Computerised cardiotocography in a high-risk unit in a developing country — its influence on inter-observer variation and duration of recording

D. W. Steyn, H. J. Odendaal

Objective. To determine the role of computer-assisted cardiotocography in an obstetric special care unit and its influence on inter-observer variation in interpretation, proposed management and monitoring time.


Setting. The obstetric special care unit, Tygerberg Hospital, W. Cape.

Study population. A group of 10 registrars in obstetrics who have had experience in the interpretation of both standard and computer-assisted cardiotocographs.

Main outcome measures. The influence of method of cardiotocograph recording on inter-observer variation in respect of suggested management of the patient, as well as the observer's opinion of the duration of the recording.

Results. Variation in suggested management decreased significantly after assessment of the computer reports, compared with the standard cardiotocographs. While delivery was regarded to be indicated in 3.5% of patients and an immediate repeat of the cardiotocograph in a further 10%, no such action was proposed after evaluation of the computer reports of the same recordings. Thirty-four per cent of tracings were considered to have been too long and 12.5% too short. However, suggested management in 40% of the latter cases seemed inappropriate for tracings regarded as of too short a duration.

Conclusion. While computer-assisted cardiotocographs significantly decrease inter-observer variation in the proposed management of patients, its cost-effectiveness in an obstetric special care unit in a developing country should be validated, as it might increase monitoring time.


Antepartum fetal heart rate (FHR) monitoring is widely used for fetal surveillance, although its benefits have yet to be convincingly proved in randomised controlled trials. One of the most important deficiencies, which certainly contributes to inconsistencies between the test interpretation and eventual neonatal outcome, is the considerable inter- and intra-observer variation in assessment. Repetition of the recording regularly assists in early diagnosis of fetal distress in some cases of abruptio placentae in patients with severe pre-eclampsia remote from term who are managed expectantly. This approach requires meticulous observation of maternal and fetal condition, which is best achieved in an obstetric special care unit (OSCU). Locally, we routinely repeat the non-stress test (NST) every 6 hours in these patients as abruptio placentae may develop suddenly, even in a patient who had a reactive NST earlier the same day. These tests are assessed by the registrar who rotates through the OSCU in consultation with one of the two consultants on call at the OSCU. Recently a cardiotocograph unit equipped with a programme for computer analysis of the FHR was established at our obstetric high-risk unit. Among the major reported advantages of this system, the Sonicaid System 8000, are the objective reporting of certain parameters which should facilitate management and the monitoring time which could possibly be saved. It has also been demonstrated that the long-term as well as short-term FHR variability, as determined by the computer, correlate well with fetal condition. Prolonged low FHR variability has been associated with hypoxaemia, and progressive deterioration precedes fetal death. Normal and abnormal values for long- as well as short-term FHR variability have been determined and validated.

A study was undertaken to determine to what extent the method of cardiotocography and the reporting thereof influence inter-observer variation in interpretation as well as decisions on patient management, and also to define the place of the Sonicaid System 8000 in the cost-effective management of the high-risk obstetric patient.

Materials and methods

Permission was obtained from patients in the OSCU with severe pre-eclampsia to record the FHR simultaneously with the Hewlett-Packard model 8041 and the Sonicaid System 8000. The technique of acquiring and analysing the data has been presented in detail elsewhere. In essence, the computer fits a baseline to the trace, recognises accelerations and decelerations according to their definition, and calculates the FHR range in milliseconds for each pulse interval of 3.75 seconds, referred to as an epoch. The overall long-term variability is indicated as the mean minute range (MMR) and is determined as the mean of the differences between the minimum and maximum epochal FHR range in each minute. An overall MMR of > 30 milliseconds is regarded as normal, between 20 and 30 milliseconds as equivocal and < 20 milliseconds as abnormal. The short-term variability is calculated as the mean of the FHR differences between each two successive epochs. The computer collects the information for as long as 60 minutes. Analysis is performed after 10 minutes and every 2 minutes.
thereafter. Should the record appear normal at any stage according to the system's criteria, referred to as the Dawes
and Redman criteria (DRC), advice is given to stop the
recording. Alternatively, the advice to continue recording is
given.

Termination of the recording in this study depended on the
DRC of fetal well-being being fulfilled, and its duration was
thus determined by the Sonicaid System 8000. Twenty
tracings were collected in each group. The purpose of the
double recording was not revealed and the Sonicaid
recordings were used for patient management. The
registrars who, at the time of the study, had already worked
in the OSCU since the introduction of the Sonicaid System
8000 were selected to participate in the study. The clinical
situation given to participants was similar for each patient,
to exclude other factors which might have influenced the
management. The NST was said to have been that of a
patient with severe pre-eclampsia at 32 weeks' gestation.
Her condition was stabilised and the only reason for delivery
would be the nature of the NST. The next NST would be
recorded in 6 - 8 hours' time unless otherwise decided by the
participant. Collaborators were asked to categorise each
NST as reactive or non-reactive, or to state if they were
uncertain. Appropriate action to be taken had to be outlined
as immediate (either delivery or continuation of the NST with
delivery as option if the pattern persisted or deteriorated) or
routine (next assessment at a later stage either after 6 hours
as suggested or at a later stage but earlier than the 6 hours
as suggested). The length of recording had to be specified
as too long if the recording could have been stopped earlier
without influencing the categorisation of the NST, as too
short if a decision could not yet be made, or as adequate if
the recording was long enough to make a decision but a
decision would not have been possible had the recording
been stopped earlier. Two weeks later the computerised
numerical reports were given to the 10 registrars. They were
asked to state what their action would be, given the same
clinical situation as before.

Proportions were compared using the \( \chi^2 \)-test, the odds
ratio (OR) and 95% confidence limits (CL), or the Fisher
exact test where numbers were small.

Results

Of the 199 reports based on own interpretation that were
returned by the 10 participants, 83 were reported to be
reactive, 94 non-reactive while in 22 cases there was
uncertainty regarding the category (Table I). This
classification significantly influenced the proposed
management of the patient, with immediate action planned
in 13 (13.8%) cases where the NST was regarded as non-
reactive and in 14 (63.6%) where the physician was
uncertain \((P = 1.85 \times 10^4, \ OR = 10.9, \ 95\% \ CL = 3.44 -
35.88)\). This difference was even more significant when
compared with reactive tests where no immediate action
was planned \((P = 0.0008 \ compared \ with \ non-reactive \ tests
and \ P < 10^{-4} \ compared \ with \ tests \ where \ the \ category \ was
uncertain)\). No immediate action, either repeat of NST or
delivery, was anticipated after evaluation of the Sonicaid
System 8000 analysis of the same recordings. The
difference in intended management from that suggested

after assessment of the standard recordings was statistically
significant \((P < 10^{-4})\) (Table II). When all 199 records available
for analysis were considered, unchanged management was
suggested in 137 cases, while more active management was
proposed in 21 cases, and more expectant management in
41 cases (Table III). Of the 27 recordings where prompt
reaction was regarded as appropriate initially, 16 would now
only be repeated after 6 hours and the remaining 11 later
but in less than 6 hours' time (Table IV). In 5 of the 7 cases
where delivery was originally considered to be warranted,
routine management was considered sufficient after
computerised analysis. In the remaining 14 cases where
more expectant management was decided upon, a decision
was taken to repeat the NST routinely instead of in less than
6 hours. More active management invariably involved
repeating the NST at a later stage, but earlier than the 6
hours that were originally suggested.

Table I. Suggested management of patients according to
physician's own interpretation of the CTG

<table>
<thead>
<tr>
<th>Report category</th>
<th>Repeat CTG after 6 hrs</th>
<th>Repeat CTG before 6 hrs</th>
<th>Repeat CTG immediately</th>
<th>Deliver immediately</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactive</td>
<td>83</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Non-reactive</td>
<td>51</td>
<td>30</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Uncertain of category</td>
<td>0</td>
<td>8</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>134</td>
<td>38</td>
<td>20</td>
<td>7</td>
</tr>
</tbody>
</table>

CTG = Cardiotocograph.

Table II. Suggested management of patients according to the
physician's interpretation of the computerised analysis of the
CTG grouped according to the original report based on the
Hewlett-Packard analysis

<table>
<thead>
<tr>
<th>Original report category</th>
<th>Repeat CTG after 6 hrs</th>
<th>Repeat CTG before 6 hrs</th>
<th>Repeat CTG immediately</th>
<th>Deliver immediately</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactive</td>
<td>73</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Non-reactive</td>
<td>56</td>
<td>38</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Uncertain of category</td>
<td>14</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>56</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

CTG = Cardiotocograph.

Table III. Proposed management after evaluation of the computer
analysis of CTGs compared with proposed management after own
evaluation of standard CTGs

<table>
<thead>
<tr>
<th>Proposed new management</th>
<th>Original category</th>
<th>More expectant</th>
<th>Unchanged</th>
<th>More active</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-reactive</td>
<td>21</td>
<td>62</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Reactive</td>
<td>0</td>
<td>73</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Uncertain</td>
<td>20</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>41</td>
<td>137</td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>

CTG = Cardiotocograph.
In 12 of the 20 recordings analysed by the participants themselves, all 10 were unanimous that no immediate action was indicated. However, there was no unanimity in respect of those cases in which urgent action was deemed necessary. After the computer analysis became available, all individuals agreed that no immediate measures had to be taken (P = 0.0016).

Recording time was considered to have been adequate in 106 (53.3%) cases, too long in 68 (34.2%) cases and too short in 25 (12.7%) cases (Table V). However, in 10 (40%) cases where recording time was considered to be inadequate, no need was seen for immediate action (Table VI). Nine of these tests were reported to be non-reactive and in 1 case the NST was categorised as uncertain. In 8 of the remaining cases uncertainty prevailed regarding the category of the NST, while the other 7 were regarded as non-reactive. In the 22 cases where there was uncertainty about the category of NST, only 9 were considered to have been stopped too early and 11 to be of adequate length. Of the 12 cases among these 22 in which it was recommended that recording be repeated immediately, 4 were reported to have recordings of satisfactory length; 1 was even thought to have been too long.

**Discussion**

The major purpose of this study was to define the extent of inter-observer variation in interpretation of the NST and to assess the influence of computer-assisted analysis on the former, as well as their influence on decision-making in patient management. The absolute endpoint, namely perinatal outcome, was not assessed.

The availability of computer analysis significantly decreased inter-observer variation as far as the suggested management is concerned. Approach to management was more expectant, with 7 probable deliveries prevented. In 5 of these 7 cases routine repetition was recommended. After the computer analysis became available, there was complete agreement on the lack of indications for urgent intervention, no doubt the result of the numerical report of FHR variability together with guidelines supplied about the normality of the various parameters analysed by the computer programme.

It has been suggested that FHR monitoring might lead to increased interventions. Indiscriminate use in pregnancies of 32 weeks’ gestation or less might have serious consequences for neonatal units, especially where access to neonatal intensive care is limited, such as in the developing world. While it is gratifying that the Sonicaid System 8000 decreases inter-observer variation, any new system should be validated before being introduced into a population in which it has not been tested. The typical growth-retarded fetus of the mother with severe pre-eclampsia of early onset often illustrates a non-reactive pattern which is not necessarily a sign of fetal distress, but which could be an indication of fetal adaptation.26

Approximately one-third of the records were thought to have been of longer duration than was necessary for evaluation, meaning that the interpreter was of the opinion that the same clinical decision could have been taken at an earlier stage of the recording. Six (30%) of the 20 recordings used were 60 minutes long. The average duration was 30.39 minutes (median 18 minutes). As the length of recording was determined by the Sonicaid System 8000, this might lead to logistical problems if the new system is applied in the exact way as the old one, i.e. as much as 4 hours or more of recording time per patient per day. The same tendency was noted when all the recordings for the month were considered (mean = 18 minutes).

To classify the duration of the NST as too short is only
High frequency of the median artery of the forearm in South African newborns and infants

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In a sample of 60 neonates and infants from black communities in the Johannesburg area, the median artery of the forearm was found in 50% of individuals (11.7% in one forearm only, 38.3% in both forearms). The frequency per forearm was 44.2%, much higher than that found in any previous study, even among adults from the same community (27.1% per forearm). The artery occurs bilaterally significantly more often than it does in one antimer only. There are no differences in its frequency between sexes or between antimeres. The artery provides an additional route of blood supply to the forearm that should be kept in mind by hand surgeons. It can also be harvested for vascular grafts.


Practitioners tend to regard anatomical structure of the human body as rigidly determined. It seems natural to refer to a standard text in order to learn about a particular anatomical arrangement in a particular patient. Human anatomy is variable from individual to individual and seems to undergo changes between generations.1 Knowledge of variations in the anatomy of organs, muscles, nerves, vessels etc. is useful for diagnosis and in surgical procedures.2

We recently reported4 a 27% frequency of the median artery of the forearm among adult South Africans. Acting as a third route of blood supply to the hand, this vessel may be of importance in cases of hand and wrist injuries requiring surgical repair of arteries. Since it lies in a relatively superficial position in the distal forearm, the artery may also be harvested for vascular grafts.

The large median artery supplying blood to structures in the forearm and the hand was reported by other authors to have an incidence ranging from 2.2%4 to 4.4%6 to 8.3%8 and 20%.6 The very high frequency of the median artery found by us needs to be confirmed by further study of individuals from the same population. This paper reports on the frequency of the median artery in a group of South African neonates and infants.

REFERENCES


Accepted 16 Nov 1993.