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APPARATUS

Evaluation of four airway training manikins as patient simulators for the insertion of eight types of supraglottic airway devices*

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Summary

We evaluated the performance of four currently available manikins: Airway Management Trainer^{TM} (Ambu, UK), Airway Trainer^{TM} (Laerdal, Norway), Airsim^{TM} (Trucorp, Ireland), 'Bill 1'^{TM} (VBM, Germany), with eight supraglottic airway devices: Airway Management Device^{TM}, Cobra Perilaryngeal Airway, Combitube^{TM}, i-Gel, Laryngeal Tube®, Laryngeal Tube Disposable, Laryngeal Tube Suction II and Streamlined Liner of the Pharynx Airway. Ten anaesthetists inserted each supraglottic airway device twice into each manikin. Each insertion was scored and ranked. Manikin score and rank data showed statistically significant overall performance differences. Post hoc analysis showed the Trucorp manikin performed best, followed by the Laerdal manikin. No one manikin performed best for all individual supraglottic airway devices. The Trucorp manikin performed adequately for all supraglottic airway devices. Comparing supraglottic airway devices, i-Gel insertion was significantly the easiest. Our results show that manikin performance for supraglottic airway device insertion is unequal, which has implications for selecting manikins for supraglottic airway device training and for manikin studies assessing performance of supraglottic airway devices.

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Anaesthesia and cardiopulmonary resuscitation may now be performed with a variety of supraglottic airway devices (SADs) [1, 2]. Manikins are used for practical training in the use of SADs and also for studying the performance of new and existing SADs. Many manikins have traditionally been designed for practising facemask ventilation and/or tracheal intubation. More recently, several new manikins have been developed to assist in the training of SAD use. We are not aware of any study that validates the performance of the manikins used for these tasks or examines performance differences between manikins.

We therefore evaluated four currently available manikins to determine whether they performed adequately as patient simulators for teaching insertion of currently available SADs [3] and to compare their performance.

The study aims were to determine (1) which manikin performs best for all eight SADs, (2) which manikin is best for each individual SAD and (3) to compare the performance of individual SADs in all the manikins.

Methods

The study was approved by the Local Research and Ethics Committee and each voluntary participant gave written consent.

We evaluated the following manikins: The Airway Management Trainer^{TM}, The Airway Trainer^{TM}, Airsim^{TM} and 'Bill 1'^{TM}. These are referred to by their manufacturer (i.e. Ambu, Laerdal, Trucorp, and VBM). Each manikin studied was designed for laryngeal mask and SAD insertion and was the latest version available in March 2006 (Fig. 1, Table 1).

The eight SADs are Airway Management Device^{TM} (AMD^{TM}) (Nagor Limited, Isle of Man; manufactured by

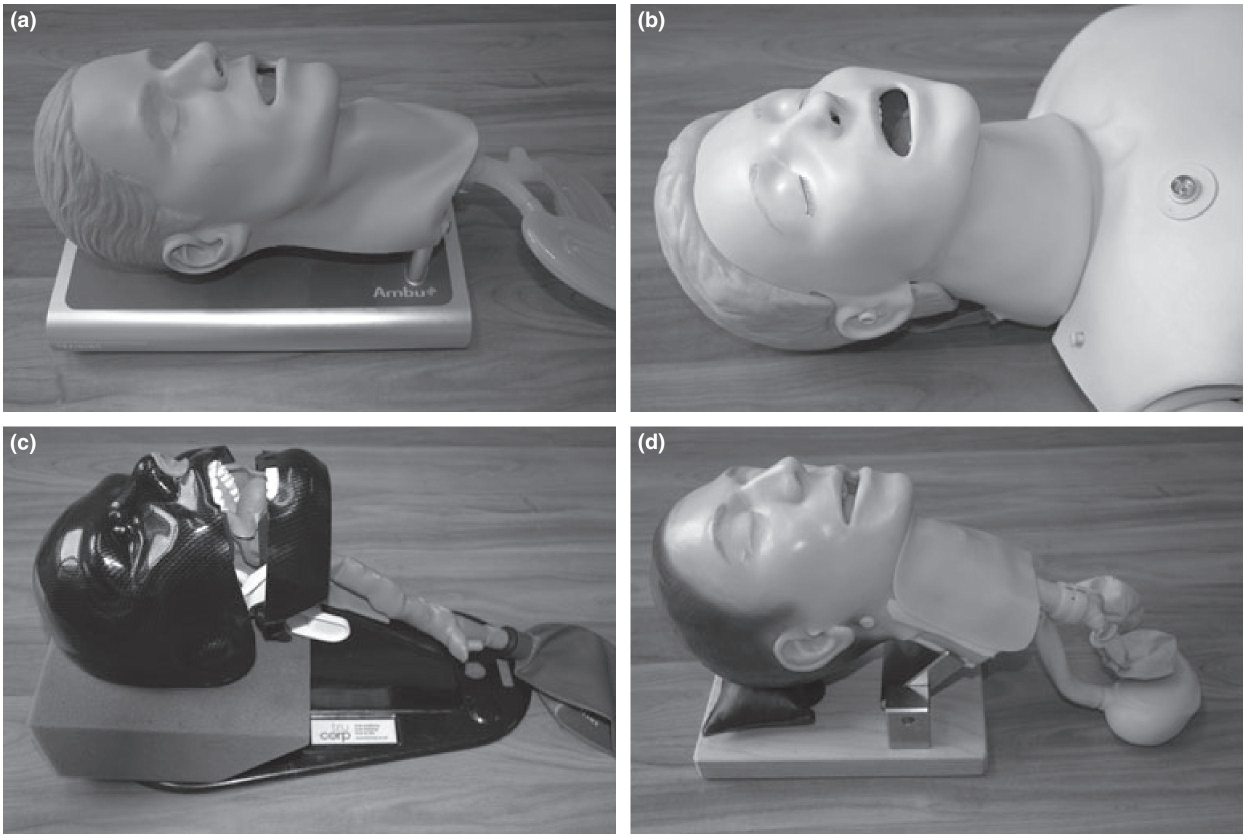

Figure 1 Airway manikins used for inserting the SADs. (a) Airway Management Trainer, Ambu, UK. (b) Airway Trainer, Laerdal, Norway. (c) Airsim, Trucorp, Ireland. (d) 'Bill 1', VBM, Germany.

Table 1 Details of airway manikins used for inserting SADs.

	Airway Management Trainer	**Airway Trainer**	**Airsim**	**'Bill 1' Airway Management Simulator**
Date released	February 2005	December 2004*	March 2005	December 2004
Manufacturer	Ambu Ltd. Burrel Road, St Ives, Cambridgeshire PE27 3LE, UK	Laerdal Medical, Stavanger, Norway	Trucorp Ltd, Whitla Medical Building, 97 Lisburn Road, Belfast BT9 6JQ, UK	VBM Medizintecknik GmbH, Einsteinstrasse 1, D-72172 Sulz a.N., Germany
Approximate cost; £ (€)	600 (871)	600 (871) ⁄ 800 (1162)†	1200 (1743)	1250 (1816)

*Resusci-Anne head released as prototype.
†For head to attach to existing Resusci-Anne manikin ⁄ for head with electronic sensors for use with recording Resusci-Anne manikin.

Biosil Ltd, Cumbernauld, UK), Cobra Perilaryngeal Airway (CobraPLA™) (Engineered Medical Systems, Indianapolis, IN), Combitube™ (Kendall-Sheridan, Argyll, NY), i-Gel (Intersurgical, Wokingham, UK), Laryngeal Tube® (LT), Laryngeal Tube Disposable (LTD), Laryngeal Tube Suction II (LTS II) (all VBM GmbH Sulz, Germany) and the Streamlined Liner of the Pharynx Airway (SLIPA™) (Hudson RCI, Temecula, CA) (Fig. 2). Each device was the newest version of the device available in March 2006.

Before starting the study we inserted all available adult sizes of the SAD into each manikin several times to determine the correct size of device to be used. The 'best fit' of each SAD for each manikin is listed in Table 2.

We determined each volunteer's experience with each device prior to its use (Table 3). Each volunteer was given verbal instruction and practical demonstration of technique of insertion for each SAD that they were unfamiliar with, prior to evaluation. The order of manikin and SAD use was randomised by picking names from a hat.

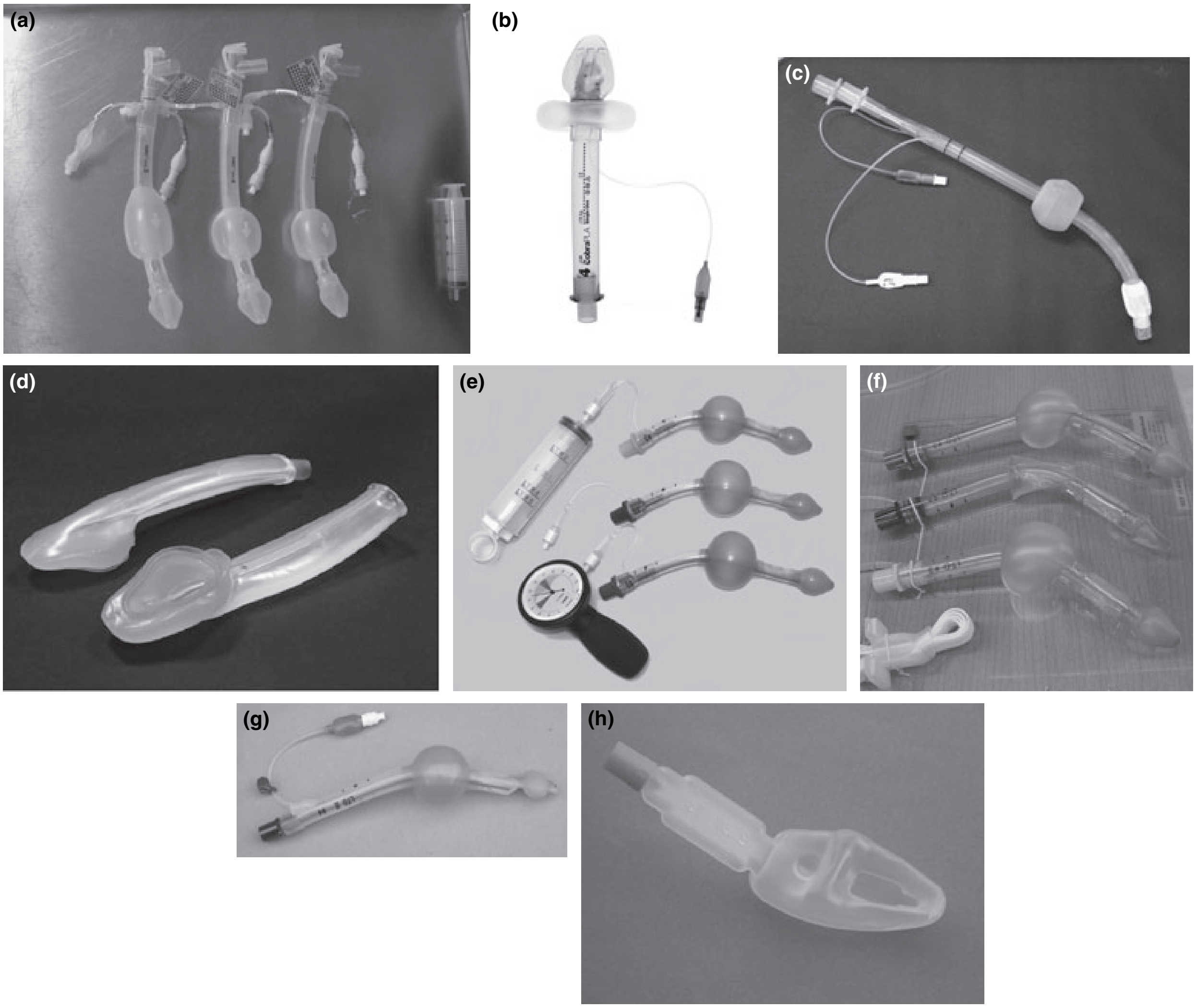

Figure 2 Supraglottic airway devices. (a) AMD. (b) CobraPLA. (c) Combitube. (d) i-Gel. (e) Laryngeal Tube. (f) Laryngeal Tube Disposable. (g) Laryngeal Tube Suction II. (h) SLIPA.

Table 2 Sizes of SADs used in the four manikins.

	Ambu	Laerdal	Trucorp	VBM
AMD	3–3.5	3–3.5	3–3.5	3–3.5
CobraPLA	3	4	3	3
Combitube	SA 37F	SA 37F	SA 37F	SA 37F
i-Gel	3	4	4	4
LT	5	5	5	4
LTD	5	5	5	4
LTS II	5	5	5	4
SLIPA	51	55	49	51

Ten volunteer anaesthetists inserted each SAD into all four manikins in a random order, twice. For each insertion, both the SAD and the manikin were well lubricated according to the manufacturer's instructions.

Table 3 Experience of anaesthetists in using SADs prior to the study.

No. of insertions	AMD	CobraPLA	Combi Tube	i-Gel	LT	LTD	LTS II	SLIPA
None	70%	90%	50%	100%	60%	90%	80%	100%
<10	10%	10%	40%	0%	30%	10%	10%	0%
10–20	10%	0%	0%	0%	0%	0%	0%	0%
>20	10%	0%	10%	0%	10%	0%	10%	0%

Each insertion was scored by the volunteer (SCORE data). A score of zero indicates worst performance and the highest score achievable for each insertion is 5 (Table 4). After inserting the SAD into each manikin twice, the volunteer ranked the manikins for that specific device

Table 4 Scoring system used to assess each insertion of SAD. Minimum and maximum scores are 0 and 5.

	2 points	1 point	0 points
Ease of insertion	Easy	Difficult	Impossible
Definite end point to insertion	–	Yes	No
Device remained in midline after deployment	–	Yes	No
Able to ventilate	–	Yes	No

(RANK data, 1, 2, 3, 4); 1 indicates best performance and 4 worst performance. This process was repeated for the other seven SADs.

Comments about performance of the manikins were recorded. These were assessed as 'positive', 'negative' or 'neutral' about a given manikin.

Friedman ANOVA compared score and rank data. Post hoc analysis used Wilcoxon signed rank test. The p value was corrected for multiple comparisons. Differences were considered significant where corrected p was < 0.05.

Results

Overall performance of manikins for all eight SADs

There were statistically significant performance differences between manikins (Friedman ANOVA analysis SCORE $p < 0.0001$, RANK $p < 0.0001$). Post hoc analysis of SCORE and RANK data showed significant differences between the four manikins (Table 5).

The results of both SCORE and RANK data rate the Trucorp manikin as performing significantly better than all other manikins. The Laerdal manikin scored and ranked higher than the VBM and Ambu manikins without differences in performance being consistently significantly better. The VBM and Ambu manikins performed less well than the Trucorp and Laerdal manikins. Differences between the VBM and Ambu manikins were inconsistent and did not reach statistical significance.

Table 6 Performance of individual SADs in each manikin.

	SCORE scores	RANK scores
AMD	T > L and A > V	T > L and A and V; L > V
CobraPLA	No significant differences	T and V > A
Combitube	T > V > A; L > A	T > A and V; V and L > A
i-Gel	No significant differences	No significant differences
LT	T > V and A; L > V	T and L > V and A
LTD	T > V and A; L > A	T and L > A and V
LTS II	T > A and V;	V and A > l
SLIPA	T, A, V all > l	T, A, V all > l

Statistically significant results only (Friedman ANOVA p < 0.05 for that SAD and post hoc Wilcoxon Rank corrected p < 0.05).
A = Ambu, L = Laerdal, T = Trucorp, V = VBM.
A > B indicates manikin A performed statistically significantly better than manikin B.
Friedman ANOVA for p < 0.0001.
Post hoc analysis i-Gel vs each other SAD corrected p < 0.05.

Performance of manikins with individual SADs

We assessed the performance of each SAD in each manikin. Significant performance differences were noted for all of the SADs (Table 6) but the findings were not consistent, i.e. it was not always the same manikin that performed best for each SAD. The Trucorp manikin performed best for SCORE (objective) data for all devices except CobraPLA^{TM} and i-Gel and for RANK (subjective) data except LTS II and i-Gel. Individual SAD performance comparisons that reached statistical significance are presented in Table 6. Summarising this data, the Trucorp manikin performs best using both SCORE and RANK data.

Performance of individual SADs

Table 7 records the sum of the SCORE data scores for each SAD in all manikins. A device that is easily and effectively placed in each manikin will score highest (maximum achievable = 400). The i-Gel scored highest (95% of maximum) and the SLIPA lowest (71% of maximum). ANOVA analysis showed statistically significant differences in summed scores for the devices. Interpretation of post hoc analysis was complex, with 28 post hoc

Table 5 Overall performance of each manikin for all the SADs investigated.

	Ambu (A)	Laerdal (L)	Trucorp (T)	VBM (V)
Mean of SCORES	3.8	4.1	4.5	3.7
Median of SCORES	4 (3–5 [0–5])	4 (3–5 [0–5])	5 (4–5 [0–5])	4 (3–5 [0–5])
Median of RANKS	3 (2–4 [1–4])	2 (2–4 [1–4])	1 (1–3 [1–4])	2.5 (2–3 [1–4])

(interquartile range), [range].
Friedman ANOVA for SCORES p < 0.0001. Post hoc analysis of SCORES T vs V, T vs A, T vs L all p = 0.006. L vs V p = 0.024
Friedman ANOVA for RANKS p < 0.0001. Post hoc analysis of RANKS T vs V, T vs A, T vs L all p = 0.006. V vs A p = 0.003.

Table 7 Sums of SCORE data for each SAD.

	Device							
	AMD	CobraPLA	Combitube	i-Gel	LT	LTD	LTS II	SLIPA
Score	295	333	289	380	331	320	345	281

comparisons, requiring a 28-fold multiplication of p before considering significance. The notable feature was that the i-Gel scored statistically significantly higher than all other devices (Wilcoxon rank test, corrected $p < 0.05$ for comparison with each other SAD). This reflected our clinical observations with the i-Gel being easily deployed in all manikins.

Discussion

This study has shown that manikin performance for SAD insertion is unequal. For a department wishing to use a single manikin for training with these eight SADs, the Trucorp Airsim manikin performed best in terms of objective performance and when ranked by volunteers. The Laerdal Airway Trainer also performed significantly better than the VBM and Ambu manikins. Determining this was the primary goal of our study.

However, we have also been able to examine the performance of each SAD in each manikin. This has allowed us to determine which manikin is 'most suited' to a particular SAD. This may have relevance when choosing a manikin to teach with a specific SAD, for instance the Laerdal manikin, though performing well with all other devices performed particularly poorly with the SLIPA. Data on individual SADS may also be useful when designing and interpreting manikin studies. This information will allow researchers to choose a manikin that is appropriate for studying the SAD or SADs they wish to investigate. Understanding which devices perform well or poorly in which manikin, also allows clearer interpretation of manikin studies comparing more than one different SAD.

Finally, we have been able to examine the relative performance of each SAD. We have found that the i-Gel performed significantly better than all other SADs. The i-Gel is a new airway device manufactured from a soft plastic polymer and has an inbuilt drainage tube and bite block. There is no cuff to inflate, it just requires lubrication on all surfaces and is ready for insertion. Whether this performance is replicated in patients requires further study.

The Trucorp manikin performed adequately for all SADs and was the best manikin for several individual SADs. There was subjective observation and some evidence (Table 5) to suggest that the stiffer SADS (e.g. the Combitube and the CobraPLA) were more easily inserted into the Ambu and VBM manikins than the more flexible SADs.

We have collected and reported data as objectively as possible; however, it was notable that volunteers did comment on each manikin. More negative comments were made about the performance of the VBM, Ambu and Laerdal manikins than about the Trucorp manikin. Problems with the VBM manikin included the rigidity of the airway, leading to difficulty inserting some of the more flexible SADs, and the lack of a distinct end point, leading to insertion of devices too far. There were similar complaints regarding the rigidity of the Ambu manikin and the combination of prominent teeth and stiff 'skin' also make mouth opening difficult in this manikin. The sagittal split of the Ambu manikin is useful for examining device position but can allow significant airway leaks, cuff herniation or even device misplacement outside the airway. The oral cavity of the Laerdal manikin was notably larger than the other manikins, which assists easy insertion of the SADs but may on occasion lack verisimilitude or lead to airway leaks during attempted ventilation. The Trucorp is the least lifelike in appearance of all the manikins.

There are several caveats to these findings. Firstly, although we used the most recent versions available for the manikins, they may have been modified further since our study was conducted in March 2006. Secondly, we have evaluated only one of each manikin: there may variations between individual manikins of the same type despite originating from the same production line and we have not examined this. Neither have we examined consistency of manikin performance over a prolonged period or durability of the manikins. Thirdly, despite concluding that the Trucorp manikin performed better than the other manikins for insertion of these SADS, we have not performed any comparison of cost (Table 1) or other features which may affect a department's choice. Finally, we have compared how these devices perform with each manikin. This does not equate to determining how each device performs in human subjects. Clinical observation suggests that most airway devices are easier to deploy in humans than in most simulators.

Our previous study examining these four manikins for LMA Classic™ (Intavent Orthofix) insertion showed similar results, with Airsim (Trucorp) performing best [4]. With this study we can now conclude that Trucorp's Airsim and Laerdal's Airway Trainer are suitable for use for a wide variety of SADs.

Acknowledgements

This study was supported by a grant from the Difficult Airway Society, which purchased two of the manikins (VBM and Ambu). The manikin from Trucorp was donated to the study and that from Laerdal loaned for the period of the study. TMC has participated in informal evaluation of Laerdal equipment for the company. He has also received payment for lecturing from Intavent Orthofix and the LMA Company, both of which manufacture laryngeal mask airways. All SADs used in the study were donated by their manufacturers either free of charge or at cost price.

References

1 Cook TM, Hommers C. New airways for resuscitation? *Resuscitation* 2006; **69**: 371–87.

2 European Resuscitation Council. European Resuscitation Council Guidelines for Resuscitation 2005. Section 4: Adult Advanced Life Support. *Resuscitation* 2005; **67**: S39–86.

3 Cook TM. Spoilt for choice? New supraglottic airways. *Anaesthesia* 2003; **58**: 107–10.

4 Silsby J, Jordan G, Bayley G, Cook TM. Evaluation of four airway training manikins as simulators for inserting the LMA Classic^{TM}. *Anaesthesia* 2006; **61**: 576–9.