A nonpenetrating fetal scalp electrode

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ABSTRACT

Objective To develop a nonpenetrating scalp electrode for intrapartum fetal monitoring.

Design Preliminary observational evaluation of the device.

Setting An urban academic hospital in Johannesburg, South Africa.

Subjects Fifteen women in labour.

Intervention Application of the electrode for intrapartum monitoring.

Outcome measures Quality of tracings, duration of application, disconnection of the electrode, marking of the scalp.

Results Application was successful in 13 of 15 women, and high quality tracings obtained in 12.

Conclusions The design of scalp electrode tested is effective and produces high quality tracings in most cases.

The fetal scalp electrodes currently used to obtain fetal heart rate (FHR) recordings during labour employ single or double curved needles which penetrate the fetal skin to obtain a purchase and electrical contact. There have been reports of neonatal scalp abscesses at a rate varying between 0.3% and 5.4% (Okada & Chow 1977), cerebrospinal fluid leakage (Sorokin et al. 1990), sepsis (Thadepalli et al. 1976) and necrotising fasciitis of the scalp (Siddiqi & Taylor 1982) following the use of such electrodes. Furthermore, though it is not proven that such penetration would necessarily increase the risk of infection of a fetus whose mother is infected with the human immunodeficiency virus (HIV) or serum hepatitis, the avoidance of penetrating scalp electrodes is recommended in these cases (Deepak 1990). As early HIV infection cannot be excluded even with routine screening, the use of penetrating electrodes at all in the presence of increasing rates of HIV infection is questionable.

Subjects and methods

We have designed a nonpenetrating scalp electrode (provisional patent application 91/7479) (Fig. 1). Application to the fetal scalp (or buttock) is maintained by means of suction. The nickel fetal plate of the electrode measures 16 mm in diameter and has multiple perforations to distribute the effect of the suction and maintain optimal electrical contact over its whole surface. Suction tubing is connected to the silicone rubber cover of the fetal plate, and at the distal end to a 20 ml syringe which is held in a simple adaptor to keep the plunger of the syringe in the withdrawn position once the suction has been established.

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Electrode applied

Fig. 2. Recording from an unmodified AMS IM76 cardiotocograph showing the time of application of the electrode and the lag period before detection of a good quality recording.

The syringe acts as a vacuum reservoir to maintain suction over prolonged periods of time. Electrode wires are attached to the scalp plate and to a reference electrode at the back of the device.

The fetus is prepared as for insertion of a conventional scalp electrode. Using sterile technique, the electrode is guided with the fingertips of the examining hand to a convenient position alongside the fetal head. The other hand

Fig. 3. Fetal electrocardiograph (ECG) (top tracing) recorded with a standard AMS IM76 Cardiotocograph using the noninvasive electrode (A) and a standard spiral electrode (B). The ECG record is printed with a different timescale to the fetal heart rate and uterine contraction tracings below.
is used to flush saline previously drawn into the syringe through the system, then to withdraw the plunger of the syringe and lock it in the withdrawn position in the adaptor. Adherence to the scalp is confirmed and the examining fingers withdrawn. The electrode wires are connected to a standard FHR monitor, and the syringe taped to the mother's leg next to the leg plate of the monitor. The electrode has an overall diameter of 20 mm and can be applied to the presenting part from 2 to 3 cm cervical dilatation.

Evaluation of the electrode has been approved by the Committee for Research on Human Subjects of the University of the Witwatersrand. A preliminary prototype has been evaluated in labouring women who gave written informed consent to the procedure. Application of the electrode as described above was attempted in 15 consecutive pregnancies. All problems experienced were recorded, and the FHR tracings were saved and examined later for quality and continuity. The newborn babies were examined after birth and daily thereafter for evidence of scalp trauma.

Table 1. Details of 15 consecutive applications of the nonpenetrating scalp electrode.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>25</td>
<td>21–36</td>
</tr>
<tr>
<td>Parity</td>
<td>1</td>
<td>0–3</td>
</tr>
<tr>
<td>Gestational age (weeks)</td>
<td>40</td>
<td>35–42</td>
</tr>
<tr>
<td>Cervical dilation (cm)</td>
<td>5</td>
<td>3–9</td>
</tr>
<tr>
<td>Duration of tracing (n = 13)</td>
<td>3 h 10 min</td>
<td>47 min to 7 h 22 min</td>
</tr>
</tbody>
</table>

Results

Of the 15 consecutive application attempts, 13 were successful. The two unsuccessful attempts were due to a blocked suction tube following repeated resterilisation and reuse of the electrode in one instance, and in the other to failure to position the electrode correctly in an excessively anxious woman who was unable to cooperate during vaginal examination. Of the 13 successful applications, the quality of FHR tracing in 12 was considered good (continuous recording with minimal interference as shown in Fig. 2). In one woman the quality of tracing was poor. Good quality tracings were obtained even when the electrode was applied over thick negroid hair, which was present in most of the babies studied, in the presence of vernix caseosa, and in the one application to the buttock in a breech presentation. In 9 applications the tracing started immediately after application. In the remaining four, there was a lag period ranging from 2 to 20 min before the tracing commenced. We have subsequently changed to a more finely apertured stainless steel mesh electrode plate which appears to have eliminated the problem of a lag phase. In one instance the electrode was disconnected during a vaginal examination. In two cases it was detached 10 min in one and 1 min before delivery in the other; in the remaining 10 cases the electrode remained in place until delivery.

Transient redness of the fetal scalp was noted in six babies and in two babies fine vesicles were noticed which disappeared within 2 to 3 days. This problem appears to be avoidable by using less suction pressure.

Successful tracings have been obtained with unmodified Corometrics 115 (Wallingford, USA), Advanced Medical Systems (AMS) IM76 (Connecticut, USA) and Hewlett Packard 8040A (Boeblingen, Germany) FHR monitors.

In this study the quality of FHR tracings was evaluated. The quality of fetal electrocardiograph (ECG) configuration was not systematically studied. However, representative examples of the ECG waveforms recorded with a standard AMS IM76 cardiotocograph monitor are shown (Fig. 3).

Discussion

To avoid fetal scalp penetration, use of a fetal scalp electrode placed within the uterus but not attached to the fetus has recently been reported (Randall et al. 1988; Strong et al. 1991). This has required additional processing of the electrical signal to filter out the maternal ECG, and the signal detection has been reported to be inconsistent.

Other methods of obtaining a FHR signal are by means of maternal abdominal ECG leads, which has proved technically difficult, and Doppler ultrasound detection of fetal heart movement. The latter is widely used but has certain disadvantages, such as the need to maintain accurate positioning of the abdominal probe, the discomfort of the belt, restriction of movement, less reliable indication of short term FHR variability, exposure of the fetus to ultrasound, susceptibility of the probe to damage and sometimes poor record quality. Thus there remains a need in certain pregnancies for direct ECG monitoring of the fetal heart rate during labour. Analysis of the fetal ECG configuration is also dependent upon signal detection by fetal scalp electrodes (Westgate et al. 1990; Greene 1987).

The complications seen with conventional scalp electrodes and the potential risks that can be anticipated from disruption of the fetal skin integrity are a matter of concern. In view of the promising results obtained with the prototype described in this report, further testing of a revised version of our electrode is in progress.

Conclusion

We report a simple design of fetal scalp electrode which shows promise as a means of providing high quality FHR recordings without the risks of scalp penetration.
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References


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