Fetal Signal Telemetry with Suction-Cup Mounted Transducer and Bluetooth Transmitter to Monitor Mainframe or Networked PDA

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Abstract

We devised a fetal cardiac signal acquisition and telemetry system mounted within a suction-cup which can stick and keep on to gravidae's abdomen for itself with mild negative pressure. For prototyping we use fetal phonocardiography microphone with necessary filter and amplifier and lithium polymer battery, followed by a Bluetooth downlink transmitter to send the signal to monitor mainframe (HP8041A) externally equipped with Bluetooth receiver. The suction cup used for prototyping is glass or hard-plastic one driven by external pump to initiate to suck and stick action. They are coming from acupuncture device in China or Korea or Japan. However, with our early experience, we believe a soft, silicone rubber made, deformable self-sucking cup performs better and more patient friendly. In model environment using adult heart activity the system works almost equivalent to wired system, while real gravidae trial is yet to be performed soon. For monitor mainframe we are attempting to replace legacy excellent HP8041A with just a networked PDA like an Android smart-phone to have extended connection to central database for gravidae group management. Also, ultrasound Doppler will certainly outperform phono, at cost of complex and power consumption, for future challenge. The connection reach distance of the Blue-Tooth transceiver used in prototyping is more than sufficient for home, self-managed NST (non stress test), a lower RF power, lower battery drain device is desired for power hungry environment like this application.

Keywords: Wireless Health, Bluetooth, Smartphones.

Introduction

Fetal Heart Rate (FHR) monitoring is usually done during consultation with a doctor in a non stress (NST) situation. Such practice is important not only to accompany the baby's growth and development but also detect any problems that may arise during pregnancy. Although very common, such procedure requires the gravida to relocate to hospital or clinic in order to meet with doctors and nurses who will, in turn, be responsible for acquiring fetal cardiac signal. In most cases, (non-risk pregnancies), such relocation adds not only cost but also unnecessary risk to the fetus and the gravida.

New researches are being conducted not only in order to improve FHR monitoring itself [1] but also to provide women options to monitor their pregnancy at home in NST situations and with the popularization of smart-phones, not only electronic health management systems [2] but also pregnancy related applications can make future mothers in charge of NST FHR monitoring in real time.

Nonetheless, while research has shown that projects focusing on e-health application development might be favorable to Android base smartphones [3], a quick search for pregnancy related applications in any platform will return dozen of results that range from baby names, contraction timers, dietary hints, and delivery date calculators to cite only a few possibilities.

Clearly, one advantage of such application is the possibility of continuous monitoring not only for gravidae but also opening numerous possibilities regarding automatic diagnostics, real-time communication with hospitals and doctors and also allowing data to be transfer to central management systems inside and outside health related institutions.

But before such advantages can be reached, a trustable fetal cardiac signal acquisition device must be able to transmit FHR data to a networked PDA, smartphone or (in the case of our model environment) mainframe.

Materials and Methods

Material

Experiments were conducted in Miyazaki International College during low noise periods as the noise canceling mechanism of our phono

suction cups is yet to be improved. Several heart rate samples of an adult were taken in order to show usability of new prototype cups.

Fig. 1: Acupuncture cups before mounting the phono-transducers (top) and after mounting the microphone (bottom)

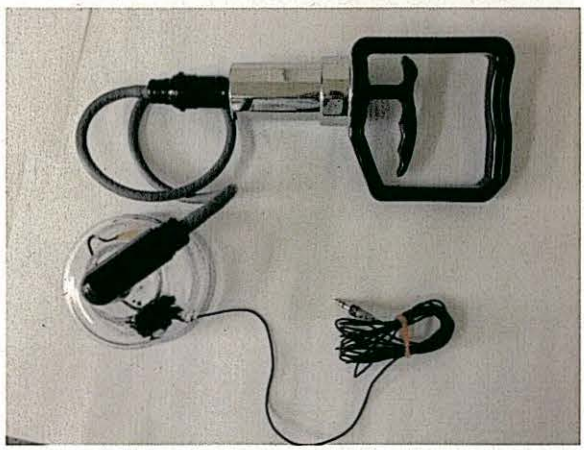

Fig. 2: Suction effect provided by external mechanism to pump out the air inside the cup

Our phono-transducers were mounted inside acupuncture cups coming from China, and South Korea (Fig. 1). These cups are made of glass and hard plastic and, although previous experience [4] [5] showed that soft silicone cups perform well for 20 min NST, we opted for those because of the existing "pumping" mechanism that drives the suck and stick effect (Fig. 2).

System and data Collection

Equipping our suction cup phono-transducer with a Bluetooth transmitter gives it a huge flexibility and makes it available to any other mainframe, PDA or smartphone that can connect and pair with it.

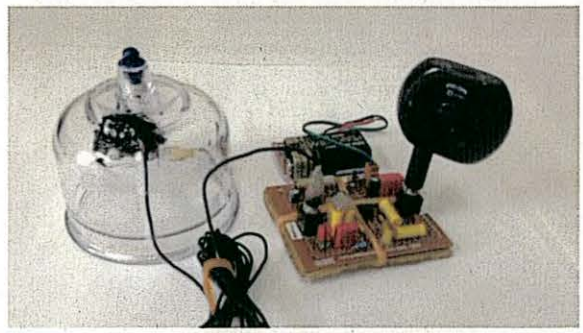

Fig. 3: Prototype suction cup connected to a home-made amplifier and its external battery providing fetal cardiac signal to HP8041A via Bluetooth transceiver.

As it can be seen on Fig. 3, our prototype suction cup phono-transducer connects to the Bluetooth transmitter throughout our simple home-made amplifier. The signal is transmitted from the transmitter to the receiver and arrives our main frame through its telemetry back port (Fig. 4).

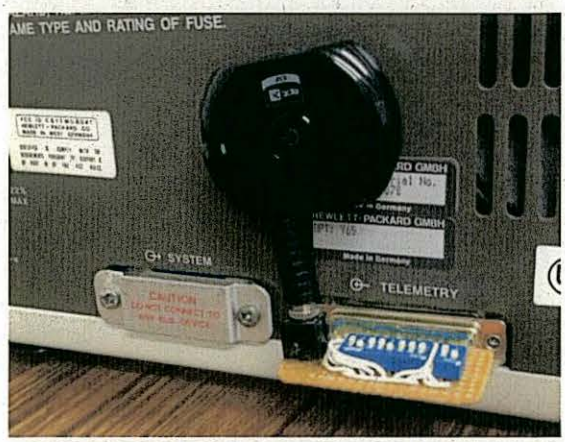

Fig. 4: Bluetooth receiver connected to the telemetry port of HP8041A

Results & Discussion

Due to non-availability of gravidae when performing this experiment, heart rate samples were taken from an adult using our prototype suction cup and reproduction done by our HP8041A mainframe using two methods: (1) direct

connection using a male to male audio cord and (2) using a Bluetooth transmitter and a receiver as it can be seen on Fig. 3 and Fig. 4.

For showing purposes, Fig. 5 shows a continuous five minute data sampling of heart rate data acquired in this experiment.

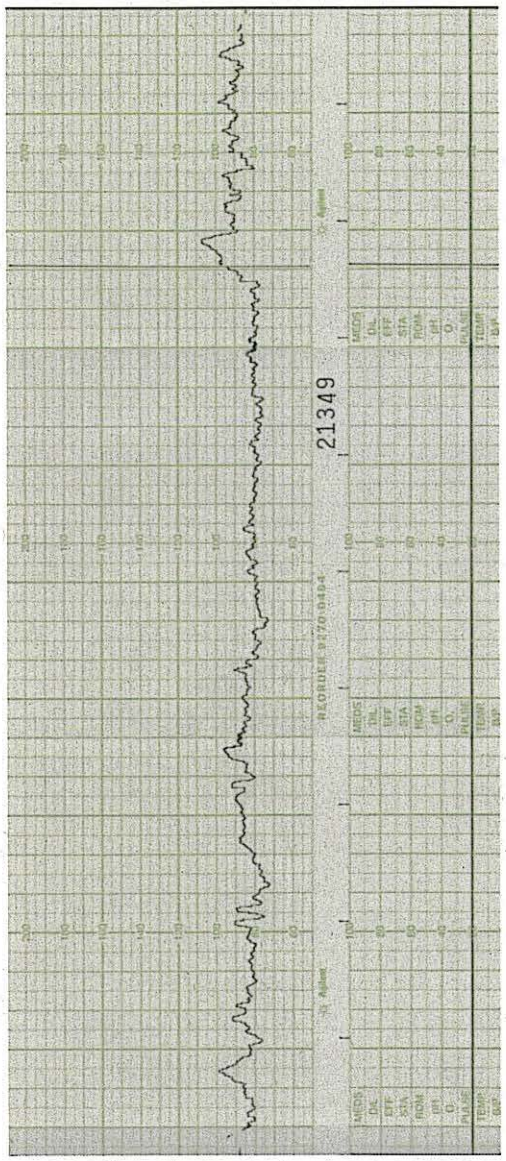

Fig. 5: Sample heart rate taken with HP8041A from adult heart activity for a little more than 5 minutes.

Conclusions

During our tests, the Bluetooth connection was reliable and the maximum range specified by the transceiver maker (10 meters) was more than sufficient to keep connection even while the person was moving.

Although we have already verified usability of phono suction cups for fetal heart rate monitoring, this experiment was performed using adult heart activity due to the lack of gravidae availability but real gravidae trial is expected to be performed soon.

As for future directions, system trial with real gravidae is expected to follow soon as well as a smartphone prototype application that will substitute our HP8041A mainframe used in this experiment, bringing home NST FHR monitoring a closer to reality.

References

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