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Detection of predefecatory rectosigmoid wave activity for prevention of fecal soiling in infants

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1. ABSTRACT

Identification of an electrophysiologic sign before defecation can prevent fecal soiling in infants. To identify such a sign, the contractile activity of sigmoid colon was recorded percutaneously in 48 healthy infants. The recorder was equipped with a digital clock synchronized to the recorder so as to set off an alarm upon significantly increased electromyographic activity of sigmoid colon. Examination of the recordings at high speed revealed three types of basal, signaling and predefecatory waves of activities. The 'basal' component was comprised of as negatively deflected slow waves. The signaling waves exhibited an increase in amplitudes, cycle rate and conduction velocity, were repeated 8.2±1.2 times and lasted for 14.6±2.1 minues prior to defecation, The 'predefecatory' waves preceded defecation by 40.3±7.3 seconds, showed a significant increase in wave parameters and sounded the alarm. The findings show a method for early detection of defecation that can be used clinically to prevent fecal soiling in infants.

2. INTRODUCTION

Defecation is an intricate mechanism which is controlled by voluntary and reflex responses in adults (1-4). In newborns and infants, up to the age of four , however, defecation is uncontrollable (5). Stool reaches sigmoid colon by means of a mass colonic contraction (6). Initially, the sigmoid colon distends upon receiving the stool, but then adapts and returns to its original shape. The sigmoid colon continues receiving the stool from colon until colonic expansion leads to a sigmoido-rectal junction reflex (7). This reflex is comprised of contaction of sigmoid colon, relaxation of rectosigmoid junction and movement of fecal mass in sigmoid colon through the rectosigmoid junction to the rectum. Rectal distension, induced by the fecal mass, evokes the recto-anal inhibitory reflex leading to rectal contraction, relaxation of internal anal sphincters causing defecation of the fecal mass (8). Since in infants up to the age of 4, there is no control over defection, detection of any physiologic signal preceding defecation can help to prevent fecal soiling. To identify such a signal, in this

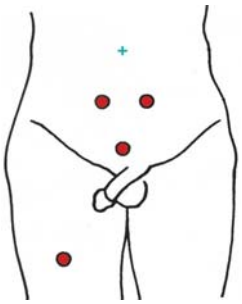

Figure 1. Diagram illustrating the sites of the transcutaneous electrodes. Location of umbilicus is marked by plus sign and locations of the electrodes are shown as circles. The circle on the right limb shows the location of the reference electrode.

Figure 2. Transcutaneous electrosigmoidography showing regular and similar basal slow waves from the 3 electrodes.

communication, we report of percutaneous recordings of the contractile activity of sigmoid colon in infants that established a warning mechanism for early detection of defecation responses.

3. MATERIAL and METHODS

3.1. Subjects

The study was comprised of 48 infants with a mean age of 10.7±3.2 SD months (range 6-17); 26 were males and 22 were females. Infants had no anorectal or gastrointestinal disorders and were defecating without control. All infants were breast-fed. Physical examination was unremarkable. Blood count and renal and hepatic function test results were normal. An informed consent approved by the Cairo University Faculty of Medicine and Ethics Committee was obtained from the father of each infant prior to study.

3.2. Ambulatory transcutaneous electrosigmoidography

Ambulatory sigmoid colon electromyography was recorded transcutaneously. The bowel was evacuated by normal saline enema. The sites for applying the electrodes for recording the electrophysiologic of sigmoid colon was selected based on published criteria (9). Briefly, one electrode (Smith Kline-Beckman, Los Angeles, CA) was applied 1-1.5 cm from each side of the mid-line drawn from the umbilicus to the symphysis pubis (Figure 1). A third electrode was placed just above the symphysis pubis and a reference electrode was applied to one of the lower limbs. To exclude artifacts introduced by respiration, a strain gauge respiratory transducer was attached to the thoracic wall. Long-term EMG recording using Holter monitoring (10-12) was applied for three continuous days in each infant.

The electrophysiologic activity of sigmoid colon was continuously recorded on tape. The tape recorder was a battery-powered miniaturized device with a very slow tape speed (10,11); it was suspended by a strap over the shoulder or around the waist. The recorder was equipped with a digital clock, synchronized to the recorder, so as to sound the alarm upon significant increase of amplitude and frequency of sigmoid colon EMG. The mother was instructed to keep a day-to-day account of the times of defecation, any symptoms occurring during the recording period and the time at which they had occurred, and of the infant's activities. During the whole test period, special attention was paid to the proper placing of the electrodes in their defined site on the abdominal wall. At the end of the 3 days recording period, the readings were analyzsed by scanning the tape on an oscilloscope at 120 times the real time (12).

4. RESULTS

No adverse side effects were encountered during or after the three days of recordings. All infants completed the study and were evaluated. During the ambulatory recording period, 3 types of waves were recorded: basal, signaling and predefecatory.

4.1. The basal waves

Slow waves were recorded from the 3 electrodes applied transcutaneously. The waves had a mean of 4.2±1.1 cycle/minute (range 3.6-5.3), amplitude of 0.53±0.06 mV (range 0.41-0.68), and conduction velocity of 4.8±0.9 cm/s (range 3.6-5.9) (Figure 2). The slow waves from each of the three electrodes exhibited the same frequency, amplitude, and conduction velocity in each infant. These parameters were constant, reproducible and identical in all infants (Figure 2). Bursts of action potentials were not recorded in any of the studied subjects.

4.2. The signaling waves

During the ambulatory recording period of 72 hours, the basal slow waves showed an increase in wave parameters. They recorded a mean frequency of 8.4±1.8 cycle/min (range 6.3-9.8), an amplitude of 0.93±0.06 mV (range 0.6-1.1), and a conduction velocity of 6.4±1.4 cm/s (range 5.2-8.7, Figure 3). These episodes of increase of the wave parameters were not associated with defecation. They occurred randomly and lasted for 6 to 8 seconds (mean 7.2±0.8) each time. They preceded the predefecatory waves by 10 - 17 minutes (mean 14.6±2.1) and were repeated 6 - 10 times (mean 8.2±1.2). Each subsequent burst of signaling waves exhibited an increase in wave parameters as compared to the previous waves.

4.3. The predefecatory waves

These waves were registered 32-48 seconds (mean 40.3±7.3) before the infant started defecating. They were morphologically similar to the basal waves but they exhibited significantly higher wave parameters. The wave

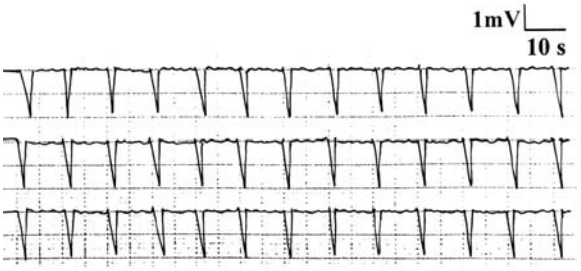

Figure 3. Transcutaneous electrosigmoidography showing the signaling waves**.** These waves are similar to the basal waves but have higher wave amplitude**.**

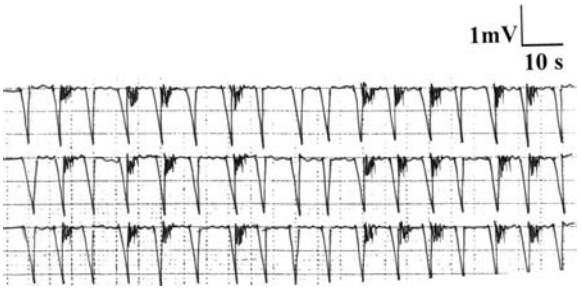

Figure 4. Transcutaneous electrosigmoidography showing the predefecatory waves. These waves have higher wave parameters compared to the basal and signaling waves. Also fast activity spikes or action potentials followed, or were superimposed over, the slow waves.

frequency recorded a mean of 10**.**3±2**.**1 cycle/min (p<0**.**05**,** range 8**.**3-12**.**6)**,** the amplitude 1**.**6±0**.**08 mV (p<0**.**05**,** range 1**.**2-2**.**1)**,** and the conduction velocity 9**.**8±1**.**2 cm/s (p<0**.**05**;** range 8**.**4-11**.**2**;** Figure 4)**.** Bursts of fast activity spikes or action potentials were recorded and followed, or were superimposed over, the slow waves (Figure 4)**.** They occurred randomly and did not accompany each slow wave**,** yet had a similar pattern and distribution from the 3 recording electrodes of an individual infant**.**

During the 72 hour recording**,** each predefecatory episode was associated with a significant increase of the slow wave parameters which after defecation returned to the basal values**.** The wave parameters recorded after defecation were similar to those before defecation with no significant difference**.** The significant increase of the wave parameters which occurred in 2-3 bouts of wave activity, led to an audible alarm and was followed by defecation 9-14 sec (range 12**.**3±1**.**2) after the last bout**.** There was no false positivity as each alarm predictably was followed by defecation.

5. DISCUSSION

The sigmoid colon receives the stool from the colon by mass contraction (6)**.** The new content distends sigmoid colon and gradually accumulates until it is expelled to the rectum. In infants, defecation is uncontrollable until the age of four years (5)**.** During this period, fecal soiling might occur despite the use of modified underpants that are designed to minimize the soiling of the perineal skin.

The three types of waves registered during the period of recording**:** basal**,** signaling**,** and predefecatory represent different stages of myoelectric activity**.** These waves are inconsistent with the peristaltic activity of the small bowel and do not originate from abdominal wall musculature since striated muscles**,** unlike the smooth muscle, exhibit no resting electric activity**.** These activities are not respiratory artifacts since application of a respiratory transducer to the chest wall does not record similar wave activity**,** while cardiac waves are identified by their shape and wave characteristics**.** These data as well as the reproducibility of the waves during the 3 days-recording period seem to indicate that the recorded waves originate from sigmoid colon and do not constitute artifacts**.** The basal waves represent myoelectric activity of sigmoid colon at rest**.** The signaling waves are likely due to distention of sigmoid colon. The increase in this activity, then, precedes defecation. We utilized such an increased in activity to cause an audible alarm, 40 seconds prior to defecation. This warning can be used clinically to prevent fecal soiling.

6. ACKNOWLEDGMENT

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