

Alcohol-based hand rub and ventilator-associated pneumonia after elective neurosurgery: An interventional study

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Abstract

Background: Interventional studies on the effect of alcohol-based hand rub on ventilator-associated pneumonia (VAP) among neurosurgical patients are scarce. **Aim:** To observe the effect of alcohol-based hand rub on tracheobronchial colonization and VAP after elective neurosurgical procedures. **Materials and Methods:** An interventional study using a “before–after” design in a tertiary care center in Kerala. Two 9-month study periods were compared; between these periods, an infection control protocol incorporating an alcohol-based hand rub was implemented for a period of 3 months and continued thereafter. Consecutive patients who required mechanical ventilation after neurosurgery between January and September 2006 and 2007, respectively, were included. Outcome measures included VAP rate, tracheobronchial colonization rate, profile of microorganisms and patient survival. **Results:** A total of 352 patients were on mechanical ventilator for a varying period of 1–125 days. The patients in the control and intervention groups were similar with regard to sex, age and type of neurosurgery. Tracheobronchial colonization was seen in 86 (48.6%) of 177 in the control group and 73 (41.7%) of 175 among the intervention group ($P = 0.195$). The VAP rates in the control and intervention groups were 14.03 and 6.48 per 1000 ventilator days ($P = 0.08$). The predominant organisms causing VAP and tracheobronchial colonization were *Klebsiella* and *Pseudomonas aeruginosa*, respectively, in both groups. Patient survival rates were 87.6% (control) and 92% (intervention). **Conclusion:** Clinical results indicated a better outcome, showing a reduction in tracheobronchial colonization rate and VAP rate, although this was not statistically significant.

Keywords: Alcohol-based hand rub, hand hygiene, neurosurgical, tracheobronchial colonization, ventilator-associated pneumonia

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Introduction

Ventilator-associated pneumonia (VAP) is one of the most common healthcare-associated infections (HAIs) acquired by adults and children in intensive care units (ICUs).^[1] The mortality associated with VAP is 25–50%.^[2] The incidence of VAP was 6.5 in Neurosurgical intensive care units (NSICUs),^[3] and ranged from 2.1

to 11.0 per 1000 ventilator days in various types of hospital units within the National Health Care Safety Network (NHSN) facilities during 2006–07.^[4] Many evidence-based guidelines and ventilator care bundles have come into practice to reduce the incidence of VAP. Recent publications report rates of VAP as 10.4 cases per 1000 ventilator days after the introduction of multiple interventions.^[5] The introduction of an electronic dashboard for monitoring ventilator bundle compliance has reduced the incidence of VAP to 9.3 cases per 1,000 ventilator days.^[6] Alcohol-based hand rub and hand hygiene are also included as part of ventilator care bundle.^[7–10] Hand hygiene is an effective strategy for the prevention of HAIs. Hand rubs may be an alternative to hand washing,^[11] and are the first choice according

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to the World Health Organisation (WHO) and Centers for Disease Control and Prevention (CDC) guidelines. Studies have shown that an alcohol-based antiseptic rub decontaminates hands effectively for a wide variety of organisms.^[12,13] The objective of the present study is to assess the effect of alcohol-based hand rub on tracheobronchial colonization and VAP rate after elective neurosurgical procedures.

Materials and Methods

This study was undertaken in the Neurosurgical Department of a 239-bed tertiary-level referral hospital in Kerala, India. This department has a bed strength of 50, which consists of a 37-bedded ward and a 13-bedded ICU, and performs approximately 1300 elective adult and pediatric neurosurgical procedures annually. Majority of these procedures are performed under general endotracheal anesthesia and the patients' trachea are extubated in the operating room itself. However, some of these patients require prolonged mechanical ventilation and are cared initially in the NSICU and later transferred to the intermediate ICU/neurosurgical ward. Tracheal aspirate is sent for bacterial culture and sensitivity at the time of tracheal extubation or after 48 h of tracheal intubation. All mechanically ventilated neurosurgical patients are maintained on semirecumbent position (30°–45° elevation of the head end of the bed) unless contraindicated, stress ulcer prophylaxis using H₂ receptor blocking agent and deep vein thrombosis prophylaxis measures. These patients also received chlorhexidine (0.2%) oral care twice a day. The anesthetists practice early weaning and early tracheal extubation. Nurses provide complete care to patients on mechanical ventilators. Nurses performed sterile endotracheal suctioning using single-use suction catheters, and used separate suction catheters for oral suctioning. Closed method of endotracheal suctioning was not in practice. Parenteral antimicrobial agents were started shortly before operation and discontinued after 2 days. In this department, health care workers used soap and water for maintaining hand hygiene, and the use of alcohol-based hand rub was limited to decontaminating hands before invasive procedures. The infection control nurse (ICN) of the institute maintained the concurrent record of VAPs by direct method of surveillance, based on CDC criteria.

The details of the infection control protocol implementation are reported elsewhere.^[14] To summarise, we inculcated the habit of using chlorhexidine/alcohol skin antiseptic with emollient and moisturizer before and after each patient contact through a series of lectures, demonstrations and hand hygiene promoting post-

ers. The easy accessibility of alcohol-based hand rub at the bed side promoted its use by all the health care workers before and after each patient contact, including suctioning/manipulation of ventilator circuits. The implementation phase extended from October 2006 to December 2006.

VAP is defined as pneumonia in a patient intubated and ventilated at the time of or within 48 h before the onset of the event.^[15] The VAP rate is defined as the number of VAP per 1000 ventilator days. In the present study, VAP was considered to be present when such a condition was diagnosed and treated based on clinical and chest X-ray criteria combined with positive culture of tracheal aspirate in neurosurgical patients who were on mechanical ventilator during the study period. The rest of the cases, where only the tracheal aspirate was positive, were considered separately as tracheobronchial colonization.

To determine the number of ventilator days, the CDC recommends that the data on number of patients receiving mechanical ventilation be collected daily at the same time each day by specific surveillance units. The specific time of day at which to determine the presence of a ventilator however is not given. In this study, 3 pm was taken as the monitoring time for calculating the number of patients on ventilator, taking into account the shift change of the nurses at 3 pm. The change of shift nurses' record would indicate whether the patient was on mechanical ventilator or not. In addition, each patient's actual number of ventilator days was also calculated from the time of tracheal intubation to either tracheal extubation or discontinuation of positive-pressure ventilation, whichever is earlier. Ventilator days for patients whose trachea were reintubated during the same hospitalization were added together to avoid duplication of patients. The primary author did these calculations by referring each patient's medical records (anesthesia record, nurses' record). Number of hospital days, post-operative days and ICU days were also calculated from the medical records. Positive-pressure ventilation for more than 48 h is considered as prolonged ventilation. The supply of alcohol-based hand rub to the NSICU was reviewed from the pharmacy supply records.

An observational study (before-after design) was undertaken. The duration of the study extended from 1st January 2006 to 30th September 2007, excluding the infection control protocol implementation period from October to December 2006.

The patients in the before intervention group (control

group) included all patients who were admitted to the NSICU and were on mechanical ventilator after neurosurgery during the 9 months between 1st January 2006 and 30th September 2006 before protocol implementation. The patients in the intervention group included all patients who were admitted to the NSICU and were on mechanical ventilator after neurosurgery during the 9 months between 1st January 2007 and 30th September 2007 after protocol implementation. We excluded the patients who had undergone neurosurgery during the transition period of protocol implementation (October–December 2006).

The operating theater registers of the Department of Neurosurgery covering the study period were reviewed for getting the patients' details like age, sex, diagnosis, type of surgical intervention and evidence of subsequent repeat surgery. The tracheal aspirate culture and sensitivity reports of these patients were reviewed from the records of the Department of Microbiology. HAI data maintained by the ICN were reviewed. The medical records of those patients whose tracheal aspirates were cultured were counterchecked for evidence of VAP, tracheobronchial colonization, calculating ventilator days, duration of ICU stay, post-operative stay, hospital stay and discharge status, as discussed earlier.

The *t* test, chi-square tests or Fisher exact tests were carried out to assess statistical significance of the comparisons. For the VAP rates, 95% confidence intervals were calculated. Data were analyzed using SPSS statistics version 17.0 and OpenEpi version 2.3.1. A *P*-value of 0.05 or less was the criterion used to conclude statistical significance.

Results

There were 352 patients, 177 in the control group and 175 in the intervention group, who required mechanical ventilation. The age of the control group ranged from 0.25 (3 months) to 76 years, with a mean \pm SD of 40.37 ± 18.27 years, and that of the intervention group ranged from 0.25 to 76 years, with a mean \pm SD of 38.68 ± 18.34 years ($P = 0.386$). Male predominance was noticed among both control (52.5%) and intervention groups (52.6%), but the difference between the groups was not significant ($P =$

0.996). The study periods of the control and intervention groups were similar – a period of 9 months from January to September of two consecutive years, 2006 and 2007. Craniotomy was the predominant surgery among both control (82.5%) and intervention groups (84.6%), and there was no difference between the groups with regard to type of neurosurgery ($P = 0.598$).

During the study period, a total of 15 episodes of VAP occurred during a total of 1485 ventilator days (monitoring time 3 pm) among 352 patients [Table 1]. Among the control group, 10 episodes of VAP were noted out of 772 ventilator days among 177 patients and in the intervention group, five episodes of VAP were noted out of 713 ventilator days among 175 patients. This calculates to a VAP rate of 14.03 per 1000 ventilator days in the control group (95% confidence interval [CI]: 6.72, 25.79) and 6.48 per 1000 ventilator days in the intervention group (95% CI: 2.09, 15.11) ($P = 0.08$). The reduction was not statistically significant when the actual number of ventilator days (calculated as discussed earlier) were considered ($P = 0.07$).

The month-wise distribution and outcomes based on the presence of VAP showed that there was zero VAP during two consecutive months in both the groups. Nevertheless, in the intervention group, zero VAP was noted during two more months. In all three quarters, mean VAP rate was lesser in the intervention group [Table 2].

Tracheobronchial colonization in the control and intervention groups were 48.6% and 41.7%, respectively ($P = 0.195$). However, a strong association was found between tracheobronchial colonization and VAP. Of the 352 patients on ventilator, 193 had sterile tracheal aspirate and none of them developed VAP, whereas all the 15 patients who developed VAP had tracheobronchial colonization ($P = 0.000$).

A significantly higher percentage of patients in the control group had more than one tracheal intubation than the intervention group (28.2% and 14.9%, $P = 0.002$). However, more than one tracheal intubation was not found to be a significant risk factor for the development of VAP ($P = 0.1$) [Table 3].

Table 1: VAP rate in the control and intervention groups: Ventilator days monitoring time 3 pm/actual number of ventilator days

Control group (n = 177)		Intervention group (n = 175)		P
Ventilator days	VAP rate (95% CI)	Ventilator days	VAP rate (95%CI)	
Monitoring time 3 pm 713	14.03 (6.72, 25.79)	772	6.48 (2.09, 15.11)	0.08
Actual number of ventilator days 672.37	14.87 (7.1, 27.4)	753.19	6.64 (2.14, 15.49)	0.07

VAP: Ventilator-associated pneumonia

Table 2: Month-wise distribution of VAP in 352 neurosurgical patients on mechanical ventilator between January and September 2006 and 2007

Month	Control				Intervention			
	VAP absent	VAP +	Ventilator days		VAP absent	VAP +	Ventilator days	
			Range	Total			Range	Total
January	18	1	1-15	34	29	0	1-20	44
February	21	2	1-125	225	18	1	1-98	137
March	19	2	1-59	80	16	1	1-82	215
VAP rate 1 st quarter			14.75				5.05	
April	29	1	1-46	81	33	0	1-11	43
May	22	1	1-39	67	26	1	1-48	91
June	13	1	1-18	47	20	1	1-19	54
VAP rate 2 nd quarter			15.38				10.63	
July	17	2	1-71	113	11	1	1-67	87
August	16	0	1-4	17	11	0	1-50	63
September	22	0	1-12	49	11	0	1-20	38
VAP rate 3 rd quarter			11.17				5.32	
Total	177	10	1-125	713	175	5	1-98	772

VAP: Ventilator-associated pneumonia

There were 45 (35%) patients in the control group and 52 (44%) patients in the intervention group who required prolonged ventilation (>48h) or (more than 48 h). Among the total 15 patients who developed VAP, all except one patient in the control group had prolonged ventilation. In spite of having more patients with prolonged ventilation in the intervention group, which is a known risk factor for the occurrence of VAP, a reduction in VAP rate was observed among the intervention group [Table 3].

The mean number of ventilator days in the control group and intervention group were 3.8 ± 13.47 and 4.3 ± 12.88 , with a range of 1-125 days and 1-98 days, respectively ($P = 0.72$). The mean duration of ICU stay in days in the control group and intervention group were 6.73 ± 6.06 and 7.07 ± 9.594 ($P = 0.69$), with a median of 5 days in both groups. The mean duration of post-operative stay in days in the control group and intervention group were 13.67 ± 14.45 and 15.2 ± 14.54 ($P = 0.32$), with a median of 10 and mode of 7 in both groups. The mean duration of hospital stay in days in the control group and intervention group were 20.38 ± 15.62 and 21.62 ± 14.954 ($P = 0.45$), with a median of 16 and 18, respectively.

Patients with VAP had increased duration of ICU stay, post-operative stay and hospital stay in both control and intervention groups compared with patients who had not developed VAP. Patients with VAP had increased mean ICU stay (26 vs. 6 days), increased mean post-operative stay (51 vs. 13 days) and mean total hospital stay (56 vs. 19 days).

Patient survival rates in the control and intervention groups were 87.6% and 92%, respectively, which was not

Table 3: Ventilatory characteristics and outcomes in patients who underwent neurosurgical procedures between January 2006 and September 2007

Ventilatory characteristics	VAP absent n (%)	VAP present n (%)	P-value
More than one intubation			
One intubation only	267 (96.7)	9 (3.3)	
More than one intubation	70 (92.1)	6 (7.9)	0.1
Prolonged ventilation			
<48 h	260 (99.6)	1 (0.4)	
≥48 h	77 (84.6)	14 (15.4)	0.000
Total	337 (95.7)	15 (4.3)	

found to be significant ($P = 0.17$). Six of the 22 patients who died among the control group and two of the 14 patients who died among the intervention group had VAP. Among the patients who developed VAP, six of 10 in the control group (60%) and two of five (40%) in the intervention group died. However, none of these were attributed to VAP.

The most common microorganism isolated from the tracheal aspirate in the control group as well as the intervention group was *Klebsiella pneumoniae* (58% and 75%), whereas the most common microorganism isolated from the tracheal aspirate of patients with VAP in the control group as well as the intervention group was *Pseudomonas aeruginosa* (50% and 60%). An interesting fact to note here is the reduction in percentage of VAP in relation to the tracheobronchial colonization in the case of *P. aeruginosa*. Five of six (83.3%) tracheobronchial colonization with *P. aeruginosa* resulted in VAP in the control group, whereas it was three of eight (37.5%) in the intervention group [Table 4].

A reduction in tracheobronchial colonization and the

Table 4: Positive isolates from the tracheal aspirates of the control and intervention groups

Isolates	Control		Intervention	
	Tracheobronchial colonisation	VAP	Tracheobronchial colonisation	VAP
Gram negative				
<i>K. pneumoniae</i>	50 (58.14)	2 (20)	55 (75.34)	2 (40)
<i>P. aeruginosa</i>	6 (6.98)	5 (50)	8 (10.96)	3 (60)
<i>A. calcoac</i>	1 (1.16)		2 (2.74)	
Non-fermenter	4 (4.65)		2 (2.74)	
Enterobacter	7 (8.14)	1 (10)	2 (2.74)	
<i>E. coli</i>	2 (2.32)		2 (2.74)	
Gram positive				
<i>S. aureus</i>	11 (12.79)	2 (20)	1 (1.37)	
Streptococci	5 (5.81)		1 (1.37)	
Total	86 (100)	10 (100)	73 (100)	5 (100)

absence of VAP with Gram-positive organisms in the intervention group could be attributed to the use of alcohol-based hand rub.

The average monthly use of alcohol-based hand rub in the NSICU has increased from 1.7 L during the control period to 19.5 L during the intervention period, implicitly indicating the increased adherence of health care workers to the alcohol-based hand hygiene protocol.

Discussion

The main outcome measure in this study was the effect of alcohol-based hand rub on VAP. VAPs, as previously defined, were documented in 10 patients in the control group and five patients in the intervention group. The VAP rates in the control and intervention groups were 14.03 and 6.48 per 1000 ventilator days, respectively. Although this reduction was not statistically significant, we could achieve a reduction in VAP rate at par with published studies from other countries.^[3-6,16] Nevertheless, Arabi *et al.* reported a higher VAP rate in developing countries than the NHSN benchmark rates, based on a recent systematic review.^[17]

CDC strongly recommends to decontaminate hands with soap and water (if hands are visibly soiled) or with an alcohol-based hand rub after performing any procedure or handling the fluid in the breathing circuits, humidifiers and heat moisture exchangers (category IA—strongly recommended for implementation).^[9] However, improved hand hygiene, measured by increased alcohol-based hand rub consumption, did not result in a significant reduction in VAP.^[10]

Marra *et al.* reported that the incidence density of VAP in the ICU per 1000 patient-days could be reduced from 16.4 in 2001–02 to 10.4 in 2007–08 after implementing

multiple performance measures and interventions.^[5] The application of multi-module programmes showing reduction in VAP was brought out in many other studies also.^[16,18,19] Zaydfudim *et al.* reported a reduction in the VAP rate following improved compliance of ventilator bundle measures after the implementation of an electronic dashboard.^[6] Staff education programs, implementation of hand hygiene and VAP prevention practice guidelines and/or implementation of sedation protocol were associated with a significant reduction in VAP rates in a recent systematic review.^[17]

Although the predominant microorganism isolated from the tracheal aspirate was *K. pneumoniae*, the predominant microorganism isolated from the tracheal aspirate in patients with VAP was *P. aeruginosa* in the present study. *P. aeruginosa* was the most frequently isolated Gram-negative aerobic organism associated with VAP in many earlier studies,^[9,20,21] whereas Salahudeen *et al.* reported *P. aeruginosa* as the second common organism, *Acinetobacter lwoffii* being the first most common.^[16] Nevertheless, Gram-negative bacilli were the most common pathogens causing VAP in other studies.^[17,21]

Bacteria causing VAP usually originate in the oropharynx.^[22] Microaspiration of contaminated oropharyngeal secretions seems to be the most common cause of healthcare-associated pneumonia.^[23] The 2003 guidelines from the CDC reported that 63% of the patients admitted to an ICU have oral colonization with a pathogen associated with VAP. In 76% of the VAP cases, the bacteria colonizing the mouth and lung are the same.^[9] A significant association between tracheobronchial colonization and VAP was noted in the present study supporting this and stressing the importance of oral care in preventing VAP. Although we use chlorhexidine for oral care, the use of toothbrush for providing oral care is not in practice among patients on mechanical ventilator. Further studies are indicated in this area in the Indian setting.

Increased duration of ICU stay as well as extended hospitalisation among patients with VAP was noted in the present study, which was reported earlier.^[17,24-27] Although not attributed to VAP, the mortality among patients who received mechanical ventilation and developed VAP in this study (66%) was within the estimated mortality in this group (between 20% and 70%),^[27,28] and was more than the reported mortality.^[2]

The strength of the present study is that we could sensitize all the health care personnel to the importance

of hand hygiene and achieve improved hand hygiene as measured by increased alcohol-based hand rub consumption in the NSICU, which resulted in VAP reduction. Because of the importance of hand washing in the prevention of VAP, Cason *et al.*^[29] recommended placement and use of alternatives to antimicrobial soap as a means of improving hand washing rates and evaluating the effects on VAP rate.

Conclusions

Infection control protocols for VAP were already being followed at our institution, and the introduction of use of alcohol-based hand rub before and after each patient contact in the NSICU could reduce the incidence of VAP to a level comparable with the rates reported by developed countries. Considering the clinical relevance of reduction in VAP, especially that caused by *P. aeruginosa*, further large sample studies are indicated to confirm the utility of the intervention.

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