Two Dimensional Ultrasonic Demonstration of Lateral Pharyngeal Wall Movement in Real Time—A Preliminary Report

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The recent commercial availability of real time ultrasonic multi-transducer two dimensional cardiac B-scanning equipment (4) presents exciting technological possibilities for evaluating the dynamics of lateral pharyngeal wall movement. This paper will present preliminary observations on the use of such equipment on three normal subjects, one of whom has a frontal cine x-ray study to compare with the ultrasound examination. Because these ultrasound examinations were performed on equipment[1] exhibited at the American Institute of Ultrasound meeting in Seattle, Washington, October, 1974, and not available to us after the meeting, this study is of very limited scope. Our purpose in presenting these observations is to demonstrate the feasibility of such equipment in recording lateral pharyngeal wall movement and to encourage other investigators to further pursue this mode of inquiry if they have similar equipment presently available for echocardiographic studies at their institutions.

Until the development of multi-transducer ultrasonic imaging equipment, the only method for ultrasonically evaluating lateral pharyngeal wall movement was to place a single transducer on the skin of the neck pointing towards the lateral pharyngeal wall and to record the motion of a single point on one lateral pharyngeal wall during phonation, either at a single level (*2*, *3*) or at two levels, one above the other (*7*).

The great advantage of this multi-transducer equipment is that it continually visualizes approximately an 8 cm long vertical length of one lateral pharyngeal wall extending from the nasal to the oral pharynx. Movements of this entire length of pharyngeal wall are continuously and simultaneously displayed. Therefore, the various motions at different levels of one pharyngeal wall during phonation and swallowing are visualized in a manner similar to that seen on frontal cine or video fluorography.

Materials and Methods

The heart of the ultrasound unit is a 4.5 MHz multi-element transducer. It consists of a 8 cm long linear array of 20 crystals each 4 mm high by 10

[1] Echocardiovisor 01, Organon Teknick bv, Industrielaan 84, Oss, Holland.

mm wide. In operation, the individual crystals are sequentially energized with pulsed ultrasound. One hundred and fifty sequences or frames per second are produced. During each sequence 20 parallel ultrasound beams are emitted. The beams are dual interlaced on an oscilloscope to produce 40 parallel lines at 75 frames per second. Structures intercepted by the individual ultrasound beams reflect ultrasound back to the individual transducer. These intercepted structures are represented as dots on the oscilloscope screen (1). The lateral pharyngeal wall appear as a vertically oriented structure of closely spaced dots, each of which moves horizontally during phonation or swallowing.

The transducer is vertically oriented to the lateral side of the neck with its upper edge just below the external auditory canal and over or just behind the superior portion of the mandibular ramus. The transducer covers the level from the nasal to the oral pharyngeal region (Figure 1). Slight anterior or posterior angulation of the transducer is necessary as the patient phonates so as to orient the transducer most perpendicularly to the lateral pharyngeal wall. The greatest excursions of the lateral pharyngeal wall are visualized when the ultrasound beam is perpendicularly oriented to the wall. Using a video camera pointed at the oscilloscope screen and a microphone, the ultrasonic images and subject's speech were simultaneously recorded on video tape. The lateral pharyngeal wall closest to the transducer is the only wall demonstrated. This wall is seen because the ultrasound beam is totally reflected by the soft tissue-air interface between the pharyngeal wall mucosa and the air in the pharyngeal cavity. Since ultrasound does not travel through air, only one lateral pharyngeal wall can be demonstrated with the transducer on one side of the neck.

Results

Localized medial movement of the left pharyngeal wall from the nasal to the oral pharyngeal levels in three normal subjects during breathing and speech (Figure 2a, 2b) show a configuration very similar to that seen on a frontal cine fluorographic study of one of these subjects (Figure 3a, 3b). During the dry swallow, medical movement of the pharyngeal wall is seen (Figure 4) in a manner similar to that previously reported by Shprintzen

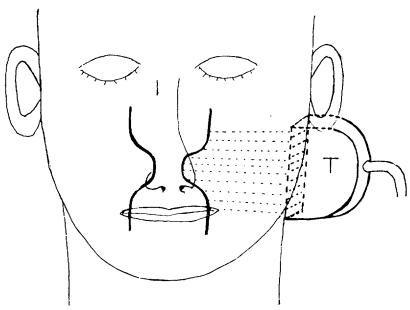

FIGURE 1. Schematic drawing illustrating] multi-element transducer placement along left side of neck oriented perpendicular to lateral pharyngeal walls. Dotted lines indicate paths of ultrasound beams between the multiple elements of transducer and the lateral pharyngeal walls.

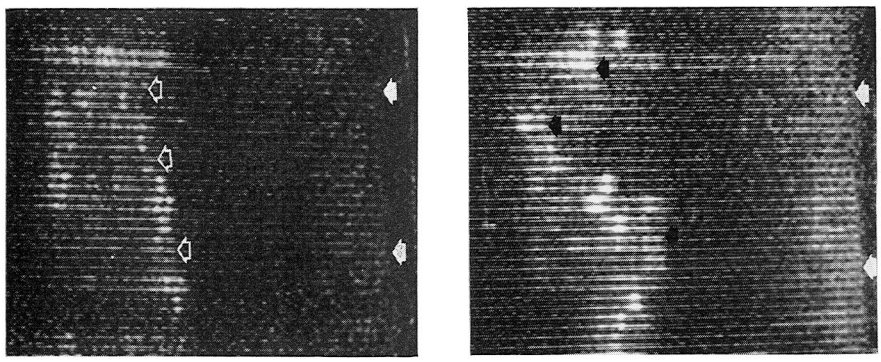

FIGURE 2. Still frames from video tape showing ultrasonic image of left lateral pharyngeal wall from nasal to oral pharynx. A) Quiet breathing. Solid white arrows indicate left wall of neck. Open white arrows indicate mucosal surface of left lateral pharyngeal wall. B) Phonation of E. White arrows denote skin of left side of neck. Black arrows indicate mucosal surface of left lateral pharyngeal wall. Note localized medial movment of pharyngeal wall in nasopharyngeal region (middle black arrow).

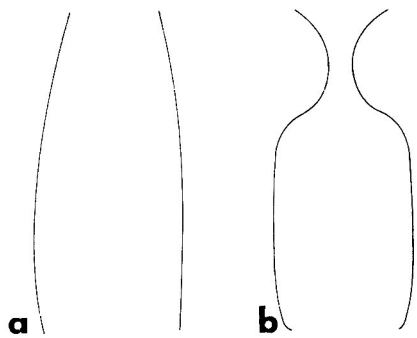

FIGURE 3. Frontal tracings from still frames from cine x-ray of barium coated nasal pharynx demonstrating lateral pharyngeal walls during quiet breathing (A) and during phonation (B).

using frontal videofluoroscopy (*5*). A composite line drawing superimposing breathing, speech and swallow is shown in Figure 5.

Discussion

The use of multi-element ultrasonic transducers opens a whole new area of research in recording the dynamics of lateral pharyngeal wall movement with a non-invasive, non-injurious technique. There is no documented evidence that the pulsed ultrasound used in this equipment (average energy 2 mW/cm^2 and peak energy 3.6 mW/cm^2) has injured tissue (*6*).

Though the present equipment demonstrates movements of only one lateral pharyngeal wall at a time, it is technically feasible to make an apparatus with two multi-element transducers that can be applied to both sides of the neck for simultaneous display of both lateral pharyngeal walls.

The potentials of this technique are several. 1) It could be used to eliminate the need for frontal video fluoroscopic technique in evaluating lateral pharyngeal wall movement. Lateral video fluoroscopy at present will still be needed to demonstrate the velar-pharyngeal relationships in the

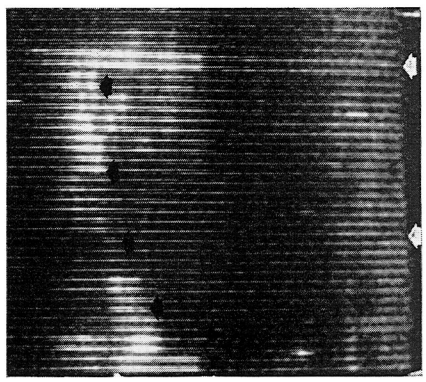

FIGURE 4. Still frame of video tape showing ultrasonic demonstration of left lateral pharyngeal wall during swallowing. White arrows indicate skin surface of left side of neck. Black arrows indicate position of left lateral pharyngeal wall. Note that during swallowing medial movement of both the nasal and oral portions of the lateral pharyngeal wall occurs.

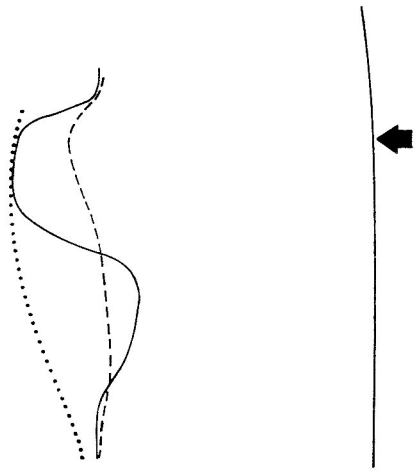

FIGURE 5. Composite sketch demonstrating positions of left lateral pharyngeal wall during quiet breathing (dashed line), phonation of E (solid line), and swallowing (dotted line). Black arrow indicates left neck skin surface. Note while with phonation, lateral pharyngeal wall shows localized medial movement in nasopharyngeal area, with swallowing medial movement of entire pharyngeal wall occurs.

mid-saggital plane and base videofluoroscopy will also be necessary in many cases. 2) Because of the non-injurious nature of ultrasound, repeat studies could frequently be performed to assess change in lateral pharyngeal wall movement during therapy. 3) Patients could be permitted to visually monitor their own lateral pharyngeal wall movement, thereby reinforcing their auditory perception of newly learned speech tasks.

Summary

Preliminary observations are reported in three normal subjects using a multi-element, ultrasonic transducer unit for demonstrating in real time and two dimensions the movements of the lateral nasal and oropharyngeal walls during phonation. Ultrasonic images produced are similar to those seen on frontal roentgen motion recordings. Present limitations, potential applications and advantages of this technique are discussed.

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