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Review Article

Bleeding around a tracheostomy wound: what to consider and what to do?

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Abstract

All patients with bleeding in and around a tracheostomy must be investigated to exclude a serious cause. The overall incidence is approximately 5 per cent of tracheostomies performed in Adult Intensive Care Units (AICU). When bleeding commences more than 72 hours post-operatively, the possibility of a trachea innominate artery fistula needs to be excluded by endoscopic examination of the trachea in an operating theatre environment, with the facility to proceed to exploration of the neck and possibly to sternotomy to enable ligation of the innominate artery. With appropriate recognition, diagnosis, resuscitation and surgical intervention, the associated high death rate of trachea innominate artery fistula can be reduced.

Key words: Tracheostomy; Haemorrhage; Innominate Artery; Postoperative Complications

Introduction

Tracheostomy is a commonly performed procedure in the critically ill. Since its introduction, percutaneous dilatational tracheostomy has become firmly established in intensive care practice, and is currently the technique of choice for creating a tracheostomy. The short- and long-term complications of percutaneous tracheostomy are at least comparable to, and possibly less than, those following open surgical tracheostomy.[1–3]

Haemorrhage as a procedural complication of tracheostomy is estimated to occur in approximately 5 per cent of patients, and is less likely following an open surgical approach compared with a percutaneous dilatational approach.[4] Reports have described death due to haemorrhage during tracheostomy procedures, including percutaneous dilatational tracheostomy;[5,6] however, in a larger series death due to such haemorrhage was estimated to occur in approximately 0.25 per cent (three deaths in a series of 1187 procedures in a single intensive care unit over a 13-year period).[5] This is comparable to the all-cause operative mortality rate for surgical or open tracheostomy procedures, 0.3 per cent.[7]

Otolaryngologists must be aware of the various techniques of open and percutaneous tracheostomy,[8] as we remain involved in long-term tracheostomy management. There is published evidence of insufficient knowledge of tracheostomy-related emergencies among non-ENT healthcare professionals;[9] as a consequence, ORL specialists will continue to be frequently consulted and involved in the management of tracheostomy complications.[8,10]

Any peristomal bleed or haemoptysis in a tracheostomised patient should prompt a full clinical investigation to ascertain the underlying cause. The differential diagnosis of tracheostomy bleeding is determined by the lag time between tracheostomy creation and haemorrhage onset. Haemorrhage that occurs within 48 hours of placement is termed 'early' and that occurring days or months later is termed 'late'.[11]

A review was performed of the published English literature, using the Pubmed database and the following keywords: 'tracheostomy', 'bleeding', 'haemorrhage', 'tracheoinnominate artery fistula', 'diagnosis', 'complications' and 'management'.

Differential diagnosis

Haemorrhage within 48 hours of tracheostomy is typically associated with local factors such as: traumatic puncture of the anterior jugular or inferior thyroid veins; systemic coagulopathy; erosions secondary to tracheal suction; or bronchopneumonia. Usually, the haemodynamic stability of the patient allows easy identification of the problem, and corrective action can be taken with minimal morbidity.[12]

Haemorrhage occurring three days to six weeks after tracheostomy should be considered to indicate trachea innominate artery fistula until proven otherwise.[13] Other causes of catastrophic pulmonary haemorrhage include: pulmonary artery flotation catheter induced arterial rupture; thoracic aneurysm rupture; and, less commonly, vascular fistula (from the carotid artery or inferior thyroid artery).

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A 'sentinel bleed' is reported in more than 50 per cent of patients who go on to develop massive, delayed haemorrhage. The majority of these patients are accommodated in intensive care units, as 70 per cent of all delayed haemorrhage occurs during the first three weeks.[14]

Haemorrhage occurring more than six weeks post-operatively is rarely related to trachea innominate artery fistula, and is more likely to be secondary to granulation tissue, tracheobronchitis or malignancy.

Definition of stomal bleeding

One large study reported bleeding in 8 per cent of tracheostomised patients; they included patients with coagulation abnormalities.[15] This high figure may reflect the authors' definition of bleeding. Other workers have defined minor bleeding as blood loss of 25–100 ml[16] or as bleeding controllable by digital pressure,[17] whereas moderate and major bleeding have been defined as blood losses of 150–250 ml and >250 ml, respectively,[18] or as bleeding requiring surgery or blood transfusion.[19]

Another working definition was proposed by Nates *et al.*;[20] they considered major external bleeding as a loss of more than 100 ml, or an intratracheal blood loss of more than 25 ml. Investigation of intratracheal bleeding should proceed as a matter of urgency, as even a small amount of endobronchial blood can cause significant deterioration of gas exchange and resultant hypoxaemia.

Thrombocytopenia is the strongest single risk factor for 'chronic bleeding'. An evaluation of the effects of pre-operative coagulation status on the incidence of acute and chronic bleeding in 415 consecutive patients undergoing percutaneous dilatational tracheostomy was undertaken[16] and demonstrated that acute bleeding was independent of the coagulation variables tested. The risk of chronic bleeding was higher and associated with the findings of an activated partial thromboplastin time over 50 s, and the platelet count below 50×10^9 L^{-1} and in the presence of two or more abnormal coagulation variables. The use of low dose heparin did not significantly increase the risk of chronic bleeding. They also recommended that patients with thrombocytopenia be treated with platelet transfusion immediately before percutaneous dilatational tracheostomy may also decrease the risk of chronic bleeding.

The vulnerability of major vessels to injury during percutaneous dilatational tracheostomy is related to the close proximity of the trachea to major arteries and veins in the neck. This risk is more likely if there has been previous neck surgery, local neck or upper chest radiotherapy, or anything likely to result in distortion of the local anatomy.[5]

The National Institute for Clinical Excellence has recently advised the use of ultrasonography during insertion of central venous cannulae, to make this procedure simpler, safer and less invasive.[21] The routine use of neck ultrasound for percutaneous tracheostomy continues to be debated,[22,23] but certainly the risk of complications is increased when performed post per-cutaneous trachesotomy by residents during their initial period of training.[24]

The tracheostomy should be sited between the second and third tracheal rings in the midline. Measures to prevent off-centre and low puncture into the trachea may reduce the likelihood of vessel puncture. The routine use of fibre-optic bronchoscopy should ensure midline placement of the tracheostomy and should also allow some estimate of the level of placement. Clinicopathological studies have shown that up to 17 per cent of percutaneous tracheostomies are incorrectly sited.[25]

In a review of haemorrhagic complications in a series of 497 cases, percutaneous tracheostomy was abandoned in six and was problematic in a further 18 (thus, tracheostomy was difficult or impossible in 4.8 per cent).[12] All cases of haemorrhage were successfully arrested. Surgical tracheostomy was necessary in the six patients with failed percutaneous tracheostomy. In four of the 497 patients, the source of bleeding was the inferior thyroid vein (two cases), high brachiocephalic vein (one case) or possibly an aberrant anterior jugular communicating vein (one case). Minor bleeding occurred in fewer than 20 per cent of the 497 cases, and varied from oozing (requiring a change of dressings) to bleeding controlled by digital pressure. Major bleeding (necessitating transfusion or surgical intervention) occurs in fewer than 5 per cent of cases, and was usually identified as venous.

Catastrophic haemorrhage is rare. It is usually delayed and is commonly the result of a trachea innominate artery fistula. The development of a fistulous communication between the trachea and the innominate artery will result in death in almost 100 per cent of cases, unless suspected and diagnosed early and treated surgically.[26] Although these fistulae occur most commonly after tracheostomy (involving either an open or a percutaneous dilatational approach), they have also been reported following other surgical procedures (e.g. tracheal resection and tracheal stenting). This fatal condition was first reported in 1879. The first short-term survivor was reported in 1964, with a long-term survivor reported four years later.[26] The innominate artery probably becomes involved because of its close proximity to the anterior wall of the thoracic trachea. The artery typically crosses the midline level of the ninth tracheal cartilage, but the level may vary from the sixth to the 13th tracheal cartilage.[27]

There are two categories of trachea innominate artery fistulae.[26]

The first includes extratracheal fistulae caused by direct injury of the artery below the 'elbow' of the cannulae, just underneath the incision. In patients with tracheostomies placed below the third tracheal cartilage, or those with a high-riding (i.e. cephalad) innominate artery, there is the risk of a trachea innominate artery fistula developing due to the concave surface of the tube at the elbow.

The second category includes endotracheal fistulae developing due to erosion of the anterior wall of the trachea. Two main mechanisms are capable of producing erosive pressure sufficient to lead to fistula

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formation.[28] Firstly, a fistula may occur between the anterior tracheal wall and the innominate artery secondary to the mechanical force generated by either the tracheostomy tube cuff or the tube tip, depending on the relative positioning of the tube within the trachea. Secondly, pressure generated beneath the angulated neck of the tracheostomy tube may produce ischaemia extending anteriorly through the tracheal mucosa and into the innominate artery.

Clinical presentation

Two-thirds of trachea innominate artery fistulae occur in the first three weeks after tracheostomy. In any patient developing haemoptysis less than three weeks post-operatively, a trachea innominate artery fistula should be the chief differential diagnosis.[29] The warning signs of impending massive haemorrhage from a trachea innominate artery fistula include premonitory minimal bleeding (termed sentinel bleeding) and pulsation of the tracheostomy tube which coincides with the heartbeat. These signs have been reported as pathognomonic of a trachea innominate artery fistula. Between 35 and 50 per cent of reported fistula cases have been reported to exhibit a minor 'herald' or sentinel bleed between two hours and four days prior to major haemorrhage.[30] Such sentinel bleeding may present as bleeding from the tracheostomy site, haemoptysis, aspiration of blood or suctioning of blood from the trachea.[30] Therefore, a high index of suspicion should be maintained, and more than a trivial amount of bleeding (i.e. more than 10 ml, 48 hours post-tracheostomy) should always prompt investigation to establish the cause.[31]

Resuscitation if bleeding

Hazarika *et al.*[32] have suggested that, if the source of the bleeding cannot be confirmed and a trachea innominate artery fistula cannot be ruled out, the patient should be taken promptly to the operating theatre for direct exploration of the neck and upper mediastinum, in order to exclude a trachea innominate artery fistula.

Jones *et al.*[31] have proposed that the thoracic field should be prepared and the tracheostomy explored via a bronchoscopy in the operating theatre under anaesthesia. If sudden haemorrhage occurs, a sternotomy should be immediately performed. Hyperinflation of the tracheostomy cuff is said to be successful in controlling acute haemorrhage for a temporary period in more than 85 per cent of cases.

The 'Utley manoeuvre' has been proposed in the event that hyperinflation of the cuff proves unsuccessful in controlling the haemorrhage.[33] A short, right-sided, infraclavicular incision is made in order to enter the skin and superficial fascia. The mediastinum is then dissected with the index finger until the innominate artery is reached, and this is occluded by compression of the index finger against the posterior wall of the manubrium of the sternum. Haemostasis can then be achieved until removal of the cannulae or division of the sternum. Utley *et al.* described the successful use of this method in nine of 10 cases. The technique usually requires replacement of the tracheostomy tube with a cuffed endotracheal tube in order to gain access.[31,34–36]

Emergency management

A patient with a sentinel bleed or with mild to moderate active bleeding should be brought immediately to an operating theatre with staff and facilities adequate to perform a midline thoracotomy. Before any airway manipulation or bronchoscopy, the patient should have adequate intravenous access for blood replacement. It is imperative that the surgeon has the facilities to perform rigid and flexible bronchoscopy. In the absence of such facilities, any type of airway instrumentation or manipulation is ill-advised for the patient who is not exsanguinating.

A short-acting inhalational or intravenous anaesthetic should be administered. Intratracheal lignocaine instilled via the tracheostomy tube can be used to blunt the cough reflex and potentially lessen the need for pharmacological muscle relaxation.

Assuming the patient is not in extremis, a flexible bronchoscope is gently introduced into the tracheostomy tube, and the airway distal to the tube is examined to help localise the source of the bleeding. If the distal airways do not show any blood or retained clot, one can exclude various causes of haemoptysis that may arise from the lung parenchyma and distal trachea. If the bleeding is profuse, the surgeon is best advised to switch to a rigid bronchoscope immediately.[26]

Before decannulation, the rigid bronchoscope is inserted through the glottis. A 0° telescope and rigid suction should be immediately available. An assistant deflates the tracheostomy cuff and slowly removes the tracheostomy tube while the surgeon observes the stoma and anterior wall for ulceration or frank fistula. In the event that the removal of the tube incites haemorrhage, the rigid bronchoscope can be passed beyond the fistula and used to compress the innominate artery against the manubrium to temporarily control bleeding.[33] In this situation, it is important not only to prevent exsanguination but also to keep the lungs and airway clear of blood and clots. After some time, it may be possible to railroad an orotracheal tube over a bougie beyond the trachea innominate artery fistula.

Operative management

A full midline sternotomy has traditionally been the most common approach for repair of a trachea innominate artery fistula; however, this wound becomes contaminated by tracheal secretions and thus puts the patient at risk of mediastinitis and sternal dehiscence.[26,37] An upper partial sternotomy that is carried laterally into the right third interspace has therefore been suggested. This method allows access to the base of the innominate artery, and has been reported to reduce the potential morbidity of wound complications. While there is no supporting evidence, a surgical modification involving 'filling in' the surgically created mediastinal and lower

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neck 'dead space' is also likely to reduce the infection rate.[26,34]

The innominate artery is exposed by division of the thymus, with superior retraction of the innominate vein. The artery is encircled on both sides of the trachea innominate artery fistula to gain vascular control. At this stage, inspection must rule out an anomalous origin of the left common carotid artery. The fistula site is usually small and surrounded by an inflamed and indurated arterial wall. The natural tendency to repair the defect in the innominate artery is doomed to failure – the incidence of recurrent bleeding (60 versus 7 per cent) and death (86 versus 29 per cent) is much higher following attempts at repair, compared with patients whose artery is simply divided, respectively.[37] The innominate artery should be debrided back to healthy tissue and closed. In those patients who survive the initial operation, the risk of stroke following innominate artery division is quite low; three studies found arm weakness in only two of 52, zero of four and one of 22 patients, variously.[31,34,37] Ligation of the innominate artery only results in the subclavian and carotid circulation being left in continuity. Innominate artery ligation results in neurological deficit in less than 5 per cent of patients.[32]

Management of the tracheal defect is controversial and must be individualised – from allowing granulation to occur to resection. Regardless of the method used, vascularised tissue needs to be interposed between the tracheal defect and the divided ends of the innominate artery, in order to eliminate dead space, to stave off infection and to reduce the risk of rebleeding. The use of a pectoralis major muscle flap is ideal for this purpose.[38] If the tracheostomy has been placed in a low position, it should of course be re-sited in the usual position (between the second and fourth tracheal cartilage rings).

After irrigation and drainage, the wound is closed, and an endotracheal tube or inflated tracheostomy cuff is left in place at the tracheal defect for several days, to allow the wound to heal. Post-operative antibiotics should be maintained for a week or so, with the choice guided by the patient's tracheal bacterial flora.

Recently, there have been individual case reports of successful management of trachea innominate artery fistula using percutaneous endovascular stenting of the innominate artery,[39–41] either as a definitive procedure or a temporary measure.[42] Another report, of a nine-year-old child, described using endovascular embolisation of the innominate artery to secure control of innominate artery bleeding; this patient had no indications for further surgical intervention in a post-procedure period of more than 12 months.[43] While such non-surgical interventions may be successful, they are unlikely to be availability in an emergency. Therefore, the immediate surgical option remains the current treatment of choice, i.e. taking the patient to the operating theatre for evaluation and confirmation of correct diagnosis, and then proceeding to open surgical arterial ligation.

Conclusion

Patients with bleeding in and around a tracheostomy must be investigated to exclude a serious cause. The overall reported incidence is approximately 5 per cent of tracheostomies performed in Adult Intensive Care Units (AICU). When bleeding commences more than 72 hours post-operatively, the possibility of a trachea innominate artery fistula must be excluded by endoscopic examination of the trachea in an operating theatre environment, with the facility to proceed to exploration of the neck and possibly to sternotomy to enable ligation of the innominate artery. With appropriate recognition, diagnosis, resuscitation and surgical intervention, the associated high death rate of trachea innominate artery fistula can be reduced.

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