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Papers

Systematic review and meta-analysis of studies of the timing of tracheostomy in adult patients undergoing artificial ventilation

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Abstract

Objective To compare outcomes in critically ill patients undergoing artificial ventilation who received a tracheostomy early or late in their treatment.

Data sources The Cochrane Central Register of Clinical Trials, Medline, Embase, CINAHL, the National Research Register, the NHS Trusts Clinical Trials Register, the Medical Research Council UK database, the NHS Research and Development Health Technology Assessment Programme, the British Heart Foundation database, citation review of relevant primary and review articles, and expert informants.

Study selection Randomised and quasi-randomised controlled studies that compared early tracheostomy with either late tracheostomy or prolonged endotracheal intubation. From 15 950 articles screened, 12 were identified as "randomised or quasi-randomised" controlled trials, and five were included for data extraction.

Data extraction Five studies with 406 participants were analysed. Descriptive and outcome data were extracted. The main outcome measure was mortality in hospital. The incidence of hospital acquired pneumonia, length of stay in a critical care unit, and duration of artificial ventilation were also recorded. Random effects meta-analyses were performed.

Results Early tracheostomy did not significantly alter mortality (relative risk 0.79, 95% confidence interval 0.45 to 1.39). The risk of pneumonia was also unaltered by the timing of tracheostomy (0.90, 0.66 to 1.21). Early tracheostomy significantly reduced duration of artificial ventilation (weighted mean difference −8.5 days, 95% confidence interval −15.3 to −1.7) and length of stay in intensive care (−15.3 days, −24.6 to −6.1).

Conclusions In critically ill adult patients who require prolonged mechanical ventilation, performing a tracheostomy at an earlier stage than is currently practised may shorten the duration of artificial ventilation and length of stay in intensive care.

Introduction

Tracheostomy is among the most commonly conducted procedures in critically ill patients. It has many potential advantages over translaryngeal endotracheal intubation in the critical care setting, including reduced laryngeal ulceration and respiratory resistance; it is better tolerated by patients and improves their capacity to communicate; and it makes for easier nursing care.[1–4] However, the procedure is not without risk. Complications resulting from the procedure include stomal infections, stomal haemorrhage, pneumomediastinum, pneumothorax, and occasionally death.[5–8] Although the procedure used to create a tracheostomy does not influence outcome, as both surgical and percutaneous techniques carry comparable modest risks, the effect the timing of the procedure has on outcome is less clear.[9–11]

Evidence to guide practice has been limited. In 1989 the National Association of Medical Directors of Respiratory Care recommended that translaryngeal (endotracheal) intubation be used only for patients requiring less than 10 days of artificial ventilation and that a tracheostomy should be placed in patients who still require artificial ventilation 21 days after admission.[12] Although these recommendations are based only on expert opinion, modern practice broadly seems to follow them.[13] In 1997 Kane et al recommended early tracheostomy in patients with multiple injuries on the basis of a descriptive review of the relevant literature,[14] but a systematic review (without meta-analysis) of randomised trials of tracheostomy timing published in 1998 by Maziak et al concluded that there was insufficient evidence to support the view that the timing of tracheostomy alters the duration of mechanical ventilation or extent of airway injury in critically ill patients.[15] Since the review by Maziak et al we are aware that at least two more trials have been completed, both of which were methodologically more sound than their predecessors.[16 17] We decided to appraise critically and summarise all randomised clinical trials involving the timing of tracheostomy in adult patients in intensive care units.

Methods

We defined a randomised trial as one in which patients were assigned prospectively to either early tracheostomy or late (or no) tracheostomy by random allocation at time of enrolment. We defined early tracheostomy as a tracheostomy conducted up to seven days after admission to the intensive care unit, initiation of translaryngeal intubation, and mechanical ventilation. Late tracheostomy was any time thereafter.

We used several techniques to identify published and ongoing studies for this review. We searched Medline, CINAHL, Embase, the Cochrane Central Resister of Clinical Trials, the National Research Register, the NHS Trusts Clinical Trials Register, the Medical Research Council UK database, the NHS Research and Development Health Technology Assessment Programme, and the British Heart Foundation database in January, May, and November 2004. The search strategies for Medline were based on the terms recommended by the Cochrane Collaboration to identify randomised trials coupled with the term "trache*" to identify tracheostomies. We identified relevant studies initially by title, then by abstract, and finally by full text. Initially two authors did the electronic searches in duplicate and then repeated them independently. We also searched the

bibliographies of reports of randomised trials and any identified reviews. Finally we contacted UK experts in the subject.

Study selection and data extraction

We selected studies for inclusion in the analysis if they were randomised or quasi-randomised clinical trials including adult patients requiring artificial ventilation. The intervention was early tracheostomy, compared with either continued translaryngeal intubation or continued translaryngeal intubation followed by late tracheostomy. The primary outcome measure in the review was mortality; secondary outcomes were length of stay in the critical care unit, duration of artificial ventilation, and incidence of ventilator associated pneumonia. We combined hospital and 30 day mortality in the analysis, and if the point at which mortality was assessed was not given we assumed it to be hospital mortality. Not all studies included all outcome measures.

Statistics and analysis

We recorded mortality and the presence of hospital acquired pneumonia at any time in the study period as binary variables and length of stay in the critical care unit and duration of artificial ventilation as continuous variables. We used a random effects meta-analysis with RevMan 4.1 software (Cochrane Collaboration, Oxford) to analyse the data. We considered $I^2 > 50\%$ to indicate significant heterogeneity between the trials.

Results

The initial searches identified 15 950 unique titles. After initial screening by title and then abstract, we identified 12 randomised clinical trials from manuscript review. We excluded studies without either an English title or abstract. We also identified one study from a published conference abstract.[18] We did not find any further relevant publications by reviewing the bibliography of the selected studies and review articles.

We then excluded two of the randomised studies because the timing of early and late tracheostomy were separated only by a 24 hour period,[19 20] another because the timing of the early tracheostomy was after seven days (a criterion of this review),[18] and a further two because the articles did not contain any data on the outcome measures on which this review is based.[5 21] We excluded another study because of clear evidence of bias either in the selection of patients or their exclusion after randomisation, as a 1:1 randomisation schedule resulted in an approximately 5:1 final distribution of patients between study arms.[22] Finally we excluded another study as it described only the study design.[23] Figure 1 shows the search process.

Overall, only five trials with a combined study population of 406 patients were original, randomised or quasi-randomised, methodologically sound clinical trials of the timing of tracheostomy in the management of artificially ventilated, critically ill adults. These studies spanned a 20 year period between 1984 and 2004. One of the studies compared tracheostomy only with continuing translaryngeal intubation.[24]

Table 1 summarises the study characteristics. The two oldest studies[25 26] were quasi-randomised, using randomisation techniques that allowed the assignment of the patient to be determined before enrolment, thereby producing a potential for bias. The studies by Saffle et al and Rumbak et al were appropriately randomised.[16 17] The most recent study was described as randomised but did not define its randomisation strategy.[18 24]

Each of the studies examined different populations of critically ill patients, in critical care units for surgical, trauma, and burns patients and one multicentre study in three medical critical care units. All studies came from the United States, with the exception of the Moroccan study of Bouderka et al.

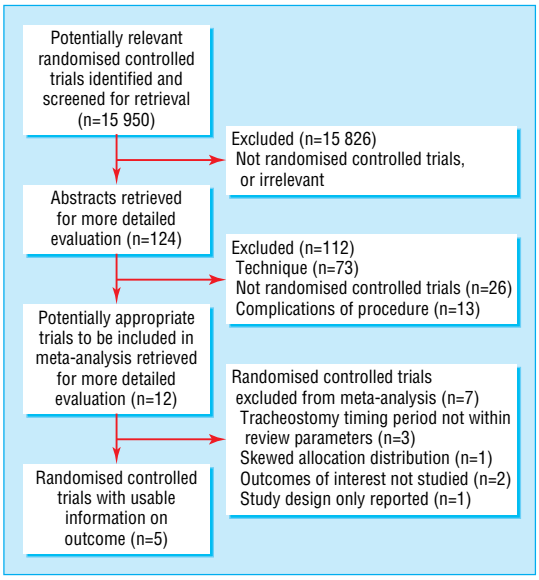

Fig 1 Process of study selection of randomised controlled trials

Mortality

Information on hospital mortality was available for four of the five studies (332 patients). Figure 2 shows the random effects meta-analysis of relative risk of hospital mortality for early compared with late tracheostomy. The timing of tracheostomy did not alter mortality significantly (relative risk 0.79, 95% confidence interval 0.45 to 1.39, P = 0.42).

Risk of hospital acquired pneumonia

Information on the number of patients developing hospital acquired pneumonia while in the intensive care unit was available for all five studies. Figure 3 shows the random effects meta-analysis of relative risk of hospital acquired pneumonia for early versus late tracheostomy. The risk of developing hospital acquired pneumonia was unchanged by tracheostomy timing (0.90, 0.66 to 1.21, P = 0.48).

Duration of artificial ventilation

Information on the duration of artificial ventilation was available for four of the five studies (332 patients). Figure 4 shows the forest plot. The combined results showed duration of artificial ventilation to be significantly lower in the early tracheostomy group (weighted mean difference −8.5 days, 95% confidence interval −15.3 days to −1.7 days, P = 0.03).

Length of stay in the critical care unit

Information on the length of stay in a critical care unit was available for two of the five studies (226 patients). Figure 5 shows the forest plot. Overall the length of stay in the critical care unit was significantly lower in the early tracheostomy group (−15.3 days, −24.6 days to −6.1 days, P = 0.001).

Discussion

Early tracheostomy placement may lead to a markedly reduced duration of ventilation and shorter stays in critical care units in artificially ventilated, critically ill adult patients. However, the limited numbers of studies and patients available for analysis leave some doubt as to the accuracy of the result.

Table 1 Summary of studies included in systematic review

Study	No of patients (n=406)	Timing of tracheostomy		Intensive care setting	Randomisation	Mortality expressed on intention to treat basis	Duration of ventilation and critical care stay expressed on intention to treat basis
		Early	Late				
Bouderka et al 2004[24]	62	5-6 days after admission	Prolonged endotracheal intubation	Unit for patients with head injuries	Randomised; method not stated	Implied	Implied both
Dunham et al 1984[25]	74	3-4 days after initiation of translaryngeal intubation	14 days after initiation of translaryngeal intubation	Trauma unit	Quasi-randomised	Mortality not recorded Pneumonia analysed by intention to treat	Yes
Rodriguez et al 1990[26]	106	1-7 days after admission to intensive care unit	8 or more days after admission to intensive care unit	Surgical unit	Quasi-randomised	Implied	Implied both
Rumbak et al 2004[17]	120	0-2 days after initiation of mechanical ventilation	14-16 days after initiation of mechanical ventilation	Three medical units	True randomisation	Implied	Yes
Saffle et al 2002[16]	44	Next available operative day	14 days after burn injury	Burns unit	True randomisation	Implied	Yes

Possible limitations

It is possible that we did not identify all available published research, but by performing a comprehensive and repeated literature search we minimised this risk. In spite of this extensive searching, we identified only five original, randomised or quasi-randomised clinical trials of the timing of tracheostomy in the

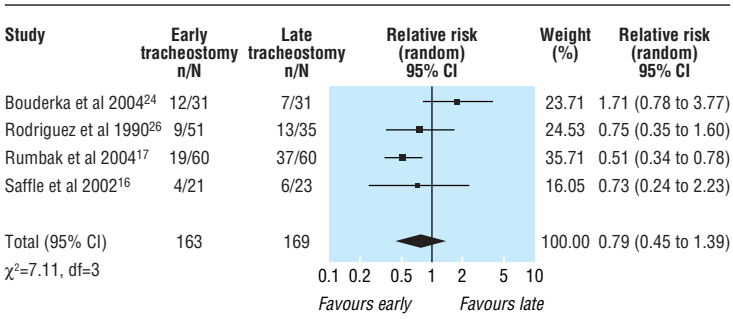

Fig 2 Random effects meta-analysis of relative risk (95% confidence interval) of mortality with early compared with late tracheostomy

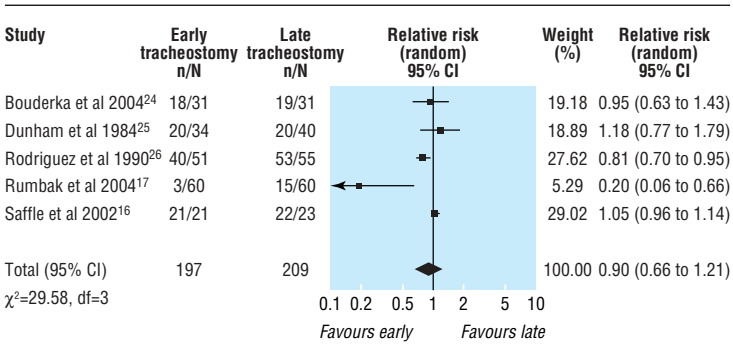

Fig 3 Random effects meta-analysis of relative risk (95% confidence interval) of hospital acquired pneumonia with early compared with late tracheostomy

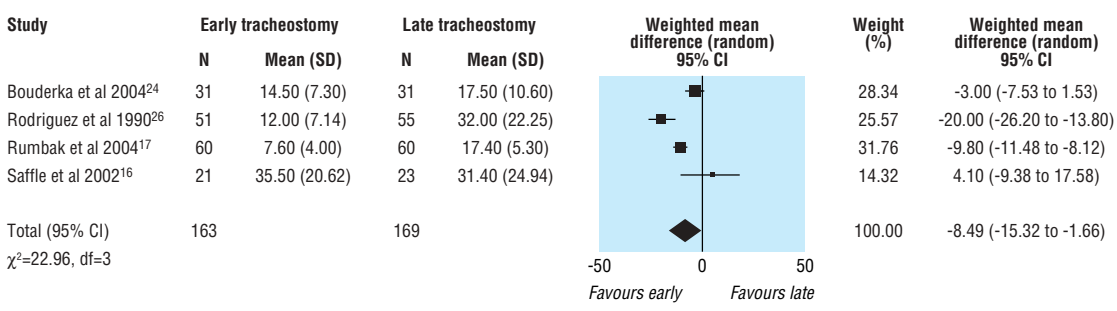

Fig 4 Random effects meta-analysis of weighted mean difference (95% confidence interval) of duration of ventilation in days

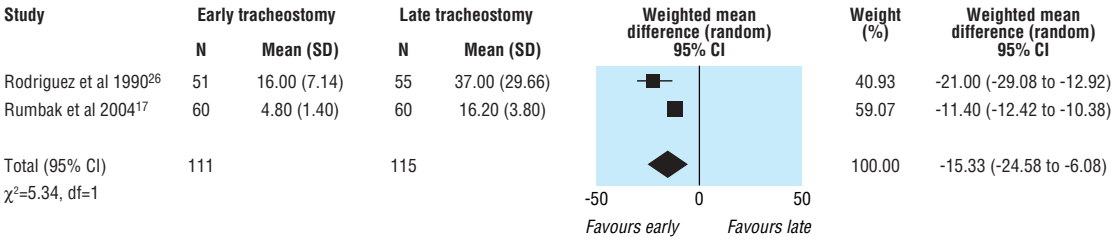

Fig 5 Random effects meta-analysis of weighted mean difference (95% confidence interval) of length of stay in the critical care unit in days

management of artificially ventilated, critically ill adults. The trials all had relatively small study populations, giving a total combined population of only 406 patients.

Heterogeneity between studies

Heterogeneity between the studies included in this review arises because the exclusion and inclusion criteria differed across the trials and because each trial used a different definition of what constituted an "early" or "late" tracheostomy (table 1). The critical care populations studied also differed because the trials were undertaken in different specialist rather than general critical care units. Some heterogeneity existed in the way some outcomes were defined. The diagnostic criteria for hospital acquired pneumonia varied between studies (table 2), leading to large differences in the proportion of patients reported as developing this complication in the same treatment arm of different studies. The heterogeneity of the studies was also quantified (I^2).[27] All had high I^2 values (57.8%, 86.5%, 81.3%, 86.9%), showing that most of the variability across the studies is due to heterogeneity rather than chance.

If an early tracheostomy strategy were adopted widely many mechanically ventilated patients could have a tracheostomy placed earlier in their stay, a procedure they would not receive when a more conservative, late approach is used. However, in the randomised controlled trial by Rumbak et al, eight patients (35% of survivors) in the late tracheostomy arm no longer had a clinical need for a tracheostomy by the time this procedure was indicated by protocol.[17] Although this review would support a limited benefit—that is, a shorter stay in the intensive care unit and duration of ventilation—premature or ill advised placement of a tracheostomy may not represent an appropriate balance of risk. To avoid this problem, attempts have been made to develop formulas to predict the probability of a patient requiring prolonged ventilation,[28] allowing better selection of patients likely to benefit from early tracheostomy. However, to date no validated specific and sensitive test or scoring system is available that predicts the need for prolonged ventilation in general populations in critical care, and so the selection of patients for tracheostomy remains a subjective decision.

Table 2 Criteria used to diagnose hospital acquired pneumonia

Study	Diagnosis of pneumonia
Bouderka et al[24]	Criteria not stated
Dunham et al[25]	Respiratory infections confirmed and documented by the hospital infectious disease service, using rigorous criteria
Rodriguez et al[26]	Required all five of the following: temperature >38.6°C, white blood cell count >15×10⁹/l inflammatory cells and bacteria on Gram stain, positive sputum culture, and new infiltrate on chest x ray film
Rumbak et al[17]	Confirmed by bronchoscopy using semi-quantitative cultures from protected specimen brushes (>1000 organisms/ml^{-1}) or broncho-alveolar lavage (>10 000 organisms/ml^{-1}) or a positive Gram stain
Saffle et al[16]	CDC standard criteria for intubated patients (Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC definitions for nosocomial infections. *Am J Infect Control* 1988;16:128-40)

CDC=US Centers for Disease Control and Prevention.

Conclusion

Current practice for definitive airway management in critically ill adults uses translaryngeal intubation in the early stages. Tracheostomy is subsequently performed if the attending doctor estimates that the patient will require an extended period of artificial ventilation. However, if the results from our meta-analysis can be generalised, in spite of the small numbers of trials and patients, it may be advisable to place a tracheostomy earlier on in the proceedings. The UK critical care community has recently highlighted this specific clinical question in a priority setting exercise. The first, large scale study in UK intensive care units of the effect of the timing of tracheostomy powered on mortality has now started recruitment.

Contributors: JDY, LM and VSB selected studies, extracted and analysed data, and with JG wrote the paper. JDY is guarantor.

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Competing interests: JDY and LM are involved in TracMan, a randomised controlled trial in UK intensive care units for adults, which compares the effect of the timing of tracheostomy, funded by the Intensive Care Society.

Ethical approval: Not required.

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What is already known on this topic

Tracheostomy is considered to be the standard care in patients requiring long term ventilation

Many trials have reported the use of tracheostomy in adult patients, but most involved small numbers of participants with specific conditions

Previous reviews have reached different conclusions about the timing of tracheostomy in adult patients

What this study adds

Earlier placement of a tracheostomy in critically ill patients may shorten duration of artificial ventilation and length of stay in intensive care

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