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Special Article

Title: Anesthetic Management of Patients with Suspected 2019 Novel Coronavirus Infection During Emergency Procedures

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Structured Abstract

Objectives: To prevent cross-infection in the operating rooms by taking anesthesia management procedures for emergency procedures in patients with confirmed or suspected 2019-nCoV, and report clinical and anesthesia-related characteristics of these patients.

Design: This was a retrospective, multicenter clinical study.

Setting: This study used a multicenter dataset from four hospitals in Wuhan, China.

Participants: Patients and healthcare providers with confirmed or suspected 2019-nCoV from Jan 23 to Jan 31, 2020, at Wuhan Union Hospital, Wuhan Children's Hospital, The Central Hospital of Wuhan and Wuhan Fourth Hospital in Wuhan, China.

Interventions: Anesthetic management and infection control guidelines for emergency procedures in patients with suspected 2019-nCoV were drafted and applied in four hospitals in Wuhan.

Measurements and Main Results: Cross-infection in the operating rooms of these four hospitals has been effectively reduced by taking these measures and procedures. As for patients with laboratory-confirmed 2019-nCoV infection or suspected infection, majority of them were female (23 [62%] of 37); with a mean age of 41.0 years old (SD, 19.6; range, 4 to 78). Ten (27%) patients had chronic medical illness, including 4 (11%) with diabetes, 8 (22%) with hypertension, and 8 (22%) with digestive system disease. Twenty-five (68%) patients showed lymphopenia and 23 (62%) patients exhibited multiple mottling and ground-glass opacity on CT scanning.

Conclusions: Our study indicated that 2019-nCoV specific guidelines for emergency procedures in patients with confirmed or suspected 2019-nCoV may effectively
prevent cross-infection in the operating rooms. Most patients with confirmed or suspected 2019-nCoV presented with fever, dry cough, and developed bilateral multiple mottling and ground-glass opacity on chest CT scans.

**Key Words:** Infection control; Cross-infection; Occupational health; 2019 novel coronavirus; Viral pneumonia

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**Manuscript**

**Introduction**

A novel and ongoing outbreak of pneumonia was reported in Wuhan city, Hubei province, China\(^1\)–\(^3\), which has caused significant concerns internationally. Isolation of a novel coronavirus (CoV) from patients in Wuhan had been completed by the Chinese scientists. It was a novel betacoronavirus and named 2019 novel coronavirus (2019-nCoV)\(^4\). As of Jan 30, 2020, a total of 9692 laboratory-confirmed 2019-nCoV infections were reported in China, of whom 213 have died and with 1527 severe cases\(^5\).

Chaolin Huang and colleagues\(^2\) reported clinical features of the first 41 laboratory-confirmed patients with 2019-nCoV infections in Wuhan by Jan 2, 2020. Clinical manifestations were very similar to SARS-CoV. Dyspnoea developed in 22 (55%) of 40 patients. Patients with severe illness developed acute respiratory distress syndrome (ARDS) and required intensive care unit (ICU) admission, oxygen therapy and endotracheal intubation. Concurrently, human-to-human transmission was confirmed by Jasper Fuk-Woo Chan and colleagues\(^6\) and the recently documented infections in hospital staff caring for patients with 2019-nCoV\(^7\). Unfortunately, 15 hospital staff members, some of whom were working in the same ward, have been confirmed to be infected with 2019-nCoV in Wuhan Union Hospital\(^4\), although the possible role of so-called super-spreaders remain to be clarified.
Considering that many patients with SARS and MERS were infected in the hospital\textsuperscript{8}, precautions need to be taken to prevent nosocomial spread of this new 2019-nCoV virus. In particular, there is evidence of efficient human-to-human transmission with 2019-nCoV\textsuperscript{6,7,9}. Meanwhile, the first case of 2019-nCoV was reported in the United States\textsuperscript{10}. Patient presented with pneumonia and showed nonspecific signs and symptoms of mild illness. This undoubtedly increased the difficulty of early protective preparation for operating room personnel. Therefore, in containing the spread of 2019-nCoV in health-care settings, the Department of Anesthesiology, Wuhan Union Hospital has drafted a guideline for 2019-nCoV-related prevention and control, including emergency intubation, preoperative evaluation and infection control in the operating rooms. Furthermore, we aim to describe clinical features and anesthesia-related characteristics of patients infected with 2019-nCoV and suspected cases after emergency intubation and surgical anesthesia.

We hope the current study will help prevent cross-infections in the operating rooms by implementing strict anesthesia management and infection control procedures while caring for patients with confirmed or suspected 2019-nCoV. Moreover, the clinical features and anesthesia-related characteristics may provide further insights into 2019-nCoV from the perspective of anesthesiology.
Materials and Methods

Patients
For this retrospective, multicenter clinical study, we recruited patients with suspected 2019-nCoV from Jan 23 to Jan 31, 2020, at Wuhan Union Hospital, Wuhan Children's Hospital, The Central Hospital of Wuhan and Wuhan Fourth Hospital in Wuhan, China. All methods were conducted following the relevant regulations and guidelines of the institutional ethics committee of Tongji Medical College, Huazhong University of Science and Technology.

Data collection and procedures draft
We reviewed electronic medical records, anesthesia records, preoperative evaluation records, nursing records, laboratory findings, and chest x-ray and CT for all patients. Clinical outcomes were followed up to Jan 31, 2020. American Society of Anesthesiologists (ASA) physical status classification and Mallampati score were determined by skilled anesthesiologists. All data were collected and checked by two independent investigators. The procedures of anesthesia management for emergency procedures in patients with confirmed or suspected 2019-nCoV infection were drafted by an expert panel in Department of Anesthesiology, Wuhan Union Hospital.

Outcomes
We describe demographics, key clinical features (i.e., fever, cough), anesthesia-related clinical characteristics (i.e., ASA classification, Mallampati score, anesthetic methods), key laboratory findings (i.e., lymphocyte count) and chest x-ray and CT findings for all patients.

Statistical analysis
Data are expressed as mean (SD) and categorical variables as count (%). For laboratory results, we also assessed whether the measurements were outside the normal range. All statistical analysis was performed with GraphPad Prism version 8 (Graph-Pad Software Inc., San Diego, CA, U.S.) and SPSS software (version 25 for Mac; IBM, New York, USA)

Results
The choice of January 23, 2020 for starting this study was because of the Chinese
Lunar New Year started on January 23, and Wuhan also started to suspend public transportation on January 23, 2020 (Fig 1), after that time the major hospitals in Wuhan suspended all elective procedures. The four hospitals selected for this study were the closest hospitals to and 1 to 4 kilometers away from the Huanan Seafood Wholesale Market, the suspected origin of 2019-nCoV outbreak (Fig 2). Anesthesiologists in Wuhan have made great efforts to control this epidemic (Fig 3). Anesthetic management and infection control guidelines during emergency procedures in patients with confirmed or suspected 2019-nCoV had been drafted by an expert panel in Department of Anesthesiology, Wuhan Union Hospital in Fig 4 and detailed in Supplementary Materials: (I) Anesthesiologists’ Procedures for emergency intubation of patients with confirmed or suspected 2019-nCoV infection; (II) Precautions for 2019-nCoV infection in Outpatient Evaluation Center; (III) Precautions for 2019-nCoV infection control in the Operating Rooms. After adopting these above-mentioned procedures, four hospitals have completed a total of 321 cases of emergency surgical anesthesia, of which 37 patients were laboratory-confirmed or suspected with 2019-nCoV. A total of 3 healthcare providers were infected with 2019-nCoV in clinic settings from January 23, 2020 to January 31, 2020.

As for clinical features, 37 patients (5 confirmed and 32 suspected 2019-nCoV cases) were included in this retrospective, multicenter clinical study. In total, most patients were female (23 of the 37 patients), with the mean age of 41.0 years old (SD, 19.6; range, 4 to 78). Ten (27%) patients had chronic medical illness, including 4 (11%) with diabetes, 8 (22%) with hypertension, 8 (22%) digestive system disease, 3 (8%) with nervous system disease and 8 (22%) with respiratory system disease (Table 1). On admission and/or before anesthesia, many patients presented with fever [16 (43%)], cough [12 (32%)], or sputum production [2 (5%)] (Table 1). Twenty-five (68%) patients showed lymphopenia (lymphocyte count <1.1x10^9/L; (normal range 1.1–3.2); Table 1). According to chest x-ray and CT findings, abnormalities in chest images were detected among 30 (81%) patients. In particular, 10 (27%) patients exhibited bilateral pneumonia with 15 (41%) patients showing unilateral pneumonia.
23 (62%) patients exhibited multiple mottling and ground-glass opacity (Table 1). All patients underwent surgery under anesthesia, including 26 (70%) patients with general anesthesia, 11 (30%) patients with spinal anesthesia (Table 2). Types of surgery include abdominal surgery [10 (27%)], cardiovascular surgery [2 (5%)], orthopedic surgery [6 (16%)], obstetrics and gynecology surgery [11 (30%)], neurosurgery [2 (5%)] and others [6 (16%)]] (Table 2). Most patients [21 (57%)] were healthy or with well-controlled medical conditions (ASA physical status classification I and II). Only one (3%) patient with acute peritonitis was determined as ASA V (Table 2). Thirty-six (97%) patients were found to have Mallampati I/II and one with Mallampati IV on airway evaluations (Table 2).

For anesthesia duration, 28 (76%) patients underwent short operative anesthesia time (≤3 hour) and 9 (24%) patients underwent longer operative anesthesia time (>3 hour). Finally, as of Jan 30, 2020, 10 (27%) of 37 patients had been discharged and 27 (73%) patients were still being hospitalized, no patient had died (Table 2).

**Discussion**

In our study, we drafted and published anesthesia management and infection control guidelines for emergency procedures in patients with confirmed or suspected 2019-nCoV to prevent nosocomial infection. In the operating rooms in which infection control procedures are rigorously applied, the risk for staff to contract 2019-nCoV from patient contact is low, despite long exposure times. In addition, we reported the clinical and anesthesia-related characteristics of 2019-nCoV patients in four most affected hospitals in Wuhan, China.

On Jan 7, 2020, a novel coronavirus was identified by the Chinese Center for Disease Control and Prevention (CDC) and subsequently named 2019-nCoV by WHO. Coronaviruses mainly cause respiratory tract infections in humans, such as severe
acute respiratory syndrome (SARS)\textsuperscript{11,12} and Middle East respiratory syndrome (MERS)\textsuperscript{13,14}. In our study, most patients presented with fever, dry cough, and bilateral multiple mottling and ground-glass opacity on chest CT scans. These data are consistent with recent reports\textsuperscript{2,6,9}.

Transmission rates are unknown for 2019-nCoV; however, there is strong evidence of efficient human-to-human transmission\textsuperscript{6,7,9}. The number of infections is rising quickly. As of Jan 30, 2020, 9692 laboratory-confirmed 2019-nCoV infections were reported in China, with 213 fatal cases\textsuperscript{5}. In particular, 15 healthcare workers have been reported so far to be infected by 2019-nCoV, and 14 of whom were assumed to have been infected by are caring for 2019-nCoV patients, and the total healthcare workers infected are unknown currently, precautions and related management procedures need to be implemented immediately. This has challenged healthcare workers to use effective infection control procedures and measures. Anesthesiologists, as specialists in airway management, generally undergo endotracheal intubation in severe cases for hypoxia and provides emergency anesthesia for surgery in these cases. This undoubtedly increases the exposure risk for anesthesiologists because of frequent exposures to patients’ respiratory secretions and blood. Therefore, 2019-nCoV specific anesthesia guidelines need to be developed and used to avoid nosocomial spread of the virus.

Our results are consistent with recent reports, some infected patients had no obvious symptoms initially, including slight fever or even no fever\textsuperscript{2,9,10}. But it exhibited infectious characteristics during the incubation period (1-14-day medical observation period)\textsuperscript{7}. Transmission of 2019-nCoV probably occurs by means of large droplets and contact, and less so by means of aerosols and fomites. Meanwhile, exposure to oral and respiratory secretions at the time of endotracheal intubation will put anesthesiologists at high risk for infection. Therefore, all anesthesiologists who may be in contact with 2019-nCoV patients must take level 3 protective measures, detailed information is provided in Supplementary Materials. WHO have also released
important information that prompted healthcare workers caring for patients infected with 2019-nCoV to re-examine the precautionary procedures of infection control.

Diagnosis before entering the operating room is very important as well. The body temperature, laboratory findings (especially lymphocyte count) and chest x-ray and CT findings (especially multiple mottling and ground-glass opacity) should be confirmed before entering the operating room. If the patient has a fever with unknown cause, the examination results show pulmonary infection or low oxygen saturation of unknown cause (SPO$_2$ < 90%), and the surgery is not an emergency case, anesthesiologists should communicate with the patient, family and the surgeon to suspend the surgery. During anesthesia induction and surgery, close attention should be paid to heart rate, blood pressure, and oxygen saturation especially.

To prevent cross-infection in the operating rooms, single-use of all anesthetic equipment, utensils and drugs for each patient must be guaranteed. Anesthetic devices in contact with the respiratory tract, such as video laryngoscope lenses, plastic respiratory pipes, filters, respiratory balloons, suction tubes, and sputum suction tubes should be discarded after single use. Meanwhile, thorough disinfection and sterilization of the operating room should be conducted at the end of the operation day or immediately after the surgery suspected 2019-nCoV cases. The sterilization includes routine disinfection of the anesthesia machine, whole operating room ultraviolet radiation, disinfectant spray and mopping. All these procedures should be inspected by the infection control team for backtracking purposes. In addition, healthcare workers who are routinely exposed to viral respiratory infections in the hospital may transmit infection to others. Potentially contaminated clothing worn back to the operating room by healthcare workers cannot be ignored as well. Thus, transmission-preventive protocols and disinfection measures should be properly followed before entering the operating room after intubation, consultation or postoperative patient transportation in the areas suspected of 2019-nCoV infection. It is forbidden to take any potentially contaminated clothing back to the operating room.
Additionally, if healthcare workers develop the symptoms like fever, cough, soreness and feebleness etc. after contact with suspected/confirmed cases, evaluations such as blood test, C-Reactive Protein and pulmonary imaging should be timely acquired. If the following criteria are met, they should immediately report to the hospital and isolate themselves at home, even without direct contact with suspected/confirmed cases. Their vital signs and health conditions will be closely monitored, and they should receive proper diagnosis and treatment if their symptoms get worse.

Despite a series of precautionary measures suggested by our institutional guidelines, it is still difficult to consider all possible problems encountered in clinical practice. Questions concerning best practice remain. A low infection rate in operating rooms in four hospitals were demonstrated after following strict guidelines of infection control procedures. We believe that these protective measures are effective when rigorously applied and that this is responsible for the relatively low infection rate amongst our healthcare workers.

Conclusions
In summary, public health measures and precautions in health care settings are critical in controlling 2019-nCoV. The current study may prevent cross-infection in the operating rooms by means of implementing anesthesia and infection control management procedures for emergency procedures in patients with confirmed or suspected 2019-nCoV. Institution of similar measures might be important and, it is hoped, successful in reducing the nosocomial transmission of 2019-nCoV in the perioperative settings.

Supplementary Materials
Supplementary material associated with this article can be found in the online version at xxx.
References

1. December I: A novel coronavirus outbreak of global health concern. Lancet 6736:1–4, 2020

2. Huang C, Wang Y, Li X, et al: Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. [Internet] Lancet [Internet] 6736:1–10, 2020 Retrieved from: https://doi.org/10.1016/S0140-6736(20)30183-5

3. Zhu N, Zhang D, Wang W, et al: A Novel Coronavirus from Patients with Pneumonia in China, 2019. [Internet] N. Engl. J. Med. [Internet]:NEJMo2001017, 2020 Retrieved from: http://www.nejm.org/doi/10.1056/NEJMo2001017

4. WHO Retrieved from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019

5. CDC Retrieved from: https://www.cdc.gov/coronavirus/2019-ncov/index.html

6. Fuk-Woo Chan J, Yuan S, Kok K-H, et al: A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. [Internet] Lancet [Internet] Elsevier Ltd, 6736:1–10, 2020 Retrieved from: https://doi.org/10.1016/S0140-6736

7. Li Q, Guan X, Wu P, et al: Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus-Infected Pneumonia. [Internet] N. Engl. J. Med. [Internet]:1–9, 2020 Retrieved from: http://www.ncbi.nlm.nih.gov/pubmed/31995857

8. De Wit E, Van Doremalen N, Falzarano D, et al: SARS and MERS: Recent insights into emerging coronaviruses. [Internet] Nat. Rev. Microbiol. [Internet] Nature Publishing Group, 14:523–34, 2016 Retrieved from: http://dx.doi.org/10.1038/nrmicro.2016.81

9. Chen N, Zhou M, Dong X, et al: Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. 6736:1–7, 2020

10. Lofy KH, Wiesman J, Bruce H, et al: First Case of 2019 Novel Coronavirus in
the United States. N. Engl. J. Med.:1–9, 2020

11. Ksiazek TG, Erdman D, Goldsmith CS, et al: A novel coronavirus associated with severe acute respiratory syndrome. N. Engl. J. Med. United States, 348:1953–66, 2003

12. Drosten C, Gunther S, Preiser W, et al: Identification of a novel coronavirus in patients with severe acute respiratory syndrome. N. Engl. J. Med. United States, 348:1967–76, 2003

13. de Groot RJ, Baker SC, Baric RS, et al: Middle East respiratory syndrome coronavirus (MERS-CoV): announcement of the Coronavirus Study Group. J. Virol. United States, 87:7790–2, 2013

14. Zaki AM, van Boheemen S, Bestebroer TM, et al: Isolation of a novel coronavirus from a man with pneumonia in Saudi Arabia. N. Engl. J. Med. United States, 367:1814–20, 2012

15. Radonovich LJ, Simberkoff MS, Bessesen MT, et al: N95 respirators vs medical masks for preventing influenza among health care personnel: A randomized clinical trial. JAMA - J. Am. Med. Assoc. 322:824–33, 2019

Tables:

Table 1. Demographics, key clinical and laboratory features of 37 patients with confirmed/suspected 2019-nCoV infection. Data are n (%), n/N (%), and mean (SD).

2019-nCoV = 2019 novel coronavirus.

Table 2. Anesthesia-related clinical characteristics and clinical outcomes of 37 patients with suspected 2019-nCoV infection. Data are n (%) and n/N (%). ASA = American society of anesthesiologists

2019-nCoV = 2019 novel coronavirus.
Figure legend:

Fig 1. Timeline of early stages of 2019 novel coronavirus (2019-nCoV) outbreak.  
2019-nCoV = 2019 novel coronavirus.

Fig 2. Geographical map of four hospitals included in our study and Huanan Seafood Wholesale market. 
ASA = American society of anesthesiologists
Fig 3. Photo of healthcare providers including anesthesiologist, surgeons and nurses perform an emergency surgery.

Fig 4. Flow chart of anesthesia and infection control management guidelines for emergency procedures in patients with confirmed or suspected 2019-nCoV. 2019-nCoV = 2019 novel coronavirus; OR = Operating room.
Patients (n=37)

Characteristics

Age, years
- Mean (SD): 41.0 (19.6)
- Range: 4-78
- ≤39: 21 (57%)
- 40-59: 7 (19%)
- 60-69: 6 (16%)
- ≥70: 3 (8%)

Sex
- Female: 23 (62%)
- Male: 14 (38%)

Chronic medical illness
- Diabetes: 4 (11%)
- Hypertension: 8 (22%)
- Digestive system disease: 8 (22%)
Nervous system disease 3 (8%)
Respiratory system disease 8 (22%)

**Signs and symptoms**

**Fever**
- <37.3 21 (57%)
- 37.3–38.0 11 (30%)
- 38.1–39.0 5 (13%)
- >39.0 0 (0%)

Cough 12 (32%)
Sputum production 2 (5%)
Dyspnea 0

**Laboratory findings**

Lymphocyte count (× 10^9/L)
- <1.1 25 (68%)
- ≥1.1 12 (32%)

**Chest x-ray and CT findings**

- Unilateral pneumonia 10 (27%)
- Bilateral pneumonia 15 (41%)
- Multiple motting and ground-glass opacity 23 (62%)

Table 1. Demographics, key clinical and laboratory features of 37 patients with confirmed/suspected 2019-nCoV infection. Data are n (%), n/N (%), and mean (SD). 2019-nCoV = 2019 novel coronavirus.

| ASA classification | Patients (n=37) |
|--------------------|---------------|
| ASA I or II        | 21 (57%)      |
| ASA III            | 10 (27%)      |
| ASA IV             | 5 (13%)       |
| ASA V              | 1 (3%)        |
| Mallampati score          |          |          |
|--------------------------|----------|----------|
| Mallampati I             |          | 8 (22%)  |
| Mallampati II            |          | 28 (75%) |
| Mallampati III           |          | 0 (0%)   |
| Mallampati IV            |          | 1 (3%)   |

| Type of surgery                        |          |          |
|----------------------------------------|----------|----------|
| Abdominal surgery                      |          | 10 (27%) |
| Cardiovascular surgery                 |          | 2 (5%)   |
| Orthopedic surgery                     |          | 6 (16%)  |
| Obstetrics and gynecology surgery      |          | 11 (30%) |
| Neurosurgery                           |          | 2 (5%)   |
| Others                                 |          | 6 (16%)  |

| Anesthetic methods                  |          |          |
|-------------------------------------|----------|----------|
| General anesthesia                   |          | 26 (70%) |
| Spinal anesthesia                    |          | 11 (30%) |

| Duration of anesthesia (hour)        |          |
|-------------------------------------|----------|
| ≤1                                  | 6 (16%)  |
| 1-3                                 | 22 (60%) |
| 3-5                                 | 6 (16%)  |
| ≥5                                  | 3 (8%)   |

| Clinical outcome                    |          |
|-------------------------------------|----------|
| Hospitalization                     | 27 (73%) |
| Discharge                            | 10 (27%) |
| Death                               | 0        |

Table 2. Anesthesia-related clinical characteristics and clinical outcomes of 37 patients with suspected 2019-nCoV infection. Data are n (%) and n/N (%).

ASA = American society of anesthesiologists