

Chapter 18

A Linear Time Series Analysis of Fetal Heart Rate to Detect the Variability: Measures Using Cardiotocography

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ABSTRACT

Real time analysis and interpretation of fetal heart rate (FHR) is the challenge posed to every clinician. Different algorithms had been developed, tried and subsequently incorporated into Cardiotocograph (CTG) machines for automated diagnosis. Feature extraction and accurate detection of baseline and its variability has been the focus of this chapter. Algorithms by Dawes and Redman and Ayres-de-Campos have been discussed in this chapter. The authors are pleased to propose an algorithm for extracting the variability of fetal heart. The algorithm's accuracy and degree of agreement with clinician's diagnosis had been established by various statistical methods. This algorithm has been compared with an algorithm proposed by Nidhal and the new algorithm is found to be better at detecting variability in both ante-partum and intra-partum period.

INTRODUCTION

It is important to monitor the fetus during late pregnancy (ante partum) and labor (intrapartum). Since the fetus is not directly accessible the fetal status can be best determined by monitoring its heart rate and rhythm. Under normal circumstances the fetal heart rate is between 110 – 160 beats per minute (bpm).

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It may vary by 5 – 25 bpm. The heart rate may be affected by various factors ranging from external stimuli to maternal health to any sort of fetal distress. Primary aim of fetal monitoring is to maximize the likelihood of detecting a fetus at risk and make a timely intervention to avoid fetal compromise.

It has been found by National Center for Health Statistics, USA, that perinatal mortality rate (PMR) was 10.14/1000 live births. In USA stillbirth contribute to 55% of perinatal mortality (Macdorman & Gregory, 2015). The Indian scenario is even more staggering. According to a WHO report of 2009 the PMR in rural India is 47/1000 live births and 30/1000 in urban area and 44/1000 in combined rural and urban areas (United Nations Children's Fund [UNCF], 2009).

Main causes of perinatal mortality are intrauterine and birth related hypoxia and asphyxia. These are reflected in the fetal heart rate (FHR) pattern. Imperfection in the fetal heart rate pattern reflects developing acidosis which precedes major neurological damage to the fetus.

Risk factors in the perinatal stage of a fetus may produce adverse effects which range from cardiovascular problems, cognitive learning and behavioral disorder such as cerebral- palsy to even fetal demise. This makes it necessary to monitor the fetus during ante-partum and intrapartum period.

Fetal monitoring primarily aims to prevent metabolic acidosis by evaluating whether or not the fetus is suffering from lack of oxygen during labor. During intrapartum period hypoxia can set in due to umbilical cord compression or decreased placental perfusion during the uterine contraction of the mother. This is exhibited by the late deceleration of FHR. There are other factors that affect the FHR changes but are not directly related to hypoxia. These are maternal fever, infection, medications etc. (Heelen, 2015).

(FHR) produces an automatic rate controlled by the autonomic nervous system (ANS) and its activities are reflected in the heart rate patterns which can provide information regarding the status of the fetus. ANS has two branches: parasympathetic and sympathetic. They have complementary effect on the FHR. Sympathetic branch tends to increase the heart rate while parasympathetic branch tend to reduce it (Fanelli, Giovanni, Companile, & Signorini, 2013). These two opposing effects tend to produce moment-to-moment change in the FHR, known as fetal heart rate variability (FHRV). Its presence thus implies that both branches of ANS are adequately oxygenated and are working well. This makes FHRV one of the most important characteristics of FHR.

Since fetus is not directly accessible, monitoring heart rate signals can be done only noninvasive way to evaluate the condition of the fetus. Cardiotocograph is the predominantly established method for fetal monitoring.

This chapter explores various algorithms including a novel method proposed by the authors for estimating FHRV by analyzing and interpreting fetal heart rate patterns from CTG signals. This method has been compared with another method proposed by Shahad Nidhal, another researcher currently working in this field.

PHYSIOLOGY OF FETUS

Placenta exchanges oxygen and carbon dioxide between the mother and the fetus. There are two types of metabolism: anaerobic and aerobic. Waste products of aerobic metabolism are carbon dioxide and water. The energy produced controls the fetal growth and activity. Aerobic metabolism is dependent on the oxygen.

In anaerobic metabolism oxygen is not available. The waste product is lactic acid and the energy produced controls the basal/ vital activity. Since anaerobic metabolism only provides energy for vital

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