Case Report

Tracheal Tube Kinking Amidst Prone Position During Neurosurgical Procedures: An Attempt to Elucidate the Mechanism

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The tracheal tube (TT) kink during the intraoperative period is commonly observed and is worrisome once the positioning is done during neurosurgical procedures. The complications related to tube kink are more in the prone position and the mechanism of this with the neck in flexion has not been explained anywhere. We have made an attempt to elucidate the probable mechanism of this TT kink by using SOLIDWORKS 2020 {3D Computer assisted design (CAD) design software} and the precautions that can be taken to prevent perioperative catastrophe by describing a case of a pediatric patient undergoing a neurosurgical procedure while in the prone position.

**KEYWORDS:** Flexion, inflection point, kink, pediatric, tracheal tube

INTRODUCTION

The airway obstruction during the intraoperative period in pediatric patients is time and again reported in the literature. The obstruction may occur from various causes, and it becomes all the more grueling when the patient is already positioned for surgery. The airway obstruction in a pediatric patient needs expeditious management, as they land up in a catastrophe within a flash, owing to their complex respiratory physiology, high metabolic requirements, and negative effects of anesthesia on pulmonary mechanics.

CASE REPORT

A 5-year-old female child weighing 23 kg posted for posterior fossa tumor excision in the prone position. After induction of anesthesia, the child was intubated orally with a cuffed polyvinyl chloride (PVC) TT (Portex blue-line, single-use) of 5.5-mm internal diameter. The pilot balloon was inflated with 1 mL of air, and cuff pressure was measured to be around 18 cm of H$_2$O by a cuff pressure manometer. The TT was secured at 15 cm at the teeth along with placement of a soft bite block. An equal bilateral air entry was confirmed in both extension and flexion by chest auscultation.

The head was stabilized by using a skull pin holder in prone position with flexion of the atlanto-axial joint for appropriate surgical exposure. After around 10 min just before surgical incision, the airway pressures began to rise from 20 to 32 cm of H$_2$O. The saturation and end-tidal CO$_2$ were normal, with an upward sloping pattern along with decreased compliance felt in the bag. The surgeons were intimated, and the chest was auscultated for any signs of bronchospasm or decreased air entry. The nasopharyngeal temperature was 36.4°C, and the circuit was checked for any obvious external kink, obstructions, or leaks. The tube was examined to ascertain any kink at the angle of the mouth, and the bite block was readjusted but to no avail. A 10 French flexible suction catheter was passed and could not pass freely down the tube beyond 16–18 cm, suggesting some lower intraoral issue. It was decided to readjust the headpins slightly from above the drapes to decrease the neck flexion.

Despite optimal efforts using a gloved index finger to ascertain any intraoral kink, the cause and site of the obstruction were still not revealed.

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TT kink could be not be ascertained and the patient was turned supine. On inspection of the TT, a gross kink was found in the endotracheal tube (beyond the attachment of cuff inflation tube) approximately 1.5 cm proximal to the black mark [Figure 1A]. The child was reintubated with a smaller size TT of 5.0 mm ID, and the surgery was commenced.

**DISCUSSION**

The TT kink during posterior fossa surgery may result from excessive bending of the softened tube due to raised oral temperature and neck flexion. Campoy et al. demonstrated a higher incidence of kinking of TT during maximal flexion at the atlanto-axial joint. The smaller size tubes may be more prone to airway obstruction, and the external reinforcement of tube has also been described. Once the force generated by the flexion was removed, the kink developed in TT partially persisted and did not obliterate completely, leading to limited obstruction.

All these maneuvers are helpful prophylactically or when the point of kink is visible extra orally. In our case, despite all maneuvers, airway pressures did not come down, leaving us with no option other than turning the patient prone and changing the tube completely.

We assume that the TT in the first place was not of optimal size and got snugly fitted below the vocal cords. The application of the skull pin holder and flexion at the atlanto-axial joint generated an external force that was transmitted along the length of the tube. The tube being fixed at the distal end because of “tube within tube phenomenon” could not migrate inward with head flexion, causing it to kink above the brim of the trachea. Below this point, the TT lay in the tracheal lumen and was supported by its covering. In the index case, the reintubation with a smaller-sized tube prevented the recurrence of a similar phenomenon.

A simulation was carried out in SOLIDWORKS 2020 (3D Computer Assisted design (CAD) software) with the prescribed boundary conditions as shown in [Figure 1B]. The resulting configuration [Figure 1C] shows an inflection point near about 1.5 cm from the TT Cuff translating toward the proximal end. At the inflection point, the tendency of the tube structure to buckle under load increased. At this zone, the annular tube section failed to carry normal or bending load, leading to a kink formation. In situ simulation can be proposed in near future, as this simulation was carried out *in vitro* and is a proposed mechanism to elucidate the site of obstruction. This hypothesis will encourage the anesthetist to predetermine the appropriate size of the tube and inculcate an idea of the distal tube kink as well.

In other reported studies in this context, airway pressure began to rise toward the end, suggesting mild and progressive kink and that was resolved with routine measures such as manual straightening, repositioning of the head, external reinforcement etc.

The checking of the TT in complete flexion and extension before fixation is mandatory, although this also is not infallible. Although cuffed tubes are advocated in the prone position for adequate ventilation, we need to be cautious of this rare implication of a relatively tight-fitted tube in neck flexion. The anesthetist needs to be vigilant during patient positioning and head fixation in pins to avoid extreme neck flexion, and two finger-breadth (patient’s finger) space should be allowed between any two bony prominences. If the TT issue was not addressed at the start of the surgery, it would have been a tricky situation when the patient was already in prone position with the head fixed in pins with skull open. We should never hesitate to turn the patient supine if there are even slight hints of inadequate ventilation, because “life of patient takes priority over time” in these situations.

Hence, the inferences drawn are that the use of a flexible reinforced tracheal tube may be considered but the cost and availability is a major issue in developing countries. Moreover, the use of an uncuffed tube may also prevent kinking of TT by slipping down through the trachea during flexion but at the same time it may increase the risk of endobronchial intubation. The unexpected site of kink as described in this case may be kept in mind as well to clinch the cause of airway obstruction briskly.

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**Figure 1:** (A) ETT showing kink with suction catheter *in situ*. (B) A simulation carried out in SolidWorks with the prescribed boundary conditions. (C) Resulting configuration showing an inflection point near about 1.5 cm from the ETT cuff toward the proximal end.
Author contributions
RC: concept, final approval, and editing of this case report to be published; NS: first draft of the paper; RS: revising it critically for important intellectual content.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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