Prolonged Application of Closed In-Line Suction Catheters Increases Microbial Colonization of the Lower Respiratory Tract and Bacterial Growth on Catheter Surface

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Abstract

Background: Microorganisms become attracted to polymer surfaces for a number of reasons including positive charge of biomaterial or concentration of nutrients on the biomaterial surface. Many bacteria additionally possess specific receptors for the interaction with extracellular host protein components that adhere on the biomaterial surface. Several authors suggest that application of closed in-line polypropylene suction catheters (CISC) in intubated patients for more than 24 h is safe and can reduce the costs associated with mechanical ventilation. Therefore, we evaluated the possible role of prolonged application of CISC to cause enhanced colonization of both the biomaterial and the lower respiratory tract.

Patients and Methods: The prospective, randomized study included 23 mechanically ventilated patients. The CISC tips, adjacent segments and tracheobronchial aspirates of each patient were examined for microbial growth.

Results: Application for 72 h significantly enhanced the microbial growth on the CISC tips and on the adjacent catheter segment. Usage for 3 days led to a significant increase in colonization in the lower respiratory tract.

Conclusion: Normal saline instillation in conjunction with endotracheal suctioning may lead to a dispersion of microorganisms into the lower respiratory tract. More effective self-cleaning mechanisms are necessary to decontaminate the CISC surface after suctioning.

Introduction

Mechanically ventilated patients are at risk of developing ventilator-associated pneumonia [1]. The outcome of this nosocomial infection depends on several risk factors such as underlying disease and colonization of the respiratory tract with facultative pathogenic microorganisms [2–4]. Studies comparing single-use versus multiple-use suctioning systems (for 1-day usage) suggest that the risk of ventilator-associated pneumonia is similar in both suctioning systems [5–8].

The role of multiple-use in-line suction catheters in increasing colonization of the lower respiratory tract when applied for more than 24 h is controversial [9]. Manufacturers of in-line suction catheter systems recommend routinely changing the catheter every 24 h. This recommendation is based, in part, on the ability of bacteria to aggregate on the surface of biomaterial to form biofilms that may protect microorganisms from antibiotics and from host defense mechanisms [10–13].

Several intensive care units employ longer application intervals because the daily costs of closed systems are 11.6 times higher than single-use open system suction catheters [14]. Recent studies suggested that application of closed in-line suction catheters (CISC) for more than 24 h did not increase the risk of ventilator-associated pneumonia and might be safe [11].

The main focus of our randomized controlled trial was to compare the microbial colonization of CISC after in vivo application for 24 and 72 h, to prove whether the application for more than 1 day increases the content of bacteria or yeasts in the tracheal secretions of the patients and to examine the efficacy of the positive end-expiratory pressure (PEEP) seal.

Patients and Methods

Hospital and Patients

The study was conducted at a ten-bed intensive care unit of the Division of Pulmonology and Critical Care, Department of Cardiology, Angiology and Pulmonology and microbiological analysis was performed in the Institute of Medical Microbiology, both located at the Otto-von-Guericke-University, Magdeburg, Germany. Patients were entered into the investigation if they required mechanical ventilation while in the intensive care unit setting.

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Study Conditions
All patients potentially requiring mechanical ventilation for more than 4 days were included in our study. Patients were excluded if they had already received mechanical ventilation. No patient had undergone tracheotomy. Selective digestive decontamination was not administered in any case. For this investigation, a commercially available in-line suction catheter was employed (Ballard Trach Care/14 Ch/540 mm™). Each patient received two multiple-use systems for a total of 4 days in a randomized manner. Group one started with a first system that was replaced after 24 h. After this short period a second catheter system remained connected to the patients for 72 h. Group two started with a system left in place for 3 days before completing the study with a second CISC that was removed after 1 day. Tracheobronchial aspirate was collected to determine the content of colonization. Tracheobronchial secretions were always aspirated with a new, sterile catheter. Standard protocols were followed to intubate and suction the patients and to change ventilator equipment. Only results from patients who completed the study were taken into consideration. The same ventilator circuit tubing was used throughout each patient’s course of mechanical ventilation – unless the circuit became soiled or showed a mechanical failure. In-line suction catheters were inspected for function and mechanical failure or visible soiling (e.g. blood or emesis) every 2 h.

Figure 1a. Overview of a multiple-use in-line suction catheter connected to an oropharyngeal tube system (T). The catheter is covered with a plastic sheet (P). Suction regulation device (S). Rectangle 1 c,d surrounds the T-piece that connects the suction catheter and respirator unit. Rectangle 1b surrounds the cuff and the tip of the oropharyngeal tube.

Figure 1b. Position of the CISC tip and adjacent segment during suctioning procedure. The black marking shows the boundary between catheter tip and adjacent segment. Tip of the patient’s tube (T). Cuff of the oropharyngeal tube (C).

Figure 1c. T-piece of a CISC. The upper part (CT) is connected to the patient’s tube. Arrows demonstrate catheter movement. Connection to the respirator unit (R).

Figure 1d. Position of CISC tip and adjacent segment after catheter retraction. Every in-line suction catheter is colonized once it has been introduced into the tube and lower respiratory tract of a patient. By pulling the segments through the seal, a mechanical force is responsible for the reduction of adherent bacteria and mucus. All catheter segments except the tip are decontaminated after suctioning in the course of catheter retraction. It is obvious that a tight fit of the PEEP seal is necessary to reduce adherence of the patient’s slime and bacteria.