COMPARISON OF CLOSED ENDOTRACHEAL SUCTION VERSUS OPEN ENDOTRACHEAL SUCTION IN THE DEVELOPMENT OF VENTILATOR-ASSOCIATED PNEUMONIA IN INTENSIVE CARE PATIENTS: AN EVALUATION USING META-ANALYTIC TECHNIQUES

JOHN VICTOR PETER, BINILA CHACKO, JOHN L. MORAN*

ABSTRACT

BACKGROUND: *Ventilator-associated pneumonia (VAP), a frequent nosocomial infection in the intensive care, is associated with considerable morbidity. Endotracheal suctioning is routinely performed in mechanically ventilated patients to clear secretions. This study assessed if there were advantages of closed endotracheal suctioning (CES) over open endotracheal suctioning (OES) with respect to clinical outcomes.* ***MATERIALS AND METHODS:*** *Trials comparing CES with OES were identified by search of MEDLINE® (1966-July 2006) and bibliographies of relevant articles. Only trials reporting VAP and/or mortality were considered. Studies reporting only physiological outcomes were excluded.* ***STATISTICAL ANALYSIS USED:*** *A meta-analysis of randomized controlled trials (RCTs) was performed using the random-effects estimator. The effect of suctioning type on VAP and mortality was reported as risk difference (RD) and duration of mechanical ventilation (MV) as mean weighted difference (MWD).* ***RESULTS:*** *Nine RCTs fulfilled criteria for inclusion. There was no differential treatment effect of suctioning type (closed versus open, n = 9 studies) on VAP (RD - 0.01; 95% CI - 0.05, 0.03; P = 0.63) or on mortality (n = 5; RD 0.01; 95% CI - 0.04, 0.05; P = 0.8). Although OES was associated with a shorter duration of MV (n = 4; MWD - 0.64; 95% CI 0.21, 1.06; P = 0.004), one study contributed significantly to the estimates. Heterogeneity of treatment effects was not observed.* ***CONCLUSIONS:*** *This meta-analysis has not demonstrated a superiority of CES over OES with respect to VAP or mortality. Thus the decision for the use of CES may be based on possible benefits in patients requiring high respiratory supports, reduced costs in those needing prolonged MV or occupational health and safety concerns with OES.*

Key words: *Endotracheal suctioning, meta-analysis, publication bias, random effects*

Ventilator-associated pneumonia (VAP) is a common nosocomial infection in the intensive care unit (ICU) with an incidence ranging from 6.8 to 44%.[1-4] VAP increases costs,[5,6] length of hospital stay[7] and mortality,[8,9] and any strategy to reduce its occurrence is worthy of consideration. Endotracheal suctioning is performed in intubated mechanically ventilated patients as a routine essential part of care to clear endotracheal secretions. Two methods of endotracheal suctioning are in practice - the open endotracheal suctioning (OES) system, where suctioning is performed after disconnecting the respiratory circuits and using sterile single-use suction catheters. This technique of suctioning has been reported to be associated with arterial desaturation, inability to maintain PEEP and cardiac arrhythmias, particularly in patients with cardiorespiratory instability.[10,11] In the closed endotracheal suctioning (CES) system, which was developed to minimize these complications, suctioning is performed without disconnecting the respiratory circuit and uses multi-use in-line catheters that are enclosed in a sheath along with the respiratory circuit. This mode of suctioning has comparatively fewer physiological disturbances and consequences during suctioning[10,12] and provides ease of use, given that only one operator is required for suctioning.[13] Further, CES is postulated to reduce VAP rates by decreasing environmental contamination during suctioning.[14] These potential advantages have led to the conduct of several randomized controlled trials (RCTs) that compared CES and OES. These individual trials failed to show a superiority of one type of suctioning over the other. This evaluation was undertaken to assess if there was any advantage of CES over OES with respect to the development of VAP. The hypothesis was that there would be no difference in the incidence of VAP between CES and OES suctioning. Secondary outcomes assessed in the study were mortality, duration of ventilatory support, as well as hospital and ICU length of stay (LOS).

Department of Medical Intensive Care, Christian Medical College and Hospital, Vellore, India, *Department of Intensive Care, The Queen Elizabeth Hospital, Woodville, South Australia

Correspondence
Dr. J. V. Peter, Medical Intensive Care Unit, Christian Medical College and Hospital, Vellore - 632 004, India.
E-mail: peterjohnvictor@yahoo.com.au

MATERIALS AND METHODS

Selection of trials

RCTs comparing CES with OES in mechanically ventilated patients were considered for inclusion. CES was defined as endotracheal suctioning performed without disconnection from the respiratory circuit, employing a multi-use in-line suctioning catheter. OES was defined as endotracheal suctioning done after disconnection of the respiratory circuit and employing a single-use-suctioning catheter under aseptic precautions. Only trials reporting VAP rates and/or mortality were considered for inclusion. Studies reporting only physiological endpoints, those performed in children or infants and non-English articles were excluded.

Search strategy

A computerized literature search was performed using PubMed® and OVID® Medline for the period 1966-July 2006. The search was restricted to studies on adult human population and was carried out using the search terms: *suction or suctioning or endotracheal suctioning or tracheal suctioning or open suctioning or closed suctioning AND randomised or randomized trials or clinical trials or controlled trials*. Abstracts of trials generated by electronic search were reviewed, and trials pertaining to open and closed suctioning were retrieved for detailed evaluation. The references of identified articles were reviewed to identify other relevant articles. The Cochrane Central Register of Controlled trials was also searched to identify other trials on this topic. A systematic review was identified at the completion of this study.[15] A second meta-analysis on the same subject was also published following submission of this article for journal review.[16] Personal correspondence

with authors was not sought.

Quality assessment

Quality assessment was performed in an unblinded fashion by two investigators using a quality score[17] modified for this study and adapted for ventilated patients. This score assessed composite aspects of study quality (10 aspects in total, with scores 0 or 1; minimum total score 0 and maximum total score 10). Differences in opinion were settled by consensus.

Data abstraction

Two investigators independently abstracted data using standardized data collection forms. The extracted variables were predefined and differences in data abstraction were settled by consensus.

Outcome measures

The primary outcome assessed was number of patients developing VAP. This was defined in various studies as - new onset of purulent bronchial secretions, body temperature of >38°C or <35.5°C (definitions of body temperature were variable), white cell count (WCC) of >10,000 or <4,000/cmm (cut off values for WCC were variable), chest radiography showing new or progressive infiltrates and a (quantitative in some studies) culture of respiratory secretions (endotracheal or lavage or protected brush catheter) suggesting infection. Secondary outcomes included:

(i) Hospital and ICU length of stay in days
(ii) Mortality defined as deceased when discharged from hospital
(iii) Duration of MV in the two groups

Statistical methods

Preliminary analyses of baseline characteristics of the two groups were performed using inverse variance weighted differences. The effect of the suctioning type on VAP rates and mortality was expressed with 95% CI and '*P*' values as risk difference (RD) and hospital and ICU LOS and duration of ventilation as mean weighted difference (MWD) in days. Treatment effect was assessed using the methods of Mantel Haenszel (fixed-effects); and where heterogeneity of treatment effects was present, the DerSimonian and Laird (random-effects) estimator was used. Alternative estimates of treatment effects were obtained using quality scores as weights, as provided by the METAN program,[18] using Stata® Release 8 (College Station, Texas, 2003).

Heterogeneity of treatment effects was assessed as (i) the extent, diagnosed by means of the Q statistic, considered significant at $P \leq 0.1$[19,20] and (ii) the impact (upon the variation of pooled treatment effect) by means of the I^2 measure, where an I^2 of <30% indicates mild heterogeneity, 30-50% moderate, and substantially >50%, severe heterogeneity.[20] Meta-regression analysis[21] was undertaken to assess the (potential) effect of average age; percent male patients; average percent of medical, surgical and trauma patients on the development of VAP and mortality.

Publication bias was not reported, as the ability to adequately detect bias is limited when the number of trials included is less than 10 and when the sample size in the individual studies is small.[22] A cumulative meta-analysis was also performed[23] to study possible time trends in treatment effects.

RESULTS

Preliminary search identified 731 trials on suctioning in the adult population. A single investigator reviewed these abstracts, and 48 articles were identified for detailed evaluation by two authors. Forty-two articles were excluded [Figure 1]. Six articles fulfilled criteria for inclusion, and a further three articles were identified by hand-search and review of other articles. The study cohort thus consisted of 9 RCTs from 1966-2006 that compared CES with OES.[5,6,12,24-29] Table 1 summarizes the study characteristics as well as the quality scores. A breakdown of the quality scores for the different studies is provided in the Appendix.

The CES group consisted of 644 patients; and the OES group, 648 patients. The two groups were matched [Table 2] for age; sex; APACHE II score; and the number of medical, surgical or trauma patients (inverse variance weighted differences, $P \geq 0.26$).

VAP rates

All studies reported VAP rates. VAP developed in 19.2% of patients (248/1,292) and ranged from 0 to 53% in the individual studies [Table 3]. There was no differential treatment effect [Figure 2, Table 4] of the type of suctioning on VAP rates (fixed effect, RD - 0.01, 95% CI - 0.05, 0.03, $P = 0.63$, heterogeneity $P = 0.2$). Heterogeneity was not observed.

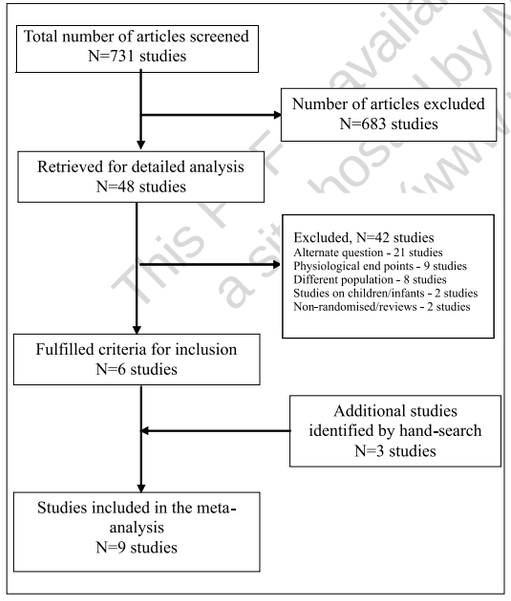

Figure 1: Process of identification of trials flow diagram depicting the process of identification of trials that were included for the meta-analysis

Mortality rate

The overall mortality was 22.9% (266/1,164) and reported in only five studies and ranged from 13 to 68% in the individual studies [Table 3]. The mortality rates of 23.2% (135/581) in the CES group and 22.5% (131/583) in the OES group [Figure. 3, Table 4] were similar (fixed effect, RD - 0.01, 95% CI - 0.04, 0.05, $P = 0.8$, heterogeneity $P = 0.9$). There was no heterogeneity.

Other outcomes

Hospital LOS was not reported in the studies. The duration of ICU stay was evaluated using

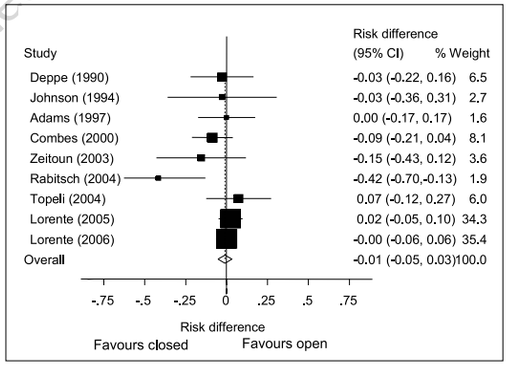

Figure 2: Effect of type of suctioning on ventilator-associated pneumonia rates forest plot representation - fixed-effects model. The vertical straight line denotes null effect; and the dotted line, the overall mortality effect of treatment with early enteral nutrition compared with early parenteral nutrition. The individual boxes denote the risk difference of each study; and the lines on either side, the 95% confidence intervals. There is no effect of the type of suctioning (open or closed) on VAP rates.

the random-effects estimator due to heterogeneity of treatment effects; this was not different in the two studies reporting ICU LOS [Table 4]. The duration of mechanical ventilation, in four studies, assessed by the fixed-effects estimator was significantly lower in the OES group [Figure 4]; however, one study[28] contributed substantially (93%)

Table 1: Summary of the included studies

Study (ref)	Year	Country	I/E criteria catheter	Type of closed suctioning	Randomisation	Allocation concealment	Definition of ventilator-associated pneumonia	QS~	Number of aspirations/day	
									Open	Closed
Deppe[27]	1990	USA	Y/N	Trachcare™	Random number table	Nil	Yes	6	16.6	12.4
Johnson[12]	1994	USA	Y/N	Trachcare®	Randomly assigned	Nil	Yes	6	NA	16
Adams[6]	1997	UK	Y/N	Trachcare®	Randomly allocated	Nil	Yes	3	16.6	10
Coombes[25]	2000	France	Y/N	Stericath®	Randomly allocated	Nil	Yes	4	NA	NA
Zeiuton[26]	2003	Brazil	Y/Y	NA	Alternate day Randomization	Nil	Yes	4	NA	NA
Rabitsch[28]	2004	Austria	Y/Y	Trachcare™	Randomized (sealed envelopes)	Yes	Yes	7	8	8
Topeli[29]	2004	Turkey	Y/Y	Stericath®	Randomly allocated	Nil	Yes	6	NA	NA
Lorente[5]	2005	Spain	Y/N	Hi-Care®	Random number	Nil	Yes	5	8.13±3.54*	8.32±3.71*
Lorente[24]	2006	Spain	Y/N	Hi-Care®	Randomly assigned	Nil	Yes	4	8.1±2.7*	7.9±2.6*

I/E - Included /exclusion criteria defined, NA - Not available, *Mean and standard deviation provided in the text, ~Quality score (minimum score 0, maximum score 10)

Table 2: Summary of baseline characteristics of the two treatment groups

Characteristic	Number of studies	CES group	OES group	P value
Number of patients	9	644	648	
Age (Mean ± SD years)	6	52.3 (14.0)	54.8 (13.2)	0.15
Male: Females	6	398:177	388:198	0.30#
Number (%) of medical patients	4	284 (53.0)	289 (65.7)	1.00#
Number (%) of surgical patients	4	178 (37.7)	184 (38.1)	0.95#
Average APACHE II score (Mean ± SD)	4	17 (5.3)	16.5 (5.3)	0.40

CES - Closed endotracheal suctioning, OES - Open endotracheal suctioning, Continuous variables analyzed by t-test, categorical results by Fisher Exact (#),

Table 3: Incidence of ventilator-associated pneumonia and mortality rates in the individual studies included in the meta-analysis

	Year	Total number of patients		Number (%) developing ventilator-associated pneumonia		Mortality (%)	
		CES	OES	CES	OES	CES	OES
Deppe[27]	1990	46	38	12 (26.1)	11 (28.9)	12 (26.1)	11 (28.9)
Johnson[12]	1994	16	19	8 (50.0)	10 (52.6)	NA	NA
Adams[6]	1997	10	10	0 (0)	0 (0)	NA	NA
Coombes[25]	2000	50	54	4 (8.0)	9 (16.7)	13 (26.0)	15 (27.8)
Zeiuton[26]	2003	23	24	7 (30.4)	11 (45.8)	NA	NA
Rabitsch[28]	2004	12	12	0 (0)	5 (41.7)	NA	NA
Topeli[29]	2004	41	37	13 (31.7)	9 (24.3)	27 (65.9)	25 (67.6)
Lorente[5]	2005	210	233	43 (20.5)	42 (18.0)	52 (24.8)	50 (21.5)
Lorente[24]	2006	236	221	33 (14.0)	31 (14.0)	31 (13.1)	30 (13.6)

CES - Closed endotracheal suctioning, OES - Open endotracheal suctioning

Table 4: Outcomes

Outcome parameter	Number of studies reporting	Number of patients~	Difference % (95% CI)	P value	Heterogeneity (P)	I^2 (%)
Number with ventilator-associated pneumonia	9	644/648	-0.01 (-0.05, 0.03)#	0.63	0.16	32
Mortality (number)	5	583/583	0.01 (-0.04, 0.05)#	0.78	0.94	0
Duration of ventilation (days)	4	537/545	0.64 (0.21, 1.06)##	0.004	0.39	1.1
Intensive care unit, length of stay (days)	2	91/91	-0.90 (-5.61, 3.81)##	0.71	0.09	66

I^2 - variation in risk difference attributable to heterogeneity, CI - Confidence interval, ~Number of patients - Number in the closed suctioning group/number in the open suctioning group, #Risk difference, ##Weighted mean difference, Fixed-effects estimator used in the above estimates except for Intensive care unit length of stay, where random-effects estimator was used

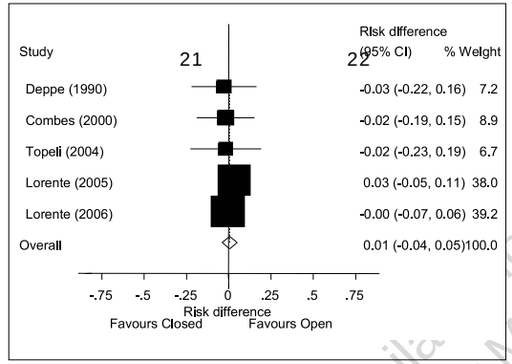

Figure 3: Effect of type of suctioning on mortality. The effect of suctioning on mortality represented as risk difference using the fixed-effects model. There is no difference in mortality when closed endotracheal suctioning was compared with open endotracheal suctioning.

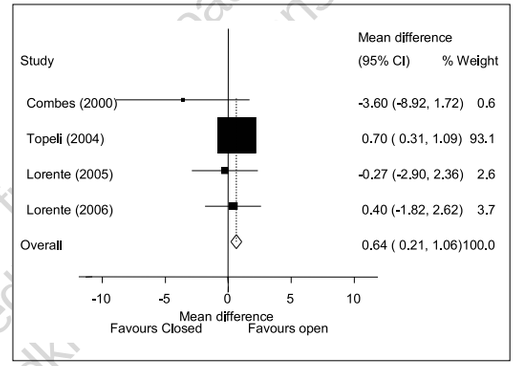

Figure 4: Effect of open and closed endotracheal suctioning on duration of ventilation
Forest plot representation - fixed-effects model. The vertical straight line denotes null effect; and the dotted line, the overall treatment effect of the type of suctioning on ICU length of stay represented as mean weighted difference. The individual boxes denote the risk difference of each study; and the lines on either side, the 95% confidence intervals. Open suctioning was associated with a significant reduction in the duration of ventilation when compared to closed suctioning.

to the estimates.

The cost of suctioning

The cost of suctioning was provided in four studies. Two studies[5,6] reported higher costs with closed suctioning, one study reported similar cost[24] and in one study cost was marginally higher with open suctioning.[12]

Meta-regression analysis

Meta-regression analysis showed that none of the predefined clinical variables (average age; percent male patients; average percent of medical, surgical and trauma patients) predicted VAP or mortality ($P \geq 0.34$). Small numbers precluded multi-variate analysis.

Cumulative meta-analysis

Cumulative meta-analysis [Figure 5] did not demonstrate any substantial variation in the point estimates for VAP, although there was a retraction in the confidence intervals over

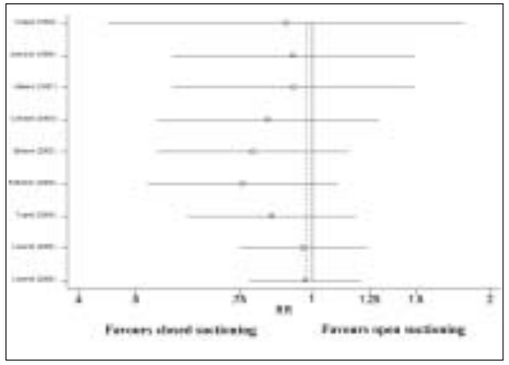

Figure 5: Cumulative meta-analysis. Cumulative meta-analysis effect for ventilator-associated pneumonia. All values are expressed as relative risk (RR) with 95% confidence intervals. The line of effect has always been on the left of the Plimsoll line.

time with the addition of the more recently published studies.

The effect of trial quality score, assessed as 'quality-weights,' on treatment outcomes (VAP and mortality) was minimal with no change in the point estimates or level of significance. Similarly, there was no substantial effect of the quality score on the duration of ventilation (*P* value remaining significant at 0.001).

DISCUSSION

This meta-analysis has not demonstrated an advantage of CES over OES in the primary outcome (VAP rates). Given that no difference was established between the two methods of endotracheal suctioning (CES and OES) on primary outcome, the expectation would have been a translation of this 'lack of difference' to secondary outcomes. No difference was established with respect to mortality or ICU length of stay; but a statistically significant reduction in the duration of ventilation, favoring OES, was found. However, the number of studies reporting these secondary outcomes varied from two to five [Table 4], reflecting intra-study publication bias[30]; and the estimates of these outcomes are therefore uncertain. However, if one were to speculate a reason for the observed reduction in the duration of ventilation with OES, more effective clearance of respiratory secretions with OES compared with CES might have effected this difference.

CES is postulated to have several advantages over OES, which include lower gasometrical and hemodynamic impairment,[12] lower risk of contamination of the endotracheal system due to a protective sheath[25] and decreased environmental exposure,[14] as well as ease of use and reduced nursing time.[12] These potential advantages have not been demonstrably translated into improvements in clinically meaningful outcomes (incidence of VAP, mortality and ICU LOS). The disadvantages of CES - higher costs[5,6] and reduced effectiveness in clearing secretions[31] - may actually favor the use of OES in the routine suctioning of patients in different ICU environments.

Despite the theoretical advantages of CES, failure to demonstrate a clinical benefit may be due to several reasons - a true effect, the meta-analysis being under-powered to detect a difference or a relatively low incidence of VAP in the cohorts included in these studies. The VAP rates of 18.6% (120/644) and 19.8% (128/648) in the CES and OES groups respectively are considerably lower than other studies, where incidences of up to 44% have been recorded.[2] With the use of

conventional power calculations, as suggested by Flather and colleagues,[32] we observed that this meta-analysis was actually under-powered (power 63%) to detect a difference between the groups. In order to demonstrate a 5% difference in VAP assuming a baseline VAP rate of 20%, 1,252 patients would need to be evaluated in each treatment arm for 80% power. It is also interesting to note, in the cumulative meta-analysis [Figure 5], that the effect-line favored CES suctioning, albeit the 95% CI always extended beyond unity.

Although a similar meta-analysis was published at the time of completion of this meta-analysis,[15] as well as a second one during the review process of this article,[16] the current meta-analysis is more comprehensive: the systematic process of trial identification and data abstraction is formally presented; other clinically relevant endpoints (mortality, ICU length of stay and duration of MV) have been canvassed and the potential effect of differential trial quality has also been formally addressed. More importantly, the cumulative meta-analysis, power analysis and the presumed intra-study publication bias suggest that the information required to definitively address these questions is incomplete.

Given the null results of the meta-analyses, the question of applicability of this meta-analysis to all ICU patients needs to be addressed. Only two studies[5,24] explicitly stated that all patients admitted to the ICU requiring mechanical ventilation were included to the trial. The majority of trials included only a small number of patients (and the reasons for exclusion were not stated), and this may limit generalizability. Further, there was a wide variation in VAP rates as well as mortality in the individual studies included in the meta-analysis [Table 3]. We also did not specifically look at physiological endpoints, and the question of use of CES in patients on high respiratory supports was not addressed in the current meta-analysis. Several other studies[10-12] have suggested that there is less desaturation with CES in patients on high respiratory support, in whom the CES may be preferred. The favorable effect of CES on arterial de (saturation) in the smaller studies has not translated to a benefit in the recent meta-analysis.[16] The same meta-analysis also reported significant differences in heart rate (6 beats/min) and mean arterial pressure (3-5 mmHg) in favor of CES.[16] These differences are however unlikely to be clinically significant or meaningful.

Costs are also vital, more so in developing countries such as ours, where any increase in cost without a definitive improvement in clinical endpoints cannot justify the use of CES. Until definitive clinical benefit is demonstrated in further trials, OES may continue to be favored in these nations.

Other issues may impact upon the question of CES versus OES. In developing countries where the space allocated to individual beds may be restricted (picture), close proximity of beds may lead to environmental contamination of the respiratory tract. The high incidence of pulmonary tuberculosis in developing countries such as ours poses greater risk to the health personnel, and the mode of suctioning assumes greater

importance. Thus, studies comparing CES with OES may be more relevant in the developing world. These issues may not be paramount in countries where occupational health and safety concerns preclude the use of OES and where the ease of use as well as reduced nursing time with CES may override cost concerns.

We submit therefore that the question of open or closed endotracheal suctioning in mechanically ventilated patients is still very much an 'open' issue.

ACKNOWLEDGMENTS

No funding source was used for this analysis nor were there any conflicts of interest for the three authors. Conception and design of the study were done by John Victor Peter (JVP). Electronic search, data collection, abstraction and data entry were carried out by JVP and Binila Chacko (BC). Quality assessment of trials and quality scores were done by JVP, BC and John L. Moran (JLM). Statistical expertise was provided by JLM and JVP. Overall direction of the text and discussion of the results were rendered by JVP, JLM and BC.

REFERENCES

1. Alp E, Guven M, Yildiz O, Aygen B, Voss A, Doganay M. Incidence, risk factors and mortality of nosocomial pneumonia in Intensive Care Units: A prospective study. Ann Clin Microbiol Antimicrob 2004;3:17.
2. Rodriguez JL, Gibbons KJ, Bitzer LG, Dechert RE, Steinberg SM, Flint LM. Pneumonia: Incidence, risk factors and outcome in injured patients. J Trauma 1991;31:907-14.
3. Fagon JY, Chastre J, Domart Y, Trouillet JL, Pierre J, Darne C, *et al*. Nosocomial pneumonia in patients

Appendix: Quality scores

Study and year	*Randomisation*	*Allocation concealment*	*Blinding*	*Inclusion and exclusion criteria*	*Baseline comparability define at*	*Treatment protocol clearly described study entry*	*Co-interventions that could affect outcome*	*Outcome definition (particularly VAP)*	*Extent of follow up described clearly*	*Intention to treat analysis*	*Final score*
Deppe (1990)	1	0	0	1	1	1	0	1	1	0	6
Johnson (1994)	0	0	0	1	1	1	1	1	1	0	6
Adams (1997)	0	0	0	0	1	1	0	1	0	0	3
Coombes (2000)	0	0	0	1	1	1	0	1	0	0	4
Zeitoun (2003)	0	0	0	1	1	0	0	1	1	0	4
Rabitsch (2004)	1	1	0	1	1	1	1	1	0	0	7
Topeli (2004)	0	0	0	1	1	1	1	1	1	0	6
Lorente (2005)	1	0	0	0	1	1	1	1	0	0	5
Lorente (2006)	0	0	0	0	1	1	1	1	0	0	4

Score '0' if not described or inadequate or unclear and '1' if appropriately described

receiving continuous mechanical ventilation. Prospective analysis of 52 episodes with use of a protected specimen brush and quantitative culture techniques. Am Rev Respir Dis 1989;139:877-84.
4. Cook DJ, Walter SD, Cook RJ, Griffith LE, Guyatt GH, Leasa D, *et al*. Incidence of and risk factors for ventilator-associated pneumonia in critically ill patients. Ann Intern Med 1998;129:433-40.
5. Lorente L, Lecuona M, Martin MM, Garcia C, Mora ML, Sierra A. Ventilator-associated pneumonia using a closed versus an open tracheal suction system. Crit Care Med 2005;33:115-9.
6. Adams DH, Hughes M, Elliott TS. Microbial colonization of closed-system suction catheters used in liver transplant patients. Intensive Crit Care Nurs 1997;13:72-6.
7. Tejerina E, Frutos-Vivar F, Restrepo MI, Anzueto A, Abroug F, Palizas F, *et al*. Incidence, risk factors and outcome of ventilator-associated pneumonia. J Crit Care 2006;21:56-65.
8. Zaidi M, Sifuentes-Osornio J, Rolon AL, Vazquez G, Rosado R, Sanchez M, *et al*. Inadequate therapy and antibiotic resistance. Risk factors for mortality in the intensive care unit. Arch Med Res 2002;33:290-4.
9. Kollef MH, Silver P, Murphy DM, Trovillion E. The effect of late-onset ventilator-associated pneumonia in determining patient mortality. Chest 1995;108:1655-62.
10. Lasocki S, Lu Q, Sartorius A, Fouillat D, Remerand F, Rouby JJ. Open and closed-circuit endotracheal suctioning in acute lung injury: Efficiency and effects on gas exchange. Anesthesiology 2006;104:39-47.
11. Maggiore SM, Lellouche F, Pigeot J, Taille S, Deye N, Durrmeyer X, *et al*. Prevention of endotracheal suctioning-induced alveolar derecruitment in acute lung injury. Am J Respir Crit Care Med 2003;167:1215-24.
12. Johnson KL, Kearney PA, Johnson SB, Niblett JB, MacMillan NL, McClain RE. Closed versus open endotracheal suctioning: Costs and physiologic consequences. Crit Care Med 1994;22:658-66.
13. DePew CL, Moseley MJ, Clark EG, Morales CC. Open vs closed-system endotracheal suctioning: A cost comparison. Crit Care Nurse 1994;14:94-100.
14. Cobley M, Atkins M, Jones PL. Environmental contamination during tracheal suction. A comparison of disposable conventional catheters with a multiple-use closed system device. Anaesthesia 1991;46:957-61.
15. Vonberg RP, Eckmanns T, Welte T, Gastmeier P. Impact of the suctioning system (open vs. closed) on the incidence of ventilation-associated pneumonia: Meta-analysis of randomized controlled trials. Intensive Care Med 2006;32:1329-35.
16. Jongerden IP, Rovers MM, Grypdonck MH, Bonten MJ. Open and closed endotracheal suction systems in mechanically ventilated intensive care patients: A meta-analysis. Crit Care Med 2007;35:260-70.
17. Keenan SP, Sinuff T, Cook DJ, Hill NS. Which patients with acute exacerbation of chronic obstructive pulmonary disease benefit from noninvasive positive-pressure ventilation? A systematic review of the literature. Ann Intern Med 2003;138:861-70.
18. Bradburn MJ, Deeks JJ, Altman DG. Metan - An alternative meta-analysis command. In: Newton HJ, editor. The Stata Technical Bulletin, Vol 8. College Station, TX: Stata Corp; 1999. p. 86-100.
19. Sutton AJ, Abrams KR, Jones DR, Sheldon TA, Song F. Systematic review of trials and other studies. Health Technol Assess 1998;2:1-276.
20. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. Stat Med 2002;21:1539-58.
21. Sharp SJ. metareg, sbe 23: Meta-analysis regression. Stata Technical Bulletin Reprints 1998;7:148-55.
22. Sterne JA, Gavaghan D, Egger M. Publication and related bias in a meta-analysis: Power of statistical tests and prevalence in the literature. J Clin Epidemiol 2000;53:1119-29.
23. Lau J, Antman EM, Jimenez-Silva J, Kupelnick B, Mosteller F, Chalmers TC. Cumulative meta-

analysis of therapeutic trials for myocardial infarction. N Engl J Med 1992;327:248-54.
24. Lorente L, Lecuona M, Jimenez A, Mora ML, Sierra A. Tracheal suction by closed system without daily change versus open system. Intensive Care Med 2006;32:538-44.
25. Combes P, Fauvage B, Oleyer C. Nosocomial pneumonia in mechanically ventilated patients, a prospective randomised evaluation of the Stericath closed suctioning system. Intensive Care Med 2000;26:878-82.
26. Zeitoun SS, de Barros AL, Diccini S. A prospective, randomized study of ventilator-associated pneumonia in patients using a closed vs. open suction system. J Clin Nurs 2003;12:484-9.
27. Deppe SA, Kelly JW, Thoi LL, Chudy JH, Longfield RN, Ducey JP, *et al*. Incidence of colonization, nosocomial pneumonia and mortality in critically ill patients using a Trach Care closed-suction system versus an open- suction system: A prospective, randomized study. Crit Care Med 1990;18:1389-93.
28. Rabitsch W, Kostler WJ, Fiebiger W, Dielacher C, Losert H, Sherif C, *et al*. Closed suctioning system reduces cross-contamination between bronchial system and gastric juices. Anesth Analg 2004;99:886-92.
29. Topeli A, Harmanci A, Cetinkaya Y, Akdeniz S, Unal S. Comparison of the effect of closed versus open endotracheal suction systems on the development of ventilator-associated pneumonia. J Hosp Infect 2004;58:14-9.
30. Williamson PR, Gamble C. Identification and impact of outcome selection bias in meta-analysis. Stat Med 2005;24:1547-61.
31. Lindgren S, Almgren B, Hogman M, Lethvall S, Houltz E, Lundin S, *et al*. Effectiveness and side effects of closed and open suctioning: An experimental evaluation. Intensive Care Med 2004;30:1630-7.
32. Flather MD, Farkouh ME, Pogue JM, Yusuf S. Strengths and limitations of meta-analysis: Larger studies may be more reliable. Control Clin Trials 1997;18:568-79.

Source of Support: Nil, **Conflict of Interest:** None declared.

Announcement

Dr. J. C. Patel Birth Centenary Celebration Committee

The year 2008 is the Birth Centenary Year of Dr. J. C. Patel. Some of his students/admirers felt that it would be a good idea to celebrate this Centenary Year by organizing CMEs, Orations/ Lectures, Conferences, etc. during the year. He was associated with many professional bodies, which meet regularly every year; during these annual meetings/conferences, a lecture/symposium, etc can be organized as a part of Centenary celebrations. We would like to form a Dr. J. C. Patel Birth Centenary Celebrations Committee. All his past students/admirers are invited to join the committee (without any financial commitment). Kindly communicate your name, designation, postal address, telephone number and E-mail ID to Dr. B. C. Mehta at Flat 504, Prachi Society, Juhu-Versova Link Road, Andheri (W), Mumbai 400 053 (drmehta.bc@gmail.com).