MRI Measurement Of Oropharyngeal Curves In Children

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Citation

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Abstract

The shape and curve of the intubating laryngeal mask airway (ILMA) tube were derived from head and neck sagittal magnetic resonance imaging (MRI) views in 50 adults. Three sizes of the ILMA were manufactured, differing only by the size of the mask. Validation of the possibility of blind intubation with the smallest ILMA has been attempted in children, and a high number of failures have been encountered in children under 30 kg. The aim of the present study was to determine the evolution of the radius of the oropharyngeal curve in children with age and weight and to establish a relationship between the oropharyngeal curve radius and simple clinical parameters such as weight and age, in order to design a correctly fitting paediatric ILMA. The radius of the oropharyngeal curve of 52 children was measured with head and neck sagittal MRI views. By using only bony landmarks, it was easy to calculate the curve radius independently of the child's head position and of the modification of the soft pharyngeal structures in case of general anaesthesia. The radius of the oropharyngeal curve in children increased with age and correlated with age and weight. This study highlights airway modifications as a function of age, particularly the oropharyngeal curve modification. Such modifications are probably the main reason why insertion and intubation with a size 3 ILMA in children under 30 kg regularly failed in our series. Paediatric ILMA design will need more than a simple miniaturisation of the ILMA mask. Particular attention should be paid to children's anatomic differences.

INTRODUCTION

The intubating laryngeal mask airway (ILMA) has been designed to overcome the difficulties encountered when attempting blind tracheal intubation with the standard laryngeal mask airway (LMA). High rates of successful blind tracheal intubations (93%-100%) have been reported with the ILMA ([1,2,3,4,5,6]), including patients presenting with difficult airway.

The ILMA has been bioengineered by using head and neck MRI views in 50 normal adults whose heads were held in a neutral position. The radius and angle of the tube curve (41.5 mm and 128° respectively) were chosen to best fit the palato-pharyngeal arch measured in these subjects. Keeping the size and the shape of the tube constant, 3 sizes of the ILMA (3, 4 & 5) were manufactured, differing only by the dimensions of the mask.

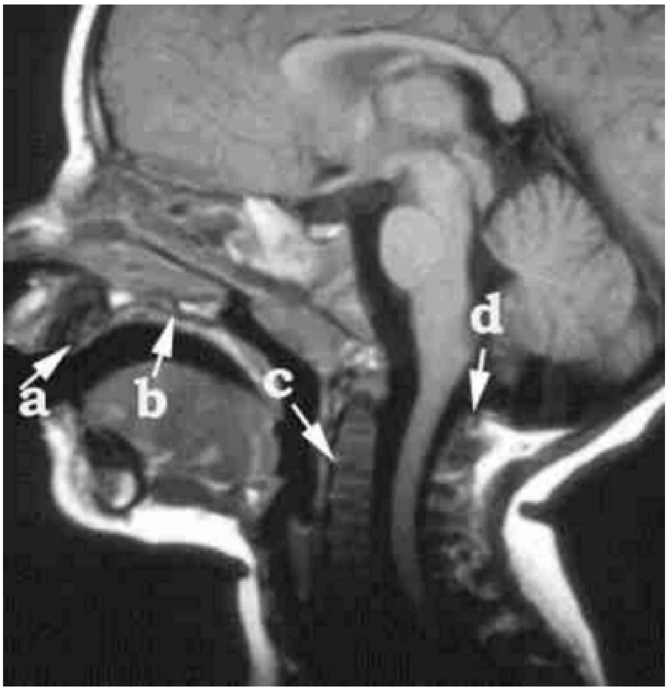
Size 3 LMA is recommended for children over 25 kg and size 3 ILMA was accordingly used in children over 25 kg ([8]). Blind tracheal intubation attempts with the ILMA often failed in children under 30 kg, even though the insertion of the device was deemed satisfactory. This is to be compared with high success rates in adults. Such failures can be explained by many reasons. First, the size 3 ILMA tube is wider than that of standard LMAs. Second, the curve of the ILMA might be unsuited to children's upper airway morphology. The aim of the present study was therefore to determine the evolution with age of the oropharyngeal curve radius in children, using a technique close to Brain's (2), in order to design a correctly fitting paediatric ILMA.

METHODS

We retrospectively reviewed head and neck sagittal MRI views of 52 children. Ethics committee approval was not sought as the images had already been taken for clinical reasons unrelated to the airway. Confidentiality was maintained. For most children under 5 years, inhalational general anaesthesia was required to achieve the investigation. Patent airway was then managed with a Guedel airway. To provide a clear airway, the patient's head could not always be maintained in a neutral position. Since this made measurements according to Brain's method unreliable, we used bony landmarks, to obtain measures independent of head position or airway device presence. These landmarks were: teeth/gums, the top of the hard palate, C2 synchondrosis and posterior edge of the occipital foramen (fig 1).

Figure 1

Figure 1: Bony landmarks used to determine the oropharyngeal curve.a: teeth; b: top of hard palate; c: axis synchondrosis; d: posterior edge of the occipital foramen

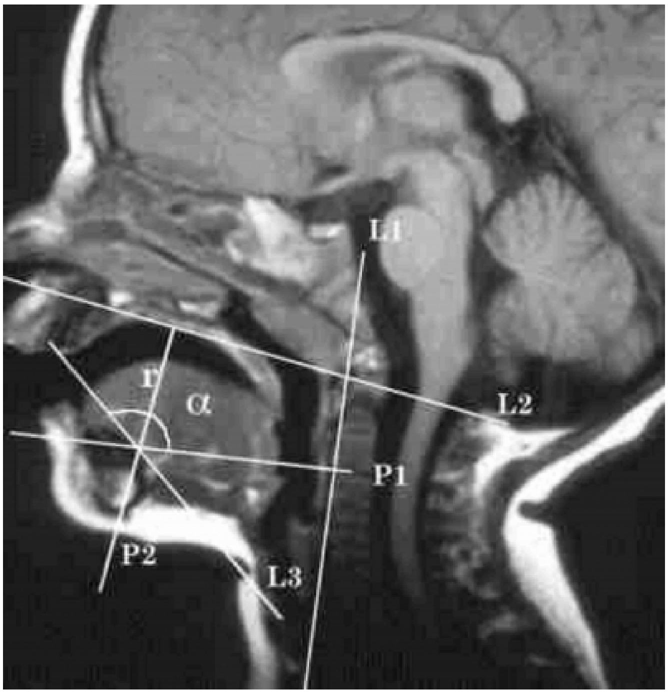


Many parameters were measured, but only two were retained: the radius (r) and the angle (a) of the oropharyngeal curve.

Five lines were drawn on the MRI films: L1, parallel to the anterior edge of the Axis body; P1 perpendicular to L1 crossing the C2 synchondrosis; L2 between the posterior edge of the occipital foramen and the top of the hard palate. P2 was drawn perpendicularly to L2 at the top of the hard palate. L3 lies from the intersection of P1 and P2 to the teeth/gums edge, thus defining the angle a . The radius r represents the distance between the intersection P1/P2 and the top of the hard palate (fig 2).

Figure 2

Figure 2: Measurement method of oropharyngeal curve angle and radius. (see the text)



Correlation between r, a and age and weight was obtained by using a logarithmic regression curve.

RESULTS

We studied MRI sagittal images of the head and upper airway of 52 patients. The subjects were 2 months to 12 years old and weighing from 4 to 35 kg. The male:female ratio was 27:25. Demographic details are given in figure 3.

Figure 3

Figure 3: Patients studied: demographic details

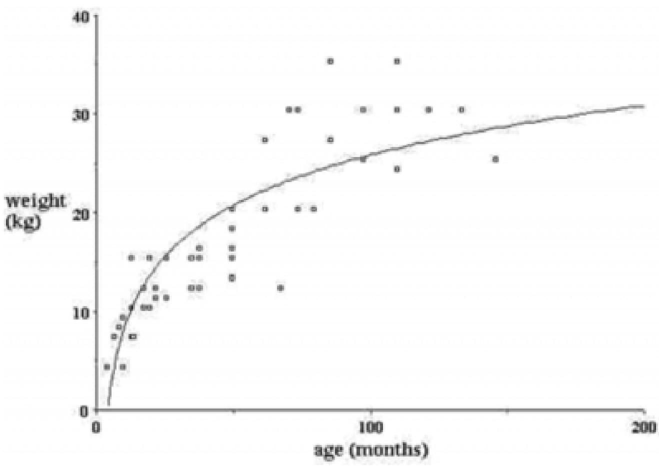


Figure 4

Figure 4: Plot of weight (kg) versus radius (mm) and angle (degrees) of oropharyngeal curve, with the correlation indicated

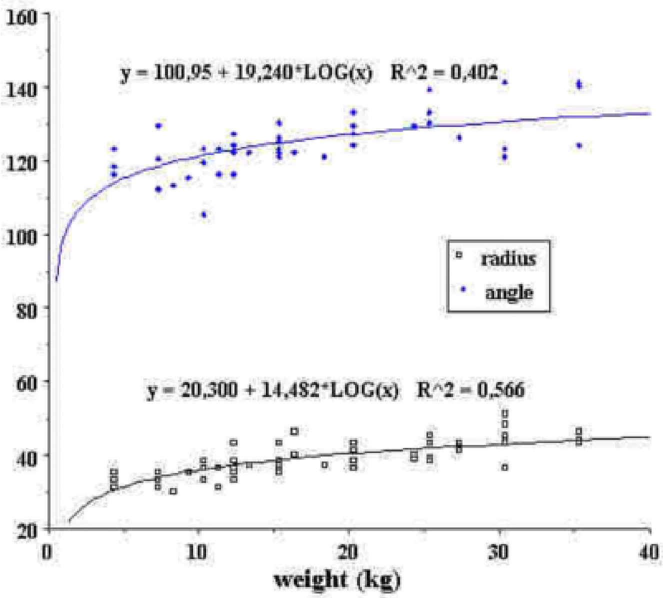
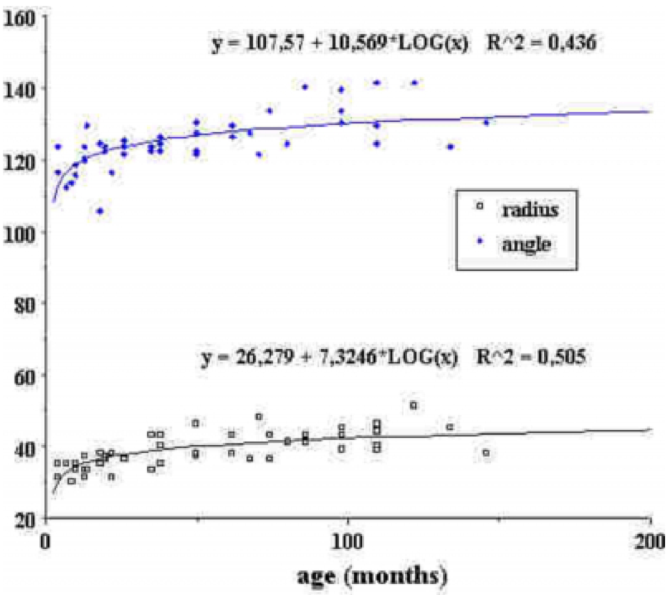


Figure 5

Figure 5: Plot of age (months) versus radius (mm) and angle (degrees) of oropharyngeal curve, with the correlation indicated



The oropharyngeal curve radius varied from 29 to 50 mm with age. It was well correlated with both age and weight. Similarly, the oropharyngeal curve angle varied from 105° to 140° and also correlated with age and weight.

DISCUSSION

We report the oropharyngeal curve radius and angle related to age and weight in 52 children aged from 2 months to 12 years. The results show that the two parameters varied with age. Both angle and radius were significantly related with age and weight. Adult mean values as reported by Brain (i.e.: r = 41.5 mm, a = 128°) are encountered only in children above 30 kg and 8 years (8). Since height was not available in this retrospective study, we considered only age and weight These results corroborate those of Maigrot et al. Study in which blind tracheal intubation was achieved at the first attempt with a n° 3 ILMA in only 28% of cases in children under 30 kg. Above 30 kg, the success rate at the first attempt, 74%, was similar to that reported in five published series (2-6).

The position of the oropharyngeal structures and the soft tissue morphology changes with flexion and extension of the neck ($_{12}$) and with the presence or absence of an airway device that might be required for clear airway in case of general anaesthesia. Consequently, measurement of the oropharyngeal curve in these conditions was unreliable. Using bony landmarks gave measurements independent of changes to the mandibular structures.

The four landmarks allowed us to determine an arc closely following the oropharyngeal curve. This is unnecessary in adults whose heads are usually held in the same neutral position. Our method seemed more appropriate and reliable in children.

The sample size might be too small to be able to predict values for each year of age. In a comparable study, Greenberg et al ($_{9}$) reviewed 200 MRI views of the head and the upper airway of patients aged from 0 to 17 years, providing at least five scans for each year of age. By measuring the distance from the teeth/gums to the prevertebral pharyngeal space, they created an algorithm to predict this distance based on weight, age and gender, in order to determine the most suitable Guedel airway size for infants and children. Yet the anatomic landmarks used by Greenberg can be altered by sedation or general anaesthesia. This maybe due to pharyngeal relaxation, or to the presence of an airway device, and may lead to erroneous measurements.

Our study was done with MRI views of normal subjects without predicted or patent difficult intubation. However, it may give a partial explanation of the difficulties encountered in children when using scaled-down versions of the adult airway devices.

Paediatric airway devices can be manufactured by modelling the oropharyngeal curve using the appropriate value of r and a for each age range. This might have some implications for designing paediatric LMAs and ILMAs. Several studies have evaluated the LMA in young patients. Misplacement, assessed by fibrescope, MRI or CT scans, was frequently noticed with n° 1 and 2 LMA ($_{10,11}$). Goudsouzian (11) found a posterior deflection of the epiglottis with n° 1 & 2 LMA in 74% of the infants and children evaluated, with no effect on ventilatory parameters. In another study (10), the epiglottis was within the confines of the cuff of n°1 LMA in 57% of the cases.

The cause of failures to intubate the trachea of children < 30 kg with a n° 3 ILMA may be related to the rigidity of the tube, which prevents self-adaptation of the device to the continuously varying oropharyngeal curvature, in spite of the malleability of the mandible and the pharyngeal soft tissues. Currently available ILMA sizes are suitable for patients > 30 kg. However, the paediatric population is also concerned by difficult airway, so smaller sizes of ILMA are required. The design of such devices should take into account the wide variability of the oropharyngeal form as a function of age.

CONCLUSION

In summary, ILMA is an effective blind intubation guide and is very useful in the management of the difficult airway in adults. However, paediatric sizes are required. Close attention to children's oropharyngeal curve variability would provide a more rational determination of the proper ILMA tube form for infants and children.

References

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