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Best practice in stabilisation of oral endotracheal tubes: a systematic review

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Abstract

Mechanical ventilation of patients in intensive care units is common practice. Artificial airways are utilised to facilitate ventilation and the endotracheal tube (ETT) is most commonly used for this purpose. The ETT must be stabilised to optimise ventilation and avoid displacement or unplanned extubation. Tube movement is a major factor in causing airway trauma. A destabilised tube can cause fatal complications. A systematic review was conducted to identify and analyse the best available evidence on ETT stabilisation to determine which stabilisation method resulted in reduced tube displacement and the least amount of unplanned or accidental extubations. The types of stabilisations included one or a combination of the following methods: twill or cotton tape, adhesive tape, gauze, or a manufactured device. All relevant randomised controlled and quasi-experimental studies of ETT stabilisation practices, identified through electronic and hand searching, were assessed for inclusion in the study. One published randomised controlled trial and six published quasi-experimental studies met the inclusion and exclusion criteria and were retrieved. Data were extracted independently by two reviewers. Results of the systematic review showed that no single method of ETT stabilisation could be identified as superior for minimising tube displacement and unplanned or accidental extubations. Rigorous randomised controlled trials with clearly identified and described ETT stabilisation methods are required to establish best practice. In addition, comparative research to evaluate cost effectiveness and nursing time requirements would also be of significant benefit to critical care nursing practice.

Background

Mechanical ventilation of patients in the Intensive Care Units (ICU) is common practice. Artificial airways are utilised to facilitate mechanical ventilation and the endotracheal tube (ETT) is most commonly used for this purpose. The ETT must be stabilised to optimise ventilation and avoid displacement or unplanned extubation. Tube movement is a major factor in causing airway trauma. A destabilised tube can cause fatal complications such as bronchospasm, respiratory distress and myocardial infarction [1]. Other complications associated with ETT stabilisation include facial skin and mucosal breakdown, which can cause patient discomfort and disfigurement.

Various techniques have been employed by intensive care nurses to ensure ETT stabilisation in order to maintain a patent airway and prevent or minimise complications. The optimal stabilisation method should not only be secure but also require infrequent changing [2]. Other nursing considerations in ETT stabilisation include ease of use, cost and time effectiveness, and patient comfort [3]. Stabilisation techniques, often unit-specific, may include the use of twill, cotton, or adhesive tape, different methods of tying tape, and/or the use of a commercially available tube holder.

Our intensive care unit had an unacceptable increase in the number of accidental extubations and variability in practice associated with unresolvable differences of opinion about the best way to secure ETTs. These problems precipitated a review of the literature surrounding this clinical issue. We found that there was no single acceptable standard for ETT stabilisation described in the literature and this led us to plan a study to resolve the issue to meet our local need. We submitted a proposal for a clinical trial to our institutional human research ethics committee. The committee, however, did not accept our assertion that there was no definitive method for this common procedure and requested a more extensive examination of the literature. We accepted the challenge to conduct a systematic review with the intention of identifying either *best* practice in ETT stabilisation or what further research was needed to resolve this controversial, yet important, clinical problem. The investigating team comprised both researchers and clinical staff with varying levels of experience in conducting systematic reviews. Therefore, the project was also designed to maximise the potential for learning. The review team was divided into three groups of two members each. In each review group, a senior nurse researcher with experience in literature searching and critical appraisal was paired with a nurse clinician.

Objective

The objective of this systematic review was to identify and critically appraise the available evidence on ETT stabilisation with respect to tube displacement, unplanned or accidental extubation, and facial skin and/or oral mucosa breakdown.

The research questions guiding the review were:

For patients in adult ICUs, requiring stabilisation of a cuffed ETT;

1. which method of ETT stabilisation results in the least amount of tube displacement?

2. which method of ETT stabilisation results in the least amount of unplanned or accidental extubations?
3. which method of ETT stabilisation results in the least amount of facial skin, lip and/or oral mucosa breakdown?
4. which method of ETT stabilisation is preferred by nurses for maintenance of oral hygiene?

Methods

Criteria for considering studies for this review

Types of studies

Randomised controlled trials comparing or assessing one or more methods of ETT stabilisation were included. In the absence of randomised controlled trials, criteria were extended to non-randomised controlled trials, quasi-experimental trials, cohort studies, and case-controlled studies.

Types of participants

Patient populations included patients in adult intensive care units requiring cuffed ETT stabilisation. Studies that only assessed neonatal or paediatric patients were not included because the problems surrounding stabilisation of ETTs in this patient population are very different. Specifically, the anatomy of small children and neonates poses special concerns and the tubes are usually uncuffed, introducing an added dimension to the risk of accidental extubation.

Types of interventions

Types of interventions included ETT stabilisation by one or a combination of any of the following methods: twill or cotton tape, adhesive tape, gauze, or commercially available tube holder.

Types of outcome measures

Primary outcome measures included:

- incidence and amount of ETT displacement
- incidence of accidental or unplanned extubation
- incidence of facial skin or lip breakdown
- incidence of mucosal breakdown

Secondary outcome measures included:

- nurse satisfaction with ease of mouth care

Search strategy

A preliminary search was made in MEDLINE, Current Contents, CINAHL, EMBASE and The Cochrane Library, and proceeded to include Database of Reviews on Effectiveness (DARE) from 1993 to 2003. These databases were searched using the following search strategy:

1. (endotracheal OR intratracheal) AND tube
2. tube displace*
3. intensive care
4. critical care
5. (skin breakdown)

6. (oral mucosa*)
7. (unplanned extubation) AND (accidental extubation) AND (traumatic extubation)
8. complications
9. stabilisation
10. secur*
11. (nurse satisfaction)

The search strategy used whole words or words beginning with specified letters and including or ending with the 'truncation' symbols * and ?. Thus 'stabilisation' found both 'stabilisation' and 'stabilization'. Reference lists of all retrieved and relevant publications identified were searched for additional studies. Unpublished data were sought using online forums, such as the Australian College of Critical Care Nurses. Hand searching of key critical care journals for the last three years was undertaken. Critical care and anaesthesia conference proceedings were also examined. Due to limited funding, only English language papers were retrieved.

Data extraction and analysis

Titles and abstracts of all studies identified by the search strategy were examined for relevance and design according to the selection criteria. This assessment was performed by each review group independently. Full papers were retrieved where the studies appeared to satisfy the inclusion criteria. Where there was disagreement about whether to retrieve the full paper or not, the paper was retrieved. Each of these selected studies was then independently appraised by two review groups. Studies agreed upon by both groups as meeting the selection criteria were included in the final review. Studies were critically appraised using a piloted, standardised tool for assessing methodological quality, randomisation process, inclusion and exclusion criteria, baseline comparability of study populations, and sub group analysis by grouping studies according to specific interventions (for example, types of tape) and units of measurement (for example ventilator days or entire ventilated period).

Finally, data were extracted for possible meta-analysis. These data were also extracted using a piloted, standardised form. The following data were collected: patient demographics (age, sex, APACHE II score or medical diagnosis), type of ETT tube (oral or nasal), method of tube stabilisation, incidence of tube displacement, accidental or unplanned extubation, facial skin breakdown, and/or oral mucosa breakdown. For this data synthesis, studies were grouped according to population, intervention, and measurement outcomes. Where possible, data were pooled and analysed using Review Manager 4.1 [4] to obtain an average effect. Odds ratios and confidence intervals were calculated for dichotomous data, and weighted mean differences and confidence intervals were calculated for continuous data.

Results

Seven studies were initially selected for the review. The great disparity in outcome measures, coupled with the variation in interventions, resulted in only three studies that could be combined for meta-analysis. However, given the importance of the topic as an issue for patient safety, a narrative summary of the seven studies has been

included [5]. Thus, this section begins with a description of all seven studies followed by meta-analysis using three studies (see Table 1 for summary).

[Table 1 here]

Description of studies

Design

All studies used a prospective design. Only one study [3], had a randomised, active control equivalence design. All other studies were quasi-experimental or observational in design [2, 6-10].

Setting

All studies were conducted in hospital-based critical care or intensive care units. Two studies [6, 10] were multi-centred, two studies used multiple clinical units within single hospitals [3, 7], two studies used single clinical units [2, 9], and one study did not specify the setting beyond naming the hospital [8], though it is reasonable to assume that a single clinical unit was involved.

Population and sample

The population for all studies was orally intubated adult inpatients admitted to critical care or intensive care units. Study sample sizes ranged from 30 to 687 with three study samples reported as less than 100 participants [6-8].

Intervention and outcome measure

The description of the intervention, that is, the method of ETT stabilisation, was different for each of the seven studies. Two studies compared adhesive or adhesive waterproof tape with various commercially available tube holders [2, 7]. One study compared adhesive tape with twill tape [6]. One study compared cloth or Velcro tie with waterproof cloth tape [9]. One study compared adhesive tape, twill tape, and twill tape or Velcro with a bite block [8]. One study compared thin adhesive tape, strong cloth adhesive tape, and cloth string [10], each method being used in a different study centre. One study simply compared stabilisation using a knot, with stabilisation using bow methods of tying cotton tape [3].

While the type of outcome measure was more standardised than the interventions, the units of measurement varied greatly, with not every study informing each systematic review research question. Outcome measures included ETT stability [2, 3, 7, 8], facial skin integrity [2, 3, 6, 7], inadvertent or unplanned extubation [3, 6, 7, 9, 10], oral mucosa status [6], and nurse or nurse and patient satisfaction [2, 3, 7, 8].

The great disparity in units of measurement, coupled with the variation in interventions, resulted in very little potential for meta-analysis. For each of the three studies included in meta-analysis [2, 7, 8], only some of the published data were utilised. Studies were combined to determine the comparative incidence of ETT displacement [2, 7] and the extent of lip excoriation and facial trauma [2, 7]. Two studies were also combined to examine the amount of ETT displacement expressed in centimetres [7, 8].

Methodological quality of studies

Only three studies provided information about sample size calculation [2, 3, 6]. None of these studies had sufficient power to enable the conduct of multivariate analysis. Consequently, no studies were able to comprehensively control for potential confounding factors. Other methodological limitations included changes to protocol during studies, patient self-selection out of an intervention group; non-standardised lengths of time on trials; method of randomisation not clearly described in the publication and the comparability of groups at start of studies was not presented. Table 1 provides a narrative summary of all studies that were prospective in design and made comparison between methods of securing ET tubes either over pre-arranged time periods or concurrently. This narrative summary is included to demonstrate the diversity of methods of ETT stabilisation and because of the dearth of studies available for meta-analysis. Clarke and her team [3] commented on the strong personal preferences of some nursing staff for a particular method and this may explain the myriad methods that were more broadly identified in the search of the literature.

Meta-analysis

Meta-analysis was conducted to determine the extent of lip excoriation [2, 7], facial trauma [2, 7], and ETT displacement [7, 8]. Fewer patients suffered lip excoriation (OR 0.2, CI = 0.1-0.5) if their ETT was stabilised using a commercially manufactured device rather than adhesive tape ($z=3.6, p<0.001$) (see Figure 1). Fewer patients suffered facial trauma (OR 0.4, CI = 0.1-1.2) if their ETT was stabilised using a commercially manufactured device rather than adhesive tape but this result was not statistically significant ($z=1.61, p=0.11$) (see Figure 2).

[Figures 1 and 2 here]

The amount of ETT displacement was 0.6cm less (CI = 0.4-0.9) if a commercially manufactured device was used ($z=5.07, p<0.001$). However, tests for heterogeneity revealed that, for the meta-analysis of incidence and amount of ETT displacement, the results could be explained by factors other than chance, thus suggesting that the difference, while statistically significant, should be regarded with great caution. This meta-analysis is not shown therefore.

Discussion

This systematic review was undertaken to identify best practice in ETT stabilisation. Nonetheless, despite a clinical problem that has been identified in the critical care literature for more than a quarter of a century, there is still insufficient rigorous published research to answer the problem identified in the systematic review. There were many limitations to studies initially identified as being pertinent to this important clinical question. For several studies, the published data did not include measures of dispersion. Even for those studies included in the meta-analysis, some data were incomplete [8, for example], restricting which intervention groups could contribute data and further limiting the potential for meta-analysis.

The relative age of the studies also presented the problem of obsolescence of equipment. Most of the commercially manufactured devices are no longer available in

the form in which they were manufactured at the time of their use in the studies. In addition, endotracheal tubes currently in use are very different in design and materials from those manufactured in 1987, [7, for example], and we simply do not know to what extent the design of the tube (in particular, the type of cuff) is implicated in ease of accidental extubation.

Chemical management of patients undergoing mechanical ventilation is an important factor and yet only one study considered level of sedation worthy of comment [9]. Again, sedation practices have changed, with many new agents becoming available. International variation in staffing practices, such as differing staff to patient ratios and levels of nursing qualification, is another factor that has the potential to confound comparison.

Another continuing clinical problem is the difficulty of reconciling the need for a secure stabilisation method with often contradictory needs for ease of access to enable completion of mouth care and for prevention of skin and mucosal damage (often precipitated by overly firm application of adhesive tape or ties) [3, 8].

In the discussion sections of some studies, researchers identified difficulty with clinical staffs' personal preferences potentially interfering with measurement and assessment of the study outcomes [2, for example, 8].

Due to the heterogeneity of methods of securing ETTs and in the quality and rigour of research reporting, the research team experienced a considerable amount of difficulty in evaluating the quality of study designs and extracting data for meta-analysis. Implementation of the CONSORT guidelines [11] when reporting studies should improve these problems.

Clarke and others wrote in 1998:

Given that ETT securing is common practice in ICUs, it is remarkable that there has not been more research on methods of ensuring safety and maximum care [3, p 50].

Seven years later, there have been no further studies published and there remains no better indication for best practice in ETT stabilisation. To echo Clarke's astonishment, this is more remarkable given that ETT design and materials have undergone considerable refinement and there are many new commercially manufactured devices for ETT stabilisation. A research protocol that describes a multicentre, prospective, randomised trial, blinded for data analysis (because clearly the intervention cannot be hidden from patient, family or bedside caregivers) is very feasible and should be implemented as soon as possible.

The review has two limitations. First, the search strategy was limited to English language literature and so research published in other languages would not have been identified for this systematic review. Second, as already discussed, the paucity of randomised controlled trials and incomplete presentation of results severely limited the potential for meta-analysis.

Reviewers' conclusions

From the limited results, it was not possible to identify conclusively which method of ETT stabilisation resulted in the least amount of tube displacement; the least amount of unplanned or accidental extubations; and the least amount of facial skin, lip or oral mucosa breakdown. It was also not possible to identify conclusively which method of ETT stabilisation was preferred by nurses for maintenance of oral hygiene. The actual number of variations of methods of securing ETTs is, in itself, a barrier to conducting multicentre trials with many methods being local and idiosyncratic in origin. There is insufficient information to make any recommendations regarding clinical practice.

Finally, there is a significant dearth of rigorous, well-reported studies on this topic. There is an urgent need for large, multicentre, well designed, randomised controlled trials to rectify this gap in the critical care research and clinical literature. The practical difficulties outlined in this review suggest that such studies will need to be carefully planned. Rigorous trials with clearly identified outcome measures and explicitly described ETT stabilisation methods are required to establish best practice. Multicentred trials would improve generaliseability and promote clinical acceptance of the findings, given the identified problems with resistance to practice change of many clinicians. Economic studies evaluating cost effectiveness, including quantification of nursing hours, would also be of significant benefit to critical care nursing practice.

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Potential conflict of interest

None.

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Table 1: Summary of studies included in narrative review

Citation	Research design	Setting	Sample	Intervention	Method	Outcomes	Methodological quality
Barnason et al 1998 [6]	Prospective quasi-experimental pilot study	Critical care units in 3 community hospitals and 1 veterans' hospital in America	52 patients 30 male 22 female	Comparison of twill tape versus adhesive tape	All intubated patients in a 6-month period randomised to method by alternate month. Demographic data tool (on enrolment), Oral Assessment Guide, and Extubation Data Collection tool (both on completion) completed by nurse	No significant differences found between two methods for accidental extubation and for maintenance of oral mucosa and facial skin integrity	Insufficient data provided to enable inclusion in meta-analysis
Boulain et al 1998 [10]	Prospective multicentre observational study	11 ICUs in 11 hospitals in France	426 patients 262 male: 164 female	No intervention: type of ETT fixation used ('lasso', strong, or thin adhesive tape) studied as potential risk factor for unplanned extubation	Data collected on all intubated patients over two-month period. Usual clinical and demographic characteristics recorded, and attending physician collected additional clinical and therapeutic data on daily basis. Questionnaire completed by physician for each unplanned extubation	Univariate analysis revealed lack of strong tube fixation as significant risk factor for unplanned extubation	Insufficient data provided to enable inclusion in meta-analysis
Clarke et al 1998 [3]	Randomised active control equivalence design	Three ICUs in a large Australian tertiary hospital	228 patients commenced, 222 completed 154 male: 74 female	Comparison of standard 'knot' method (gauze) versus 'bow' method (cotton tape)	All orally intubated patients in a 5-month period randomised to knot or bow method. Allocated tying method evaluated once daily by attending nurse using 5-point Likert scale for each outcome measure: mouth care, patient comfort, ETT position, tape security, ease of use. Data collection ceased on permanent extubation	Bow method found to be as effective as standard knot method.	Most rigorous study but methods of securing ETT were not used by any other study therefore unable to be included in meta-analysis.
Kaplow & Bookbinder, 1994[2]	Prospective quasi-experimental comparison	American adult critical care oncology unit	111 adult patients 55 male: 56 female	Comparison of adhesive tape (known as 'Lillihei' method, waterproof) versus 3 commercially available:	Four methods examined sequentially with 30 patients per method. Random procedure to decide order of methods. Every 12 hours each patient assessed for tube movement equal or greater than 2cm, facial skin integrity, nursing assessment of potential of device to prevent self-extubation,	SecureEasy most secure using Kaplan Meier survival analysis. Lowest incidence of skin breakdown with Dale and SecureEasy.	Comfit method ceased after 21 patients due to poor stability of ETT. Lillihei method only assessed for facial skin integrity when tape

				Comfit, Dale and SecureEasy	other parameters. Nurses evaluated each method daily on a 5-point Likert scale. Patients (who were able) rated comfort on 3 point scale		removed for other reasons
Levy & Griego, 1993[8]	Prospective comparative study	Medical ICU (not clear if this is a single unit) at an American university hospital	36 adult patients 15 male: 21 female 18 patients had complete day cycles	Comparison of adhesive tape, twill tape, and twill tape or Velcro with a bite block	Each patient had each stabilisation method for one day per method. Data were collected for 4 continuous days on each patient: tube movement in cm was measured at the end of each shift; nurses and patients evaluated each method daily on a 5-point Likert scale	No statistically significant difference identified in tube movement between the four methods evaluated. Adhesive tape was found statistically superior to both tube holders on all other parameters; twill tape was statistically superior to both tube holders on all parameters except oral hygiene. Twill tape was stated to be superior to adhesive tape in incidence of skin breakdown but no reliable measurement method was cited in support of this claim.	Only half of patients completed study cycle and reasons for missing one stage in cycle were open to potential bias
Tasota, Hoffman, Zullo, & Jamison, 1987[7]	Quasi-experimental evaluation	Medical and surgical ICUs at an American university hospital	30 adult patients 16 male: 14 female	Comparison of adhesive tape versus commercially available tube holder	Each patient had both stabilisation methods for two days per method. Data were collected for 4 continuous days on each patient: tube movement in cm was measured once per day; each patient was examined daily for oral and facial excoriation. Approx 50 nurses completed daily questionnaires	Commercially available tube holder had a lower incidence of internal and external tube displacement and skin breakdown and a higher level of nurse acceptance compared with adhesive tape	No control group or randomisation. For nurse questionnaire, content validity mentioned but no reliability tests
Tominaga et al 1995 [9]	Prospective time series evaluation	American surgical ICU	687 patients 449 male: 238 female	Comparison of accidental extubation rate with cloth or Velcro ties in first time period versus waterproof cloth tape in second and subsequent time periods	Four time periods over two years. First period was baseline of standard care. Accidental extubation rate measured in each time period	Significant decrease in accidental extubation rate with waterproof cloth tape (15% to 2-6%)	Potential for confounding because other, potentially related practices altered in ICU during study period, eg sedation practice.

Figure 1: Incidence of lip excoriation

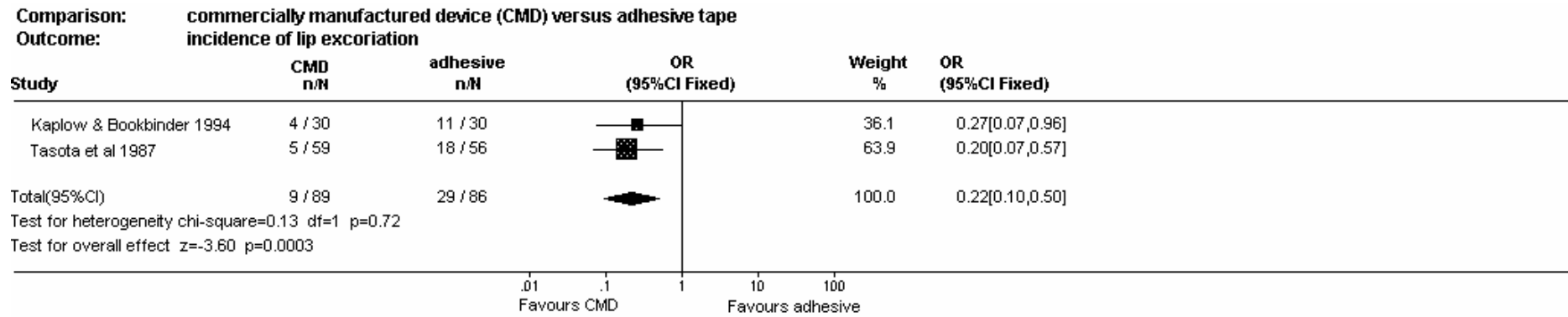


Figure 2: Incidence of facial trauma

Comparison: commercially manufactured device (CMD) versus adhesive tape
Outcome: incidence of facial trauma

