Comparison of results from novice and trained personnel using the Macintosh laryngoscope, Pentax AWS®, C-MAC™ and Bonfils intubation fibrescope: a manikin study

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INTRODUCTION Indirect laryngoscopes offer improved laryngeal view and higher success rates of intubation, particularly for difficult airways. We hypothesised that: (a) the time required for intubation, overall success rates and ease of intubation with indirect laryngoscopes would be better than with the Macintosh laryngoscope; and (b) novices may achieve higher success rates and intubate faster using indirect laryngoscopes.

METHODS In a cross-sectional observational study, 13 novices and 13 skilled anaesthetists were recruited. Participants were compared when intubating a manikin simulating normal and difficult airway scenarios using the Macintosh laryngoscope, Pentax Airway Scope® (AWS), C-MAC™ and Bonfils intubation fibrescope.

RESULTS There was no significant difference in intubation success rates between the groups. Skilled anaesthetists intubated faster than novices with Pentax AWS in the difficult airway scenario (22 s vs. 33 s, $p = 0.047$). The mean intubation times for C-MAC and Pentax AWS were shorter than for the Macintosh laryngoscope and Bonfils intubation fibrescope in both difficult (C-MAC: 24 s, Pentax AWS: 28 s, Macintosh: 80 s, Bonfils: 61 s; $p < 0.001$) and normal (C-MAC: 17 s, Pentax AWS: 19 s, Macintosh: 39 s, Bonfils: 38 s; $p = 0.002$) airway scenarios.

CONCLUSION We found that intubation success was more than 85% with all indirect laryngoscopes compared to 69% for the Macintosh laryngoscope. Both C-MAC and Pentax AWS achieved faster intubation times compared to the Macintosh laryngoscope and Bonfils intubation fibrescope for both airway scenarios. Skilled anaesthetists were 33% faster than novices when intubating a difficult airway using Pentax AWS.

Keywords: difficult airway, manikin, novice, video laryngoscopy
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INTRODUCTION

Securing the airway with an endotracheal tube has its potential advantages, as it offers protection against aspiration and in the application of assisted or controlled mechanical ventilation as well as positive end expiratory pressure.(1) Direct laryngoscopy using the Macintosh laryngoscope is considered the gold standard for intubation. However, conventional direct laryngoscopy is a difficult skill to acquire and proficiency deteriorates over time if not practised regularly. This issue is compounded by the fact that poorly performed intubation attempts can result in morbidity and mortality either due to direct airway trauma or as a result of the systemic effects of hypoxia.

While no single device is a complete solution to all difficult airway scenarios, multiple intubation tools have been developed and commercialised to facilitate intubation success in difficult airway scenarios. The Glidescope® (Saturn Biomedical System Inc, Burnaby, BC, Canada) was the first commercially available video laryngoscope that became available in 2001. Since then, advances in optical technologies have facilitated the development of several novel indirect or video laryngoscopes. Video laryngoscopes have been proven to improve the view of laryngeal structures, facilitate faster intubation and increase intubation success rates, particularly for difficult airways.(2)

The Pentax Airway Scope® (AWS; Pentax Corporation, Tokyo, Japan) is a handheld rigid video laryngoscope that has a charge-coupled device imaging and light-emitting diode light attached to the tip of its blade. A side channel is incorporated for loading the tracheal tube. Intubation is thus possible by viewing a 2.4-inch liquid crystal display (LCD) monitor, without the need to align the oral, pharyngeal and laryngeal axes.(3) The C-MAC™ (Karl Storz Endoscopy, Tuttlingen, Germany) consists of a laryngoscope that is attached directly to an LCD screen by a cable. Laryngoscopy can then be performed either directly, as with the Macintosh laryngoscope, or indirectly by looking at the monitor.(4) The Bonfils intubation fibrescope (Karl Storz GmbH & Co KG, Tuttlingen, Germany) is a long, slender, cylindrical device with a curved tip. A tracheal tube is loaded onto the shaft of the fibre-optic instrument before the instrument is inserted into the mouth and advanced into the glottis aperture. The tracheal tube is then railroaded into the trachea after identifying the vocal cords.(5)

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Using an indirect laryngoscope requires new skills not traditionally taught in the anaesthesia curriculum, such as eye-hand-brain coordination. A novel study provided some evidence that surgeons who played video games performed better at laparoscopic surgery than those who did not.[6] Anecdotally, it has been observed that senior and experienced practitioners may experience relatively greater difficulty in learning how to use various types of indirect laryngoscopes. While many emerging studies compare direct laryngoscopy with indirect laryngoscopy using various new intubation devices, none has investigated the ability of novice versus skilled anaesthetists to learn and successfully use a variety of airway devices for intubation on a high-fidelity manikin. Hence, we hypothesised that: (a) the time required for intubation would be shorter, the overall success rates better and intubation easier with indirect laryngoscopes than with the Macintosh laryngoscope; and (b) novices might be able to achieve higher success rates and intubate faster using newer indirect laryngoscopes than traditionally trained and more experienced anaesthetists.

METHODS

This was a cross-sectional observational study sponsored by a peer-reviewed enabling grant from Alexandra Health Private Limited (Singapore). Following approval from the institutional review board, informed written consent was obtained from all participants. All the anaesthetists (100%) in the Department of Anaesthesia, Khoo Teck Puat Hospital, Singapore, agreed to participate in the study. Two groups of physicians with different levels of airway management experience were recruited. These included novice anaesthetists of grade medical officer (trainee doctors with less than three years of anaesthesia training) and skilled anaesthetists (experienced anaesthesia specialists with more than three years of conventional anaesthesia training). All participants were recruited from August 2010 to May 2011. Demographic data collected from the participants included age, gender, years of anaesthetic training or experience, prior experience with various airway devices and personal skills such as playing a musical instrument or computer games.

All anaesthetists were assumed to be competent in tracheal intubation using the Macintosh laryngoscope. A standard 15-minute presentation and demonstration were provided for the three indirect laryngoscopes – Pentax AWS, C-MAC and Bonfils intubation fibrescope – which were new to the department. The participants then underwent a practical session and were required to achieve two successful intubations with each airway device on a high-fidelity simulation manikin before the study could commence. The four airway devices used included the Macintosh laryngoscope, Pentax AWS, C-MAC and Bonfils intubation fiberscope. A size 7.5 portex-cuffed endotracheal tube was chosen for all intubations. A disposable intubation stylet was used to aid intubation with the Macintosh laryngoscope and C-MAC. For the Bonfils intubation fibrescope, insertion was done via the midline approach and the view during endotracheal intubation was obtained using the eyepiece of the instrument. A single, high-fidelity simulation manikin, iSTAN® (Medical Education Technology Inc, Sarasota, FL, USA) was used to simulate both normal and difficult airway scenarios. The investigators used both the 'swollen tongue mode' and the 'jaw trismus mode' of the iSTAN manikin to simulate a difficult airway.

Participants consecutively intubated the manikin eight times in no particular order, such that all four airway devices were used once each in both the normal and difficult airway scenarios. Only one attempt per scenario was allowed, and airway manoeuvres such as external laryngeal manipulation to optimise the view of the larynx during intubation attempts were disallowed. Both the participants and the observer of outcomes were unaware of the airway difficulty simulated by the manikin. Blinding to the airway device, however, was not possible. The outcomes observed were time to intubation, success rate of intubation and the subjective ease of intubation as judged by the participants. We defined time to intubation as time in seconds (s) from the time when the manikin's mouth was opened until the time when the cuff of the tube was inflated. A successful attempt was visually confirmed by opening up a window in the neck of the manikin, and a failed attempt was defined as inability to intubate within 180 s, or oesophageal intubation. Participants ranked the ease of intubation for each scenario as follows: grade 1: very easy; grade 2: easy; grade 3: moderate; grade 4: difficult; and grade 5: impossible. Participants were also asked to grade the laryngeal view according to the Cormack and Lehane classification.[7]

According to a similarly designed study by Lim et al, the average time to intubation for a difficult airway was 70.5 s with the Macintosh laryngoscope.[8] The investigators estimated that a sample size of 13 participants per group would be adequate to provide 80% power and show a difference of 15% in the primary outcome of time to intubation. The data for time to intubation were compared using one-way analysis of variance (ANOVA) and post-hoc Bonferroni tests. The data for success of endotracheal intubation were analysed using chi-square test. A p-value < 0.05 was considered to be statistically significant. The data for ease of intubation were analysed using the Friedman and post-hoc Wilcoxon signed-rank tests, with the Bonferroni adjustment, which resulted in the significance level being set at $p < 0.008$. All analyses were performed using the Statistical Package for the Social Sciences for Windows version 19.0 (SPSS Inc, Chicago, IL, USA).

RESULTS

The demographic data of the study participants are presented in Table I. There were more men among the skilled anaesthetists, but fewer participants in this group had skills such as playing musical instruments. The mean times for intubation in a difficult airway scenario with C-MAC (24 ± 14 s) and Pentax AWS (28 ± 14 s) were shorter than that with the Macintosh laryngoscope (80 ± 66 s) and Bonfils intubation fibrescope (61 ± 56 s), ($p < 0.001$). Similarly, intubations in the normal airway scenario with C-MAC (17 ± 5 s) and Pentax AWS (19 ± 6 s) were faster than with the Macintosh laryngoscope (39 ± 34 s) and Bonfils intubation fibrescope (38 ± 42 s), respectively (p = 0.002; Fig. 1).

The mean time to intubation with Pentax AWS was found to be significantly faster for skilled anaesthetists (22.3 ± 12.7 s) when compared to the novice medical officers (33.1 ± 13.5 s) in the difficult airway scenario (p = 0.047). No other differences were observed between novice medical officers and skilled anaesthetists for the other airway devices or scenarios (Table II). There was no significant difference with regard to the success rates of intubation between novice medical officers and skilled anaesthetists (Table III). Both medical officers and skilled anaesthetists had more than 85% success rate for intubation using the indirect laryngoscopes in both the normal and difficult airway scenarios. Success rate for the difficult airway scenario using the Macintosh laryngoscope was only 69% for both groups of anaesthetists.

Data on the ease of intubation for both normal and difficult airway scenarios for the different airway devices are shown in Table IV. There was a statistically significant difference in the ease of intubation depending on which airway device was used in the normal (χ^2 = 34.266, p < 0.001) and difficult (χ^2 = 25.996, p < 0.001) airway scenarios. The ease of intubation was graded least favourably for the Macintosh laryngoscope. There were statistically significant differences when ease of intubation for the Macintosh laryngoscope was compared to the other three indirect laryngoscopes (normal airway scenario: Macintosh vs. C-MAC, p < 0.001; Macintosh vs. Pentax AWS, p < 0.001; Macintosh vs. Bonfils intubation fiberscope, p = 0.001; difficult airway scenario: Macintosh vs. C-MAC, p < 0.001; Macintosh vs. Pentax AWS, p < 0.001; Macintosh vs. Bonfils intubation fiberscope, p = 0.003). There were no significant differences when ease of intubation was compared among the three indirect laryngoscopes.

DISCUSSION

Comparing among the four airway devices, both C-MAC and Pentax AWS achieved faster intubation times than the Macintosh laryngoscope and Bonfils intubation fibrescope in both airway scenarios. The skilled anaesthetists needed a shorter time for intubation when using Pentax AWS in the difficult airway scenario compared to novice medical officers. The success rates of intubation for both groups of anaesthetists when using an indirect laryngoscope were more than 85% in all airway scenarios. However, the success rate was only 69% when using the Macintosh laryngoscope in a difficult airway scenario. Participants also graded ease of intubation more favourably when using the three indirect laryngoscopes than with the Macintosh laryngoscope.

Several recent studies have shown that indirect laryngoscopes fare better than the Macintosh laryngoscope. For instance, Serocki et al found that video-assisted, blade laryngoscopes (Karl Storz, Tuttlingen, Germany) provided significantly better laryngoscopic views than the Macintosh laryngoscope.[4] Liu et al found that Pentax AWS was a superior airway device for difficult intubation by inexperienced personnel in a manikin-simulated scenario.[9] Malik et al also concurred that Pentax AWS provided novices with better intubation conditions, resulting in greater success rates than the Macintosh laryngoscope.[3] Our data support the findings that mean intubation times were shorter for Pentax AWS and C-MAC in any given airway scenario compared to the Macintosh laryngoscope, as the success rate of intubation in the difficult airway scenario was more than 85% even for novice medical officers when using an indirect laryngoscope. Indirect laryngoscopes facilitated the ease of intubation and obtained more favourable subjective scores from the participants.

Table I. Demographics of the study participants.

Demographic	No. (%)		p-value
	Skilled anaesthetists (n = 13)	Medical officers (n = 13)	
Age* (yrs)	42 ± 12	27 ± 1	< 0.001
Experience* (yrs)	14 ± 11	1 ± 1	< 0.001
Gender			
Male	10 (76.9)	5 (38.5)	0.047
Female	3 (23.1)	8 (61.5)	
Other skills involving eye-hand-brain coordination			
Playing computer games	2 (15.4)	5 (38.5)	0.185
Playing musical instruments	5 (38.5)	10 (76.9)	0.047

*Data is presented as mean ± standard deviation.

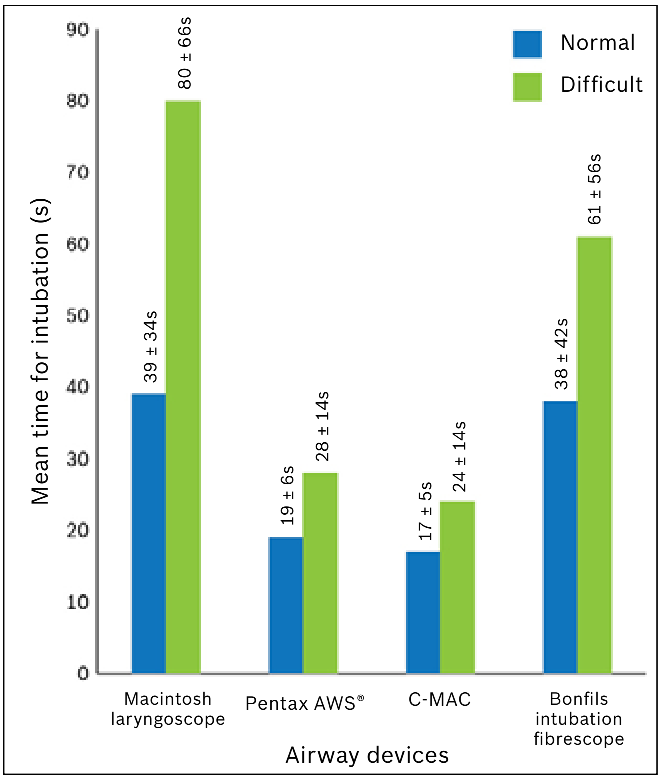

Fig. 1 Graph shows the mean times taken for intubation using the different airway devices in normal and difficult airway scenarios. C-MAC™ and Pentax AWS® were faster than Macintosh laryngoscope and Bonfils intubation fibrescope in normal (p = 0.002) and difficult (p < 0.001) airway scenarios.

Table II. Intubation time for skilled anaesthetists and novice medical officers using the different airway devices.

Airway device	Airway scenario	Intubation time taken* (s)		p-value
		Skilled anaesthetists	Medical officers	
Macintosh laryngoscope	Normal	36.4 ± 20.5	42.1 ± 44.3	0.681
	Difficult	81.2 ± 70.6	78.7 ± 63.0	0.925
Pentax AWS	Normal	18.5 ± 5.1	18.6 ± 7.7	0.974
	Difficult	22.3 ± 12.7	33.1 ± 13.5	0.047†
C-MAC	Normal	17.0 ± 4.4	17.4 ± 6.5	0.833
	Difficult	25.6 ± 14.9	21.8 ± 13.2	0.502
Bonfils intubation fibrescope	Normal	50.8 ± 50.2	25.8 ± 28.0	0.129
	Difficult	53.2 ± 40.8	68.1 ± 67.0	0.501

*Data is presented as mean ± standard deviation. †$p < 0.05$ was statistically significant.

Table III. Success rates of intubation for skilled anaesthetists and medical officers using the different airway devices.

Airway device	Airway scenario	Success rate*		p-value
		Skilled anaesthetists	Medical officers	
Macintosh laryngoscope	Normal	12 (92.3)	12 (92.3)	1.000
	Difficult	9 (69.2)	9 (69.2)	1.000
Pentax AWS	Normal	13 (100)	13 (100)	1.000
	Difficult	13 (100)	13 (100)	1.000
C-MAC	Normal	13 (100)	13 (100)	1.000
	Difficult	13 (100)	13 (100)	1.000
Bonfils intubation fibrescope	Normal	12 (92.3)	13 (100)	0.308
	Difficult	13 (100)	11 (84.6)	0.141

*Data is presented as number of participants (%).

Piepho et al found, in an airway manikin study, that the Bonfils intubation fibrescope could be used successfully even by physicians unfamiliar with the technique.[5] In contrast with the study by Piepho et al, our study showed a disparity between the intubation times observed with the Bonfils intubation fibrescope and the other video laryngoscopes. In the study by Piepho et al,[5] 30 physicians who were untrained in the use of rigid fibrescopes took 20–25 s to intubate a SimMan airway manikin simulating two difficult airway scenarios with the 'tongue oedema' and 'decreased cervical range of motion with jaw trismus' modes. In our study, however, medical officers required a mean time of 68.1 ± 67.0 s while skilled anaesthetists needed a mean time of 53.2 ± 40.8 s to intubate a simulated difficult airway using the Bonfils intubation fibrescope. The reasons for a longer time for intubation in our study might include the use of a different airway manikin as well as the use of the 'swollen tongue' and 'jaw trismus' modes concurrently, possibly resulting in a more difficult airway. Interestingly, Halligan and Charters, who studied the learning curve of the Bonfils intubation fibrescope, showed that a novice would take a longer time to intubate a patient using the Bonfils intubation fibrescope.[10] The results of this study suggested that an anaesthetist would become proficient only after 20–25 intubations. It is therefore likely that the Bonfils intubation fibrescope may have a steeper learning curve compared to the other indirect laryngoscopes.

When results were compared between skilled and novice anaesthetists, significantly shorter intubating times in the difficult airway scenario with Pentax AWS were only seen for skilled anaesthetists. There was also no significant difference when the success rates were compared between the two groups of anaesthetists. A cut-off of three years of experience was chosen in our study, as this is the transition period in which a novice medical officer becomes a specialist anaesthetist. In contrast to our study, which involved medical officers with prior experience in intubation, some other airway studies involving manikins have recruited medical students as novices.[3,9] Our selection criteria might have contributed to the lack of difference observed between the intubation times and success rates of the two groups of anaesthetists.

Table IV. Ease of intubation in the normal and difficult airway scenarios using the different airway devices.

Airway device	Grade of ease of intubation*	
	Normal airway scenario	Difficult airway scenario
Macintosh laryngoscope	3 (3–4)	4 (3–5)
Pentax AWS	2 (2–2)†	2 (2–3)†
C-MAC	2 (1–2)†	2 (2–3)†
Bonfils intubation fibrescope	2 (2–3)†	3 (2–4)†

*Data is presented as median (interquartile range).
†Friedman test $p < 0.001$ for both normal and difficult airways. Post hoc test $p < 0.008$ for both normal and difficult airways, when ease of intubation for the Macintosh laryngoscope was compared with the other three indirect laryngoscopes.

In our study, we hypothesised that novices may have a higher success rate and intubate faster using indirect laryngoscopes, especially the Bonfils intubation fibrescope where the intubation technique is significantly different from conventional direct laryngoscopy. We postulated that this could be due to greater exposure to video games and musical instruments, leading to better eye-hand-brain coordination in younger anaesthetists. Although our results did not reach statistical difference, there was a trend for skilled anaesthetists to take a longer time than novice medical officers when using the Bonfils intubation fibrescope in a normal airway scenario (50.8 ± 50.2 s vs. 25.8 ± 28.0 s, $p = 0.129$). A larger sample size may be required to arrive at a statistically significant difference between novice and skilled anaesthetists in the use of the Bonfils intubation fibrescope.

Difficult airway situations are a culmination of different anatomical and pathological conditions. Manikin studies have limitations and may not entirely simulate the exact conditions of a difficult situation in an emergency real-life scenario, as shown in a recent study by Schebesta et al, which found major differences in the airway anatomy of manikins and actual patients.[11] In the study, computed tomography imaging was used to compare the upper airways of manikins and real patients. The authors found a larger pharyngeal airspace in all the manikins and high-fidelity patient simulators studied, possibly leading to easier intubating conditions in manikin studies. Given this recent finding, clinical studies in real airway scenarios may be necessary to confirm our findings. However, ethical and logistic considerations are likely to render such endeavours prohibitive.

In conclusion, the Macintosh laryngoscope is still the most widely used intubation device today, and trainee doctors in anaesthesia are still taught how to use the Macintosh laryngoscope as the airway management tool of choice. In our study, the time taken for intubation was found to be shorter with C-MAC and Pentax AWS when compared to the Macintosh laryngoscope and Bonfils intubation fibrescope in both the normal and difficult airway scenarios. We found that after a teaching session and familiarisation with new airway devices, novices were equally successful at intubation attempts as skilled anaesthetists, even in difficult airway scenarios. Intubation success was more than 85% with all indirect laryngoscopes, compared to only 69% for the Macintosh laryngoscope. The indirect laryngoscopes were favoured by the participants for their ease of achieving intubation compared to the Macintosh laryngoscope. Thus, we recommend that training in airway management should include the use of indirect laryngoscopes in addition to the conventional Macintosh laryngoscope. In areas where the intubation of patients may be carried out by less experienced first-line medical practitioners, video laryngoscopes may increase the speed and rate of successful intubation, especially in difficult airway situations.

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