بررسی سلامت قلب جنین با استفاده از مگنتوکاردیوگرافی

کلید واژه‌ها: 1- مگنتوکاردیوگرافی
2- قلب جنین
3- روش‌های ته‌جایی

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FETAL HEART ASSESSMENT BY MAGNETOCARDIOGRAPHY: A PILOT STUDY

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ABSTRACT

Fetal magnetocardiograph (fMCG) provides a new non-invasive technique for monitoring fetal cardiac wellbeing during the last 10 weeks of pregnancy. Using a single channel second order SQUID gradiometer located over the maternal abdomen we have successfully recorded QRS complexes in 9 of 11 subjects from 30-40 weeks gestation and full PQRST complexes in all 4 subjects in whom off-line averaging techniques were applied.

Key Words: 1) Magnetocardiography 2) Fetal Heart 3) Non-invasive techniques 4) Pregnancy

INTRODUCTION

There is an urgent need to reduce the unexplained antepartum stillbirth rate which now accounts for the majority of all stillbirths in different countries. Many tests have been proposed to aid detection of the loss of critical fetal reserves, but the "ideal" test which would have to be simple, non invasive, reliable and predictive has not yet been discovered. Current methods of fetal monitoring during the last trimester of pregnancy have limitations in the prediction of outcome. At present the most commonly used biophysical examining of fetal wellbeing is cardiotocography (CTG). A Reactive CTG tracing has been claimed to be a reliable indicator of satisfactory fetal condition, whilst decreased heart rate variability is associated with fetal acidemia and perinatal loss (5). Biophysical profile scoring (a combination of CTG with ultrasonic assessment of liquor volume, fetal breathing movements and tone has been shown in several studies to have a close relationship with perinatal outcome and this method of assessment is now extensively

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used. Its major disadvantages are that it
does not measure fetal/placental reserve and
that it is a technique wholly dependent on the
skill and experience of the ultrasonographer.
Serial growth measurements by ultrasound
scanning has the disadvantage that weeks
have to pass before the static trend is clear,
often too late for optimal management.

Analysis of the fetal Electrocardiography
(fEKG) waveform during labour has been
suggested for fetal surveillance as animal
studies have demonstrated ST segment
elevation and peaked T waves with resultant
increase in the T/QRS ratio (8) associated
with hypoxia, although visualisation of the T
wave may be difficult. Preliminary clinical
reports have been disappointing, in that
statistically significant relation was found
between T/QRS ratios in labour and fetal
hear rate abnormalities on the CTG (5,6).

Antenatal fetal Electrocardiography
(fEKG) has been recorded using rectal,
vaginal, cervical and abdominal electrodes,
but only the QRS complex has reliably
detected and therefore analysis has
concentrated on R-R intervals and variance.
In addition the amplitude of the fetal
 complexes diminishes from 27-32 weeks
gestation, probably because of the insulating
properties of the vernix caseosa on the fetal
skin (7). In all reported fEKG there is a large
inter and intra-individual variability related to
the variability of fetal presentation and the
heterogeneity of the volume conducting
pathways.

An alternative to antenatal fEKG is
fMCG, where the magnetic field set up by
the current density of the intracellular
electrical activity of the heart is detectable
noninvasively over the maternal abdomen.
This is unaffected by the insulating
properties of the vernix and the tissue
conductivity heterogeneity. The first adult
magnetocardiogram (MCG) recording was
reported by Baule and McFee (2). Kariniemi
et al (4) recorded the first fMCG which is an
order of magnitude smaller in amplitude
than the adult MCG. For that reason studies
have concentrated on the QRS complex and
heart rate variability as a method of fetal
surveillance rather than the full MCG
complex. They did not report the detection
of the P and the T wave. Dunajski and
colleagues (3) has reported a single averaged
fMCG with a full PQRST complex.

We report the results of fMCG recordings
in 11 normal pregnancies from 30-40
weeks gestation. Subjects were recruited
with informed consent and local ethical
committee permission.

METHODS

Since the discovery of superconductivity
by Kamerlingh Onnes in 1911, this
phenomenon has found several important
application. The application described here is the use of superconducting magnetometers for measuring weak biomagnetic fields. Superconducting devices work only at low temperature; such a temperature is usually maintained with the aid of liquid helium. Storage and use of liquid helium requires special thermally isolated dewars. The name "superconductivity" refers to a specific physical property that the electrical resistance of a material is identically zero below the critical temperature. Superconducting Quantum Interference Device (SQUID) magnetometers have been used for biomagnetic studies since 1970.

Subjects were placed semi-reclining on an adjustable bed in our 4×4×3.5 m eddy current shielded room (1). The presentation of the baby and the approximate location of fetal heart was determined by auscultation. The top of a single channel neuromagnetometer (BTI Model 60, San Diego, California) was placed in a position of maximum QRS signal over the maternal abdomen. The neuromagnetometer output was amplified further and analogue bandpass filtered (0.03-100Hz), single pole high and low pass) using a PAR Model 113 preamplifier. Recordings were made in two separate ways. Sequential 9 second epochs were stored on a personal computer via an analogue-to-digital processor board. At the same time several segments of 5 minutes duration were stored on a high quality FM tape recorder for subsequent off-line analysis using the motor unit potential averaging algorithm of a clinical EMG system (medelec MS60, Woking U.K.). Both an automatic trigger with a peak detection algorithm and a manual trigger were used, the latter when there was substantial baseline drift. The number of averages required to define the full PQRST complex varied from 15 to 100 depending on the signal to noise ratio. In some subjects we varied the magnetometer location and were able to detect the alterations of field polarity related to the orientation of the vectors of the cardiac components.

RESULTS & DISCUSSION

In a series of pilot experiments, we completed the successful unaveraged recording of fMCG in 9 of 11 pregnant women from 30 to 40 weeks gestation with all subjects demonstrating QRS complexes (Fig 1a), with occasional P wave detection (Fig 1b). With care in choosing sensor placement, maternal MCG signals were either absent from recordings or easily distinguished from fetal signals. Using off-line averaging techniques we detected P and T wave in all 4 subjects in whom this technique was applied, Fig 2. This technique has
several implications. It provides for the first time an accurate method of fetal cardiac surveillance at a gestation time where other methods such as the fEKG are unavailable. The recording of the full fMCG complex allows calculation of measures thought in the intrapartum EKG to relate to hypoxia, e.g. the T/QRS ratio. Finally the size of the R wave amplitudes, 4-8pT, were within the potential sensitivity range high temperature SQUIDS (running on liquid nitrogen) which would make this technique much more widely available in clinical practice.

**Fig. 1 Unaveraged fMCG:**
- a. 30 weeks
- b. 37.5 weeks

**Fig 2:**
- a. fMCG (55 averages), 37.5 week pregnancy
- b. fMCG (17 averages), 37.5 week pregnancy changed sensor location
REFERENCES


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