ETView tracheoscopic ventilation tube for surveillance after tube position in patients undergoing percutaneous nephrolithotomy

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Background. Tracheal tube (TT) displacement during general anaesthesia may result in life-threatening complications and continuous direct vision of the position of the tube may enable safer management. The ETView tracheoscopic ventilation tube (TVT™) is a single-use TT incorporating a video camera and a light source in its tip. The view from the tip appears continuously on a portable monitor in the anaesthetist’s vicinity. This study was designed to test the ETView TVT™ in monitoring the TT position during general anaesthesia.

Methods. In this prospective study, the ETView TVT™ was used to ventilate the lungs of 30 adult patients undergoing percutaneous nephrolithotomy (PCNL), which required changing patient position three times. During surgery, the anaesthetist followed the carinal view on the ETView TVT™ portable monitor. Tube movement within 1 cm was recorded, as was the need for repositioning of the tube when the carina was not seen on the camera monitor.

Results. During anaesthesia, tiny movements synchronous with heart beats and lung ventilation were observed. Tube movement of 1 cm was detected in eight (26%) patients. In two (7%) patients, the carina was no longer viewed after moving to the lithotomy position and the tube was repositioned. None of the events was associated with changes in oxygen saturation, end-tidal CO₂, or airway pressure.

Conclusions. We found that the ETView TVT™ facilitated surveillance of tube position by providing a clear high-quality view of the carina, throughout PCNL with several changes of patient position.

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Tracheal tube (TT) displacement from its proper position above the carina may result in life-threatening complications.¹ If the tube is advanced into a main bronchus, single lung ventilation can occur causing volume trauma or pneumothorax in the ventilated lung and atelectasis in the non-ventilated lung. If the TT is withdrawn proximally, there is a risk of inadvertent extubation. These scenarios are more likely if the patient’s position is changed during general anaesthesia, as demonstrated by early radiographic tests and later fibreoptic bronchoscope studies.² ³ ⁴ ⁵ Unfortunately, the anaesthetist can often only detect tube movement from indirect signs such as increased airway pressure or decreased oxygen saturation. Currently, there is no tool for direct continuous monitoring of the TT position.

The aim of this study was to evaluate the ETView tracheoscopic ventilation tube (TVT™) (ETView Ltd, Misgav, Israel) for surveillance of tube position during general anaesthesia. The ETView TVT™ is a single-use TT, which is available in sizes of 7.0, 7.5, and 8.0 mm internal diameter. The external structure, wall thickness, and length of the ETView TVT™ are similar to the standard TT. The ETView TVT™ incorporates a mini-video camera, 2 mm in diameter, and a light source embedded...
in the tip of the tube (Fig. 1). The view from the TT tip appears continuously on a portable monitor available in sizes of ~9 or 18 cm and can be battery or cable operated (Fig. 2). Resistance to air flow through the various ETView TVT™ sizes is reported by the manufacturer to be comparable with the standard TT. The ETView TVT™ has the US Food and Drug Administration approval and CE marking, is available in Europe and North America, and has been used in a study of 80 patients who underwent lung resection in Italy.⁶

Methods
This prospective study of 30 adult patients undergoing elective percutaneous nephrolithotomy (PCNL) with combined general–epidural anaesthesia in our hospital was approved by our local Ethics Committee and all patients gave informed consent. PCNL was chosen as this procedure requires several changes in patient position and the risk of tube movement is relatively high. In addition, during part of the procedure, the patient is distant from the anaesthetist, and access to the TT is difficult. Exclusion criteria were: American Society of Anesthesiologists (ASA) class ≥IV, pregnancy, patient weight >120 or <45 kg, known tracheal pathology, and patients at risk of gastric content regurgitation.

On the day of surgery, patients were premedicated with metoclopramide 10 mg and diazepam 10 mg p.o. On arrival in the operating theatre, patients were monitored with non-invasive arterial pressure, ECG, and pulse oximeter, and i.v. arterial cannulae were placed. An epidural catheter was inserted in the midline approach, at the level of L 1–2. After preoxygenation of the patients’ lungs for 5 min, anaesthesia was induced with propofol (2–3 mg kg⁻¹) and fentanyl (0.001–0.002 mg kg⁻¹), followed by vecuronium (0.08 mg kg⁻¹) i.v.. Endotracheal intubation was performed by one of two anaesthetists (M.B. and V.P.), each with more than 4 yr experience. Both had performed more than three intubations with the ETView TVT™ before beginning the study and both were experienced in bronchoscopy, and hence familiar with bronchial views. The ETView TVT™ size 7.5 was used in all patients; it was fixed with an adhesive tape and a cotton band when the picture of the carina was clear on a 9 cm ETView TVT™ camera monitor (Fig. 3). After endotracheal intubation and tube fixation in the supine position, the patient was advanced to the distal end of the operating table and moved to the lithotomy position for cystoscopy and insertion of a ureteric catheter under radiographic guidance. The patient was then turned to the prone position for the PCNL. After completion of the procedure, the patient was turned to the supine position and the trachea extubated. During surgery, the anaesthetist followed the carinal view on the ETView TVT™ portable monitor to detect any tube movements (Fig. 4). Using the carina as the point of reference, movement distances were estimated according to the number of tracheal cartilage rings seen: movement of less than two tracheal rings was defined as a movement of 1 cm. All tube movements and the need for repositioning of the tube when the carina was not seen on the camera monitor were recorded. The ETView TVT™ camera and monitor have no alarm, and their utility relies on the judgement of the anaesthetist.

PCNL involves approaching the kidney from its upper pole with the attendant risk of pneumothorax, so we...
performed postoperative chest X-ray and blood gas analyses. Data recorded during surgery included: any occurrence of $\text{SpO}_2 < 90\%$, $\text{PaO}_2$, intra-operative pneumothorax, or other respiratory complication. After tracheal extubation, patients were transferred to the post-anaesthesia care unit (PACU), for at least 2 h for further monitoring.

Data were analysed using SigmaStat 3.5 (Systat Software, Inc., CA, USA). Data are presented as mean and standard deviation (SD), or median (range) as appropriate.

Results

Thirty patients were included in the study (Table 1). $\text{SpO}_2$ was $>95\%$ in all the patients at all times. There were no intra-operative respiratory events such as pneumothorax or aspiration, and all the patients had uneventful stays in the PACU.

During anaesthesia, there were continuous, ongoing, tiny movements of the tube against the tracheal wall or carina that were synchronous with heart beats and lung ventilation. Tube movements $<1$ cm were detected in eight (26%) patients. The TT moved to a position in which the carina was no longer viewed on the portable monitor in two (7%) patients and tube repositioning was required. In both cases, this occurred while the patients were being moved to the lithotomy position, and it was not associated with change of $\text{SpO}_2$, capnometry, or airway pressure. Tube repositioning was performed immediately after detection of the event, and within seconds, the carinal view was resumed on the monitor. The visual follow-up data are summarized in Table 2.

The tip of the TT and camera were covered with secretions requiring suction in two (7%) patients. In both events, the patient was in the prone position and after having $>2$ h of anaesthesia.

Discussion

Adverse respiratory events during general anaesthesia are a major cause of morbidity and mortality, and although the incidence has reduced in the past two decades, death or brain damage may occur in up to 85% of cases. Moreover, a review of 1175 anaesthetic-related closed malpractice claims suggested that most negative outcomes were considered to be preventable with better monitoring. The leading causes for anaesthesia-related respiratory mishaps are inadequate ventilation, oesophageal intubation, or difficult tracheal intubation. Caplan and colleagues demonstrated that oesophageal intubation cases are notable for a recurring diagnostic failure: in 48% of cases, auscultation of breath sounds was performed and documented, leading to the erroneous conclusion that the TT was correctly located in the trachea. Various clinical signs and technical aids are described to verify tracheal intubation, but direct visualization of the tracheal rings and carina is the only foolproof method of confirming proper TT position. The use of the ETView TVT™ verifies TT position indisputably.

Respiratory complications occur not only during intubation but also after the TT is in place. TT displacement during general anaesthesia can be the result of inadequate fixation or a change of the internal organs in relation to the lungs or carina, as during the Trendelenburg tilt or laparoscopy. In our study, we followed the TT position throughout surgery, during which the patient’s position was changed three times. The view of the carina on the portable monitor enabled on-line continuous monitoring of the tube position. In two patients, the carinal view disappeared during the lithotomy position and the TT was repositioned. We do not know what could have happened if no action had been taken, and therefore cannot argue that a life-threatening event would have occurred. The validation of a monitoring device as a tool for safety improvement necessitates a large cohort study and a retrospective evaluation, as were performed for oximetry and capnometry.

It is important to remember that the ETView camera and monitor have no alarm, and their value relies entirely

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**Table 1** Patient characteristics and surgical data presented as mean (SD), median (range), or number

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>54 (25–84)</td>
</tr>
<tr>
<td>Male/Female (n)</td>
<td>11/19</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>71 (55–110)</td>
</tr>
<tr>
<td>ASA class</td>
<td>2.3 (0.65)</td>
</tr>
<tr>
<td>Duration of surgery (h)</td>
<td>2.5 (0.54)</td>
</tr>
<tr>
<td>Side of the surgery: right/left (n)</td>
<td>10/20</td>
</tr>
<tr>
<td>$\text{PaO}_2$ (kPa) during surgery</td>
<td>30.8 (14.9)</td>
</tr>
<tr>
<td>$\text{PaO}_2$ (kPa) in PACU</td>
<td>21.2 (6.5)</td>
</tr>
</tbody>
</table>

**Table 2** Visual follow-up data of the ETView TVT™ camera monitor

<table>
<thead>
<tr>
<th>Event</th>
<th>Number of patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good view of the carina during the whole procedure</td>
<td>20 (66)</td>
</tr>
<tr>
<td>Tube movement within 1 cm limit</td>
<td>8 (26)</td>
</tr>
<tr>
<td>Tube movement with loss of view of the carina</td>
<td>2 (7)</td>
</tr>
<tr>
<td>Endobronchial intubation</td>
<td>None</td>
</tr>
</tbody>
</table>

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Fig 4 The carina is seen on the ETView monitor (arrow), while the patient is in the lithotomy position.
on the judgement of the anaesthetist who keeps an eye on the monitor.\textsuperscript{17} It is essential that the users of the ETView TVT\textsuperscript{TM} must be trained and be able to distinguish between the primary and secondary carinii; otherwise, they may fail to detect movement of the tube into the main bronchus and the key benefit of the tube is entirely lost. This knowledge is usually obtained during training in performing bronchoscopy.

In our study, two patients had secretions on the ETView TVT\textsuperscript{TM} tip that blocked the view, and suction was needed. We assume that this may happen more frequently during prolonged procedures. In selected patients, the use of an antisyndrome drug may be considered, since the camera surface area is miniature, and even a small amount of secretion could prevent vision.

One of the main advantages of the ETView TVT\textsuperscript{TM} is that it enables a clear and good view of the carina and hence verifies the TT position, even when the patient is at a distant location, away from the anaesthetist, covered, and there is difficulty in observing chest movements or tube position. In such cases, auscultation is impractical and handling the tube when it is dislocated is complicated. We conclude that using the ETView TVT\textsuperscript{TM} for continuous direct vision of the carina in selected cases and procedures could improve patient safety and provide reassurance and confidence for the anaesthetist.

Acknowledgements

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References