

2.9 Fetal Monitor and Fetal Doppler

2.9.1 Clinical Use and Principles of Operation

Fetal monitors document two major functions: 1) the heart rate of the fetus, and 2) the contractions of the mother. A normal fetal heart rate is between 110 to 160 beats a minute. The sound of the beat is usually strong and regular. It is normal to have some changes in the fetal heart rate during labor, but drastic changes in heart rate before or after a contraction may indicate that the fetus is in distress. A fetus with large changes in heart rate may need to be removed from the womb immediately, by Caesarean section.

Fetal monitoring during labor, when it is most commonly applied, has been controversial since its inception. Some claim that fetal monitoring offers a monitoring tool that can reduce fetal mortality and morbidity. Others blame the technology for the large increases in Caesarean sections and the attendant maternal morbidity.

Currently, there are three widely used methods of monitoring the fetal heart rate: Doppler, Surface Electrodes, and a Scalp Electrode.

Surface electrodes are applied directly to the mother's body, typically with adhesive silver-silver chloride electrodes. The surface electrode technique operates identically to a typical electrocardiogram, but with much more complex signal processing to reduce the probability of mistaking a maternal heart beat for a fetal heart beat. The surface electrode approach to measuring the fetal heart rate has the advantages of being not invasive, being applicable at any time during pregnancy, and are very low cost. However, they are subject to artifacts from the maternal heart beat, don't work well with certain fetal positions and can't resolve multiple fetal pregnancies.

For the Doppler technique, a doctor, nurse, or technician applies ultrasound gel to the end of a flat transducer and moves it across the abdomen until a good reflection is found from the heart. The Doppler technique is the most common as it is less prone to artifacts than the surface electrodes and it is equally easy to apply. However, the transducer and accompanying electronics are expensive, may require repositioning during labor, and don't resolve multiple fetal pregnancies well.

The fetal Doppler probe is also used by itself to detect the fetal heart beat. As a hand-held device it can be used from about the end of the first trimester to delivery. The probe produces ultrasonic pressure waves at about 2.5 MHz and hand-held unit produces a sound with heart beat. A typically hand held device has no display or chart. The doctor must time or count the heart beats to determine the fetal heart rate.

The principle of operation of the Doppler probe is the Doppler Effect. If waves of a given frequency are transmitted to a stationary reflector, the reflected waves are of the same frequency as those transmitted. If the reflector is moving towards the transmitter-receiver, the reflected frequency will be higher than the transmitted frequency. In this case, the waves are bounced off the fetal heart. The occurrence of a frequency shift is taken as the presence of a heart beat by the machine.

Scalp electrodes are applied directly on the fetus' head and operate in a manner identical to a standard electrocardiogram. This approach is used only with high-risk patients, if labor is going

very slowly or if the external fetal monitor is not detecting the fetal heart rate. The amniotic sac must be broken to apply the electrode. The scalp electrode gives accurate fetal electrocardiograms. However, it is invasive, opens the amniotic sac for infection, and cannot be easily applied to multiple fetal pregnancies.

The contractions are measured with a strain gage transducer (usually called TOCO) either mounted externally or with a belt around the abdomen.

The fetal heart rate is displayed digitally on many units and in graphic form on a chart. Typical fetal heart rates are in the range of 110 to 160 beats per minute. During contractions the heart rate will decrease and revert to previous levels after the end of the contraction. If there is a delay in the heart rate returning to its previous level it can indicate that there is fetal distress.

2.9.2 Common Problems

User errors are common with fetal monitoring. Incorrect connections of the transducers and incorrect loading of the paper, or the loading of the wrong paper are the most common of these problems. Power supply problems, typically dead batteries, are common with the hand held fetal Doppler devices. Be sure that gel is being used between the ultrasonic transducer and the patient.

The Doppler probe is the most sensitive part of both the handheld and bedside devices. When it breaks no output is heard, even when a stethoscope or fetoscope indicate the presence of a fetal heart beat. You can quickly check the probe operation by gently tapping the probe surface about once per second. If this is not detected, there is certainly a probe problem.

The probe consists of the transducer assembly, the cable, and a multi-pin fixable connector. The cable contains between 5 and 80 separate conductors. The most frequent malfunction occurs as a result of a break in one or more of the cable conductors. Such malfunctions are usually the result of mishandling of the cable or of soaking it with gel. The probe is expensive and typically cannot be replaced in the developing world.

Fortunately, the cable can often be mended. The face of the probe is usually an acoustic lens. It must be handled with care. Do not drop the probe, and avoid scratching the face with sharp objects. Keep the probe assembly clean of oil and gel. Always clean the probe and cable with a tissue or damp cloth, after finishing work.

The surface electrode problems are similar or identical to those discussed in the chapter on electrocardiograms. Poor electrode function will result in no fetal heart beat being reported. Check that the patient electrode connections are clean and in good condition. Check that the leads to the patient are in good condition, that the conductor is not broken, and that there is not a short circuit to the shielding that surrounds the other connectors.

The last most common problem is with the paper. The paper is often installed wrong or the wrong paper is used with the device. Check that the digital heart beat and the paper trace are giving the same reading when you tap the transducer, or apply the electrodes to yourself. The chart recorders themselves are identical to those used for electrocardiograms. Check that chapter for ideas on what could be wrong with a chart recorder.

2.9.3 Suggested Minimal Testing

All of the transducers designed to measure the fetal heart rate can be used to measure your own heart rate. For surface electrodes, you may have to attach one set of electrodes to yourself (as the mother) and one set of electrodes to a friend (as the fetus) in order to satisfy any alarm conditions before operating the machine. The Doppler probe should work when placed on your chest, with the proper gel, near your heart. Check for the accuracy of both the digital display and the paper trace by comparing their output with a measure of your own heart rate from a watch. The two should be within 1 or 2 beats per minute of the correct rate.

For the contraction monitor, stretch the belt, or very gently press on the transducer at a rate of about one gentle push every minute. Use a watch to verify the time between applications. The monitor should reflect your application pressure (approximately) and rate (accurately – about 10%).

If both contraction rate and fetal heart rate are reported accurately, then the device is ready to release to the floor.