CASE REPORT

ENDOTRACHEAL TUBE CONNECTOR AS A POSSIBLE SOURCE OF INCREASED AIRWAY RESISTANCE

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ABSTRACT

It is a known fact that airway resistance varies with the change in the diameter of the endotracheal tubes. In fact the resistance increases to an amount of sixteen times if the diameter of the tube is halved. Disposable endotracheal tubes are made of PVC material and have a connector fitted to their proximal end. Usually the internal diameter of this connector must be equal to the internal diameter of the tube itself. Tubes of different makes and different origins are available in our country. The hospitals usually purchase the cheapest tubes, due to fund constraints. I present a case report in which the connector of the tube had a disproportionately narrow hole, thereby causing severe respiratory obstruction in a child. I compared the diameters of different sizes of the tubes and their connectors from different producers, and present the data here. I conclude that the anaesthetists should keep in mind the possibility of connector diameter disproportion if encountered with unexpected increased airway resistance in ventilated patients.

CASE REPORT:

A three year old child was to undergo cataract surgery at Eye OR of Military Hospital, Rawalpindi. He had no history of recent upper respiratory tract infections, asthmatic signs or respiratory difficulties. There was no history of any heart disease. He was pink and well-cooperative. Chest auscultation revealed normal breath sounds with no wheeze etc. Anaesthesia was induced with intravenous propofol through an indwelling canula, and muscle relaxation was achieved with injection atracurium. Then he was ventilated manually with a mixture of oxygen, nitrous oxide and isoflurane with gentle pressure. After the relaxant took its effect, a non-cuffed orotracheal tube (K&K Kaisha, China) was passed under direct vision with the help of a laryngoscope. The child was ventilated with the previous mix of gases after readjusting their relative concentrations. An immediate increase in resistance to ventilate was noted. The breath sounds were auscultated on both sides, but were weak in intensity. The tube was rechecked for its position and was confirmed to be in trachea. The gas mixture was converted into a 100% oxygen, and ventilation was continued. The increased resistance persisted. An intratubal puff or two of ventoline was equally ineffective. A second chest auscultation was again negative for any wheeze. Then, the orotracheal tube was removed and replaced with another tube of similar size of the same make. The resistance to ventilation was immediately decreased and the chest rise improved. The chest was clear of any wheeze. The pulse oxygen saturation remained 100% throughout this episode. The child recovered smoothly after switching off anaesthesia.

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The removed tube was examined, and a startling finding was made. The connector marked 4 for its size, had a very narrow lumen (internal diameter) as compared to inner diameter of the tube itself. This was probably the cause of the increased resistance felt during ventilation. Some other tubes of similar make were examined and it was found that the internal diameter of the connectors varied in different t tubes.

DISCUSSION:

Endotracheal anaesthesia is today the form of general anaesthesia most often applied. It represents more than 80% of the total in hospitals with different surgical specialties[1]. The technique of endotracheal anaesthesia is already more than 1,000 years old. At the beginning of our century all preconditions had been given for a widespread and safe performance of endotracheal anaesthesia.

The Arabian doctor Avicenna (980-1037) described the first orotracheal intubation in dyspnoea. Vesalius in 1543 reported the first tracheal intubation in an animal. The history of peroral endotracheal intubation actually begins in the 18th century. At that time obstetricians and lifesavers used breathing tubes. In the early 1870's, Trendelenburg from Germany performed the first endotracheal anesthesia in man. In 1880 Macewen preoperatively intubated a patient to prevent the aspiration of blood during extirpation of a tumour from the base of the tongue. Regular peroral intubation to keep the respiratory tract clear during narcosis was first applied by Franz Kuhn in 1900[2]. . Later, Rosenberg and Kuhn administered cocaine as local anesthetic to obtund the cough reflex during intubation. Magill (1888-1986) recognized the advantages of tracheal intubation. Kuhn was a major protagonist of endotracheal intubation, perfected his flexo-metallic endotracheal tubes, worked on different techniques of intubating the trachea, applied positive pressure to the lungs during thoracic surgery and developed anaesthesia machines. The value of his work and his revolutionary ideas were not appreciated until 40 years later[3-5]. The famous American paediatrician Joseph O'Dwyer re-initiated the technique of intubation and his excellent results became great success and promoted world-wide use, although it was a well-known procedure at that time. His intubation method - also called the O'Dwyer-Method-was first published in the N. Y. Medical Journal as "Intubation of the Larynx" 100 years ago.[6] Magil red rubber tubes have been used until recently, when these were replaced with PVC disposable tubes. PVC tubes are cheap, and are single use, thus eliminating the risk of transmission of communicable disease. Plastic 'Portex' connectors have replaced old versions of metallic connectors. Both, cuffed and non-cuffed tubes are commonly available. Tubes are numbered according to internal diameter in millimeters. The internal diameter of the connector must not be less than that of the internal diameter of the tube itself, as it will produce excessive resistance to breathing, thereby increasing the work of breathing in a spontaneously breathing patient. Tube size is especially important in paediatric patients with narrow airways.[7]

Although various formulae / guidelines have been proposed for estimation of correct size and length of insertion, Many authors have cast doubt on the validity of these. In children, the best practice is to insert a tube slightly smaller than the laryngeal opening. This has the benefit of avoiding laryngeal damage and excessive pressure build-up in the lungs.

Increased airway resistance may be encountered in a number of conditions, including laryngeal / bronchial spasm or other lung conditions. Tube related causes include blockage by secretions, kinking, bending, dislodgement, bronchial intubation etc. A few reports[8] have been made in the literature regarding defective tubes. The search of literature for increased resistance due to defective tube connector was negative. However, Manczur T. and his colleagues discussed the relationship of resistance to flow rate, size, and shape of ETT. They examined straight tubes with inner diameters between 2.5 and 6 mm and shouldered (Cole) tubes with inner diameter/outer diameter between 2.5/4 and 3.5/5 mm. They assessed ETT resistance at standard and "appropriate for patient use" lengths at flow rates from 0 L/min to 30 L/min. The ETT resistance was calculated by dividing the proximal ETT pressure by the measured flow and expressed as the mean of three measurements at each flow rate. : Resistance increased as ETT diameter decreased; at flows of 5 L/min and 10 L/min, the resistances of the 6 mm inner diameter ETT were 3.1 H2O/L/sec and 4.6 cm H20/L/ sec, respectively, and the resistances of the 2.5 mm inner diameter ETT were 81.2 H2O/L/sec and 139.4 cm H20/L/sec, respectively. Shortening an ETT to a length appropriate for patient use (e.g., a 4.0 mm inner diameter, from 20.7 to 11.3 cm) reduced its resistance on average by 22%. The resistance of a Cole tube was approximately 50% lower than that of a straight tube with an inner diameter corresponding to the narrow part of the shouldered tube. They concluded that the use of a small-diameter, straight ETT would significantly increase the work of breathing[9]. In fact it has been estimated that resistance to flow increases sixteen times if the diameter of a tube is halved, and vice versa. In our case the measured diameter was found to be 2.13 mm. It was almost half of the desired diameter of 4 mm. It can be seen that the resistance was almost sixteen times to that of expected resistance out of a 4 mm ID ETT.

This case report highlights the importance of maintaining an awareness that airway obstruction or leak due to structural defects can still occur even with high quality, prepacked single use plastic endotracheal tubes. It also emphasizes the need to have a systematic approach when dealing with such critical events.

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