagnosis of COVID-19 pneumonia was based on the New Coronavirus Pneumonia Prevention and Control Program (7th revised edition) published by the National Health Commission of China [10]. Suspected cases were identified as patients with an epidemiological history who satisfied at least 2 out of 3 requirements: typical respiratory symptoms or fever, abnormal results on a haemogram and positive results on a chest CT scan. Confirmed cases were patients suspected of having COVID-19 who had positive qRT-PCR results on samples from the respiratory tract.

An open or hybrid operation via a standard median sternotomy was performed on all patients. The brain was protected via bilateral antegrade cerebral perfusion. Moderate hypothermia (nasopharyngeal temperature 26°C) and circulatory arrest were used for total arch replacement in all cases.

Surgical staff working with patients in the COVID-19 group who were untested or who were suspected of having COVID-19 performed the operations with level III personal protective equipment, which included a disposable surgical cap, a respiratory protective device or positive pressure head cover, a medical protective mask (N95), goggles, a disposable gown worn over the surgical gown, two-layer disposable latex gloves and disposable shoe covers. For the patients whose test results were negative for COVID-19 cases, level II personal protective equipment was still required [including disposable surgical cap, goggles, medical protective mask (N95), disposable gown outside the operating coat, disposable latex gloves and disposable shoe covers].

All patients in the COVID-19 group received postoperative treatment in isolated intensive care units (ICUs) and postoperative wards. Two consecutive qRT-PCR tests were carried out on respiratory tract samples before the patient was discharged to exclude COVID-19 infection. Afterwards, the discharged patients were transported to local medical centres for isolated observation for at least 14 days. Serological samples were collected from all the patients in the COVID-19 group, and the levels of specific immunoglobulin M(IgM) and immunoglobulin G(IgG) antibodies were detected by enzyme-linked immunoassay. All the relevant medical staff also received chest CT scans and qRT-PCR tests to rule out possible cross-infection after the operation.

Statistical analysis

Continuous variables were expressed as the average ± the standard deviation. Categorical variables were summarized as the counts and percentages in each category. The Student's *t*-test was used for continuous variables. Pearson's χ^2 or Fisher's exact test

Table 1: Preoperative characteristics

Variables	Total (*N* = 118), *n* (%)	Non-matched cohort			Propensity matched cohort		
		COVID-19 group January 2020–March 2020 (*N* = 27), *n* (%)	Control group January 2019–March 2019 (*N* = 91), *n* (%)	*P*-value	COVID-19 group January 2020–March 2020 (*N* = 26), *n* (%)	Control group January 2019–March 2019 (*N* = 52), *n* (%)	*P*-value
General							
Age (years), mean ± SD	52.3 ± 13.2	51.1 ± 13.1	52.7 ± 14.8	0.614	50.3 ± 12.6	51.7 ± 12.5	0.644
Male gender	85 (72.0)	20 (74.1)	65 (71.4)	0.788	20 (76.9)	37 (71.2)	0.588
BMI(kg/m^2), mean ± SD	24.1 ± 4.1	24.4 ± 3.7	24.0 ± 4.3	0.397	24.4 ± 3.8	24.2 ± 3.7	0.824
Smoking	66 (55.9)	15 (55.6)	51 (56.0)	0.964	14 (53.8)	29 (55.8)	0.872
Risk factors							
Hypertension	92 (78.0)	18 (66.7)	74 (81.3)	0.107	17 (65.4)	39 (75)	0.374
Diabetes	28 (30.8)	9 (33.3)	19 (20.9)	0.219	8 (30.8)	13 (17.3)	0.588
COPD	29 (24.6)	6 (22.2)	23 (25.3)	0.746	5 (19.2)	11 (21.2)	0.811
Coronary disease	12 (10.2)	2 (7.4)	10 (11.0)	0.589	2 (7.7)	6 (11.5)	0.653
Cerebrovascular disease	14 (11.9)	1 (3.7)	13 (14.3)	0.135	1 (3.8)	8 (15.4)	0.174
Hypertension	92 (78.0)	18 (66.7)	74 (81.3)	0.107	17 (65.4)	39 (75)	0.374
Clinical presentation							
Cardiogenic shock	4 (3.4)	0 (0)	4 (4.4)	0.268	0 (0)	2 (3.8)	0.302
Stroke	6 (5.1)	1 (3.7)	5 (5.5)	0.71	1 (3.8)	3 (5.8)	0.717
Cardiac tamponade	17 (14.4)	1 (3.7)	16 (17.6)	0.071	1 (3.8)	5 (9.6)	0.506
Visceral ischaemia	7 (5.9)	0 (0)	7 (7.7)	0.137	0 (0)	2 (3.8)	0.666
Limb ischaemia	34 (28.8)	4 (14.8)	32 (35.2)	0.047	3 (11.5)	9 (17.3)	0.506
Previous cardiac surgery	7 (5.9)	1 (3.7)	6 (6.6)	0.577	0 (0)	1 (1.9)	0.83
Extension of dissection							
Asc Ao	8 (6.8)	1 (3.7)	7 (7.7)	0.469	1 (3.8)	3 (5.8)	0.827
Asc Ao + Arch	20 (16.9)	4 (14.8)	16 (17.6)	0.736	4 (15.4)	9 (17.3)	0.815
Asc Ao + Arch + Desc	90 (76.3)	22 (81.5)	68 (74.7)	0.468	21 (80.8)	40 (76.9)	0.361

Asc Ao: ascending aorta; BMI: body mass index; COPD: chronic obstructive pulmonary disease; COVID-19: coronavirus disease 2019; Desc: descending aorta; SD: standard deviation.

was used for categorical variables. A two-tailed *P*-value <0.05 was considered statistically significant. SPSS software v19.0 (SPSS, Inc., Chicago, IL, USA) was used.

Confounding due to differences in baseline characteristics was addressed using propensity score matching [13]. The propensity score was generated using a logistic regression algorithm. Covariates entered into the model included all measured baseline characteristics: age, gender, body mass index; risk factors such as hypertension, diabetes mellitus, smoking, chronic obstructive pulmonary disease, coronary disease, cardiovascular disease and bicuspid valve; clinical presentations such as cardiogenic shock, stroke, cardiac tamponade, visceral ischaemia, limb ischaemia, previous cardiac surgery; and extension of dissection. The area under the receiver operating characteristic curve for this model was 0.80. A 1:2 match was then performed using a caliper of 0.01 of the logit of the propensity score computed by this model [14]. The baseline characteristics of the patient pairs matched by the propensity score were compared using the paired *t*-test for continuous variables and the McNamara test for categorical variables. A standardized difference <0.1 was deemed indicative of acceptable balance [15].

RESULTS

Baseline characteristics

Twenty-seven patients in the COVID-19 group and 91 in the control group were identified. The demographic characteristics of the entire cohort are presented in Table 1. For the entire cohort, the ages in the 2 groups were not different (51.1 ± 13.1 vs 52.1 ± 14.8 years; $P = 0.753$). Limb ischaemia occurred more frequently in the control group (14.8% vs 35.2%; $P = 0.047$). The preoperative cardiac tamponade rate was higher in the control group, though it did not reach statistical significance (3.7% vs 17.6%; $P = 0.071$). Twenty-six pairs (1:2) of patients were included after the propensity score match, and the differences in preoperative data between them were eliminated (Table 1).

Clinical characteristics in the coronavirus disease-19 group

Laboratory test results showed that most patients in the COVID-19 group had abnormal white blood cell counts (17/27, 63.0%) and about half of them had lymphopenia (11/27, 40.7%). All 27 patients had chest CT scans, and pulmonary exudation or ground-glass opacities were found in 7 patients (7/27, 25.9%). Due to the suddenness of the outbreak and the lack of standard COVID-19 PCR kits in the early phase of the pandemic, not all patients had preoperative qRT-PCR results. The results for the 18 patients for whom we had qRT-PCR results from samples from the respiratory tract were all negative. According to the guideline of the National Health Commission, 9 patients were categorized as suspected cases (9/27, 33.3%), and other patients were excluded from COVID-19 diagnosis (18/27, 66.7%) (Supplementary Material, Tables S1–S3).

Operative variables

The average waiting time (from administration to operation) was longer in the COVID-19 group (22.9 ± 8.3 vs 9.7 ± 4.0 h; $P < 0.001$).

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Table 2: Operative variables

Variables	Total (*N* = 118), *n* (%)	Non-matched cohort			Propensity matched cohort		
		COVID-19 group January 2020–March 2020 (*N* = 27), *n* (%)	Control group January 2019–March 2019 (*N* = 91), *n* (%)	*P*-value	COVID-19 group January 2020–March 2020 (*N* = 26), *n* (%)	Control group January 2019–March 2019 (*N* = 52), *n* (%)	*P*-value
Waiting time to operation (h) mean ± SD	13.7 ± 6.5	22.7 ± 8.3	8.1 ± 3.7	<0.001	22.9 ± 8.3	9.7 ± 4.0	<0.001
Hybrid surgery	21 (17.8)	4 (14.8)	27 (29.7)	0.123	4 (15.4)	9 (17.3)	0.830
Aortic root operation[a]	36 (30.5)	6 (22.2)	30 (33.0)	0.287	6 (23.1)	18 (34.6)	0.135
Operation time (min), mean ± SD	437 ± 109	460 ± 116	429 ± 102	0.183	456 ± 116	414 ± 119	0.145
Clamp time (min), mean ± SD	118 ± 36	136 ± 35	112 ± 40	0.006	135 ± 36	103 ± 45	0.003
CPB time (min), mean ± SD	208 ± 57	228 ± 72	206 ± 44	0.055	226 ± 72	202 ± 52	0.098
CA time (min),[b] mean ± SD	20 ± 9	24 ± 9	18 ± 9	0.003	24 ± 9	17 ± 8	<0.001
Transfusion of red blood cells (U), mean ± SD	6.3 ± 2.8	6.8 ± 2.9	6.1 ± 2.9	0.27	6.8 ± 2.9	6.4±2.5	0.531

[a]Including Bentall, David and Wheat operations.

[b]Only for operations needing total arch replacement with deep hypothermia and circulatory arrest.

CA: circulatory arrest; COVID-19: coronavirus disease-2019; CPB: cardiopulmonary bypass; SD: standard deviation.

Table 3: Early outcomes

Variables	Total (*N* = 118), *n* (%)	Non-matched cohort			Propensity matched cohort		
		COVID-19 group January 2020–March 2020 (*N* = 27), *n* (%)	Control group January 2019–March 2019 (*N* = 91), *n* (%)	*P*-value	COVID-19 group January 2020–March 2020 (*N* = 26), *n* (%)	Control group January 2019–March 2019 (*N* = 52), *n* (%)	*P*-value
30-Day mortality (%)	4 (3.4)	1 (3.7)	3 (3.3)	0.908	1 (3.8)	2 (3.8)	1
Stroke (%)	6 (5.1)	1 (3.7)	5 (5.5)	0.729	1 (3.8)	3 (5.8)	0.817
Neurological deficit (%)	6 (5.1)	1 (3.7)	5 (5.5)	0.729	1 (3.8)	4 (7.7)	0.644
Acute kidney injury (%)	15 (12.7)	2 (7.4)	13 (14.3)	0.166	2 (7.7)	7 (13.5)	0.488
Pulmonary infection (%)	29 (33.1)	14 (51.9)	25 (27.5)	0.018	14 (53.8)	10 (19.2)	0.003
ARDS (%)	1 (0.8)	0 (0)	1 (1.1)	0.584	0 (0)	0 (0)	1
CPR (%)	2 (1.7)	0 (0)	2 (2.2)	0.437	0 (0)	2 (3.8)	0.311
ECMO usage (%)	0 (0)	0 (0)	0 (0)	1	0 (0)	0 (0)	1
Septic shock (%)	0 (0)	0 (0)	0 (0)	1	0 (0)	0 (0)	1
Unplanned reintubation (%)	5 (4.2)	0	5 (5.5)	0.248	0 (0)	3 (5.8)	0.212
Reoperation (%)	8 (6.8)	1 (3.7)	7 (7.7)	0.419	1 (3.8)	5 (9.6)	0.367
ICU time (days), mean ± SD	5.2 ± 3.6	7.2 ± 3.9	4.3 ± 2.9	<0.001	7.4 ± 3.8	4.5 ± 2.7	0.002
Ventilation time (h), mean ± SD	49 ± 23	79 ± 71	41 ± 20	<0.001	81 ± 71	45 ± 19	<0.001
Postoperative qRT-PCR	N/A	0 (0)	N/A	N/A	0 (0)	N/A	N/A
COVID-19 IgM positive	N/A	0 (0)	N/A	N/A	0 (0)	N/A	N/A
COVID-19 IgG positive	N/A	7 (25.9)	N/A	N/A	7 (26.9)	N/A	N/A

ARDS: acute respiratory syndrome; COVID-19: coronavirus disease-2019; CPR: cardiopulmonary resuscitation; ECMO: extracorporeal membrane oxygenation; ICU: intensive care unit; IgM: Immunoglobulin M; IgG: Immunoglobulin G; qRT-PCR: quantitative real-time polymerase chain reaction.

There was no difference in the percentage of hybrid operations between the 2 groups (15.4% vs 17.3%; $P = 0.830$). Aortic root operations, including the Bentall, David and Wheat procedures, were necessary for 6 patients (23.1%) in the COVID-19 group, whereas they were necessary for 18 patients (34.6%) in the control group ($P = 0.135$). Patients in the COVID-19 group had significantly longer clamp times (135 ± 36 vs 103 ± 45 min; $P = 0.003$) and circulatory arrest times (24 ± 9 vs 17 ± 8 min; $P < 0.001$). There were no statistical differences between the 2 groups in operation times, cardiopulmonary bypass times and transfusions of red blood cells, confirmed in propensity score matching cohorts (Table 2).

Early outcomes

The early postoperative outcomes are summarized in Table 3. The overall in-hospital/30-day mortality was 3.4% (4/118). A comparison of both unmatched and matched in-hospital mortality showed no significant differences between the 2 groups. There was 1 death (3.8%; multiorgan failure) in the COVID-19 group and 2 deaths (3.8%) in the control group ($P = 1.0$).

As of 8 April 2020, all patients in the COVID-19 group were extubated. There was no cardiopulmonary resuscitation, acute respiratory syndrome, septic shock or extracorporeal membrane oxygenation usage in the entire cohort. The patients in the COVID-19 group had longer ventilation times and ICU stays compared to the control group (81 ± 71 vs 45 ± 19 h; $P < 0.001$; 7.4 ± 3.8 vs 4.5 ± 2.7 days; $P = 0.002$, respectively). No statistical differences in the incidence of stroke, permanent or temporary neurological deficit, acute kidney injury, pulmonary infection, unplanned reintubation and reoperation were found between the 2 groups. Four patients (15.4%) in the COVID-19 group had already been discharged. Although results from the qRT-PCR tests and the IgM tests of all patients in the COVID-19 group were negative postoperatively, 7 of them (25.9%, all categorized as suspected cases before) were positive for COVID-19 IgG antibody. No cross-infection occurred in surgeons, nurses, anaesthetists and other medical staff who had close contact with the patients.

DISCUSSION

Hubei is the centre and most seriously affected province of the COVID-19 pandemic in China. As of April 4, the proportion of confirmed COVID-19 patients in Hubei province was 83.02% (67 803/81 669), whereas the proportion of the population of Hubei compared to that of the entire country was only 4.23% (59.2 million/1400.8 million, as of 2018) [6]. Normal medical activities including cardiovascular surgical procedures were severely disturbed by the pandemic. However, the pandemic broke out between winter and spring, the high incidence seasons of acute aortic dissection. These factors make it extremely challenging for cardiovascular surgeons who must treat these critically ill patients in the context of COVID-19. Moreover, it has been suggested that COVID-19 has a close relationship with the cardiovascular system. Infection with SARS-CoV-2 may aggravate pre-existing cardiovascular disorders through virulence, inflammation, downregulation of the angiotensin-converting enzyme 2 and activation of the renin-angiotensin-aldosterone system [16, 17]. Dyspnoea, fever and hypoxaemia caused by COVID-19 may also be a precipitating cause of an acute onset of aortic dissection [18]. Additionally, the essential steps during cardiovascular operations such as mechanical ventilation, cardiopulmonary bypass, deep hypothermia and circulatory arrest produce unfavourable effects on cardiopulmonary function and add complexity to the perioperative management of patients with TAAD concomitant with diagnosed or suspected COVID-19. Therefore, it is of great clinical significance to summarize the effects and management strategies of emergency dissection operations during the COVID-19 pandemic.

This multicentre retrospective study adopted a propensity score matching method to compare the clinical characteristics and early outcomes of patients with TAAD during the pandemic versus those during the normal period. Based on our findings, the pandemic and the corresponding protective measures have little influence on the early mortality and morbidities of the major postoperative complications after emergency operations for patients with TAAD. No patients or relevant medical staff were cross-infected after medical observation for at least 14 days. Only longer ventilation times and ICU stays were found in the COVID-19 group. However, the pandemic still had some negative impacts on clinical practice for cardiovascular surgeons.

After the outbreak of the pandemic, the first important challenge faced by cardiovascular surgeons was differential diagnoses because the signs and symptoms of COVID-19, such as fever, cough, shortness of breath, chest pain and fatigue, are also common in cardiovascular disorders. A definitive diagnosis of COVID-19 still relies on chest CT scans and qRT-PCR test results [19, 20]. However, in the early phase, there was a shortage of PCR kits in Hubei, and the average timespan for receiving the test results was longer than 24 h. Because TAAD is a severe cardiovascular disease that deteriorates rapidly with high natural course mortality, there was no time for patients to wait for the final diagnosis if there was haemodynamic instability or any signs of dissection progression. In addition, we noticed that the preoperative preparation took more time than usual, such as waiting for the results of the qRT-PCR test, which may increase the risk of preoperative death. There were 4 preoperative deaths in our centre during the pandemic because of dissection rupture. Therefore, if emergency surgery is required, the relevant medical staff should adopt all integrative systemic protection measures as if the diagnosis of COVID-19 has been confirmed.

The personal protective equipment, especially level 3, hampers the performance of the surgeons: The positive pressure headgear with the electric supply air filter respirator and googles narrows the view of the surgeons and interferes with the communication between them; double-layer latex gloves make the sensation and movement of the surgeons' hands dull, which may slow some delicate manipulations such as coronary artery anastomosis; disposable impermeable gowns and the unavailability of air-conditioning make the surgeon feel very hot during the operation and increase their strength consumption. So, we found that the cross-clamp time and circulatory arrest time were prolonged in the COVID-19 group. However, with practice and cooperation, these adverse impacts were gradually overcome.

Limitations

This study is limited by its small sample size and retrospective method. Heterogeneity in data from different centres also needs to be taken into account when interpreting the findings. Although 7 patients in this cohort showed a positive COVID-19 IgG result postoperatively, no one was laboratory diagnosed preoperatively. The relatively high false-negative rate of the qRT-PCR test results in the early phase may lead to a certain level of misdiagnosis. Because there was no prespecified plan to adjust for multiple comparisons, *P*-values may not be interpreted as confirmatory but rather as descriptive. Finally, we must be aware of the uncertainty around this evolving pandemic and the regional variability around the world.

CONCLUSION

This multicentre, retrospective, propensity score matching study showed that the number of patients with TAAD treated surgically significantly decreased whereas the waiting time for surgical procedures was significantly prolonged during the COVID-19 pandemic. Although the surgery during the pandemic required extended cardiopulmonary and ischaemic times, the early outcomes are comparable with those in the normal era.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *ICVTS* online.

Funding

This work was financially supported by the National Natural Science Foundation [81400290, 81800413, 81730015].

Conflict of interest: none declared.

Author contributions

Xingjian Hu: Funding acquisition; Project administration; Supervision; Visualization; Writing—original draft. **Yin Wang:** Formal analysis; Methodology; Software; Writing—original draft. **Junwei Liu:** Data curation; Project administration. **Xuefeng Qiu:** Data curation; Project administration. **Xiaobin Liu:** Data curation; Project administration. **Xionggang Jiang:** Data curation; Project administration. **Xiaofan Huang:** Data curation; Project administration. **Xianqing Feng:** Data curation; Project administration. **Yulin Zhang:** Data curation; Project administration. **Songlin Zhang:** Data curation; Project administration. **Haiyun Qian:** Data curation; Project administration. **Wei Liu:** Data curation; Project administration. **Jun Zhang:** Data curation; Project administration. **Jiashou Dong:** Data curation; Project administration. **Jiajun Chen:** Data curation; Project administration. **Jiahong Xia:** Resources; Supervision; Validation. **Nianguo Dong:** Conceptualization; Funding acquisition; Supervision; Writing—review & editing. **Long Wu:** Conceptualization; Funding acquisition; Investigation; Methodology; Writing—review & editing.

Reviewer information

Interactive CardioVascular and Thoracic Surgery thanks the anonymous reviewers for their contribution to the peer review process of this article.

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