Comparison of the laryngoscopy views with the size 1 Miller and Macintosh laryngoscope blades lifting the epiglottis or the base of the tongue in infants and children <2 yr of age†

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Editor’s key points
- There are few data comparing the Miller and Macintosh (MAC) laryngoscope blades in children aged <2 yr.
- In this study, similar views at laryngoscopy could be obtained with Miller and MAC size 1 blades.
- The views with the Miller blade were similar when placed under the epiglottis or into the vallecula.
- Views with the MAC blade were better when placed into the vallecula compared with under the epiglottis.

Background. Miller laryngoscope blades are preferred for laryngoscopy in infants and children <2 yr of age. Despite their long history, the laryngeal view with the Miller blade size 1 has never been compared with that with the Macintosh (MAC) blade in children. This prospective, single-blinded, randomized study was designed to compare the laryngeal views with the size 1 Miller and MAC blades in children <2 yr.

Methods. With IRB approval, 50 ASA I and II children <2 yr undergoing elective surgery were enrolled. After an inhalation induction and neuromuscular block with i.v. rocuronium 0.5 mg kg⁻¹, two laryngeal views were obtained with a single blade (Miller or MAC) in each child: one lifting the epiglottis and another lifting the tongue base. The best laryngeal views in each blade position were photographed with a SONY® Cyber-shot camera and rated by a blinded anaesthesiologist using the percentage of glottic opening scale.

Results. The scores with the Miller blade lifting the epiglottis and the MAC blade lifting the base tongue were similar. The scores with the Miller blade lifting the epiglottis and the tongue base were similar. The scores for the MAC blade lifting the tongue base were greater than those lifting the epiglottis (95% confidence interval: 7.6–26.8) (P=0.0004).

Conclusions. In infants and children <2 yr of age, optimal laryngeal views may be obtained with either the Miller size 1 blade lifting the epiglottis or with the Miller or MAC blades lifting the tongue base.

Clinical trial registration. NCT01717872 at Clinical Trials.gov.

Keywords: age groups; child, infant; equipment, laryngoscopes; larynx, laryngoscopy

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The Miller (straight) laryngoscope blade is regarded as the preferred blade to expose the laryngeal inlet in infants and children during tracheal intubation.¹⁻³ The reasons for the blade’s popularity include the belief that the Miller blade provides a superior view of the laryngeal inlet [compared with the Macintosh (MAC) (curved) blade], effectively displaces the tongue to the left of the blade, and lifts the long and floppy epiglottis out of view during laryngoscopy.¹ In contrast, Macintosh⁴ advocated his blade for use in children, not so much because of its unique physical characteristics (e.g. its curve), but because of the technique that he advocated to expose the laryngeal inlet.⁵ He advocated inserting the blunt tip of the MAC blade into the vallecula and depressing the hyoepiglottic ligament. This manoeuvre flips the epiglottis upwards, exposing the laryngeal inlet to facilitate tracheal intubation. Those who advocate Macintosh’s approach argue that his blade reliably exposes the laryngeal inlet without traumatizing the under surface of the epiglottis and without the often difficult challenge of lifting the floppy epiglottis in infants. In addition, they maintain that using the MAC blade is less stimulating than the Miller blade since the former is inserted into the vallecula stimulating the glossopharyngeal nerve, whereas the latter lifts the epiglottis from its under surface, stimulating the recurrent laryngeal nerve. Furthermore, some have modified the...
practices recommended by Miller and Macintosh by advocating that the Miller blade may be inserted into the vallecula, pressing on the hyoepiglottic ligament to lift the tongue base\(^6\) to expose the laryngeal inlet. Others recommend inserting the MAC blade under the epiglottis and lifting the latter. However, none of these approaches has been evaluated in a systematic manner.

Despite the widespread use of Miller blades in paediatric anaesthesia, there is a dearth of evidence to support the superiority of the Miller blade to expose the laryngeal inlet compared with the MAC blade or other blades in this age group.\(^2\)\(^\text{6}^\text{7}\) Therefore, we designed this prospective randomized study with the null hypothesis that the laryngeal views with the Miller and MAC size 1 blades in infants and children \(<2\) yr of age are the same. The primary hypothesis was to compare the POGO (percentage of glottic opening)\(^8\)\(^9\) score from the Miller size 1 blade directly lifting the epiglottis from the under surface with the score from the MAC size 1 blade lifting the tongue base (by pressing on the hyoepiglottic ligament). The secondary hypothesis was to compare the POGO scores for each blade directly lifting the epiglottis and lifting the tongue base.

**Methods**

After ethics approval from the Children and Youth Institutional Review Board at the Women and Children’s Hospital of Buffalo, informed written consent was obtained from the parents of 50 infants and children undergoing elective surgery. In approving this study, the review board restricted the protocol to taking two views of the larynx in each child, but only with the same laryngoscope blade. This study followed the Ethical Principles for Medical Research Involving Human Subjects as outlined in the Declaration of Helsinki. This trial was registered at Clinical-Trials.gov: NCT01717872.

Children were included if they were ASA physical status I or II, \(<2\) yr of age, undergoing elective surgery, and unpremedicated. Children were excluded if there was a known history of a difficult airway (failed laryngoscopy or intubation), a history of asthma, prematurity (gestational age \(<37\) weeks at birth), neonatal intensive care unit stay for more than a week after delivery, or a history of acute or chronic pulmonary or neuromuscular diseases.

Children were randomized using www.stattrek.com into two groups of equal size to undergo laryngoscopy using either a Miller or MAC laryngoscope blade. The randomization assignment was stored in opaque and sealed envelopes. When the child arrived in the operating theatre, the randomization envelope was opened to reveal the blade that would be used.

Once standard monitors were applied, baseline data were obtained. Anaesthesia was induced with nitrous oxide (66%) and oxygen (33%), followed by sevoflurane (8%) while maintaining spontaneous respiration. After i.v. access was established, rocuronium 0.5 mg kg\(^{-1}\) was administered. The lungs were ventilated by a mask using 100% oxygen and sevoflurane. After 3 min, laryngoscopy was performed with the assigned blade (Miller or MAC size 1 blade) inserted into the mouth at the right commissure, sweeping the entire tongue to the left of the blade (Fig. 1A and B). The Miller blade size 1 was manufactured by Karl Storz, Tuttingen, Germany. The MAC blade size 1 was manufactured by Medline Industries Inc., Mundelein, IL, USA. All laryngoscopies were performed by the same paediatric anaesthesia fellow (Y.P.). The laryngeal view was optimized by positioning the head and by applying external pressure to the larynx until the best view was achieved. Two laryngeal views were obtained with the same blade in each child, one by directly lifting the epiglottis from the under surface and one lifting the tongue base (by pressing the hyoepiglottic ligament). The order of the views (lifting the epiglottis or the tongue base) was determined by a flip of the coin by the laryngoscopist immediately before laryngoscopy. The laryngeal views were photographed by a second anaesthesiologist using a SONY\(^\text{®}\) Cyber-shot camera in the Macro mode with autofocus and without zooming (SONY Corp., Japan). The camera was first positioned near the angle of the mouth to the right of the laryngoscope handle and then optimized to capture the best possible view of the larynx.

Patient data collected included the child’s age and weight and the type of surgical procedure. The time intervals from administration of rocuronium until the first laryngeal view, from the first to second view, and from second view to tracheal intubation were recorded. Heart rate, non-invasive systolic arterial pressure, and oxyhemoglobin saturation were recorded.
every minute for 5 min after administration of rocuronium. The number of attempts at tracheal intubation and all complications incurred during the study period were recorded.

Upon completion of the study, the digital photographs were coded to remove any identifiers of the blade and randomized using www.stattrek.com. A third (blinded) anaesthetist (M.M.) reviewed the randomized digital photos estimating the POGO score. This anaesthetist was blinded to the study by ensuring he remained unaware of the hypothesis of the study, unaware of the outcome variables of the study, and unaware of which blade was used in each photo by removing all identifiers of the blade from the photos and by randomizing the order of the photos he reviewed. A full view of the laryngeal inlet was a POGO score of 100. The span of the vocal cords from the anterior commissure to the posterior aspect at the interarytenoid notch was divided into five equal parts of 20% each for the purpose of the posterior aspect of the study, assessing the order of the photos he reviewed. The intra- and inter-rater reliability of the POGO scores have been evaluated to be very good. The blinded anaesthetist was apprised of the hypothesis and outcomes of the study only after all of the data were analysed and finalized.

To estimate the sample size, we assumed a difference of 25 points in the POGO scores between the two blades would hold clinical relevance. We also assumed the standard deviation in the POGO scores in the two groups of 25 points. These assumptions, together with a two-tailed $\alpha$ of 0.05 and $\beta$ of 0.2, yielded a sample size of 15 children in each group. To account for photographic difficulties, unreadable photos, and dropouts, we enrolled 25 children in each group.

For the primary hypothesis of the study, the POGO scores from the Miller size 1 blade lifting the epiglottis and the MAC size 1 blade lifting the base of the tongue were compared using the Mann–Whitney U-test. For the secondary hypothesis, the POGO scores for the Miller and MAC blades lifting the epiglottis and the tongue base within subjects were compared using the Wilcoxon paired rank-sum test. Data whose distribution deviated from normality (Kolmogorov–Smirnov test) are presented as medians and ranges and analysed using the above tests. Data that were normally distributed are presented as means and standard deviations, and were analysed using Student’s $t$-test. $P<0.05$ for two-tailed testing was accepted. Data were analysed on an intention-to-treat basis.

**Results**

A total of 50 children were enrolled and completed the study (Fig. 2). Patient characteristics and surgical procedures for the two groups were comparable (Table 1). The laryngoscopist experienced no difficulty in visualizing the larynx in any child.

The POGO scores for the Miller size 1 blade lifting the epiglottis and the MAC size 1 blade lifting the tongue base were similar (Fig. 3). The POGO scores for the Miller blade lifting the epiglottis and the tongue base were also similar (Fig. 3). In contrast, the POGO scores for the MAC blade lifting the tongue base were greater than the scores lifting the epiglottis (Fig. 3) [95% confidence interval (CI): 7.6–26.8] ($P=0.0004$). The laryngeal views in five children were poor (POGO score $\leq 25$) (Fig. 3). In one child in whom the Miller blade was used to lift the tongue base, the epiglottis could not be displaced from view. In two children in whom the MAC blade was used to lift the epiglottis, the curve of the MAC blade obstructed the laryngeal view. In one child in whom the Miller blade was used to lift the epiglottis and in another in whom the MAC blade was used to lift the tongue base, the views were poor. Post hoc, three additional analyses were performed. In the first, the frequency of POGO scores $\geq 80$ was compared: Miller blade lifting the epiglottis 16/25; Miller blade lifting the tongue base 17/25; MAC blade lifting the base 21/25; MAC blade lifting the epiglottis 14/25 ($P=NS$). In the second, the POGO scores were 90/25; 6/25; 11/25; 4/25, respectively ($P=NS$). In the third, the POGO scores in infants $<1$ yr of age with the Miller blade lifting the epiglottis and the MAC blade lifting the tongue were also similar.

The times to first and second laryngoscopies and to tracheal intubation were similar between the two blades (Table 2). The minimum $\text{Sa}_2$ values during laryngoscopy with the two blades were similar. Heart rate increased $\sim 10\%$ and systolic arterial pressure decreased $\sim 10\%$ with both blades during the 5 min study. There were no episodes of bradycardia or arrhythmias.

The blade assigned to each child was used to successfully complete the laryngoscopy and tracheal intubation in every child. No blades were exchanged or replaced. There were no complications associated with participating in this investigation.

**Discussion**

In the present study, we compared the laryngeal views using a Miller or MAC size 1 blade in infants and children $<2$ yr of age with normal airways (Fig. 2). We found that the laryngeal views with the Miller blade lifting the epiglottis and the MAC blade lifting the tongue base were similar. We also noted that the laryngeal views with the Miller blade lifting the epiglottis were similar to those with the blade lifting the tongue base. Lastly, we determined that the laryngeal views with the MAC blade lifting the tongue base were better than they were with the blade lifting the epiglottis (95% CI: 7.6–26.8) ($P=0.0004$).

Few studies have compared the laryngeal views with the Miller and MAC blades in young children. In the emergency department, the speed and success of tracheal intubation in infants using several laryngoscope blades were compared among emergency resident trainees. They determined that the Miller blade and other straight laryngoscope blades were preferred for the first-line use, whereas other blades (such as Seward and Soper blades) were relegated to the reserve list. The MAC blade was not addressed in that study. In another study in which the Miller size 1 and Cardiff blades in infants $<1$ yr and the MAC size 2 and Cardiff blades in children 1–16 yr were compared, the investigators concluded that the laryngeal views with the Miller and Cardiff size 1 blades in infants were similar, but the views with the MAC size 2 blades were significantly less favourable than those with the Cardiff blades. We cannot infer that the Miller blade is superior to the MAC blade based on that study as the two blades were not directly...
compared. The only direct comparison of the laryngeal views with the Miller and MAC blades was performed in adults. A full (100%) laryngeal view with the Miller blade in the parapharyngeal approach was obtained in 78% of patients, whereas a full view with the MAC blade was obtained in 53% of patients ($P=0.0014$). Thus, there is a dearth of evidence that the laryngeal view with the Miller blade in young children is superior to that with the MAC blade.

This study determined that the laryngeal views, with the Miller and MAC laryngoscope size 1 blades when used as they were originally intended, were similar in children <2 yr of age. However, limitations in the study design may have undermined our ability to detect a true difference. We designed this study assuming that a 25% difference in the POGO scores is clinically significant. With the POGO scale divided into increments of 20, a difference of 25 would require a 40% difference between the laryngeal views to reach statistical significance. The comparable scores obtained with the two blades in the primary hypothesis would suggest that these two blades do provide comparable laryngeal views. It is possible that notwithstanding the current results, these two blades may give disparate laryngeal views in neonates and in children with
Miller and Macintosh blades in young children

**Table 2** Procedural times and \(\text{Sa}_2\) measurements. Data are summarized as medians (ranges). Time to first laryngoscopy was the time from administration of rocuronium until laryngoscopy. Time to second laryngoscopy was the time interval between the first and second laryngoscopy. Time to tracheal intubation was the time interval between the second laryngoscopy and tracheal intubation.

<table>
<thead>
<tr>
<th></th>
<th>Miller</th>
<th>Macintosh</th>
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<tr>
<td>Time to first laryngoscopy (s)</td>
<td>180 (180–300)</td>
<td>180 (180–300)</td>
</tr>
<tr>
<td>Time to second laryngoscopy (s)</td>
<td>20 (10–30)</td>
<td>30 (10–60)</td>
</tr>
<tr>
<td>Time to tracheal intubation (s)</td>
<td>20 (10–50)</td>
<td>30 (10–40)</td>
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<tr>
<td>Minimum (\text{Sa}_2) during the study</td>
<td>94 (93–97)</td>
<td>95 (92–98)</td>
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**Fig 3** The POGO scores for the Miller and MAC blade views for each child are displayed. The solid symbols are the scores lifting the epiglottis and the open symbols are the scores lifting the tongue base. *The mean POGO scores for lifting the epiglottis with the MAC blade, 67.2 (56.1–78.3), were significantly less than those for lifting the tongue base, 84.4 (76.5–92.3) \(P = 0.0004\). The mean POGO scores for lifting the epiglottis with the Miller blade, 78.4 (70.0–87.0), did not differ from those lifting the tongue base, 76 (67.1–84.9). Data are means (95% CI).

difficult airways. The youngest infants in the current study were 4 months of age, and none were neonates. Further studies are required to determine whether these two blades have equipoise in neonates. Lastly, all laryngoscopies were completed by the same paediatric anaesthesiology fellow. The fellow had several years of experience performing laryngoscopy in neonates and infants. Using a single laryngoscopist reduced the inter-operator performance and variability in optimizing the view of the laryngeal inlet, but may limit the external validity of the results. Even though care was taken to obtain the optimal laryngeal views with both blades, the operator’s bias in using the blade cannot be completely eliminated.

The choice of blade when undertaking laryngoscopy in young children depends on the preferences and training of the practitioner. Most clinicians prefer to use the Miller blade in infants and young children, although there is a learning curve to proper placement of the blade tip to lift and continue to suspend the epiglottis. Those who criticize the use of the Miller blade because pressure on the glottis surface of the epiglottis may traumatize the mucosa, do so with little evidence. Additionally, the greater vertical profile of the MAC blade when compared with the Miller blade hinders the view in infants because of the limited space inside the oral cavity. Few are aware that MAC advocated inserting his blunt tip into the vallecula and pressing down on the hyoepiglottic ligament to flip up the epiglottis. At times, some may be disappointed with the MAC blade because the laryngeal inlet is not maximally exposed if they fail to press down on the hyoepiglottic ligament and simply lift the tongue base. Some advocate using the MAC blade to lift the epiglottis using the glottis surface, but our data suggest that this approach yields a partially obstructed laryngeal view. The obvious reason for this rests with the curved design and height of the MAC blade. The ‘standard’ MAC blades are designed such that the angle between the handle and a line that joins the distal curve of the blade to the handle is 58°. Therefore, the blade extends into the line of vision when it is positioned to lift the epiglottis from the undersurface. Even with a flattened mid-portion to the blade, there is some compromised view of the laryngeal inlet. The ‘English’ MAC blade with its greater distal curve would likely interfere even more with the line of vision in a young child compared with the ‘standard’ MAC. Thus, the design of the MAC blade interferes with a full laryngeal view, but this can be ameliorated if the blade is inserted into the vallecula rather than on the glottic surface of the epiglottis. The laryngeal view with the Miller blade does not suffer when the blade is used to lift the tongue base or the epiglottis.

We acknowledge that the laryngeal view is only a surrogate to successful tracheal intubation. Even though every larynx was successfully intubated in the current study with the assigned blade, there may be instances in which the tracheal tube cannot be passed through the glottic opening even with an adequate view of the larynx. However, the incidence of failed intubations is so small that we would need a very large cohort of subjects to demonstrate any difference in the rate of successful intubation with these two blades. Moreover, even though the laryngoscopist experienced no difficulty in visualizing any larynx in the present study, the small numbers of children in this study limit the external validity of the results to the entire population of young children.

Lastly, some of the outliers of the POGO scale may have been caused by the technical challenge of maintaining an optimal view of the larynx during laryngoscopy and taking a photograph. Furthermore, the picture of the larynx is close to but not always identical with the view of the larynx observed by the laryngoscopist. This introduces another source of error.

In conclusion, the median POGO scores using the Miller size 1 blade lifting the epiglottis and the MAC size 1 blade lifting the tongue base were similar. The primary hypothesis that the laryngeal views with the Miller and MAC size 1 blades are similar appears to hold true in young healthy children <2 yr of age. Furthermore, the MAC size 1 blade yields a superior laryngeal view if it is used to lift the base of the tongue rather than the epiglottis.
Supplementary material

Supplementary material is available at British Journal of Anaesthesia online.

Authors’ contributions


Declaration of interest

None declared.

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