

An observational study of feasibility of tracheal intubation using Airtraq in pediatric population

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Abstract

Background and Aim: There is a paucity of observational studies for the use of Airtraq (AT) in children, especially infants. We undertook a prospective observational study to compare ease of use of infant (size 0), pediatric (size 1), and small (size 2) AT. **Material and Methods:** AT was used for endotracheal intubation in healthy pediatric patients of 3 months to 18 years age. The primary outcome was success of intubation which was noted as number (%) and analyzed using Fisher's exact test. The secondary outcomes were percentage of glottis opening (POGO) score, visual analog scale (VAS) for field of view, time to best view (TTBV), time to intubation (TTI), and VAS for ease of use and were presented as median (interquartile range) in each subgroup of sizes and analyzed using Kruskal–Wallis test.

Results: Overall POGO score was 100 (100, 100 [50–100]) %, VAS field of view was 10 (10, 10 [5–10]), and TTBV was 6 (4, 10 [1.5–24]) s. There was no statistically significant difference in any of the subgroups. The success rate of intubation with AT was 100% with AT size 1 and 2, whereas 45% with AT 0, $P < 0.001$. VAS for ease of use was 5 (4, 10 [3–10]) with AT 0 compared to 10 (10, 10 [9–10]) with AT 1 and 10 (10, 10 [6–10]) with AT 2 ($P < 0.001$). TTI was 28 (20, 36 [11.8–59]) s in those who could be successfully intubated.

Conclusions: All sizes of AT provide quick, easy, and excellent glottic visualization. However, failure rate for intubation with infant (size 0) is high compared to nil with pediatric (size 1) and small (size 2).

Keywords: Airtraq, glottis visualization, laryngoscopy, optical laryngoscope, pediatric intubation

Introduction

In the past decade, indirect laryngoscopy has become an alternative for tracheal intubation in adults. It has been incorporated in difficult airway algorithm.^[1] Airtraq (AT), an indirect laryngoscope™ (Prodol, Vizcaya, Spain), has an optical channel containing a series of lenses, prisms, and mirrors that reflect the magnified image from the tip of the blade to the viewfinder.^[2] It has a guiding conduit in which the tracheal tube is preloaded and advanced. Since direct line of sight is not required, there is neither need to displace tongue nor need of sniffing position. Pediatric sizes, that is,

infant (size 0), pediatric (size 1), and small (size 2) have been made available recently.

Initially, few cases were reported describing successful use of AT in syndromic children with difficult airway.^[3–5] Many pediatric manikin-based simulation studies compared AT with direct laryngoscopy.^[6–8] However, the results of the manikin studies cannot be extrapolated to live human beings. Infants have unique airway anatomy and have low oxygen reserves. Most of pediatric studies, comparing AT with direct laryngoscopy have included only 10–20 children in AT group. These studies have either nil or few or unspecified number of infants.^[9–11] Hence, we undertook a prospective observational study to assess safety and ease of use of AT in children of various age groups including infants.

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Material and Methods

The Institutional Ethics Committee approval was obtained and the study was registered with Clinical Trials Registry-India (CTRI/2016/10/007390). Sixty-one healthy pediatric patients in the age group of 3 months to 18 years, of either gender with the American Society of Anesthesiologists (ASA) physical status 1 or 2, scheduled for routine surgical procedure requiring endotracheal intubation under general anesthesia were enrolled for this study. Children with difficult airway or history of difficult intubation, risk of gastric aspiration, active upper or lower respiratory tract infection, severely raised intracranial tension, and cyanotic heart disease were excluded from this study. Informed consent was obtained from parents/guardians. Older children who could understand the nature of procedure were explained about the study and assent was taken.

All children received general anesthesia as per routine protocol in our hospital. This comprised preoperative starvation as per the ASA fasting guidelines 2011^[12] and establishment of monitoring such as electrocardiogram, pulse oximetry, capnography, and noninvasive blood pressure measurement. All patients received intravenous (IV) glycopyrrolate 0.004 mg/kg, IV fentanyl 2 mcg/kg, and IV midazolam 0.02 mg/kg. The patient was preoxygenated with 100% oxygen for 3 min. Anesthesia was induced with IV thiopentone sodium 5–7 mg/kg till the loss of eyelash reflex. Neuromuscular blockade was achieved with IV atracurium 0.75 mg/kg. Patient was ventilated with a mixture of oxygen, nitrous oxide plus sevoflurane (0.6%–2.5%) for 3 min. All intubations were performed using AT laryngoscope as per manufacturer's instructions. Both the investigators were experienced anesthesiologists with expertise in pediatric and neonatal intubations. Each one performed more than 20 endotracheal intubations using regular size of AT before this study. Three sizes of AT laryngoscope used were infant size 0, pediatric size 1, and small size 2 corresponding to tracheal tube sizes 2.5–3.5, 4.0–5.5, and 6.0–7.5 mm ID, respectively, as per the manufacturer's instructions. The anterior blade and endotracheal tube (ETT) were lubricated before loading the ETT in the tube channel. Patient's head was maintained in a neutral position to facilitate insertion. AT was inserted in the middle of the mouth and then slid over the tongue till vallecula. Side-to-side movement or gentle vertical lift was done to obtain the best view of the glottis in the center of the field. The ETT was then advanced and ventilation was checked with the AT *in situ*. Confirmation of proper endotracheal intubation was done by observation of chest expansion, auscultation of bilateral breath sounds, and

square wave capnogram. The AT was disengaged from the ETT with a lateral movement and ETT was fixed.

Following parameters were assessed:

1. Percentage of glottis opening (POGO) score: Denotes visual estimation of the laryngeal opening in score of 0% to 100%. 0 = none of the glottis opening is seen, 100 = full visualization of larynx from the interarytenoid notch to anterior commissure of the vocal cords
2. Visual analog scale (VAS) for field of view: 0–10-point scale. 0 = poor, 10 = excellent^[2,13]
3. Time to best view (TTBV): Time interval between blade entry past the lips and the laryngoscopist's verbal declaration that the best view for endotracheal intubation is achieved
4. Tube at glottis (TAG): Time interval between blade entry past the lips and the tube passed the vocal cords
5. Time to intubation (TTI): Time interval between blade entry past the lips and the appearance of first upstroke of the end-tidal CO₂ tracing
6. Visual analog scale (VAS) for ease of use: 0–10-point scale. 0 = poor, 10 = excellent.^[2,13-15]

Timing was performed by a member of the anesthesia team using a stopwatch.

Failed attempts, if any were noted. Failed attempt was considered when there was inability to pass ETT within 60 s of AT blade entry past the lips; abandoning the intubation attempt due to decrease in oxygen saturation <94%; and change of premounted ETT.

Difficulties encountered, for example, anterior or posterior impingement of ETT, loss of visualization due to "fogging" or "red-out" were noted. Optimization maneuvers such as repositioning the head or use of external laryngeal manipulation (ELM) were noted. Number of attempts (1 or 2) was noted. If successful intubation could not be achieved in two attempts using AT, it was considered as failed intubation. Subsequent intubation was accomplished by Macintosh or Miller laryngoscope. Complications associated with laryngoscopy and intubation such as injury to lips, oral cavity and laryngeal structures, bleeding, sore throat, hoarseness, stridor, and respiratory distress were noted.

Data were presented as median and interquartile range (IQR) with minimum–maximum values for POGO score, VAS-field of view, TTBV, and VAS-ease of use in all 61 patients. In cases of successful intubation, TAG and TTI were also expressed as median and IQR with minimum–maximum values (median (IQR [minimum–maximum])). Statistical analysis was done using Kruskal–Wallis test. If *P* value was found to be significant, further analysis was done using

Mann–Whitney U-test. Intubation attempts and failed intubations were presented as number (percentage) and analyzed using Fisher's exact test. The $P < 0.05$ was considered statistically significant. Data were analyzed using IBM SPSS 16.0 for Windows (SPSS Inc., Chicago, USA).

Sample size calculations

Success rate of intubation with AT was 94% in children of 1–5 years^[9] and 43% in infant manikin study.^[6] Power and sample size calculations software (version 3.0.43) derived sample size of 19 patients in each group after assuming power of 0.9 and type I error of 0.05.

Results

A total of 61 children were studied over 6 months. There were 49 male and 12 female patients. The age group ranged from 3 months to 14 years [Table 1]. Successful intubation could be achieved in 45 patients in the first attempt and five patients in the second attempt. Hence, the overall success rate of intubation with AT was 81.96% (50 out of 61). There was no significant difference in POGO %, VAS field of view, and TTBV between the AT groups. VAS for ease of use was significantly lower in the AT 0 group than in the other groups ($P < 0.001$) [Table 2]. There was no significant difference between AT 1 and AT 2 group for the

same. Out of 50 successful intubations, we could intubate 45 children in the first attempt. ELM was needed in one case only among 50 successful intubation cases. In five cases out of 50, intubation was done in the second attempt. The first attempt abandoned was either due to secretions or anterior and posterior impingement of the ETT despite an excellent view of the glottis. Intubation was then successful in the second attempt either by withdrawing and lifting AT upward and backward or rotating AT to the left side or repositioning of the head with change of head ring. For successful intubation ($n = 50$), time for tracheal intubation was 28 (20, 36 [11.8–59]) s [Table 3].

We failed to intubate 11 out of 20 cases in AT 0 group. Incidence of failed intubation was 55% ($n = 20$) in infant group (AT size 0) as compared to 0% in pediatric and small group (AT size 1 and 2), $P < 0.001$ as shown in Table 2. In cases of failed intubation, ETT was impinging against the right side of anterior larynx, epiglottis or vallecula in four, right aryepiglottic fold in two, right pyriform fossa in one, and posteriorly toward esophagus in four patients. Complications related to laryngoscopy and intubation, visual “red-out” or “fogging”, sore throat, trauma, hoarseness of voice, laryngospasm, bronchospasm, and patient oxygen saturations below 94% were not seen in any of the groups.

Table 1: Patient characteristics

Parameters	AT size 2 (n=22)	AT size 1 (n=19)	AT size 0 (n=20)
Male/female (n)	19/3	15/4	15/5
Age (months)*	132 (120-139.5 [48-168])	36 (22-66 [13-120])	5.5 (3-12 [3-30])
Weight (kg)*	25 (23.8-28.8 [15-58])	10 (9.8-17.0 [8-25])	7.15 (5.48-8.38 [3.4-11.0])

*The data are presented as median (IQR [minimum-maximum]). AT=Airtraq, IQR=Interquartile range

Table 2: Glottis visualization and intubation characteristics

Parameters	AT total (n=61)	AT size 2 (n=22)	AT size 1 (n=19)	AT size 0 (n=20)	P
POGO	100 (100-100 [50-100])	100 (100-100 [60-100])	100 (100-100 [100-100])	100 (100-100 [50-100])	0.108
VAS field of view	10 (10-10 [5-10])	10 (10-10 [6-10])	10 (10-10 [9-10])	10 (9-10 [5-10])	0.066
TTBV seconds	6 (4-10 [1.5-24])	6.35 (3.43-10 [2.6-18.3])	6.3 (4.5-9.4 [1.5-23])	5.1 (4.05-12.5 [2-24])	0.821
VAS ease of use	10 (9-10 [3-10])	10 (10-10 [6-10])	10 (10-10 [9-10])	5 (4-10 [3-10])	<0.001
Successful intubation, n (%)					
First attempt	45 (73.77)	21 (95.5)	17 (89.5)	7 (35)	0.247
Second attempt	5 (8.19)	1 (4.5)	2 (10.5)	2 (10)	
Failed intubation, n (%)	11 (18.04)	0	0	11 (55)	<0.001

The first four parameters are presented as median (IQR [minimum-maximum]). P value is by Kruskal-Wallis test for these parameters. For successful and failed intubation data, P value is by Fischer's exact test. POGO=Percentage of glottis opening, VAS=Visual analog scale, TTBV=Time to best view, AT=Airtraq, IQR=Interquartile range

Table 3: Details of patients with successful intubation (n=50)

Parameters	AT total (n=50)	AT size 2 (n=22)	AT size 1 (n=19)	AT size 0 (n=9)	P
VAS ease of use	10 (10-10 [5-10])	10 (10-10 [6-10])	10 (10-10 [9-10])	10 (9-10 [5-10])	0.201
Time at glottis seconds	16.75 (11.86-26.5 [6.2-44.3])	15.85 (9.3-25.75 [6.2-44.3])	16 (14-25 [10-43])	25 (12.3-37.5 [5.3-48])	0.426
Time to intubation seconds	28 (20-36 [11.8-59])	24 (18.12-33.4 [11.8-58])	29 (22-34 [17-59])	36 (22.3-50.0 [19-58])	0.214

The data are presented median (IQR [minimum-maximum]). P value is by Kruskal-Wallis test for these parameters. AT=Airtraq, IQR=Interquartile range, VAS=Visual analog scale

Discussion

Videolaryngoscopes (VLs) have been included as a primary option or rescue device for intubation in the ASA difficult airway guidelines.^[1] Although different kinds of VLs are available for use in adults since more than a decade, pediatric versions, especially infant sizes were introduced more recently. The decision to incorporate a particular device depends on cost, ease of availability, and use. We selected AT for our study because of the simplicity of the design, portability, easy availability of smaller sizes, low cost, and fast learning curve.^[16,17]

Sun *et al.* performed a meta-analysis of 14 randomized controlled trials to compare the clinical efficacy between video and direct laryngoscopes in children. Compared with adults, the full view of the larynx occupied a much smaller portion of the eyepiece view in the pediatric AT. In addition, guiding the pediatric ETT through the vocal cords was not always straightforward due to channeled track. They concluded in this meta-analysis that in spite of the inconsistent results across all outcomes, VLs improved glottis visualization in pediatric patients, but at the cost of prolonged TTI and increased failures (relative risk: 6.70; 95% confidence interval: 1.53–29.39).^[18] In our study also high POGO score and VAS field of view were noted. However, success rate for intubation was 81.96% and TTI was 30.39 ± 12.26 s.

There are differences in airway anatomy in children of different ages. Especially infants have short jaw, large tongue, highly situated larynx, anterior angulation of the vocal cords, and long bifid epiglottis. Moreover, the oxygen reserve is usually much smaller because of a low functional residual lung capacity and high oxygen consumption. Hence, results from studies involving adult and older children cannot be extrapolated to infants.

Kalbhenn *et al.* performed a prospective model-based comparison of different laryngoscopes for difficult intubation in infant manikin. They noted intubation success rate of only 43% with the AT.^[6] The retroglottal airspace volume of this infant manikin significantly differs from that in real patients. Although inferences drawn from manikin studies may not always hold true, we too found success rate of 45% in infants of our study. Most of the pediatric studies, comparing AT with direct laryngoscopy have small sample size. These studies have either included only few infants or have not specified the number of infants in these studies.^[9-11] Therefore, we decided to study glottic visualization characteristics and ease of intubation using AT in children of various age groups including infants.

We failed to intubate 11 out of 20 cases in AT 0 group. In all failure cases, ETT was hitting posteriorly into the right side of the larynx in spite of excellent view of laryngeal inlet. ETT could not be negotiated even after ELM or any other recommended optimization maneuver in stipulated time of 60 s. As infants were included in this study, apnea time of more than 60 s can lead to desaturation. Therefore, attempt time was limited to 60 s. Vlatten *et al.* noted TTI in the range of 14-50 s with AT in age group 1 to 5 years.^[10] White *et al.* noted TTI is 43 ± 22.6 s with AT in infants.^[2]

It has been suggested that the distance between the point that the ETT exits the guide channel and the glottic opening must be just right to intubate the trachea successfully.^[19] Viewing and guiding channel are side by side in AT. When the viewing channel tip is located such that best view of larynx is obtained, the guiding channel will point toward the right of glottis. The advancing tracheal tube tends to hit the right arytenoid, aryepiglottic fold, or right pyriform fossa in most of the failed intubation cases.

Direct laryngoscopy allows precise manipulation of a tracheal tube in three dimensions. The inbuilt conduit for tracheal tube in AT does not permit free manipulation of the ETT to facilitate endotracheal intubation. Hence, we were left with no option other than maneuvering the whole device rather than the ETT itself. Nasal AT which is devoid of the posterior guiding channel, was used successfully for nasotracheal intubation by Xue *et al.*^[20]

As per Vlatten *et al.*, the fully visualized larynx occupies a much smaller portion in anterior quadrant of the field of view in small children. Advancing the tracheal tube in this position causes the tube to pass below the larynx into the esophagus.^[10] Following meta-analysis of randomized controlled trials assessing VL versus direct laryngoscope, Sun *et al.* concluded that compared to adult version, pediatric AT is difficult to use, especially in small children.^[18] Compared with adults, the full view of the larynx occupied a much smaller portion of the eyepiece view in the pediatric AT. In addition, guiding the pediatric ETT through the vocal cords was not always straightforward, although the laryngeal view provided was good.^[20] As the VLs prolonged TTI and increased failed intubations, VLs should be recommended with caution in children, especially those who may not tolerate long-time apnea. We also concur with this observation. This can be one of the drawbacks of the disparity between optical magnification and relative size of the eyepiece in case of small children.

In spite of keeping glottis view in the center of the field, we noticed ETT tip pointing toward the right side. We tried to manipulate ETT tip in the center of glottic opening, by

rotating or tilting the entire device or withdrawing it upward and backward. In 11 infants with AT 0, intubation attempt was abandoned after a TTI of 60 s following failure of all above-mentioned maneuvers. We could intubate all these patients in the first attempt with Macintosh laryngoscope with or without ELM.

Holm-Knudsen reported two infants with difficult airway in which the AT provided an excellent view of the glottis, but where it was not possible to direct or pass the ETT toward or through the vocal cords. The tracheal tube was consistently displaced posterior to the larynx toward the esophageal inlet despite manipulation of the head position and application of external pressure on the neck. Subsequently, the airway was secured uneventfully by fiber-optic intubation and Storz VL with an intubating stylet. They concluded that when there is limited space in the oral cavity, the AT may not be the best choice and the use of a VL or a fiberscope probably should be the preferred method of choice.^[21]

According to Xue *et al.*, large space between the ETT and the tip of the AT because of wide tube conduit results in failure to guide the tube in the glottis. They suggested ELM, withdrawal and lifting of the device, use of an intubating stylet, an endoflex-tube, or a fiber-optic bronchoscope to overcome these technical difficulties.^[22] We also used the first two maneuvers whenever we had difficulty in negotiating the tube.

Xue *et al.* further reiterated that problem of wide conduit may be exacerbated whenever a thin flexible ETT is used in the infants. Flexible intubating stylet was used successfully to complete the tracheal intubation in seven infants aged 3–12 months with normal and difficult airways after a failed attempt using the AT because of a posterior ETT tip location.^[23] We did not use stylet as it was not included in our study methodology. In addition, combining the AT with a stylet or bougie can increase the risk of injuring the airway and their use is questionable. Shimada and Hirabayashi reported laceration over right palatine tonsil in a 4-year-old child while using AT possibly by the right corner of the blade tip or by the edge of guiding channel.^[24]

AT usage was excellent in term of ease of overall use in pediatric patients except infants as shown in our results. However, the outcome of glottis visualization and time to obtain best glottic view (POGO and TTBV) is less important than the outcome of TTI because good glottis visualization does not guarantee a rapid or successful intubation.

We did not see any complications related to laryngoscopy and intubation. However, the study sample size is small. The other limitation of our study is that AT being a single use and

costly device, we had limited experience of using it in infant manikin. Safety data for new devices are difficult to establish, especially if adverse events are rare and most safety data come from extensive clinical use rather than controlled trials.

The use of the AT laryngoscope (channeled) as a primary airway device cannot be recommended in the infants. Considering the unique airway anatomy of infants, we suggest research in modification in the design and technique of use of AT to make it safe and useful in infants. Perhaps, a study using nasal AT laryngoscope (nonchanneled) is warranted in infants.

Conclusions

All sizes AT (0, 1, and 2) provide quick, easy, and excellent glottic visualization. However, success rate for intubation in ≤ 2 attempts is $< 50\%$ with infant (size 0) compared to 100% with pediatric (size 1) and small (size 2) AT.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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