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Original article

Clinical sequelae of COVID-19 survivors in Wuhan, China: a single-centre longitudinal study

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ABSTRACT

Objectives: To describe the prevalence, nature and risk factors for the main clinical sequelae in coronavirus disease 2019 (COVID-19) survivors who have been discharged from the hospital for more than 3 months.

Methods: This longitudinal study was based on a telephone follow-up survey of COVID-19 patients hospitalized and discharged from Renmin Hospital of Wuhan University, Wuhan, China before 1 March 2020. Demographic and clinical characteristics and self-reported clinical sequelae of the survivors were described and analysed. A cohort of volunteers who were free of COVID-19 and lived in the urban area of Wuhan during the outbreak were also selected as the comparison group.

Results: Among 538 survivors (293, 54.5% female), the median (interquartile range) age was 52.0 (41.0–62.0) years, and the time from discharge from hospital to first follow-up was 97.0 (95.0–102.0) days. Clinical sequelae were common, including general symptoms ($n = 267$, 49.6%), respiratory symptoms ($n = 210$, 39%), cardiovascular-related symptoms ($n = 70$, 13%), psychosocial symptoms ($n = 122$, 22.7%) and alopecia ($n = 154$, 28.6%). We found that physical decline/fatigue ($p < 0.01$), postactivity polypnoea ($p = 0.04$) and alopecia ($p < 0.01$) were more common in female than in male subjects. Dyspnoea during hospitalization was associated with subsequent physical decline/fatigue, postactivity polypnoea and resting heart rate increases but not specifically with alopecia. A history of asthma during hospitalization was associated with subsequent postactivity polypnoea sequela. A history of pulse ≥ 90 bpm during hospitalization was associated with resting heart rate increase in convalescence. The duration of virus shedding after COVID-19 onset and hospital length of stay were longer in survivors with physical decline/fatigue or postactivity polypnoea than in those without.

Conclusions: Clinical sequelae during early COVID-19 convalescence were common; some of these sequelae might be related to gender, age and clinical characteristics during hospitalization.

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Introduction

As of 3 July 2020, the global pandemic caused by coronavirus disease 2019 (COVID-19) has affected more than 10 000 000 people and caused more than 500 000 deaths in over 215 countries or regions worldwide (<https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>). There were also a large number of patients who had been cured and discharged from the hospital; the follow-up time of COVID-19 survivors from China was longer than that in other countries around the world [1]. Early clinical sequelae associated with COVID-19, such as cardiac sequelae, are known to exist in some survivors [2]. The clinical

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characteristics, treatment and prognosis of COVID-19 have been extensively studied; however, the prevalence, nature, duration and related factors of sequelae in convalescent COVID-19 survivors have not been studied [3–5]. Patients who recovered from severe acute respiratory syndrome (SARS) had radiologic, functional and psychological abnormalities of varying degrees [6–8]. Recent studies have suggested that COVID-19 patients might have psychiatric sequelae based on the characteristics of SARS and Middle East respiratory syndrome [9]. However, few studies have systematically investigated the clinical sequelae in the early recovery of COVID-19 survivors, as well as the injury and dynamic changes of these sequelae [10]. Therefore, we performed a longitudinal study to describe the prevalence, nature and predictors of sequelae in a large cohort of COVID-19 survivors in Wuhan, China.

Methods

Study design and participants

This study included inpatients from 20 to 80 years of age from Renmin Hospital of Wuhan University (Wuhan, China), regarded as the COVID-19 survivor cohort. All survivor cohort participants included patients who were diagnosed with COVID-19 according to World Health Organization interim guidance and were cured and discharged from the hospital by 1 March 2020 [11]. Thus, the time since discharge from the hospital of all subjects was more than 3 months. Similarly, the discharge criteria for all survivors also followed the World Health Organization interim guidance. We conducted a preliminary screening that was based on the health status of discharged patients, excluding those with severe and complex underlying diseases or receiving invasive treatment, as well as women who were pregnant or breastfeeding. The selected survivors were enrolled onto a telephone follow-up study primarily to observe their clinical sequelae in early recovery from COVID-19 (3 months after discharge).

We also recruited volunteers who were free of COVID-19 living in the downtown area of Wuhan during the epidemic as a comparison group. To make a comparison, we first recruited volunteers who had similar demographic characteristics of the COVID-19 survivor cohort. We reviewed and screened the information provided by volunteers who were willing to participate in this study. All participants in the comparison group should have been completely quarantined at home for more than 3 months and had not done much physical work during the outbreak. We also excluded those who had a complex illness, were currently undergoing medical intervention or were unable to provide detailed related information. Eligible subjects in the comparison group were asked the same telephone interview questions as those in the survivor cohort.

The ethics committee of Renmin Hospital of Wuhan University approved this study and granted a waiver of informed consent from the study participants.

Data collection

The demographics, clinical features, laboratory findings, treatments and outcomes of the participants in the hospital were collected from the electronic medical record system in our hospital. All data were reviewed by an attending physician and an associate chief physician and were finally verified by the major investigators. Survivors were systematically contacted by three experienced clinicians via mobile phone, and the detailed reported symptoms related to the key points we were assessing were recorded. Any

remaining or newly occurring symptoms 3 months after discharge from the hospital were recorded as sequelae. The survivors' current symptoms were carefully distinguished from those of their preillness state or other underlying diseases not related to COVID-19. The course of the reported symptoms of the survivors was also investigated and documented in detail.

Observation key points and definitions

On the basis of the clinical characteristics of COVID-19 inpatients, studies on the common sequelae of viral pneumonia or infectious pneumonia and a small-scale clinical pretrial assessment, we finally determined whether patients had corresponding sequelae according to five aspects [3,6,12,13], as follows. General symptoms refer to the survivors' overall discomfort, including physical decline or fatigue (manifested as a different decline in physical strength than in the predisease state), sweating (pronounced sweats when slightly active or resting or night sweats), myalgia, arthralgia, chills, limb oedema and dizziness. Respiratory symptoms include postactivity polypnoea, nonmotor polypnoea, chest distress, chest pain, cough, sputum and throat pain. Cardiovascular symptoms include resting heart rate increases (an increase of resting heart rate of more than 20 bpm compared to the rate before COVID-19 was defined as an increased resting heart rate), discontinuous flushing and newly diagnosed hypertension. Psychosocial symptoms include somniphobia (with poor sleep quality or insomnia), depression, anxiety, dysphoria and feelings of inferiority. Finally, specific symptoms include alopecia. In addition, other abnormalities reported by the survivors were also documented. All points of inquiry were carefully distinguished from the original disease and were compared with the patient's pre-COVID-19 status to ensure that the patient's symptoms truly existed and might be related to COVID-19.

Data analysis

Continuous and categorical variables are presented as median (interquartile range, IQR) and number and percentage respectively. We used the chi-square test or the Fisher exact test to compare differences between the survivor cohort and the comparison group where appropriate. We used the Mann-Whitney *U* test, chi-square test or Fisher exact test to compare differences between patients with and without sequelae where appropriate. To explore the risk factors associated with the occurrence of sequelae, multivariable logistic regression models were used. We chose the variables with significant differences that showed no statistical significance but may be highly associated with the occurrence of sequelae to enter the risk factor analysis. Analyses were performed by R 3.6.1 software (R Foundation for Statistical Computing; <https://www.r-project.org/>). Two-tailed $p < 0.05$ was considered statistically significant.

Results

Study sample

A total of 2461 adult patients were hospitalized in Renmin Hospital of Wuhan University with COVID-19 before 30 April 2020. Of these, 156 patients died and 2485 were cured and/or discharged. Among the 2485 discharged patients, 891 were discharged before 1 March 2020 and were regarded as the survivor cohort. Finally, telephone follow-up was accomplished in 538 COVID-19 survivors and 184 participants in the comparison group after screening and culling. A detailed study sample is shown in Fig. 1.

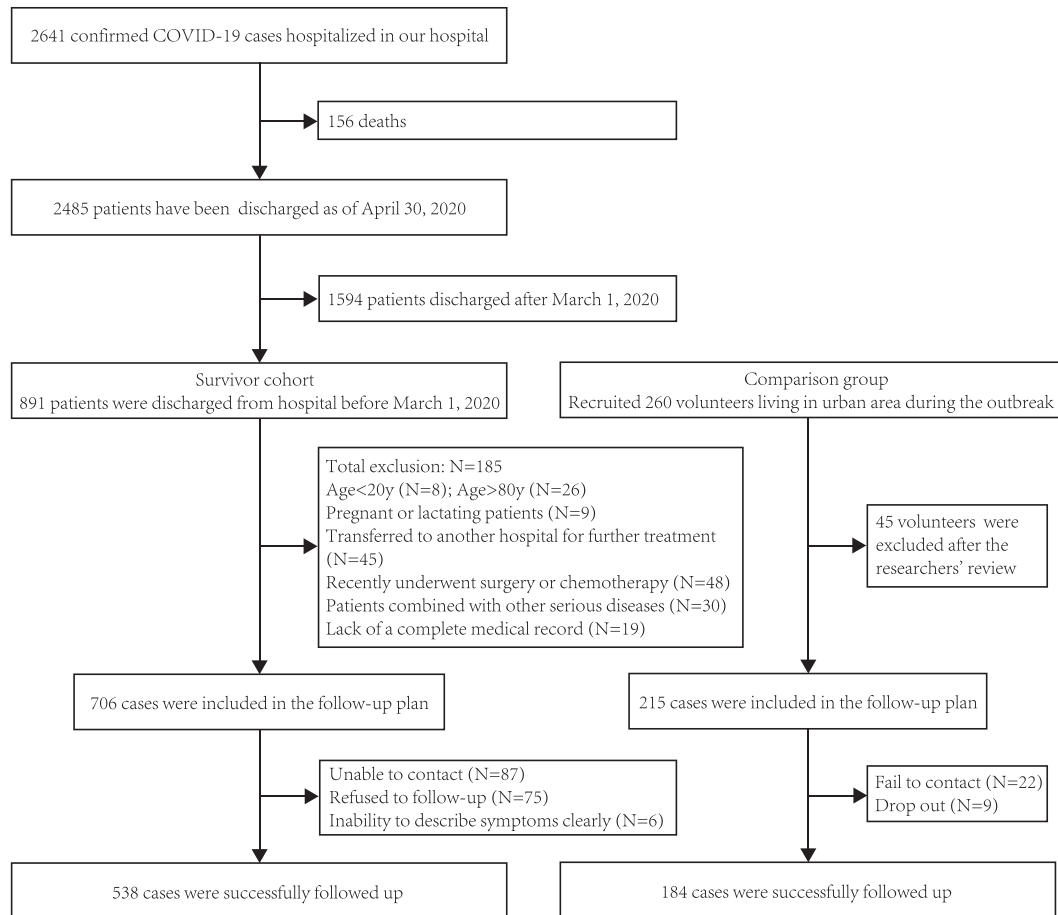


Fig. 1. Study sample.

Demographics and characteristics

The median (IQR) age of the 538 COVID-19 survivors was 52.0 (41.0–62.0) years, ranging from 22 to 79 years; 293 patients (54.5%) were female. The median (IQR) age of the 184 patients in the comparison group was 50.0 (37.0–61.0) years, ranging from 20 to 71 years, and 88 patients (47.8%) were female. Their age distribution, comorbidity, clinical symptoms and disease severity status are shown in Table 1. The sex ratio, age distribution and comorbidity between the two cohorts showed no significant difference (all $p > 0.05$). The median (IQR) time since discharge was 97.0 (95.0–102.0) days, ranging from 91 to 116 days.

Characteristics of clinical sequelae

On the basis of follow-up results, we found that 267 (49.6%) of the 538 COVID-19 survivors had one or more general symptoms, with 152 (28.3%) reporting physical decline or fatigue (Table 2). Most patients who reported these symptoms improved, but 35 survivors reported no improvement. A total of 127 survivors (23.6%) complained of excessive sweating. Twenty-four patients reported significant myalgia. Forty-one patients (7.6%) reported joint pain, most commonly in the knee joint (29 cases) but also in the elbow, ankle, wrist and spinal joints. Twenty-five patients (4.6%) complained of chilliness, such as not being able to face cold air, which they did not notice until they were discharged from the hospital.

Except for dizziness, the prevalence of all general symptoms was significantly higher in the survival group than in the comparison group (all $p < 0.05$).

A total of 210 survivors (39%) had one or more respiratory symptoms. The most common polypnoea was postactivity polypnoea (115, 21.4%), which they reported was caused by just mild activity (Table 2). Similarly, most of them reported that symptoms of polypnoea were improving, although 15 survivors showed no significant improvement. In addition, some patients also had other coexisting respiratory sequelae, including chest distress (76, 14.1%), chest pain (66, 12.3%), cough (38, 7.1%), excessive sputum (16, 3%) and throat pain (17, 3.2%). Except for sputum, the prevalence of all respiratory symptoms was significantly higher in the survival group than in the comparison group (all $p < 0.05$).

Seventy survivors (13%) reported significant cardiovascular symptoms 3 months after discharge. Of the 60 people who reported significantly higher resting heart rates than before they had COVID-19, 45 (75%) had resting heart rate increases during their hospitalization that were still present. Twenty-six patients (4.8%) said they occasionally had palpitations (Table 2). Notably, seven patients said they had recently been diagnosed with high blood pressure and they now require blood pressure-lowering drugs. The prevalence of high resting heart rates was significantly higher in the survival group than in the comparison group ($p < 0.05$).

Ninety-five patients (17.7%) showed sleep disorders since the onset of the disease, mainly manifesting as difficulty falling asleep

Table 1
Demographic and clinical features during acute COVID-19 illness in hospital among 538 COVID-19 survivors and 184 cases in comparison group

Characteristic	COVID-19 survivors (n = 538)	Comparison group (n = 184)	p
Sex			0.12
Male	245 (45.5)	96 (52.2)	
Female	293 (54.5)	88 (47.8)	
Age group			0.19
20–40 years	117 (21.7)	51 (27.7)	
41–60 years	250 (46.5)	84 (45.7)	
61–80 years	171 (31.8)	49 (26.6)	
Comorbidity			0.74
Hypertension	177 (32.9)	63 (34.2)	
Hypertension	82 (15.2)	32 (17.4)	0.49
Diabetes	40 (7.4)	16 (8.7)	0.58
Chronic obstructive lung disease	22 (4.1)	6 (3.3)	0.62
Coronary heart disease	18 (3.3)	9 (4.9)	0.34
Chronic kidney disease	12 (2.2)	3 (1.6)	0.77
Carcinoma	5 (0.9)	3 (1.6)	0.43
Other	32 (5.9)	7 (3.8)	0.27
Clinical features in hospital			
Fever	446 (82.9)	—	—
Cough	297 (55.2)	—	—
Sputum	77 (14.3)	—	—
Fatigue	144 (26.8)	—	—
Myalgia	72 (13.4)	—	—
Asthma	90 (16.7)	—	—
Dyspnoea	27 (5)	—	—
Chest pain	14 (2.6)	—	—
Throat pain	24 (4.5)	—	—
Anorexia	129 (24)	—	—
Diarrhoea	55 (10.2)	—	—
Nausea or vomiting	22 (4.1)	—	—
Pulse \geq 90 bpm	139 (25.8)	—	—
Disease severity status			
General	331 (61.5)	—	—
Severe	180 (33.5)	—	—
Critical	27 (5)	—	—

Data are presented as n (%); p values were calculated by chi-square test or Fisher exact test, as appropriate. COVID-19, coronavirus disease 2019.

Table 2
Characteristics and prevalence of residual or new symptoms in 538 COVID-19 survivors 3 months after discharge from hospital and 184 cases in comparison group

Characteristic	COVID-19 survivors (n = 538)	Comparison group (n = 184)	p
General symptoms	267 (49.6)	22 (12.0)	<0.01
Physical decline/fatigue	152 (28.3)	17 (9.2)	<0.01
Sweating	127 (23.6)	3 (1.6)	<0.01
Myalgia	24 (4.5)	0 (0.0)	<0.01
Arthralgia	41 (7.6)	0 (0.0)	<0.01
Chills	25 (4.6)	0 (0.0)	<0.01
Limb oedema	14 (2.6)	0 (0.0)	0.03
Dizziness	14 (2.6)	3 (1.6)	0.58
Respiratory symptoms	210 (39)	11 (6.0)	<0.01
Postactivity polypnoea	115 (21.4)	10 (5.4)	<0.01
Nonmotor polypnoea	25 (4.7)	0 (0.0)	<0.01
Chest distress	76 (14.1)	0 (0.0)	<0.01
Chest pain	66 (12.3)	0 (0.0)	<0.01
Cough	38 (7.1)	1 (0.5)	<0.01
Sputum	16 (3)	1 (0.5)	0.09
Throat pain	17 (3.2)	0 (0.0)	<0.01
Cardiovascular-related symptoms	70 (13)	1 (0.5)	<0.01
Resting heart rate increase	60 (11.2)	0 (0.0)	<0.01
Discontinuous flushing	26 (4.8)	1 (0.5)	<0.01
Newly diagnosed hypertension	7 (1.3)	0 (0.0)	0.20
Psychosocial symptoms	122 (22.7)	14 (7.6)	<0.01
Somniphobia	95 (17.7)	9 (4.9)	<0.01
Depression	23 (4.3)	2 (1.1)	0.04
Anxiety	35 (6.5)	3 (1.6)	0.01
Dysphoria	9 (1.7)	1 (0.5)	0.47
Feelings of inferiority	3 (0.6)	0 (0.0)	0.57
Specific symptoms	154 (28.6)	0 (0.0)	<0.01
Alopecia	154 (28.6)	0 (0.0)	<0.01

Data are presented as n (%); p values were calculated by chi-square test or Fisher exact test, as appropriate. COVID-19, coronavirus disease 2019.

and as short, interrupted sleep (Table 2). Twenty-three people (4.3%) complained of depression and lack of interest in things around them. Nine survivors (1.7%) reported feeling dysphoria after falling ill. Except for dysphoria and inferiority, the prevalence of all psychosocial symptoms was significantly higher in the survival group than in the comparison group (all $p < 0.05$).

Alopecia was another common sequela during our investigation, observed in 154 survivors (12 male and 142 female patients, Table 2). In the comparison group, however, none reported alopecia. The prevalence of this sequela in women was as high as 48.5% (Table 3). Of these, 112 patients reported alopecia starting after discharge from the hospital, and 42 cases appeared during hospitalization. In 30 patients, symptoms of hair loss improved.

Univariate analyses

After observing the sequelae prevalence of COVID-19 patients, we focused on the clinical characteristics of the sequelae with high prevalence, including physical decline/fatigue, postactivity polypnoea, resting heart rate increases and alopecia. Table 3 shows the univariate analyses of differences in demographic, clinical and laboratory features during acute COVID-19 and sequelae reported at the first telephone follow-up. Sequelae were more common in female subjects, except for high resting heart rate. In an additional exploratory analysis, dyspnoea during hospitalization was associated with subsequent physical decline/fatigue, postactivity polypnoea and resting heart rate increases, but not specifically with alopecia. A history of asthma during hospitalization was associated with subsequent postactivity polypnoea sequelae. A history of pulse ≥ 90 bpm during hospitalization was associated with resting

heart rate increase symptoms in convalescence. The duration of virus shedding after COVID-19 onset and hospital length of stay were longer in survivors with physical decline/fatigue or post-activity polypnoea than in those without.

Discussion

Survivors of COVID-19 are significantly more likely to develop clinical sequelae 3 months after discharge from the hospital than those without COVID-19 infection. This is true not only for general and respiratory symptoms but also for cardiovascular and psychosocial symptoms. This suggests that these symptoms may indeed be the sequelae of recovery for COVID-19 survivors.

We found that 49.6% of patients who had recovered from COVID-19 still had one or more common symptoms, including physical decline, fatigue and myalgia, 3 months after discharge. Respiratory sequelae were also common in early recovery from COVID-19. Most of these symptoms had been present during hospitalization, as has been reported in many studies [3,14,15]. Fortunately, most survivors reported that these symptoms improved over time. However, persistent symptoms, such as joint pain, limb oedema, chest pain and cough, deserve further attention.

The early sequelae of severe SARS and Ebola virus disease showed similar symptoms, such as fatigue, asthma and arthralgia [6,12]. The respiratory sequelae of COVID-19 may be less severe than those of SARS and Ebola virus disease [6,12]. Patients in our study did not undergo respiratory function examinations, and the specific degree of functional decline is not clear. Instead, they only compared their perception with their previous respiratory function

Table 3
Clinical features and treatments during hospitalization of COVID-19 survivors combined with major sequelae

Characteristic	Physical decline/fatigue			Postactivity polypnoea			Resting heart rate increase			Alopecia		
	Yes (n = 152)	No (n = 386)	p	Yes (n = 115)	No (n = 423)	p	Yes (n = 60)	No (n = 478)	p	Yes (n = 154)	No (n = 384)	p
Sex			<0.01			0.04			0.75			<0.01
Male	52 (34)	193 (50)		43 (37)	202 (47)		26 (43)	219 (46)		12 (8)	233 (61)	
Female	100 (66)	193 (50)		72 (63)	221 (52)		34 (57)	259 (54)		142 (92)	151 (39)	
Age group			<0.01			0.14			0.69			0.01
20–40 years	16 (11)	101 (26)		18 (16)	99 (23)		12 (20)	105 (22)		21 (14)	96 (25)	
41–60 years	72 (47)	178 (46)		54 (47)	196 (46)		26 (43)	224 (47)		82 (53)	168 (44)	
61–80 years	64 (42)	107 (28)		43 (37)	128 (30)		22 (37)	149 (31)		51 (33)	120 (31)	
Clinical features and treatments in hospital												
Fever	131 (86)	315 (82)	0.2	97 (84)	349 (82)	0.64	51 (85)	395 (83)	0.65	129 (84)	317 (83)	0.74
Cough	89 (59)	208 (54)	0.33	75 (65)	222 (52)	0.02	34 (57)	263 (55)	0.81	87 (56)	210 (55)	0.70
Sputum	24 (16)	53 (14)	0.54	20 (17)	57 (13)	0.29	11 (18)	66 (14)	0.35	22 (14)	55 (14)	0.99
Feeble	49 (32)	95 (25)	0.07	30 (26)	114 (27)	0.85	22 (37)	122 (26)	0.07	46 (30)	98 (26)	0.30
Myalgia	21 (14)	51 (13)	0.85	14 (12)	58 (14)	0.67	11 (18)	61 (13)	0.23	18 (12)	54 (14)	0.47
Asthma	26 (17)	64 (17)	0.88	28 (24)	62 (15)	0.01	12 (20)	78 (16)	0.47	31 (20)	59 (15)	0.18
Dyspnoea	13 (9)	14 (4)	0.02	11 (10)	16 (4)	0.01	7 (12)	20 (4)	0.01	6 (4)	21 (5)	0.45
Chest pain	2 (1)	12 (3)	0.24	5 (4)	9 (2)	0.16	3 (5)	11 (2)	0.22	1 (1)	13 (3)	0.07
Throat pain	6 (4)	18 (5)	0.72	8 (7)	16 (4)	0.14	5 (8)	19 (4)	0.12	5 (3)	19 (5)	0.39
Anorexia	40 (26)	89 (23)	0.43	26 (23)	103 (24)	0.69	17 (28)	112 (23)	0.40	31 (20)	98 (26)	0.19
Diarrhoea	20 (13)	35 (9)	0.16	13 (11)	42 (10)	0.67	5 (8)	50 (10)	0.60	16 (10)	39 (10)	0.94
Nausea or vomiting	12 (8)	10 (3)	<0.01	6 (5)	16 (4)	0.49	2 (3)	20 (4)	0.75	7 (5)	15 (4)	0.74
Pulse ≥ 90 bpm	41 (27)	98 (25)	0.71	29 (25)	110 (26)	0.86	45 (75)	94 (20)	<0.01	36 (23)	103 (27)	0.41
Corticosteroids	39 (26)	99 (26)	0.99	34 (30)	104 (24)	0.28	21 (35)	117 (24)	0.08	36 (23)	102 (27)	0.44
Antiviral treatment	137 (90)	352 (91)	0.7	109 (95)	380 (89)	0.10	54 (90)	435 (91)	0.79	138 (90)	351 (91)	0.51
Disease severity status			0.12			0.71			<0.01			0.13
General	87 (57)	244 (63)		67 (58)	264 (62)		22 (37)	309 (65)		103 (67)	228 (59)	
Severe	60 (39)	120 (31)		42 (37)	138 (32)		31 (52)	149 (31)		47 (31)	133 (35)	
Critical	5 (3)	22 (6)		6 (5)	21 (5)		7 (12)	20 (4)		4 (3)	23 (6)	
Duration of virus shedding after COVID-19 onset (days)	12 (8–22)	11 (7–19)	0.01	14 (8–21)	11 (7–19)	0.03	12.5 (8–24.5)	12 (7–19)	0.15	11 (7–18)	12 (7–20)	0.19
Hospital length of stay (days)	16 (11–25)	14 (10–21)	<0.01	16 (11–25)	14 (10–21)	0.05	16 (10–7.8)	14 (10–21)	0.14	14 (11–20.3)	15 (10–1.8)	0.27

Data are presented as n (%) or median (interquartile range); p values were calculated by Mann-Whitney U test, chi-square test or Fisher exact test, as appropriate.

from a subjective perspective. Further studies are needed to assess the duration of COVID-19 damage to respiratory organs and functions.

Studies have shown that cardiac injury is a common condition among hospitalized patients and is associated with a higher risk of in-hospital mortality [16–19]. This may be related to angiotensin-converting enzyme 2 (ACE2) acting as the receptor for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [2,20,21]. Our study found that 13% of patients had cardiovascular sequelae, the most important of which was increased resting heart rate. In addition, seven patients reported a recent diagnosis of hypertension after COVID-19 infection. These findings may be evidence of COVID-19's long-term damage to the cardiovascular system. The longer-term cardiac effects remain to be investigated.

Epidemic diseases have a psychological impact on both infected and noninfected persons [22–24]. Both the infected and noninfected population might be susceptible as a result of certain experiences, such as widespread anxiety, social isolation, stress in healthcare and other essential workers, unemployment and financial difficulties [9,22,25–28]. Our study found that 17.7% of COVID-19 patients had a major mental disorder characterized by sleep disorders. Only a small number of people showed symptoms such as depression and anxiety. It should be noted that our psychosocial queries were limited to those who were willing to describe their psychosocial states to us, and not all of them were willing or able to accurately describe this anomaly. Accurate data may require more detailed questioning or support with questionnaires and psychometric scales.

Finally, we found that alopecia may be a unique sequela of COVID-19 survivors, which has been observed almost exclusively in women. Studies have shown that inflammation is associated with alopecia in women [29]. Whether inflammation from COVID-19 promoted hair loss has not been reported; its pathogenesis, clinical course and treatment need to be further studied.

To our knowledge, our study is the first to report on the major clinical sequelae and possible risk factors in the early recovery of COVID-19 survivors. However, there are still some deficiencies in this study. Firstly, this study may have obtained less accurate information mainly because of the nature of telephone follow-up compared to face-to-face communication or physical examination. Secondly, only a small number of patients were included in the study, and most of them had general or severe cases. Sequelae of COVID-19 patients with critical illness or patients undergoing complex life support treatment were not reflected in this study.

COVID-19 affects a huge number of people thanks to its pandemic nature. Further studies need to be conducted on the characteristics, aetiologies and mechanisms of sequelae as well as the outcomes of COVID-19 survivors.

Conclusions

The most common early clinical sequelae in COVID-19 survivors include physical decline/fatigue postactivity polypnoea, resting heart rate increases, somnolence and alopecia. These sequelae may be related to gender, age and clinical characteristics during hospitalization. Our research provides a reference for the evaluation of symptoms in patients with COVID-19 in the early stage of recovery.

Transparency declaration

All authors report no conflicts of interest relevant to this article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.cmi.2020.09.023>.

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