Hybrid modified percutaneous dilatational tracheostomy reduces the risk of COVID-19 aerosol dissemination to healthcare workers; a prospective single centre study

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Abstract

Background Conventional tracheostomy and percutaneous dilatational tracheostomy (PDT) present risks of exposing health care workers to coronavirus disease (COVID-19). We report a hybrid modified percutaneous dilatational tracheostomy (hybrid MPDT) to reduce this risk of COVID-19 aerosol transmission. Methods We performed tracheostomy using a hybrid MPDT involving a combination of conventional tracheostomy and PDT. Hybrid MPDT requires a small incision and minimal dissection like conventional tracheostomy, followed by PDT without bronchoscope guidance and the use of an endotracheal tube cuffed at cricoid. Results Hybrid MPDT was successfully performed in 20 patients with COVID-19. The infection rate to medical staff was 0% and the average operation time was 6.45±1.02 min. Conclusion Hybrid MPDT may ensure rapid and safe airway management in critically ill COVID-19 patients.

ABSTRACT

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Conclusion Hybrid MPDT may ensure rapid and safe airway management in critically ill COVID-19 patients.

Keywords: COVID-19; Tracheostomy; Aerosol; Dissemination; Healthcare workers

Keypoints

- Hybrid modified percutaneous dilatational tracheostomy (hybrid MPDT) is defined as mixed tracheostomy procedure including conventional surgical tracheostomy and MPDT
- Hybrid MPDT needs only four instruments and no bronchoscope.
- Hybrid MPDT is found to enable rapid and safe airway management in critically ill COVID-19 patients.
- Hybrid MPDT could reduce this risk of COVID-19 aerosol transmission.
- Hybrid MPDT might be an useful tracheostomy procedure for the critically ill COVID-19 patients.

1 INTRODUCTION

COVID-19 was first detected in Wuhan, China in 2019 and has since spread worldwide.[1] Coronavirus 2 (SARS-CoV-2) has higher infectivity and transmission rates than severe acute respiratory syndrome (SARS).[2] The majority of those infected exhibit mild flu-like symptoms, but 20-30% of symptomatic patients require intensive care for respiratory distress due to pneumonia or ARDS (acute respiratory distress syndrome).[3] Some of these patients require mechanical ventilation, and procedures such as tracheostomy present the risk of occupational exposure due to aerosol dissemination.[4] Several reports have described means of minimizing aerosol transmission during and immediately after tracheostomy.[5,6] Here, we report a safe and rapid hybrid modified percutaneous dilatational tracheostomy (hybrid MPDT) technique that reduces the risk of COVID-19 aerosol transmission.

2 MATERIALS AND METHODS

2.1 Participants

We analyzed the incidence of infection to healthcare workers and clinical characteristics of patients with COVID-19 who underwent a tracheotomy from April 2020 to August 2021. We have performed hybrid modified percutaneous dilatational tracheotomy in 20 patients with COVID-19. The patients' preoperative physical condition was evaluated using Charlson Comorbidity Index Score (CCIS) and Acute Physiology and Chronic Health Evaluation II (APACHE II) Score. Mean time from intubation to the tracheostomy and decannulation, survival rate, operation time, and complications for tracheostomy were measured.

2.2 Ethical considerations

This study was approved by the Institutional Ethics and Research Committee of our institution (No. 2021-05-008) and performed in accordance with the Declaration of Helsinki and good clinical practice guidelines. All participants provided written informed consent

2.3 Surgical technique

At our institute, tracheostomy is performed in a negative pressure intensive care unit at a pressure -2.5 Pa by a tracheostomy team consisting of three individuals, that is, a surgeon (otolaryngologist), a first assistant (2^{nd} or 3^{rd} -year residents in the otolaryngology residency program), and a nurse (Figure 1). All members of the team wear level D protective clothing and powered air-purifying respirator (PAPR) equipment. Hybrid MPDT was devised to minimize the risk of SARS-CoV-2 transmission during and immediately after tracheostomy. The hybrid MPDT technique means a combination of conventional surgical tracheostomy and modified PDT. Initially, a small skin incision and minimal dissection are performed to access the trachea as for conventional tracheostomy, and then modified PDT is done using four instruments in the Ciaglia Blue Rhino Percutaneous Dilatational Tracheostomy Kit(Cook Critical Care, Bloomington, IN, USA). In detail, hybrid MPDT requires an initial horizontal minimum skin incision of < 1 cm in the neck, like conventional open surgical tracheotomy. Briefly, the trachea is exposed by making a vertical incision at the fascia center, and then the 2^{nd} or 3^{rd} tracheal cartilage is exposed. Using a cold knife, a 5 mm long incision is placed in tracheal membrane without tracheal cartilage resection, and then a hole (the tracheal window) is opened slightly with a mosquito forceps and the position of the endotracheal tube (ETT) is checked (Figure 2A). The location of the ETT tip is confirmed through the tracheal window by naked eye without using a bronchoscope. When the tip of ETT was not visible while slowly withdrawing the ETT, the ETT balloon was inflated to fix its position. A gradual dilator is inserted into the tracheal window (Figure 2B), and a guide wire is inserted along the dilator (Figure 2C). The dilator is then removed, and the guide wire left in place (Figure 2D). The tracheal window is then expanded using a 36Fr dilator (Figure 2E), and the tracheostomy tube is inserted along the guide wire, which is then removed (Figure 2F).

3. Results

Hybrid MPDT was successfully performed in 20 COVID-19 patients. No medical staff member was infected and the average procedural time was 6.45+-1.02 min. In two patients that received continuous heparin

infusion during ECMO (Extracorporeal membrane oxygenation), tracheostomy site bleeding occurred in subcutaneous soft tissue or the strap muscle, respectively. No other complication (e.g., pneumothorax or subcutaneous emphysema) was encountered.

Participants included 20 patients, 18 men and 2 women, with an overall mean (SD) age of 65.5 (8.07) years. Acute respiratory distress syndrome (ARDS) was the most common indication for tracheostomy (12 patients, 60%), followed by failure to wean ventilation without ARDS (4 patients, 20%), extracorporeal membrane oxygenation (ECMO) decannulation (3 patients, 15%), and need for sedation management (1 patient, 5%). A total of 20 patients, of which 0 (00.0%), 10 (50.0%), 6 (30.0%), and 4 (20.0%) had a CCIS of 0, 1–2, 3–4, and > 4, respectively. The mean (SD) APACHE II score for patients who received a tracheostomy was 8.4 (3.2). Mean (SD) time endotracheal intubation to tracheostomy was 18 (66) days. The mean (SD) time to discontinuation of mechanical ventilation was 31.4 (17.8) days; and from tracheostomy to decannulation, 49.5(18.50) days. The mean (SD) length of hospital stay for all patients was 65.5 (27.5) days. Mean (SD) follow-up periods after tracheotomy was 64 (35) days. The all-cause in-hospital mortality following tracheostomy in COVID-19 patients was 10% with two deaths.

4. Discussion

We describe a safe and rapid hybrid MPDT technique that reduces the risk of COVID aerosol transmission associated with tracheostomy or percutaneous dilatational tracheostomy (PDT). When performing procedures on critically ill COVID-19 patients, it is essential to minimize infection risk to medical staff. Several studies have devised various modified PDT techniques aimed at reducing the risk of occupational exposure. Takhar et al. suggested a modified PDT technique involving clamping of ETT and stopping the ventilator during the procedure.[5] However, during the ventilation pause, lack of tissue oxygenation is dangerous, especially in patients with diminished lung capacity, and preoxygenation extends procedural times. Our hybrid MPDT technique does not require preoxygenation, because the tracheal membrane incision does not take much time and the incision is too small to allow aerosol transmission. On the other hand, Vargas et al. proposed a modified PDT procedure for COVID-19 patients that included the use of a smaller ETT cuffed at the carina and a bronchoscope inserted between the ETT and the inner surface of the trachea.[6] However, replacing the ETT introduces the risk of aerosol formation and is time-consuming. In addition, because the ETT and bronchoscope are both present in the trachea, the procedure it is difficult to perform when the trachea is small and the field of view is obscured by sputum. The described hybrid MPDT technique is similar to that described by Paran et al. as it does not require a bronchoscope[7]. However, the point of Paran's technique, which was dependent on the touch sense of tracheal palpation, is not applicable when tracheal cartilages are calcified. Furthermore, blunt dissection of subcutaneous and pretracheal tissues with surgeon's finger can lead the unnecessary risk of wound infection.

In terms of operation time, the hybrid MPDT procedure seems to take less than conventional tracheostomy. Nishio et al. reported an average time for surgical tracheostomy of 27 min (range, 17 - 39 min).[8] In our patients, the average operation time was 6.71+-1.92 min, presumably because tracheal cartilage resection and unnecessary dissection were not performed.

Hybrid MPDT allows visually checking of ETT position and enables the position of the incision hole to be determined, which are not during conventional PDT, and does not require manpower to operate the bronchoscope. An experienced, small number of tracheostomy team is essential to perform safe tracheostomy in patients with COVID-19 and to minimize the risk of occupational infection.

In conclusion, hybrid MPDT comprised of conventional surgical tracheostomy and MPDT and involving the use of only four instruments and no bronchoscope was found to enable rapid and safe airway management in critically ill COVID-19 patients and to minimize the risk of occupational infections.

FIGURE LEGENDS

FIGURE 1 Tracheostomy team consists of a surgeon (otolaryngologist), a first assistant (2^{nd} or 3^{rd} -year residents in the otolaryngology residency program), and a nurse.

FIGURE 2 (A) After making a 5mm long incision for tracheal window, surgern opened slightly with a mosquito forceps and the position of the endotracheal tube is checked. (B) A gradual dilator is inserted into the tracheal window. (C) A guide wire is inserted along the dilator. (D) The dilator is then removed, and the guide wire left in place. (E)The tracheal window is then expanded using the guide wire. (F) The tracheostomy tube is inserted along the guide wire and the guide wire is removed.

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