Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Personal protective equipment during tracheal intubation in patients with COVID-19 in China: a cross-sectional survey

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Keywords: aerosol-generating procedure; COVID-19; personal protective equipment; SARS-CoV-2; tracheal intubation

Editor—Severe acute respiratory syndrome-related coronavirus-2 (SARS-CoV-2) is transmitted through droplet, contact, and aerosol routes with a basic reproductive number of 2.68.[1] About 17% of patients with coronavirus disease 2019 (COVID-19) develop acute respiratory distress syndrome, and 4% require tracheal intubation and mechanical ventilation.[2] Tracheal intubation is an aerosol-generating procedure. Healthcare workers (HCWs) who perform tracheal intubations have a three to six times greater risk of getting infected.[3] Several studies have recommended the highest level of personal protective equipment (PPE) available when taking care of infected patients.[4,5] However, the protective effects of different levels of PPE when performing tracheal intubation have not been fully studied. By collecting information on PPE use by HCWs, we aimed to evaluate the protective efficiency of different levels of PPE and make suggestions for the minimum PPE level required during tracheal intubation.

This study was authorised by the Airway Management Group of the Chinese Society of Anaesthesiology (CSA). The project was approved by Beijing Hospital and the requirement for written informed consent was waived by the institutional review board (No. 2020BJYEC-048-01). We conducted a cross-sectional survey among the hospitals designated for the treatment of COVID-19 in China. Chiefs of each anaesthesiology department were required to complete an online questionnaire giving detailed information on the number of anaesthetists in the department, PPE levels available at various different times, number of infected anaesthetists, PPE levels of infected anaesthetists, symptoms of infected anaesthetists, and their contact history with infected patients. Infection by SARS-CoV-2 was confirmed by reverse transcriptase polymerase chain reaction (RT–PCR). PPE levels in China were divided into four levels (PPE1–3^{+}; Table 1).[5] Questionnaires were uploaded to the Wenjuanxing platform (https://www.wjx.cn) on March 18, 2020 and remained through

Table 1 Level of personal protective equipment (PPE) worn by anaesthesiologists who became infected with severe acute respiratory syndrome-related coronavirus-2 (SARS-CoV-2). PPE1: surgical face mask, hand hygiene, gloves, scrubs, isolation gown, and disposable cap; PPE2: N95 mask respirator, choice between eye protection goggles or face shield, hand hygiene, gloves, scrubs, choice between isolation gown or protective clothing, disposable cap and disposable shoe covers; PPE3: N95 mask respirator, eye protection goggles, face shield, hand hygiene, gloves, scrubs, protective clothing, disposable cap, and disposable shoe covers; PPE3^{+}: all equipment needed in PPE3 and powered air-purifying respirator (PAPR).

	Total *n*=11 (%)	PPE1 *n*=6 (%)	PPE2 *n*=5 (%)	PPE3 *n*=0	PPE3^{+} *n*=0
Date of infection					
January 2020	9 (82)	5 (83)	4 (80)	0	0
February 2020	2 (18)	1 (17)	1 (20)	0	0

March 31, 2020. The website address was sent to the chiefs of designated hospitals by the CSA. Questionnaires from non-designated hospitals and hospitals without tracheal intubation cases of COVID-19 were excluded, along with any duplicated ones.

By March 31, 2020, we received a total of 101 responses of which eight met the exclusion criteria. The proportion of valid responses was 92%. Among the eight excluded responses, three were duplicates, two had no tracheal intubation cases, and the other three were from non-designated hospitals. A total of 1474 intubations were completed by 554 anaesthetists in the 93 hospitals included. In December 2019, January 2020, and February 2020, PPE 3–3^{+} was available in 30.1%, 48.4%, and 88.1% of hospitals, respectively. Four doctors, without contact history with infected patients in the hospital, were suspected to be infected through community transmission. Another 11 doctors had confirmed SARS-CoV-2 infection (by RT-PCR) after performing tracheal intubation, with an overall infection rate of 2% (Table 1). None of the 11 doctors had used PPE3 or PPE3^{+} when performing intubation. All of the 11 infected doctors had mild symptoms. Seven of the 11 infected doctors were infected after performing tracheal intubations in infected patients needing emergency operation under general anaesthesia in the operating room. The other four doctors were infected after performing tracheal intubation in infected patients in the ICU or the isolation ward.

An N95 mask respirator is recommended in aerosol-generating procedures and is included in PPE2 and above.[6] Our results revealed that five doctors using PPE2 were infected. In addition to what is included in PPE2, eye protection goggles, a face shield, and protective clothing are required in PPE3. The lack of a face shield leaves the facial skin unprotected and subject to be infected by aerosols. However, protective devices without eye goggles leave eye mucous membranes exposed to the air, even with a face shield on. SARS-CoV-2 can be detected in air 4 m from the patient[7] and is transmitted through droplets, contact, and aerosols.[8] Uncovered skin and mucous membranes could be contaminated by SARS-CoV-2.[9]

Our results suggest that besides the N95 mask respirator, both eye goggles and face shield are needed when performing tracheal intubation. Unlike protective clothing, an isolation gown cannot cover the whole body, which may be a reason for infection of doctors using PPE2. It should be noted that an N95 mask respirator, hand hygiene, gloves, scrubs, disposable cap, and disposable shoe covers were included in PPE2 and above. Our results suggest that an isolation gown without protective clothing might not be enough to protect HCWs from cross-infection by SARS-CoV-2 when performing tracheal intubation. Based on our results, we recommended PPE3 when performing tracheal intubation, although this may be excessive.

This study has some limitations. First, HCWs infected through other sources other than patients such as colleagues in the hospital could not be excluded. Second, PPE availability was different at different times and most doctors included performed more than one intubation case, which made it difficult to have all the protection information for every intubation. Different protective devices were used in different levels of PPE. Whether one or more of these devices could be deleted cannot be determined in this study and more studies are needed.

In conclusion, PPE3 appears to reduce the risk of HCW infection when performing tracheal intubation in COVID-19 patients. Our study suggests that N95 mask respirator, eye goggles, face shield, and protective clothing are indispensable during tracheal intubation.

Declarations of interest

The authors declare that they have no conflicts of interest.

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Pre-procedural screening for COVID-19 with nasopharyngeal polymerase chain reaction testing

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Editor—Non-emergent procedures ceased in many regions early in the coronavirus disease 2019 (COVID-19) pandemic to ensure adequate hospital resources for patient surges. As restrictions lift, we must resume normal operations while keeping patients, clinicians, and staff safe. An early case series from China reported poor outcomes for patients undergoing surgeries while unknowingly infected.[1] Coupled with concerns over clinician and staff exposure, these data led many centres to screen patients before procedures, primarily with nasopharyngeal polymerase chain reaction (PCR) testing.[2–4] We sought to assess the frequency of positive pre-procedural COVID-19 tests, to identify patient/procedural factors associated with testing positive, and to evaluate the need for more than one test.

We conducted a retrospective cohort study of all adult cases (surgeries and procedures) scheduled at the University of Miami Hospital and Clinics from April 1, 2020 to June 9, 2020. During this time, institutional practice was to obtain one or more nasopharyngeal PCR tests ≤72 h before procedures. Case-specific data, results of all PCR tests, and answers to screening questions (about symptoms, exposure, and travel) were obtained. Cases with no interpretable test results or set of screening questions within 7 days pre-procedure were excluded (Supplementary Fig. S1).

We used summary statistics to describe the cohort and χ^2 and Mann–Whitney testing to compare cases stratified by test positivity. On April 16, it became possible to provide indications for testing upon order entry; thus, as a sensitivity analysis, we separately evaluated cases with tests done within 7 days pre-procedure which were specifically marked as 'pre-procedural' (in contrast to, for example, symptoms concerning for COVID-19). The low test positivity rate precluded multivariable modelling. Among cases with more than one test, we evaluated the predictive accuracy of the first test for the second test. Institutional Review Board (IRB) approval was obtained from the University of Miami (#20200739).

Our cohort consisted of 4176 cases (3804 patients). Of these patients, 51.7% were male with a median age of 60 (interquartile range, 49–69) yr. Only 19 (0.5%; 16 patients) had at least one positive test (Table 1). Positive PCR cases were more likely to have positive symptoms screens (15.8% *vs* 3.4%; $P=0.003$); symptoms screening had low sensitivity (15.8%) and positive predictive value (2.1%) for PCR positivity. Out of 3536 cases (3240 patients) with at least one test marked specifically as 'pre-procedural', only eight (0.2%; seven patients) had at least one positive PCR test.

There were 480 (11.5%) cases with more than one test performed within 7 days pre-procedure (median time between tests was 1.75 [inter-quartile range, 0.98–3.20] days). Compared with cases with only one test performed, these multi-test cases were more commonly inpatients (35.2% *vs* 10.2%, $P<0.001$) undergoing elective procedures (65.4% *vs* 49.9%, $P<0.001$), often by otolaryngology (46.7% *vs* 2.1%, $P<0.001$). Nine (1.9%) cases had either of their first two tests positive; three on test #1, five on test #2, and one on both. The negative predictive value of the results of the first test for the results of the second test was 98.9%; the positive predictive value was 25.0%, specificity 99.4%, and sensitivity 16.7%.