The quality of cardiotocography in obstetric practice

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SUMMARY

Electronic fetal heart rate monitoring (EFM) is universally adopted in obstetrics for clinical use since the early sixties. EFM enables recording of tracings from the fetal heart rate (FHR) and the uterine contraction curve using two methods: external or internal monitoring. With both methods the FHR and uterine contractions are graphically displaced on a paper tracing which is called a cardiotocogram (CTG). Continuous monitoring of the FHR provides more complete and objective information on the fetal condition than intermitted auscultation of the FHR. It enables interpretation of FHR patterns and more important interpretation of FHR patterns in relation to uterine contractions. The latter is the principle of EFM since uterine contractions decrease uterine and spiral artery blood flow and eventually can cause adverse fetal outcome.

Fetal death is almost always preceded by pathological changes in the FHR pattern. EFM is therefore in potential able to predict and prevent fetal death. A clinically significant benefit from the use of continuous EFM has been reduction in the incidence of neonatal seizures. However, the general view is that following its introduction, the incidence of cerebral palsy has remained unchanged while the percentage cesarean and operative deliveries has increased. This opinion originates from randomized controlled trials (RCTs) performed in the seventies and eighties. These studies suffer from a number of serious drawbacks and inadequacies. They compromise a mixture of low and high risk patients and preterm and term labours. Allocation and outcome parameters varied likewise. Nearly all of the randomized controlled trials would not fulfill current standards for quality of RCTs.

Following the introduction of cardiotocography, changes in attitudes on obstetrics and maternal-fetal medicine by the clinicians and the public have favoured obstetric interventions. The main line in obstetric policies has moved towards prevention of serious maternal and fetal risks under all circumstances.

The quality of the cardiotocogram is hardly ever questioned in reviews on EFM. However, medico-legal allegations do address inadequate quality traces as a major cause of errors in CTG interpretation. Good quality uterine activity (UA) and fetal heart rate traces are of prime importance for proper use of EFM.

This thesis reports on the quality of intrapartum EFM. The aim has been to investigate the quality of FHR and uterine contraction monitoring in everyday's practice and the impact of UA on fetal condition. Part 1 focuses on the fetal heart rate and part two on uterine contraction monitoring.

The quality of intrapartum FHR monitoring in singletons is addressed in **chapter 1.** The amount of fetal signal loss was quantified in relation to the method of monitoring: external via ultrasound or internal via a scalp electrode.

Intrapartum recordings stored during a six month period were analysed. The recordings, 239 in total, were from consecutive deliveries at the Vrije Universiteit Medical Center in

Amsterdam. Included intrapartum FHR recordings were obtained from spontaneously delivered singletons. The recordings had a duration of at least one hour prior to birth of the infant. Subdivision in three groups took place on the basis of the recording technique which had been used; i.e. ultrasound, scalp electrode or a combination of both methods. Fetal signal loss is defined as absent FHR recording or recording of the maternal heart rate in stead of the fetal heart rate.

Recordings obtained via ultrasound have significantly more fetal signal loss than those obtained via the direct mode. Fetal signal loss in the first stage of labour is 5.2% with external ultrasound and 0.8% with application of a scalp electrode. In the second stage of labour, fetal signal loss increases to 9.5% for the external and 3% for the internal method. In the second stage of labour, nearly half of the cases (48%) monitored with external ultrasound, exceeded the 20% acceptable limit for fetal signal loss as defined by the International Federation of Gynecology and Obstetrics (FIGO). Intrapartum FHR monitoring via a scalp electrode provides far better quality FHR signals than via external ultrasound. The general opinion that external FHR monitoring provides adequate quality tracings appears to be untrue. If there is an indication for FHR monitoring, the best method available should be applied. Internal monitoring deserves a more prominent position in fetal surveillance than it currently has in many obstetric units worldwide.

Twins are of increased risk for neonatal morbidity and also mortality, especially during labour. Adequate intrapartum monitoring is therefore essential. **Chapter 2** focuses on the quality of the intrapartum FHR recordings in twins.

In a period of eight years, one hundred seventy- two intrapartum FHR recordings were found eligible. The recordings were from twins born at the Vrije Universiteit Medical Center in Amsterdam. All twins delivered via the vaginal route. FHR recordings had a duration of at least one hour prior to the birth of the second twin. Subdivision took place on the basis of the recording technique; i.e. ultrasound or scalp electrode.

There is significantly more fetal signal loss in recordings obtained via ultrasound than in those obtained via the direct mode. In the first stage of labour, fetal signal loss with the ultrasound mode is 11% while with the direct mode fetal signal loss is as low as 0.4%. The percentage of fetal signal loss increases to 23% for the external ultrasound mode in the second stage of labour. Again, the direct mode has far better quality FHR traces since signal loss is only 9%. 26-33% of first stage and 41-63% of second stage ultrasound intrapartum fetal heart rate recordings in twins exceed the FIGO criteria for fetal signal loss. The deplorable quality of the external obtained FHR recordings, especially during the second stage of labour, is distressing. In this stage of labour fetuses are the most at risk. In addition, the second twin is more at risk and less well monitored than its birth mate. The management of intrapartum fetal surveillance in twins should be by means of internal monitoring for the first twin and should also be considered for the second twin after the first twin is born, especially when the expulsion period of the second twin exceeds 10-15 minutes.

Chapter 3 provides an overview of the currently available knowledge on the methods to monitor UA and the units to quantify UA. It assesses the importance of abnormal contraction patterns on the condition of the fetus.

Internal monitoring of uterine contractions is still considered the "golden standard". Although internal UA monitoring is invasive and does not appear to improve obstetric outcome it has many advantages over external UA monitoring. The main advantages are: (1) ability to obtain objective information on quantitation of UA and (2) ability to obtain a good quality trace in an obese, restless patient. Since additional information on UA is required in situations like slow or induced labour and obesity is a growing problem in western countries, it is to be expected that internal UA monitoring will be of more significance in the near future.

Accurate information on UA is essential because elevated UA during the first and second stage of labour can increase the risk of adverse fetal outcome. The relaxation time appears to be an important contraction parameter to maintain fetal well-being during labour. Abnormal contraction patterns like skewed contractions and polysystole are characterised by a shortening of the relaxation time. If they persist over a longer period of time severe fetal asphyxia can occur. Duration, amplitude and frequency of contractions are of importance as well. Quantitative units that incorporate these three contraction parameters are therefore recommended. The mean active pressure unit, in contrast to the Montevideo unit, meets these criteria and is therefore the recommended unit to quantify UA. Unfortunately, tachysystole sometimes remains unidentified in cases of frequent low amplitude contractions. Therefore, it is safer if additional information on uterine contraction parameters such as frequency and relaxation is acquired as well.

Only limited research in the area of UA monitoring has been performed recently. Most of the presented literature is more than 20 years old. International guidelines provide the clinician limited or even no advice on how to monitor and quantify UA. This is even more distressing since proper application of UA monitoring is a prerequisite for high quality cardiotocograms and adequate reading and interpretation of the FHR pattern.

External uterine activity monitoring is the most frequently used method worldwide to monitor uterine contractions. In 1997, 80-85% of the deliveries in the United States were monitored by means of external tocography. The quality of the external tocogram is presumed to be comparable with the quality of the internal tocogram. **Chapter 4** describes whether this assumption is correct. It addresses the quality of the intrapartum uterine contraction curve. First and second stage labour uterine contraction curves were analysed in relation to the technique applied: external or internal.

Intrapartum tocograms collected during a six month period were analysed. Included recordings were from singleton, spontaneous vaginal deliveries at the Vrije Universiteit Medical Center in Amsterdam. The last two hours of the first stage and the complete second stage had to be monitored. The total database consisted of 192 UA recordings. Internal and external UA recordings were judged by their quality: adequate or inadequate.

An adequate UA recording means that a recognisable and reliable UA pattern during the complete registration is obtained. Recordings labelled as inadequate were divided in two groups: absence of UA recording (non recognisable) or inadequate calibration of uterine contractions (unreliable).

The percentages adequate UA recordings in the first stage of labour are much higher for the internal than the external mode. Only 2% of the external recordings are of good quality against 40% of the internal recordings. In the second stage percentages of adequate UA recordings are nearly equal, approximately 30%.

Inadequate external registrations are characterised by almost 30% of the time absent UA monitoring, while with inadequate internal registrations the primary problem is correct calibration.

We conclude that intrapartum UA monitoring via the direct mode provides a more recognisable UA trace. Inadequate registration caused by avoidable calibration errors is of less significance than inadequate registration caused by absent UA. With calibration errors interpretation of the uterine contraction curve is still possible, while persistent absence of the UA trace for a significant period of time will make it troublesome or even impossible to interpret the FHR pattern in relation to the uterine contraction curve, in particular when FHR decelerations occur. Hyperstimulation or tachysystole can remain unrecognised and the appropriate action can be delayed or will not be performed at all. A high quality tocogram is a necessary condition to monitor the fetus condition.

Chapter 5 provides more insight in the fetal mechanisms as a response to uterine contractions. The focus in this chapter is why correct assessment of uterine activity patterns is so important.

UA causes a decreased blood flow through the uterine artery. In the healthy uncompromised fetus, this will not immediately lead to fetal acidemia. The fetus has developed protection mechanisms and can survive labour without being damaged. First, fetal preload increases during a contraction and enables to maintain a constant blood flow through the umbilical artery. Second, UA increases the blood flow in the fetal middle cerebral artery, i.e. the brain-sparing effect. Third, the fetus has more capacity to carry oxygen due to an increase in haemoglobin. Finally, the fetus has an increased oxygen affinity and a relatively high heart rate resulting in a high cardiac output.

In the compromised fetus or in case of excessive UA a fetus cannot compensate the stress of labour. Umbilical artery blood flow starts to decrease and oxygenation is diminished. To compensate, the flow in the middle cerebral artery increases even more.

One must be alert to excessive UA in all circumstances and, in compromised fetuses, even to apparently normal intrapartum UA. Elevated UA during the first and second stage of labour increases the risk of adverse fetal outcome. Oxytocin has to be administered with care and if this potentially dangerous drug is administered, a good quality uterine contraction trace must be obtained. Adequate UA monitoring is a prerequisite for proper reading and

interpretation of cardiotocograms. It alarms us in case of excessive UA and helps us to avoid fetal acidemia.

The objective of this **chapter 6** is to assess the role of uterine activity on fetal outcome. Intra uterine pressure (IUP) recordings from consecutive vaginal deliveries during a period of 11 years have been analysed. Included recordings were from term singletons. Fourteen hundred thirty-three recordings have been included. For each recording the uterine contraction curve has been analysed. The following contraction parameters were determined: relaxation time; contraction duration, frequency, amplitude and surface; Montevideo units and active planimeter units. IUP recordings and contraction parameters from deliveries ending with an umbilical artery pH of ≤ 7.11 were compared with those ending with an umbilical artery pH of ≥ 7.12.

Increased uterine activity is significantly associated with a higher incidence of fetuses born with an umbilical artery pH ≤ 7.11. Logistic regression demonstrates that two of the contraction parameters predict an adverse umbilical artery best: increased first stage contraction frequency and a high cumulative contraction surface. Elevated UA during the first and second stage of labour increases thus the risk of adverse fetal outcome. The hazards of tachysystole and hyperstimulation are once again emphasized. From this study and ample clinical experience it is obvious that contraction monitoring deserves full attention in daily obstetric practice.

In **Chapter 7,** the general discussion, the results of the thesis in relation to the implications for clinical practice are discussed. The problems with EFM are discussed and possible solutions are postulated.

The efficacy of EFM is limited due to a number of factors. At first, not all cases of cerebral palsy can be prevented with the use of intrapartum FHR monitoring. Although around 20% of the cases of cerebral palsy can be attributed to intrapartum events there is still 80% cerebral palsy not related to asphyxial birth injury. Second, the FHR patterns associated with intrapartum asphyxia are not always understood and recognized. Third, lack of standardized definitions of FHR patterns leads to inter- and intra-observer variability.

To overcome these problems, the interpretation of FHR patterns and the resulting management of labour should be standardized. Clinicians attending the process of labour must have knowledge of technical aspects and related pitfalls, CTG reading and interpretation, and the most appropriate obstetric management. Gathered knowledge ought to be preserved by repetitive training and education.

CTG reading and interpretation is not possible if the quality of the traces is inadequate or not obtained at all. A high quality trace for both the FHR and the uterine contraction trace should be obtained at any time. This thesis demonstrates that the quality of both traces in daily practice often is not adequate, a problem that especially may occur with the use of the external method of EFM. Signal loss is a frequent phenomenon and maternal heart rate monitoring instead of the FHR can easily happen. Incorrect assessment of the FHR pattern

and the uterine contraction curve to assess the fetal condition in relation to uterine activity may be the consequence. Ability to adequately read and interpret the FHR trace and the uterine contraction curve can be one solution to the problems with EFM and may reduce the number of unnecessary obstetric interventions.