Best Practice & Research Clinical Obstetrics and Gynaecology 30 (2016) 22–32

Contents lists available at ScienceDirect

Best Practice & Research Clinical Obstetrics and Gynaecology

journal homepage: www.elsevier.com/locate/bpobgyn

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Technical characteristics of current cardiotocographic monitors

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Keywords:
heart rate
foetal
cardiotocography
monitoring
physiologic
foetal monitors

Cardiotocographic (CTG) monitors are complex electronic devices developed to acquire, process and display foetal heart rate (FHR) and uterine contraction (UC) signals. This chapter describes the main characteristics of current CTG monitors, in order to allow a better understanding of the technology. An ultrasound transducer is used for the external monitoring of FHR signals, whereas a tocodynamometer is used for the external monitoring of UCs. These technologies are recommended for routine clinical use in both the antepartum and intrapartum periods. Foetal electrode and intrauterine pressure sensors provide internal monitoring of FHR and UC signals, respectively, which are more precise than external signals. They are only applicable during labour, after cervical dilatation and ruptured membranes, and they have established contraindications. The registration of foetal movements, simultaneous monitoring of twins and triplets, continuous maternal heart rate monitoring, monitoring of other maternal parameters, alarms, digital outputs and telemetry are other available characteristics in some CTG monitors.

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http://dx.doi.org/10.1016/j.bpobgyn.2015.05.005
1521-6934/

Introduction

In the late 1950s and early 1960s, Hon in the United States [1], Caldeyro-Barcia in Uruguay [2] and Hammacher in Germany [3] independently developed different parts of the equipment and basic principles necessary for the continuous monitoring of foetal heart rate (FHR) and maternal uterine contraction (UC) signals, in a technique that became known as cardiotocography (CTG). The first commercial monitor was commercialised in 1967 [4], and in high-resource countries, the technology rapidly gained a prominent place in routine obstetric practice.

CTG monitors are complex electronic devices developed to acquire, process and display FHR and UC signals. Although there have been substantial technical advances since the initial models were developed, particularly in system software and in the ultrasound (US) sensor, the basic principles of the technology have remained unaltered. The main aim of this chapter is to describe the principal characteristics of current CTG monitors, in order to allow a better understanding and use of the technology.

The core features of the CTG monitor

All software features required for the acquisition, processing and display of FHR and UC signals, as well as that of other additional signals (see subsequent text), are incorporated in the central unit of the CTG monitor. This unit usually has a digital display showing currently acquired FHR and UC values, FHR signal quality displays and imbedded speakers to provide an audible representation of the FHR. The central unit usually also incorporates a thermal printer to provide a paper output of the acquired CTG tracing.

The horizontal scale of CTG tracings is commonly called 'paper speed', and the options that are usually available are 1, 2 or 3 cm/min. In most countries, 1 cm/min is selected, whereas in North America and Japan it is almost exclusively 3 cm/min. Some clinicians feel that 1 cm/min provides records of sufficient detail for clinical analysis, and this option has the advantage of reducing paper costs. Others feel that the small details of CTG tracings are better evaluated using higher paper speeds [5]. The vertical scale of CTG tracings may also be different, and the available alternatives are 20 or 30 beats per minute (bpm)/cm. The selected scales should be the ones with which health-care professionals are most familiar, because different options produce slightly different CTG patterns. The inadvertent use of paper scales, which staff is unaccustomed to, may lead to an erroneous interpretation of CTG features [5].

External monitoring of the FHR – the US transducer

The US transducer (Fig. 1) is used for the external monitoring of the FHR, in both the antepartum and intrapartum periods. This transducer contains piezoelectric effect crystals that convert electrical energy into US waves, and that use the Doppler effect to detect movements of the cardiac structures. It is based on the principle that US waves inciding on a moving object are reflected with an altered frequency, which can be detected by the emitting transducer. The signal is thus constituted based on the

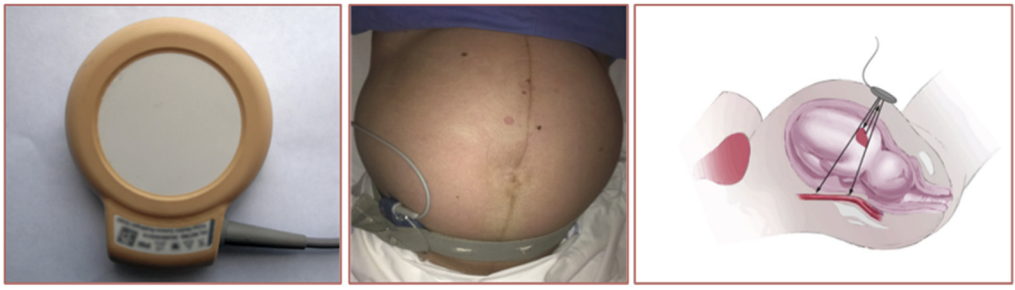

Fig. 1. The ultrasound transducer (left), held in place by an elastic band on the maternal abdomen (centre), and a representation of the ultrasound beam inciding on the foetal heart (right).