

## Weekly Versus Daily Changes of In-Line Suction Catheters: Impact on Rates of Ventilator-Associated Pneumonia and Associated Costs

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**BACKGROUND:** An earlier randomized, controlled trial showed that weekly or as-needed (as opposed to daily) changes of in-line suction catheters were associated with substantial cost savings, without a higher rate of ventilator-associated pneumonia (VAP). To examine the impact of decreasing the frequency of in-line suction catheter changes in our medical intensive care unit, we conducted an observational study, comparing the catheter costs and frequency of VAP during (1) a control period, during which in-line suction catheters were changed daily, and (2) a treatment period, during which the catheters were changed every 7 days or sooner if needed, for mechanical failure or soilage. **METHODS:** All adult patients admitted to our 18-bed medical intensive care unit were evaluated for the 3-month interval 1 year prior to the practice change (May through July 1998) and for the 3 months after implementing the new policy (May through July 1999). To avoid bias related to usual seasonal variation in VAP frequency, we also determined (via medical records) the VAP rate during May through July 1997. The occurrence of VAP was ascertained by an infection control practitioner, using criteria established by the Centers for Disease Control and applied in a standard fashion. The VAP rate was calculated as the mean number of VAPs per 100 ventilator-days for each 3-month interval. Use of ventilators, humidifiers, and non-heated-wire, disposable circuits was uniform during the study, as were policies regarding humidity, temperature settings, and frequency of routine ventilator circuit changes. **RESULTS:** During the control period 146 patients accounted for 1,075 ventilator-days and there were 2 VAPs (0.19 VAPs per 100 ventilator-days). During the treatment period 143 patients accounted for 1,167 ventilator-days and there were no VAPs. The mean  $\pm$  SD duration of in-line suction catheter use during the treatment period was  $3.8 \pm 0.8$  days, and 51% of the patients had the same catheter in place for  $> 3$  days (range 4–9 days). The actual cost of catheters used during the treatment period was lower than during the control period (\$1,330 vs \$6,026), predicting annual catheter cost savings of \$18,782. **CONCLUSIONS:** We conclude that (1) a policy of weekly (vs daily) change of in-line suction catheter is associated with substantial cost savings, with no significant increase in the frequency of VAP, and (2) to the extent that these findings confirm the results of prior studies they support a policy of changing in-line suction catheters weekly rather than daily. *Key words:* suction catheter, ventilator-associated pneumonia. [Respir Care 2003;48(5):494–499. © 2003 Daedalus Enterprises]

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## Introduction

Because mechanical ventilation of patients suffering respiratory failure incurs risks (eg, volutrauma, ventilator-associated pneumonia [VAP]<sup>1</sup>) and is costly, interventions that accelerate patients' liberation from mechanical ventilation and extubation and that lessen costs have been actively investigated. Strategies to accelerate liberation from mechanical ventilation have included implementation of weaning protocols,<sup>2-5</sup> preferential use of ventilatory modes that shorten the duration of ventilatory support,<sup>6,7</sup> and early extubation followed by noninvasive ventilation.<sup>8,9</sup> Similarly, strategies to reduce the risk of VAP have included head elevation, subglottic suctioning,<sup>10,11</sup> early extubation followed by noninvasive ventilation,<sup>8</sup> use of in-line suction catheters (to minimize airway contamination),<sup>12</sup> and lowered frequency of changing ventilator equipment, including tubing,<sup>13-15</sup> heat and moisture exchangers,<sup>15</sup> and in-line suction catheters.<sup>12</sup> Indeed, although the results of recent randomized, controlled trials do not show that in-line suction catheters lower the VAP rate,<sup>1</sup> they do support lowering the frequency of routine changes of ventilator circuit tubing and in-line suction catheters, because less frequent changes are safe and cost-effective.<sup>12</sup>

As part of an ongoing effort to adopt and validate cost-effective respiratory strategies in our medical intensive care unit (MICU) we implemented a policy of decreasing the frequency of in-line suction catheter changes, from daily to weekly. To assess the impact of this policy change and to reassess the results of an earlier randomized, controlled trial of eliminating routine in-line suction catheter changes,<sup>1</sup> we undertook this observational cohort study to examine the frequency of VAP and catheter costs before and after implementing this policy of decreased-frequency changes.

## Methods

In-line suction catheters (Trach Care, Ballard Medical Products, Draper, Utah) have been used in the MICU at The Cleveland Clinic since 1994. Beginning in May 1999, our policy of daily change of in-line suction catheters was modified to specify that catheters would be changed every 7 days routinely, or sooner in the event of mechanical failure (eg, leakage of secretions into the catheter sheath) or catheter soilage (eg, by emesis or by blood).

The primary outcome measure of the study was the VAP rate, as defined in a standard and consistent fashion in our ICU during the study interval (see below). Secondary outcome measures included ICU readmission rate, ICU length of stay, and frequency of bacteremia. We also assessed costs (the per capita number of in-line suction catheter kits used in patients with endotracheal or tracheostomy tubes). The unit costs of the in-line suction catheters

during the study interval (1998-1999) were \$7.05 for endotracheal tube suction kits and \$7.40 for tracheostomy tube kits.

To minimize seasonal effects on the frequency of VAP, we elected to assess the outcomes during 2 similar 3-month periods: (1) a control period (May through July, 1998), during which in-line suction catheters were changed daily, and (2) a treatment period (May through July, 1999), during which in-line suction catheters were changed every 7 days, or sooner if mechanical failure or soilage occurred.

As per usual practice in our MICU, VAP was monitored prospectively by a registered nurse (CF) who is a member of the Department of Infection Control and Epidemiology. We used standard criteria throughout the study interval, based on guidelines from the Centers for Disease Control.<sup>16</sup> Specifically, the criteria for diagnosing VAP included a combination of clinical, radiologic, and laboratory evidence of infection. Diagnosis required the occurrence (beginning at least 48 h after admission) of a new or progressive infiltrate for at least 48 hours and achievement of at least 10 points based on the following criteria: presence of polymorphonuclear leukocytes on sputum Gram stain (grades 0-4), presence of a predominant organism on culture (grades 0-4), white blood cell count exceeding 15,000/mm<sup>3</sup> (1 point), temperature exceeding 38.5° C (1 point), and/or evidence of copious secretions (grades 0-4). Rates of VAP were calculated as the mean per 100 ventilator-days for each 3-month interval.

During both intervals we monitored the number of in-line suction catheter kits used for all patients receiving suctioning through endotracheal or tracheostomy tubes. In our MICU, we routinely collect data on ICU length of stay, ICU readmission, admission Acute Physiology and Chronic Health Evaluation (APACHE) III score, and the frequency of positive blood cultures.

No other changes in routine ventilator management were made during the 2-year study interval. Specifically, ventilator tubing was changed routinely every 7 days and humidifiers (Fisher and Paykel Healthcare, New Zealand) and disposable non-heated-wire circuits (Allegiance, McGaw Park, Illinois) were routinely employed. The ventilators used during the study interval were Puritan-Bennett 7200 AE machines (Puritan-Bennett Corporation, Carlsbad, California). Weaning and sedation were managed with standard protocols that were consistent during the study interval. Endotracheal and/or tracheostomy tubes for subglottic suctioning were not used. Use of acid suppression medications was at physician discretion.

Statistical analysis was conducted with the SAS software package (SAS Institute, Cary, North Carolina). Continuous data were analyzed with a 2-sided *t* test to compare the groups. Categorical comparisons were performed with the chi-square test or Fisher's exact, as appropriate. Median and quartiles are provided for the duration of me-

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Table 1. Characteristics of Patients\*

	Control Period (May–July 1998)	Treatment Period (May–July 1999)
Patients ( <i>n</i> )	146	143
Age (mean ± SD)	63.5 ± 14.5	59.6 ± 16.1
Female (%)	50	45
APACHE III score (mean ± SD)†	93.8 ± 39.0	89.5 ± 33.7
Patients who received sucralfate (%)	1.4 ( <i>n</i> = 2)	6.6 ( <i>n</i> = 8)
Patients who received antacids and/or histamine 2 blockers (%)	32.2 ( <i>n</i> = 47)	30.0 ( <i>n</i> = 40)
Patients who underwent tracheotomy (%)	23	21

\*There were no statistically significant differences between the 1998 and 1999 values.  
 †APACHE III (Acute Physiology and Chronic Health Evaluation) scores were available for 122 of the 1998 patients and 121 of the 1999 patients (*p* = 0.36 for 1998 versus 1999 comparison).

chanical ventilation, and comparisons were made with a *t* test on the log-transformed data. The number of patients presenting with VAP was compared with Fisher’s exact test.

**Results**

A total of 289 patients were included: 146 during the control period and 143 during the study period. Table 1 shows that the 2 groups were similar at baseline regarding age, gender distribution, APACHE III scores, and receipt of acid neutralizing or suppressing medications (sucralfate, antacids, and/or histamine 2 blockers).

The mean ± SD duration of in-line suction catheter use during the treatment period was 3.8 ± 0.8 days, and 51% of these patients had the same catheter in place for > 3 days (range 4–9 d). In the treatment group, reasons for changing the in-line suction catheters before the routine 7-day change were: patient extubation before 7 days of mechanical ventilation (*n* = 74 [40%]), death before 7 days of mechanical ventilation (*n* = 26 [14%]), patient

transfer to another hospital or unit (*n* = 14 [7%]), change of overall ventilator circuit (eg, due to circuit soilage) (*n* = 2 [6%]), tracheotomy performed (*n* = 10 [5%]), in-line catheter soiled (*n* = 6 [3%]), in-line catheter damaged (eg, hole or tear in plastic casing) (*n* = 5 [3%]), or kit not functioning (*n* = 4 [2%]). Routine 7-day change of the in-line catheter occurred for 36 (19%) of the 187 catheters used in the treatment group.

There were 2 episodes of VAP during the control period (0.19 episodes per 100 ventilator days) versus none during the study period (*p* = 0.50 using rate of VAP per patient) (Table 2). To measure the stability of the baseline VAP rate in this ICU, we determined (via medical records) the VAP frequency during the period May through July, 1997, using the same VAP definition. The VAP rate was similar: 0.10 episodes per 100 ventilator days.

Comparison of secondary outcomes (see Table 2) showed trends toward shorter ICU length of stay in the treatment group (mean 7.1 vs 8.0 d, *p* = 0.42) and fewer ICU readmissions within 24 hours of discharge (0.025 vs 0.042 admissions per patient, *p* = 0.53). The number of episodes

Table 2. Outcomes

	Control Period (May–July 1998)	Treatment Period (May–July 1999)
Patients ( <i>n</i> )	146	143
Ventilator-days	1,075	1,167
Median duration of mechanical ventilation* (25th and 75th percentiles)	13‡ (7, 22)	11 (6, 22)
Occurrences of VAP ( <i>n</i> )‡	2	0
VAP rate (VAPs/100 ventilator-days)	0.19	0
Mean duration of MICU stay (d)§	8.03	7.12
ICU readmission rate within 24 h of discharge‡	5/122 (0.042/patient)	3/121 (0.025/patient)

\**p* = 0.92 based on *t* test of log<sub>2</sub> (duration of mechanical ventilation)  
 VAP = ventilator-associated pneumonia  
 ‡Based on 137 patients with available ventilation data  
 †‡*p* = 0.50 by Fisher’s exact test for comparison of the rate of VAP per patient  
 MICU = medical intensive care unit  
 ICU = intensive care unit  
 §Based on 121 treatment and 122 control patients

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Table 3. Costs of In-Line-Suction Catheters

	Control Period (May–July 1998)	Treatment Period (May–July 1999)
Number of in-line ETT suction kits used	776	153
Number of in-line tracheostomy suction kits used	75	34
Total number of in-line suction kits used	851	187
Unit cost of in-line ETT suction kit	\$7.05	\$7.05
Unit cost of in-line tracheostomy suction kit	\$7.40	\$7.40
Total cost of in-line suction kits	\$6,025.80	\$1,330.25

ETT = endotracheal tube

of bacteremia was the same: 10 in each group (0.87 episodes per 100 patient days in the treatment group vs 0.76 in the control group).

Table 3 shows that the number of in-line suction kits used was significantly lower during the study period than during the control period (187 [1.55/patient] vs 851 [6.98/patient],  $p < 0.001$ ). The actual cost of catheters used during the treatment period was lower than during the control period (\$1,330 vs \$6,026), which predicts annual catheter cost savings of \$18,782.

### Discussion

The main findings of this observational cohort study are that changing in-line suction catheters weekly (or sooner for mechanical failure or soilage), rather than daily, is associated with (1) nonsignificant trends toward a lower frequency of VAP, shorter ICU length of stay, and lower frequency of ICU readmission within 24 hours of discharge, and (2) use of fewer in-line suction catheters, with concomitant cost savings.

Our finding that changing in-line suction catheters less frequently is associated with lower cost and no higher incidence of VAP replicates the findings of a randomized, controlled trial conducted by Kollef et al,<sup>12</sup> upon which our amended policy was based. That trial compared 263 patients in whom catheters were changed daily to 258 patients in whom catheters were changed less frequently (according to the same criteria used in the present study). The number of catheters used decreased from 1,224 to 93, the associated costs were lowered from \$11,016 to \$837, and the VAP rates were similar (14.7% vs 14.8%, relative risk 0.99, 95% confidence interval 0.66–1.50).

Comparison of these studies warrants comment on several points. First, the baseline VAP rate was lower in our study than in that of Kollef et al,<sup>12</sup> despite which the amended catheter-change policy was associated with a trend toward a lower VAP frequency. Though we cannot discount the possibility that the decrement in the VAP rate could be ascribed to so-called detection bias in this unblinded comparison<sup>17</sup> (ie,

the lack of blinding in the present observational study may have conditioned the nurses' detection of VAP), the overall lower VAP rate in the present study is unlikely to be on that basis. Indeed, the baseline VAP rate in our medical ICU was consistently lower, as was observed during the 3-month sampling periods during 1998 and 1999.

Certainly, differences in the specific criteria used to define VAP could contribute to the rate differences between the present study and that of Kollef et al.<sup>12</sup> For example, comparison of the criteria for nosocomial pneumonia in our study with the criteria used by Kollef et al<sup>12,18</sup> shows similar component features but different rating schemes to establish the diagnosis. Specifically, the modified Centers for Disease Control criteria used in our study<sup>16</sup> required appearance of a new radiographic infiltrate at least 48 hours after admission and achievement of points assigned by characteristics of the sputum, the peripheral white blood cell count, and the patient's temperature. In contrast, the 1988 Centers for Disease Control criteria applied by Kollef et al<sup>12</sup> allow the diagnosis of nosocomial pneumonia based on the presence of rales or dullness to percussion on chest examination, plus at least one other clinical feature (ie, new-onset purulent sputum; positive blood culture; or isolation of a pathogen from transtracheal aspirate, bronchial brushing, or biopsy), or the new radiographic appearance of an infiltrate, consolidation, cavity, or effusion with these or other features (ie, isolation of a virus or viral antigen in respiratory secretions, elevated immunoglobulin M or paired rising immunoglobulin G titers for a pathogen, or histopathologic evidence of pneumonia). It is conceivable that differences in these criteria could contribute to the different observed rates of nosocomial pneumonia in the compared studies.

The benefits of weekly versus daily changes of in-line suction catheters augment the previously reported benefits, both physiologic and financial, of closed in-line versus open suctioning. Specifically, Johnson et al<sup>19</sup> reported that closed suctioning systems conferred the advantages of shorter suctioning time (ie, mean 93 vs 153 s) and fewer physiologic derangements associated with use (eg, more

stable mean arterial pressure, oxygen saturation, and heart rate, and fewer dysrhythmias). Applying the net \$1.88 per day savings conferred by closed (versus open) suctioning, under conditions of use in the Johnson et al study<sup>19</sup> to our patients on mechanical ventilation for  $\geq 3$  days, the data suggest a savings of \$12.09 per patient per week with the closed suctioning approach, with our suctioning practices.

In the context of our confirming prior benefits associated with a policy of weekly versus daily changes of in-line suctioning devices, several shortcomings of the present study warrant comment. First, because the study is an observational cohort study with a “before-and-after” comparison, rather than a randomized trial with concurrent controls, we cannot exclude the possibility that our results are biased by natural variation in event rates. Still, it strengthens the findings that favorable effects and trends were observed for several of the study outcomes (VAP rate, ICU readmission rate, and ICU length of stay). Second, in contrast to the complete data set for the primary outcome measure (VAP rate) and key secondary measures for this analysis (use of in-line suction catheters and associated costs), some descriptive data (ie, APACHE III scores) and information on secondary outcomes (ie, ICU readmissions and length of stay) were available in only a subset of the total cohort. Though the incompleteness of data invites the possibility of bias related to selective absence of data, the unavailability of data resulted from missing records rather than any systematic clinical issue, so we believe that such bias is unlikely because of the relatively small number of missing records, which was similar in both groups (16% for the control group vs 15% for the treatment group). The analyses regarding the primary outcome measure (ie, VAP rate), as well as utilization of in-line suction catheters and associated costs, are unaffected. Furthermore, because the weaning strategies and use of the sedation protocol were uniform during the study interval, differences in VAP rates are unlikely to be attributable to other practice changes. Finally, as in the earlier trial of weekly versus nonroutine changing of in-line suction catheters,<sup>2</sup> the diagnostic criteria for VAP were based on clinical features rather than on quantitative cultures. Although more recent practice favors the use of quantitative culture criteria,<sup>1</sup> the consistent use of the clinical diagnostic criteria for VAP throughout the study interval supports the internal validity<sup>17</sup> of our findings.

### Conclusions

In summary, our findings suggest that a policy of weekly (versus daily) changes of in-line suction catheters is associated with substantial cost savings, with no increase in the frequency of VAP. To the extent that these findings confirm the results of prior studies, they support a policy of

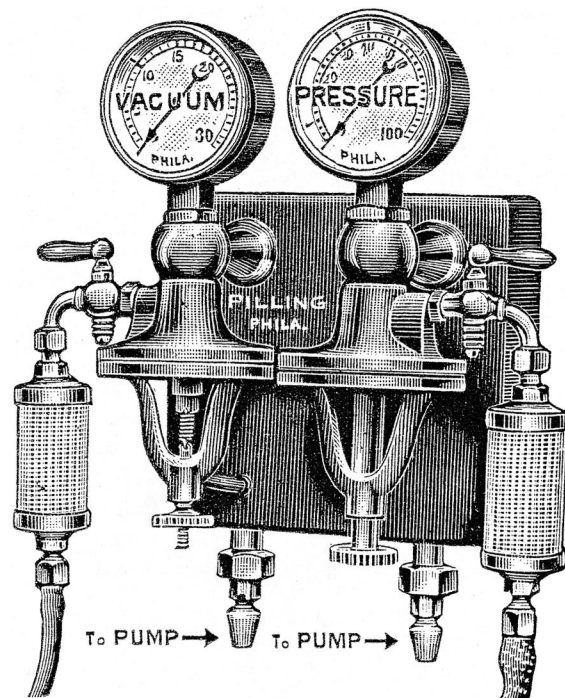
changing in-line suction catheters weekly (or even not at all<sup>2</sup>) rather than daily.

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