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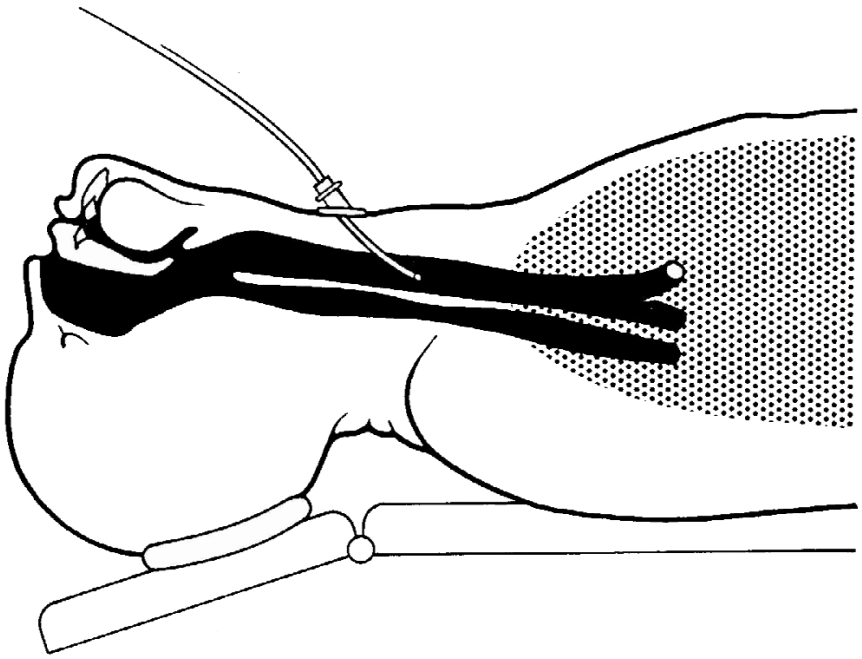
Oxygen delivery to the tissues has to be maintained continuously, otherwise organ function will be threatened within minutes. Obstructive processes within the airway system are a major reason for problems with gas exchange. 2 millennia ago attempts were made to bypass obstruction of an airway: surgical tracheostomy is such a technique. Another one is the emergency creation of a transtracheal access at the level of the cricothyroid ligament. In the practice guidelines of the ASA [1], the emergency transtracheal approach to the airway comes low in the algorithm. In spite of thorough pre-anaesthetic examination and careful search for predictors for a difficult airway, there are still 10% unpredictable difficulties. Unfortunately, a substantial part of these cases lead to the so called ìcannot intubate, cannot ventilateì scenario. This occurs usually after anaesthesia induction with or without persisting neuromuscular relaxation and is characterised by an inability to secure the airway by tracheal intubation, inability to maintain oxygenation by means of face mask or supraglottic device ventilation, and an extremely low chance of awakening the patient to return to spontaneous ventilation in a short time. This situation represents a justifiable indication for any kind of transtracheal oxygenation technique. The transtracheal route can be opened up either by surgery or by transcutaneous insertion of a specially designed cannula.

FIGURE 1



Among the great variety of cannulae we must distinguish between those (narrow) for transtracheal puncture for subsequent oxygenation and wide ones for transtracheal cannulation and subsequent ventilation. The main difference between these 2 categories is the technique of gas transmission for that specific device. While wide cannulae are designed for regular ventilation with alternating in- and exhalation, narrow cannulae are suitable for one way oxygen insufflation only. In the latter, any attempt to manually insufflate oxygen (e.g. from a manual resuscitator or anaesthesia circuit) has only a small chance of providing sufficient oxygenation. If the cannula gas pressure can be elevated to 200-300 mbar, continuous apnoeic oxygenation is possible. However, in this case CO_2 elimination is either very poor or absent, which limits the practicability of apnoeic oxygenation to about 15-20 minutes. However, in many cases this might be sufficient to create an alternative ventilation pathway and to solve the problem definitively. If the gas source can deliver a pressure of >1000 mbar, then jet ventilation (JV) is possible and oxygenation and CO_2 elimination can be maintained for a long period.

Mechanisms of Jet Ventilation

The most important consideration for transtracheal puncture and JV is a free gas exhalation pathway. If this is not guaranteed, transtracheal puncture and JV is absolutely contraindicated [2]. To delineate the role of JV in airway management, one must be aware of the main characteristics of this ventilation method. It is essential to understand the mechanisms and basic physical properties of JV in order to understand how it may help in the ìcannot intubate - cannot ventilateî situation. In contrast to conventional ventilation, where a bulk gas volume is pushed forward rather slowly into the airway via an endotracheal tube with an airtight seal within the trachea, JV relies on rapid gas (oxygen) insufflation at high velocity via a narrow nozzle into the open airway. While in conventional ventilation gas flow in the delivery system is bidirectional and happens sequentially (alternating inspiration and expiration), in JV the gas flow is mainly coaxial, partially simultaneous in both directions (inward and outward) and the delivery system allows insufflation only. Thus exhalation happens completely outside of the delivery system. With these characteristics, in conventional ventilation the dead space has to be considerably smaller than the tidal volume in order to enable alveolar ventilation. In JV this consideration is not valid to the same extent. Dead space plays a role in JV as well, in particular for the efficiency of CO_2 elimination, but is much less important and good gas exchange can even be maintained with a tidal volume no larger than the dead space itself. Nevertheless, due to various mechanisms unique to JV such as ambient gas entrainment, Taylor-Type dispersion, molecular and facilitated diffusion, pulsatile effects deriving from thoracic vibrations and cardiac action, both oxygenation and CO_2 elimination can be controlled in a large range of patients and situations. The technical conditions and possibilities offered by JV allow the application of oxygen into the airway through narrow cannulae that otherwise are absolutely unsuitable for ventilation purposes. Additionally, with JV there is no need for an airtight seal. JV is the oxygenation and ventilation method of choice if transtracheal access to the airway through a narrow cannula or catheter is considered to be the next appropriate step in an algorithm to manage a difficult airway situation.

Indications for Transtracheal Jet Ventilation

The need to create an emergency transtracheal airway is fortunately rare. On the other hand, it is not easy to gain expertise in this technique. This led to attempts to find an elective indication for transtracheal jet ventilation (TTJV). Laryngeal surgery is a possible choice, allowing a clear surgical field, especially for operations on the posterior laryngeal region. However, since oral flexible and laser resistant jet catheters are now available, the need for the more invasive and risky transtracheal route has to be questioned. A retrospective study of 90 elective TTJV cases in Leicester revealed a high percentage of unsuccessful or even life threatening situations [3]. Transtracheal puncture with the possibility of using JV electively can be considered in the prophylactic percutaneous catheterisation under local anaesthesia in patients with expected difficult intubation before they undergo an airway intervention. The transtracheal catheter can be used to maintain oxygenation if the intubation procedure runs into problems [4]. Another opportunity to practice transtracheal puncture and JV under realistic conditions is in the patient who is prepared and anaesthetised for laryngectomy. It has to be admitted that in most of these cases regular intubation is possible too and is therefore the preferred approach. That means that justifying elective TTJV is difficult and must be carefully evaluated on an individual basis. Additionally, it must be emphasised that the somewhat neglected retrograde intubation is a potentially life saving alternative in the predictable difficult airway, especially when the anatomy is grossly distorted. A retrograde technique can be used with JV if a rigid cannula (e.g. Touhy 16G) is used; its tip can be intermittently directed caudally, which allows intermittent TTJV. While the guide wire is advanced to the oropharynx, the cannula has to be redirected into a cephalad orientation.

In conclusion, TTJV is a safe and efficient oxygenation and ventilation technique, provided that stringent safety rules are considered. It has to be regarded as a 3rd line technique that may be applied if more simple techniques and less demanding invasive techniques failed and a return to sufficient spontaneous ventilation seems unlikely. TTJV is a temporary means to gain time until a definitive method of securing the airway can be adopted, and it can be combined with various other techniques such as retrograde intubation, cricothyrodotomy under local anaesthesia or with fibreoptic intubation.

References

1. Practice Guidelines for Management of the Difficult Airway. Anesthesiology 1993; 78:597.
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3. Russell WC et al. Anaesthesia and Intensive Care 2000; 28: 62-7.
4. Gerig HJ et al. Anaesthesia 2005; 60: 801-5