Feeding tube securement in critical illness: Implications for safety.

Taylor SJ, Allan K, Clemente R, Marsh A, Toher D. Feeding tube securement in critical illness: Implications for safety. British Journal of Nursing. 2018; 27: 1036-41.

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Abstract

Background: Over 50% of tape secured feeding tubes are inadvertently lost.

Aims: Determine the impact of nasal bridle securement on tube loss, outcome and duration of use and potential complications.

Methods: Observing the effect of nasal bridle securement on nasogastric (NG) and nasointestinal (NI) tube loss from 01.10.2014 (NG) and 01.01.2010 (NI), respectively, to 31.12.2017.

Findings: Use of nasal bridles was independently associated with reduced NI (and NG) tube loss 36.9% to 11.8% (odds ratio, [OR]: 95% confidence interval [CI]: 0.2: 0.12-0.33, p< 0.0001), increased duration of tube use (OR: 2.2 days, 95%CI: 0.8-2.9, p = 0.004) and increased likelihood of tubes being used until no longer needed (18.1% to 33.8%, OR: 2.3, 95%CI: 1.6-3.3, p < 0.0001). In a single-room ICU, tube loss dropped from 53% to 9% and tube redundancy (no longer required) rose from 20% to 64%.

Conclusions: UK-wide bridle securement could reduce premature tube loss need for replacement by 40% and could be associated with 1422 fewer pneumonias or pneumothoraces and 768 fewer deaths.

Running title

Tube securement: Safety implications.

Keywords

Nasal bridle; feeding tube; inadvertent, loss, safety; securement.

What is already known

- Most feeding tubes are lost to inadvertent patient removal or slippage.
- Nasal bridles reduce tubes loss and increase delivery of goal nutrition.

What this paper adds

- Use of nasal bridles is independently associated with reduction of inadvertent tube loss and this appears to increase the number of tubes reaching redundancy.
- By obviating the need for tube replacement, nasal bridle use may reduce risk of tube-related complications by 40%; this potentially translates into more than 1400 fewer major complications and deaths in the UK.

Acknowledgements

We thank the nursing, medical and dietetic ICU staff for making this study possible.

Conflict of interest

ST: Involved in developing a new nasal bridle with no commercial connection to the one used in the current study.

Other authors: None.

Ethics

The study observed standard practice and therefore did not require ethical approval.

Financial support

None.

Authorship contributions

- Conception and design of the study (ST), the acquisition of data (ST, KA), or the analysis (DT, ST) and interpretation of the data (All).
- Drafted or provided critical revision of the article (All).
- Provided final approval of the version submitted for publication (All).

Introduction

In the UK 790,000 naso-enteral tubes are purchased each year [NHSI. 2016]. However, in ICU 54% of tubes are lost to inadvertent patient removal and slippage with at least 44% requiring replacement [Taylor et al. 2014a]. Risk from tube loss and replacement depends on how accurate tube guidance and confirmation are and the frequency of misplacement.

X-ray and pH are the most common methods to confirm feeding tube position, but both methods often fail. X-ray misinterpretation is the single most common cause of serious harm (45-47%) resulting from feeding through a misplaced tube [NPSA. 2011; NHSI. 2016]. Similarly, using colorimetric strips, 12% of pH 6.0 samples are mis-identified as reaching the UK critical pH of 5.5 [Clemente and Taylor. 2016]. In rare cases, such as tonsillar squamous cell carcinoma, lung aspirates of pH 4.5-5.5 occur [Sellers. 2012]. In addition, using a threshold of 5.5 carries a 50% risk of identifying tube position as gastric when it is oesophageal [Ni et al. 2014]; oesophageal placement occurs in 20% of blind placements, so using a pH threshold of 5.5 would result in 10% being fed into the oesophagus. Undetected tube misplacements result in approximately 20 cases of serious harm, including 4 deaths, per year in the UK [NHSI. 2016]. However, 1.5% of blindly placed tubes are misplaced into the respiratory tract, 0.5% resulting in pneumonia or pneumothorax [Taylor. 2018]. Harm from oesophageal misplacement is unknown. These much more common complications cannot be prevented by an end-of-procedure pH test or X-ray [Taylor. 2013].

Reducing the pH threshold from 5.5 to 4.0 would reduce placement errors from 9.4% to 0.6% and but increase the need for X-ray confirmation from 24% to 34% [Ni et al. 2014]. This, the restriction of X-ray interpretation to senior Radiologists and a ban on overnight placement [NPSA. 2011] was associated with an 8-9h delay to feed and drugs [Brazier et al. 2017]. These changes also increased the delay before feeding after nasogastric (NG) tube (re-)placement (median: 5.3h [IQR: 2-9] to 10 [6-16], p = 0.028), increased the energy deficit per NGT (re-)placement (Kcal: 402 to 768, p = 0.04) and per enteral nutrition episode (Kcal: 2423 to 5660, p = 0.00024) and reduced the nutrition goal delivered (84% to 71%, p = 0.018) [Segaran et al. 2015]. Finally, placement-associated complications are related to placement frequency, therefore if tube securement reduces preventable loss there could be a proportionate reduction in risk.

We determined associations between bridle use and inadvertent (patient or slippage) feeding tube loss and, for NI tubes, all causes of tube loss and the likelihood of tubes reaching redundancy. Based on these findings and published tube placement risk, we estimated the safety implications of bridle placement.

Methods

Study design

Nasogastric tube loss data was collected, prospectively, as part of a 'device loss' audit from 1.10.2014 to 31.12.2017 and compared per patient admission and ventilated day. Nasointestinal tube loss, reason for loss and duration of use were collected prospectively from 1.1.2010 to 31.12.2017 from the 'bedside NI tube placement service' audit.

1.1 Bridle use

In May 2014 two predominantly open ward ICUs were merged into an ICU with single-patient rooms. From 01.11.2014, a policy of fitting AMT™ nasal bridles to NG tubes was gradually introduced, as staff were trained, if one tube had been inadvertently removed by a patient, the tube was difficult to place or was a vital feed and/ or drug route. For NI tubes, all were fitted with bridles immediately after tube placement from 01.1.2015.

Analysis

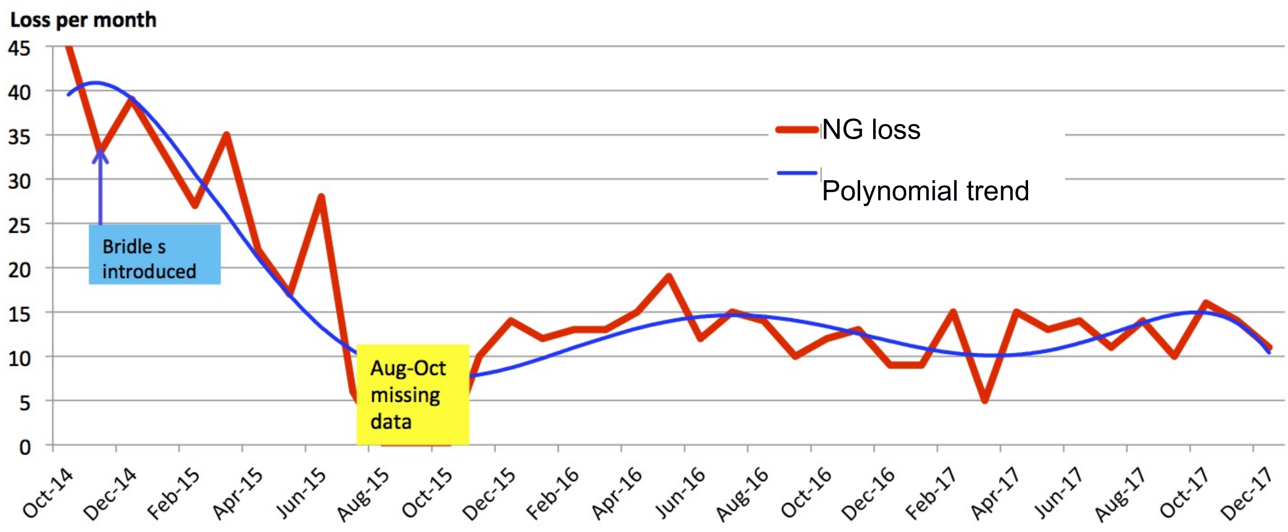
We determined the effect of bridle securement on NG and NI tube loss and the potential impact on UK-wide safety. Parameters did not have normal distribution (Shapiro-Wilk test) therefore univariate analysis was carried out using Mann-Whitney signed-rank and Fisher's exact test using 'R Studio' v1.1.383. Because groups were dis-similar, age, acute physiology and chronic health evaluation (APACHE) 2 score, height, weight, disease category, conscious state, airway and days from ICU admission were entered into linear or logistic regression models. Independent variables with a p-value < 0.1 were retained and associations re-tested including 'bridle use'.

Findings

NG tube loss

During October 2014, 45 NG tubes were lost. From 01.11.014 nasal bridles began to be fitted to NG tubes but the policy only became established over several months as staff trained in bridle use. Although NG tube and bridle use were not audited, compared with October 2014, one year from 'bridle introduction' NG tube loss (Figure 1) or tube loss per ICU admission or per ventilated days fell by more than 50%, using data from 648 tube losses.

Figure 1: NG tube loss per month.



NI tube loss

Reasons for tube loss was documented in all 710 NI tube placements from 01.1.10 to 31.12.17. Unbridled versus bridled patients were similar in age, APACHE 2 score, height, weight, sex and the proportion sedated or unconscious (Table 1.1). However, in the new ICU it became practice to place a tracheostomy later so a higher proportion of bridled patients retained an endotracheal tube, patient mix included more non-trauma neurosurgical and fewer trauma patients and NI tubes were placed earlier during ICU admission.

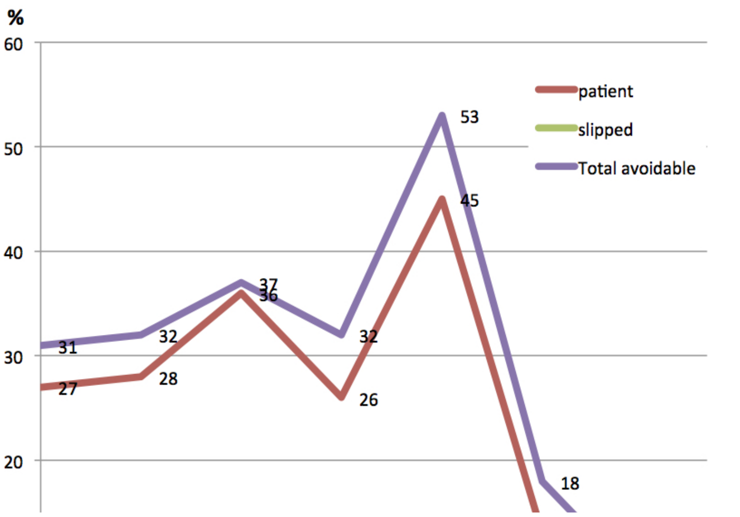
Table 1 Patient demography and clinical state.

Parameter		No Bridle		Bridle		P value
		Median	**IQR**	**Median**	**IQR**	
Age		55.4	38.3-69.2	53.6	37.6-69.5	0.75
APACHE 2 score		15	8-22	15	10-20.5	0.76
Height		174	166-180	175	166-180	0.38
Weight		77.4	68-88	80	70-90	0.15
		N	**%**	**N**	**%**	
Sex (male)		211	72.5	160	69.3	0.44
Disease category	Medical	86	29.6	47	20.3	< 0.0001
	Neurosurgical (non-trauma)	21	7.2	46	19.9	
	Surgery (non-neurosurgery)	75	25.8	69	29.9	
	Trauma	109	37.5	69	29.9	
Consciousness	Awake	47	22	48	21	0.82
	Sedated or unconscious	167	78	181	79	
Artificial airway	None	43	15.5	27	11.8	< 0.0001
	Endotracheal	153	55	176	76.9	
	Tracheostomy	82	29.5	26	11.4	

From 2010-2014, 67-77 tubes were placed per year except for 2013 when only 47 were placed; 25 patients were randomised to a prokinetic drug study instead of NI feeding. Following the combining of two hospitals and preferential use of NI feeding over erythromycin when metoclopramide fails, annual NI tube use rose to between 95-101.

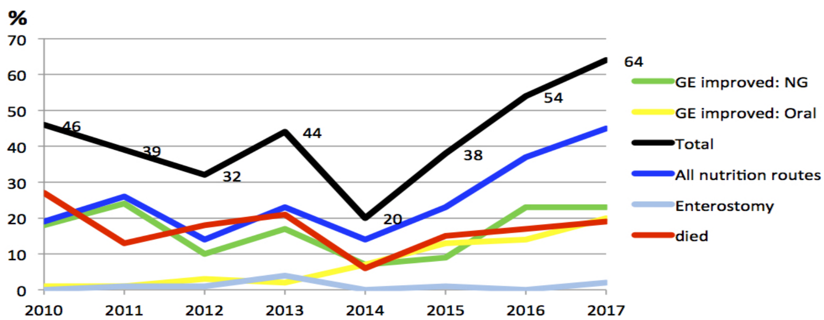
The predominant reason for NI tube loss, prior to bridle use, was inadvertent patient removal or slippage. On an open ICU, 2010-2013, this occurred in a before, during and after ICU patients wer approximately 9% once all NI tubes were brid risk reduction (OR: 0.2, 95%CI: 0.12-0.33, p < risk of loss. Apart from tubes being lost to bloc losses (spontaneous or endoscopic displace term feeding routes, clinical procedures or vor

Figure 2: Cause of inadvertent NI tube loss.



Reduced tube loss was paralleled by an inde 0.7-3.7, p = 0.004); age was negative nearly 3-fold increase in **planned** tra 0.0001) (weight, male gender negativ redundant at its removal (OR: 2.3, 95 and male gender were positively and n

Figure 3: Reason for NI tube removal due to redundancy.



Effect on potential risk

Table 2 represents the potential current complication rates associated with ‘blind’, that is unguided, NG and NI tube placement. This assumes 90% of UK-purchased tubes are placed, current misplacement rates and estimates the risk reduction if bridle securement, as in the current study, achieved a 40% reduction in premature tube loss and replacement.

Table 2 UK tube use, complication rates and potential effect of bridles.

Tube use and complications	N or %	Tape	Bridle
		90% placed*	40% reduction
Tubes per y UK	790000	711000	284400
Complication rate:**	%		
■ Lung	1.5	10665	4266
■ Pneumothorax,	0.5	3555	1422

pneumonia			
■ Death	0.27	1920	768
■ Oesophageal: placement	20	***142200	56880
undetected**		35550	14220

*90% of UK purchased tubes are placed to a length approximating the gastric or lung positions.

** Summarised from [Taylor. 2018 from Sorokin and Gottlieb. 2006; Kooperman et al. 2011; Krenitsky. 2011; Rayner. 2013; Rollins et al. 2012].

*** Assumption: 50% detected by X-ray; 50% of the remainder (25%) detected by pH ≤5.5.

Discussion

Primary findings

Most NG and NI tubes secured with tape are lost before they are no longer required. For NI tubes approximately 35% were lost to inadvertent patient removal and slippage on an open ICU ward. This increased to 53% when combining two ICUs and nursing patients in single rooms, then fell to 9% after bridle securement. Bridle securement was independently associated with this reduction in inadvertent tube loss. Bridle securement was associated with a more gradual increase in the proportion of patients progressing to alternative feeding routes; it is unclear why this lagged behind the decline in tube loss.

Inadvertent tube loss

Inadvertent tube removal or slippage occurs in up to 73% of tubes when using tape securement [Brazier et al. 2017]. Patients with neurological disease appear most prone to patient removal [Taylor et al. 2015], occurring in 82% of stroke patients [Brazier et al. 2017]. In a hospital-wide population although risk of patient tube removal increases with each removal (0: 61%, 1: 66%, 2: 70%) it was not confined to specific patient groups [Taylor et al. 2015]. And, the rapidity of changes in sedation, level of consciousness and tape adherence make patient tube removal or slippage unpredictable.

In contrast, because about 6% of hospitalised patients require NG or NI feeding [Elia. 2015] the need for 30-50% of tubes to require replacement represents a significant healthcare risk and cost [Taylor et al. 2014a]. National alerts and extra radiological training have failed to prevent undetected misplacements [NHSI. 2016]. Many patients require several tube replacements (≥3: 28-59% [Brazier et al. 2017; Taylor et al. 2015] and misplacement risk increases from an average of 2.1% to 32% when there has been previous misplacement and risk of pneumothorax increases from 5% after the first misplacement to 36% after ≥3 [Marderstein et al. 2004].

Implications for safety

pH or X-ray confirmation do not prevent tube misplacement which represents more than 90% of the burden of misplacement morbidity and mortality [NPSA. 2011; NHSI. 2016] (Table 2). The number of complications from undetected oesophageal misplacements is unknown. Because most misplacements are detected and the tube correctly repositioned, clinicians often fail to realise that misplacement was the cause of complications. The reduction in complications when nasal bridles are placed pre-emptively is based on the reduction in inadvertent patient removal and slippage in this study, in single patient rooms, obviating the need for tube replacement.

Actual placements, and thus misplacements and complications, will depend upon the patient population. Patients with impaired neurology, including critically ill and stroke patients, are prone to inadvertent tube loss but also form a large proportion of tube fed populations [Taylor et al. 2014a; 2015; Brazier et al. 2017]. If the UK tube-fed population were similar to our ICU NI tube-fed patients, pre-emptive bridle placement is predicted to prevent 1422 major complications and 768 deaths. Bridle securement could also reduce delays to feed and drug delivery [Segaran et al. 2015; Brazier et al. 2017] thereby improving clinical outcome and reducing healthcare staff burden.

Cautions

This study was observational so un-measured confounders may partly explain findings. For example, after introducing nasal bridles, there was a progressive, rather than single-step, reduction in tube loss and increase in patients no longer needing their tube prior to 'loss'. However, improved training in positioning of the bridle clip could explain the decremental reduction in tube loss after introduction of bridles. Equally, increased retention of tubes until redundant might lag behind reduction in tube loss, because only once tubes are secured would there be an imperative to improve tube maintenance, such as flushing. Lastly, the effects of bridle introduction were large after accounting for most potential confounders.

Conclusions

On moving from tape to bridle securement, inadvertent tube loss fell from 53% to 9% while the number of patient’s tube’s that reached redundancy increased from 20% to 64%. While this study is retrospective and single-centre the independent associations appear very strong. A similar effect UK-wide should achieve major reductions in misplacement-associated complications and death. Further investigation, including randomised controlled trials, is required to determine whether these changes affect hospital length of stay and holistic treatment cost.

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Appendix Regression models including bridle securement adjusted for potential confounding factors.

Model	Independent variable	*	95% CI		P value
Inadvertent tube loss		**OR**	**2.5%**	**97.5%**	
	(Intercept)	0.51	0.21	1.15	0.11
	bridle	**0.20**	**0.12**	**0.33**	**< 0.0001**
	disease_neurosurgical (non-trauma)	1.60	0.68	3.68	0.27
	disease_surgery (general)	1.03	0.50	2.12	0.93
	disease_trauma	2.57	1.42	4.76	**0.002**
	sedated_unconsciousness (vs awake)	1.53	0.69	3.55	0.31
	airway_endotracheal	0.58	0.22	1.49	0.26
	airway_tracheostomy	0.71	0.27	1.82	0.48
Tube duration of use		**Days**	**2.5%**	**97.5%**	
	(Intercept)	**9.63**	**6.19**	**13.06**	**< 0.0001**
	bridle	2.21	0.70	3.72	**0.004**
	age	-0.06	-0.09	-0.02	**0.005**
	kg	0.03	-0.01	0.06	0.13
Planned transfer to alternative nutrition		**OR**	**2.5%**	**97.5%**	
	(Intercept)	0.41	0.15	1.10	0.08
	bridle	**2.83**	**1.86**	**4.34**	**< 0.0001**
	APACHE 2 score	**0.94**	**0.91**	**0.97**	**< 0.0001**
	age	1.00	0.99	1.01	0.90
	sex	0.58	0.36	0.94	0.03
	kg	1.01	1.00	1.02	0.13
Tube no longer needed		**OR**	**2.5%**	**97.5%**	
	(Intercept)	0.48	0.25	0.91	0.03
	bridle	**2.26**	**1.55**	**3.31**	**< 0.0001**
	sex	**0.55**	**0.36**	**0.82**	**0.004**
	airway_endotracheal	**2.04**	**1.15**	**3.73**	**0.017**
	airway_tracheostomy	**2.24**	**1.14**	**4.51**	**0.021**
	NJ tube_ICU day of placement	0.98	0.94	1.00	0.165

*95% confidence interval of OR or estimate.