Changing ventilator circuit routinely?

B.S. Niël-Weise[1], J.C. Wille[2], P.J. van den Broek[3]
[1]Dutch Infection Prevention Working Party, Leiden, The Netherlands
[2]Dutch Institute for Healthcare Improvement CBO), Utrecht
[3]Department of Infectious Diseases, Leiden University Medical Centre

Study population: mechanically ventilated ICU patients
Comparison: less frequent changes ventilator circuits versus more frequent changes ventilator circuits
Outcome: ventilator-associated pneumonia

Methods

Data sources

Publications were retrieved by a search of Medline and the Cochrane Library up to february 2006. Terms included were 'pneumonia' and 'ventilator*' and 'heat and moisture exchanger* or circuit*'. To identify randomised controlled trials in Medline the following search strategy was used: (humid* OR humidification OR circuit* OR humidity OR humidifier OR humidifiers OR heat and moisture exchanger* OR artificial nose) AND ((((ventilator associated pneumonia) OR (VAP AND (pneumonia OR pneum*)) OR ("Respiration, Artificial"[MAJR] AND pneumonia) OR (ventilated AND pneumonia) OR (ventilation AND pneumonia)) AND (((randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized controlled trials[mh] OR random allocation[mh] OR double-blind method[mh] OR single-blind method[mh] OR clinical trial[pt] OR clinical trials[mh] OR ("clinical trial"[tw]) OR ((singl*[tw] OR doubl*[tw] OR trebl*[tw] OR tripl*[tw]) AND (mask*[tw] OR blind*[tw])) OR ("latin square"[tw]) OR placebos[mh] OR placebo*[tw] OR random*[tw] OR research design[mh:noexp] OR comparative study[mh] OR evaluation studies[mh] OR follow-up studies[mh] OR prospective studies[mh] OR cross-over studies[mh] OR control*[tw] OR prospective*[tw] OR volunteer*[tw]) NOT (animal[mh] NOT human[mh])))))). Additionally, all reference lists of identified trials were examined.

Selection criteria

All randomised and quasi-randomised trials comparing less frequent changes ventilator circuits with more frequent changes ventilator circuits and ventilator-associated pneumonia as the outcome measure.

Review methods
Data were extracted by two reviewers independently and compared. Disagreements were resolved by discussion. Data from the original publications were used to calculate the relative risk of ventilator-associated pneumonia. Data for similar outcomes were combined in the analysis where appropriate, using a random-effects model.

Results
Seven parallel-group randomised controlled trial were included (1-7)

Study population, interventions and outcome definitions
See Table I

Validity assessment
See Table II

Summary estimates of associations between treatment and control group
See Figure I

Table I: Study population, interventions and outcome definitions

	Participants	**Interventions**	**Definition of ventilator associated pneumonia (VAP)**	**Limitations to study quality (possible factors for bias) and directness**
Boots et al. 1997	Incl: ICU patients undergoing mechanical ventilation for a minimum period of 48 h Excl: patients with asthma, airway burns, pulmonary hemorrhage Median number of ventilation	Treatment (33 analyzed): ventilator circuit changes every 4 days; HME with a bacterial-viral filter changed every 24h (and more frequently if necessary) VAP: 8/33 Control (42 analyzed): ventilator circuit changes every 2 days; HME with a bacterial-viral filter changed	New infiltrate and T> 39^0C or < 36^0C and WBC <$4x10^9$/l or > $11x10^9$/l and endotracheal secretion cultures positive for potential pathogen and increased sputum production /purulent sputum, occurring 48h of ventilation	❖ Possible selective loss after randomisation in the treatment group (selection bias): patients ventilated less than 4 days were excluded. There were fewer patients and the median days of ventilation were lower. It is conceivable that patients in the treatment group were sicker.

	days (range): T: 7.6 (4-40); C: 5.2 (2-58.5)	every 24h (and more frequently if necessary) VAP: C: 6/42 Notes: 1) circuits (reusable): inspiratory limbs, exspiratory limbs, Y-connector; 2) Humid-Vent Filter Light, Gibeck Respiration, Väsby, Sweden End of the study protocol: not described		
Kollef et al. 1995	Incl: 305 medical and surgical patients requiring MV for more than 5 days, older than 18 years Excl: extubation within 24h after randomization, patients transferred from other hospitals and already ventilated for more than 24 hours, lung transplantation, hemoptysis Mean number of ventilator days (SD): T: 14.9 (± 12.2); C: 16.5 (± 14.8)	Treatment (147): no routine ventilator circuit changes VAP: T: 36/147 Control (153): ventilator circuit changes every 7 days VAP: C: 44/153 Notes: 1) ventilator circuits (disposable): gas delivery tubing, humidifier water reservoirs (wick-type humidifier), water traps, Y-connector, medication delivery devices; 2) all non-scheduled circuit changes were done when mechanical defect or soil End of the study protocol: 1) Successfully weaning from the ventilator 2) Hospital discharge 3) Death	VAP was defined as a new and persistent infiltrate more than 48h after intubation or within 48h of extubation and positive ETS culture and a) same organism found in pleural or blood cultures or b) two of the following: fever, leukocytosis and purulent tracheal aspirate	❖ More tracheostomy patients in the control group; tracheostomy was a significant risk factor for VAP. Adjusted odds ratio by multiple logistic regression analysis was 0.68 (0.33 – 1.38); not reported whether adjusted for tracheostomy.
Dreyfuss et al. 1991	Incl: 73 consecutive patients (not specified) requiring continuous MV for more than 48 hours Excl: documented	Treatment (35 randomized, 28 analyzed): no change of ventilator circuit VAP: T: 8/28 Control (38 randomized, 35	VAP was defined as a new and persistent infiltrate more than 48h after intubation or within 48h after weaning and purulent ETS and positive PCB $\geq 10^3$ cfu/ml	❖ High prevalence of VAP

	contraindication to fiberoptic bronchoscopy and/or bronchial brushing, HIV seropositivity, extubation within 96h after randomization Mean number of ventilator days (SD): T: 10 (± 5.7); C: 12.8 (± 11)	analyzed): ventilator circuit changes every 48 hours VAP: C: 11/35 Note: 1) ventilator circuits: swivel adaptor (disposable), Y-connector, inspiratory and expiratory tubing and traps, cascade humidifiers End of the study protocol: 1) The first episode of VAP 2) 48 h after weaning from the ventilator 3) Death		
Craven et al. 1986	Incl: all medical, surgical and cardiac patients requiring MV for > 48 hours Excl: not reported Mean number of ventilator days 10 ± 10 (SD) and a range of 3 to 81 days	Treatment (127 analyzed): change of ventilator circuit every 48 hours VAP: T: 18/127 Control (106 analyzed): change of ventilator circuit every 24 hours VAP: C: 31/106 Note: ventilator circuits: swivel adaptor, flex tube, temperature sensor, non-heated, disposable tubing, cascade humidifier End of the study protocol: not described	VAP was defined as a new and persistent infiltrate during or within 48 h after MV and purulent sputum with positive gram stain and positive sputum culture for potential pathogen or positive gram stain for bacteria and a peripheral leukocyte count of > 10^4 mmm^3 and T > 38^o C.	❖ Comparability for risk factors between groups not shown ❖ Humidifier with possibly open water reservoir
Long et al. 1996	Incl: patients located in the medical and neurosciences intensive care units requiring mechanical ventilation Excl: not reported Mean number of ventilator days: 12.3 days (SD was not reported)	Treatment (234 analyzed): change of ventilator circuits once per week VAP: T: 26/234 or 26/2.624 ventilator days Control (213 analyzed): change of circuit three times per week VAP: C: 27/213 or 27/2.877 ventilator days	VAP was defined as a new or progressive infiltrate and any of the following: new onset of purulent sputum or change in character of sputum; positive blood culture; positive bronchial washing or brushing or biopsy;	❖ Comparability for risk factors between groups not shown

		Note: ventilator circuits (disposable): dual heated wire circuits. It is unclear whether the heated humidifiers (wick-type) were also changed. End of the study protocol: not described		
Makhoul et al. 2001	Incl: 60 premature infants of 35 weeks or less and 72 hours of age, need for substantial ventilatory support because of respiratory distress syndrome or recurrent apnoea or prematurity Excl: pneumonia before intubation, known immunodeficiency, multiple severe congenital malformations, delivery complicated by chorioamnionitis Mean number of ventilator days (SD): T: 11.7 (± 6.87); C: 11.54 (± 6.47)	Treatment (30 randomized, 26 analyzed): change of ventilator circuit every 72 hours. VAP: T: 7/26 or 7/300 ventilation days Control (30 randomized, 29 analyzed): change of ventilator circuit every 24 hours VAP: C: 13/29 or 13/345 ventilation days Note: ventilator circuits: heated humidifier, inspiratory tube, tube for airway pressure monitoring and expiratory tube. It is unclear whether heated or unheated wire circuits were used. End of the study protocol: 1) Extubation 2) Death 3) For a maximum of 21 days	VAP was defined as a new and persistent infiltrate during mechanical ventilation or within 48 hrs after weaning along with either of the following: a) positive blood culture with organisms similar to that of tracheal aspirate b) two of the following: leukocytosis or leukopenia or fever or hypothermia or purulent tracheal secretion.	
Lorente et al. 2004	Incl: All medical and surgical ICU patients requiring mechanical ventilation during more than 72 hours from April 2001 to August 2002. Excl: not reported Mean number of ventilator	Treatment (161 analyzed): no change of circuits VAP: T: 37/161 or 47/3.180 ventilation days *(3de reviewer)* Control (143 analyzed): change of ventilator circuits every 48 hours VAP: C: 33/143 or 36/2.329 ventilation days *(3de reviewer)*	VAP was defined as new onset of purulent sputum and T > 38^{o} C or < 35.5^{o} C and WBC > 10^{4} mmm^{3} or < $4x10^{3}$ mm^{3} and new or progressive infiltrate and positive cultures of EBS > 10^{6} CFU/ml or BAL > 10^{4} CFU/ml or PSB > 10^{3} CFU/ml or same organism found in blood culture and bronchial secretion.	

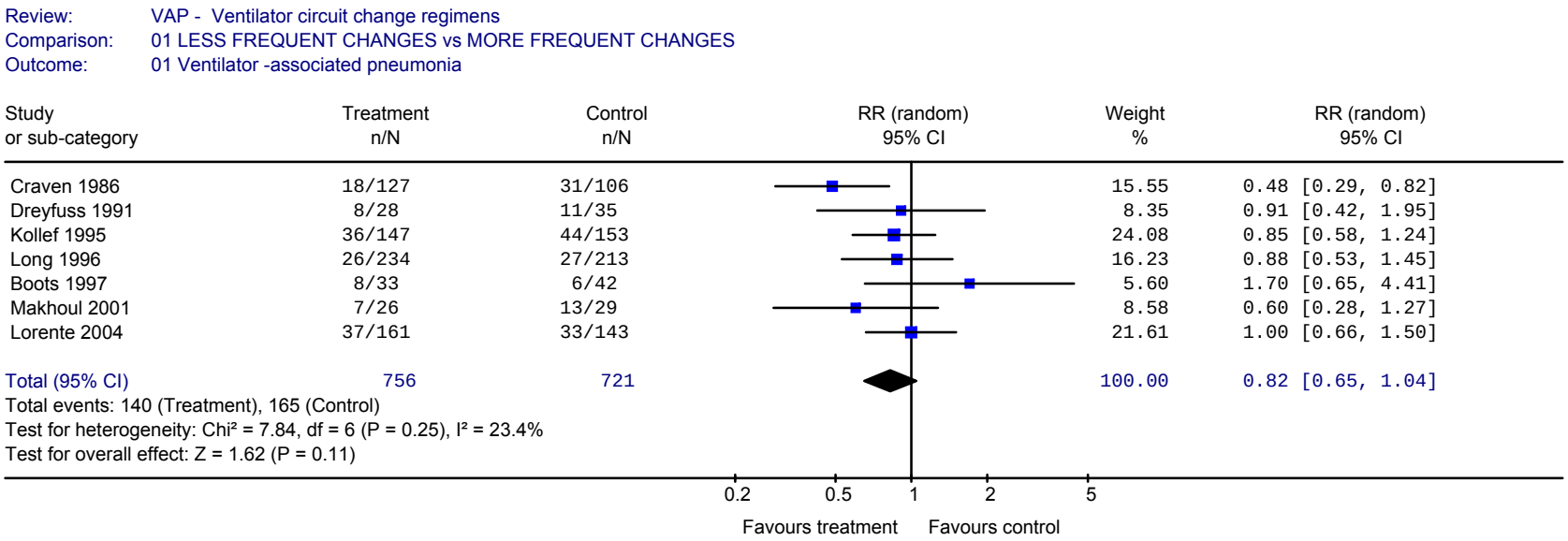
	days (SD): T: 19.8 (± 22.1); C: 16.3 (± 14.3)	Note: ventilator circuits: tubes and HME End of the study protocol: not reported		

Table II: Data on quality assessment

Boots et al. 1997	*Generation of allocation sequence:* *Concealment of allocation:* *Blinding attending physician:* *Blinding outcome assessors:* *Description of dropouts:* *Analysis by intention-to-treat:*	Not reported Unknown No Microbiology staff was blinded to specimen origin Inadequate: just reported that similar numbers were excluded from each group because of ventilation less than the randomized time to the first circuit change No
Kollef et al. 1995	*Generation of allocation sequence:* *Concealment of allocation:* *Blinding attending physician:* *Blinding outcome assessors:* *Description of dropouts:* *Analysis by intention-to-treat:*	Randomization within each hospital by using opaque, sealed envelopes, which were opened at the time each patient was enrolled in the study Adequate No All patients suspected for VAP were independently reviewed by a second investigator who was blinded to the patient's treatment group assignment (Scheduled circuit changes were done during the evening or night shifts to minimize the identification of individual patient group assignments to blinded investigators) Five patients were randomized on two different occasions during one hospitalization: there second study admissions were excluded Unclear
Dreyfuss et al. 1991	*Generation of allocation sequence:* *Concealment of allocation:* *Blinding attending physician:* *Blinding outcome assessors:* *Description of dropouts:*	Randomization by the odd or even year of birth Inadequate No No Treatment group: 7 patients were ventilated for less than 96 h (four died, three were weaned before 96 h); Control: 3 patients were ventilated for less than 96 h (one died, two were weaned before 96 h)

	Analysis by intention-to-treat:	No
Craven et al. 1986	*Generation of allocation sequence:* *Concealment of allocation:* *Blinding attending physician:* *Blinding outcome assessors:* *Description of dropouts:* *Analysis by intention-to-treat:*	Randomization by the odd or even year of birth Inadequate No Chest X-rays were read by at least two of the writers without knowledge of the patient's randomization No Not known
Long et al. 1996	*Generation of allocation sequence:* *Concealment of allocation:* *Blinding attending physician:* *Blinding outcome assessors:* *Description of dropouts:* *Analysis by intention-to-treat:*	Patients were allocated randomly on the basis of permanent medical record numbers: those with odd numbers had circuits changed three times a week, those with even numbers once per week. Inadequate No No Not described Not known
Lorente et al. 2004	*Generation of allocation sequence:* *Concealment of allocation:* *Blinding attending physician:* *Blinding outcome assessors:* *Description of dropouts:* *Analysis by intention-to-treat:*	Randomization occurred by a random number generated with Excel software. Unclear No No Not described No. Note: authors stated a priori that only patients who required mechanical ventilation more than 72 consecutive hours were analysed.
Makhoul et al. 2001	*Generation of allocation sequence:* *Concealment of allocation:* *Blinding attending physician:* *Blinding outcome assessors:* *Description of dropouts:* *Analysis by intention-to-treat:*	The randomization procedure, performed by an independent observer, assigned consecutive numbers to the patients at the time of inclusion corresponding to a randomized management order. A nurse who was not involved in the study provided individual code envelopes indicating the management of each patient. Unclear No No Treatment group: 3 were weaned before the second ventilator circuit change, 1died from severe intraventricular hemorrhage within 2 days of the study; control group: 1died from severe intraventricular hemorrhage within 2 days of the study No

Figure I: Summary estimates of associations between treatment and control group expressed as relative risk (RR) and 95% confidence interval (CI) using a random effects model



Conclusion

The evidence of seven trials indicates that ventilator circuits should not be changed routinely. The evidence, however, was low because the quality of the trials and their reporting were generally unsatisfactory. Just one trial clearly had adequate concealment of randomisation. Concealment of allocation was inadequate in three trials and unclear in another three trials. Just two trials described adequately dropouts. Four trials did not use intention-to-treat analysis and in three trials it was unclear whether the analysis was by intention-to-treat.

References

1. Boots RJ, Howe S, George N, Harris FM, GFaoagali J. Clinical utility of hygroscopic heat and moisture exchangers in intensive care patients. Crit Care Med 1997;25(10):1707-1712.
2. Makhoul IR, Kassis I, Berant M, Hashman N, Revach M, Sujov P. Frequency of change of ventilator circuit in premature infants: Impact on ventilator-associated pneumonia. Pediatr Crit Care Med 2001;2(2):127-132.
3. Lorente L, Lecuona M, Galván R, Ramos MJ, Mora ML, Sierra A. Periodically changing ventilator circuits is not necessary to prevent ventilator-associated pneumonia when a heat and moisture exchanger is used. Inf Contr Hosp Epid 2004;25:1077-1082.
4. Long MN, Wickstrom G, Grimes A, Benton CF, Belcher B, Stamm AM. Prospective, randomized study of ventilator-associated pneumonia in patiënts with one versus three ventilator circuit changes per week. Infect Control Hosp Epidemiol 1996;17:14-19.
5. Craven DE, Kunches LM, Kilinsky V, Lichtenberg DA, Make BJ, McCabe WR. Risk factors for pneumonia and fatality in patients receiving continuous mechanical ventilation. Am Rev Respir Dis 1986;133(5):792-6.
6. Dreyfuss. Prospective study of nosocomial pneumonia and of patient and circuit colonization during mechanical ventilation with circuit changes every 48 hours versus no change. Am Rev Respir Dis 1991;143(738-43).
7. Kollef M. Mechanical ventilation with of without 7-day circuit changes. A randomized controlled trial. Ann Intern Med 1995;123:168-174.