Effect of Closed Suctioning on Reducing the Contamination Released into the Environment

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With the development of critical care medicine, mechanical ventilation is extensively used in the Intensive Care Units (ICUs). Patients receiving invasive mechanical ventilation require sputum suctioning either regularly or as required to clear secretions from the airway and maintain airway patency. Accordingly, the requirement to disconnect the breathing loop tube for sputum suctioning is determined by the use of open or closed modes of suctioning. At present, the open suctioning system is most commonly used for clearing airway secretions. Since resistance to bacterial strains is rapidly increasing, the possibility of open suctioning in contaminating the ICU environment is often questioned, which was investigated in this study.

This study was approved ethically by The First Hospital of Jiaxing (approval ID: 2018-087). A total of 60 critical patients admitted to the ICU of our hospital between January 2015 and October 2015 were selected. Inclusion criteria were as follows: (1) age ≥18 years, male or female; (2) patients receiving invasive mechanical ventilation by endotracheal intubation or tracheostomy; (3) clinical pulmonary infection score >6; and (4) leukocyte intracellular phagotrophy visible in a sputum smear. A random number table was used to divide the patients into the closed suctioning group (n = 30) and the open suctioning group (n = 30).

In the two groups, sputum was collected, and ordinary nutrient agar plates with a diameter of 9 cm were simultaneously placed 10 cm, 50 cm, 100 cm, 200 cm, and 300 cm in front of the endotracheal intubation site for 15 min to collect air culture samples. During sample collection, all culture plates were at the same height of 1.0 m from the ground. In addition, one control plate was placed 1.5 m away from the patient. The lid of the control plate was opened for 1 s and then closed for 15 min. The agar plates were placed in a 37°C incubator for 48 h, and the number of colonies that formed on each petri dish was observed and recorded. If the same type of bacteria was observed in both the air and sputum samples, they were determined to be consistent and used to calculate the percent identity.

The colony counts in air cultures collected 10 cm, 50 cm, and 100 cm away from the endotracheal intubation site in the open suctioning group were significantly greater than the counts in the closed suctioning group (colony-forming units [CFU]/plate: 72.3 ± 142.4, 57.8 ± 144.9 and 15.7 ± 26.2 vs. 3.4 ± 1.6, 3.3 ± 1.6 and 3.1 ± 1.5, $P < 0.05$). The differences between the colony counts from the air cultures collected 200 cm and 300 cm away from the endotracheal intubation site between the open and closed suctioning groups were not statistically significant (CFU/plate: 3.2 ± 1.6 and 2.5 ± 1.0 vs. 2.7 ± 1.6 and 2.2 ± 1.3, $P > 0.05$). These findings define an effective range of approximately 100–200 cm for pathogenic aerosols that spread by open suctioning, and this contamination occurs in a short time. Meanwhile, control plates included in the two experimental groups had similar colony counts (CFU/plate: 0.2 ± 0.4 vs. 0.1 ± 0.3, $P > 0.05$). Air culture results from typical patients with different suctioning methods are displayed in Figure 1.

In the open suctioning group, 29 dominant strains were obtained from the samples collected at 10 cm and used for

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Figure 1: Air culture results from typical patients with different suctioning methods. (a) Air culture obtained from a patient in the open suctioning group with severe infection and prominent cough reflex. (b) Air culture obtained from a patient in the open suctioning group with mild infection and poor cough reflex. (c) Air culture obtained from a patient in the closed suctioning group.

identification. The results were compared with those from sputum cultures, and 75.86% (22 strains) had the same type of pathogen in the two culture methods. One patient was excluded due to a very small colony count.

Although not fully confirmed, the potential negative effects of open suctioning are often questioned. These effects include potential contamination of the ICU environment and spread of drug-resistant bacteria by open suctioning.[1] Condensed water containing numerous pathogens may splash from the sputum and breathing loop tube during suctioning, and consequently, generate aerosols that contaminate the air. In addition, operators and surrounding items (bed, equipment, and other room items) may also be contaminated, and this effect could last for 5 months if *Acinetobacter baumannii* or other special pathogens are present.[2]

Theoretically, the closed suctioning system could overcome the above shortcomings. Currently, studies on closed tracheal suctioning are mainly focused on whether it can reduce the incidence of ventilator-associated pneumonia (VAP). However, majority of these studies failed to obtain satisfactory results, and showed that closed suctioning was unlikely to reduce the incidence of VAP.[3] The closed tracheal suctioning system is the only system recommended by the American Association for Respiratory Care and the Canadian Association of Critical Care Diseases.[4,5] However, it is not recommended in respiratory or critical care guidelines for China and other countries.

In this study, we assessed whether open suctioning could severely contaminate ICU environments, particularly whether it contaminates the air. The results showed that the air within 100–200 cm of the endotracheal intubation site is contaminated after open suctioning. Furthermore, dominant strains from air culture were highly consistent with those obtained in sputum cultures, and confirm a clear source of bacterial contamination. However, we believe that the prevention and control of VAP is a systemic task, which requires the combined effects of numerous measures. Thus, it is inappropriate to ignore the positive effect of one factor if it is unable to significantly reduce the incidence of VAP. The closed tracheal suctioning system has a definite positive effect, and it should be recommended in the ICU.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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