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The importance of antepartum cardiotocography*

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1 Introduction

Currently a available biochemical, biophysical and electronic methods of monitoring in addition to the clinical examination permit exact statements on the intrauterine development and status of the fetus. Since no single method is able to assess all disturbances of the uteroplacental unit simultaneously the choice of the most suitable method and the rational combination of the various surveillance methods is of great importance [1, 6, 10, 14, 18].

In regard to the antepartum and intrapartum assessment of the actual fetal status and for the recording of uterine contractions, cardiotocography has a special position. We investigated the role of intermittent antepartum fetal heart rate recording and attempted to establish guidelines for the use of this method as a part of antenatal care. For this purpose we analyzed the course of pregnancies and births during the years 1982 and 1983 at the Women's Hospital of the University of Cologne and correlated them with neonatal outcome.

2 Patient material and methods of analysis

During the study period there were 1,521 deliveries with 1,490 (97.9%) singletons, 30 (2.0%)

Curriculum vitae

KARL-HEINZ BREUKER, M.D., was born 1939 in Hattingen, FRG. He studied medicine at the Universities of Münster, Vienna and Freiburg. After his graduation he worked for one year at the Institute of Pathology, University of Düsseldorf. Since 1969 he has been at the Department of Obstetrics and Gynecology, University of Cologne. He qualified as a lecturer in Obstetrics and Gynecology in 1981 and was appointed Professor in 1984. His fields of interest include computerized monitoring of fetal heart rate, problems of twin pregnancies and deliveries, and chromosome anomalies in case of habitual abortions.



twins and 1 (0.1%) triplet pregnancy. Analyzable cardiotocograms before and during delivery were available from 1,463 patients. The records used fetal monitors which allowed beat-to-beat registration (Hewlett-Packard). Recording methods included predominately phonocardiography and in isolated cases abdominal fetal EKG as well as increasingly since 1983 auto-correlating ultrasound cardiotocographs.

A total of 13,310 antepartum fetal heart rate recordings were analyzed. Two physicians analyzed the recordings according to the score of HAMMACHER [5] which considers and weighs

* Dedicated to Prof. Kaiser on the occasion of his 65th birthday.

baseline rate, periodic patterns and variability. Additional analysis utilized a computer (Mod-comp, Model Classic 7801) with a 128 K memory.

3 Results

Of the 1,463 patients with a total of 13,310 recordings, 1,413 women (96.7%) had 13,244 (99.5%) normal fetal heart rate recordings. In 40 patients (3.7%) suspect CTG findings were seen, resulting in 56 (0.4%) suspect heart rate recordings. In 10 patients (0.6%) a pre-pathologic CTG was found 24 hours before birth corresponding to 0.1% of the total number of the heart rate recordings (table I).

In women with a normal fetal heart rate recordings, 67.7% (957) had no complications during pregnancy; in 32.3%, the CTG's were unremarkable despite the presence of complications. Of 50 patients with suspected and pre-pathological recordings, all had complications during pregnancy (table II).

Table III gives an overview of the complications during pregnancy with normal and abnormal antepartum heart rate recordings. For both groups an incipient premature delivery with 53.6% and 30.3% respectively is the leading risk factor. This was followed by toxemia of pregnancy with 35.7% and 2.3% respectively, first and second trimester bleedings (17.9% and 5.4%), placental dysfunction (7.1% and 0.7%), polyhydramnios (7.1% and 0.7%) and, lastly, other maternal diseases (10.7% and 6.7%). Among the latter we found diabetes mellitus, anemia and urinary tract infections of the mother.

The analysis of the cardiotocograms shows that the CTG items "floating line" (periodic patterns) and "oscillation" (variability) type together accounted for 43.9% by far the greatest proportion of the total score. The single parameters (baseline 1.5%, variability 6.1%, periodic pattern 15.1%) by comparison had a comparatively lower contribution to the total score, as did the other combinations ("baseline and floating line" 12.2%, "baseline and oscillation

Table I. Patients with normal, suspect and prepathologic antepartum cardiotocograms in the years 1982/83 at the University of Cologne.

	Cardiotocogram		Patients	
	N	%	N	%
Total Number	13 310	100	1 463	100
Normal cardiotocogram	13 244	99.5	1 413	96.7
Suspect cardiotocogram	56	0.4	40	2.7
Prepathologic cardiotocogram	10	0.1	10	0.6

Table II. Number of patients with normal and suspect/prepathologic antepartum cardiotocograms in correlation to complications during pregnancy.

Patients with normal cardiotocogram N = 1413				Patients with suspect/prepathologic cardiotocogram N = 50			
Complications				Complications			
With		Without		With		Without	
N	%	N	%	N	%	N	%
957	67.7	456	32.3	50	100	—	—

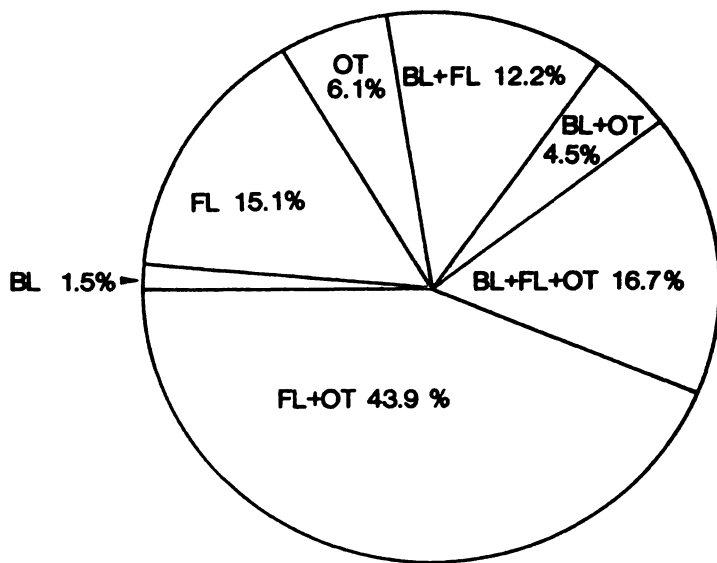


Figure 1. The proportion of single CTG parameters and their combinations in the total score. BL = baseline, FL = Floating line = decelerations (periodic pattern), OT = oscillation type = fluctuations (variability).

type” 4.5%, “baseline and floating line and oscillation type” 16.7%) (figure 1).

Spontaneous delivery occurred in 75.5%, whereas in 7.4% a vaginal operative procedure

and in 17.1% a cesarean section was necessary. Dividing the patients into groups with normal and abnormal (= “suspect” or “pre-pathological”), we found that in the CTG first group, 76.7% of the patients were delivered spontaneously, in 6.6% there was a vaginal procedure and in 16.7% a cesarean section was performed. As expected, in the second group the proportion of spontaneous deliveries was comparatively low with 42%, in 2% there was a vaginal intervention, and in 56% a cesarean section (table IV).

The one minute Apgar score in infants with abnormal antepartum CTG, was 4–6 and in 18.0% of the cases 1–3. For the five minute Apgar score there was a noticeable shift into the normal range with 85% having a score of 7–10. Only 10.8% of the newborns had a score of 4–6 and 4.2% of 1–3. At ten minutes all but 0.5 and 2.0% respectively children were normal.

For patients with a normal antepartum fetal heart rate pattern, the proportion of newborns born depressed, i. e., with an Apgar score of

Table III. Complications during pregnancy in patients with normal and suspect/prepathologic antepartum cardiotocograms.

Normal cardiotocogram %	Complication	Suspect/prepathologic cardiotocogram %
30.3	Impending premature delivery	53.6
12.3	Toxemia	35.7
5.4	Hemorrhage in the first through third trimester	17.9
0.7	Placental dysfunction	7.1
0.4	Polyhydramnios	7.1
1.4	Rh incompatibility	—
6.7	Other maternal diseases	10.7

Table IV. Method of delivery in patients with normal and suspect/prepathologic antepartum cardiotocograms.

	Patients		Normal cardiotocogram		Suspect/prepathologic cardiotocogram	
	N = 1463	100%	N = 1413	99.3%	N = 50	0.7%
Spontaneous delivery	1105	75.5%	1084	76.7%	21	42%
Vaginal surgery	108	7.4%	107	6.6%	1	2%
Cesarean section	250	17.1%	222	16.7%	28	56%

4-6 and 1-3, was 5.4% and 2.7% respectively. After five minutes 2.0% and 1.1% of the newborns were still depressed and after ten minutes only 0.9% and 0.4% (table V).

Neonates with a severe acidosis were found in 4.75% of the cases with a suspect antepartum CTG, whereas, this was true for only 2.1% in cases with a normal fetal heart rate pattern. Mild to moderate acidosis was found in 25.6% of the infants with an abnormal pattern, and 16.9% of the neonates with a normal heart rate pattern. All other infants had a umbilical artery pH of over 7.21 (table VI).

Table V. Apgar scores at one, five, and ten minutes in newborns with normal and suspect/prepathologic antepartum cardiotocograms.

Normal cardio-tocogram	Apgar score	Suspect/prepathologic cardiotocogram
%	One minute	%
91.9	10-7	64.0
5.4	6-4	18.0
2.7	3-1	18.0
	Five minute	
96.9	10-7	85.0
2.0	6-4	10.8
1.1	3-1	4.2
	Ten minute	
98.7	10-7	97.5
0.9	6-4	0.5
0.4	3-1	2.0

Table VI. Umbilical artery pH in neonates with normal and suspect/prepathologic antepartum cardiotocograms.

Normal antepartum cardiotocogram	pH value (umbilical artery)	Suspect/prepathologic antepartum cardiotocogram
N = 1299 %		N = 43 %
27 2.1	7.00-7.10	2 4.65
219 16.9	7.11-7.20	11 25.58
563 43.3	7.21-7.30	14 32.56
490 37.7	> 7.30	16 37.21

Only 56.5% of the newborns with an abnormal antepartum heart rate pattern weighed more than 2500 grams. Thirteen percent weighed less than 1000 grams, and in 17.4% the birth weight was between 1000 and 1500 grams (table VII).

Thus, the proportion of premature newborns in this group was 32.1%, in addition 7.1% of the newborn were premature and dysmature

Table VII. Birth weight of neonates with normal and suspect/prepathologic antepartum cardiotocograms.

Normal cardio-tocogram	Weight (g)	Suspect/prepathologic cardiotocogram
0.4%	< 1000	13.0%
1.7%	1001-1500	17.4%
2.0%	1501-2000	4.4%
4.9%	2001-2500	8.7%
91.0%	> 2500	56.5%

Table VIII. Maturity in infants with normal and suspect/prepathologic antepartum cardiotocograms.

Normal cardio-tocogram	maturity	Suspect/prepathologic cardiotocogram
(N = 1413)		(N = 50)
90.2%	term - normal	53.6%
2.2%	term - growth retarded	7.1%
6.6%	premature	32.1%
1.1%	premature - growth retarded	7.1%

Table IX. Perinatal mortality of infants with normal and suspect/prepathologic antepartum cardiotocograms.

	Total	Normal cardio-tocogram	Suspect/prepathologic cardiotocogram
	N = 1463	N = 1413	N = 50
Perinatal mortality (excluding non-viable malformations)	1.7%	1.2%	16%

and 7.1% of the infants were termed dysmature (table VIII). The overall perinatal mortality during the study period was 17 per 1000 births, or 12 per 1000 when non-viable malformations are discounted. We achieved a perinatal mortality in cases with normal antepartum fetal heart rates of 9 per 1000 excluding non-viable malformations. In children with an abnormal antepartum CTG, the perinatal mortality without non-viable malformations was 80 per 1000 (table IX).

4 Discussion

The importance of antepartum cardiotocography is based on the interactions between fetal hypoxia and the response of the fetal heart rate [6, 15, 17]. There is now general agreement that this method allows the diagnosis of acute fetal distress [1, 7, 19]. However, this does not answer the question whether the method is useful for routine antenatal care. This can only be seen in a larger number of patients with an appropriate stratification. In particular, risk pregnancies should be adequately represented because they are the ones to most likely to yield abnormal antepartum fetal heart rate recordings.

Our patient material during the study period consisted of 1,463 patients. As expected for a referral center, 32.3% of the patients had complications during pregnancy. Thus the at risk group was well represented as demonstrated in the perinatal statistics for the state of North Rhine-Westphalia where in 1982 there were 38.3% and in 1983 48.9% pregnancies with defined risk factors [13].

The 1,463 patients yielded 13,310 cardiotocograms for analysis. In 50 (3.3%) patients, there were 66 (0.5%) suspect and/or prepathological heart rate patterns. Thus, abnormal antepartum CTGs in an unselected patient population are notably rare. Therefore, cardiotocography is not suitable as a general screening method during pregnancy.

The analysis of the pregnancies of these 50 women showed in all cases pregnancy complications. Threatening prematurity, toxemia, hem-

orrhage in the first and second trimester, as well as placental insufficiency and polyhydramnios were the most commonly seen complications. These conditions were symptomatic enough that they could be recognized with simple clinical assessment methods. A comparison with patients which had normal antepartum fetal heart rate recordings despite complications, demonstrates that pathologic CTGs changes are seen only with severe forms of maternal illness. Consequently, the use of antepartum cardiotocography is only indicated when risk factor indicate fetal compromise.

The semiquantitative analysis of heart rate patterns with the Hammacher score considers the characteristics "baseline," "floating line" (periodic patterns), and the "oscillation type." In order to process these parameters the recording has to be of technical good quality in regard to the recording and documentation. Therefore, only those methods should be used which allow a true beat-to-beat recording. Integrating recording methods are not suitable to reliably recognize criteria relevant for fetal wellbeing. We have been particularly satisfied in the last few years with cardiotocographs which process fetal heart rates with a Doppler autocorrelation method. This form of monitoring is technically superior to other external methods including those using phonocardiography for beat-to-beat registration and those using the abdominal fetal EKG [2, 3]. Our results match very well those of RÜTTGERS [16]. In comparison to direct fetal electrocardiography, the CTG characteristics "oscillation amplitude" and "oscillation frequency per minute" correlated very well. It must, however, be pointed out that decelerations cannot always be correctly recorded [4, 16] as to their number, oscillation amplitude, and depth of deceleration because of interferences from the maternal pulse. In difficult cases an additional continuous recording of the maternal heart rate should be made.

The contribution of single CTG parameters to the total score was fairly low: for baseline it was 1.5%, the oscillation type 6.1% in comparison to periodic pattern with 15.1%; the latter was the most important subscore. Of particular

importance was the combination of the characteristics "floating line and oscillation" type. In 43.9% this combination accounted for the magnitude of the total score and thus influenced the classification; i. e., it caused a shift from the normal into the suspect or prepathological range. Thus, the combination of the two parameters not only quantitatively but qualitatively are the most important items of the score.

An exact classification of the decelerations is only possible when there are uterine contractions at the same time. Obviously, in cases of severe decelerations, classification is possible even without labor activity. We agree with KÜNZEL [8, 9] that in borderline situations a statement regarding the fetal oxygenation is only possible in the presence of contractions. If spontaneous contractions cannot be recorded they should be generated by a contraction stress test.

The subsequent outcome of fetuses with abnormal antepartum CTGs shows 32% prematures, 7.1% growth retarded prematures and 7.1% growth retarded term infants. Considering in addition birthweight classes, it is seen that 30% have a birth weight of less than 1500 grams.

Thus, pathological antepartum heart rate changes can be expected particularly in cases of premature onset of labor as early as the late second and early third trimesters, as well as in impaired uteroplacental perfusion such as toxemia and placental dysfunction. These complications therefore pose an absolute indication for antepartum cardiotocography in order to recognize a fetal emergency timely or to evaluate the efficacy of tocolysis. The frequency of the intermittent recordings is determined by the severity of the pathological condition [6, 9, 8, 10, 15].

Summary

The significance of antepartum cardiotocography was examined on patients at the University of Cologne in the years 1982 and 1983. We analyzed 13,310 cardiotocograms of 1,463 women and correlated their pregnancies

Apgar scores, blood gases, and the high perinatal mortality demonstrates that fetuses with suspect or prepathologic antenatal heart rate recordings have a poor prognosis. In our material perinatal mortality was 80 per 1000 in comparison to 9 per 1000 in fetuses with normal CTGs and thus was increased nine-fold. These results correlate well with those of the Bavarian and Rhenish perinatal statistics [12, 13]. The least stressful method of delivery should be selected for this group and decisions to perform Cesarean sections should readily be made. If a vaginal delivery is decided upon any possible resistance should be minimized and any additional traumas such as hypertonic or too frequent contractions, as well as protracted courses of labor, or maternal shock and hypertension should be avoided [11, 20, 21].

We draw the following conclusions from these data:

1. Abnormal antepartum fetal heart rate recordings are rare and always accompany severe complications of pregnancy. A technically adequate recording and accurate analysis is a prerequisite for the evaluation of abnormal CTG characteristics.
2. Antepartum cardiotocography is not a general screening method but should be used for specific indications in high risk pregnancies.
3. Suspect or prepathologic antepartum cardiotocograms should be detected early, if not prevented altogether by careful monitoring of high risk pregnancies.
4. Perinatal mortality without non-viable malformations is 8% and thus exceeds by a factor of 9 that of infants whose mothers had normal CTGs during pregnancy.
5. Delivery must occur under optimal conditions with as little fetal stress as possible.

and deliveries with the status of their newborns. There were only 66 suspect/prepathologic fetal heart rate recordings in 50 patients. All these patients had severe complications during their pregnancies. Impending pre-

maturity, toxemia, first and second trimester bleeding as well as placental insufficiency and polyhydramnios were the leading complications. The analysis of the cardiotocograms using HAMMACHER's criteria demonstrated that the CTG characteristics "floating line" and "oscillation type" together accounted for the largest proportion (43.9%) to the total score and thus constituted the most important parameters.

Fetuses with abnormal CTGs had a birthweight of less than 1500 grams in 30% of the cases. This group also had poorer Apgar scores and umbilical artery pH values than neonates with normal antepartum cardiotocograms. After excluding non-viable malformations the perinatal mortality was 80 per 1000, i. e. it was nine

times higher for newborns with abnormal antepartum heart rate patterns. The study demonstrated that abnormal antepartum CTGs in non-selected patients are rare and are always associated with severe complications of pregnancy. Thus, the method is not suitable as a general screening method but should be used for specific indications in high risk pregnancies and for the evaluation of any tocolytic treatment. The recognition of abnormal CTG characteristics requires technically adequate recording and accurate analysis. It is desirable to diagnose abnormal antepartum cardiotocograms as early as possible. Deliveries should occur under optimal conditions with the least possible stress for the infant.

Keywords: Antepartum fetal heart rate monitoring, cardiotocographic score, floating line, oscillation type, screening method.

Zusammenfassung

Die Bedeutung der antepartualen Kardiotokographie

Die Bedeutung der antepartualen Kardiotokographie wurde am Patientengut der Universitäts-Frauenklinik Köln der Jahre 1982/1983 untersucht. Von 1.463 Frauen mit insgesamt 13.310 Kardiotokogrammen wurden die Schwangerschafts- und Geburtsverläufe analysiert und dem Zustand der Neugeborenen gegenübergestellt. Lediglich von 50 Patientinnen konnten antepartual 66 suspekten/präpathologische fetale Herzfrequenzkurven abgeleitet werden. Alle Frauen wiesen erhebliche Komplikationen während der Gravidität auf. Im Vordergrund standen die drohende Frühgeburt, EPH-Gestose, Blutungen im I. und II. Trimenon sowie die Plazentainsuffizienz und das Hydramnion.

Die Auswertung der Kardiotokogramme nach HAMMACHER zeigte, daß die CTG-Merkmale Floatingline und Oszillationstyp in Kombination mit 43,9% den weitaus größten prozentualen Anteil am Gesamtscore bildeten und somit die wichtigsten Parameter waren.

Von den Kindern mit suspekten/präpathologischen CTG's wiesen 30% ein Geburtsgewicht von weniger als 1.500 g auf. Auch im Hinblick auf die Apgarbewertung

und den Nabelarterien-pH schnitt dieses Kollektiv schlechter ab als Kinder mit normalen, antepartualen Kardiotokogrammen. Die perinatale Mortalität betrug nach Abzug der nichtlebensfähigen Mißbildungen 8% und lag damit um das 9fache höher als bei Neugeborenen mit unauffälligen antepartualen Herzfrequenzkurven.

Die Untersuchungen zeigten, daß unauffällige antepartuale Kardiotokogramme in einem unselektionierten Patientengut selten sind und immer mit schweren Komplikationen während der Schwangerschaft einhergehen. Das Verfahren ist daher als generelle Screeningmethode nicht geeignet, sollte aber gezielt bei Risikograviditäten und zur Prüfung der Effektivität einer medikamentösen Wehenhemmung eingesetzt werden. Die Erfassung auffälliger CTG-Merkmale setzt eine gute, technisch einwandfreie Registrierung und eine exakte Auswertung voraus. Suspekten/präpathologische, antepartuale Kardiotokogramme sollten so früh wie möglich diagnostiziert werden. Die Geburt hat unter optimalen Bedingungen – so schonend wie möglich – für das Kind zu erfolgen.

Schlüsselwörter: Antepartuale Kardiotokographie, Floatingline, Kardiotokogramm-Score, Oszillationstyp, Screening-Methode.

Résumé

Importance de la cardiotocographie antepartale

On a examiné la signification de la cardiotocographie antepartale chez les patientes suivies à l'université de Cologne en 1982 et 1983. Nous avons analysé 13 310 cardiotocogrammes de 1463 femmes et nous avons corrélé grossesses et accouchements avec l'état du nouveau-né. Il n'y avait que 66 enregistrements du rythme cardiaque fœtal suspects et/ou pathologiques chez 50 patientes.

Toutes ces patientes ont eu des complications graves au cours de leur grossesse. Les complications dominantes ont été: menace d'accouchement prématuré, toxémie, saignement du premier et du second trimestre, ou encore insuffisance placentaire et hydramnion. L'analyse des cardiotocogrammes selon les critères d'HAMMACHER a démontré que le niveau du rythme de base et le type des oscillations sur le CTG sont pris en compte tous les

deux ensemble pour la proportion la plus importante (43,9%) du score total et qu'ils constituent ainsi les paramètres les plus importants.

Les fœtus avec un CTG anormal ont un poids de naissance inférieur à 1500 grammes dans 30% des cas. Ce groupe a également des scores d'Apgar plus faibles et des valeurs du pH artériel ombilical plus bas que ceux des nouveaux-nés qui avaient des cardiotogrammes normaux avant le travail. Après élimination des malformations non viables, la mortalité périnatale est de 80 pour 1000 et est neuf fois plus élevée chez les nouveaux-nés ayant eu un rythme cardiaque anormal avant le travail.

Cette étude démontre que les CTG anormaux avant le travail chez des patientes non sélectionnées sont rares et qu'ils sont toujours accompagnés de complications graves de la grossesse. Ainsi, cette méthode n'est pas réalisable comme méthode de dépistage générale mais doit être appliquée pour des indications spécifiques pour les grossesses à haut risque et dans le bilan de tout traitement tocolytique. La mise en évidence d'anomalies du CTG nécessite un enregistrement techniquement adéquat et une analyse appropriée. Il est souhaitable de diagnostiquer un cardiotogramme anormal avant le travail, le plus tôt possible. Les accouchements devraient s'effectuer dans des conditions optimales avec le moins de stress possible pour l'enfant.

Mots-clés: Enregistrement avant l'accouchement du rythme cardiaque fœtal, méthode de dépistage général, oscillations, rythme de base, score cardiotocographique.

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