Tracheostomy on the intensive care unit – a two-month network-wide snapshot 3C00

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Tracheostomy is a common and invasive procedure performed on the intensive care unit and has significant associated complications. Current evidence is insufficient to clearly guide practice. We conducted a two-month prospective service evaluation of tracheostomy within our local critical care network. We found 80 tracheostomies were performed during this time. Tracheostomy was performed at a median of six days after commencement of invasive ventilation, most commonly using the Ciaglia technique. Eighteen tracheostomies (23%) were performed surgically. The facilitation of weaning from invasive ventilation was the most common indication for tracheostomy. The median (IQR) time from tracheostomy to completion of weaning from mechanical ventilation was seven (4-11) days and from tracheostomy to decannulation was 14 (9-26) days. Eleven patients (14%) sustained complications possibly relating to tracheostomy insertion, three of whom subsequently died, although tracheostomy insertion was only possibly linked to one of these deaths. While our sample is small, it benchmarks a UK critical care network's tracheostomy practice in the UK.

Keywords: *tracheostomy; complications; intensive care; intermittent positive-pressure ventilation; airway management*

Introduction

Tracheostomy is a procedure commonly performed on critically ill patients. Although indications vary, it is typically performed during the recovery phase to facilitate weaning from invasive positive pressure ventilation (IPPV) and sedative medications. There are numerous theoretical advantages to critically ill patients having a tracheostomy performed. Despite various case series[1-3] demonstrating the popularity of percutaneous tracheostomy and a number of relevant studies seeking to prove the purported benefits, there remains a lack of conclusive evidence to guide clinicians as to the correct timing[4] and methods[5] of performing tracheostomy in this patient group. Subsequently practice varies between units and between individual clinicians, each with their own interpretation of the available evidence balanced with a pragmatic clinical approach. It therefore falls to individual clinicians, intensive care units (ICUs) and networks to ensure that safe practice is maintained in this area by undertaking appropriate surveillance. For this reason we conducted a service evaluation of tracheostomies performed within our critical care network.

The Mid-Trent Critical Care Network (MTCCN) has been in existence since April 2000 and consists of eight adult general ICUs, across five different Trusts. Two are within the Nottingham University Hospitals NHS Trust, the others are in the neighbouring district general hospitals (DGHs) in Boston, Burton upon Trent, Derby, Grantham, Lincoln and Sutton-in-Ashfield. All major medical and surgical specialities are represented across these units with the exception of non-renal solid organ transplantation. Cardiac surgery is supported by a separate ICU not included in this study.

Methods

We conducted a two-month prospective service evaluation of tracheostomies performed on patients currently being cared for on adult ICUs within the MTCCN. The only patients excluded were those who underwent a tracheostomy during a primary surgical procedure prior to admission to the ICU, for example as part of a laryngectomy.

Each unit within the network was invited to participate in this project and nominate an investigator to oversee the collection of local data. The project was registered with the Clinical Audit Department at Nottingham University Hospitals NHS Trust. Each centre was encouraged to register the project with their local audit department. This project was considered service evaluation.

Data were collected using a modified version of a form already in use at one centre (Queen's Medical Centre Campus, Nottingham University Hospitals) for continuous appraisal of tracheostomy practice. This data included the dates of ICU admission, onset of invasive ventilation, insertion of tracheostomy, successful weaning (defined as the first day in which the patient was free from mechanical ventilatory support for 24 hours), discharge from intensive care and decannulation. The indication for tracheostomy, the method of insertion including the specialty and grade of operator and assistant, the type and size of the tracheostomy inserted and any complications or adverse events relating to the tracheostomy were reported. Data were then locally anonymised, collated centrally and analysed. Data relating to number of patients ventilated were retrieved from the Critical Care Minimum Data Set (CCMDS) records after the study was complete.

Hospital	Total number of patients receiving advanced respiratory support (ARS)	Number of patients receiving ARS undergoing tracheostomy n (% of total receiving ARS)	Number receiving ARS for six days or more n (% of total receiving ARS)	Number of tracheostomies performed six days or more after onset of ARS n (% of total undergoing tracheostomy)	Proportion of all patients receiving six days or more of ARS undergoing tracheostomy %
QMC	134	40 (29.9)	47 (35.1)	25 (62.5)	61
Lincoln	98	10 (10.2)	27 (28.6)	6 (60)	25
KMH	74	6 (8.1)	28 (38.8)	5 (83.3)	18.5
City	70	10 (14.3)	31 (44.3)	5 (50)	18.5
Boston	51	9 (13.7)	17 (33.3)	2 (28.6)	15.4
Burton	28	8 (28.6)	9 (32.1)	5 (62.5)	83.3

Table 1 Proportions of all patients receiving advanced respiratory support and those undergoing tracheostomy after six days or more of advanced respiratory support, by centre. **Key:** QMC, Queen's Medical Centre Campus; City, Nottingham City Hospital Campus (both Nottingham University Hospitals NHS Trust); KMH, King's Mill Hospital, Sherwood Forest Hospitals NHS Foundation Trust.

Results

One district general hospital ICU chose not to take part in the study and another unit does not manage ventilated patients; all other units participated in the study. One unit collected their data retrospectively. During the study a total of 80 tracheostomies were performed on intensive care patients within the MTCCN. **Table 1** shows, by centre, the total number of patients receiving advanced respiratory support, the number receiving advanced respiratory support for more than six days and the proportion of each group undergoing tracheostomy.

Nine (11.3%) patients in this study died with a tracheostomy *in situ*. A further 10 (12.5%) patients had incomplete data relating to weaning, decannulation or death as they were transferred between units, due largely to bed/capacity pressures. One tracheostomy was inserted for bilateral vocal cord palsy and was judged to be permanent.

Indication for tracheostomy

A total of 62 (77.5%) tracheostomies were performed to facilitate weaning from invasive ventilation, while 11 (13.8%) were performed for airway protection and seven (8.8%) for airway toilet (defined as either the need for continued airway protection OR toileting, AND with the expectation in both cases that weaning from IPPV would occur within 24 hr of tracheostomy). The majority of the non-weaning tracheostomies (14/18, 77.8%) were performed at the Queen's Medical Campus of Nottingham University Hospitals, most of these patients were admitted with neurological illness or injury, very few actually weaned within 24 hr.

Technique

Sixty-two (77.5%) of the tracheostomies were performed using a percutaneous technique. Of these 47 (75.8% of percutaneous tracheostomies) were performed using the Ciaglia[6] or percutaneous dilational technique. One consultant performed the remaining 15 (24.2% of percutaneous tracheostomies) using Griggs' dilational forceps.[7] Eighteen (22.5%) tracheostomies were performed surgically by a variety of surgical specialties. The frequency of surgical tracheostomy ranged from 0% to 90% between hospitals; nine surgical tracheostomies (50% of total) were from a single DGH unit. During the period of our study one attempted percutaneous tracheostomy was abandoned, with subsequent surgical insertion.

The primary operator was a consultant for 55 (68.8%) of all tracheostomies performed. Tracheostomies with an inner tube were inserted in 67 (83.8%) cases. The tracheostomies inserted without an inner tube, were all adjustable flange systems. A fibreoptic bronchoscope was used to guide the procedure in 36 of 47 (76.6%) Ciaglia percutaneous tracheostomies, in one (5.65%) of the surgical tracheostomies and in none of those performed with Griggs' forceps. Ultrasound guidance was used in only seven (11.3%) of percutaneous tracheostomies and in no surgical tracheostomies.

Timing of tracheostomy, weaning and decannulation

The timings of various significant events are detailed in **Table 2**. Those with incomplete data or who died are included as far as data allows. Sixty-two patients (77.5%) who went on to need a tracheostomy were ventilated on the same day as admission to the ICU. The median (IQR) time from the institution of invasive ventilation to insertion of tracheostomy was 6 (3.8-8) days. The median (IQR) time to percutaneous tracheostomy was also 6 (4-8) days, while the median (IQR) time to surgical tracheostomy was 7 (4-16) days.

The median (IQR) time from tracheostomy to completion of weaning was 7 (4-11) days. Weaning took longer in the patients who had a surgical tracheostomy, with a median (IQR) duration of 8.5 (5-13.3) days compared with patients who were undergoing percutaneous tracheostomy, who completed weaning in a median (IQR) time of 6 (5-13.3) days. Similarly, the time from weaning to decannulation was longer in the patients who had a surgically inserted tracheostomy, occurring at a median (IQR) time of 7 (3-9) days after weaning in the surgical cohort, compared with 4.5 (2-7.5) days in the percutaneous group. Decannulation took longer at Queen's Medical Centre, taking a median of 6 (2-10) days, compared with the other centres combined where it took 3.5 (1-9) days. This was as a result of neuroscience patients with prolonged loss of airway protection.

Duration (days)	All (n=80)	Surgical (n=18)	Percutaneous (n=62)
From admission to IPPV	0 (0-0)	0 (0-0)	0 (0-0)
From admission to tracheostomy	6 (3.8-8)	7 (4-16)	6 (4-8)
From decision to tracheostomy	1 (0-1)	1 (1-2)	0 (1-2)
From tracheostomy to weaned	7 (4-11)	8.5 (5-13.3)	6 (5-13.3)
From weaned to decannulation	4 (1-9)	7 (3-9)	4.5 (2-7.5)
From tracheostomy to decannulation	14 (9-26)	13.5 (12.3-22.8)	13 (8-24.5)

Table 2 Duration between significant events in the patient's pathway through intensive care. Data are expressed as median (IQR). 'admission' refers to admission to the intensive care unit, 'IPPV' refers to onset of intermittent positive pressure ventilation, 'tracheostomy' refers to insertion of tracheostomy, and 'weaned' refers to the first day when the patient was free from IPPV for 24 hr.

Complications

Procedural complications were reported in 11(13.75%) patients, however some patients could be judged to have suffered more than one complication (**Table 2**). Although no deaths were clearly directly attributed to tracheostomy insertion, three patients in this group died. One of these deaths may have been contributed to by the complications of tracheostomy insertion. The case involved a difficult surgical tracheostomy in a morbidly obese patient, with intraoperative complications of desaturation and postoperative complications of marked subcutaneous emphysema. He was electively decannulated and an orotracheal tube was reinserted. He subsequently developed worsening respiratory failure and died.

Two patients suffered a pneumothorax possibly relating to the insertion of a tracheostomy. One patient had significant rib fractures, which may have caused the pneumothorax. Other than intermittent positive pressure ventilation (IPPV), the other patient had no other reason to develop a pneumothorax. Three patients who needed repositioning of their tracheostomies all had surgically inserted, adjustable flange tracheostomies performed without bronchoscopic guidance. No wound infections were reported.

Discussion

Our survey of practice shows that tracheostomy is a common procedure within the MTCCN. While numbers of ventilated patients varied greatly, roughly 33% of patients were ventilated for more than six days in all centres. This proportion was slightly higher at Nottingham City Hospital Campus (44.3%). This most likely reflects the complex nature of the patient cohort on this site (including haematology, oncology and thoracic surgery). Most centres appear to perform tracheostomy on 10-15% of all ventilated patients. The higher rate of tracheostomy at Queen's Medical Centre (29.9%) is probably attributable to the neuroscience patients on this unit, many of who required tracheostomy for airway protection and/or toilet. A similar rate was seen at Burton (28.6%), though overall numbers were much smaller. All patients undergoing tracheostomy at Burton during the study period had a primary respiratory diagnosis, the numbers involved do not allow us to tell if this is typical of their practice and patient cohort.

Considerable variability was noted in the proportion of tracheostomies performed within six days of the onset of ventilation (17-50%). With the exception of Queen's Medical Centre (40%) a high proportion (85-100%) of these patients went on to receive six days or more of ventilation. Approximately half of the non-weaning tracheostomies performed at Queen's Medical Centre, and a third of the total in this study, were performed before six days of ventilation, and account for at least part of this difference.

We do not have data on the fate of patients who were ventilated for more than six days but did not undergo tracheostomy, however this is of great interest and could form the basis of a future study.

We found percutaneous techniques to be far more popular than surgically inserted tracheostomies across our study sites. Surgical tracheostomy was more common in DGHs, with one unit accounting for 50% of the total number performed. This may be due to intensivists struggling to maintain skills with a percutaneous technique in a centre with relatively low numbers of patients requiring tracheostomy. It is notable that only one surgical tracheostomy was positioned using bronchoscopy, although surgically placed tracheostomies were more likely to have an adjustable flange and more likely to need subsequent repositioning. Total complications were slightly more common in the surgical group than the percutaneous group (16.6% *vs* 11.3%), however it was not our intention to compare the two techniques and the numbers of patients involved do not allow for such comparison. It is also highly likely that those patients referred for surgical tracheostomy were a self-selecting group with difficult anatomy or related co-morbidity making tracheostomy more challenging.

Various trials have compared surgical and percutaneous tracheostomy in critically ill patients, looking to establish which is safer, more cost effective, and associated with less long-term complications. Silvester *et al* conducted the largest randomised controlled trial to date,[8] randomising 200 patients to either surgical or percutaneous (using the Ciaglia technique) tracheostomy, both were performed at the bedside. Both techniques were demonstrated to be safe in the short- and long-term, with no significant differences demonstrated. The results of this trial and 16 others were considered in a systematic review and meta-analysis by Delaney *et al*[9] in 2006. They concluded that percutaneous tracheostomy resulted in significantly fewer wound infections, and when compared to surgical tracheostomy performed in theatre there was less

Description of complications	Time from insertion	Technique of insertion	Grade of primary operator	FOB guidance	Adjustable flange
Procedure abandoned	At insertion	Ciaglia	Registrar	Yes	Yes
Tracheostomy off midline, large leak, pneumothorax	At insertion and first 24 hr	Ciaglia	Registrar	Yes	No
Desaturation, surgical emphysema, removed and re-intubated orally*	At insertion, first 24hr and after first 24 hr	Surgical	Consultant	No	Yes
Pneumothorax (possibly related to rib fractures)	First 24 hr	Ciaglia	Consultant	Yes	No
Unplanned change of tracheostomy	First 24 hr	Ciaglia	Consultant	No	No
Occlusion of tracheostomy	First 24 hr	Ciaglia	Consultant	Yes	No
Tracheostomy repositioned	First 24 hr	Surgical	Consultant	No	Yes
Unplanned change of tracheostomy*	After first 24 hr	Griggs	Consultant	No	Yes
Tracheostomy repositioned *	After first 24 hr	Surgical	Consultant	No	Yes
Tracheostomy repositioned	After first 24 hr	Surgical	Consultant	No	Yes
Unplanned decannulation	After first 24 hr	Ciaglia	Consultant	No	No

Table 3 Details of the 11 patients with tracheostomy-related complications. *Indicates patients who died on the intensive care unit. FOB, fibreoptic bronchoscopy.

bleeding and lower mortality. At least one study has considered the duration and cost of the procedure, both concluding that percutaneous tracheostomy is quicker and cheaper.[10]

There were two techniques of percutaneous tracheostomy utilised within our study. The single tapered dilator modification of Ciaglia's technique was by far the most common, although one intensive care consultant used Griggs' dilational forceps. Kaiser *et al* compared the two techniques in a randomised controlled trial in 2006.[11] They showed that hypercapnia was more common when the Ciaglia technique was used, probably as a consequence of the greater time taken to complete the procedure. However this trial used the original serial dilators described by Ciaglia,[6] rather than the modified single tapered dilator, which is more common in our network. Two earlier trials compared the single tapered dilator adaption of Ciaglia's technique with Griggs' technique and showed there to be no difference in duration of the procedure.[12,13] Kaiser *et al* also showed minor bleeding and mild hypoxaemia (both defined as minor complications) to be significantly more common with the Ciaglia technique, however no individual major complication was significantly more common. Another study has shown that the risk of under- or over-dilatation of the tracheal wall to be significantly more commonly used with Griggs' dilational forceps.[13] While there may be little to choose between the techniques, the single tapered dilator is by far the most common within our region and subsequently is being taught to trainees as the default method.

Bronchoscopic guidance was used in only 60% of percutaneous tracheostomies. Many of these were probably performed with blunt dissection to pre-tracheal fascia, a popular local technique, however this information was not included in our data set.

The optimum timing of tracheostomy has been a source of much debate and investigation. Our median duration from onset of IPPV to tracheostomy of six days would be considered an early tracheostomy in some trials but not all. Definitions vary, with some trials describing an early tracheostomy as one performed within 48 hours of ventilation[14] and others up to seven days,[15] making comparison of trials difficult. Despite this, Griffiths *et al* conducted a meta-analysis in 2005[16] which found only five randomised or quasi-randomised trials meeting their inclusion criteria; the studies spanned 20 years of clinical practice and contained varying patients groups. They concluded that early tracheostomy led to reduced duration of ventilation and length of ICU stay in those patients who needed prolonged ventilation, however they qualify this by pointing out that this group of patients are difficult to identify early in the ICU admission. We identified a median (IQR) duration from tracheostomy to decannulation of 14 (9-26) days which may provide a useful benchmark for other clinicians in discussing tracheostomy with relatives.

It is difficult to compare our complication rate with other published series as definitions vary greatly and the number of patients in our study is relatively small. Furthermore we did not pre-define minor and major complications, and reporting of complications may not have been complete, especially after discharge from the ICU. We have included all reported complications, some of which may not have been directly related to the tracheostomy itself, and the degree of harm to the patient has not been formally assessed. However, clear evidence of direct harm from tracheostomy is rare in MTCCN, especially from percutaneous techniques. Patients undergoing surgical tracheostomy warrant extra attention as they are usually referred because of complicated anatomy, pathology or

both. It may be appropriate to delay tracheostomy to establish that direct extubation is definitely not achievable given the higher complication rate demonstrated in our investigation and in other larger studies. The three surgically-inserted adjustable flange tracheostomies which needed repositioning did not have their position checked fibreoptically at insertion and this might have avoided the subsequent problems. It is important to be aware that not all tracheostomies have the same length or curvature[17] and, especially in the 'difficult neck', one adjustable flange tracheostomy may not suit all.

Conclusion

Our investigation shows that tracheostomy is a common procedure in the MTCCN. Direct harm from tracheostomy is very uncommon and our current practice is in keeping with much of the published data. Lack of bronchoscopic guidance may be associated with complications and warrants further investigation. We particularly recommend using bronchoscopy in surgically-placed tracheostomies, especially those with an adjustable flange. We realise the limitations of a relatively small study, especially when half of the data included comes from one centre. Future work could be undertaken to investigate patients who are ventilated for more than six days but who do not undergo tracheostomy.

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