APPARATUS

Comparison of the Berman Intubating Airway and the Williams Airway Intubator for fibreoptic orotracheal intubation in anaesthetised patients

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Summary
Sixty patients with no clinical indicators of a difficult airway were selected to undergo a fibreoptic assessment after induction of general anaesthesia using both the Berman Intubating Airway and the Williams Airway Intubator. The bronchoscopic view and ease of railroading a tracheal tube during fibreoptic orotracheal intubation were studied. The bronchoscopic views obtained by the Berman Airway and the Williams Airway were significantly different ($p < 0.008$, test of symmetry). The estimated odds ratio of obtaining an obstructed path was 3.06 times higher for the Berman than the Williams Airway. However, if the glottis could be reached with the bronchoscope, there was no significant difference in the degree of ease of intubation between the two airways.

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Intubating patients with a fibreoptic bronchoscope after induction of anaesthesia is an important method of securing an airway when there is difficulty intubating. Specific airways have been devised to assist the anaesthetist during fibreoptic intubation to allow a clear view in front of the bronchoscope as it passes from the mouth, through the glottis and into the trachea. There are, at present, a number of such airways available, including the Berman Intubating Airway (Vital Signs, Totowa, NJ, Fig. 1), the Williams Airway Intubator (Williams Airway Intubator Ltd, Calgary, Canada, Fig. 2) and the Ovassapian Fibreoptic Intubating Airway.

Only a few studies in the anaesthetic literature have critically appraised the available airways [1–3]. Previously, two of the authors (KG and MI) studied the Williams Airway Intubator and the Ovassapian Fibreoptic Intubating Airway, showing that the Williams Airway Intubator was more likely to provide an unobstructed path for bronchoscopy [1]. Randell et al. [3] studied the functioning of the Berman Intubating Airway and the Ovassapian Fibreoptic Intubating Airway and found that the Berman Airway was superior during fibreoptic intubation. This study compares the Berman Intubating Airway and the Williams Airway Intubator, thereby completing a full comparative investigation of these three airways. Similar to our previous work, we chose to investigate the time taken to view the glottis, the bronchoscopic view and ease of intubation.

Methods
Approval for the study was granted by the local institutional review board. Informed consent was obtained from 60 adult patients of American Society of Anesthesiologists grading (ASA) 1–2 who presented for elective surgery requiring tracheal intubation. Those with upper airway disease, a past history of difficult tracheal intubation, or the following signs of possible difficult tracheal intubation (a modified Mallampati score of 3 or 4, limited mouth opening < 3 cm, thyromental distance < 4 cm, or limited neck movement) were excluded from the study. To avoid skill variability and maintain consistency of results, one experienced specialist anaesthetist (KG) was chosen to perform all the assessments and intubations in the selected
patients. Oxygen saturation was maintained above 95% at all times during the procedure.

All patients were placed the supine position with their head in the classic ‘sniffing position’ that the operator felt was optimal for intubation. Routine non-invasive monitoring (including ECG, non-invasive blood pressure measurement, pulse oximetry and end tidal carbon dioxide analysis) was applied and after pre-oxygenation for 3 min, the patient received intravenous induction with fentanyl 1–1.5 μg.kg⁻¹, ‘sleep dose’ of propofol, and rocuronium 0.5–0.6 mg.kg⁻¹. After induction of anaesthesia, either the Berman Intubating Airway or the Williams Airway Intubator was inserted into the mouth in random order by the operator performing the assessment. The length of airway chosen was determined to ensure that it was slightly greater than the distance from the angle of the mouth to the angle of the mandible. It was impossible to blind the operator to the airway being used as he needed to observe the airway while he performed the procedure. The patient’s lungs were ventilated by bag and facemask with 100% oxygen and 2–3% sevoflurane. A bronchoscope (Olympus LF-GP, Olympus America Inc., Orangeburg, New York, USA) with a preloaded 7.0-mm tracheal tube (Portex Ltd, Hythe, Kent, UK) was then inserted through the airway for bronchoscopic assessment. The tracheal tubes were well lubricated with K-Y® Brand Jelly (Johnson & Johnson Inc., New Brunswick, New Jersey, USA). At this time, an assistant applied chin lift and ensured the airway was in the midline to optimise positioning and placement. The bronchoscopic view of the glottis via the airway was formally assessed once the bronchoscope had just passed the distal end of the airway. The time taken to view the glottis was recorded as the time from initially inserting the bronchoscope at the proximal opening of the airway until the tip of the bronchoscope was positioned at the level of the vocal cords. The bronchoscopy times were recorded by a second assistant using a stopwatch.

The first airway was then removed, the other airway was inserted and the assessment was repeated. Following this second assessment the bronchoscope was advanced into the trachea to a level just above the carina and the tracheal tube was railroaded over it, through the airway and into the trachea. The number of attempts and any difficulties advancing the tracheal tube over the bronchoscope and through the trachea were noted. The bronchoscope was then removed and the patients’ lungs ventilated via the tracheal tube.

We used a previously proposed classification for the bronchoscopic view [1] (Table 1) in an attempt to clarify the sites of obstruction that may lead to bronchoscopic difficulties. Ease of intubation was assessed using the scoring system proposed by Jones et al. [4] (Table 2). The anaesthetist performing both the assessment and intubation used these same classification systems.

The demographic data was assessed with the $t$-test and Chi-squared test. Pre-operative assessment data was analysed with the Mann–Whitney $U$-test and Chi-squared test. Test of symmetry and Kappa index were
Results

Patient characteristics and pre-operative assessments are shown in Table 3. Demographic data were not significantly different between the two groups. There was no significant difference in the pre-operative assessments.

Table 4 indicates the frequency of unobstructed, partially obstructed and totally obstructed airways during bronchoscopic assessments. The bronchoscopic views obtained by the Berman Airway and Williams Airway were significantly different \((p < 0.008, \text{test of symmetry})\). A totally clear view was achieved in 80% of cases with the Williams compared to only 56.6% with the Berman Airway. Complete obstruction (failures) occurred in 23.3% with the Berman Airway compared to only 5% with the Williams Airway. The incidence of partial obstruction was 20% with the Berman Airway and 15% with the Williams Airway. The estimated odds ratio of obtaining an obstructed path was 3.06 times higher for the Berman than the Williams Airway (Table 5). The bronchoscopic views obtained the first and second time were not significantly different \((p < 0.73; \text{Table 6})\). The kappa index between the Berman Airway and Williams Airway was 0.274 (95% CI: 0.092–0.455), which showed that the strength of agreement between the two airways was fair.

Of the 12 cases of partial obstruction with the Berman Airway, 11 were due to the epiglottis (grade 3) and one to both tongue and epiglottis (grade 4). In the 14 cases of complete obstruction, 13 were due to the epiglottis (grade 6) and one to the tongue (grade 5). Of the nine cases of partial obstruction with the Williams Airway, eight were due to the epiglottis (grade 3) and only one to the tongue (grade 2). Only three cases of complete obstruction

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**Table 1** Classification of bronchoscopic views through the Williams Airway Intubator or the Berman Intubating Airway.

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**Table 2** Classification of ease of intubation through the Williams Airway Intubator or the Berman Intubating Airway.

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**Table 3** Patient characteristics and pre-operative assessments in patients undergoing fibreoptic tracheal intubation.

Values are mean (SD) [range] or median (interquartile range) [range] or number of observations.

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<table>
<thead>
<tr>
<th>Group B (n = 30)</th>
<th>Group W (n = 30)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age; years</td>
<td>45.5 (16.7) [18–80]</td>
<td>41.3 (17.0) [19–79]</td>
</tr>
<tr>
<td>Sex; M : F</td>
<td>11 : 19</td>
<td>12 : 18</td>
</tr>
<tr>
<td>Weight; kg</td>
<td>78.4 (16.1) [42–104]</td>
<td>78.3 (16.8) [50–110]</td>
</tr>
<tr>
<td>Height; cm</td>
<td>171.7 (9.4) [155–189]</td>
<td>170.1 (8.9) [152–188]</td>
</tr>
<tr>
<td>BMI; kg.m(^{-2})</td>
<td>26.4 (5.6) [17.5–38.0]</td>
<td>26.8 (4.0) [19.1–35.8]</td>
</tr>
<tr>
<td>Thyromental distance; cm</td>
<td>5 (4–5) [4–6]</td>
<td>5 (4–5) [4–6]</td>
</tr>
<tr>
<td>Mouth opening; cm</td>
<td>3 (3–4) [3–5]</td>
<td>3.5 (3–4) [3–4]</td>
</tr>
<tr>
<td>Neck movement; normal : restricted</td>
<td>30 : 0</td>
<td>30 : 0</td>
</tr>
<tr>
<td>Modified Mallampati Score; 1 : 2</td>
<td>17 : 13</td>
<td>15 : 15</td>
</tr>
<tr>
<td>Size of airway used; 9 cm : 10 cm</td>
<td>12 : 18</td>
<td>14 : 16</td>
</tr>
</tbody>
</table>

Group B, Berman Airway first, then Williams split airway; Group W, Williams split airway first, then Berman Airway. BMI, body mass index.

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occurred with the Williams Airway, all caused by the epiglottis (grade 6). Hence, of the 38 partial and complete obstructions, 35 (92.1%) could be attributed to the epiglottis alone (Table 7).

Table 8 gives the bronchoscopy time from entering the airway with the bronchoscope until the tip of the bronchoscope reached the glottis. This time tended to be slightly longer with the Berman Intubating Airway but this was not statistically significant \((p = 0.087, \text{signed-rank test})\) and unlikely to be of clinical significance. The ease of intubation was similar with both airways (Table 9). Of the 51 cases where the bronchoscope could be inserted into the trachea and intubation with a 7.0 mm cuffed tracheal tube was possible, 21 (41.1%) required withdrawal and rotation of the tracheal tube 90° anticlockwise, with one patient requiring head or neck manipulation as well as tracheal tube rotation.

### Discussion
We have found that the Berman Intubating Airway and the Williams Airway Intubator both function well as conduits for fiberoptic intubation in anaesthetised patients. However, the Williams Airway Intubator was more likely to provide an unobstructed path. When these airways provided a clear path for the bronchoscope, the ability to railroad a tracheal tube down the bronchoscope and into the trachea was similar for both airways. In the following discussion, we describe the functional aspects of the Berman and Williams intubating airways and high-
light the structural characteristics which affect these aspects.

‘Dedicated airways’ have been defined as ‘an upper airway device dedicated to the maintenance of airway patency while other major airway interventions are anticipated or in progress – the device should be compatible with spontaneous and controlled ventilation’ [5]. Neither the Berman Intubating Airway nor the Williams Airway Intubator fulfil these criteria. As these airways are now frequently used after induction of anaesthesia and their connection to any anaesthetic circuits during fibreoptic intubation is difficult, it is essential that they function reliably as conduits for successful oral fibreoptic intubation in anaesthetised patients. Oropharyngeal airways like these have particular advantages over many ‘dedicated’ airways where mouth opening is limited, cervical spine movement is undesirable, and when larger tracheal tubes are preferred. In addition, they are relatively easy to insert and cheap compared to the more complex ‘dedicated’ airways.

The Berman Intubating Airway is available in 10 cm and 9 cm, for adults, and 8 cm for children sizes, whereas the Williams Airway Intubator is only available in a 10-cm and 9-cm size.

In the original study by Randell et al. [3], where the Berman Intubating Airway was compared to the Ovassapan Intubating Airway, the need for adequate size and midline positioning for successful oral fibreoptic intubation was highlighted. Despite the importance of appropriate sizing, at present the choice of size is only made on the basis of subjective assessment. It is noted that most of the failures with the Berman Intubating Airway in the series by Randell et al. [3] were attributed to the airway being too short, and hence impacting on the base of the tongue. As the sizes used in their study were not stated, we are unable to make a direct comparison with the selection of airways in our study. In general, we used the 10-cm airway for males and the 9-cm airway for females. We found that the 14 failures (23.3%) with the Berman Intubating Airway occurred particularly when using the 10-cm airway. This incidence of complete obstruction of the airway to bronchoscopy in our cases appears to be unacceptably high. In all of these cases, the airway was lodged in the vallecula with posterior folding of the epiglottis. This was likely due to the structure of this particular airway with its long lingual curvature ending in a distal flange called the ‘laryngoscope tip’ (due to its resemblance of the tip of a Macintosh laryngoscope blade). An improved view may be obtained by withdrawing the airway 1–2 cm from the mouth if excessive length is considered the cause. Also, when these airways are too long, it is possible that the distal part of the airway becomes lodged in the oesophagus, although this problem did not occur in any of our cases. In contrast to the Berman Intubating Airway, the Williams Airway Intubator has a much shorter lingual curvature with an opened distal lingual end. This may account for the lower incidence of complete obstruction to the bronchoscopic view. This result was similar to that found by Greenland et al. [1]; however, we had a higher success rate of achieving a totally clear view (80% vs 68.3%). The possibility of either the variation in patient airways (Caucasian vs Asian) or the degree of jaw thrust administered by the two groups of anaesthetic assistants may have influenced the results.

Positioning these airways in the midline is important but there are several features that make this difficult. Both the Berman and Williams intubating airways are latex free and made from polyethylene plastic. The particular plastic used in their construction adds to their structural strength and protects the bronchoscope from damage by the teeth; however, the inflexibility of these devices prevents moulding in the mouth and consequently makes them prone to malpositioning [6]. In addition, these devices may cause dental and soft tissue damage during blind insertion and when excessive jaw thrust is exerted. The smooth outer surface, especially in the presence of loose or missing incisors, may also cause the airways to shift from their original positions during bronchoscopy. Gaps between the teeth may be overcome by placing a dental roll or gauze over the front teeth [6]. However, apart from malpositioning problems, no patients in our series suffered from any dental or soft tissue damage. Given the very similar shape and mould of these two devices there was little difference in the ease of inserting or positioning them in the mouth.

The addition of chin lift and jaw thrust are important manoeuvres to improve further the view with these airways. In anaesthetised patients, muscle tone is reduced and the soft palate, base of the tongue and epiglottis all move towards the posterior pharyngeal wall [7]. Therefore, during oral fibreoptic intubation under general anaesthesia, a skilled assistant is required to maintain jaw thrust, as well as midline positioning of the intubating airway without trauma to the teeth or surrounding soft tissues [6, 8]. Jaw thrust widens the oropharyngeal cavity and opens the laryngeal inlet [9]. However, alone it often fails to produce full airway clearance [8].

Although we attempted to select patients with normal airways on physical assessment such as modified Mallampati scores, it is recognised that there is a low correlation between clinical airway assessment and laryngoscopy grading [10]. In our study, a ‘floppy’ or posteriorly positioned epiglottis was an unexpected finding, which may have caused it partially or completely to obstruct the bronchoscopic view. Of the 38 partial and completely
obstruction of the tracheal tube by the epiglottis was similar for both airways. It was not possible, even with chin lift and jaw thrust, to overcome this problem using either airway. As mentioned previously, these devices may contribute to some down-folding of the epiglottis when the tip of the airway lodges in the vallecula (especially with the long lingual curvature of the Berman Intubating Airway). Given the structure of the Williams Airway Intubator, the tongue would be expected to frequently cause obstruction to the bronchoscopic view, but none of the three cases of complete obstruction with this airway and only one case of partial obstruction was caused by the tongue.

Recently, a study by Stacey et al. [11] compared jaw thrust with direct laryngoscopy as a means for clearing the airway for oral fiberoptic intubation. Based on their shorter bronchoscopy times, they inferred that using direct laryngoscopy may be superior to using airway devices such as the Berman, Williams or Ovassapian intubating airways. However, using a laryngoscope may be difficult in those patients where mouth opening is restricted or limited. Further studies could be undertaken to compare the use of direct laryngoscopy with an oropharyngeal intubating airway for fiberoptic orotracheal intubation using a single operator. Durga and colleagues [8] have also suggested comparing the technique of lingual traction with an intubating airway.

After successful fiberoptic identification of the vocal cords and descent of the scope to the carina is achieved, a smooth advancement of the tracheal tube is often the next challenge. A number of reasons for difficulties with this include floppy epiglottis, mucus, insufficient jaw thrust, obscured vision, narrow passage to the larynx, large glands at the base of the tongue, and inadequate placement of the intubating airway [12]. Asai [9] recommended removing the airway prior to advancement of the tracheal tube to avoid potential obstruction. The Berman Intubating Airway has a longitudinal split whereby it can be removed from the bronchoscope. This is also advantageous as it allows for insertion of larger tracheal tubes sizes than would otherwise be possible. However, to enable a comparison with the Williams Airway Intubator we did not remove the Berman Intubating Airway prior to railroading of the tracheal tube. The Williams Airway Intubator can only be removed after the bronchoscope has been extracted. We found that some manipulation was expected in nearly half the cases when using either the Berman or Williams intubating airways. The ease of intubation in this study was similar to that found by Greenland et al. [1] when the Williams Airway Intubator was compared with the Ovassapian Airway Intubator. Complications such as damage to the tracheal cuff during railroading of the tracheal tube may occur; however, we did not experience this problem in any of our cases.

In summary, while both the Berman Intubating Airway and the Williams Airway Intubator functioned well as conduits for fiberoptic intubation in anaesthetised patients, the Williams Airway Intubator was less likely to present a completely obstructed view which results in failure of the procedure. The Williams Airway Intubator was more likely to provide a totally clear bronchoscopic view of the glottis. The size and longer lingual curvature of the Berman Intubating Airway may have contributed to its lower success rate compared to the Williams Airway Intubator. Despite the open lingual surface of the Williams Airway Intubator, the tongue was not a significant cause of obstruction. For both airways the epiglottis was shown to be a major cause of obstruction to the bronchoscopic view and may be difficult to predict on clinical airway examination. Once a view was obtained, there was no difference in the ability to railroad the tracheal tube, but hold-up of the tube on the initial attempt occurred in nearly half the cases, requiring manipulation of the tracheal tube by withdrawal and rotation 90° anticlockwise.

Studies comparing three different types of oropharyngeal intubating airways have been performed previously [1, 3]. The Berman Intubating Airway has been shown to be better than the Ovassapian Intubating Airway [3]. The Williams Airway Intubator has now been shown to be better than the Berman Intubating Airway as well as the Ovassapian Intubating Airway [1]. This information may aid the use and selection of these devices when fiberoptic intubation in anaesthetised patients is required.

Based on the experienced gained from this study, we would like to propose the following concerning the design of the airways studied:

The inner curvature of the Berman Intubating Airway extends 1–2 cm beyond the main body of the airway and has a tendency to lodge within the vallecula and push the epiglottis backwards against the posterior wall of the pharynx, particularly in the 10-cm airway. To avoid this problem, we feel that this extension of the distal end of the Berman airway should be removed from future designs and that the end of the airway should be at right angles to its distal portion.

The Williams Airway Intubator designer, Dr R. T. Williams (personal communication, 20th October 2005) feels that the open nature of the anterior surface of the Williams Airway is intended to provide maximum manoeuvrability of the bronchoscope and the ability to observe anatomical structures as a guide to the operator’s progress during fiberoptic intubation, while still providing a conduit within the patient’s pharynx for the bronchoscope. While the Berman airway lacks this open nature,
the operator in this study found that both airways usually terminated proximal to the epiglottis and there was sufficient room between exiting the airway and reaching the glottis to manoeuvre the bronchoscope. It would appear therefore that the exposed anterior surface of the Williams Airway is not necessary for bronchoscopic manoeuvrability. However, the ability to observe part of the patient’s airway with the passage of the bronchoscope as well as the ability to grasp the tracheal tube as the Williams Airway is being removed from the patient’s mouth after intubation makes this an advantageous feature of this particular airway.

Both the Berman and the Williams airways are ‘non-dedicated’ airways and, in their current design, do not have a supraglottic cuff, a feature that is incorporated in dedicated airways such as the laryngeal mask. The omission of this cuff allows for a narrow profile for the airway which in turn assists in its insertion, particularly in situations where there is limited mouth opening. The two major drawbacks of not providing for a cuff in their design is that ventilation (both spontaneous and controlled) is not possible during the fibreoptic intubation and that these airways are more prone to shift within the patient’s pharynx than if a supraglottic cuff was present to stabilise their distal section. Consequently, it is essential when using these airways that the assistant both maintains the airway in the midline during the bronchoscopy and provides maximal jaw thrust so that the epiglottis is shifted forwards away from the posterior wall of the pharynx. This may be achieved by the assistant standing to the side of the patient, facing the operator and lifting the jaw upwards with the index fingers behind the angles of the patient’s mandible and simultaneously placing their thumbs on the flange of the airway to stabilise it. We feel that although there are disadvantages to not incorporating a supraglottic cuff, the need for both dedicated and non-dedicated airways during difficult intubations will continue.

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References

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