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Original Article

Removal of the tracheostomy tube in the aspirating spinal cord-injured patient

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Study design: Four related case reports, occurring within a 10-month time frame during 2001.
Objectives: Aspiration is commonly reported in the literature as a contraindication to decannulation. We report four examples of successful removal of the tracheostomy tube in the presence of aspiration by an experienced team, utilising a risk management approach.
Setting: Victorian Spinal Cord Service (VSCS), Austin Hospital, Melbourne, Australia.
Methods: Four individuals in our unit with traumatic spinal cord injury, three quadriplegic and one paraplegic, presented with aspiration identified by a positive modified Evan's blue dye test or constant coughing, gagging and oxygen desaturation during cuff deflation trials. In three of the four cases, the tracheostomy tube had been *in situ* for a prolonged period and the patients had failed to progress towards decannulation. A decision was made to decannulate these four patients in spite of the presence of traditionally held contraindications for decannulation. The multidisciplinary team carefully compared the inherent risks of premature decannulation against those of prolonged tracheostomisation. Given the risk associated with this procedure, a closely monitored decannulation protocol was instituted.
Results: All four patients were successfully decannulated with improved quality of life, eating between 1 and 4 days and communicating immediately after decannulation. None experienced respiratory deterioration.
Conclusion: It is possible to safely decannulate aspirating spinal cord injured individuals in some instances, using a risk management approach.
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Keywords: spinal cord injury; aspiration; assisted cough; decannulation; airway reactivity; tracheostomy

Introduction

At the Austin Hospital (AH), tracheostomy tubes (TTs) are frequently inserted to facilitate ventilation following spinal injury in approximately 60% of cases. In straightforward circumstances, the TT can be removed a week or two after the patient is weaned from the ventilator and satisfies the standard criteria for decannulation used at the Victorian Spinal Cord Service (VSCS). Considerable diversity exists in the literature as to what the usual criteria may be[1–8] (see Table 1); however, in practice at the VSCS we assess for a patent upper airway,[9] cough effectiveness and the ability to protect the airway from saliva.[6,7] Failure to protect the airway can result in aspiration, defined as 'the passage of material below the vocal folds into the trachea'.[8] The incidence of aspiration in patients with an artificial airway has been reported at approximately 77% and even greater for tracheostomised patients despite preventative measures such as inflated tracheal cuffs.[10] Harmful consequences of aspiration include hypoxaemia, chemical pneumonitis, mechanical obstruction, bronchospasm and pulmonary infection.[11]

A commonly used practice under review is the need for spigotting and downsizing the TT prior to decannulation.[2] A recent study performed by the Royal Brisbane Hospital compared two methods of assessing readiness for decannulation. One method involved spigotting or capping and progressive downsizing of the tube, and the other involved decannulation following 24–48 h of successful, continuous cuff deflation. The latter procedure of cuff deflation proved to be equally successful in predicting safe removal of the TT and was more efficient, decreasing cannulation time by 5–6 days on average.[2]

Spinal cord-injured (SCI) patients frequently do not satisfy a number of the suggested criteria for

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decannulation (see Table 1). They may not have an effective cough or be free from chest infection. They may be aspirating their secretions and therefore unable to tolerate 24–48 h of cuff deflation, as recommended in the Royal Brisbane study. As a result, their TTs remain *in situ* for prolonged periods, placing them at risk of complications, such as stomal infection, haemorrhage, tracheal injury, accidental dislodgement and decannulation, pulmonary complications and mechanical problems with the cuff.[12] Sputum plug occlusion of the TT is a significant risk. In addition, cuffed TTs can impair swallowing and increase the risk of aspiration,[7,8,10] interrupt the glottal and subglottal airflow,[13] and lead to further deconditioning of the swallow due to disuse and atrophy. It has been demonstrated that the incidence of aspiration in tracheostomised individuals is increased when they have been weaned from positive pressure ventilation and are breathing spontaneously.[10]

Clinicians working with aspirating tracheostomised SCI populations face a dilemma. Removing the TT prematurely places the patient at risk of respiratory compromise, whereas leaving the tube *in situ* indefinitely has associated complications and may be deleterious to quality of life. On four occasions, the AH Spinal Unit has chosen to decannulate or temporarily downsize to minitracheostomy tube (MT) patients known to be aspirating.

In order to minimise the risks potentially associated with decannulation, the multidisciplinary team managing the patient assessed and reviewed the risks of removing the tracheostomy versus those of prolonged tracheostomisation for each case. The physiotherapist was responsible for determining each patient's ability to cough. The speech pathologist considered the patient's swallow function and assessed upper airway patency. Referral to appropriate consultants such as ear, nose and throat specialist (ENT) was made where required. After deciding to remove the TT, a carefully monitored decannulation process was instituted and videofluoroscopic assessment of swallow function was conducted where necessary.

All four patients were unable to protect their airway from oral secretions with the TT *in situ*. We suspected that they might in fact be better able to manage their own secretions if the tube was removed and their airway anatomy was returned to normal. This paper aims to address the question 'Can aspirating patients be safely decannulated?' We present four case studies where this has been achieved, acknowledging the clinical risk involved and describing the procedures employed to control potential negative consequences.

Table 1 Published indicators of readiness for decannulation

Greenbaum (1976)
- Weaned from mechanical ventilation
- Normal gag
- Effective cough
- 24 h cuff deflation tolerated
- Negative Evan's blue dye test

Note: also disagrees with progressive downsizing of TTs and spigotting.

Thompson-Ward *et al* (1999)
- '…safely tolerate 24–48 hours of full cuff deflation and no longer requires a cuff or access to the trachea for management of secretions' (p 275)

Tamburri (2000)
- Reason for TT resolved
- Patent airway can be maintained
- Downsizing of TT
- Insertion of fenestrated tube and corking of TT

Ladyshewsky and Gousseau (1996)
- Fenestrated TT *in situ*
- Intact gag
- Strong spontaneous cough
- Ability to swallow own secretions as per speech pathology assessment
- $SaO_2 > 90\%$ within 24 h
- Arterial blood gases within normal limits within 24 h

Hoffman (1994)
- Trachea should be examined for the presence of obstructive lesions

Godwin and Heffner (1991)
- '…adequate ventilatory reserve, adequate nutritional state, a patent upper airway, an absence of serious bronchopulmonary infection, a cough adequate to clear airway secretions without suctioning, and minimal well tolerated aspiration' (p 579)

Heffner *et al* (1986)
- Maintain own ventilation
- '…no longer requires a cuff or access to the trachea to prevent aspiration or control secretions' (p 272)
- Recommends use of interim stoma button that can be removed when suction or assisted ventilation is no longer required.

Higgins and Maclean (1997)
- Negative EBDT

Method

Subjects

The subjects were three quadriplegic patients and one paraplegic patient of the VSCS. The patients were admitted to our Spinal Unit between April 2001 and December 2001. Subjects A, B and C had tracheostomies surgically inserted by a thoracic surgeon at the level between the third and fourth tracheal rings. Subject D had his tracheostomy inserted by a ear, nose and throat surgeon between the second and third tracheal rings. The surgical procedures involved a transverse incision through the skin around the level of the suprasternal notch and a vertical incision through the tracheal rings. The TTs were fixed in place with tracheostomy tapes tied around the neck. None of the

Table 2 Demographic and medical details

ID	*A*	*B*	*C*	*D*
Age (years)	45	25	71	20
Sex	M	F	M	M
ASIA classification	T9, ASIA A	T1, ASIA A	C5, ASIA B	C6, ASIA A
Internal fixation	Posterior thoracic	Posterior cervical	Posterior and anterior cervical	Posterior cervical
Period of ventilation	4 + 16 days	14 days	78 days	17 + 6 days
Total days TT *in situ* (not including MT)	35 days	9 days	101 days	80 days
Days post injury an artificial airway was required	ETT 1–4, 23–25, TT 25–61	ETT 1–9, TT 9–18	ETT 1–17, TT 17–118	ETT 1–6, TT 6–86
Type of TT	9 mm ID, cuffed soft	8 mm ID, cuffed soft	9 mm ID, cuffed soft	8 mm ID, cuffed hard
Nutrition mode at time of decannulation	Percutaneous gastrostomy	Nasogastric tube	Percutaneous gastrostomy	Nasogastric tube

ETT: Endotracheal tube; TT: tracheostomy tube

patients described had a history of dysphagia prior to their SCI or pre-existing conditions placing them at risk of dysphagia, such as bulbar dysfunction. The demographic and relevant medical details are listed in Table 2.

Procedure

A detailed chart review was performed on each patient. All patients had been weaned from ventilation. They were assessed by the speech pathologist and found to be aspirating saliva either through clinical observations such as gagging and frequent need for suction of saliva-like secretions during cuff deflation or via a failed modified Evan's blue dye test (MEBDT). The MEBDT involves administering a few millilitres of blue dye to the patient's mouth and observing tracheal secretions for evidence of blue dye, indicating aspiration of dyed saliva.[14,15] The MEBDT is significantly limited in sensitivity, with a 50% false-negative rate; however, when present (as in three of the described cases) it identifies aspiration 100% of the time.[15] Where a negative MEBDT occurs, further bedside evaluation, fibre optic or videofluoroscopy evaluation needs to be performed. The latter two provide objective data regarding swallow function; however, they are invasive and/or require the patient to be able to attend the X-ray department. Airway patency and vocal fold function were assessed by evaluation of voice quality during temporary occlusion of the TT with the cuff deflated. The physiotherapist assessed the patient's ability to cough to their mouth. A one-way speaking valve was used in some cases to assess airway patency, voice and ability to clear airway secretions over longer periods of time. Following assessment, the patients were placed nil by mouth and approval from the treating medical practitioner was obtained to trial decannulation. The TTs were removed early in the morning, and preferably towards the start of the week to maximise the number of professionals available to monitor the patient over the subsequent 24–48 h. Patients were placed on continuous pulse oximetry and checked approximately half hourly to determine the need for suction and/or assisted coughing. The forced vital capacity (FVC) of the patient was monitored 4 hourly to identify any deterioration or signs of fatigue. The physiotherapist reviewed the patient approximately 2 hourly and was on call overnight if the patient appeared to be at risk of sputum retention or respiratory muscle fatigue. A spare tracheostomy of the same size and one size smaller was at the bedside in case of the need for recannulation. Laborde forceps, also known as 'tracheal dilators', were kept at the bedside of all tracheostomised patients to assist with recannulation if needed.

Case studies

Case 1

Mr A was admitted to the intensive-care unit subsequent to a high-speed motor vehicle accident (MVA) the previous day. He sustained a complete T9 paraplegia and significant chest trauma, requiring intubation and ventilation for 4 days. Following emergency abdominal surgery on Day 25, Mr A required tracheostomy insertion and was ventilated for 8 days. He was transferred to the ward on Day 43.

Mr A was found to have a patent upper airway via clear voicing and adequate airflow in the upper airway. He was able to clear tracheal secretions to his mouth while occluding the TT. Mr A was unable to protect his airway by swallowing oral secretions with the TT *in situ* as demonstrated by numerous failed MEBDT (Days 38,

54 and 60). Indeed, his swallow appeared to be deteriorating in strength and speed of initiation on each review. On Day 61 of his admission, following team discussion, decannulation was trialled despite his poor airway protection and significant sputum production. After 24 h, he commenced eating and drinking as per speech pathology recommendations. Sputum production diminished to minimal by the following day. He had been requiring four sessions of intermittent positive pressure breathing (IPPB) per day and a fraction of inspired oxygen (FiO_2) of 40%. After decannulation, he was breathing room air and no longer required IPPB.

Notably, Mr A was the only subject in the group whose lesion was not cervical. Fewer dysphagia risk factors can be attributed to his thoracic level of injury. It is noteworthy that prior to the abdominal surgery and consequential TT insertion, he did not aspirate saliva. It is probable that the TT contributed to his inadequate swallow function.

Case 2

Ms B sustained a C7 fracture and subsequent complete quadriplegia at the level of T1 following an MVA. She was admitted to a trauma center, and posterior surgical fixation was performed on the day of the injury. On Day 3, an anterior cervical fusion was performed. The next day extubation was unsuccessfully attempted. Ms B was transferred to the AH on Day 5. An elective tracheostomy was performed on Day 9 and ventilation ceased on Day 14.

Assessment by the speech pathologist on Days 10–17 indicated that the patient was not adequately protecting her airway from oral secretions, confirmed by a failed MEBDT on Day 15. The physiotherapist found that the patient was unable to clear secretions adequately without tracheal suction and produced moderate amounts of sputum. Following discussion, the medical team approved a trial decannulation in spite of these risks, and on Day 18 the TT was removed and an MT inserted to facilitate secretion removal. Oxygen therapy requirements were unchanged. The patient continued to produce moderate amounts of sputum for the first 12 h and thereafter only minimal amounts. No subsequent respiratory complications occurred.

Following videofluoroscopy 4 days later, the patient commenced eating and drinking. On Day 23, the MT was removed and an ENT consultation was requested as the patient was noted to present with persistent dysphonia. Nasendoscopy revealed right unilateral vocal fold paresis. This was the same side as the surgical approach. The authors recommend that the status of the vocal cords should be established prior to decannulation where normal voicing could not be elicited with cuff deflation.

Case 3

Mr C presented to a regional hospital following a fall and delayed onset C4-5 incomplete quadriplegia, as a result of spinal cord compression. Anterior and posterior cervical fusions were performed on Day 7 after the injury. Tracheostomy was performed on Day 17. He was admitted to the AH on Day 56, having been continuously ventilated since surgery. Two attempts to wean Mr C from ventilation had failed during that time due to sputum retention. Ventilation was finally ceased on Day 78. Speech pathology assessment revealed a patent upper airway and inadequate airway protection. Numerous failed MEBDTs (Days 71, 78, 84, 97 and 115 of his admission) indicated that he was unable to swallow his secretions safely. Throughout this time, Mr C continued to be unable to tolerate more than 5 min with the cuff deflated due to coughing, gagging and oxygen desaturation. This laryngeal irritability seemed to affect his ability to manage his secretions when the cuff was deflated.[16] His ability to cough to his mouth was inconsistent. He was productive of moderate to large amounts of thick sputum via the tracheostomy. By Day 118, the patient's management of oral secretions with the cuff down had not improved. The team decided to trial decannulation despite his poor airway protection and sputum clearance. Following TT removal and MT insertion, he produced small to moderate amounts of sputum for 1 week, and did not require supplemental oxygen to maintain his oxygen saturation above 95%. He commenced eating and drinking modified textures 24 h after decannulation. The MT was removed 7 days after insertion with no adverse sequelae.

Case 4

Mr D, a 20-year-old man, was admitted to the AH the day after he sustained a C6 complete quadriplegia in an MVA. He underwent posterior surgical fixation of his cervical fractures on Day 3 after injury. A halothoracic vest was applied following surgery to augment spinal stability and the neck was positioned in an extended posture. He had a tracheostomy performed on Day 6. During his stay in the intensive-care unit, he had numerous episodes of persistent lung collapse and consolidation and was discharged to the ward on Day 20. Development of pneumonia required a further intensive care admission on Day 49. On Day 61, the patient returned to the ward. Swallow review indicated poor airway protection with cuff deflation trials characterised by desaturation, coughing, gagging and an inability to manage oral secretions. On Day 85, the patient was able to tolerate 20 min of cuff deflation time, but still required frequent tracheal suction of thin watery secretions. Silent aspiration of copious quantities of saliva was suspected, as the patient did not cough or react to the foreign material in his airway. Airway patency was deemed adequate with clear voicing elicited with temporary TT occlusion. Mr A was dependent on tracheal suction for secretion removal due to absent abdominal muscle function. On Day 86, a closely monitored decannulation was successfully performed. Insertion of an MT was not required, and the patient was productive of minimal sputum after the first day.

The patient was breathing room air and commenced oral diet within 2 days following a favourable videofluoroscopy result.

Discussion

The unique spinal-injured population
The group of patients examined here is clearly not representative of the large majority of patients undergoing tracheostomy. Our aim was to investigate this challenging group, and therefore our results cannot be generalised to other populations.

Airway protection and the spinal-injured tracheostomised patient SCI patients present with dysphagia causing aspiration for a variety of reasons. As a result of the cervical trauma, the patient may suffer oedema in the prevertebral tissues with compression of the pharyngeal space.[17] This can cause mechanical dysphagia with inadequate opening of the upper oesophageal sphincter, as well as pooling of material in the pharynx.[18]

Cord injuries may extend several segments above and below the level of the spinal column injury, depending on the degree of force involved in the incident. In a particularly high lesion, this may involve the brainstem and related cranial nerve function and result in a neurological dysphagia.[19] Surgical treatments for the cervical spine, used to decompress neural structures or stabilise and realign the spinal column, can be associated with potentially significant complications. The anterior approach involves exposure and retraction of the trachea and oesophagus, the carotid artery and the laryngeal nerves, making them vulnerable to trauma,[18,20] commonly on the side of the surgical approach.[21] Patients with spinal injuries may also be dysphagic as a result of their posture. Patients may be immobilised in neck hyperextension in collars or braces, or required to lie flat in head traction while their spinal column stabilises.[22] It has been shown that normal healthy individuals can experience some swallowing abnormalities when placed in cervical orthoses (halo and SOMI braces, and Philadelphia collars).[23]

Lung volumes of acutely injured spinal patients can be reduced to 30% of normal.[24] Such respiratory insufficiency can alter the duration of the inspiratory phase and the time available for airway closure during the swallow.[25] Reduced vital capacity and abdominal muscle strength may also affect the timing and strength of the expiratory airflow, which provides airway clearance of material pooled in the pharynx and larynx.[25] Debate exists about the affect of nasogastric feeding tubes (present at the time of decannulation in subjects B and D) on the incidence of aspiration. Cameron *et al*[14] and Leder *et al*[26,27] note no increase in aspiration, whereas other authors have found a significantly increased incidence of aspiration, particularly of gastric contents.[10,28]

Effects of 48 h of endotracheal intubation on swallow function have been shown to be significant, with aspiration rates as high as 56%, and up to 25% presenting without outward symptoms (silent aspiration).[10,27,29–31] The incidence of swallow dysfunction increases with prolonged intubation: 85% of patients following 8 days of intubation.[32] Postextubation dysphagia appears to be transient,[33,34] with reports of patients being able to resume an oral diet approximately 5 days postextubation.[27] The cases presented were all intubated for between 6 and 17 days; however, given the subjects were then tracheostomised for between 9 and 101 days, the effects of the intubation are likely to have resolved and therefore have no impact on the study findings.

Research has shown that the TTs themselves can impair swallow function through both mechanical and physiological causes.[10,11] As a consequence, a cycle may develop where the TT impairs the patient's swallow function, resulting in silent aspiration. The patient is then unable to prove that they can protect their airway, and as a result the TT remains *in situ*.

The degree to which a patient's swallow is affected by the presence of a TT appears to vary. There are numerous examples of tracheostomised patients who tolerate 24 h per day cuff deflation and full oral intake. Some patients appear to present with very sensitive or reactive airways evidenced by paroxysmal coughing and gagging. It can be postulated that this inability to protect the airway stems from altered sensation and airway reactivity. Three of the cases presented here demonstrated symptoms of airway irritability, which was greatly improved postdecannulation.

Airway clearance Extreme caution is required when making the decision to remove a TT from SCI patients who are clinically aspirating, and a team approach is recommended. Airway clearance issues must be considered and a closely monitored decannulation process instituted.

Owing to varying degrees of abdominal muscle strength, a strong cough may be difficult to achieve. A technique called 'assisted coughing' is used to help clear secretions for those with abdominal weakness. This involves providing a firm upward thrust below the diaphragm at the precise moment of coughing. Additional pressure may also be exerted over the chest wall to increase the generation of intrathoracic pressure.[35] It is vital that the patient learn to perform this technique effectively to avoid sputum retention. In our experience at the AH, insertion of an MT immediately after removal of the cuffed TT allows patients time to acquire this skill.

Benefits of removal of the TT
The amount of care required by all four patients decreased significantly 24–48 h after decannulation. They were able to communicate verbally and progressed from full enteral feeding to oral intake within 4 days. Although two patients continued to present with mild dysphagia after removal of the TT, they were able to protect their airway from oral secretions and

commenced appropriate modified diets. None experienced deterioration in respiratory status. All patients had reduced respiratory care needs 24 h after removal of the TT. In fact, all had reduced sputum production, reduced oxygen requirements and reduced need for chest physiotherapy. Although an overnight physiotherapy service was made available for all patients, none required this service.

Timely removal of a TT has many financial benefits. The length of hospital stay may be decreased and there is also a reduction in the use of human, technical and consumable resources.[2] It is costly to manage permanently tracheostomised patients and very difficult to plan discharge for such individuals. In our experience, residential care facilities in Australia are rarely equipped to provide the care that this client group requires.

The tracheostomised patient is unable to voice unless they can tolerate cuff deflation or are using a talking TT. These tubes enable the patient to voice with the cuff inflated by introducing an external airflow across the vocal folds. In our experience not all patients are able to achieve voice in this manner. Quadriplegic patients are particularly disadvantaged, as they are unable to write. The inability to communicate effectively can be immensely distressing for patients and families. We have found that agitated or distressed tracheostomised patients become calmer when they are able to communicate their needs to staff verbally, request information about their condition and direct their care.

Conclusion

Aspiration is commonly considered to be a contraindication for TT removal.[4,7,8] We have presented four cases of successful decannulation of SCI patients who had been assessed as aspirating. We do not suggest that removing the cuffed TTs of aspirating patients be undertaken lightly. All patients in the study group were assessed by a physiotherapist and speech pathologist experienced in the care of tracheostomised, SCI individuals in consultation with medical and nursing staff. The patients' airway protection, airway patency and secretion clearance were evaluated. The risks of premature decannulation were weighed against those associated with leaving the TT *in situ* in the light of assessment findings. In cases where normal voicing is not evident, ENT surgeon opinion is recommended prior to decannulation. A decannulation plan was established to minimise the risk of negative consequences. In all cases, a contingency plan for tube reinsertion was in place, but was not required. All four patients described had reduced care needs following decannulation, and enjoyed significant improvements in their health and quality of life.

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