ATRAUMATIC ELECTRODES FOR CARDIAC MONITORING

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ABSTRACT

An atraumatic electrode specially designed for cardiac monitoring on neonates is described. The electrode is a single use, throw-away device consisting of a polyethylene band 4 inches long, 3/4 inch wide and 1.5 mil thick, to which is cemented a folded paper electrode and the insulator of a lead wire assembly. It is applied to the limb in bracelet fashion. A small quantity of saline or water introduced under the plastic film activates the electrode. Sets of 3, sometimes 4 electrodes were tested on 26 babies in a pilot study. Good quality signals were routinely obtained. An average time between application of saline of over 10 hours was found. The main advantages of the electrode are: (1) ease of application, (2) infrequent replacement, and (3) reliable almost noise-free signal collection.

INTRODUCTION

Cardiac monitoring is the most frequently employed form of patient surveillance. Used in hospital O.R.'s, I.C.U.'s and post-operative recovery rooms, the technique differs from the familiar clinical studies known as cardiography and vectorcardiography. The difference is mainly a matter of duration. While clinical studies require an exacting procedure to position and affix in a standardized fashion to a patient's body a set of four and sometimes five electrodes, rarely more than 15 minutes is required to record the series of waveforms corresponding to each lead position. Analysis of the recorded results is usually performed after the completion of the study. In contrast cardiac monitoring serves a more vital function: It registers the gross activity of the heart in a patient judged likely to experience cardiac distress. In this sense, it is an "on-line" measurement, the duration of which may be hours, if not days and sometimes even weeks.

This paper describes an atraumatic electrode specially designed for cardiac monitoring on neonates, although there is no reason why the electrodes may not be used for all cardiac monitoring. The electrode is easy to apply, can be regenerated in situ, requires infrequent replacement and, when properly applied, collects reliable, almost noise-free signals continuously and without undue attention. Materials no more hostile than a band of polyethylene film and dampened filter paper contact the skin. Since no adhesive is needed to hold the electrode in place, skin damage is virtually eliminated.

CONSTRUCTION

The electrode consists of two parts: A limb-band and a lead-wire assembly. A single use throw-away device, its appearance around the arm of a 3 kg neonate is illustrated in Fig. 1.

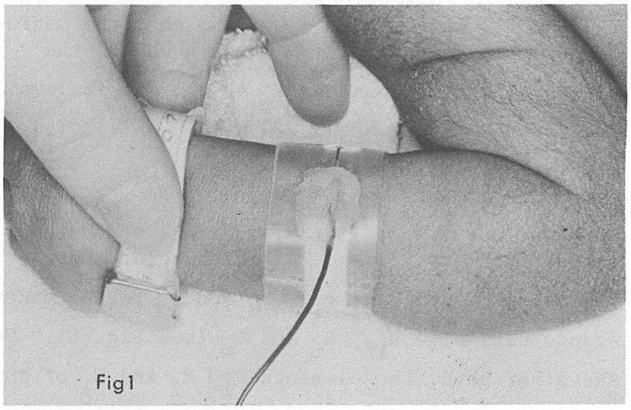

Fig 1

1) Limb-Band

A drawing in perspective of the limb-band is presented in Fig. 2. The limb-band is constructed on a strip (A) of polyethylene 3/4" wide, 4" long and 1.5 mil thick. Adhesive is applied at one end (B) and a pull-tab (C) is placed over the exposed adhesive to render it non-adhesive until needed. Filter paper is cut into strips one inch wide and folded along its length into halves and then into thirds. Rubber cement is used to attach the folded filter paper (D) along the center of the plastic film and on the same side as the pull-tab.

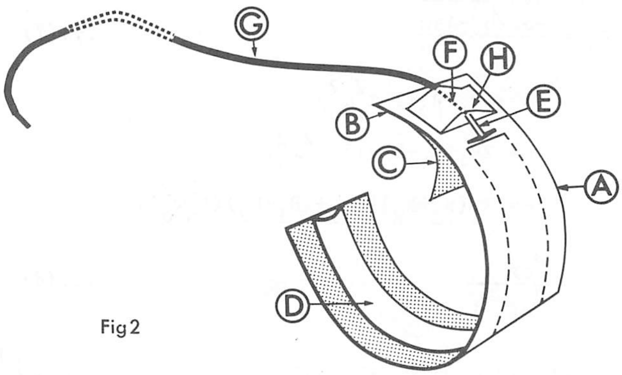

Fig 2

2) Lead-Wire

The lead-wire assembly consists of a short length of chlorided silver wire (E), (0.015 inch diameter) which extends 7/10" into the folds of the filter paper and is connected by means of a crimp connector (F) to a light, flexible, insulated lead-wire (G). Insulation at the junction of the silver and copper wires is provided by a molded plastic fitting (H) having a flat surface for cementing to the band. Strain relief is provided by this fitting.

APPLICATION

The limb-band is firmly but not tightly wound around the patient's limb starting with the filter paper end and in such a way that the filter paper is in contact with the skin. To prevent the electrode from unwinding, the peel-away film is removed by pulling the tab and the exposed adhesive strip is applied to the limb-band. (Fig. 2). The strip must not adhere to the patient's skin, else one advantage of this electrode will be lost. A small quantity of normal saline introduced under the plastic film moistens the filter paper and activates the electrode. The saline serves as the conducting medium between the skin and the chlorided silverwire. Notice the plastic film forms both an insulating substrate for the filter paper and a barrier against evaporation of the water-electrolyte.

EXPERIMENTAL PROCEDURE

Sets of three, and sometimes four, electrodes were tested on 26 babies in a pilot study. To gauge the performance of these electrodes, the following observations were made. First, the quality of the signal monitored was recorded at various times after the electrodes were applied and second, the frequency of application of saline in order to regenerate the electrode-electrolyte-skin contact was noted. Good quality signals after long-term monitoring and infrequent regeneration with saline are the two most desirable performance factors for electrodes used in prolonged patient surveillance.

RESULTS

Good quality signals were routinely obtained. Two tracings, one 8 hours, the other 36 hours after saline had been applied illustrate the signal quality. (Fig. 3). The obvious low-frequency component in the latter is induced by respiration. Neonates are rarely motionless when they are awake. The immunity to noise of these electrodes is demonstrated in Fig. 4.

When the child is motionless the tracing is virtually free of noise, when it moves vigorously the noise seen in the tracing is due to muscle and electrode-electrolyte potentials. Even in the latter the immunity to motion induced noise of our electrodes is so great that there is adequate signal amplitude above the noise for a good rate-meter to register the heart rate and thereby provide good cardiac monitoring.

In the pilot study, we logged 1944 hours of monitoring and during this time 192 applications of saline were recorded. These figures indicate that the average time between applications of saline is over 10 hours.

DISCUSSION

The results of our pilot study verify the advantages of the new limb-band electrode. Skin damage due to irritation from electrode paste has been eliminated. The substituting saline solution is not only physiological but penetrates the horny layer of the skin so that surface preparation is unnecessary. For the first few minutes after the application of saline, the quality of the signal improves markedly due to the penetration of the saline into the skin.

In spite of the action of the vapour barrier, the length of the time-interval between applications of saline depends on the environmental humidity. If the infant is in an isolette in which the air is moisturized, the need to regenerate the electrode with saline is greatly reduced. Precisely these conditions allowed one infant to be monitored for five days without a single addition of saline-electrolyte.

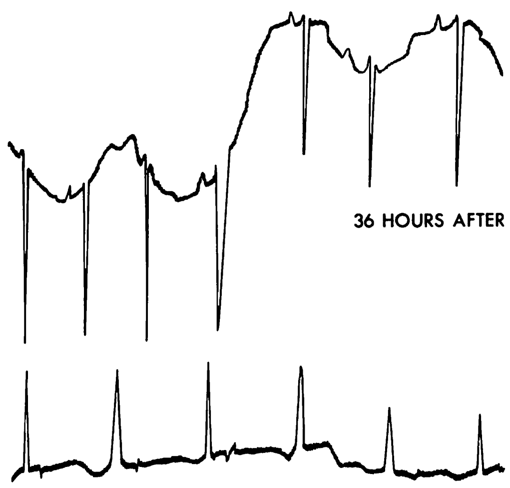

Fig3

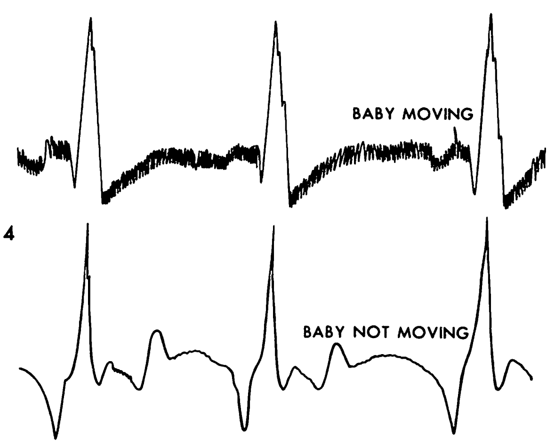

Fig 4

CONCLUSIONS

In conclusion, our limb-band electrode is easy to apply, can be regenerated in situ, requires infrequent replacement and, when properly applied, collects reliable, almost noise-free signals continuously and without undue attention.

Materials no more hostile than a band of polyethylene film and dampened filter paper contact the skin. Since no adhesive is needed to hold the electrode in place, skin damage is virtually eliminated and electrode jelly is also unnecessary. These atraumatic electrodes have permitted us to simplify the clinical aspects of long-term cardiac monitoring.