1 History of Tracheostomy

Early references

The earliest known references to tracheostomy were made in the *Rigveda*, a sacred Hindu book published around 2000 BC.[1] The surgical procedure of tracheostomy is thought to be portrayed on Egyptian wooden tablets dating back to around 3000 BC.[2] Two tablets were discovered dating from the beginning of the first dynasty, one in Abydos concerning King Aha (Figure 1.1) and the other in Saqqara, concerning King Djer (Figure 1.2). Each tablet depicts a seated person directing a pointed instrument to the throat of another person who is leaning backwards. Some experts believed that this denotes human sacrifice whereas others believe it to be a tracheostomy or other surgical procedure. Ankh, the sign of life (Figure 1.3) is seen in this tablet, in which a God presents life to a King. The same sign is present in Aha's tablet, above the heads of both operator and patient, signifying that life is given from one to the other. The way the scalpel is handled suggests that it is more appropriately directed to the trachea than the neck vessels. The arms placed behind

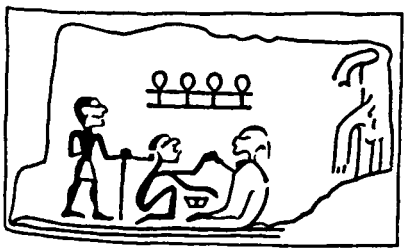

Fig. 1.1 King Aha tablet – tracheostomy, first dynasty.

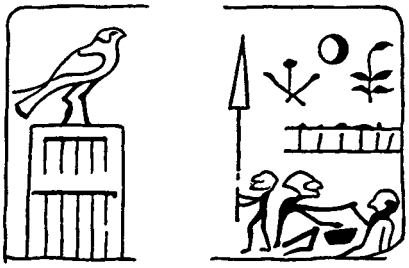

Fig. 1.2 King Djer tablet – tracheostomy, first dynasty.

Fig. 1.3 Ankh, sign of life, presented by a God to a King.

the person operated upon can be explained in terms of the modern practice of placing a sandbag between the shoulder blades of patients undergoing tracheostomy. It is of note that most authorities believe that human sacrifice was not practised in ancient Egypt.

In the Roman era, tracheostomies were performed using a large incision and a warning was given that it was dangerous to divide the whole trachea.[3]

Fig. 1.4 George Washington, 1732–1799.

In the middle ages, there were sporadic reports of such procedures, but the history of surgical access to the airway was largely one of condemnation. The technique of slashing the throat to save life was known as 'semislaughter'.

During the Renaissance, most surgeons were reluctant to perform the procedure, even after the Italian Antonio Musa Brasavola's (1500–1570) report of a successful tracheostomy.[4]

One cold December afternoon in the year 1799, in Virginia, USA, three physicians were gathered around a dying man. The man was gasping for air, so the physicians gave him sage tea with vinegar to gargle, but this almost choked him. The patient's airway was severely compromised. It had been only a year since the medical literature of the time had described a surgical procedure in which the trachea could be accessed in cases of upper airway obstruction. Before 1800, elective or emergency tracheostomy was rarely performed. The patient's condition continued to deteriorate as he struggled for breath. One of the physicians was aware of the tracheostomy procedure described earlier in the literature but was reluctant to attempt it on such a famous person. After a short time, the patient became calm and died. Historians may recognise this story as that of George Washington (Figure 1.4). The most popular theory is that he

Fig. 1.5 Boy with tetanus in Leeds unit, 1950s.

died from an upper airway obstruction caused by bacterial epiglottitis.[5] Perhaps if a tracheostomy procedure had been successfully performed, it would have popularised the technique earlier.

In the early 1800s, it became more common for children to receive tracheostomies as a treatment for advanced diphtheria. Modern open surgical tracheostomy techniques were standardised in 1909 by Chevalier Jackson.[6]

In the early days of intensive care (Figure 1.5), including the Scandinavian poliomyelitis epidemics of the 1950s, tracheostomy become the accepted means of airway management for the provision of long-term ventilation.[7] Thereafter, there were few changes in surgical techniques until the introduction of percutaneous tracheostomy.

Development of percutaneous tracheostomy

There were devices available historically to facilitate rapid percutaneous tracheostomy but without the benefit of guidewires and flexible dilators/introducers. Such devices were inherently unsafe and never achieved widespread usage. The Italian surgeon Sanctorio Sanctorius (1561–1636), a professor at the University of Padua, was probably the first surgeon to describe percutaneous tracheostomy.

Fig. 1.6 Pasquale Ciaglia, 1912–2001.

Sanctorius described the procedure in his book[8] but does not seem to have performed it himself.[3]

The term percutaneous tracheostomy was first used by Shelden in 1955.[9] To minimise the risk of damaging vital structures, Shelden first introduced a slot-needle into the tracheal lumen. He loaded the cannula onto a cutting trocar, slid it along the slot and then introduced it into the tracheal lumen. In 1969, Toye and Weinstein used a Seldinger guidewire to allow the safe introduction of a cannula, providing a vital step towards popularisation of percutaneous techniques.[10]

Pasquale Ciaglia (Figure 1.6), a thoracic surgeon at St Elizabeth Hospital, New York, was concerned about tracheal stenosis from surgical tracheostomy. Encouraged by work done by Brantigan and Grow in 1976[11] on cricothyroidotomy, Ciaglia first developed subcricoid fingertip tracheostomy before moving on to full percutaneous tracheostomy, where the only incision needed is to the skin to admit the index finger for palpation of the cartilages. He reported the first percutaneous progressive dilatational technique in June 1985 on a series of 26 patients.[12] He used a modified percutaneous nephrostomy set to perform the tracheostomy.

Early results were excellent, comparing favourably with open surgical techniques. The technique gained popularity in 1990 with the availability of a commercial kit produced by Cook® Critical Care Products. The first use in the UK was in January 1990 by Leinhardt and Mughal, of the University Department of Surgery at Hope

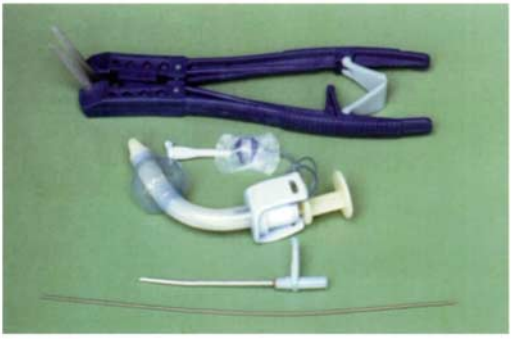

Fig. 1.7 Rapitrach (Surgitech, Sydney, Australia).

Hospital, Salford. Other units soon followed.[13] The use of percutaneous tracheostomy quickly spread throughout the UK, making it a European leader in the use of the technique. Since then, numerous authors have supported the findings of the pioneers of the technique. Others have reported additions to further improve the technique, such as bronchoscopy guidance and the use of ultrasound.

Schachner described an alternative technique, the Rapitrach kit (Figure 1.7) in 1989. This involved placing a guidewire into the tracheal lumen, followed by the passage of a short-jawed metal tracheotome. This was opened in the trachea, allowing a tracheostomy tube to be inserted between the open jaws of the instrument.[14] This device was originally designed for emergency use, providing rapid access to the trachea. However, the forceps, when opened, often lay in the pretracheal tissues, the sharp bevelled tip was associated with rupture of the tracheostomy tube cuff and there were reports of posterior tracheal wall damage. As a result of such complications, some resulting in death, it is no longer widely used. The Percutrac[15] was a minor modification of the Rapitrach, designed to be reusable (Figure 1.8). The longer jaws were designed to make pretracheal placement less likely.

In 1990, Griggs described an alternative technique using a pair of dilating forceps.[16] This is marketed by Portex in the UK.

Fig. 1.8 Percutrac (John Weiss and Son Ltd, Milton Keynes, UK).

In 1997, Fantoni described the translaryngeal approach. This was a new approach where the tracheostomy tube was pulled from inside the trachea to the outside.[17]

In 1999 (before his death in June 2001, aged 89), Ciaglia further modified his original sequential dilatational technique into a one-step dilatational technique with the Blue Rhino kit. This is said to have a number of advantages over the original kit, including the use of a softer hydrophilic coated single-step dilator.[18] In 2001, Portex brought out a similar kit with a white single stage dilator.

The latest modification to percutaneous tracheostomy kits comes in the form of the PercuTwist developed by Rüsch in 2002.[19] The screw-tipped dilator is claimed to offer more controlled dilation of the trachea.

There have been parallel developments of other devices utilising similar principles (e.g. the Minitrach Seldinger and Melker emergency cricothyroidotomy kit). The so-called minitracheostomy technique was first described in 1984[20] and subsequently modified into a Seldinger technique.[21] Such techniques appear to be used less frequently since the advent of larger-bore percutaneous tracheostomy sets.

A recent survey showed that percutaneous tracheostomy is performed in 75% of intensive care units in England and Wales, making bedside percutaneous tracheostomy the technique of choice for patients requiring tracheostomy.[22] The most commonly used kit in the survey was the original Cook Ciaglia kit (46.6%), followed by the latest Cook Blue Rhino kit (31.3%), which appears to be increasing in popularity. The routine use of fibreoptic bronchoscopy guidance has increased from 30% in 1998[23] to 80.6% in 2002. However, capnography was only used in 1.2% of the ICUs.

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2 Anatomy of the Trachea

Basic anatomy

The trachea (Figures 2.1 and 2.2) begins at the level of the C6 vertebra in continuity with the larynx, being attached to the lower margin of the cricoid cartilage by the cricotracheal ligament. The trachea is a mobile cartilaginous and membranous tube made up of 16–20 C-shaped rings of hyaline cartilage, which provide rigidity and maintain the patency of the tube. Posteriorly, the circumference is flattened slightly by the presence of the fibroelastic membrane stretching between the ends of each cartilaginous ring. The membrane has smooth muscle embedded in it. This muscle has been called the trachealis muscle and is involved in regulating the diameter of the trachea. The trachea begins at the lower end of the cricoid cartilage and extends downwards in the midline of the neck to the carina. In an adult, the traches is 10–12 cm long and 2.5 cm in diameter, but this varies with age, sex and race. Individuals with a short stature tend to have smaller tracheas. The root of the index finger gives a rough estimation of tracheal diameter. It is a unique structure in the body and to date, no natural or prosthetic material has been found satisfactory for reconstructive surgery. This is one reason why stenotic or other complications of the trachea are so feared by medical practitioners.

In the elderly or diseased patient, the trachea may become considerably distorted and have significant acute angulations (Figures 2.3 and 2.4). Any change in the angle of the cervical or upper thoracic spine will cause similar angulation of the trachea.[1]

In the neck, the trachea is located relatively close to the anterior skin surface and, as it descends into the thoracic cavity, it moves posteriorly (Figure 2.5). This backward angulation in relation to skin