

CASE REPORTS

Acute fatal haemorrhage during percutaneous dilatational tracheostomy

D. Shlugman^{1*}, R. Satya-Krishna² and L. Loh¹

¹Neuro-intensive Care Unit, Radcliffe Infirmary, Woodstock Road, Oxford OX2 6HE, UK. ²Nuffield Department of Anaesthetics, John Radcliffe Hospital, Oxford OX3 9DU, UK

*Corresponding author. E-mail: david.shlugman@orh.nhs.uk

Percutaneous dilatational tracheostomy (PDT) is associated with a number of life-threatening complications. We present a case of massive and fatal arterial haemorrhage that occurred in the intensive care unit during an elective PDT on an 86-year-old woman following earlier evacuation of a traumatic subdural haematoma. An avulsed right subclavian artery was found at *post mortem*. Previous thyroid surgery and aberrant arterial anatomy contributed to the fatal outcome.

Br J Anaesth 2003; **90**: 517–20

Keywords: complications, arteriovenous malformation; complications, haemorrhage; equipment, tubes tracheostomy

Accepted for publication: November 12, 2002

Previous neck surgery has been regarded as a relative contraindication to percutaneous dilatational tracheostomy (PDT).^{1–3} The rationale for this is not clear but an inability to identify landmarks and distortion of the normal internal anatomy are obvious reasons. The former is readily recognized and would contraindicate the procedure. However, distortion of the normal anatomy is difficult to predict, especially when compounded by aberrant anatomy. We present a case where aberrant arterial anatomy and previous neck surgery contributed to acute massive arterial bleeding with fatal consequences.

Case report

An 86-year-old woman with a history of ischaemic heart disease and hypertension sustained a fall at home. There was no initial loss of consciousness but over the next 24 h she complained of headache, vomiting and drowsiness. Following admission to hospital, her level of consciousness deteriorated, and she required tracheal intubation and artificial ventilation. A CT scan revealed an extensive left-sided subdural haematoma with significant mass effect and midline shift. At craniotomy, a large diffuse blood clot was evacuated and a frontotemporal lobe contusion noted.

Over the next 2 days in the intensive care unit there was no improvement in her level of consciousness. A second CT

scan showed that she had developed a large left frontal intracerebral haematoma with midline shift. There was also blood in the fourth ventricle and over the tentorium, but no evidence of any residual subdural haematoma. After discussion with her family, during which a poor prognosis was communicated, it was decided to proceed with surgery. A frontal lobectomy was performed and necrotic brain tissue was removed.

The patient remained in a deep coma over the following days. A decision was taken to perform a tracheostomy to facilitate weaning and protect the respiratory tract, as her bulbar function was uncertain. The procedure was performed by two consultant anaesthetists, using the Ciaglia Blue Rhino™ (Cook UK Ltd, Letchworth, UK) tracheostomy set. A thyroidectomy in the past was felt not to be a contraindication as the trachea was readily palpable. The first operator experienced difficulty in locating the trachea with the seeker needle, but this was eventually achieved by the second operator. Tracheal fiberoptic endoscopy confirmed that the cannula and guide wire were in the trachea. The stoma was dilated using the Rhino dilator, but on its removal profuse arterial bleeding occurred, accompanied by extensive bleeding from the tracheal tube and mouth. Attempts to stem the flow by advancing the tracheal tube were unsuccessful. Full resuscitative measures were commenced and surgical assistance summoned. The initial

horizontal 2 cm infracricoid incision was extended laterally in an attempt to locate the bleeding point, but this was unsuccessful. In spite of prolonged and comprehensive resuscitation, the patient continued to exsanguinate, and died within an hour.

The case was referred to the coroner for further investigation. The tracheostomy guide wire was left *in situ* to assist the pathologist at *post mortem*. The entry point of the guide wire in the trachea was to the right of the midline, between the first and second tracheal cartilage. Only the right lobe of the thyroid gland had been removed previously at surgery. Adhesions in the area of the thyroid gland were noted, and tethering of the great vessels to the adjacent structures was seen. There was no evidence of damage or puncture marks to the carotid artery or jugular vein, but an avulsed right subclavian artery was found at a level corresponding to the entry point of the Rhino dilator in the trachea. It was also noted that the high rising subclavian artery made an almost right-angle bend at the level of the cricoid cartilage before descending into the upper limb.

Discussion

In 1985, Ciaglia and colleagues⁴ described a bedside technique for PDT. It rapidly gained worldwide acceptance for its safety, simplicity, cost-effectiveness and low complication rate. A meta-analysis of five studies (236 patients)³ comparing PDT with surgical tracheostomy found similar overall complication rates in the two groups. However, one difference was less perioperative blood loss in the PDT group, as well as a lower incidence of postoperative bleeding. This is probably a reflection of the smaller skin incision, the blunt dissection of tissues and the tight fit of the tracheostomy cannula having a tamponading effect on the bleeding.

To our knowledge, there are no published references to fatal arterial bleeding during the performance of PDT. Anecdotal evidence, however, suggests such complications have occurred.⁵ Minor bleeding, varying from oozing requiring dressing changes to bleeding requiring only digital pressure to control, occurred in fewer than 20% of cases.^{6,7} Major bleeding necessitating transfusion or surgical intervention occurred in fewer than 5% of cases, and was usually venous in origin.^{2,6,8-11}

Catastrophic haemorrhage is rare, usually delayed and commonly the result of a tracheo-brachiocephalic (innominate) fistula. The majority of these haemorrhages (78%) occurred within the first 3 weeks after tracheostomy, and is thought to result from erosion of the tracheal mucosa into the underlying brachiocephalic vessel by the high-pressure tracheostomy cuffs. Haemorrhage is also more common in head-injured patients, possibly because of excessive head movements by the unconscious patient.¹²

A number of modifications to the equipment and technique have evolved to improve the safety of the procedure. In 1999, the serial tracheal dilators were replaced

by the single curved Blue Rhino™ dilator. It is coated with a slippery hydrophilic layer, making insertion and one-step dilatation of the trachea easier and smoother. This has lessened the incidence of posterior tracheal wall damage, intraoperative bleeding and episodes of airway obstruction and hypoxaemia.¹³

PDT is an invasive, semi-blind technique that relies on surface markings for correct identification of the anatomy. Two additions to the technique have improved the safety record of PDT, namely portable ultrasound and tracheal endoscopy. An ultrasound scan before PDT helps to identify the tracheal midline and the levels of the tracheal cartilages. In a clinicopathological study of 42 patients, incorrect siting of the tracheostomy occurred in 17% (7/42).¹⁴ Whilst the manufacturer recommends siting the tracheostomy between the first and second, or second and third tracheal rings, in the Walz and Schmidt study¹⁴ five of the incorrect sitings were located between the cricoid cartilage and the first tracheal ring, one fractured the cricoid cartilage and one was inserted through the cricothyroid membrane. Direct visualization with tracheal endoscopy can further reduce the likelihood of misplacement of the seeker needle. In another study, a fifth of the initial tracheal punctures were paramedian, as seen at endoscopy.¹⁵ Endoscopy also helps to avoid the more serious problem of extratracheal insertion, which can result in hypoxia, subcutaneous emphysema and haemothorax.

Ultrasound is also of benefit in identifying overlying or vulnerable adjacent structures such as the thyroid gland and isthmus, and blood vessels.¹⁶ Using ultrasound, Bertram and colleagues¹⁷ found that in 15% of cases, the common carotid artery was less than 10.5 mm from the fourth tracheal ring and warned that the neck extension necessary for PDT can bring these vessels closer to the upper tracheal rings. Hatfield and Bodenham¹⁸ found that two of their 30 patients had carotid arteries in the immediate paratracheal position, making them vulnerable to the consequences of non-midline placement of the needle and dilators, whilst another two had prominent brachiocephalic arteries. Half of the patients had anterior jugular veins and eight were considered at risk, necessitating appropriate 'safety measures'. In a review of 497 PDT procedures,² haemorrhagic complications occurred in 24 (5%) instances. In only two cases was surgical intervention required to control bleeding, both from thyroid vein puncture. However, in another case PDT was abandoned because of bleeding; at surgery, an abnormally high left brachiocephalic vein was found coursing across the trachea.

To our knowledge, there is no available population data on the disposition of the subclavian arteries. In an accompanying paper,¹⁹ we investigate the distribution of two morphometric variables using magnetic resonance imaging in a population of 'normal' subjects (i.e. without neck pathology). The vertical displacement of the subclavian artery above the clavicles is highly variable, as is the distance between the cricoid cartilage and the highest point of the vessel. There appears to be no reliable way of

determining these values from standard clinical morphometric data.

One other important anomaly of the subclavian artery is the aberrant right subclavian artery (ARSA) or lusorian artery. In up to 2% of the population, the ARSA arises as the last branch of the aorta, distal to the origin of the left subclavian artery,²⁰ and is the most common of the major intrathoracic arterial anomalies.²¹ To reach the right upper limb, it courses behind the oesophagus in the majority of cases (80%), but in 15% of cases it passes between the oesophagus and trachea, and in the remaining 5%, it passes anterior to the trachea.²² Presence of an ARSA is associated with congenital heart disease in 10–15% of cases,²³ and can give rise to dysphagia as a result of oesophageal compression. The latter was termed dysphagia lusoria or difficulty with swallowing because of a 'quirk of nature' by Bayford in 1735. In children, an ARSA can cause tracheal compression.²¹ There are also many case reports of aneurysmal formation of the ARSA.^{21 23}

The arterial supply to the thyroid gland is from the superior and inferior thyroid arteries. These vessels arise from the external carotid artery and thyrocervical trunk of the subclavian artery, respectively, and are non-midline structures. However, in 6% of individuals an aberrant thyroidea ima artery arises from one of the major vessels in the superior mediastinum (the brachiocephalic artery, right common carotid artery or the aortic arch).²⁴ It ascends on the anterior surface of the trachea in the midline and can be of reasonable size,²² and hence vulnerable to damage during PDT. Although rare, 25 cases of a cervical aortic arch have been reported.²⁰ It is conceivable that extension of the neck for PDT can elevate the arch and increase its vulnerability to damage.¹⁹ These anomalies have the potential to make PDT a particularly hazardous procedure.

In the case reported here, a combination of factors led to catastrophic haemorrhage. The patient had an abnormally high rising right subclavian artery. She also had had a right partial thyroidectomy. It would seem that the resulting fibrosis had tethered the vessels firmly and in close proximity to the adjacent trachea. This tethering also had the effect of inducing an almost right-angle bend in the subclavian artery before its descent behind the scalenus anterior muscle into the upper limb. Because of the tight adherence of the artery to the upper trachea by the post-surgical fascial band, it is conceivable that the dilatation of the trachea by the Rhino dilator stretched and tore the subclavian artery at exactly the same level as the entry point of the dilator into the trachea. However, another possibility is that downward movement of the trachea during dilatation avulsed this vessel. There was no evidence at *post mortem* to suggest direct trauma to the subclavian artery or any other major vessel.

It could be argued that the situation was aggravated by the off-midline entry into the trachea. If the trachea is dilated to the black mark on the Rhino dilator (the maximum level of insertion recommended by the manufacturer), the resulting

hole in the trachea will be approximately 12.4 mm in diameter, corresponding to the outer diameter of a size-9 Portex Blue Line™ tracheostomy tube. It is therefore probable that, irrespective of the entry site, avulsion of the vessel would have occurred because of the size of the tracheal hole, the downward movement of the trachea and the tight adherence of the artery to the trachea.

A number of lessons can be learnt from this case. Unless there are any obvious contraindications to PDT, the benefits of the technique outweigh the risks. Case selection is paramount. Patients with previous neck or upper mediastinal surgery should be regarded with caution. An ultrasound scan will identify any structures at risk, especially aberrant vessels. Fibreoptic endoscopy is of great benefit in confirming entry at the correct level and in the midline. Although the risk of catastrophic haemorrhage is rare, there may well be a need for urgent surgery. We recommend performing PDT during working hours only, when surgical expertise and theatre staff are readily available.

References

- 1 Bewsher MS, Adams AM, Clarke CWM, McConachie I, Kelly DR. Evaluation of a new percutaneous dilatational tracheostomy set. *Anaesthesia* 2001; **56**: 859–64
- 2 Muhammad JK, Major E, Wood A, et al. Percutaneous dilatational tracheostomy: haemorrhagic complications and the vascular anatomy of the anterior neck. A review based on 497 cases. *Int J Oral Maxillofac Surg* 2000; **29**: 217–22
- 3 Freeman BD, Isabella K, Lin N, et al. A meta-analysis of prospective trials comparing percutaneous and surgical tracheostomy in critically ill patients. *Chest* 2000; **118**: 1412–8
- 4 Ciagli P, Firsching R, Syniec C. Elective percutaneous dilatational tracheostomy: a new simple bedside procedure: preliminary report. *Chest* 1985; **87**: 715–9
- 5 Wise H. Experience of complications of percutaneous dilatational tracheostomy. *Anaesthesia* 2002; **57**: 195–7
- 6 Crofts SL, Alzeer A, McGuire GP, et al. A comparison of percutaneous and operative tracheostomies in intensive care patients. *Can J Anaesth* 1995; **42**: 775–9
- 7 Holdgaard HO, Pedersen J, Jensen RH, et al. Percutaneous dilatational tracheostomy versus conventional surgical tracheostomy. *Acta Anaesthesiol Scand* 1998; **42**: 545–50
- 8 Hazard P, Jones C, Benitone J. Comparative clinical trials of standard operative tracheostomy with percutaneous tracheostomy. *Crit Care Med* 1991; **19**: 1018–24
- 9 Friedman Y, Fildes J, Mizock B, et al. Comparison of percutaneous and surgical tracheostomies. *Chest* 1996; **110**: 480–5
- 10 VanHeurn LW, van Geffen GJ, Brink PRG. Clinical experience with percutaneous dilatational tracheostomy. *Eur J Surg* 1996; **162**: 531–5
- 11 Porter JM, Ivatury RR. Preferred route of tracheostomy – percutaneous versus open at the bedside: a randomized prospective study in the surgical intensive care unit. *Am Surg* 1999; **65**: 142–6
- 12 Kapural L, Sprung J, Gluncic I, et al. Tracheo-innominate artery fistula after tracheostomy. *Anesth Analg* 1999; **88**: 777–80
- 13 Byhahn C, Wilke H-J, Halbig S, et al. Percutaneous tracheostomy: Ciaglia Blue Rhino versus basic Ciaglia technique of

- percutaneous dilatational tracheostomy. *Anesth Analg* 2000; **91**: 882–6
- 14** Walz MK, Schmidt U. Tracheal lesions caused by percutaneous dilatational tracheostomy – a clinico-pathological study. *Intensive Care Med* 1999; **25**: 102–5
- 15** Winkler WB, Karnik R, Seelmann O, et al. Bedside percutaneous dilatational tracheostomy with endoscopic guidance: experience with 71 ICU patients. *Intensive Care Med* 1994; **20**: 476–9
- 16** Sustic A, Kovac D, Zgaljardic Z, et al. Ultrasound-guided percutaneous dilatational tracheostomy: a safe method to avoid cranial misplacement of the tracheostomy tube. *Intensive Care Med* 2000; **26**: 1379–81
- 17** Bertram S, Emshoff R, Norer B. Ultrasonographic anatomy of the anterior neck. *J Oral Maxillofac Surg* 1995; **53**: 1420–4
- 18** Hatfield A, Bodenham A. Portable ultrasonic scanning of the anterior neck before percutaneous dilatational tracheostomy. *Anaesthesia* 1999; **54**: 660–3
- 19** Farmery AD, Shlugman D, Anslow P. The anatomical relationship of the subclavian arteries and the larynx: a population study using magnetic resonance imaging. *Br J Anaesth* 2003; **90**: (aeg075 this issue)
- 20** Houghton VM, Rosenbaum AE. The normal and anomalous aortic arch and brachiocephalic arteries. In: Newton TH, Potts DG, eds. *Radiology of the Skull and Brain Angiography*, Vol. 2, Book 2. Saint Louis: Mosby, 1974; 1149–50
- 21** Freed K, Low VHS. The aberrant subclavian artery. *Am J Roentgenol* 1997; **168**: 481–4
- 22** Scheldrup EW. Vascular anomalies of the retro-infrathyoid (pretracheal) space and their importance in tracheostomy. *Surg Gynecol Obstet* 1957; **105**: 327–31
- 23** Hogg JP, Dominic AJ, Counselman RL, et al. Expanding aneurysms of aberrant right subclavian artery. *Clin Imaging* 1997; **21**: 195–9
- 24** Lippert H, Pabst R. *Arterial Variations in Man*. Munich: Bergman Verlag, 1985; 6