ORIGINAL ARTICLE

Fetal Heart Sound Analysis : A Preliminary Evaluation

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Summary

The aim of this study, is to determine whether the fine characteristics of the fetal heart sounds could be used to identify intrauterine growth retarded fetuses. A preliminary evaluation, was conducted to compare these characteristics between intrauterine growth retarded fetuses and normal fetuses in the antenatal period after 36 weeks of gestation. Altogether, 7 IUGR fetuses were compared with 12 normal fetuses.

An instrument named the Fetal Frequency Phonocardiogram was designed for this purpose. When connected to a personal computer and with a software programme specially written, the fetal heart sound characteristics were analysed.

After detailed analysis, there were 3 significant differences between IUGR and normal fetuses, all of which gave a p-value of < 0.01. The frequency of the first heart sound was significantly higher in the IUGR fetuses compared to normal fetuses. The ratio of the amplitude of the first heart sound over the second heart sound was higher in the IUGR group. Finally, the ratio of the time between the first and second heart sound over the cardiac cycle was shorter in the IUGR fetuses.

Fetal heart sound analysis, may provide a simple non-invasive method of detecting and monitoring fetuses at risk in the antenatal period.

Key Words: Fetal heart sound, Intrauterine growth retardation, Fetal frequency phonocardiogram

Introduction

Various modalities of fetal surveillance are available today. They range from the simple fetal kick chart[1,2] to the more sophisticated doppler ultrasonography[3,4]. Of these, one of the more frequently used fetal monitoring facility is the cardiotocography[5]. Cardiotocography evaluates mainly the fetal heart rate and its variations.

Very little work, however, has been carried out to determine the importance of other aspects of fetal cardiac function as a fetal surveillance facility. One such aspect, where little work is done is on the characteristics of the fetal heart sounds.

We attempt here to determine whether analysis of the characteristics of the fetal heart sounds, can be used to identify fetuses at risk. The aim of this preliminary evaluation, is to compare various characteristics of the fetal heart sounds between intrauterine growth retarded and normal fetuses in the antenatal period.

Materials and Methods

To study the characteristics of the fetal heart sounds a special fetal phonocardiogram was devised by the Department of Obstetrics and Gynaecology in Ipoh General Hospital. Named the Fetal Frequency Phonocardiogram, it consists of an air-interface transducer, an amplifier, electronic sound filters and an

analogue to digital conversion card. When connected to a personal computer (IBM compatible 286 or higher) and with a software programme specially written for this study, the characteristics of the fetal heart sounds could be documented (Fig. 1).

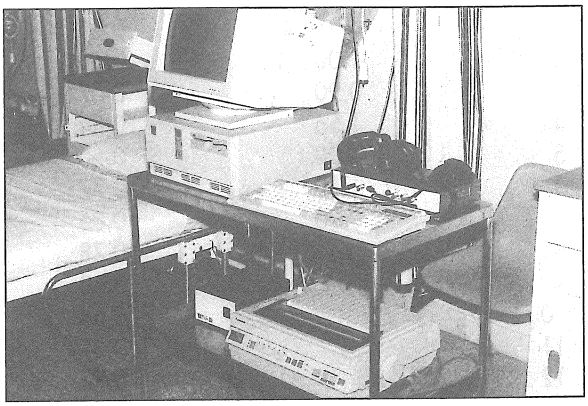

Fig. 1: Fetal Frequency Phonocardiogram equipment

An air-interface sound transducer, instead of a compliance matching transducer as used in other fetal phonograms[6,7,8] was used, to reduce unwanted sounds e.g. fetal breathing movements, fetal movements. The software programme was written with GWBasic for this study. The prototype of the Fetal Frequency Phonocardiogram was made ready in December 1992. Patients were recruited from the high risk antenatal ward and the antenatal clinic of the Ipoh Hospital between 1st January 1993 to 31st March 1993.

The sound characteristics of 7 intrauterine growth retarded fetuses were compared with 12 normal fetuses. All fetuses, were more than 36 weeks of gestation. The fetuses were diagnosed initially by ultrasonography and later confirmed upon delivery.

Of the 7 intrauterine growth retarded fetuses, 6 were from mothers with pregnancy induced hypertension and one was from a mother with systemic lupus erythematosis. The intrauterine growth retarded fetuses had head circumference over abdominal circumference above the 90th percentile on ultrasonography. All of them weighed less than 2 kg upon delivery and were admitted to the special care nursery where they were confirmed to be intrauterine growth retarded for their gestational age.

The 12 normal fetuses were from mothers with no antenatal complications according to the risk score of the Ministry of Health. They were all within the normal growth curve on ultrasonography and their birth weights were between 2.5 kg and 3.5 kg.

The fetuses had their heart sounds analysed at various speeds of the Fetal Frequency Phonocardiogram. Each heart sound had a splaying or frequency band as the heart sound was derived from two valves e.g. the first heart sound from the tricuspid and mitral valve. Only the frequency and the amplitude of the waveform with the highest amplitude was taken for analysis.

The sound characteristics which were analysed were :

1. The frequency of the first heart sound.
2. The frequency of the second heart sound.
3. The ratio of amplitude of the first heart sound over the second heart sound.
4. The time between the first heart sound and the second heart sound over the cardiac cycle.
5. Splaying of the first heart sound.
6. Splaying of the second heart sound.

The ratio of amplitude of the first heart sound over the second heart sound was taken rather than the individual amplitudes as this will not be affected by the distance of the transducer from the fetal heart. The splaying of the heart sound is actually the time from the start to the completion of the heart sound.

The above characteristics were analysed and compared between intrauterine growth retarded fetuses and the normal fetuses. To test for statistical significance, the Student's t-test was used.

This study was approved by the local ethical committee.

Results

Three characteristics of the fetal heart sounds were recognised to be different with statistical significance (p-value < 0.01) between intrauterine growth retarded fetuses and normal fetuses.

(i) The frequency of the first heart sound in the IUGR fetuses was 46.9 +/- 5.0 hertz compared to that of normal fetuses which was 31.8 +/- 3.2 hertz (Table I).

(ii) The ratio of amplitude of the first heart sound over the second heart sound was higher in the IUGR group (Table II).

(iii) The ratio of time interval between the first heart sound and the second heart sound over the cardiac cycle was also significantly different (Table III). The IUGR fetuses had a value of 0.447 +/ - 0.016 compared to that of normal controls (0.487 +/- 0.011).

Although there was a difference in the splaying of the first heart sound between the IUGR and normal fetuses this was primarily due to difference in the frequency.

Table I
Fetal heart sound analysis:
Frequency of the first heart sound

	IUGR Fetuses (hertz)	Control (hertz)
1	54	27
2	44	30
3	41	30
4	50	35
5	48	28
6	50	32
7	41	36
8		29
9		36
10		30
11		35
12		33
Mean	46.9	31.8
S.D.	5.0	3.2

p-value less than 0.01

Table II
Fetal heart sound analysis:
Ratio of amplitude*

	IUGR Fetuses	Control
1	1.56	0.85
2	1.00	0.66
3	0.90	0.77
4	1.56	0.84
5	1.00	0.68
6	1.58	0.77
7	0.90	0.85
8		0.78
9		0.68
10		0.64
11		0.87
12		0.77
Mean	1.21	0.76
S.D.	0.33	0.09

* *Amplitude of the first heart sound over the second heart sound, p-value less than 0.01*

Table III
Fetal heart sound analysis:
Ratio of time*

	IUGR Fetuses	Control
1	0.465	0.491
2	0.456	0.497
3	0.424	0.495
4	0.424	0.487
5	0.448	0.462
6	0.458	0.486
7	0.450	0.495
8		0.494
9		0.490
10		0.470
11		0.488
12		0.495
Mean	0.447	0.487
S.D.	0.016	0.011

* *Time between the first heart sound and the second heart sound over the cardiac cycle, p-value less than 0.01*

Discussion

There has been few studies using the fetal phonocardiogram in the past. Most of these studies were concerned with cardiac arrhythmias[9] and systolic ejection fraction of the cardiac cycle[10]. Other fetal phonograms were used to detect and monitor fetal movements and fetal breathing movements[7,8]. In this study, three characteristics of the fetal heart sounds were shown to be different between IUGR and normal fetuses. All three of these parameters could be used to identify and monitor IUGR fetuses.

The changes in the characteristics of the heart sounds of the IUGR fetuses may have sound pathophysiological principles. In fetuses with IUGR, there are selective changes in cardiac afterload. Cerebral vasodilation decreases the left ventricular afterload and systemic vasocontriction increases the right ventricular afterload[11]. Furthermore, hypoxemia may impair myocardial contractility while polycythemia which is usually present, may influence blood viscosity and therefore the preload[12]. These changes may alter the fetal heart sounds characteristics and may form the basis of our experimental findings.

These preliminary findings will form the basis of further studies with larger samples. We hope to further improve on the sound analysis equipment, giving detailed analysis of the parameters above. The prototype of the Fetal Frequency Phonocardiogram devised has limitations in the transducer and the analogue to digital conversion card. The software programme written also needs further improvement. With these improvements, other characteristics of the fetal heart sounds may be detected.

Fetal heart sound analysis may provide a simple, non-invasive method of identifying and monitoring fetuses at risk in the antenatal period.

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