Prenatal Foetal Non-invasive ECG instead of Doppler CTG – A Better Alternative?

Introduction

In the last 30 years cardiotocography (CTG) has become the most common method to monitor foetal health during birth [1,2]. The benefits of electronic foetal monitoring are still discussed [3-5]. To solve the problem of high inter- and intra-observer variability [1,6-8], guidelines and computer-assisted analysis pro-
grammes have been developed for the assessment CTG measurements [6–9]. In 2008 a non-invasive abdominal electrocardiogram (ECG) device was licensed for use in clinical practice [10]; however it was initially only licensed for antenatal use [11–13]. Neilson et al. [2] reported on the interference of maternal heart rate signals with foetal heart rate signals. This report together with a recent warning by the FDA (Food and Drug Administration Agency Med Watch) [14] about similar problems with CTG sensors indicates the necessity of improving foetal monitoring systems. A recently licensed non-invasive ECG system which monitors foetal heart rate while simultaneously monitoring maternal heart rate could be useful in this context. This method would allow episodes in which the maternal heart rate is mistaken for the foetal heart rate to be identified.

Alternatively, there are also CTG devices available which are used to monitor twin pregnancies. They give an acoustic warning signal when the heart rates of the twins coincide. It would be theoretically possible to use such a twin CTG device so that maternal and foetal heart rates could be recorded simultaneously, with a warning signal appearing when the heart rates coincide. Other proposals include the use of pulse oximetry or more frequent monitoring of the maternal pulse rate by the midwife as well as more attention to be focused on capturing the “typical” acoustic sounds of the foetal heart.

This study aimed to investigate which monitoring method offers a better foetal signal quality in gestational weeks 20 + 0 to 40 + 0 before carrying out a larger study which will analyse the risk of misidentifying the foetal heart rate.

**Material and Methods**

The Monica AN24™ system is a small, portable, battery-operated, electrophysiological monitoring system which detects foetal and maternal heart rates using abdominal electrodes. In our study, all 70 pregnant women gave their informed consent to participate in the study after receiving detailed (written and oral) information. Placing of the 5 abdominal electrodes of the Monica AN24™ system was done by a physician trained in the use of the Monica AN24™. After positioning the Monica AN24™, the sensors for the CTG (GE Corometrics 250 series) were placed. Sensors and electrodes were positioned with the pregnant woman lying either in a right or a left lateral position. The signal quality was analysed separately for each monitoring method for the time during which the foetal heart rate recorded. Signal quality and pre-pregnancy BMI were calculated.

Evaluation of the foetal ECG was done using the programme Monica DK™ Version 1.7; CTG data was stored using the Trium system.

To directly compare foetal ECG and CTG, simultaneous CTG and ECG recordings from the pregnant women were evaluated. Current heart rates at intervals of 250 ms were used for CTG measurement. ECG used heart rate duration (RR intervals) with a resolution of 3.3 ms.

Data were imported into SPSS, which was used to calculate mean values, standard deviation, Spearman’s rho coefficient, and Wilcoxon signed-rank test. A sub-group analysis of signal quality was done for the following gestational ages: Group 1 = gestational week (GW) 20–26, Group 2 = GW 27–36, Group 3 = GW 37–40. This study only analysed the heart rates calculated using the two methods. In the one method, the ECG potential, or part of it, is the trigger, while the other method is based on heart wall movements which are registered by ultrasound measurement.

**Results**

Overall, ECG signal quality was 77.4%, and signal quality with CTG was 73.1% (p > 0.05; Table 1; Fig. 1). In GW 20–26 the signal quality obtained using ECG was significantly better compared to the signal quality with CTG (75.5 vs. 45.3%, p = 0.003), while in GW 27–36 the signal quality using CTG was better (72.3 vs. 83.0%, p = 0.001). After the 37th GW no difference in signal quality could be detected between the two monitoring methods (87.7 vs. 86.1%, p > 0.05).

The difference in signal quality was not statistically significant in the BMI groups (p > 0.05; Table 2; Fig. 2). However, while the CTG signal quality was found to be significantly correlated with the BMI (r = 0.25, p < 0.05), there was no correlation between ECG signal quality and BMI.

The mean duration of synchronous monitoring using both methods was 197.6 minutes (standard deviation ± 33.2 minutes; range 116–351 minutes).

![Fig. 1 Signal quality correlated with gestational week (GW).](image-url)

**Table 1** Signal quality correlated with gestational week (GW).

<table>
<thead>
<tr>
<th>Signal quality (%)</th>
<th>Total</th>
<th>GW 21–26</th>
<th>GW 27–36</th>
<th>GW ≥ 37</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>70</td>
<td>20</td>
<td>31</td>
<td>19</td>
</tr>
<tr>
<td>ECG</td>
<td>77.4</td>
<td>75.5</td>
<td>72.3</td>
<td>87.7</td>
</tr>
<tr>
<td>ECG SD</td>
<td>23.5</td>
<td>30.2</td>
<td>21.4</td>
<td>15.3</td>
</tr>
<tr>
<td>CTG</td>
<td>73.1</td>
<td>45.3</td>
<td>83.0</td>
<td>86.1</td>
</tr>
<tr>
<td>CTG SD</td>
<td>23.7</td>
<td>24.0</td>
<td>11.5</td>
<td>10.9</td>
</tr>
<tr>
<td>p-value</td>
<td>0.21</td>
<td>0.003</td>
<td>0.001</td>
<td>0.51</td>
</tr>
</tbody>
</table>

SD: standard deviation; *: comparison of ECG vs. CTG (Wilcoxon signed-rank test)

Discussion

This study showed that signal capture of the foetal heart rate was particularly good in GW 20–26. In the vernix period, however, the signal quality was better with CTG. After the vernix period, no difference in signal quality was found between CTG and ECG. ECG signal quality was not correlated with BMI, while a correlation was found between CTG signal quality and BMI. This is particularly important because a distinct increase in maternal BMI was noted in the past few decades [15].

The limitations of this study include the limited numbers of patients and the use of a CTG device from only a single manufacturer. Further studies will be needed to show whether this trend dependent on maternal BMI, while signal capture using the CTG is more difficult in women with a higher BMI.

Ethics Committee Approval

This study was approved by the Ethics Commission of the Medical Faculty of Ruhr University Bochum.

Conflict of Interest

Professor Hayes-Gill is professor at the University of Nottingham and a director of Monica Healthcare Ltd. Monica Healthcare Ltd, United Kingdom, supported this study with 15 000 Euros.

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References

2 Neifond DR, Freeman RK, Mangan S. Signal ambiguity resulting in unexpected outcome with external fetal heart rate monitoring. AJOG 2008; 198: 717–724

Table 2 Signal quality correlated with body mass index (BMI).

<table>
<thead>
<tr>
<th>Signal quality</th>
<th>BMI &lt; 25</th>
<th>BMI ≥ 25, &lt; 30</th>
<th>BMI ≥ 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>20</td>
<td>27</td>
<td>23</td>
</tr>
<tr>
<td>ECG (%)</td>
<td>72.1</td>
<td>82.9</td>
<td>75.6</td>
</tr>
<tr>
<td>ECG SD (%)</td>
<td>29.0</td>
<td>19.0</td>
<td>22.7</td>
</tr>
<tr>
<td>CTG (%)</td>
<td>66.8</td>
<td>72.7</td>
<td>79.0</td>
</tr>
<tr>
<td>CTG SD (%)</td>
<td>22.9</td>
<td>26.0</td>
<td>20.8</td>
</tr>
<tr>
<td>p-value*</td>
<td>0.46</td>
<td>0.20</td>
<td>0.38</td>
</tr>
</tbody>
</table>

SD: standard deviation; : comparison of ECG vs. CTG (Wilcoxon signed-rank test)

Conclusion

The use of non-invasive ECG is particularly indicated in the early weeks of pregnancy when signal capture is more difficult using CTG. In the vernix period, signal capture proved to be better using the CTG. After the vernix period, no difference in signal quality was found between ECG and CTG. ECG signal quality is not dependent on maternal BMI, while signal capture using the CTG is more difficult in women with a higher BMI.


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