Fetal Movement Monitoring Protype Design Based on Non-Invasive Fetal Electrocardiogram (Ni fECG)

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Abstract. **Background:** Fetal movements during pregnancy at 30 to 39 weeks are more often than at 20 to 29 weeks of gestation, this is because the frequently fetus moves the endometrium and the strength of fetal movement increases with fetal development. Non-invasive fetal electrocardiogram (NI-FECG) can be used in early pregnancy, easy to apply, and safe to use. This research aims to develop a prototype design of a fetal movement recording device based on NI-FECG

Methods: are used **research and development (R&D**) to develop certain products and test the effectiveness of the product**.** The analysis uses literature review and qualitative tests**.**

Results: The various distances between the electrodes and the position of the intrauterine fetus can affect the results so that they are taken into consideration in placing the electrodes in the right position. The position of the electrode shown in the image above is recommended in the cephalic position of the fetus in late pregnancy, taking into account the reduced freedom of movement of the fetus**.** The use of this belt aims to monitor fetal movement with electrocardiography (ECG) at rest and while the patient is moving**.** The maternal abdominal signal generator used asthe processor; the processor read the maternal abdominal ECG data (CU1, 2 and 3) and output three-channel ECG signals through digital-to-analog conversion**.** The three-lead abdominal signals**,** were sent to the data receiving end of the smartphone app software, and the data processing module**,** processed the received data. The processed fetal ECG and heart rate were displayed on the smartphone**,** screen in real time**.**

Conclusion: The need for a proper system to monitor fetal movements in a non-clinical setup is of paramount importance in order to maintain fetal well-being. A complete system was introduced to be used by pregnant While a significant amount of effort was spent on developing the algorithm as well as the sensing system an equal amount of effort was invested in designing and implementing proper ergonomics and a user-friendly interface to the system. It was made sure that the proposed system is feasible to be implemented.

Key words: Non-Invasive fetal Electrocardiography, fetal movement.

Background

Some studies have shown that fetal movement provides an important measure of fetal health; 25% of women who experience decreased fetal movement have the outcome, placental dysfunction, complicated delivery, and more than half of stillbirths are preceded by decreased fetal movement. (1)(2)

Fetal movement in the womb is felt around 16 to 20 weeks of pregnancy. The activity of babies in the womb can vary widely, some are active and some are not active. Therefore, it is advisable to count the fetal movements every day, and there are several ways to do this, namely by identifying the decline in the baby's normal movement patterns. (3)

Fetal movement in the 30-to-39-week group was higher than in the 20-to-29-week group, this is because gross fetal movement seems too often move the endometrium and the strength of fetal movement increases with fetal development. NI FECG can be used in early pregnancy, easy to apply, and safe to use (4) (5) (6), The fetus has two specific movement patterns for rotation and somersaults that result in a change in the fetal position from prone to supine or lateral and the opposite related to the shape of the uterus and the direction of the gravitational force. (7) Fetal movement counts from 28 to 37 weeks of gestation reported less anxiety compared to those in the control group (8). The evidence shows that fetal movement is a very convincing sign of fetal well-being. All pregnant women should receive guidance on how to monitor the well-being of their baby, preferably in writing with a fetal movement chart.

Fetal movements monitoring in NI FECG obtained results of fetal rotational movements, gross movements, isolated limb movements, and respiratory movements during 10-minute intervals which were validated by ultrasound (10). NI FECG records fetal movement fluctuations, perfect for recording fetal movements at gestational age from 24 to 41 weeks with a measurement length ranging from 10 to 20 minutes, with the mother relaxed or sleeping (11). This method allows recording of fetal movement from single bipolar abdominal NI FECG recordings making it suitable for observation of fetal motility in an outpatient setting. (12), (13), (14).

The measurement of NI FECG obtained in the mother's abdomen contains several bioelectric potentials such as maternal cardiac activity, fetal heart activity, maternal muscle activity, fetal movement activity, although there are potentials generated by breathing and abdominal activity, and noise (thermal sound, noise generated from skin-electrode contact) signal separation or simple filtering can be performed (15)

The results of the analysis, it was found that the very small signal results were caused by the placement of the electrode array position which was too far from the source (the mother's heart and the fetus), then the placement of the electrode array position parallel to the pregnant woman's abdomen resulted in a very small NI FECG signal amplitude. NI FECG can be used independently by anyone without having to be accompanied by a doctor. (16)

As the underlying physical principle used for abdominal ECG monitoring is not affected by the amount of maternal adipose tissue (body fat), the quality of the measured signal is quite high; therefore, abdominal electrocardiography is the only technique that potentially makes long-term ambulatory fetal monitoring possible. In addition, the recent availability of wireless fHR-monitoring systems. Designed a portable low-power fetal ECG collector, which collected maternal abdominal ECG signals in real time.

Based on the explanation above, it is important to research the prototype of a fetal movement movement device based on Ni FECG, as an effort to develop science and technology in midwifery services. The ECG data were sent to a smartphone client via Bluetooth. Smartphone app software was developed based on the Android. Fetal movement measurement using NI FECG is important to be developed to detect fetal well-being.

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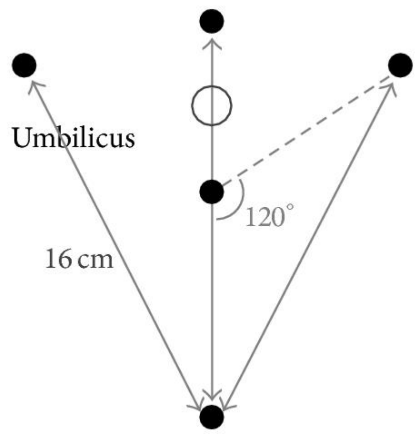
Methods

The research method used is the research and development (R&D) research method, the first stage of finding information by studying literature in several scientific journals related to the design of prototype designs for fetal movement detection devices and the components used. The analysis of the design of the fetal movement monitoring device uses literature review and qualitative analysis. Data collection was carried out by interviewing the experts and the teams of experts, namely bio electromedical engineering experts. The data collection instrument used an interview guidance.

Results

The use of fetal monitoring using electrocardiogram technology is an important new innovation for the development of applied technology in obstetrics. Several literatures use different technologies in measuring this movement, a number of electrodes are needed to reduce noise or noise, but this can reduce patient comfort.

Based on the results of interviews with "A" an expert in electro-medical midwife. Say that:



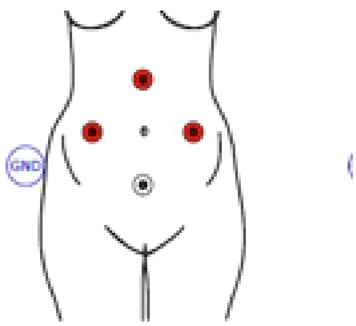


Figure 1. electrode placement display

The simulation of the use of electrodes was carried out by M. J. Rooijakkers by considering patient comfort. Based on the simulation results, the various distances between the electrodes and the position of the intrauterine fetus can affect the results so that they are taken into consideration in placing the electrodes in the right position.

The position of the electrode shown in the image above is recommended in the cephalic position of the fetus in late pregnancy, taking into account the reduced freedom of movement of the fetus. Whereas in early pregnancy, the fetus has more room to move, and additional fECG measurement instructions may be needed to ensure optimal signal quality, as shown in the image below. (17)

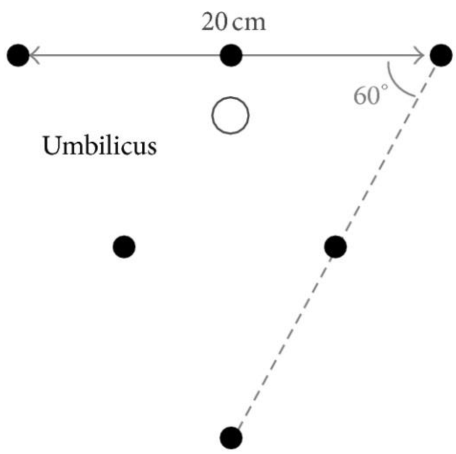


Figure 2. electrode placement display

At least one electrocardiogram sensor was configured to contact the abdominal skin of pregenant human subjects and detect fetal and maternal hearts (18).

"EKG is used to detect the body's electrical signals, in addition to heart movement signals, ECG can also detect fetal movement in the womb using a non-invasive fetal ECG. (EMG) electrical signals from the muscles so that the time to pick up the electrical signals of the muscles can be read when the fetus moves. However, signal processing that can later pick up purely fetal movements.

The electrode placement is attached to the mother's abdomen, but the electrode placement needs to be tested. How it works Every movement in the body emits electrical signals, including muscles, so that later it will be compared with a tool that shows the same movement. 3 electrode signals are enough to detect movement.

The results of interviews with obstetric specialists: "Fetal movements can be seen from ultrasound, the examination is carried out in 10-15 minutes. before the ultrasound examination, the mother is asked to empty the bladder, which aims to stimulate the fetus to move. Generally, the fetus moves when the mother is eating and doing activities.

The use of this belt is intended so that fetal movement monitoring with electrocardiography (ECG) can be carried out at rest or while the patient is moving.

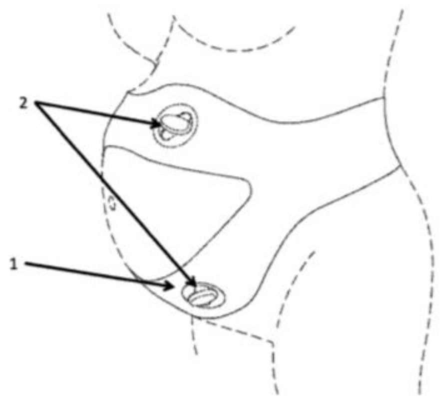


Figure 3. Belt and electrode placement display

Schematic side view of a patient wearing an abdominal belt equipped with a multi-electroderay for recording fetal movements (19). Belts consist of synthetic fibers such as nylon, polyester, and elastane, with beneficial properties such as light weight, easy cleaning, stable dimensions, and dirt resistance; However, the main disadvantage of this fiber is poor moisture absorption leading to excessive sweating, high body temperature, increased skin sensitivity, and discomfort, which affect women's adherence to clothing. (20)

We have developed textile electrodes embroidered from polyethylene terephthalate threads which are plasma coated with silver for electrical conductivity and with an ultra-thin titanium coating on top for passivity. Three electrodes are embedded into the belt. The combination of silver, titanium, and steam water produces excellent electrode chemistry. The belt is made of polyester and is elastic. Two zones of Ag/Ti coated PET yarn are embroidered directly into the fabric, forming the electrodes. With this technique, the thread is exposed on both sides of the fabric, allowing for an atmosphere with relatively high water vapor pressure. The same layered thread as used for the electrodes was also used for the embroidered connection between the electrodes and the press studs for fixation of the data logger. With this arrangement, the logger can be easily removed to wash the belt. The new embroidered electrodes with Ag/Ti coating meet the eight requirements listed in the introduction with regard to biocompatibility, cytotoxicity, signal stability, impedance, reusability, durability, wash fastness and ease of use. (21)

Two main factors affecting the impedance of the electrode shell were discovered: the nature of the textile material, and the size of the electrode. Optimal textile electrodes are silver plated, made of high stitch density weft knit conductive fabric. The flexible motion sensor circuit is designed and integrated in the textile electrode. Various materials have been used to produce conductive textiles that are embedded into the fabric as conductive threads, or coated with electrically conductive components, such as carbon, copper, nickel, or silver. However, when choosing materials that will come into contact with human skin, as in the case of ECG electrodes, their biocompatibility becomes very important because the electrodes are directly attached to the human body. Different from most other materials, silver is not only harmless to human skin, but also antibacterial. Therefore, conductive fabrics made of silver-coated nylon yarn are preferred for making textile electrodes by weaving or knitting. When compared to woven fabrics, knitted fabrics are usually more flexible, stretchable, and can easily pick up the curves of the body when installed. So, in this paper, four different knitted conductive fabrics made of silver-coated nylon yarn are considered as electrode materials. (22)

In this study, dry electrodes based on silver nanowires (AgNW) were fabricated for noninvasive and wearable ECG sensing. Signals from the AgNW electrode and the Ag/AgCl electrode were collected simultaneously under two conditions: sitting and walking. Signal quality was evaluated in terms of ECG morphology, R-peak to R-peak (RR) interval and heart rate variability (HRV) analysis. Quantitative comparisons show that AgNW electrodes can collect ECG waveforms that are acceptable as Ag/AgCl electrodes in both sitting and walking conditions. However, basic aberrations and waveform distortions exist at the AgNW electrodes, likely due to electrode motion. If the skin electrode contact is increased, dry electrodes can be a promising substitute for Ag/AgCl electrodes. The ECG sensor basically monitors the heart's biopotency. Other muscle activity can be measured in the same way. A special case is protection from the effects of continuous stress in the work environment (24) (25).

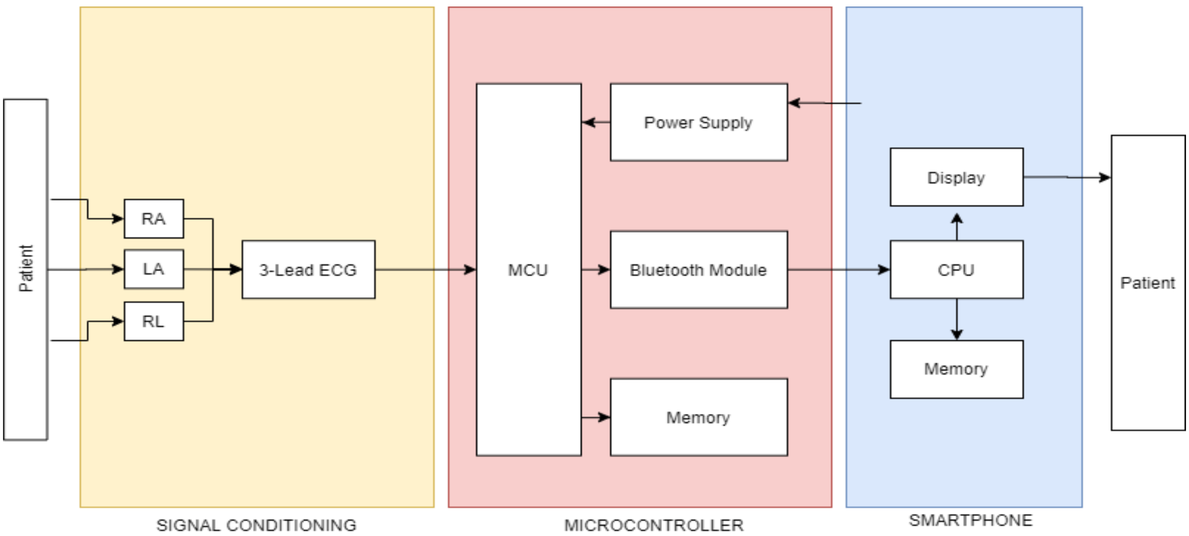


Figure 4. Design of Fetal Movement Monitoring display

In order to verify whether the system we developed could work normally, we used a maternal abdominal signal generator device developed by our laboratory to simulate the abdominal surface signals of pregnant women, and used a fetal ECG collector to collect three channel abdominal surface signals. the processor reads the maternal abdominal ECG data (Ch1, Ch2, Ch3) and outputs a three-channel ECG signal through digital to analog conversion. The three-lead belly signal is sent to the data receiver of the smartphone application software, and the data processing module processes the received data. The process of fetal ECG and fetal movement is displayed on the smartphone screen in real time. Using the maternal abdominal ECG signal simulated by the maternal abdominal signal generator, the system and algorithm proposed in this work can extract the fetal ECG for real-time monitoring. The three-lead ECG signal collector designed in this work can collect mixed-signal maternal abdomen, as shown in the collector powered by a low-power lithium-ion battery providing 24-hour fetal ECG monitoring. At the same time, the fetal ECG monitoring system has a small number of electrodes, and the electrode attachment method is relatively simple, which is convenient for pregnant women to use daily. The signal received by the collector can be transmitted to the smartphone via Bluetooth. The smartphone application software can process the ECG data in real time, display the fetal ECG waveform and fetal movement in real time on the smartphone screen, and automatically upload to the server when the fetal fetal movement is abnormal. This can assist the doctor in taking appropriate action to treat the disorder. (26)

Monitors fetal movement in real time and transmits fetal heart rate to display devices via Bluetooth. The disadvantage is that it can only display the fetal movement, but cannot display the ECG waveform, so many important fetal ECG information cannot be displayed effectively. proposes using the ECG collector to get the maternal belly Signal, and then transmits the signal to the smartphone via Bluetooth.

Pregnant women can use the portable collector to collect the mixed belly signal anytime and anywhere. This smartphone can display fetal ECG waveforms and fetal movement. rates in real time. When the fetal ECG is abnormal, the abnormality is automatically uploaded to the cloud platform for further diagnosis by the doctor the scheme showing cell phones, pagers, fax machines and other devices of a communicative nature to the patient's doctor, family members, friends, and others where information about the patient and the fetus, as assessed by the present invention, is transmitted by cable or other communication. a schematic diagram representing a pregnant patient using a home or outpatient version of this invention.

The present invention provides a method and apparatus for recording and analyzing the electrical activity of the fetus in utero, from the surface of the maternal abdomen. The present invention is a data analysis technique for analyzing measured data from the patient's surface to characterize muscle, abdominal, as well as fetal movement and activity simultaneously or separately. Nication for use a remote or homeuterine/fetal monitoring system.

Figure 5. Design Monitoring fetal movement

Conclusions

The need for a proper system to monitor fetal movements in a non-clinical setup is of paramount importance in order to maintain fetal well-being. A complete system was introduced to be used by pregnant. While a significant amount of effort was spent on developing the algorithm as well as the sensing system an equal amount of effort was invested in designing and implementing proper ergonomics and a user-friendly interface to the system. It was made sure that the proposed system is feasible to be implemented. This was done by studying the preferences and habits of pregnant mothers. Furthermore, it was ensured that the system is user friendly in nature

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