[Frontiers in Bioscience 1, b1-4, July 1, 1996]

TRANSCUTANEOUS ELECTROSIGMOIDOGRAPHY. STUDY OF THE MYOELECTRIC ACTIVITY OF SIGMOID COLON BY SURFACE ELECTRODES.

Ahmed Shafik, MD, PhD

Department of Surgery and Experimental Research, Faculty of Medicine, Cairo University, Cairo, Egypt.

ABSTRACT

The purpose of this study was to determine the feasibilty of performing transcutaneous electrosigmoidography (TC-ESG). The study involved 19 healthy volunteers (11 men, 8 women; mean age 38.2 ± 14.8 years). To validate the results of TC-ESG, the latter was performed simultaneously with intrasigmoid ESG. TC-ESG was done also in five patients who underwent sigmoidectomy.

The optimal position of the electrodes was determined after several trials. Two electrodes (Beckman) were applied, each 2-3 cm away from the middle of a line drawn from the umbilicus to the symphysis pubis. A third electrode was placed just above the symphysis pubis. A reference electrode was applied to one of the lower limbs. For intra-sigmoid IS-ESG, two silver-silver chloride electrodes were introduced from the anal orifice into the sigmoid colon and were attached to the mucosa by suction.

Pacesetter potentials (PPs) were recorded as regular negative deflections. They had constant amplitude, frequency and velocity when recordings were obtained in the same subject. The PPs registered transcutaneously had the same amplitude, frequency and velocity as those recorded intrasigmoidally. Action potentials could be registered only intrasigmoidally and not transcutaneously. No electric waves could be recorded by TC-ESG in 5 patients who had undergone sigmoidectomy.

In conclusion, TC-ESG is a simple, non-invasive and non-radiologic technique that can substitute intra-sigmoid ESG and potentially can be used in the diagnosis of various pathologic conditions of sigmoid colon.

INTRODUCTION

Electric activity has been recorded from the gut in the form of slow waves or pacesetter potentials (PPs) in normal subjects and patients with various pathologies of the bowel (1-13). The PPs in normal subjects were regular and consistent when repeated in the same individual (1-11). They were followed randomly by spikes of action potentials (APs) which were inconsistent and which were associated with elevation of rectal pressure (10, 11).Various pathologies of the bowel have been associated with electrorectographic irregularities (12, 13).

Electric activity has also been recorded from the sigmoid colon as PPs and Aps (14). Specific patterns of electrosigmoidogram (ESG) were recorded for the sigmiod colon (14). ESG was performed using silver-silver chloride electrodes attached by suction to the mucosa of sigmoid colon. The electrodes were introduced through a left-sided colostomy (14). As this method of ESG is not suitable for the conventional use, in this study we examined the feasibility of performing the ESG transcutaneously, making it more convenient and acceptable to the patient.

MATERIAL AND METHODS

Subjects: 19 healthy subjects volunteered for the study after giving an informed written consent. Eleven individuals were men and eight were women. The mean age of the subjects was 38.2 ± 14.8 SD years (range 21-54). The subjects had no gastrointestinal complaint in the past or at the time of procedure. Physical examination, including neurologic assessment, was normal. Colonoscopy and barium enema studies were also normal. To validate the results, TC-ESG was performed simultaneously with the intrasigmoid ESG. TC-ESG was also done in five patients in whom sigmoidectomy had been carried out for sigmoid cancer 6 to 18 months earlier. Three patients were men and two were women with a mean age of 41.2 ± 12.8 years (range 23-58).

Technique of transcutaneous electrosigmoidography.

Before the procedure, each subject was instructed to urinate to empty the bladder. After fasting for 12 hours, the bowel of each subject was evacuated by defecation or enema.To exclude the possibility of the impact of the enema on the electromechanical activity of the bowel, recordings were obtained two hours later.

Each subject was placed in the supine position. The site of electrodes was prepared by shaving

Received 05/21/96; Accepted 06/12/96

[1] To whom correspondence should be addressed, at 2 Talaat Harb Street, Cairo, Egypt. Tel/Fax #: +20-2-349 8851

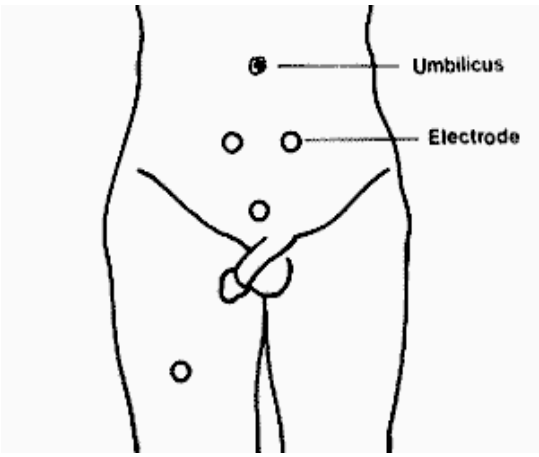

Fig. 1: The optimal position of the electrodes for recording transcutaneous ESG.

of the skin. The Beckman silver-silver chloride electrodes (Smith Kline-Beckman, Los Angeles, California, USA) were used. The optimal position of the electrodes was determined by placing the leads at several sites overlying the sigmoid colon (Fig. 1).

Studying the barium enema films helped us to define the location of the sigmoid colon and to select the proper transcutaneous position of the electrodes. One electrode was applied 2-3 cm from each side of the middleof a line drawn from the umbilicus to the symphysis pubis. A third electrode was placed just above the symphysis pubis and a reference electrode was applied to one of the lower limbs. These positions were determined as representing the ascending and descending limbs of the sigmoid after having studied the sigmoid colon and its surface anatomy in the barium enema. The third electrode above the symphysis pubis overlies the sigmoid termination. The most marked, regular and reproducible signals were selected for further analysis. In order to exclude artifacts introduced by respiration, a strain gauge respiration transducer was attached to the thoracic wall. The signals were recorded on paper (Van Gogh EP-8b, Disa, Copenhagen) and stored on magnetic tape (Recall Store 14, Disa, Copenhagen). High and low pass filters (6 decibel/octave) were set at 0.01 and 0.5 Hz, respectively. At least two 30-minute recording sessions were performed for each subject.

Intra-sigmoid electrosigmoidography.

To validate our transcutaneous electrosigmoidographic findings, intra-sigmoid ESG was performed synchronously with the TC-ESG in all 19 individuals. The intra-sigmoid ESG has been described (14). Briefly, with the bowel and urinary bladder empty, the myoelectric activity of the sigmoid colon was recorded by means of 2 silver-silver chloride electrodes. Each electrode was 0.25 mm in diameter and was situated 1 cm from the tip of a 10 F tube. A length of 25-30 cm of the tube was introduced into the sigmoid colon and was attached to the sigmoid mucosa by suction with a negative pressure of 30 mmHg. The 2 electrodes were placed 5 cm distant from each other and their positions in the sigmoid colon were confirmed by fluoroscopy. The reference electrode was a metal disk applied to the skin of the abdomen. The signals detected by the electrodes were amplified using an AC amplifier with a frequency response within ± 3 dB from 0.016 Hz to 1kHz, and were displayed on a recorder at a sensitivity of 1 mV/cm.

Statistics: The results were analysed statistically using the Student's t-test for the intragroup comparisons and analysis of variance (ANOVA) for comparison between the 2 groups. Values were given as mean ± standard deviation (SD).

RESULTS

No complications were encountered during the study and the recordings could be obtained from all the subjects. To determine the optimal location of the electrodes, many sites had to be tested. At some of these sites, no electrosigmoidographic signals were obtained over long periods of time. The electrodes were moved to new sites until continuous, marked and reproducible electrosigmoidographic signals were recorded. Finding the appropriate location for the electrodes was facilitated by studying the position of the sigmoid colon in the barium enema films.

The ESG showed pacesetter potentials (PPs). The PPs were slow waves, monophasic and consisted of negative deflections (Fig. 2).The frequency, amplitude and velocity of conduction of thePPs are shown in Table 1.These parameters were constant when the examination was repeated in the same subject ($p > 0.05$) during the recording sessions which were performed for each of the 19 healthy volunteers and the 5 patients who had undergone sigmoidectomy. In none of the subjects the APs could be recorded. It might be that these APs can be re-

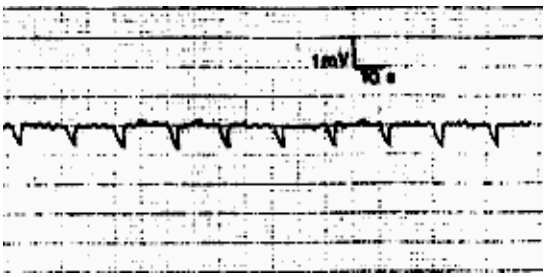

Fig. 2: Transcutaneous ESG showing PPs. APs are not shown.

Table 1: Frequency, amplitude and velocity of conduction of the pacesetter potentials of transcutaneous electrosigmoidograms in 19 subjects.

	Frequency (cyc/min)	Amplitude (mV)	Velocity (cyc/sec)
Mean (± SD)	3.2 ± 1.1	0.8 ± 0.3	3.8 ± 0.9
Range	2 - 5	0.5 - 1.2	2.5 - 5

corded only when the electrodes are applied directly to the sigmoid wall. The intervening abdominal wall and the inconsistency and low amplitude of the APs seem to impede their recording transcutaneously.

The intra-sigmoid ESG recorded synchronously with the TC-ESG showed that the PPs of the TC-ESG had the same frequency, amplitude and velocity of conduction as those recorded by intra-sigmoid ESG without showing a significant difference ($p > 0.05$, Fig. 3). The only difference is that the intra-sigmoid ESG revealed APs which were not recorded by the TC-ESG. The APs were fast activityspikes; they occurred randomly and were inconsistent when the test was repeated in the same subject. They were displayed as negative deflections of a smaller amplitude than the PPs (Fig. 3).

Despite repeated attempts to obtain PPs by changing the position of the electrodes, no electric activity was recorded in the 5 patients whose sigmoid colons were removed (Fig. 4). The evidence that the PPs of TC-ESG are derived from the sigmoid colon is: a. the synchronicity and similarity of the transcutaneous to the intra-sigmoid waves, and b. that no waves could be recorded from the sigmoidectomy patients. This evidence also rules out the possibility

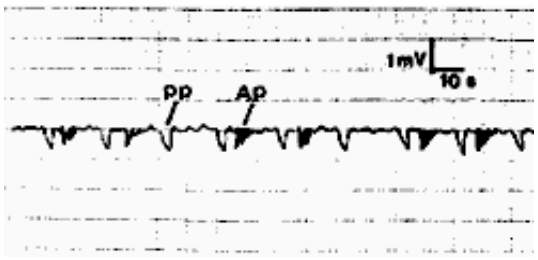

Fig. 3: Intra-sigmoid ESG of the same subject as in Fig. 2 showing PPs as well as APs. The frequency, amplitude and velocity of conduction of the PPs are identical to those recorded by transcutaneous ESG.

that these waves arise from the small bowel. It may be argued that these waves represent artifacts. However, the consistency and reproducibility of the waves are against this argument. The ESG could be easily differentiated from the electrocardiographic waves (EKG). The possibility of respiratory artifacts were excluded by recording respiratory electric activity via placement of a transducer attached to the chest wall. It may be presumed, that these waves arise from the colon, small bowel or rectum. However, the synchronicity and similarity of the TC-ESG to the intra-sigmoid one negates such a possibility. Furthermore, a recent study has demonstrated that the electric waves from the rectum could not be recorded from the abdomen; they were registered from the lower part of the back over the sacrum (14). The origin of the electric waves in the sigmoid colon is not known. It could be myogenic or neurogenic in nature. Some investigators provide evidence that the electric activity of the colon and stomach arises from the muscle of the organ (15, 16).

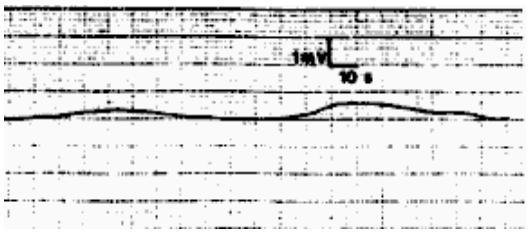

Fig. 4: Silent ESG in a patient who had undergone sigmoidectomy.

Various pathologies of sigmoid colon may disturb the electric activity of this part of bowel. Thus, TC-ESG may be a simple, non-invasive procedure that potentially can be used in the differential diagnosis of such conditions. The recording of the TC-ESG in colonic abnormalities such as cancer, diverticulitis, and ulcerative colitis should provide us with an insight whether TC-ESG may be useful in their diagnosis.

ACKNOWLEDGMENTS

The secretarial assistance of Waltraut Reichelt and Margot Yehia is greatly appreciated.

REFERENCES

1. J. Berkson, E.J. Baldes, W.C. Alvarez: Electromyographic studies of gastrointestinal tract. *Am J Physiol* 102, 683-92 (1932)

2. J. Berkson: Electromyographic studies of the gastrointestinal tract. *Am J Physiol* 104, 67-72 (1933)

3. H. Geldof, E.J. Van der Schee, M. Van Blankenstein, J.L. Grashuis: Electrogastrographic study of gastric myoelectrical activity in patients with unexplained nausea and vomiting. *Gut* 27, 799-808 (1986)

4. J.C. Schang, G. Devroede: Fasting and postprandial myoelectric spiking in the human sigmoid colon. *Gastroenterology* 85, 1048-53 (1983)

5. M. Dapoigny, J.F. Trolese, G. Bommerlae, R. Tournut: Myoelectric spiking activity of right colon,

left colon and rectosigmoid of healthy humans. *Dig Dis Sci* 33, 1007-12 (1988)

6. J. Frexinos, L. Bueno, J. Fuiramonti: Diurnal changes in myoelectric spiking activity of the human colon. *Gastroenterology* 88, 1104-10 (1985)

7. P. Kelin, A. Zinsmeister, S. Phillips: Motor response to food of the ileum, proximal colon and distal colon of healthy humans. *Gastroenterology* 84, 762-70 (1983)

8. D. Garcia, G. Hita, B. Mompean, A. Hernandez, E. Pellicer, G. Morales, P. Parilla: Colonic motility: Electric and manometric description of mass movement. *Dis Colon Rectum* 34, 577-84 (1991)

9. G. Bassotti, A. Morelli, W.E. Whitehead: Abnormal rectosigmoid myoelectric response to eating in patients with severe idiopathic constipation (slow transit type). *Dis Colon Rectum* 35, 753-6 (1992)

10. A. Shafik: Study of the electrical and mechanical activity of the rectum. Experimental study. *Eur Surg Res* 26, 87-93 (1994)

11. A. Shafik: Study of the electromechanical activity of the rectum. II-Human study. *Coloproctology* 15, 215-7 (1993)

12. A. Shafik: Electrorectography in chronic proctitis. *World J Surg*, 17, 675-9 (1993)

13. A. Shafik: Electrorectogram in chronic constipation, ulcerative proctitis, Hirschsprung's disease and neurogenic rectum. *Dis Colon Rectum* (1994), 37, 29 (abstr.)

14. A. Shafik, A. Nour, A. Abdel Fattah: Transcutaneous electrorectography: human electrorectogram from surface electrodes. *Digestion* 56, 479-82 (1995)

15. D. Couturier, C. Roze, M.H. Couturier-Turpin, C. Debray: Electromyography of the colon in situ. An experimental study in man and in the rabbit. *Gastroenterology* 56, 317-22 (1969)

16. D. Couturier, C. Roze, J. Paolaggi, C. Debray: Electric activity of the normal human stomach. A comparative study of recordings obtained from the serosal and mucosal sides. *Dig Dis* 17, 969-75 (1972)