Journal of the All India Institute of Speech and Hearing.
1989, Vol. XX.

Effect of Varying Air Pressure in the External Auditory Meatus on Sound Pressure Level Required to Elicit Stapedius Muscle Reflex

Venkatesh Aithal
Speech Pathologist and Audiologist
Dept. of Otolaryngology
***Division** of Audiology and Speech*
Mafraq Hospital
P.O. Box 2951, Abu Dhabi, UAE.

INTRODUCTION

Is it essential to maintain the air pressure in the monitored ear equivalent to that of the middle ear pressure while measuring stapedius muscle reflex threshold?

It is customary to maintain the air pressure in the monitored ear equivalent to that of middle ear pressure while measuring stapedius reflex threshold. It is logical because reflex change could be easily detected only if the tympanic membrance is at its maximum compliance. This can be achieved when the air pressure an either side is the same.

Can stapedius reflex threshold be obtained without airtight seal?

With a little experience, one can easily learn how to obtain airtight (hermetic) seal in a majority of the cases. Obtaining an airtight seal is essential to avoid any influence of middle ear pressure obscuring measurement of acoustic reflex. It has been reported that negative middle ear pressure do affect the reflex thresholds.

Surr and Schuchman (1976) compared acoustic reflex thresholds with and without a pressure seal on 10 normal adults, 10 sensorineurally impaired adults with normal tynpanograms and 10 children with negative pressure tympanograms. They found that for adults, 95% of the measurements obtained in the sealed conditions. Surr and Schuchman concluded that when an acoustic reflex was elicited even without a pressure seal then the clinician can be confident that the probe ear was free of conductive pathology-

Basu (1977) studied acoustic reflex thresholds on two groups of subjects. Group I consisted of 15 young adults who had normal hearing, A type tympanogram and middle ear pressure within.$\pm$. 20 mm H_2O. Group II consisted of 7 subjects who had C type tympanogram with or without hearing loss and showed acoustic reflex at the point of maximum compliance. He observed that in normal subjects, acoustic reflex theresholds were not affected even without airtight sealing. In the 5 subjects, with negative middle ear pressure, the difference between acoustic reflex threshold with and without airtight sealing ranged from 10 to 35 dB. For 2 subjects with negative middle ear pressure, re-

flex could not be detected without pressure seal.

Kalpan, Bebecki and Thomas (1980) com0-pared sealed and unsealed reflex in 30 children with normal middle ears. Their results indicated that: 1. approximately two-thirds of the children demonstrated reflexes in the unsealed conditions; 2. differences between sealed and unsealed reflex thresholds were not clinically significant; 3. in most cases unsealed reflexes were measurable at all frequencies or at none; 4. neither size of ear canal volume nor amplitude of the sealed reflex at 10 dB SL seemed to be related to the presence or absence of the unsealed reflex. They concluded that reflex thresholds obtained in the absence of an hermetic seal may be considered valid, but the absence of an unsealed reflex should not be considered diagnostically significant.

Martin and Coombes (1974) have tested 20 normal hearing individuals to determine the relationship between positive and negative air pressure in the external auditory meatus and the intensity required to elicit the acoustic reflex at 1 KHz. They varied the pressure from 240 to -240 mm H_2O, in 40 mm H_2O step, and at each level, determined the acoustic reflex threshold level. The magnitude of the difference was smaller than what might have been anticipated. They also recommended to study the reflex threshold at frequencies other than 1000 Hz, by varying the air pressure levels in the external auditory meatus.

Will variation of air pressure in the external auditory meatus affect acoustic reflex threshold?

To answer this question, the following study was undertaken.

METHODOLOGY

Subjects:

The experimental group consisted of 14 males and 10 females, ranging in age from 18 to 24 years. The subjects were selected based on the following criteria:

1. Normal hearing in both the ears (thresholds no greater than 20 dB HL from 250 to 4000 Hz)
2. No history of external or middle ear pathology.
3. No history of any neuromuscular impairment.
4. Negative otological findings.
5. A pressure compliance peak within $\pm$. 20 mm of H_2O pressure.
6. A measurable reflex at a level of 115 dB SPL, at least in one ear.

Apparatus:

For preliminary screening purposes, a . commercially available diagnostic audiometer (Maico MA 22) was used. The transducer (TDH-39) of the audiometer were housed in cushions (MX-41/AR).

Impedance audiometry was carried out by means of an electro-acoustic impedance bridge (Madsen ZO 73). Contralateral reflex thresholds were eleicited using external earphone, enclosed in associated ear cushion.

Calibration or apparatus:

The diagnostic audiometer including the earphones (TDH-39) with the associated cushion (MX-41/AR) was calibrated at the commencement of the study and periodically during the course of the investigation with an artificial ear assembly (Bruel and Kjaer 4152) using a condenser microphone (Bruel and Kjaer, **4144)** and a sound level meter (Bruel and Kjaer, 2203) with its associated octave band filter net work (Bruel and Kjaer, 1613).

Before testing each patient, the probe tip

was fitted to built-in cc cavity of the electroacoustic impedance bridge (Madsen ZO 73). After ensuring that there was no pressure leakage, the sensitivity knob wass switched to position two, compliance scale was adjusted to read two by rotating the compliance knob. At this time, if the balance meter did not read zero, necessary adjustments were made as recommended by the manufacturer.

Test environment

All testing were performed in sound treated rooms. Wherethe noise level in the test room met the specifications.

Procedure

(a) Screening prodedure

All subjects were tested by both conventional and impedance audiometry as a routine part of their clinical evaluation. Otoscopic examination and impedance screening were performed prior to actual experiment to accurately rule out the influence of any unnoticed external or middle ear pathology.

Pure-tone thresholds were determined for both ears using Hughson-Westlake procedure (Carhart and Jerger, 1959). A normal audiogram was defined as one in which threshold in either ear did not exceed 20 dB HL over a range from 250 to 4000 Hz, at octave intervals.

Electroacoustic impedance bridge (Madsen ZO 73) was used to obtain three impedance measurements on each ear. 1. tympanogram; 2. static compliance; 3. threshold of the stapedius reflex for pure tones. Tympanometry was performed an each ear. All subjects showed normal tympanograms (A type). **All** subject also showed maximum compliance in the pressure range $\pm$. 20 mm H_2O

(b)Test Procedures:

For detailed investigations, impedance audiometry was carried out by means of an electroacoustic impedance bridge (Madsen ZO 73). The procedure was similar to the one given in the manual supplied with the instrument.

The main purpose of this study was to measure acoustic reflex thresholds at different air pressure levels in the external auditory ineatus. For this purpose, middle ear pressure was determined and the manometer was adjusted to the middle ear pressure. Then balance meter was then set to sensitivity position three and nulled to zero. After this, pure tones were introduced to the opposite ear. The intensity of the pure tone was varied until the tester had identified the lowest hearing level at which a deflection of the balance meter synchronous with the onset and offset of the tone could be observed. This level was recorded as acoustic refle threshold. Then air pressure inside the eternal ear cancel was varied in 100 mm H_2O pressure step from + 3000 to -6000 mm H,O. At each step, balance meter was set to zero, and acoustic reflex thresholds were obtained as explained above. In this fashion reflex thresholds were measured for signals of 500. 1000 and 2000 Hz.

When testing had been completed on one ear, headband, earphone, and probetip were reversed and the entire procedure was repeated on the opposite ear.

Reliability check: to check the reliability of the results obtained in the present study, the experiments were repeated on the four subjects (8 ears) and results were statistically analyzed.

RESULTS

Data obtained from 24 subjects or 48 ears were given in three tables (Table 1,2 and 3).

Table 1: Means and Standard Deviations of the intensities required to elicit the middle ear reflex as a function of variation of air pressure in the external auditory canal
(Total = 48 ears; Absent = 6 ears)
(Test Frequency: 500Hz)

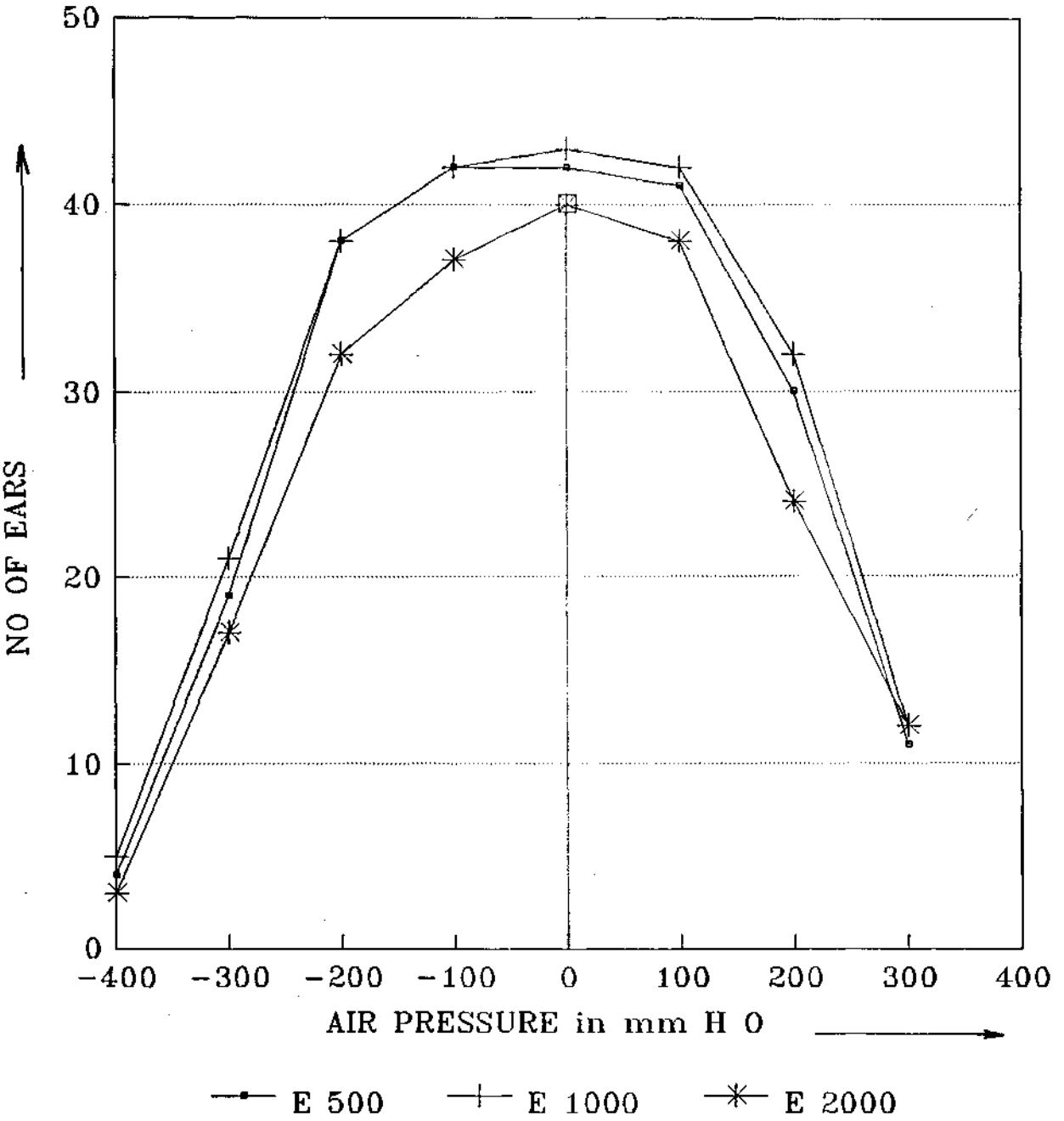
	Air Pressure (mm H_2O)									
	+300	+200	+ 100	0	-100	-200	-300	-400	-500	-600
Number of ears	11	30	41	42	42	38	19	4	1	
SPL for reflex (dB)	117.73	112.7	101.95	95.48	102.5	110.79	116.59	123.75	125	
Increase above reflex threshold with min. tympanic membrance impedance (Mean in dB)	22.25	17.22	6.47	0	7.02	15.31	21.11	28.27	29.52	
Standard Deviations	8.59	9.68	9.31	8.32	8.88	9.21	7.45	2.17	0	

Table 2: Means and Standard Deviations of the intensities required to elicit the middle ear reflex as a function of variation of air pressure in the external auditory canal
(Total = 40 ears; Absent = 5 ears)
(Test Frequency: lOOOHz)

	Air Pressure (mm H_2O)									
	+300	+200	+ 100	+ 0	-100	-200	-300	-400	-500	-600
Number of ears	12	32	42	43	42	38	21	5		
SPL for reflex (dB)	115.42	112.19	102.5	96.74	102.38	108.82	116.67	124		
Increase above reflex threshold with min. tympanic membrance impedance (Mean in dB)	18.68	16.16	5.76	0	5.64	12.08	19.93	27.26		
Standard Deviations	7.98	9.22	7.58	6.61	8.96	8.87	7.24	2		

Table 1, shows reflex thresholds obtained for 500 Hz at various air pressure levels. Similarly, Table 2 and 3 show thresholds obtained using 1000 Hz and 2000 Hz respectively.

While determining acoustic reflex thresholds, an intensity giving a minimum of 0.5 unit deflection of balance meter synchronous with the onset and offset of the stimulus was considered. This was done as per the recommendation of Moller (1962, 1964) and Borg (1972). According to them, acoustic reflex threshold value for scientific purposes should be an intensity giving at least 10% of maximum obtainable change.


50
40
30
20
10
0
NO OF EARS
−400
−300
−200
−100
0
100
200
300
400
AIR PRESSURE in mm H O
E 500
E 1000
E 2000

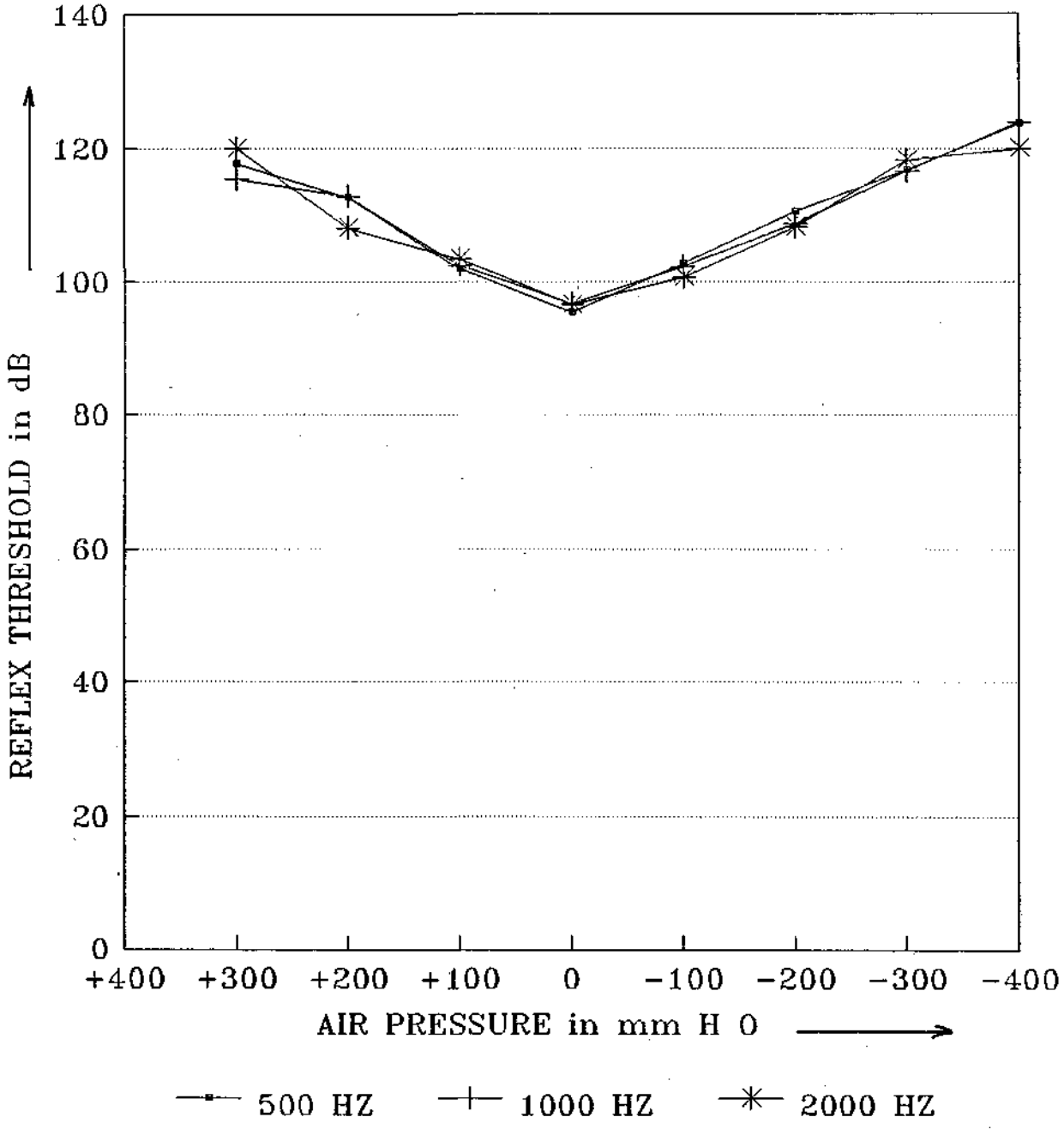

140
120
100
80
60
40
20
0
REFLEX THRESHOLD in dB
+400
+300
+200
+100
0
−100
−200
−300
−400
AIR PRESSURE in mm H 0
500 HZ
1000 HZ
2000 HZ

Table 3: Means and Standard Deviations of the intensities required to elicit the middle ear reflex as a function of variation of air pressure in the external auditory canal
(Total = 48 ears; Absent = 8 ears)
(Test Frequency: 2000 Hz)

	Air Pressure (mm H_2O)									
	+300	**+200**	**+ 100**	+0	-100	-200	**-300**	-400	-500	**-600**
Number of cars	**12**	**24**	**38**	40	37	32	**17**	3		
SPL for reflex (dB)	**120**	**108.13**	**103.42**	**96,63**	100.68	108.28	**118..24**	120		
Increase above reflex threshold wilh min. tympanic membrance impedance (Mean in dB)	**23.37**	**11.5**	**6.79**	0	4.05	11.05	**21.61**	23.37		
Standard Deviations	**5**	**10.73**	**10.53**	**11.53**	11.48	**13.34**	**7.58**	7.07		

DISCUSSION

The results indicate that higher intensities were required to elicit middle ear muscle reflex threshold as pressure level inside the external auditory meatus were either decreased or increased (Fig. 1).

The acoustic reflex thresholds obtained by changing the pressure within the ear canal, when compared to mean reflex at middle ear pressure ranged from 6.47 dB at 100mmH_2Oto29.5dBat-500mm$H_2O$for 500 Hz. From 5.64 dB at -100 mm H_2O to 27.26 dB at -400 mm H_2O for 1000 Hz and from 4.05 dB at -100 mm H_2O to 23.07 dB at 300 and -400 mm H_2O for 2000 Hz.

The increase in intensity as pressure levels inside external ear canal increased was said to be slight by Martin and Coombes (1964), not exceeding a mean of 5.1 dB at -240mmH_2O. But the present study showed geater variations even with 100 mm H_90 change inside the ear canal in both directions. Comparison of results obtained by Martin and Coombes (1974) with the present study indicated that higher intensities were required to elicit reflex threshold when air pressure inside the ear canal was changed,

Results of the present study suggest that reflex could be obtained even if the pressure was changed from 300 to -400 mm H_2O except at 500 Hz, where reflex was measured in only one ear at -500 mm H_2O.

An interesting point observed in this study was that the number of ears in which reflexes could be observed was not same at all air pressure levels, and at all three frequencies (Fig. 2). Almost all subjects exhibited reflexes when the air pressure was varied between ± 100 mm H_2O. When air pressure was further decreased or increased, from middle ear pressure the number of ears exhibiting reflexes grew small. This was observed for all three test frequencies.

Martin and Coombes (1974) observed reflexes in all of the 20 normal subjects, when pressure inside the ear canal was varied from +240 to -240 mmH_20. In the present study, number of ears in which reflex could be monitored at 300 mm H_2O was 11 for 500 Hz, 12 for 1000 Hz and 12 for 2000 Hz.

Similarly, the number of ears in which reflex could be monitored at -400 mm H_2O was 4 for 500 Hz, 5 for 1000 Hz and 3 for 2000 Hz.

Many investigators have reported that in the normal ear, at middle ear pressure, the acoustic reflex could be elicited at a sensational level of 65 to 105 dB (Moller, 1961, Jerger et al 1972). In the present study, acoustic reflex was elicited at an SPL of 80 to 115 dB at middle ear pressure. Mean acoustic reflex threshold for 500 Hz at middle ear pressure was 95.48 dB SPL, for 1000 Hz it was96.74 dB SPL and for 2000 Hz it was 96.63 dB SPL.

Surr and Schuchman (1976) reported that the acoustic reflex could be measured consistently at the point of maximum compliance (middle ear pressure) in case of subjects who exhibit negative middle ear pressure. But they did not observe reflex without a pressure seal. Basu (1977) reported that, it was possible to observe acoustic reflex in five out of seven subjects who exhibited negative middle ear pressure with and without airtight sealing.

The present study indicates that it is possible to observe reflexes in those cases in whom both negative and positive middle ear pressures are induced.

The analysis of the data for reliability showed that there was no significant difference between test and retest scores.

Change in pressure inside the external auditory meatus affects middle ear muscle thresholds considerably. Airtight sealing is essential to avoid any influence of negative or positive middle ear pressure on reflex thresholds and caution should be exercised in interpreting results without an hermetic seal.

ACKNOWLEDGEMENT

The author is thankful to Mr. J.D. Samuel, former Lecturer in Audiology, All India Institute of Speech and Hearing, Mysore and to the Director, Institute of Speech and Hearing, Bangalore. The author also extends his thanks to Dr. Reza Sowdagar, M.D., Consultant and Head of the Department of Otolaryngology, Mafraq Hospital Abu Dhabi, U.A.E.

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