Tracheal intubation with a camera embedded in the tube tip (Vivasight™)

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Summary

We studied tracheal intubation in manikins and patients with a camera embedded in the tip of the tracheal tube (Vivasight™). Four people in two teams and two individuals attempted intubation of a manikin through an i-gel™ 10 times each. The tracheas of 12 patients with a Mallampati grade of 1 were intubated with a Vivasight tracheal tube through a Berman airway, passed over a Frova™ introducer. All 60 manikin intubations were successful, taking a mean (SD) time of 1.4 (0.5) s. The fastest intubation was performed in 0.5 s. All 12 participants’ tracheas were successfully intubated in a median (IQR [range]) time of 90 (70–120 [50–210]) s. Seven participants complained of a sore throat, comparable with earlier findings for standard laryngoscopy and intubation: five mild; one moderate; and one severe. Tracheal intubation with the Vivasight through the i-gel or Berman airway is an alternative to existing techniques, against which it should be compared in randomised controlled trials in human participants. It has potential as a fast airway rescue technique.

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Technical innovations have increased the number of intubation techniques [1, 2]. Nevertheless, airway-related complications cause morbidity and mortality [3]. The Vivasight™ tracheoscopic ventilation tube (ET view Ltd, Misgav, Israel) is novel due to the camera embedded in its tip (Figs. 1 and 2). This tube was specifically designed to permit a continuous view of the trachea and carina during surgery and placement of a bronchial blocker without fibreoptic bronchoscopy [4, 5]. We describe tracheal intubation in manikins through an i-gel™ and subsequently in patients through a Berman airway without standard laryngoscopy. We aimed to assess the feasibility of this technique for airway management.

Methods

The Institutional Review Board of the VU University Medical Center approved the study. Patients gave written informed consent for participation in the study and for publication of the data.

Tracheal intubation with the Vivasight tube was first tested in a full-scale medical simulator using the SimMan® (Laerdal Ltd, Stavanger, Norway) manikin. A tube, internal diameter 7.0 mm, was pre-loaded in a size-5.0 i-gel (Intersurgical, Uden, the Netherlands). The supine manikin was programmed for ‘easy intubation’ mode (Mallampati grade 1, own teeth, good neck movement and relaxed tongue, all airways open, no spontaneous breathing). The head was placed on an
intubation pillow, neck flexed, head extended. Clinicians were asked to intubate the trachea quickly, but carefully. We measured times for i-gel insertion and tracheal intubation (verified on the monitor screen). Ten consecutive i-gel insertions and tracheal intubations were performed by two individuals in four teams, consisting of, respectively: third-year and fourth-year anaesthetic trainees (AC and EK), who alternated roles in teams 1 and 2; a consultant anaesthetist (JH), with a biomedical student (MV) without airway skills in team 3 and with the third-year trainee (AC) in team 4. In addition, the consultant and a biomedical student subsequently inserted the i-gel and intubated the trachea by themselves. Team 4 used a face-to-face technique, standing at the left side of a seated manikin, to simulate an entrapped patient in a car with difficult access from behind [6]. Video was recorded from the embedded camera for all intubations to confirm tracheal intubation.

We recruited 12 participants, of ASA physical status 1 or 2, scheduled for surgery under general anaesthesia, with Mallampati grade-1 oropharyngeal views and expected normal airways [7, 8]. We excluded patients less than 18 years old, with a body mass index more than 25 kg.m\(^{-2}\), or with inherited or acquired coagulopathies. Anaesthesia was induced intravenously with propofol and sufentanil or remifentanil whilst participants breathed 100% oxygen. After neuromuscular blockade with intravenous rocuronium or mivacurium, bag-mask ventilation was continued for 3 min. Participants were placed with their head and necks in a neutral position. A 10-cm Berman neuromuscular blockade intubating airway (GE Healthcare Hoevelaken, the Netherlands) was pre-loaded with a Vivasight tube (7.5 mm internal diameter) and connected to a video monitor. Both were inserted orally, with the tube’s tip placed 0.5 cm from the distal part of the Berman airway. After obtaining a view of the vocal cords, an assistant performed a jaw-thrust manoeuvre to improve the glottic view; the tube was advanced through the Berman airway until a clear view of the larynx was obtained. A Frova\textsuperscript{TM} 14-F introducer (Cook Medical, Bloomington, USA) was inserted through the larynx, over which the tracheal tube was advanced until the carina was seen. The Berman airway was then removed and the cuff of the tracheal tube was inflated. We recorded the time to capnographic confirmation of tracheal intubation and ventilation. Within 24 h of surgery, we asked participants whether they had a sore throat, hoarse voice, cough or other complaint related to intubation, graded as mild, moderate or severe [9, 10]

We estimated that a sample size of 12 patients would be adequate for this feasibility study [11, 12]. The intubation times were compared with ANOVA and subsequent post-hoc tests, as appropriate, using SPSS\textsuperscript{®} 20.0 software (IBM\textsuperscript{®} Stuttgart, Germany). A p value < 0.05 was considered statistically significant.
Results

All attempted manikin intubations through the i-gel were successful. The mean (SD) intubation time for all teams was 1.4 (0.5) s. Team 4 was the fastest team. Team 1 took longer than team 4; 1.7 (0.6) s vs 1.2 (0.2) s (p = 0.040). The student took longer than the consultant: 1.89 (0.45) s vs 0.81 (0.14) s, a difference of 1.08 (95% CI 0.75–1.41) s, p = 2 × 10⁻⁵. The fastest intubation was performed in 0.5 s. Table 1 shows manikin intubation data.

We recruited seven women and five men. Their median (IQR [range]) age was 41 (34–53 [23–73]) years, their weight 71 (67–75 [62–96]) kg, height 177 (171–181 [165–202]) cm and BMI 23 (22–23.5 [19–25.5]) kg.m⁻². Six participants each were of ASA status 1 and 2. All intubations were successful, with 10/12 facilitated by jaw thrusts. The time to intubation was 90 (70–120 [50–210]) s. The first three participants required two or three attempts for intubation, but only one attempt was needed for the subsequent nine participants. In all but one patient, the carina was clearly visible. There were no complications. Seven participants complained of sore throats postoperatively: five mild; one moderate; and one severe, the latter with difficulty swallowing that resolved within 48 h, when a gastric drain was removed. Three participants had a dry cough, which resolved after 1–3 days.

Discussion

We believe that this is the first report of tracheal intubation using continuous video from a camera embedded in a tracheal tube. Potential benefits of camera-in-tube intubation include: confirmation of correct tracheal tube placement when capnographic confirmation is uncertain, for instance in low-output states such as cardiac arrest; avoidance of the stimulus of laryngoscopy for patients with poor dentition, limited mouth-opening or neck mobility; and awake intubation, with possibly lower equipment and sterilisation costs compared with flexible fibrescopes. Entrapped patients with chest trauma might benefit from both the face-to-face intubation technique – that we simulated in manikins – and passage of a bronchial blocker under direct vision, to isolate a damaged lung when presenting for thoracic surgery after arriving at the hospital.

The fast intubation times with intubation through an i-gel may especially be promising for a clinical situation when rapid tracheal access is needed, such as during airway rescue. A 7.0-mm Vivasight tube fits through a size-4.0 i-gel and a 7.5-mm tube fits through a size-5.0 i-gel. Lubrication facilitates intubation; it is important to avoid smearing the camera lens. Pre-positioning the tracheal tube tip 0.5 cm within the end of both the i-gel and the Berman kept the camera lens clear during oral insertion until the glottis was exposed. The Vivasight has a special saline flush lens-cleaning system, but we did not need to use this because the conduit kept the lens clean. We intubated the trachea over a bougie to avoid possible impingement of the Vivasight bevel on the anterior tracheal wall. Vivasight tubes are available with a camera embedded in a lateral bevel, but we did not assess for these aspects.

<table>
<thead>
<tr>
<th>Attempt</th>
<th>Team 1</th>
<th>Team 2</th>
<th>Team 3</th>
<th>Team 4</th>
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<th>Consultant</th>
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<tr>
<td>Mean (SD)</td>
<td>1.7 (0.6)</td>
<td>1.4 (0.4)</td>
<td>1.3 (0.4)</td>
<td>1.2 (0.2)</td>
<td>1.9 (0.4)</td>
<td>0.8 (0.1)</td>
</tr>
</tbody>
</table>

Post hoc tests: team 1 vs team 4, p = 0.042.
Unpaired t-test: consultant vs student, p = 2 × 10⁻⁵.
these tubes. When used for airway rescue, both the Vivasight and i-gel should probably be left in situ until emergence, or until a more definitive airway can be secured. In contrast, the Berman airway can be removed very easily after intubation. The rate of sore throat and other complications was comparable with standard tracheal intubation [9, 10].

Our intubation technique through the i-gel appeared to be faster than techniques using the intubating laryngeal mask airway (ILMA), laryngeal mask airway (LMA), videolaryngoscopy or fibreoptic intubation techniques through a supraglottic airway [13–17]. As reported by Joshi et al., the i-gel has a role in airway rescue because of the ease of insertion, good airway leak pressures and the short wide airway tube [18]. The i-gel has been inserted in manikins in a mean time of 12.3 s by paramedics [13], whereas we achieved tracheal intubation through an i-gel in less than 2 s. Fibreoptic intubation through ILMAs and LMAs in manikins took 74 and 75 s, respectively [20]. Blind intubation in patients through an i-gel took a mean of 49 s, but had an initial success rate of 75%, whereas in a similar study in manikins, half of the blind attempts led to oesophageal passage of bougies [16, 19].

Our study suggests that embedded tube-tip cameras might improve the success of intubation without direct or fibreoptic laryngoscopy and may be quicker than the latter [13, 16, 17, 22]. We acknowledge that our results can only inform future research rather than guide clinical practice, given only 12 participants in an uncontrolled study. Manikin studies may be useful for practising airway management [21], but may have limited value for clinical practice [22]. We used manikins because to date there is no accepted clinical method to test airway rescue techniques in humans. Further studies in patients are in progress at our institution to evaluate whether this technique is clinically valuable.

In conclusion, the Vivasight tracheal tube, with an embedded camera in the tip, permits successful intubation through supraglottic airways in both manikins and human subjects.

Competing interests
The Vivasight tubes and monitors were provided free by ET view, Misgav, Israel. Drs Huitink, Krage, Erwteman and Schauer received equipment from Olympus, The Surgical Company Benelux, Storz, Stöpler and Laerdal.

References


