The Journal of Laryngology & Otology (2007), ***121***, *869–871*.

doi:10.1017/S0022215107005324
Printed in the United Kingdom
First published online 9 January 2007

Main Article

Estimation of tracheostomy tube cuff pressure by pilot balloon palpation

C Faris[1], E Koury[1], J Philpott*, S Sharma†, N Tolley, A Narula

Abstract

Two methods can be used to assess the intra-cuff pressure of tracheostomy tubes: digital palpation of the pilot balloon and use of a hand-held manometer. We conducted a telephone survey to determine the prevalence of both methods in intensive care units within 21 teaching hospitals across the United Kingdom. Forty-two per cent of the intensive care units surveyed used a protocol for monitoring cuff pressure with a manometer.

A study to compare these two methods, using the manometer as the reference standard, was then carried out. The cuff pressure was correctly estimated in pre-inflated tracheostomy tubes, in a tracheal model, by 61 per cent of a cross-section of intensive care unit and otolaryngology staff.

Using pilot balloon palpation is inaccurate and leaves a significant proportion of patients at risk of tracheal injury. We advocate the wider availability of hand-held pressure manometers in intensive care units and the institution of protocols for monitoring cuff pressure for any patient with a tracheostomy tube with an inflated cuff in situ.

Key words: Tracheostomy; Trachea; Pathologic Constriction; Intensive Care

Introduction

Excessive tracheostomy tube cuff pressure causes mucosal ischaemia and can lead to cuff-induced tracheal stenosis. The exact incidence of cuff-induced tracheal stenosis is not known, and its symptomatic presentation is rare.[1]

The two commonly used methods of monitoring tracheostomy tube cuff pressure are digital palpation of the pilot balloon and use of a hand-held manometer attached to the balloon's inflation valve.

We surveyed the current method of monitoring intra-cuff pressures in 21 intensive care units within teaching hospitals across the United Kingdom. A study was then carried out to compare the two monitoring methods, using the manometer as the reference standard. A range of healthcare professionals involved in the care of patients with tracheostomy tubes, in intensive care units and otolaryngology wards, volunteered to offer their skills to enable us to compare the two methods. These staff included nurses and doctors.

Methods

A telephone survey was conducted to assess current practice in the intensive care unit setting. Twenty-one intensive care units were telephoned and a nursing sister or charge nurse was questioned about the availability of manometers, presence of protocols and the actual current practice in their unit. The current practice of monitoring intra-cuff pressures was recorded as either: (1) manometers not available; (2) manometers available but used at nurses' discretion and infrequently checked (less than once per day); and (3) a protocol for minimum daily pressure monitoring was adhered to.

A double-blind study was performed to assess the accuracy of pilot balloon palpation in estimating intra-cuff pressure, compared with the reference standard (the manometer). Pilot balloons were tested by 251 intensive care nurses, specialist otolaryngology nurses and anaesthetists involved in intensive care management in eight London teaching hospitals and two district general hospitals.

The barrel of a 10 ml syringe was used as a model of the trachea. An 8.0 mm tracheostomy tube was inserted into the syringe barrel and the cuff inflated with a Portex® hand-held manometer (Portex Ltd, Hythe, United Kingdom). The tracheostomy tube used was a Portex Blueline®, which incorporates a high volume, low pressure cuff. The recommended intra-cuff pressure is 15–25 cm H_2O.[2] The inflation pressure of

From the Departments of Otolaryngology, St Mary's Hospital, London, the *Department of Head & Neck Surgery, Royal Marsden Hospital, London, and the †Department of Maxillofacial Surgery, Poole General Hospital, UK.
[1]C Faris and E Koury are the joint lead authors.
Presented at the Intensive Care Society, Annual Spring Meeting, 5–6th May 2005, Glasgow, Scotland, UK.
Accepted for publication: 28 September 2006.

tracheostomy tube's tracheal cuff: 10 cm H_2O to represent an under-inflated cuff; 15 and 25 cm H_2O to represent a correctly inflated cuff; and 40, 50, 60 and 70 cm H_2O to represent an over-inflated cuff.

Nine of the above models were filled to the pressures specified above and were arranged in random order with the cuffs hidden from sight, leaving only the pilot balloon visible. Testers palpated the pilot balloon sequentially from tubes one to nine, stating one of three outcomes: the cuff pressure was too high, too low or normal. Testers were not allowed to simultaneously palpate two balloons, and were required to give a final answer before moving on to the next balloon. The person conducting the study was also blinded to the cuff pressures. The predetermined pressures were set and rechecked every 10 tests by a third party.

The difference in accuracy of pilot balloon palpation was stratified by the experience of the person testing the two methods, to reflect the experience mix that would be expected on an intensive care unit and otolaryngology ward. This difference within specialities was analysed using the chi-square test to determine any confounding effect resulting from the level of experience. Comparisons between different specialities was not sought due to the lack of equivalences between grades.

Results

Our survey of current practice revealed that, of the 21 intensive care units surveyed, nine used a protocol for monitoring intra-cuff pressure with a manometer, nine did not routinely monitor but had manometers available for use at the nurse's discretion, and three units did not use manometers.

Two hundred and fifty-one testers volunteered to palpate the pilot balloons. They included 195 nurses and 56 doctors. The results are shown in Table I, stratified by level of experience.

On comparing overall accuracy, a significant difference was observed between staff nurses and charge nurses ($p < 0.001$). No significant difference was observed between anaesthetic consultants and registrars. On comparing accuracy at 60 cm H_2O, no significant difference was observed between staff nurses and charge nurses or between anaesthetic consultants and registrars.

TABLE I

SUBJECTS' PROFESSION AND GRADE

Subject	*n*	Error at all pressures (%)	Error at 60 cm H_2O (%)
ICU CN	30	29	43
ICU SN	140	45	60
ENT CN	6	35	50
ENT SN	19	42	63
Cons	30	32	30
Reg	26	26	19
All participants	251	39	50

ICU = intensive care unit; SN = staff nurse; CN = charge nurse or sister; Cons = anaesthetic consultant; Reg = anaesthetic specialist registrar or staff grade or associate specialist

The error in estimating whether a pilot balloon is over-, under- or correctly inflated, by digital palpation, was 39 per cent. When the inflation pressure was more than twice the recommended level (60 cm H_2O), the overall error was 50 per cent.

Discussion

It would appear that some specialist nurses and doctors believe that, in experienced hands, cuff balloon palpation can reliably estimate intra-cuff pressure. The frequency of use of hand-held manometers and their availability can therefore vary considerably. The results of our telephone survey correspond with those of a previous survey conducted in the northern and Yorkshire regions of England, which showed that 75 per cent of the intensive care units surveyed never checked tracheal tube cuff pressures.[3]

The effects of cuff pressure on mucosal blood flow have been visualised in *in vivo* human studies using an endoscopic photographic technique. At 30 cm H_2O, there was impairment of mucosal blood flow. At 50 cm H_2O, there was total obstruction of blood flow to the mucosa overlying the tracheal rings and the stretched posterior muscular wall.[4] Pressures over 68 cm H_2O (50 mmHg) for 15 minutes can cause epithelial destruction[5] which can lead to tracheitis, ulceration, persistent inflammation, chondritis, fibrosis and stenosis. To avoid mucosal ischaemia, it is therefore recommended that the intra-cuff pressure should not exceed the mean capillary pressure (i.e. 15–25 cm H_2O).[2]

A linear relationship exists between cuff pressure and peak inflation pressure, so that significantly higher inflation pressures will result in either air leak around the cuff or an increase above the original cuff inflation pressure. An *in vivo* study in humans showed that a cuff inflation pressure of 33 cm H_2O correlated to a peak airways pressure of 47 cm H_2O.[6] In the intensive care unit setting, a significant proportion of patients require high peak airway pressures for adequate ventilation, consequently requiring cuff pressures greater than the mean capillary pressure to achieve minimal occlusion pressure. This may lead to familiarity with the digital palpation feel of these higher pressures, which may explain the observed tendency of our subjects to estimate the over-inflated cuffs as normal.

- **Excessive tracheostomy cuff pressure causes mucosal ischaemia and can lead to tracheal stenosis**
- **This study compared the accuracy of two methods of assessing tracheostomy tube cuff pressure**
- **Palpation of the pilot balloon is an inaccurate method of pressure estimation**
- **Hand-held pressure manometers are a much more accurate method of cuff pressure estimation and should be used more widely in intensive care units**

https://doi.org/10.1017/S0022215107005324 Published online by Cambridge University Press

Our survey demonstrated significant variability in the current practice of tracheal tube cuff pressure monitoring in the intensive care units surveyed.

The practice of palpating the pilot balloon as a guide to cuff pressure is inaccurate, even in the hands of specialists routinely involved in the management of patients with inflated tracheostomies. We advocate the wider availability of hand-held pressure manometers in intensive care units and otolaryngology wards. We also suggest that such units institute protocols for monitoring the cuff pressure of any patient with an inflated tracheostomy tube cuff.

Acknowledgements

We would like to thank the relevant departments of the following hospitals for their participation: Charing Cross, Chelsea & Westminster, Guys, King's College, Lister, Queen Elizabeth II, Royal London, St George's, St Mary's and St Thomas' Hospitals. We would like to thank Dr Mark Sacks for his editorial comments.

References

1 Dane TE, King EG. A prospective study of complications after tracheostomy for assisted ventilation. *Chest* 1975;**67**: 398–404
2 Slutsky AS. Consensus conference on mechanical ventilation – January 28–30, 1993 at Northbrook, Illinois, USA. *Intensive Care Med* 1994;**20**:150–62
3 Vyas D, Inweregbu K, Pittard A. Measurement of tracheal tube cuff pressure in critical care. *Anaesthesia* 2002;**57**: 275–7
4 Seegobin RD, van Hasselt GL. Endotracheal cuff pressure and tracheal mucosal blood flow: endoscopic study of effects of four large volume cuffs. *Br Med J (Clin Res Ed)* 1984;**288**:965–8
5 Nordin U. The trachea and cuff-induced tracheal injury. An experimental study on causative factors and prevention. *Acta Otolaryngol Suppl* 1977;**345**:1–71
6 Guyton DC, Barlow MR, Besselievre TR. Influence of airway pressure on minimum occlusive endotracheal tube cuff pressure. *Crit Care Med* 1997;**25**:91–4

Address for correspondence:
Mr Elias Koury,
46 Queens Gate Terrace,
London SW7 5PJ, UK.

E-mail: elias@london.com

Mr E Koury takes responsibility for the integrity of the content of the paper.
Competing interests: None declared