

Dissemination of Respiratory Secretions During Tracheal Tube Suctioning in an Intensive Care Unit

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Abstract

Most intensive care patients require frequent tracheal toilet, a procedure usually performed by suctioning the tracheal tube. Such procedures often result in the production and dissemination of droplets. We measured the distance visible droplets disseminated during tracheal tube suctioning of patients in an adult surgical intensive care unit. Fifty consecutive suction procedures in 14 patients intubated with a cuffed tracheal tube were investigated. Visible droplets were scattered over a mean distance of 60 ± 39 cm (range 25 to 168 cm) from the tracheal tube. Blood agar culture plates were placed at three fixed points from the tracheal tube to identify organisms resulting from environmental contamination (control plates). This was repeated during suctioning procedures (study plates) to look into the occurrence of bacteriological cultures that differ from the control plates.

Nine of the 14 patients had tracheal tube aspirate cultures done as part of their work-up for sepsis. In more than 30% of the suctioning procedures on these 9 patients, study plates grew bacteria that were similar to those present in their tracheal tube aspirates.

In view of these observations, greater care should be taken to avoid contamination of the patient's immediate environment during tracheal tube suctioning and in the design of the intensive care unit.

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Introduction

Tracheal tube suctioning is frequently performed in critically ill patients. This procedure often results in dissemination of droplets from the patient's respiratory tract with potential spread of respiratory tract microorganisms from one patient to another. Many intensive care units (ICUs) place several patients in a single large room with incomplete physical partition between patients. In such an open-unit arrangement, there is no barrier to the spread of airborne droplets. This investigation on the dissemination distance of visible droplets and bacteriological contamination of the patient's environment was prompted by a paucity of data relevant to current intensive care practices.

Materials and Methods

This study was conducted in an adult ICU of a tertiary care university hospital from 13 to 25 February 1995. Each day, one morning tracheal tube suctioning proce-

dures from each intubated patient in the ICU constituted one study procedure. In all, 50 tracheal tube suctioning procedures were performed on 14 patients during the study period (Table I). Informed consent was not required, as the study was done in accordance with the usual tracheal tube suctioning procedures.

Prior to each suctioning procedure, a plastic sheet was draped over the patient and a set of 3 blood agar culture plates (BBL) were placed as follows (Fig. 1):

A-105 cm caudad to the tracheal tube (mid-way along the length of patient's bed),

B-210 cm caudad to the tracheal tube (foot end of patient's bed),

C-75 cm lateral to the tracheal tube (mid-way between two adjacent patients' beds).

A standardised tracheal tube suctioning procedure was then performed. The attending nurse observed universal precautions by donning disposable mask and

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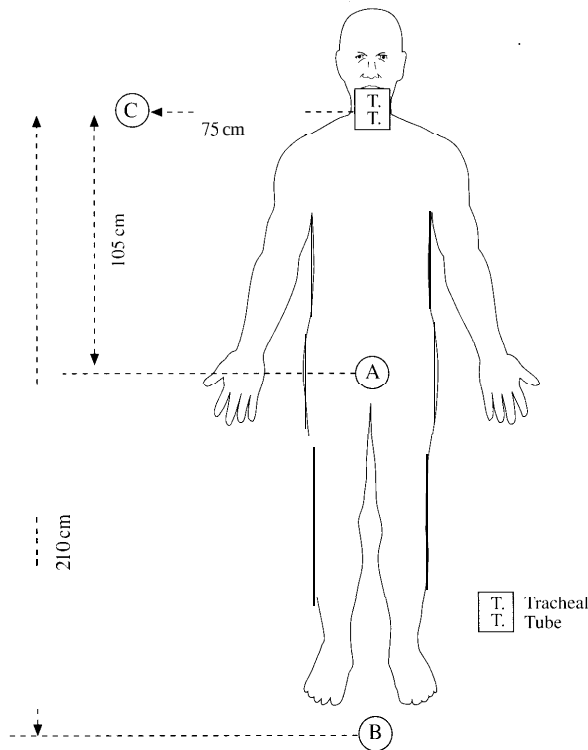


Fig. 1. Position of culture plates A, B and C

apron before washing hands. The sterile suction catheter package was handled in such a way that its sterility was maintained by keeping it coiled in the sterile gloved dominant hand. The non-dominant hand disconnected patient from ventilator and ventilator swivel connector was placed on a clean field. In the case of patients with thick secretions, 2 ml of sterile saline was instilled into the tracheal tube during inspiration. Patient was ventilated with resuscitator bag on 100% oxygen for $\frac{1}{2}$ to 1 minute, before the suction catheter was inserted as far as possible into the tracheal tube without applying suction. The catheter was withdrawn with a rotating motion as suction was applied. The duration of each suctioning episode was limited to no more than 15 seconds and suctioning pressure was limited to no more than -120 mm Hg. The suctioning sequence was repeated until secretions were cleared.

The tracheal tube was directed towards the foot end of the patient during suctioning. The distance from the tracheal tube to the furthest visible droplet on the plastic drape was measured. Results were grouped as 0 to 50 cm, 51 to 100 cm, 101 to 150 cm and >150 cm. The culture plates were incubated at 37°C in a carbon dioxide incubator for 18 hours. Gram-negative rods were identified by the use of Microbact system (DP Diagnostics, Adelaide South, Australia), while conventional methods were employed for Gram-positive organisms. A control set of culture plates were collected during the study period. Three plates were placed at similar positions (A,

B and C) as the study plates. They were exposed for a period of time similar to the duration of an average suctioning procedure. The control plates were incubated under similar conditions as the study culture plates. This was to identify bacteria that grew on the control culture plates independent of the tracheal tube suctioning procedure.

Bacteriological records of the 14 patients during the study period were reviewed. Organisms that were identified on tracheal tube aspirate cultures were noted.

Results

Visible droplets were scattered over a mean distance of 60 ± 39 cm (range 25 to 168 cm). In 2 suctioning procedures, dissemination went beyond 150 cm from the tracheal tube. The furthest distance recorded was 168 cm. Figure 2 summarises the dissemination distance of visible droplets.

Nine of the 14 patients had tracheal tube aspirate cultures done as part of their work-up for sepsis. Forty-two sets of study culture plates were done on these 9 patients. No bacteriological culture was done on the other 5 patients who had no clinical indication for the investigation. These 5 patients accounted for 8 sets of study culture plates (Table I).

Table II is a summary of the organisms that were identified on the tracheal tube aspirate culture of each of the 9 patients during the study period.

Table III summarises the bacteriological findings on the 42 sets of study culture plates from the 9 patients who had tracheal tube aspirate cultures done during the study period.

Thirteen (31%) of the culture plates at position A, 17 (40%) of those at position B and 17 (40%) of those at position C grew bacterial species similar to one or more of those identified on culture reports of tracheal tube aspirates. At each of the three positions, there was better

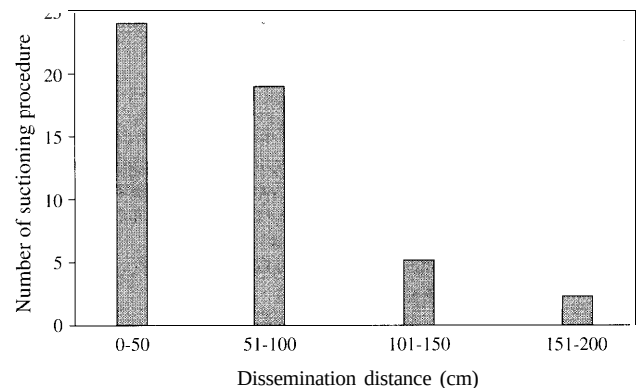


Fig. 2. Dissemination distance of visible droplets

TABLE I: PATIENTS AND NUMBER OF SUCTIONING PROCEDURES ENROLLED IN THE STUDY

Patient	13/2	14/2	15/2	16/2	17/2	18/2	19/2	20/2	21/2	22/2	23/2	24/2	25/2	Total
WKM	x	x	x	x	x	x	x	x	x	x	x	x	x	13
LKH*		x												2**
IAS														1
AK*	x	x												3**
c c c		x	x											2
FA														3
CRP					x	x	x	x	x	x	x	x	x	10
LLF*					x									1**
YH											x	x	x	8
BN								x						1
LML									x					1
KDS*														1**
CKS											x	x	x	3
LFH*													x	1**
Total	5	5	4	2	3	3	3	4	4	3	5	4	5	50

* No tracheal tube aspirate culture done.

** Procedures excluded from analysis of study plate culture results.

TABLE 11: RESPIRATORY ORGANISMS IDENTIFIED IN THE 9 STUDY PATIENTS

Patient	<i>K. pneumoniae</i>	<i>P. aeruginosa</i>	<i>A. baumannii</i>	<i>S. aureus</i>	<i>S. maltophilia</i>	<i>E. aerogenes</i>
WKM		x		x	x	
IAS			x			
c c c				x		
FA		x				
CRP	x		x			
YH						
BN	x					
LML	x					
CKS		x				

K. pneumoniae: *Klebsiella pneumoniae*

P. aeruginosa: *Pseudomonas aeruginosa*

A. baumannii: *Acinetobacter baumannii*

S. aureus: *Staphylococcus aureus*

S. maltophilia: *Stenotrophomonas maltophilia*

E. aerogenes: *Enterobacter aerogenes*

TABLE III: BACTERIOLOGICAL FINDINGS ON CULTURE PLATES A, B AND C

Culture plates	A	B	C
TTA	13	17	17
CCP	21	19	18
Others	3	3	1
NBG	5	3	6
Total	42	42	42

TTA: bacterial species similar to one or more of those identified on culture reports of tracheal tube aspirates from study patients

CCP: bacterial species similar to one or more of those identified on culture reports of control culture plates

Others: bacterial species other than TTA and CCP

NBG: no bacterial growth

correlation between study culture plates and control plates than between the former and tracheal tube aspirates.

Discussion

Tracheal tube suctioning of the intubated patient is a routine practice in the ICU. Visible droplet dissemination was detected in all 50 procedures and it was probable that dissemination of smaller droplets invariably occurred. The distance of dissemination depends to a large extent, on the intensity of the patient's cough reflex. Our study demonstrated that visible droplets can disseminate up to 168 cm from the point of suctioning. Droplets that are not visible to the naked eye can be expected to travel to an even greater distance.

Closed tracheal suction systems' were introduced about a decade ago (Fig. 3). With such systems, suctioning does not require disconnection of the patient from the ventilator. One such system, the Portex Stericath,² has been shown to effectively reduce environmental contamination during tracheal suction. However, closed suction systems are relatively costly. Funding for such systems



Fig. 3. A closed tracheal suction system

was not available to this study. Conducting this study with patients randomly assigned to either closed or open suction systems would have allowed us to more confidently demonstrate dissemination of respiratory secretions with the open system.

Coagulase-negative staphylococci, micrococci and corynebacteria were the predominant groups of bacteria isolated on the control set of culture plates. These are organisms that are normally present on skin scales." Shedding of skin scales by both patient and health care providers is a routine occurrence. This results in contamination of the surfaces of equipment and linen with such organisms. During the suctioning procedure, there is much physical movement and air turbulence. Shedded skin scales will be carried by air turbulence and contaminate the exposed culture plates. This is the likely explanation for the high degree of correlation in types of bacterial growth on the control plates and study plates.

Our study showed that 17 out of the 42 culture plates placed at 210 cm from the point of suctioning, grew bacteria similar to what was identified in the study patients' tracheal tube aspirate specimens. In a study of a hospital outbreak of multi-resistant *Acinetobacter anitratus*, Allen and Green⁴ identified the study organism in 16 out of 82 settle plates. Positive cultures were all obtained within 3 metres of 3 colonised patients. One of these 3 patients was ventilated and was colonised in the respiratory tract. This group also reported contamination of bed linen of colonised patients and previously culture-negative over-blankets of four empty beds. Bacteriological culture was positive in 8 out of 10 bed curtains around colonised patients; 1 of the curtains remained contaminated for 13 days after patient discharge. Although environmental cultures other than settle plates were not done in our study, the data on dissemination of secretions and bacteriological findings

on the settle plates suggest the presence of substantial environmental contamination.

Klebsiella pneumoniae, *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, *Staphylococcus aureus*, *Stenotrophomonas maltophilia* and *Enterobacter aerogenes* were identified in the tracheal tube aspirate cultures of 9 of the 14 study patients. *Acinetobacter baumannii* is known to survive for up to 13 days on a dry surface.⁵ Viability of bacteria in the dry state is known to be increased in the presence of proteins.⁶ In a more recent study by Smith et al,⁷ *Pseudomonas aeruginosa* and *Staphylococcus aureus* were found to survive for three to six months on a non-nutrient surface and a woven cotton fibre. These data support our concern that dissemination of bacteria in droplets during tracheal tube suctioning may persist in the ICU environment long enough to be a significant factor in the transmission of nosocomial infection in the ICU.

Zervos et al⁸ used plasmid profile as an epidemiological marker in their study of gentamicin-resistant *S. treptococcus faecalis*. Their data suggested nosocomial transmission and exogenous acquisition of *S. faecalis*. Out of 22 patients on the surgery service with gentamicin-resistant *S. faecalis*, 10 were geographically clustered in a 34-bedded hospital area. All 10 patients were infected or colonised with identical strains within a two-month period. Nourse et al⁹ also suggested that environmental contamination played an important role in patient-to-patient transmission of vancomycin-resistant *Enterococcus faecium* in a paediatric oncology unit. Using pulsed-field gel electrophoresis, they detected an identical strain in 10 of 12 *E. faecium* patient isolates and all of 5 *E. faecium* environmental isolates.

These data support our concern that environmental contamination resulting from tracheal tube suctioning in the ICU may contribute to patient-to-patient transmission of pathogenic organisms. Genetic typing techniques allow identification of strains within each bacterial species. Identification of a common strain in the tracheal aspirate of a patient and the corresponding study culture plates would have permitted greater confidence in postulating contamination of patient's environment during tracheal tube suctioning. Subsequent identification of the same strain in the tracheal aspirate of another patient would have suggested patient-to-patient transmission of respiratory tract microorganisms resulting from such environmental contamination. Unfortunately, genetic typing techniques were not available to this study.

Recommendations for Unit Design by the Society of Critical Care Medicine¹⁰ specify a minimum distance of 8 feet (240 cm) between beds in the ICU. Our study showed that bacteria have the potential to disseminate to a distance of 210 cm during tracheal tube suctioning. The open-unit structural design of this particular ICU

did not allow for study beyond the distance of 210 cm. This would have required opening the curtain barrier around the study patient and exposing the adjacent patient to a risk of direct contamination by the former.

Dissemination of droplets during tracheal tube suctioning carries the potential for uncontrolled environmental contamination with infected fluids arising from the patients' respiratory tract. In view of these findings, greater care must be taken to minimise dissemination of respiratory secretions during tracheal tube suctioning. Preventive measures should include:

1. Cordoning off patient with effective physical barriers (e.g. curtain from ceiling to below patient's bed) during procedure,
2. Staff attending to patient to don sterile hand gloves, disposable apron and face mask,
3. Hand-washing before and after procedure,
4. Disinfecting surfaces of equipment and furniture after procedure and patient discharge, and
5. Change of bedding and curtains after patient discharge.

Our study suggests a potential for the environment to be contaminated with organisms such as *Acinetobacter baumannii* and *Pseudomonas aeruginosa*. Besides *Staphylococcus aureus*, there is evidence in the literature that *A. baumannii* and *P. aeruginosa* stay viable in the ICU environmental surfaces for periods ranging from 13 days to 6 months.⁵⁻⁷

Many ICUs change curtains after patient discharge for multi-resistant *Staphylococcus aureus* (MRSA) cases. This practice arises out of concern over the long survival of *Staphylococcus aureus*, potential of infecting subsequent patients and difficulty in treating infection with a very resistant bacteria. We feel that the same practice of changing curtains should be applied to other multi-resistant bacterial species as well. In view of the implications of environmental contamination and patient-to-patient transmission of nosocomial organisms, we suggest that curtains be changed upon patient discharge when tracheal tube suctioning has caused visible soiling.

Most of the other measures are being practised in the ICU. We hope to reinforce awareness of the problem and the importance of adopting such measures to minimise dissemination of respiratory secretions during tracheal tube suctioning.

Conclusion

Our study suggests a potential for the ICU patient's environment to be contaminated with respiratory tract microorganisms during tracheal tube suctioning. Evidence in the literature indicates that such microorganisms remain viable in the ICU environment for periods ranging from 13 days to 6 months.⁵⁻⁷ We express our concern that such contamination may play a role in

patient-to-patient transmission of such microorganisms. We reiterate the importance of preventive measures to minimise dissemination of respiratory secretions during tracheal tube suctioning in the ICU. We suggest that the common practice of changing curtains after discharge of MRSA patients be applied also to patients with other multi-resistant bacterial species.

Further investigations are needed to proof or disproof that environmental contamination can contribute to patient-to-patient transmission of nosocomial organisms. More studies are also needed to examine whether the use of closed tracheal suction system will influence the dissemination distance of droplets and environmental contamination during suctioning.

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