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Study on Bacterial Contamination of ICU Spare Ventilator Panel and Inlet Port

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Abstract: Objective To carry out microbial detection on ICU standby ventilator, to clarify the bacterial contamination of ventilator panel and inlet port, and to provide basis for standardizing the disinfection management of ventilator terminal. Methods Microbiological examination was carried out on 28 spare ventilator inlet ports and ventilator operation panels in 9 ICU using ventilators, and the implementation of routine treatment measures for spare ventilator panel and inlet ports was confirmed through on-site observation and interviews. Results The unqualified rate of microorganism culture for the spare ventilator panel was 70. 37%, and the unqualified rate of microorganism culture at the air inlet port was 10. 71%; 10 sets (35. 71%) spare ventilators use dust masks, 18 (64. 29%) Ventilator inlet port is protected by ventilator test tube or rubber plug. The qualified rate of microorganism culture of ventilator panel treated with dust mask was significantly higher than that of untreated group ($p < 0. 01$) Conclusion Bacterial contamination of spare ventilator panel cannot be ignored. Dust mask can reduce pathogenic microorganism contamination on the surface of ventilator panel. Regular cleaning and disinfection should be carried out on the spare ventilator panel and the air inlet port, dust prevention should be covered in time, and bacterial filters should be installed to reduce the risk of bacterial contamination of the spare ventilator.

Keywords: ICU, Ventilator, Panel, Air inlet port, Microbial contamination, Hospital infection, Cleaning, Disinfection

Mechanical ventilation is the main method for clinical treatment of respiratory failure, which can effectively improve the success rate of treatment for critically ill patients. Ventilator, as a common artificial mechanical ventilation device, has become the core life support equipment in ICU. Disinfection and treatment of ventilator terminals is an important link in the prevention and control of hospital infection. The Guidelines for Diagnosis, Prevention and Treatment of Ventilator-Associated Pneumonia (2013) [1] clearly point out that cleaning and disinfection of ventilator is one of the important preventive measures for ventilator-associated pneumonia. Clinically, more attention is paid to the disinfection management of ventilator pipelines, but there is a lack of microbial monitoring and management of the ventilator surface and the inlet port. The disinfection process of the ventilator in use is not standardized, the ventilator is not disinfected in time for standby after being removed, the standby ventilator panel is exposed, and the inlet and outlet ports of the standby ventilator are not protected from time to time. In recent years, reports of hospital infection of patients caused by ventilator pollution have gradually increased. Pathogenic microorganisms on the surface of ventilator are one of the important causes of hospital infection [2]. From November 14 to 18, 2017, our hospital's airway nursing team, with the strong support of the nursing department, hospital infection management department, microorganism room and other departments, carried out microorganism detection on the ventilator panel and inlet port of ICU standby ventilators in all departments of the hospital, so as to clarify the current status of ventilator terminal disinfection management, and

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to provide basis for standardizing ventilator terminal disinfection management.

1. Data and Methods

1.1 General Information Our hospital is a large-scale comprehensive third-class first-class hospital in central China with 6,000 beds. From November 14 to 18, 2017, the ICU of our hospital, which is currently using breathing machine, was selected by convenient sampling method for research. This study mainly involves 28 standby ventilators in 9 departments of respiratory ICU, extrathoracic ICU, intra-divine ICU, extra-divine ICU, comprehensive ICU, extra-traumatic ICU, extra-pediatric ICU, pediatric ICU and cardiac vascular ICU. Among them, 28 samples of the inlet port of the standby ventilator and 27 samples of the panel of the standby ventilator were collected (one of which was rejected due to suspected contamination during sample collection).

1.2 methods

1.2.1 Treatment method of ventilator surface and inlet port Disinfection of ventilator and its accessories in our hospital is strictly carried out in accordance with the Standard for Prevention and Control of Hospital Infection in Intensive Care Unit [3]: the ventilator shell and panel are cleaned and disinfected 1-2 times a day, the external pipelines and accessories of the ventilator are disinfected or sterilized one by one, long-term users are replaced weekly, and disinfection of the internal pipelines of the ventilator is carried out in accordance with the manufacturer's instructions. Specific disinfection scheme: under normal circumstances, wipe and disinfect with a chlorine-containing disinfectant with available chlorine of 500mg/L or a disinfected wet paper towel. if there is obvious pollution, disinfect with a chlorine-containing disinfectant with available chlorine of 1000mg/L twice a day (8:00, 15:00). the cleaning agent and disinfectant used shall be replaced each time. Ventilator pipes shall be replaced once a week. If there are visible stains or faults, replace them in time. After the patient withdraws from the machine, the external surface of the ventilator is disinfected by the above method immediately. The ventilator pipeline system shall be disinfected, replaced and maintained regularly according to the manufacturer's instructions. The inlet and outlet ports of the ventilator shall be protected against dust by a breathing circuit test tube or rubber stopper. The ventilator panel shall be covered with a dust mask.

1.2.2 Sampling and testing methods ① A self-designed data collection table was used to collect the covering treatment of ICU standby ventilator and protection of ventilator inlet port in each department through on-site observation and semi-structured interview methods, so as to clarify the management status of ventilator in standby state in each department. ② Carry out microbial sampling on the ventilator panel and inlet port of the standby ventilator. Before sampling the specimens, the hospital infection management department personnel shall train the members of the airway nursing professional team on the standardized sampling of microorganism detection. It is required to strictly follow the principle of aseptic operation in the sampling process and strictly control the quality of the tested samples. For example, if there are suspected contaminated samples in the sampling process, they should be discarded immediately and re-sampled. The ventilators in the standby state within 1 week after disinfection in the above 9 departments are sampled. The sampling location and specific operation steps are as follows: ① Ventilator inlet port. The sampler wears a sterile gloves, dips a sterile cotton swab in physiological saline and wets it, then evenly rotates the inner wall of the inlet port of the ventilator for one week to sample, and then places the sample in a sterile test tube containing 10mL of physiological saline. (2) Ventilator panel: the sampler wears a sterile gloves, dips in the normal saline with sterile cotton swabs, and then smears the 5cm×5cm gauge plate on the surface of the ventilator for 5 times horizontally and vertically, and rotates the cotton swabs accordingly, continuously collects the area of 1-4 gauge plates, and then puts them into a sterile test tube containing 10mL of normal saline. After the sampling is completed, the samples shall be numbered uniformly and sent to the microbiological examination room in time for microbiological culture. One ml sample was taken from a straw and inoculated into a common agar culture dish, 37. Incubate at 5℃ for 24 hours and observe colony count. For the samples with bacterial strains growing, continue to inoculate, separate and purify the bacterial strains, and perform mass spectrometry analysis for microbial typing.

1.2.3 Evaluation Standard According to China's Hospital Disinfection Health Standard [4], the average colony count on the surface of objects in Class II environment (including ICU) is ≤5cfu/cm2, so the colony count on the surface of ventilator inlet port and ventilator panel is ≤5cfu/cm2, which is qualified for disinfection.

1.2.4 Statistical methods used Excel2003 for data entry, SPSS13.0 software for data processing, frequency and percentage for statistical description, Fisher exact probability method, test level α = 0. 05.

2. Results

2.1 Results of microbial culture on ventilator panel and inlet port 28 samples were taken from the inlet port of ventilator, and 25 samples were qualified for bacterial culture (89. 29%), unqualified 3 (10. 71%); Pseudomonas cepacia, Enterococcus faecium and Escherichia coli were detected in 3 unqualified samples. 27 samples were taken from ventilator panels, and 8 samples were qualified for bacterial culture (29. 63%), 19 unqualified (70. 37%), Staphylococcus aureus, Acinetobacter baumannii, Pseudomonas aeruginosa, Enterococcus faecium and Candida tropicalis were the main microbial types detected in unqualified samples.

2.2 On-site observation of the treatment measures for the backup ventilator panel and the air inlet port shows that 10 of the 28 backup ventilators use dust masks (35. 71%), the qualified rate of ventilator panel microorganism culture under different treatment measures is compared, as shown in table 1. There are 18 (64. 29%) Ventilator port is protected by ventilator test tube or rubber stopper. See Table 2 for comparison of qualified rate of microorganism culture at ventilator inlet port under different treatment measures. There are 2 respirators (7. 14%), there are 4 sets (14. 28%) The standby ventilator did not take any protective measures. Semi-structured interviews showed that before the standby ventilator was turned on again, all departments did not reprocess the ventilator panel and port.

3. Discussion

Standardized and effective management of breathing machines can effectively control breathing.

The occurrence of machine-related pneumonia is an important measure to ensure patient safety [5]. In terms of storage and management of standby ventilators, Beijing Ventilator Cleaning and Disinfection Guidelines (Trial) [6] clearly point out that after disinfection.

Table1 Comparison of qualified rate of microbial culture on ventilator panel under different treatment measures

Treatment measure	Number	Qualified	Disqualification
Respirato	10	7(70.00)	3(30.00)
Untreated	17	1(5.88)	16(94.12)
Note: P<0.01			

Table 2 Comparison of qualified rate of microbe culture of ventilator inlet port under different treatment measures

Treatment measure	Number	Qualified	Disqualification
Respirato	18	17(94.44)	1(5.56)
Untreated	110	18(80.00)	2(20.00)
Note: P>0.01			

The ventilator installed, tested and corrected is in good standby state. It is required to put on an anti-dust cover, hang a sign marked "standby state" on a prominent position, place it in a clean, tidy and ventilated room, and be ready for

clinical application at any time. However, in clinical work, due to busy work, limited space in the instrument room and other factors, the standby ventilator fails to cover the dust cover strictly according to the requirements, and is stored on the medical hanging tower instrument bearing platform beside the patient's bed and other phenomena occur from time to time. At the same time, relevant guidelines and specifications have not yet been seen to clearly regulate the storage method of standby state of ventilator inlet and outlet ports.

3.1 Pathogenic microorganism pollution of ventilator panel cannot be ignored. Pathogenic microorganism pollution of ventilator panel is an important cause of hospital infection, but currently there is no relevant guide for disinfection of ventilator panel. In this study, the ventilator was wiped and disinfected with 500mg/L available chlorine chlorine-containing disinfectant or disinfected wet tissue under normal conditions. However, Staphylococcus aureus, Acinetobacter baumannii, Pseudomonas aeruginosa and other common important pathogenic bacteria causing ventilator-associated pneumonia can still be detected in the ventilator panel and air inlet port, which is basically consistent with the pathogenic bacteria detected in the ventilator panel in the studies of Rong Jufen and others [7] and Sui and others [8]. At present, there is no clear regulation on the disinfection frequency of the standby ventilator in the storage state, and the standby ventilator in our hospital does not require repeated disinfection, and some departments repeat disinfection once every 7 days. It is one of the important measures to prevent and control ventilator-associated pneumonia to strengthen the daily disinfection management and microbial dynamic monitoring of the external surface of standby ventilator.

3.2 Dust mask covering can reduce the pathogenic microorganism pollution of the ventilator panel. in this survey, the microorganism pollution of the ventilator panel was detected to be quite serious, with the colony count of the ventilator panel > 5 cfu/cm2 reaching 70. 37%. In the research of Rong Jufen et al. [7], the positive detection rate of pathogenic bacteria in ventilator panel reached 42. 5%. 9%, the pollution rate of ventilator panel in ICU was significantly higher than that in this study, which may be related to the spare ventilator not being strictly covered and dust proof. The results showed that the qualified rate of microorganism test of ventilator panel treated with dust mask was significantly higher than that of untreated group ($p < 0.01$). Reviewing the field investigation and interview results, it was found that more than half of the specialized ICU or comprehensive ICU placed the standby ventilator on the medical tower instrument bearing platform beside the bed of the standby bed unit for reasons such as the dangerous condition of critically ill patients, rapid changes, convenience for rescue, etc., without covering and dust proof treatment, and without being transported to the instrument room for centralized storage. Although effective terminal disinfection has been carried out, due to direct exposure to the surrounding environment, during the transportation of critically ill patients, personnel walking back and forth, and routine sputum aspiration and turning over, the body fluids and secretions of surrounding patients are transmitted through the hands and air of medical personnel, thus greatly increasing the risk of microbial contamination on the surface of the standby ventilator. Chen Si Yun et al [9] analyzed and maintained the daily failures of the Sevros ventilator during its use, and also proposed that if the ventilator is not used for a long time, it should be protected with dust cover in time and cleaned and maintained on time, with emphasis on preventing cockroaches from living and laying eggs in the ventilator. According to the clinical standby ventilator placed beside the bed, a disposable bedspread dust cover consisting of non-woven fabric and PE film can be designed and used, namely, the disposable bedspread dust cover can be taken out immediately and replaced in time, thus not only avoiding the risk of bacteria accumulation and pollution in the exposed state of the standby ventilator after disinfection, but also being convenient to take down and save for standby. At the same time, the standby ventilator in the instrument room shall be covered with dust mask in strict accordance with the requirements to reduce microbial colonization on the surface of the ventilator panel.

3.3 Necessity of Standardized Disinfection Management of Ventilator Inlet. In this study, 2 unqualified samples were found in the microbiological examination of the inner wall of the ventilator inlet, which may be related to the secretion of the upper respiratory tract of the patient entering the pipeline, pathogenic bacteria moving into the ventilation pipeline along the pipe wall or airflow and colonization, or incomplete disinfection and no filter in the inner and outer pipelines of the ventilator, and the medical personnel not paying attention to hand hygiene. There was no significant difference between the qualified rate of microorganism culture in air inlet protected by test tube or rubber stopper and untreated group ($P > 0.05$), may be connected to the ventilator test tube outlet port disinfection is not complete, resulting in conventional self-check air flow under the impact of bacteria move to the inlet end, or rubber plug is easy to fall off

repeated plug increases the probability of infection, may also be related to the sample size is too small. Foreign literature emphasizes the installation of a bacterial filter at the inlet of the ventilator, the patient's inspiratory tube and expiratory tube, and regular replacement to purify the air flow and prevent internal pipeline pollution [10]. There is no relevant regulation and relevant literature research in China. For the inlet port of the standby ventilator, the basic method to reduce the positive detection rate of bacteria is as follows: ① During the use of the ventilator, install bacterial filters on the inlet port, the suction pipe and the exhalation pipe, and ensure that one person can replace or disinfect the inlet port of the ventilator one by one to reduce the probability of pathogenic bacteria contamination. (2) Standardize the management method of terminal disinfection. On the basis of conventional surface disinfection, the air filter screen shall be cleaned and replaced regularly according to the manufacturer's instructions, and dismantled, cleaned and disinfected according to the difference of ventilator pipeline system. (3) do a good job in the protection of ventilator inlet and outlet ports. In the absence of dust cover, regular disinfection of ventilator test tubes and rubber plugs should be strictly implemented to meet the daily detection standard for hospital infection and avoid the pollution of ventilator inlet port caused by this.

4. Summary

In this study, microbial tests were carried out on the spare ventilator in ICU of our hospital. The results showed that the unqualified rate of microbial culture on the panel of the spare ventilator reached 70. 37%, and the unqualified rate of microorganism culture at the inlet port reached 10. 71%; Ventilator dust mask can reduce the pollution of pathogenic microorganisms on ventilator panel. Based on routine cleaning and disinfection, ventilator management strategies such as timely covering of backup ventilators for dust prevention and installation of bacterial filters are proposed to standardize artificial airway management. The sample size of this study is small, and the study is limited to one hospital. The research conclusion needs further verification by large sample study. In the later clinical work, we can continue to develop disposable ventilator dust cover, and explore the use effect, and discuss the effect of bacterial filter on improving the detection rate of microorganism in the inlet port of ventilator, so as to reduce the risk of pollution of standby ventilator and finally achieve the goal of reducing the incidence rate of hospital infection.

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