WE report a case of bite damage to a wire-reinforced endotracheal tube caused by transcranial electrical stimulation (TES).

A 23-yr-old female patient (American Society of Anesthesiologists grade I) with mild motor deficits in the lower extremities was admitted for the extirpation of an intramedullary cervical spinal cord tumor (C3–C7). Intraoperative neurophysiological monitoring by using motor-evoked potentials (MEPs) elicited by TES and somatosensory-evoked potentials was performed to assess the functional integrity of the spinal cord. After induction of general anesthesia by using bolus administration of propofol, remifentanil, and muscle relaxation (0.6 mg/kg rocuronium), a 7.5-mm ID armoured endotracheal tube with cuff (Rüschflex; Teleflex, Kernen, Germany) was introduced, cuffed, and fixed with adhesive tape. A gauze bite block was placed in the recommended manner to prevent bite injuries because tongue bites, lip lacerations, and even a unique case of mandibular fracture were reported during TES in patients without bite block. Anesthesia was maintained by continuous infusion of propofol (100 μg·kg⁻¹·min⁻¹) and remifentanil (0.5 μg·kg⁻¹·min⁻¹). The neuromuscular blockade was omitted after induction of general anesthesia to avoid interference with MEP monitoring.

Neurosurgical access was intended from the posterior; therefore, the patient was turned to a prone position, and TES for MEP monitoring was initiated. Scalp electrodes at positions C3 and C4 were used for TES according to the International 10–20 electroencephalography electrode system. Short trains of 5–7 electrical pulses (frequency 250 Hz, duration of each stimulus 0.5 ms, intensity 80 to 250 V) were applied via corkscrew electrodes originating from a Nicolet Endeavor (Viasys Healthcare, Madison, WI) constant current stimulator to monitor MEPs from limb muscles. Single stimuli of TES were used to record epidural MEPs from an intraoperatively placed epidural catheter electrode. At critical stages of the surgical procedure, short trains of stimuli were used at a rate of 1.1 Hz to continuously assess the functional integrity of motor tracts. During the entire surgical procedure, a total of 4,200 trains of stimuli were applied.

Approximately 6 h after incision, the ventilator alarmed leakage. At this point, oxygenation and ventilation could only be performed by high-flow hand ventilation with 100% oxygen. Direct inspection of the endotracheal tube with the patient remaining in prone position revealed a bitten hole near the incisors (fig. 1), although the gauze bite block was still correctly in place. In this emergency situation, a thinner, 5 mm endotracheal tube (Microcuff; Kimberly-Clark, Neenah, WI) (table 1) was inserted into the injured endotracheal tube.

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Table 1. A Tube-in-tube Study

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<th>Inner Tuber Inner Diameter, mm</th>
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The best size for the inner tube (left column) corresponds to the size listed for the outer tube (right column). We tested tubes made by Teleflex (Kernen, Germany) and Kimberly-Clark (Neenah, WI).
(with care not to mislead the new endotracheal tube through the perforation\textsuperscript{5}), fixed using adhesive tape, and cuffed (fig. 2) without changing the patient’s position. Pulmonary auscultation was normal. The gauze bite block was replaced by a rubber bite block to prevent further biting of the tube, and mechanical ventilation was continued until the end of the surgical procedure. The critical incidence did not lead to decrease in blood oxygen saturation, which constantly remained above 97\%, as measured by pulse oximetry.

There were no further respiratory complications; however, because of the increased resistance of the inserted 5-mm tube, a higher peak-pressure was necessary for ventilation until extubation at the end of surgery. Post-operational inspection of the endotracheal tube revealed a 23-mm-long laceration located on the convex side of the endotracheal tube, encircling 70\% of the outer circumference (fig. 1 and 2). The endotracheal tube perforation on the convex side had been under the upper incisors during the operation. After extubation in the operating room, it was found that the patient had suffered no injuries that might have occurred during the use of TES. The patient was transferred in a stable condition to the postoperative care unit.

Discussion

Several publications have associated the use of wire-reinforced tubes with airway complications such as perforation\textsuperscript{5,6} occlusion\textsuperscript{7} obstruction\textsuperscript{8,9} or dissection\textsuperscript{10}. There is only a single report of a bitten and consecutively leaking tube caused by jaw muscle contraction after TES\textsuperscript{11} and a single report of tube obstruction while the patient was in prone position\textsuperscript{12}. Both were managed in a different manner from our case.

Santos et al.\textsuperscript{12} and MacDonald\textsuperscript{11} reported emergency reintubation; in both cases, the patient had to be returned to the supine position. We managed this critical event without being forced to change the patient’s position by introducing the thinner tube into the perforated one. We decided to do so, because ventilation could be maintained manually, thereby not justifying the high-risk option of breaking the sterile field by altering the position. With this strategy, the intramedullary spinal cord tumor could safely be removed under continual MEP monitoring.

The usual infusion rate of propofol is 25-100 $\mu g \cdot kg^{-1} \cdot min^{-1}$ and 0.25-1 $\mu g \cdot kg^{-1} \cdot min^{-1}$ of remifentanil when combined with propofol for maintenance of anesthesia.\textsuperscript{15} Therefore, anesthesia should have been deep enough at all times, which minimizes the possibility of the laceration being caused by the patient consciously biting the tube. This serious complication was most likely caused by the sum of repetitive strong bites as a side effect of continuous MEP monitoring, rather than by a single strong bite. The duration of the surgical procedure for the removal of an intramedullary spinal cord tumor reaching from C3 to C7 required extraordinarily frequent TES to test the functional integrity of the motor pathways, which is unusual among other types of spinal surgery.

Because of the short duration of masticatory muscle contractions associated with MEPs, no pressure warning occurred at any time, indicating airway obstruction or leakage. Leakage was noted at the point when the ventilator exceeded its standard limit (more than 25\% of min volume); before exceeding the limit, this value was not displayed on the main screen (Primus; Dräger Medical, Vienna, Austria). Particularly strong activation of the temporalis muscle has been reported when TES is applied via the C3 and C4 electrode positions because direct activation of the muscle or the motor part of the trigeminal nerve is induced by the electrical stimulus.\textsuperscript{14} This can be avoided by using alternative stimulation sites of scalp electrodes, e.g., C1 and C2. However, higher intensities of TES are necessary to reach motor threshold if C1 and C2 are used.\textsuperscript{15}

Conclusion

This emergency event demonstrates that the previously recommended gauze bite block cannot prevent endotracheal tube perforation for surgical procedures with the use of TES for MEP monitoring. Instead, a reliable device that provides both protection of the patient’s oropharynx (tongue, teeth and lips) and protection of the endotracheal tube should be used.\textsuperscript{16} Our tube in tube management could sufficiently manage this airway emergency situation in prone position. If TES is effectively accomplished via electrodes on positions C1 and C2, this method should be preferred over C3/C4 stimulation for MEP monitoring in spinal cord surgery.
References

5. Eisenach JH, Barnes RD. Potential disaster in airway management: A misguided airway exchange catheter for a hole bitten into a univent endotracheal tube. ANESTHESIOLOGY 2002; 96:1266–8