Original Research Article

Evaluation of Ultrasonic Anatomy of Epiglottis and Pre-Epiglottic Space in pre Pubertal Children: A Tertiary Hospital based Propective Study

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How to cite this article: Chiranjeev Kumar Gathwal, Monika B Gathwal, Kulvinder Singh, Saru Singh, Sweta Bhincher. Evaluation of ultrasonic anatomy of epiglottis and pre-epiglottic space in pre pubertal children: a tertiary hospital based propective study. International Journal of Contemporary Medicine Surgery and Radiology. 2018;3(1):102-106.

ABSTRACT

Introduction: The epiglottis and pre-epiglottic space assessment is becoming an important constituent of airway evaluation especially in children as precise appraisal may help the otorhinolaryngologists to manage life-threatening epiglottitis. The purpose of the study was to evaluate the utility of ultrasound in evaluating the epiglottis and pre-epiglottic space anatomy and dimensions in Pre-Pubertal children.

Material and methods: This prospective study was conducted in the Department of Radio-diagnosis, BPS GMCW Khanpur Kalan Sonepat Haryana involving 62 patients between age group 4-12 of either sex coming for non-airway related sonography. In the descriptive statistical analysis, continuous variables were noted in terms of the mean and standard deviation and nominal variables were noted in terms of percentage.

Results: In our study, average epiglottis thickness and the pre-epiglottal space thickness were found to be 1.2 +/-0.22 mm and 4.1 +/ -0.76 mm, respectively. Epiglottic and pre-epiglottic dimensions (AP) were seen to be statistically less in 4-8 years age group than 9-12 years group. Both epiglottis and pre-epiglottic space dimensions were seen to be more in male than female in both age groups (4-8 years and 9-12 years);however only the pre epiglottic space thickness difference in 4-8 years age group (more in male) is seen to be statistically significant (p=0.03).

Conclusion: There is tremendous scope for clinical applications of sonography of the epiglottis and pre-epiglottic space with potential utility in differential diagnosis.

Keywords: Ultrasonic Anatomy, Epiglottis, Pre-Epiglottic Space

INTRODUCTION

Ultrasonography is increasingly used in evaluation of upper airway considering it to be a simple, readily available, easy to perform, non-invasive, non-ionizing and bedside imaging tool. The epiglottis and pre-epiglottic space assessment is becoming an important constituent of airway evaluation especially more important in children who are known to pass through a myriad of changes in laryngeal anatomy with age. Also, the shape, size and level of epiglottis are known to permutate chronologically. Its precise appraisal may help the otorhinolaryngologists to manage life-threatening epiglottitis.[1] Besides, the anesthesiologists utilize the assessment of laryngeal structures in airway assessment for predicting difficult intubation.[2] The thickness of epiglottis and pre-epiglottic space are essential parameter in such airway evaluations. On the other hand, there have been cases reported with high rising epiglottis, even upto the level of uvula.[3] These congenital variations may obscure the epiglottis beneath bony landmarks posing a question on the feasibility of ultrasounic assessment in such cases. Ultrasonic imaging of epiglottis is challenging as it is suspended in air as compared to floor of the mouth which can be easily visualised by both transcutaneous or transoral views.

Our literature review revealed few studies of ultrasonographic identification of the epiglottis. Also, there is dearth of reports establishing normal anatomic or sonographic measurements for the adult epiglottis. Over and above, the normal values of epiglottis and pre-epiglottic space have also not been extensively studied particularly in children. Therefore, this study is being planned to investigate the utility of ultrasound in evaluating the normal anatomy and dimensions of epiglottis as well as pre-epiglottic space in children crossing toddler age group up till puberty.

The appearance of the adult epiglottis on sonography was first described by Böhme et al as "an echo free or echo-poor structure with a surrounding echogenic pre-epiglottic space.[4,5] Since this initial report, there have been several studies using these characteristics to identify the epiglottis without direct comparison to reference standard imaging modalities.[5-8] However, in a recent study by Prasad et al[9] sonographic and CT measurements of several pharyngeal and hypo-pharyngeal airway parameters, including the depth of the epiglottis and thyrohyoid membrane, were compared in 15 adult patients with normal neck anatomy. On the basis of their measurements, the authors concluded that the pre-epiglottic fat appears hypoechoic and had been mislabeled as the epiglottis in previous studies using Böhme's method of identification. Werner et al[5] reported sonographic visualization of epiglottis as a curvilinear, hypoechoic structure with echogenic pre epiglottic space. They visualized epiglottis in 100 subjects, between the ages of 18 and 50 years without any known acute or chronic laryngeal diseases or surgeries. There were 62 women and 38 men with a mean age of 35.2 (68.1) years in the sample. They reported average epiglottic thickness as 2.39 +/- 0.15mm and found it to be greater in men (2.49+-0.14 mm) than in women (2.34+-0.13 mm) ($p<0.001$). They found moderate correlation between the patient's height and epiglottic thickness, R = 0.48. However, when they analyzed it separately for men and women, there was no significant correlation between epiglottic thickness and height. Ueda et al[10] demonstrated pediatric upper airway and basic scanning positions. Garel et al.[11] also described pediatric ultrasound anatomy and compared this to fetal preparations. Parmar et al[12] examined 100 volunteers for airway imaging systemically from floor of the mouth to the sternal notch in anterior aspect of neck by ultrasound. The volunteers consisted 52 male and 48 female with a mean age of 26.13 ± 8.41 years. They showed epiglottis as a hypoechoic curvilinear structure with tongue protrusion and swallowing facilitated the identification of epiglottis in real-time sonography. Epiglottis was surrounded by pre-epiglottic space anteriorly and by a bright linear air-mucosal interface posteriorly.[13,14] They could visualize epiglottis in 90% volunteers in transverse view and 70% of volunteers in parasagittal view. Bektas et al[15] reported a case to assess the utility of ultrasonography to image epiglottal and pre-epiglottal edema. A 56-year-old man presented to the emergency department (ED) with a history of fever, sore throat and gradually increasing hoarseness, which had started 2 days previously. They found a hypoechoic structure with an increase in thickness (5.1 mm) of the echogenic pre epiglottal space using a 10 MHz linear probe (Medison Digital Sonoace 5500; Medison America, Inc, Cypress, California, USA). In this case report, epiglottic thickness and the pre-epiglottal space were found to be 3.2 mm and 5.1 mm, respectively. This case report shows that bedside ED ultrasonography could be a valuable tool to detect pathological enlargement of the epiglottis. Ultrasound may be used in unstable patients for diagnosing epiglottitis because it is cheap, rapid, non-invasive and does not aggravate the patient's symptoms. Kundra et al[16] showed epiglottis in transverse and parasagittal views through the thyrohyoid membrane as hypoechoic curvilinear structure.[17] Its anterior border is demarcated by the hyperechoic pre-epiglottic space and its posterior border by a bright linear A–M (air-mucosa) interface. Any interface between the mucosa lining the upper airway and the air within it produces a bright hyperechoic linear appearance. Epiglottis can be easily identified in almost all individuals in the transverse plane with a varying cephalad or caudad

angulation of the linear transducer. Acoustic shadowing by the hyoid bone limits the visualization of epiglottis in the parasagittal plane.[17] Epiglottis can be visualised by extended submandibular sagittal view (between the hyoid bone and mentum) using a curved transducer. Identification of the epiglottis can be facilitated by tongue protrusion and swallowing, when it becomes visible as a discrete mobile structure inferior to the base of the tongue.[17] Singh et al[18] took 24 volunteers (mean ± SD: age, 30 ± 5 years; weight, 76 ± 15 kg; height, 170 ± 10 cm; and body mass index, 24 ± 3 kg/m2) reported that the epiglottis was visible through the thyrohyoid membrane as a hypoechoic curvilinear structure on the parasagittal and transverse views. Its anterior border was delineated by the hyperechoic pre epiglottic space and its posterior border by a bright linear A-M interface. It was visible in all participants with the linear transducer oriented in the transverse plane (with varying degrees of cephalad or caudad angulation) but visible in only 71% (17 of 24) of the participants in the parasagittal plane because of acoustic shadowing by the hyoid bone. Identification of the epiglottis was facilitated by tongue protrusion and swallowing, during which it was visible as a discrete mobile structure inferior to the base of the tongue. They were able to successfully visualize all of the relevant anatomic structures of the upper airway on sonography in this volunteer study.

Study aims and objectives were to evaluate the utility of ultrasound in evaluating the anatomy of epiglottis and pre-epiglottic space in children and accomplished by - studying the sonographic anatomy of epiglottis and pre epiglottic space and assessing the dimensions of epiglottis and pre epiglottic space

MATERIALS AND METHODS

It was a prospective, observational study conducted in the Department of Radio-diagnosis, BPS GMC (W), Khanpur Kalan, Sonepat, Haryana. A sample of random 60 pediatric subjects between age group 4-12 of either sex was taken who came for routine abdominal ultrasound with the consent of their parent. The Institutional Ethical Committee (IEC) approval was taken prior to start of the STS study as per protocol. Unwilling children or guardian or subjects with any active upper respiratory tract infection or known surgery were excluded from the study.

Procedure

The children were made to lie supine in sniffing position (flexion of neck on the body and head extended on the body) position with a pillow under the occiput to achieve optimum head extension and neck flexion. Ultrasound was performed by a single experienced sonologist. The epiglottis was located and scanned in the long and short axis in all subjects by using linear transducer (L 12-3) of Philips HD 11 XE. Scanning was done systemically starting from floor of the mouth to the sternal notch in anterior aspect of neck. The transducer was oriented transverse with respect to the neck of volunteers to visualize epiglottis and pre-epiglottic space on sonography to evaluate the feasibility of ultrasound and to describe the scanning technique and sonographic anatomy of the airway. The sonographic appearance of the epiglottis and the pre-epiglottic space was recorded as per data sheet.

Measurements

Sonographic morphology of both epiglottis and pre-epiglottic space was noted in each case. AP dimensions at the midpoint in the transverse view were measured in mm.

STATISTICAL ANALYSIS

The data was analyzed using statistical software – IBM SPSS-22 and Microsoft Excel. Mean, median and standard deviation were calculated. The data was analyzed by Student 't'–test

RESULT

We have examined 60 volunteers between age group 4-12 years for airway imaging by ultrasound. The study included 26 female and 34 male with a mean age of 8.1years with standard deviation of 2.6 years. We divided 60 volunteers in

Age group	Male	
4-8 years	19	14
9-12 years	15	12

Table-1: Age group

Groups	Extent of visualization of epiglottic portions while taking transverse AP dimension	
Group 1	Only median part is well visualised	23 (38%)
Group 2	Median and paramedian parts are visualised	21 (35%)
Group 3	Most of the epiglottis is seen in transverse view	16 (26%)

Table-2: Distribution of patients as per the extent of visualization of epiglottis in three different groups

Epiglottis (mm)	
N	60
Mean	1.1578
Median	1.1755
Mode	1.00
Std. deviation	.21926
Range	1.09
Minimum	.71
Maximum	1.80

Table-3: Statistical analysis of epiglottis midline AP dimension (N=60)

Pre-epiglottic space (mm)	
N	60
Mean	4.1382
Median	4.2250
Mode	2.32
Std. deviation	.76429
Range	3.37
Minimum	2.32
Maximum	5.69

Table-4: Statistical analysis of pre-epiglottic space midline AP dimension (N=60)

	Epiglottis (mm)		Pre-epiglottic space (mm)	
	Male	Female	Male	Female
N	34	26	34	26
Mean	1.1868	1.1198	4.2819	3.9504
Median	1.2050	1.0580	4.2575	3.9725
Mode	1.06	.995	3.33	N/A
Std. deviation	.21609	.22176	.62313	.89512
Range	1.09	1.03	2.36	3.05
Minimum	.71	.72	3.33	2.32
Maximum	1.80	1.75	5.69	5.37

Table-5: Comparison of epiglottis and pre-epiglottic space thickness in male (N=34) and female (N=26)

	Epiglottis(mm)		Pre-epiglottic space (mm)	
	4-8 years	9-12 years	4-8 years	9-12 years
N	33	27	33	27
Mean	1.0731	1.2613	3.9059	4.4222
Median	1.0600	1.2850	3.8400	4.4350
Mode	1.00	1.21	2.32	3.20
Std. deviation	.18424	.21703	.74914	.69467
Range	.79	.94	3.07	2.49
Minimum	.71	.86	2.32	3.20
Maximum	1.50	1.80	5.39	5.69

Table-6: Comparison of epiglottis thickness and pre-epiglottic space thickness in 4-8 years and 9-12 years age groups

Epiglottis (mm)				
	4-8 years		9-12 years	
	Male	Female	Male	Female
N	19	14	15	12
Mean	1.1172	1.0134	1.2751	1.2440
Median	1.1550	.9950	1.2850	1.2475
Mode	1.06	1.00	1.21	.99
Std. deviation	.19306	.15898	.21728	.22508
Range	.79	.57	.94	.77
Minimum	.71	.72	.86	.99
Maximum	1.50	1.29	1.80	1.75

Table-7: Comparison of epiglottis thickness in male and female of 4-8 years and 9-12 years age groups

Pre-epiglottic space (mm)				
	4-8 years		9-12 years	
	Male	Female	Male	Female
N	19	14	15	12
Mean	4.1518	3.5722	4.4467	4.3915
Median	4.1200	3.4975	4.4500	4.3375
Mode	3.42	2.32	3.33	3.20
Std. deviation	.56367	.85629	.67427	.74841
Range	1.98	2.50	2.36	2.17
Minimum	3.42	2.32	3.33	3.20
Maximum	5.39	4.82	5.69	5.37

Table-8: Comparison of pre-epiglottic space thickness in male and female of 4-8 years and 9-12 years age groups

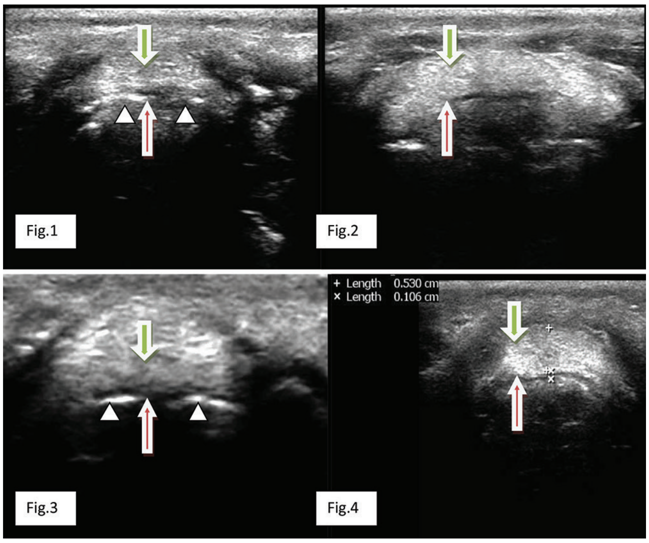

Figure-1: Group 1 Epiglottis: Only median part is well visualised; **Figure-2:** Group 2 Epiglottis: Only median and paramedian parts are well visualised; **Figure-3 and 4:** Group 3 Epiglottis: Most of the transverse dimension is visualised; **Red Arrow:** Thin hypoechoic strip like structure: EPIGLOTTIS; **Green Arrow:** Hyperechoic region: PRE EPIGLOTTIC FAT; **White Arrowhead:** AIR MUCOSAL INTERFACE

2 age groups (4-8 years and 9-12 years) (Table 1). Table-2 shows the distribution of patients as per the extent of visualization of epiglottis in three different groups. Table 3 and 4 shows statistical analysis of pre-epiglottic space midline AP dimension. Mean epiglottis thickness in male and female is 1.19 (+/-0.22) mm and 1.12 (+/-0.22) mm respectively. Mean pre-epiglottic space thickness in male and female is 4.28 (+/- 0.62) mm and 3.95 (+/-0.89) mm respectively. Both mean epiglottis and pre-epiglottic space thicknesses in male are seen to be greater than as in female but not statistically significant (table-5). Mean epiglottis thickness and pre-epiglottic space thickness is seen to be more in 9-12 years age group than as in 4-8 years, and is statistically significant (for epiglottis, p value=0.001; for pre-epiglottic space, p value=0.008) (table-6). Epiglottis thickness in both 4-8 years and 9-12 years age groups is seen to be greater in male than as in female but was not statistically significant (table-7).
Pre-epiglottic space thickness in both 4-8 years and 9-12 years age groups is seen to be more in male than female but the difference is statistically significant only in 4-8 years age group (p=0.03) (table-8).

DISCUSSION

This study was a prospective observational study conducted on 60 consecutive pediatric patients coming for non-airway related sonography between the age group 8-12 years of either sex in the Department of Radio-diagnosis of BPS Government Medical College for Women, Khanpur Kalan Sonepat. Protocol of the study has already been discussed in Material and Methods part. Sonographic morphology of both epiglottis and pre-epiglottic space with AP dimensions at the midpoint in the transverse view were noted in each case. The entire data was collected as per designed Proforma and statistically analyzed as per objectives.
In our study, we included 60 patients between the age group 4-12 years with mean age as 8.1 +/- 2.7 years. Male to female ratio in our study is 1.21.with with 34 males and 28 females. In 60 patients, we were able to visualize the epiglottis (part or whole) in all the 60 patients (100%). This is comparatively more as in study of Parmar et al.[12] They examined 100 volunteers with a mean age of 26.13 ± 8.41 years. They could visualize epiglottis in 90% volunteers in transverse view.
We grouped the patients as per the extent of visualization of epiglottis under ultrasound as:

Group	Extent of epiglottic portion visualised on transverse view	No of patients (%)
1	Only median part of the epiglottis is well visualized	23 (38%)
2	Median and paramedian parts of the epiglottis are well visualized	21 (35%)
3	Whole of the transverse dimension of epiglottis is visualized	16 (26%)

Sonographic morphology of epiglottis and pre-epiglottic space

In all the patients the epiglottis appears thin well defined strip like hypoechoic structure outlined anteriorly by echogenic pre epiglottic space and posterior by hyper echoic air –mucosal interface (Fig. 1-4).
Werner et al[5] reported that sonographically, the epiglottis appeared as a curv. Parmar et al[12] reported that epiglottis appeared as a hypoechoic curvilinear structure. Epiglottis was surrounded by pre-epiglottic space anteriorly and by a bright linear air-mucosal interface posteriorly.[13,14] Bektas et al[15] reported a case of 56-year-old man. They found epiglottis as a hypoechoic structure with an echogenic pre epiglottal space
In our study, average epiglottic thickness and the pre-epiglottal space thickness were found to be 1.2 +/-0.22 mm and 4.1 +/ -0.76 mm, respectively. Our literature review revealed few studies of evaluating ultrasonographic morphology of the epiglottis. Werner et al[5] conducted similar study on 100 adult volunteers between the ages of 18 and 50 years. They reported the average ultrasonographic epiglottic thickness as 2.39 +/- 0.15 mm almost double the thickness of pediatric epiglottis as we got in our study. Also they also found epiglottic thickness to be more in male (2.49 +/- 0.14 mm) than in female (2.34 +/- 0.13 mm) ($p<0.001$) as in our study. However literature review did not identify any prior studies of ultrasonographic identification and measurement of the pre-epiglottic space.
We also compared both epiglottic and pre-epiglottic dimensions in age groups 4-8 years and 9-12 years and found that both epiglottic and pre-epiglottic dimensions (AP) were less in 4-8 years age group than 9-12 years group and is statistically significant (for epiglottis, p value=0.001; for pre-epiglottic space, p value=0.008). There is no study in literature which did the similar comparison.
Comparison of male and female factor in both age groups (4-8 years and 9-12 years) for both epiglottis and pre-

epiglottic space was done as shown in Table-6 and Table-7. In both age groups, dimensions were seen to be more in male than female.

In 4-8 years age group, average epiglottic dimension in male is 1.12 +/- 0.19 mm which is greater than as in female candidates (1.01 +/- 0.16 mm). Also, the pre-epiglottic space dimension in male (4.15 +/- 0.56 mm) is seen to be more than female candidates (3.57 +/- 0.85 mm). The pre epiglottic space thickness difference is seen to be significant (p=0.03). In 9-12 years age group, average epiglottic dimension in male is 1.27 +/- 0.22 mm which is seen to be greater than female (1.24 +/- 0.22 mm). Also, the pre-epiglottic space dimension in male (4.45 +/- 0.67 mm) is more than female (4.39 +/- 0.75 mm) but the difference is not statistically significant.

Limtations

- The sample size was small
- No comparison with adult subjects and abnormal epiglottic morphology was done
- No significant previous literature was avilable for comparison.
- Single operator was involved and subjective bias is always there.

CONCLUSION

To conclude, ultrasound is cheap, rapid and noninvasive and does not aggravate the patient's symptoms. Epiglottis and pre epiglottic space are well visualised by ultrasound modality with measurable transverse dimensions and the knowledge can be used in future for imaging and diagnosing epiglottic and pre epiglottic pathology. More studies are needed in future to determine whether this technique could be used as a rapid bedside emergency department means of detecting epiglottitis or other pathologic enlargement of the epiglottis. Further work is also necessary to characterize the sonographic anatomy in patients with clinical abnormalities of the airway. Here a comparison with more established imaging techniques such as computed tomography and magnetic resonance imaging would be useful.

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Source of Support: Nil; **Conflict of Interest:** None

Submitted: 11-02-2018; **Published online**: 15-03-2018