Rapid Percutaneous Tracheostomy*

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We describe a new method of performing percutaneous tracheostomy rapidly and safely using a specialized instrument kit. The technique permits the safe insertion of a full-sized 7.0 (ID) or 7.5 mm (ID) cuffed cannula into the trachea within 1-2 min, through the membranous second intercartilagenous space. Animal studies have demonstrated a superior healing process compared to that seen after conventional tracheostomy techniques.

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Tracheostomy, although part of the medical armamentarium since antiquity, has gained wide and modern acceptance only in the past few decades since Galloway1 in 1943 recommended it to facilitate evacuation of secretions from the bronchial tree in polio-

myelitis. Today it has become one of the most commonly performed surgical operations.

Although generally considered a simple surgical procedure, tracheostomy carries a significant rate of both early and late complications. For this reason we sought an improved and less traumatic method for performing tracheostomy. Following the development of a variety of percutaneous vascular cannulation techniques in many different sites, we have developed a new technique utilizing a needle-introduced guidewire followed by a speculum-like device inserted along the wire to provide a rapid opening into the trachea.

This method, which was originally intended for urgent situations only, and essentially for military and mass disaster applications, has come to be used as the method of choice for both urgent as well as elective tracheostomy in our hospital. The purpose of this communication is to report our experimental results in both cadaveric and animal studies.

Material and Methods

The kit for performing the percutaneous tracheostomy includes a 5 ml disposable syringe and a 21G needle; a plastic scalpel handle and No 10 blade; a 12G needle with a plastic hub, and curved at its distal end; a slightly curved metal guidewire with a soft, flexible tip stiffer along its proximal and center portions; a plastic cannula obturator; a conventional cuffed tracheostomy cannula and a specially designed speculum-like tracheostome (Fig 1 and 2).

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Figure 1. Instruments required for the performance of percutaneous tracheostomy.
The technique is performed under local anesthesia, with the patient in the supine position and the neck hyperextended. A horizontal 15 mm skin incision is made over the third tracheal ring. The curved 12G needle is introduced into the tracheal lumen between the second and third tracheal cartilages in a caudal direction, and air is aspirated into the syringe containing 3 ml of 4 percent lidocaine, which is then injected to minimize coughing throughout the procedure. The syringe is removed and the guidewire (flexible end first) is introduced through the needle. The needle is then withdrawn and the percutaneous tracheostome, guided over the flexible metal guidewire, is firmly introduced into the trachea, and its jaws fully opened, transversely to the axis of the trachea. The guidewire is removed and the lubricated cannula, with the obturator in place and the cuff completely deflated, is gently inserted into the tracheal lumen between the opened jaws of the tracheostome. The obturator is removed, the cuff inflated, and the cannula secured with neck tapes (Fig 3). In the event of rupture of the cuff of the cannula and the need to replace it with a new cuffed cannula, the flexible guidewire is introduced through the damaged cannula, the latter removed, the tracheostome reinserted as above, and the fresh cannula is introduced.

**Cadaver Studies**

These studies were carried out at the Abu-Kabir Institute of Forensic Medicine in Jaffa. One hundred five cannulation procedures were performed on 77 cadavers, whose body weights ranged from 40 to 95 kg (average 78.5 kg). Among the 27 participants were six surgeons, 15 physicians and four paramedics. All the procedures, from skin incision to cannula insertion were accurately timed. Post-tracheostomy ventilation by an AMBU bag, and subsequent dissection of the trachea in every case served to evaluate the new method and to assess its potential complications. A No 7.0 mm (ID) cuffed Portex cannula was inserted in most of the cases, and in the others, a 7.5 mm (ID) cannula was inserted.

**Animal Studies**

Among the 23 participants in the animal studies were five surgeons, 17 physicians and one paramedic. Fifty adult mongrel dogs weighing 14 to 24.6 Kg (average 21.2 kg) were divided into three groups. A No 6.0 (ID) cuffed Portex cannula was used in all the animal procedures. Intravenous thiopentone anesthesia, without intubation, was administered to all the animals.

**Group 1**, the immediate changes group. There were 24 dogs on whom 36 procedures were carried out. The animals were sacrificed immediately after tracheostomy, and their tracheas excised and

**Figure 2. Tracheostome with the jaws opened.**

**Figure 3. Schematic diagrams showing steps in performing percutaneous tracheostomy.**
examined by an experienced pathologist.

Group 2, the late change group. There were 20 dogs on whom 20 procedures were performed. The cannula, after remaining in place for two-four weeks, was then removed, and the animals were sacrificed one-three months later.

Group 3, the induced-complications group. In six dogs, the posterior wall of the trachea was intentionally perforated by the needle to evaluate possible damage to adjacent organs.

**Figure 4.** a) Slit-like opening of the trachea of a dog after percutaneous tracheostomy, with traction on both ends of the resected trachea. b) The same, after release of the traction.

**Figure 5.** Comparison between conventional tracheostomy (left) and percutaneous tracheostomy (right), under the same conditions; an indwelling cannula for one month and its appearance two months after decannulation. *Note* the extreme "shelving" on the left versus smooth healing on the right (arrow). Below, the corresponding histologic cross-sections of the same areas, showing vastly superior healing at the stomal site.
RESULTS

Of the 23 physicians, two, who were not surgeons, failed in the successful performance of the procedure. All the others, the paramedics included, performed the percutaneous tracheostomy within 30-180 s (average time 2.2 s). In all the dissected preparations, the opening in the trachea was slit-like and measured 15-17 mm. In seven procedures, there was slight pressure damage to the second cartilage ring, and in three cases, one of the adjacent cartilage rings was found to be fractured. No damage to other adjacent tissues or organs was detected.

Animals Studies

Group 1, the immediate changes group. Three procedures failed. In the other 33 instances the time needed for percutaneous tracheostomy ranged between 30-240 s (average 2.6 min). Pathologic examination of the dissected tracheas revealed a slit-like opening in all 33 successful insertions (Fig 4). Four showed minimal pressure damage to the proximal ring, and in two cases, broken cartilage ring was found. There was no damage to adjacent organs.

Group 2, the late changes group. All 20 procedures were performed by experienced surgeons. The time needed to insert the cannula via percutaneous tracheostomy ranged between 20-110 (average 65 s). There was no mortality, no wound infection, or narrowing of the tracheal lumen. In only one instance was there a broken cartilage ring causing a very slight protrusion into the lumen of a well-healed trachea. In the vast majority of cases, the area of cannula entrance inside the tracheal lumen was smooth, having a curtain-like appearance. On histologic sections, this latter area was composed of cuboidal epithelium and neovasculature (Fig 5). The healing process was more pronounced on the outer tracheal layer.

Group 3, the induced complication group. One dog died two days after the procedure because of an occluded tracheostomy tube. No damage was found on pathologic dissection. The other five dogs survived and were sacrificed one month after the procedure. No damage was found to adjacent organs or tissue.

DISCUSSION

Although tracheostomy is one of the most common surgical operations performed today, in the past the results were so bad that physicians were reluctant to use the method. In the 13th century, tracheostomy was described as “semi-slaughter” and “a scandal of surgery,” and Dante portrayed it as “a suitable punishment for a sinner in the depths of hell.” Fabricius, however, some four centuries ago, described it as the “foremost operation by which man is delivered from a sudden death to a sudden repossession of life.” Recourse to tracheostomy started in the 19th century with Bretonneau and Trousseau, who employed it in patients with diphtheria. Trousseau was the first to use it in laryngeal carcinoma and in stenosing conditions of the larynx, such as syphilis and tuberculosis. Chevalier Jackson, in the early 20th century, described the technique for tracheostomy that is still the standard operative procedure today. Its indications are many: it may be done for severe respiratory insufficiency or for obstruction of the respiratory tract, or it may be carried out in less acute circumstances for the maintenance of respiratory toilet in patients with severe pneumonia or tracheobronchitis where excessive secretions from the inflamed lung or tracheobronchial tree may interfere with adequate respiratory gas-exchange. It is also performed in a number of nonrespiratory conditions where the patient's physiologic status is so compromised that a prolonged period of maintenance on ventilatory support may be anticipated after a major surgical procedure. This circumstance may occur in patients with severe cardiac dysfunction who undergo open-heart surgery, and in patients who have had major surgical procedures for a neoplastic disease, where pre-existing debility or the extent of surgery may compromise the respiratory function.

Tracheostomy is also carried out as an adjunctive procedure in radical excisional surgery in patients with major head and neck cancer, where significant portions of the upper respiratory tract need to be removed for control of the malignant disease.

An important additional consideration which may serve as an indication for tracheostomy is the preservation of adequate ventilation and oxygenation in patients with compromised neurologic function, where coma, due to severe head injury, or inflammatory or neoplastic brain disease, may interfere with the respiratory drive and adequacy of ventilation. This consideration may also serve as the indication for tracheostomy in patients with spinal cord injuries or degenerative spinal cord disease, where there may be an interruption of neuromuscular control so that ventilation may be impaired. Similarly, patients with toxic or pharmacologic paralysis of the respiratory muscles may also require acute tracheostomy for ventilatory management during the period of acute illness. This latter condition may be of great significance in acute poisoning with toxic gas or in the circumstances of neuromuscular blockade following the use of binary nerve gas such as may occur in chemical warfare.

Numerous articles in the literature survey discuss the nature, cause, frequency and results of complications of the standard tracheostomy operation. The rate of these complications seems inordinately high in the face of a relatively minor surgical procedure. The rate is even higher when emergency tracheostomy, under difficult environmental conditions, is impera-
The encouraging results of our percutaneous tracheostomy approach in cadavers and in animals have prompted its clinical use. The method to date has been successfully employed in over 200 patients in the Bellinson Medical Center and in a few hundred patients in other centers in Israel and abroad. In more than two-thirds of the cases, the procedure was performed at the bedside, without the need for transferring the patient to an operating room. In the majority of the patients, a Portex No 7.0 mm (ID), or 7.5 mm (ID) cuffed cannula was inserted.

The long-term results are currently being evaluated. From our experimental models and clinical use, the following conclusions have been drawn:

1. This equipment and method has enabled us to establish an effective airway below the larynx, with a high degree of safety to the patient in both elective as well as urgent circumstances. The equipment is available in a sterile disposable pre-packed set containing different sizes of cuffed tracheostomy cannulas, ranging from 6.0 mm (ID) to 8.0 mm (ID).
2. The method can be effectively used by a wide variety of different medical personnel after a short period of instruction. The operator would require only a knowledge of basic surface anatomy and have a moderate degree of surgical skill.
3. Unlike crico-thyroidotomy (coniotomy), our procedure is a definitive one, and does not require conversion to a formal standard tracheostomy at the first suitable and safe opportunity.
4. There is less trauma and tissue devitalization and therefore less infection.
5. The relativelyatraumatic insertion through the intercartilagenous membrane appears to permit better and more complete tracheal healing once the cannula is removed.
6. Where tracheostomy is being performed in a patient with a cuffed endotracheal tube already in situ, before the start of the procedure the endotracheal tube must be gently withdrawn with the cuff still inflated, so that the upper end of the cuff will be lodged immediately below the inferior surface of the vocal cords. The bevelled end of the endotracheal tube will thus be just proximal to the point of insertion of the curved 12G needle. This avoids puncture of the cuff by the needle or the guidewire, and maintains the integrity of the airway until the moment of the insertion of the tracheostome into the tracheal lumen. As in the case of a standard tracheostomy performed with an oral or nasal endotracheal tube in situ, the attendant anesthetist should keep the bevelled end of the endotracheal tube just within the glottic opening until the tracheostomy cannula has been inserted into the lumen of the trachea and its cuff inflated before withdrawing the endotracheal tube completely from the mouth or nose.

7. The technique can be safely used at the bedside, and thus solve the difficult problem of transferring the very sick ICU patient, who is dependent on high PEEP levels and accurate monitoring, to the operating room for a standard tracheostomy procedure.

In spite of the simplicity of the method, we are aware of a number of limitations to the procedure: it is contraindicated in patients with a “bull-neck,” big tumors of the neck, in the presence of tumors of the thyroid gland; and in patients with severe burns involving the neck, where extensive edema and induration of the subcutaneous tissues make localization and palpation of the tracheal rings difficult. All the above mentioned contraindications, however, represent only a small and almost negligible fraction of the candidates for tracheostomy.

Note: The percutaneous tracheostomy set is available as a sterile disposable pre-packed kit from Surgitek Medical Pty Limited, Australia or Premier, U.S.A.

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