Epidemic dynamics and clinical features of COVID-19 and government measures to control disease transmission in southern Hainan Island, China

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Abstract

Objective: The objective of this study is to determine the epidemic dynamics and clinical features of COVID-19 in southern Hainan Island, China, and provide experience for other tropical areas of the world.

Methods: This retrospective study included confirmed cases of COVID-19 in southern Hainan. All enrolled patients were treated in Sanya, and data on epidemiological and clinical features of the disease and infection prevention and control measures adopted by the local government during the epidemic were collected.

Results: Of the 74 cases, 71 (95.95%) were imported from Wuhan, Hubei Province (47, 63.51%), other cities in Hubei Province (11, 14.86%), or provinces other than Hubei and Hainan (13, 17.57%). Three (4.06%) patients were infected in southern Hainan, including one autochthonous case in Sanya. Fifty-four cases (72.97%) were detected in Sanya, and 27 cases (27.03%) were diagnosed in other cities. The rate of severe or critical cases was 28.38% (21/74), and mortality was 2.7% (2/74). The serum lactate levels and base excess of severe-critical patients were higher than those of patients with mild-moderate disease. Multivariate logistic regression analysis showed that chronic conditions were risk factors for severe and critical COVID-19. Seventy-four patients were diagnosed with COVID-19 over a 22-day period in Sanya, and the epidemic period in the city was 48 days. The outbreak was controlled rapidly because the local government adopted strict infection prevention and control measures.

Conclusions: The clinical characteristics of COVID-19 in Hainan Island were similar to those reported in other regions. In Sanya, the rate of severe and very severe cases was higher than in other regions; however, most cases were imported, and there was only one autochthonous case. The rapid control of the outbreak in Sanya may be related to the tropical climate, adoption of strict infection prevention and control measures, daily reporting of new cases, increased public awareness about the epidemic, and other emergency actions implemented by the local government.

Key words: COVID-19; SARS-CoV-2; epidemic dynamics; disease control; clinical features; tropical area

Introduction

Since December 2019, coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), rapidly spread worldwide[1][2], infecting more than 280,000 people globally as of mid-May 2020. Several clinical and epidemiological characteristics of COVID-19 infection have been reported[3][4][5][6], and the epidemic dynamics in Hubei Province has been investigated. Nonetheless, the epidemiological and clinical features of this entity in southern Hainan Island, a tropical area of China, may differ from those of other regions. For instance, the 2003 SARS outbreak in China did not occur in Hainan. Rapid economic development, improvements in transportation infrastructure, and increased population density may lead to the rapid spread of infectious diseases.

However, most COVID-19 cases in southern Hainan Island were imported, and Sanya, the most populous and touristic city in this region, had only one autochthonous case.

This study evaluated the epidemiological and clinical features of COVID-19 patients and emergency actions implemented by local governments in southern Hainan to provide experience for controlling this viral disease in other tropical areas of the world.

Methods

Study design and patients

This study collected and analyzed data on 74 COVID-19 patients from southern Hainan and emergency response measures adopted by local governments. The patients were diagnosed and classified according to the Diagnosis and Treatment of 2019 Novel Coronavirus Pneumonia Guidelines (versions 3 to 6) issued by the National Health Commission of People's Republic of China[7][8][9][10]. Patients admitted to Sanya Central Hospital and Second Southern Theater Naval Hospital, Chinese People's Liberation Army—designated for treating SARS-CoV-2 pneumonia—from January 20 to March 8, 2020, were recruited.

The study was approved by the research ethics committee of Sanya Central Hospital, and oral consent was obtained from patients. The study conforms to the ethical guidelines of the Declaration of Helsinki.

The patients were allocated to two groups according to disease severity: mild-moderate and severe-critical. Clinical severity was based on the following criteria:

Mild: mild symptoms and normal X-ray images in both lungs.

Moderate: typical symptoms, including fever, cough, and other respiratory symptoms, and radiological manifestations of pneumonia.

Severe: any one of the following criteria:

1) Respiratory distress: respiratory rate ≥30 breaths per minute

2) Arterial oxygen saturation ≤93% at rest

3) Arterial partial pressure of oxygen/fraction of inspired oxygen ≤300 mmHg

Critical: any one of the following criteria:

1) Patients with respiratory failure requiring invasive mechanical ventilation (MV)

2) Signs of shock (circulatory failure)

3) Patients with organ failure requiring intensive care

Procedures

This study collected data on demographics, symptoms, travel history, chronic illnesses, laboratory results, Chest X-ray or computed tomography (CT) findings, treatment, and clinical outcomes of patients from different regions of China (Wuhan and other cities in Hubei Province, provinces other than Hubei and Hainan, and southern Hainan Island), and infection prevention and control measures adopted by the local government during the epidemic.

Statistical analysis

Continuous variables were expressed as mean and standard deviation, or median and interquartile range. Non-normally distributed variables were presented as mean, median, or range. Categorical variables were expressed as absolute numbers and percentages in each category. In light of the small sample size, data of all patients were included in the analysis, and the last observation carried forward method was used to impute missing data. The variables gender, age, smoking history, travel history, chronic illnesses, and body mass index were evaluated by multivariate logistic regression analysis (stepwise forward Wald). Statistical analysis was performed using SPSS version 26.0.

Results

1. Patients

From January 20 to March 8, 2020, 74 patients were diagnosed with COVID-19 in southern Hainan Island and were treated in Sanya, which is the main city in this region. Most patients were male and aged ≤39 and 60–69 years. A total of 32/74 (43.24%) patients had chronic illnesses, of which cardiovascular and cerebrovascular diseases were the most common, accounting for 22.97% (17/74) of all cases. Two patients (2.7%) from the severe-critical group died of multiple organ failure (Table 1).

Seventy-one (95.95%) cases were imported from Wuhan, Hubei Province (47, 63.51%), other cities in Hubei Province (11, 14.86%), or provinces other than Hubei and Hainan (13, 17.57%). Three (4.06%) patients were infected in southern Hainan, including one autochthonous case in Sanya. Fifty-four (72.97%) patients were diagnosed in Sanya, and 20 (27.03%) patients were diagnosed in other cities in southern Hainan.

Table 1. Epidemiological characteristics of COVID-19 patients treated in Sanya, southern Hainan Island, China.

		Total cohort (N=74)
Age (years)	Mean (SD)	47.82±18.32
	≤39	25 (33.78%)
	40–49	8 (10.81%)
	50–59	13 (17.57%)
	60–69	23 (31.08%)
	≥70	5 (6.76%)
Gender	Male	29 (39.19%)
	Female	45 (60.81%)
History of smoking	Yes	7 (9.46%)
	No	67 (90.54%)
BMI	Mean ± SD	22.83±3.86
Travel history	Yes	71 (95.95%)
	No	3 (4.05%)
Chronic illnesses	All	32 (43.24%)
	Cardiovascular and cerebrovascular diseases	17 (22.97%)
	Digestive system diseases	4 (5.41%)
	Endocrine system diseases	7 (9.46%)
	Malignant tumors	7 (9.46%)
	Nervous system diseases	1 (1.35%)
	Respiratory system diseases	5 (6.76%)
Clinical outcome	Hospital discharge	72 (97.30%)
	Death	2 (2.70%)

Table 2. Region of diagnosis of COVID-19 patients in southern Hainan Island, China.

Sanya	Other cities in southern Hainan	Total
54 (72.97%)	20 (27.03%)	74

Table 3. Number of COVID-19 cases in different regions of southern Hainan Island, China.

	Imported cases			Cases in southern Hainan	
Region	Wuhan, Hubei Province	Other cities in Hubei Province	Provinces other than Hubei and Hainan	Sanya	Other cities
Number of cases	47 (63.51%)	11 (14.86%)	13 (17.57%)	1(1.35%)	2 (2.70%)

2. Clinical features

The most common symptoms on admission were fever (40, 54.06%), cough (33, 44.60%), and dyspnea (5, 6.76%) (Table 4). Other symptoms included expectoration, sore throat, diarrhea, fatigue, chest tightness, nasal congestion, inappetence, flatulence, and myalgia (Table 4). Chest X-ray and CT results showed that 47 (63.51%) patients presented bilateral pneumonia and 17 (22.97%) had unilateral pneumonia. The results of ten (13.51%) patients were unremarkable (Table 4).

Serum lactate levels and the degree of metabolic alkalosis were higher in the severe-critical group (Table 5), and chronic conditions were the most important risk factors for severe COVID-19 (Table 6).

Table 4. Clinical features of COVID-19 patients in southern Hainan Island, China.

	Number of cases (%)
Symptoms (N=74)	
Fever	40 (54.06%)
Cough	33 (44.60%)
Fatigue	22 (29.72%)
Expectoration	16 (21.63%)
Sore throat	14 (18.91%)
Chest tightness	9 (12.16%)
Dyspnea	5 (6.76%)
Diarrhea	4 (5.40%)

Flatulence		2 (2.70%)
Nasal congestion		3 (4.05%)
Inappetence		6 (8.11%)
Myalgia		1 (1.35%)
Laboratory results		
White blood cell count (N=73)*	Low	12 (16.44%)
	Normal	58 (79.45%)
	High	3 (4.11%)
Neutrophil count (N=74)	Low	14 (18.92%)
	Normal	56 (75.68%)
	High	4 (5.40%)
Lymphocyte count (N=72)*	Low	35 (48.61%)
	Normal	37 (51.39%)
Red blood cell count (N=73)*	Low	33 (45.21%)
	Normal	39 (53.42%)
	High	1 (1.37%)
Platelet count (N=72)*	Low	14 (19.44%)
	Normal	55 (76.39%)
	High	3 (4.05%)
Hemoglobin (N=73)*	Low	32 (43.84%)
	Normal	40 (54.79%)
	High	1 (1.37%)
C-reactive protein (N=67)*	Normal	31 (46.27%)
	High	36 (53.73%)
Chest X-ray or CT findings (N=74)	Normal	10 (13.51%)
	Left	5 (6.76%)
	Right	12 (16.22%)
	Bilateral	47 (63.51%)

*Number of patients with missing data: white blood cells (N=1), lymphocytes (N=2), red blood cells (N=1), platelets (N=2), hemoglobin (N=1), and C-reactive protein (N=7).

Table 5. Blood gas analysis in COVID-19 patients in southern Hainan Island, China.

		Mild-moderate (99 person-times)	Severe-critical (400 person-times)	P-value
Base excess	Mean	0.7907	0.9644	<0.05
	Median	0.9400	0.8950	<0.05
	Range	-5.42-6.28	-16.54-19.91	
Lactate	Mean	2.3551	3.1553	<0.05
	Median	2.3000	2.5000	<0.05
	Range	1.10-4.80	1.00-17.60	
pH	Mean	7.41	7.4314	<0.05
	Median	7.41	7.4335	<0.05
	Range	7.34-7.47	7.10-7.56	

Table 6. Multivariate logistic regression analysis of patients with severe and critical COVID-19 in southern Hainan Island, China.

	B	SE	Waldχ2	P	Exp(B)
Gender	-1.044	0.962	1.177	0.278	0.352
Age	-0.010	0.030	0.112	0.738	0.990
History of smoking	-21.069	17078.991	0.000	0.999	0.000
Chronic illness	3.642	1.335	7.440	0.006	38.159
Body mass index	0.145	0.151	0.928	0.335	1.156
Travel history	19.787	25118.992	0.000	0.999	391940538.194
Constant	-24.065	25118.992	0.000	0.999	0.000

3. Treatment

Patients were treated with either oxygen therapy (40, 54.05%) or non-invasive MV (19, 25.68%). Two patients in the severe-critical group received invasive MV. In the total cohort, one (1.35%) patient underwent continuous renal replacement therapy because of renal failure, and one (1.35%) patient was treated with extracorporeal membrane oxygenation (Table 7).

Five (6.76%) patients were treated with Western medicine, and 69 (93.24%) patients received traditional Chinese medicine (TCM) combined with Western medicine (27, 36.49%) or TCM combined with a Chinese herbal decoction and Western medicine (40, 54.05%). In our sample, 30 (40.54%) patients received modified Radix Fici Simplicissimae, a Chinese herbal medicine used in decoctions (Table 7).

Table 7. Treatment approaches for COVID-19 patients in southern Hainan Island, China.

Treatment	Total cohort (N=74)
Oxygen therapy	40 (54.05%)

Mechanical ventilation	21 (28.38%)
Non-invasive	19 (25.68%)
Invasive	2 (2.70%)
CRRT	1 (1.35%)
ECMO	1 (1.35%)
Antibiotic treatment	53 (71.62%)
Antiviral treatment	71 (95.95%)
Intravenous immunoglobulin therapy	13 (17.57%)
2-CM*	27 (36.49%)
2-CD*	2 (2.70%)
3*	40 (50.05%)
Combined with Radix Fici Simplicissimae	30 (46.15%)

*2-CM: Traditional Chinese medicine combined with Western medicine, 2-CD: Chinese herbal decoction together with Western medicine, 3: Traditional Chinese medicine combined with a Chinese herbal decoction and Western medicine.

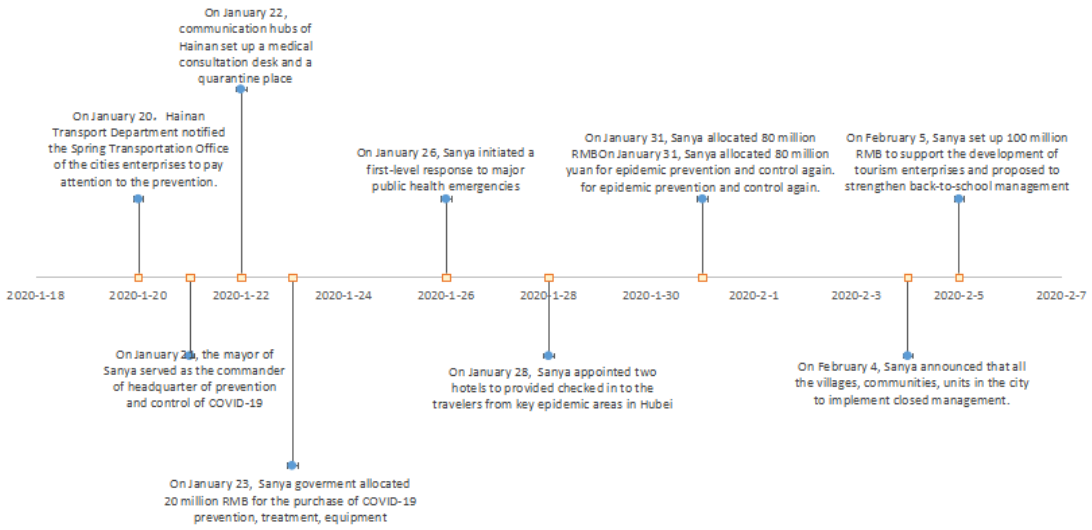
CRRT, continuous renal replacement therapy; ECMO, extracorporeal membrane oxygenation.

By March 8, 2020, 72 (97.30%) patients in our cohort had been discharged, and two (2.70%) patients had died. Of these, one patient was diagnosed with COVID-19 in Dongfang, southern Hainan, was admitted to Sanya Central Hospital because of clinical worsening, and died of multiple organ failure, and a 78-year-old patient was diagnosed with COVID-19 in Sanya, was admitted to Sanya Central Hospital, and died of severe pneumonia, respiratory failure, multiple organ failure, and septic shock.

4. Measures adopted by the government of Sanya

In Sanya, 74 patients were diagnosed with COVID-19 over a 22-day period, and the epidemic period was 48 days. The actions implemented by the local government during the outbreak are summarized in Figure 1.

Figure 1. Measures adopted by the local government during the COVID-19 outbreak in Sanya, Hainan Island, China.



Discussion

This descriptive study evaluated the epidemic dynamics and clinical features of COVID-19 and the status of SARS-CoV-2 infection in a tropical area in China.

Seventy-four patients were diagnosed with COVID-19 in southern Hainan Island and were admitted to Sanya Central Hospital or Second Southern Theater Naval Hospital, Chinese People's Liberation Army, which were designated for treating SARS-CoV-2 pneumonia. Of these, 71 cases were imported, and three cases (4.06%) originated in Hainan, including one autochthonous case in Sanya. Twenty-one (28.38%) patients had severe or critical disease, and this percentage is higher than that reported in Shanghai (8.3%)[11]. The mortality rate was 2.7% (2/74), which is lower than that reported in other cities in China[4][12] and some developed countries, including the United States (5.89%), France (19.56%), United Kingdom (14.26%), Italy (14.26%), and Spain (12.01%), as of May 23, 2020. The fact that the epidemic period in Sanya (48 days) was much shorter than that in other countries, despite the limited medical resources in this city, is encouraging and is the result of the provision of additional resources by the local government. The actions implemented in Sanya to reduce the spread of the disease included: 1. establishing isolation wards and separate areas to screen suspected patients; 2. allocating 20 million renminbi (RMB) for purchasing respirators and personal protective equipment and medications, and ensuring the adequate supply of PPE and hygiene products; 3 initiating a first-level response to major public health emergencies; 4. designating two hotels to provide accommodation to travelers coming from epidemic areas in Hubei; 5. allocating 80

million RMB for epidemic prevention and control; 6. restricting mobility in villages, communities, and health units, measuring body temperature, and issuing travel permits; 7. allocating 100 million RMB to support tourism; 8. resuming school activities (Figure 1); 9. reporting new cases daily; 10. implementing early detection, reporting, patient isolation, treatment, quarantine, and clinical observation; 11. controlling the inflow of people from key epidemic areas; 12. cancelling all gatherings; 13. raising public awareness about the epidemic; 14. educating citizens about the importance of wearing face masks and washing hands frequently[11]; 15. covering the medical costs of COVID-19 treatment; 16. managing return-to-work activities to restore production, consequently decreasing economic, health, and social burden.

The increase in air temperature may shorten SARS-CoV-2 survival, based on data on other coronavirus strains[13]; for this reason, the tropical marine climate of Sanya may not favor viral survival and transmission. Moreover, as air temperature rises, air flow is increased and ventilation conditions are improved, which helps prevent the spread of SARS-CoV-2.

The affected age groups, male to female ratio, chronic illnesses, symptoms, laboratory results, chest radiography or CT findings, and treatment strategies for COVID-19 patients in Sanya were similar to those of patients in other parts of China[11][12]. In addition, blood gas analysis showed that our cohort presented high lactate levels and metabolic alkalosis. The baseline serum levels of lactate, a product of glucose metabolism, are usually low but increase under long-term hypoxia. Therefore, the high lactate levels in critically ill patients is an indicator of tissue hypoxia and organ dysfunction. Serum lactate levels increase in response to infection, and high levels are correlated with the severity of infection[14]. Moreover, lactate is significantly associated with mortality[15]. The results of an observational study showed that high lactate levels at the onset of systemic inflammatory response syndrome were associated with progression to organ dysfunction and critical illness[16]. In our cohort, lactate levels in severe and critical patients were higher than those of patients with milder disease, indicating that the former were hypoxic and might require oxygen therapy. In addition, metabolic alkalosis is the most common acid-base disorder in critically ill patients and is accompanied by an increase in mortality[17]. In this study, the degree of metabolic alkalosis was higher in the severe-

critical group. Therefore, normalizing the acid-base balance is crucial during COVID-19 treatment.

Long distance travel, especially by car, may lead to fatigue, which increases the risk of severe disease. In our patients, travel history was not a risk factor for severe-critical COVID-19, which may be due to the small sample size. In addition, 32/74 (43.25%) patients had chronic conditions, especially cardiovascular and cerebrovascular diseases, which agrees with studies on Middle East respiratory syndrome coronavirus[12][18], and these conditions are a risk factor for severe-critical COVID-19, probably because the immunity of these patients is compromised.

Currently, there is no effective targeted therapy for SARS-CoV-2 based on high-level evidence, although some novel compounds and therapeutic agents appear to be effective against this virus, and several vaccine candidates and new drugs are being tested in clinical trials[19][20][21]. Clinical research has demonstrated that TCM combined with Western medicine may alleviate symptoms, improve the quality of life, and decrease the risk of pulmonary infection. Our cohort was treated with TCMs, especially Radix Fici Simplicissimae, from South China, combined with Western medicine. TCM treatment may improve clinical symptoms and can be used for managing COVID-19 in other tropical regions across the globe.

This study has several limitations. First, only 74 patients with confirmed COVID-19 were enrolled. Second, detailed patient information, particularly clinical outcomes, was unavailable at the time of analysis.

In conclusion, the clinical characteristics of COVID-19 in southern Hainan were similar to those reported in other regions, and most cases were severe and imported. The outbreak was relatively short in Sanya because the local government implemented several emergency actions to reduce the economic, health, and social burden of this disease.

Authors’ contributions

Author contribution: Ling Lin led the study; Sen Lin, Hua Zhang, Chang-Feng Lin, Zhi-Yong Liu, Zhi-Quan Wu, Juan Chen, Dong Liang, Yan-Tao Liu, Ya-Yun Tan, Chong-Hao Xing, Da-Ying Yang and Min-Jie Gao collected and analysed data, Bei Wang refined the analysis and wrote the manuscript, Ya-Yun Tan contributed to

study design and analysis. Bei Wang and Qin-Yi Chen finalized the manuscript. All authors have read and approved the manuscript.

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