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# An investigation of paediatric vocal functions with laryngeal ultrasound imaging

In summer 2022, I had the precious opportunity to work on a research project in the Voice Research Laboratory at the University of Hong Kong under the supervision of Dr. Estella Ma. This report summarises my progress and reflects on my research journey.

## Background of Research

My research area concerns the application of ultrasound technology on voice assessment in children. Voice disorders among children are common and deserve grave attention as they greatly compromise the patient's quality of life. Speech therapists (ST) play an important role in identifying patients with voice problems and assisting in their recovery. To achieve early detection and intervention, a handy and reliable instrument for screening voice disorders would be of great utility. Emerging research evidence is supporting the use of laryngeal ultrasonography in paediatric voice assessment and screening. Despite its functionality, this instrument has not been widely-adopted among practising STs in Hong Kong due to the lack of related knowledge and training.

As such, this research aims to extend our current understanding on paediatric vocal fold structures and functions by collecting ultrasound image data from Cantonese-speaking children with and without voice disorders. The data was analysed with respect to 4 quantitative parameters, namely vocal-fold arytenoid angle, maximum glottic angle, vocal fold length and subglottic airway diameter. It is hoped that the findings provide a preliminary reference for screening children susceptible of different voice disorders and contribute to promoting the application of ultrasound imaging among the ST community.

## Methodology

Seven children (all males), aged between 4-9 were recruited. Five of them are vocally healthy and 2 have voice problems. Their vocal health status was determined by parental-report and auditory-perceptual evaluation of examiners. The table below summarises the demographic information of the participants.

| Subject | Age / Sex | Vocally healthy? |
|---|---|---|
| 01 | 4;2/M | Yes |
| 02 | 4;7/M | No |
| 03 | 5;2/M | Yes |
| 04 | 6;0/M | Yes |

| | | |
|---|---|---|
| 05 | 6;3/M | No |
| 06 | 8;0/M | Yes |
| 07 | 8;9/M | Yes |

Ultrasound imaging was performed using the ultrasound system GE LOGiQ e8 with a linear probe of 4-15MHz by two examiners which were the investigator and another research student. The process took about 20 minutes for each participant. During the examination, the participant was put in a supine position and had the neck stretched, with a pillow placed underneath. Three sets of ultrasound videos were obtained which included i) the vocal fold view at quiet breathing, ii) the subglottic view at quiet breathing and iii) the vocal fold view at maximum phonation of /i/.

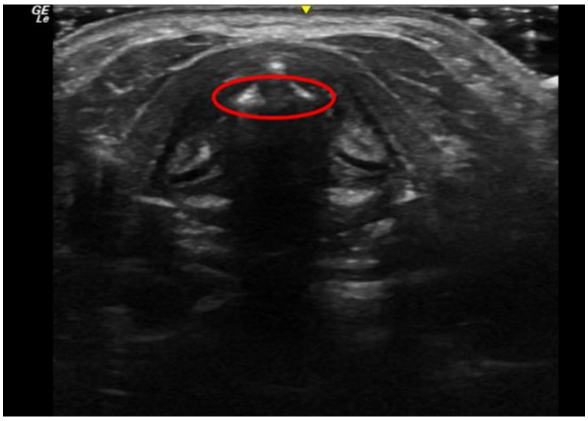
For data analysis, each examiner separately worked on the set of ultrasound videos they obtained. Prior to analysis, the examiners had confirmed the standards for plotting with one another. Each examiner first selected one static image that best captured the vocal folds or subglottic area from each set of the video. Structural landmarks (e.g., arytenoid cartilages and true vocal folds) were then identified and the measurement points were plotted manually using the software Fiji. With the plotted points, the software would compute the vocal-fold arytenoid angle, maximum glottic angle, vocal fold length as well as the subglottic airway diameter. Upon completion of individual analysis, the examiners compared their set of data and determined inter-rater reliability. The examiners also repeated the entire analysis process again around 1 week after the first analysis to determine the intra-rater reliability.

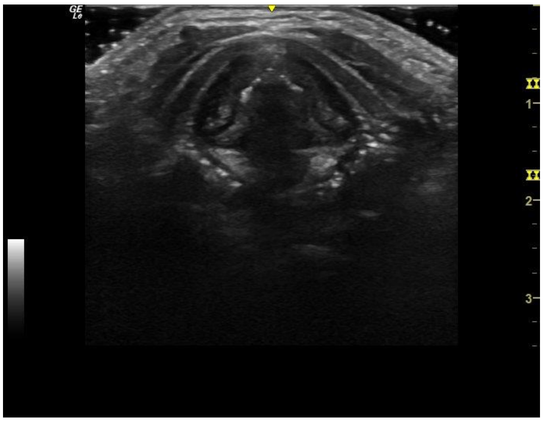
## Results

The first two parameters for analysis are angles, namely the vocal fold-arytenoid angle (VAA) and the maximum glottic angle (MGA), both of which are used for detecting the presence of vocal fold immobility. The data showed that VAA on both left and right are larger in abduction as compared to adduction. For MGA, it is usually within the range of 35-55 degrees and the value is comparable across age groups.

The other two parameters are vocal fold length and subglottic airway diameter. Consistent with the hypothesis that both lengths would increase across age groups, the data showed that in general older participants (i.e., age 6 or above) have longer right and left vocal fold lengths as compared to younger participants. However, such a difference was not observed for subglottic airway diameter.

The four parameters aside, an interesting finding is that ultrasonography may be able to visualise possible presence of vocal pathologies The picture on the left shows suspect of bilateral vocal nodules (highlighted with red circle) of a participant with vocal hoarseness while that on the right shows the vocal folds of an age-matched vocally healthy participant.





To determine whether measurements are consistent across raters and time, inter-rater reliability and intra-rater reliability were computed. For inter-rater reliability, the Pearson correlation coefficient ranges from -0.012. to 0.449 across different parameters, indicating a small to moderate correlation. Yet, none of the correlations could reach statistical significance. In addition, an independent sample t-test was performed and the result indicated that the mean difference between raters was not statistically significant.

As for intra-rater reliability, the Pearson correlation coefficient ranges from 0-0.89. Compared to inter-rater correlation, intra-rater correlation seems to be stronger. In particular, four criteria including the left VAA at abduction, left VAA at adduction, MGA as well as subglottic airway diameter had a strong correlation of 0.721, 0.61, 0.98 and 0.924 respectively, with the latter two being a statistically significant correlation. Also, a related sample t-test was conducted and the result indicated non-significant mean difference for all parameters (except for left VAA at abduction).

In sum, both the inter-rater and intra-rater reliability remains low as the correlation for most parameters are statistically non-significant. Even though the t-tests revealed no mean difference between and within raters, it is suspected that the t-tests might not be able to accurately reflect the actual variation within the data given the small size of the current sample.

## Future direction

The current study is a preliminary step to understand paediatric vocal structures and functions using laryngeal ultrasound. Improvements could be made on the research design in order to obtain more vigorous results. For the data collection procedure, clearer task instructions could be used so that the participants know what they ought to and ought not to be doing during the examination. For instance, it was noticed that some participants move their jaws or limbs during the examination which makes taking good images more difficult. Clearer task instructions would hopefully prevent any unintentional behaviour of the children and minimise disruption to the data collection process. The instructions would also make the examination procedures more standardised and more easily replicable by other researchers in the future. As for the analysis procedure, the current study is prone to the risk of bias as the examiner and the data interpreter were the same person. While it might not be feasible for the examiner to be blinded to the client's voice profile, a blind rater who is equally trained in ultrasound image interpretation could be invited to plot 10% of the images and see if the measurements are comparable to that of the original examiner.

In addition to the aforementioned improvements on research procedure, possible directions for future investigation would also be discussed. Indeed, much has to be explored to enable the use of laryngeal ultrasound imaging for clinical purposes.

To start with, future study could include more participants to establish normative data of the sonographic appearance of children's larynx. A major limitation of the current study is the small sample size. Only 7 children were recruited, with all of them being males and only 2 of them having a suspected vocal pathology. Future samples could include more children across different age groups, with a more balanced ratio between male and female so as to increase the representativeness of the sample. To study abnormal vocal structures and functions, children of various types of vocal pathology could be recruited as well.

Second, future study could work on increasing the inter- and intra-reliability of ultrasound imaging. This is crucial if ultrasonography is to be used for diagnostic or screening purposes. Operator dependency has always been a drawback of ultrasonography. It is a challenge for examiners, especially inexperienced ones, to obtain an optimal image for analysis. For instance, the vocal folds would easily be out of view when the child phonates. As such, researchers could investigate different solutions including establishment of a standard protocol, providing more training and utilizing assistive equipment such as gel pad to enhance visualization of vocal folds.

Finally, laryngeal ultrasound imaging could be validated against flexible transnasal laryngoscopy, which is the current gold standard in vocal pathology diagnosis. It is hoped that with sufficiently high sensitivity and specificity in identifying vocal pathology like vocal nodules and vocal palsy, laryngeal ultrasound could be used by community-based speech therapists for performing mass screening.

After summarising my research study, the following section would describe my personal growth through this research project

**What I learnt**

First, the experience has consolidated and expanded on what I have learnt in class. Prior to joining the program, I had little experience performing an instrumental assessment and had not used a laryngeal ultrasound machine before. It was really interesting learning to operate the ultrasound system. With many opportunities to interpret the ultrasound images, I become more familiar with various structures within a paediatric larynx. In addition to human anatomy, my understanding of research statistics has also been widened. Though I have taken statistics courses before, this experience allowed me to apply what I had learnt. It was sometimes confusing when analysing the statistical result, but I enjoyed the learning process.

Beside the knowledge, the experience has honed some of my soft skills and build up my leadership capacity. Throughout the research process, there were multiple occasions that required me to use my creativity to problem solve. For instance, during ultrasound examination, a bed is needed for the patient to lie down. Yet, on one of the data collection dates, the only bed at our lab was in use by others. Therefore, me and another research student thought of putting together two large sofa chairs to form a "temporary" bed. Problem solving involves accurately identifying, analysing and resolving a challenge. Such skill is indispensable for my study and future career.

Moreover, the research enabled me to practice effective communication. In fact, communicating with participants was not an easy job. Sometimes there might be communication breakdown. For example, one participant requested me to make a certain special arrangement for her, yet I had misinterpreted her messages and thus had not contacted the personnel involved to accommodate her needs. It was an hour away from the start of data collection when I realised the issue, I tried to stay calm and communicated with the participant and other students involved. I apologise to the participant for having caused her such trouble and I was very grateful that she still attended the data collection as scheduled. Good communication skill is important in many aspects of our life. It facilitates exchanges of ideas, enhances effectiveness of work and helps establish good relationship.

Also, my interaction skills with children were honed. I was really impressed by how the other research student engaged with the children and I learnt a lot from her. Children have shorter attention spans, especially when the examination tasks themselves were not very interesting. They might also be easily distracted by other things in the surroundings. There were several tricks that I learnt to keep children motivated, for instance having a competition with them (e.g., who says the longest /i/) and inviting children to be involved in certain procedures (e.g., squeezing the gel, asking the child to touch the probe). It is also helpful for the examiner to explain to the child what she is doing throughout the process.

While there are skills I gained, there are also areas for improvement, one of which is time management. For this project, I believe the time allocated for participant recruitment and data collection was insufficient which partly account for the low number of participants recruited. With time constraints, the number of available time slots I could offer was limited. The timing was also not the most ideal as the data collection period clashes with one of the busiest times of our target population. In the future, when similar projects are carried out, I could consult experienced researchers to obtain advice on the time management of data collection. I should have a clear deadline in mind and should be aware of any delay. Small delays in different parts might have a huge impact on the overall progress. When setting deadlines, buffer time needs to be spared in case of contingency issues. Sufficient time allows me to send out promotion materials multiple times and explore new ways of promotion so as to recruit more participants.

To sum up, this research is a rewarding journey. I would like to express my sincere gratitude to my supervisor, Dr. Ma who has guided me throughout the process and patiently answered any questions that I had.