

Application of a New Electrical Impedance Tomography System in Studying Gastric Emptying Rates of Severely Malnourished Children Under Diarrhoeal and Non-Diarrhoeal Conditions

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Introduction

In the initial phase of nutritional rehabilitation a reaction phase exists when the children suffers from diarrhoea.¹ An Electrical Impedance Tomography (EIT) system from Sheffield is available at the Biomedical physics laboratory of the University of Dhaka, which was used for the present investigation on children with malnutrition at the shishu (Children) hospital, Dhaka. EIT system is a very recently developed technique which gives a two dimensional image of the distribution of electrical impedance within the region concerned.² Since different body tissues have different electrical impedances this can be used to obtain in vivo images of the human body.³ Images can be obtained only after impedance changes due to physiological reasons have taken place after a reference data set is taken.⁴ This was developed by a group at sheffield U. K. and is

suitable for dynamic studies and has successfully been used to study gastric emptying and lung ventilation in human subjects.⁵ In nutritional rehabilitation of seriously malnourished children, it is usual that the subjects develop diarrhoea in the initial stage. This diarrhoea is non-pathogenic and the condition improves in a few days time without any specific treatment⁶. The purpose of the present study was to use this new EIT technique, which is completely non-invasive, for investigation of stomach emptying rates in children with malnutrition in two regimes : one when they are maintained on a high calorie diet which induces a diarrhoea and the second : when they are maintained on a low calorie diet and they do not have diarrhoea.

Materials and Methods

In the EIT technique, 16 electrodes are attached around the body segment to be imaged and high frequency current

(at 50 KHz) is driven through adjacent pairs of electrodes sequentially. Potential differences between all other adjacent pairs of electrodes are measured corresponding to each drive pair configuration and the values are stored in computer memory. These potentials contain information regarding the electrical impedance distribution within the body segment. The computer analyses all the collected data and reconstructs a two dimensional image of a slice in the electrode plane similar to that in a CAT scan. Since different body tissues have different electrical impedances this image essentially shows out the tissue distribution. For gastric emptying studies, the electrodes are fixed around the thorax at the stomach level (about the level of the lowest rib). The data can be stored in discs for analysis later.

However, as mentioned before, the present technology only shows up changes in impedance distribution with respect to a reference data set, and the image is essentially a differential one. For gastric emptying studies, this differential imaging is particularly suited since it shows up only the area where changes have occurred. Food which has enough water content decreases the overall electrical resistivity of the stomach and this value gradually increases when food is emptied out. A quantitative

assessment of this emptying rate can be obtained by the sum of the numerical values of electrical resistivity of the elements (pixels) within the region of interest of the displayed tomographic image.²

Three severely malnourished children of age between 7 and 10 were chosen for this study. This age group was taken for better co-operation and convenience of study. All the patients had heights and weights below 3rd centile of the standard height and weight (50th centile of the NCHS standard). There was no oedema. On admission, none had diarrhoea or any such complaints during the previous two weeks. The patients were given a high calorie fortified diet (150 Kcal/kg/day) when they developed diarrhoea. No pus cell was found in the stool and no pathogen could be isolated. During this regime, EIT recordings (frames) were made every five minutes for a period of about 45 minutes after the subjects had a meal of a local preparation of rice and lentil (with enough water content). This data gave the necessary gastric emptying rate under diarrhoeal condition. Later, the subjects were given a diet with lower calorie (110 Kcal/kg/day) within the next five days, the diarrhoea stopped. Their stomach emptying rate was again studied at this point after the subjects had a similar meal of rice and lentil as

used before, and the results were then compared to find out any similarity or difference, if present. In one case the emptying rate was also measured before the occurrence of the diarrhoea, just after admission to the hospital.

Results

In the tomographic image the stomach appeared as an area of changed resistivity between the measurement sets (called frames in this work) and as shown in the image in fig 1. As the emptying process continues, the value of the resistivity in this area

increases, and the magnitude of this increase was found out from the display using a software facility known as the region of interest analysis. In this method, the stomach area was marked out as a region of interest using a cursor on the screen and the variation in total resistivity value within this region from frame to frame was plotted out. This plot gives a measure of the desired gastric emptying rate. Such plots for the three subjects in diarrhoeal and non-diarrhoeal conditions are shown in fig 2.

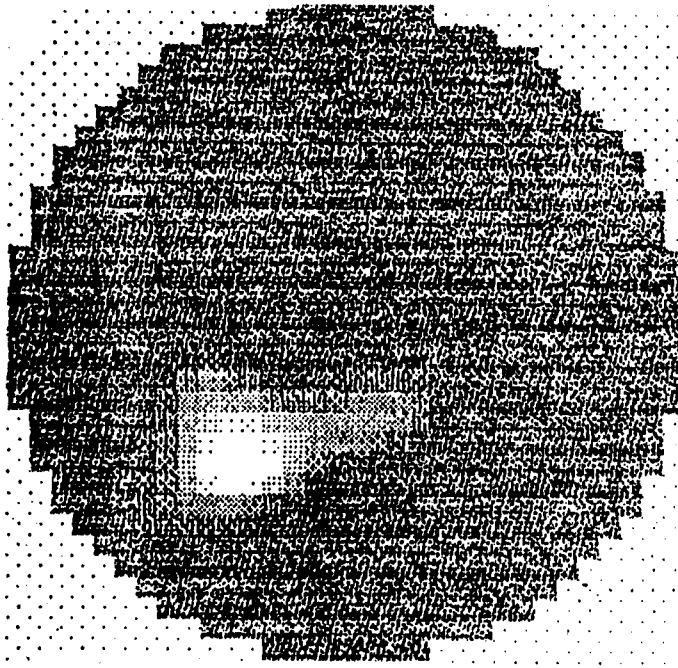


Fig 1. Electrical Impedance image of stomach during emptying as obtained from a subject.

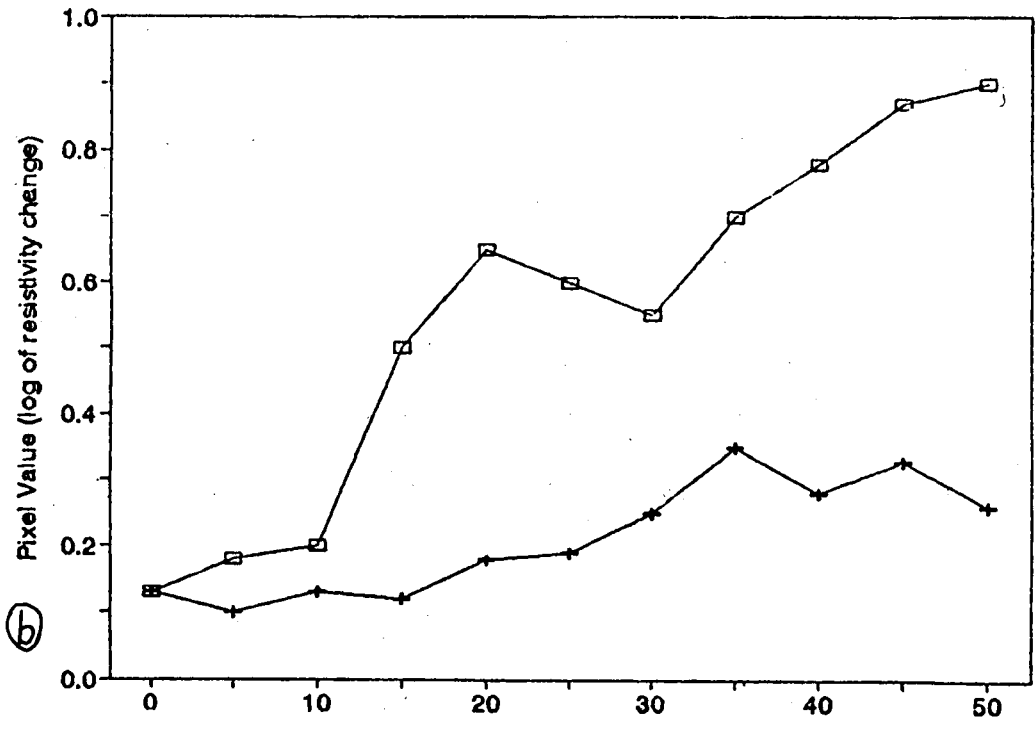
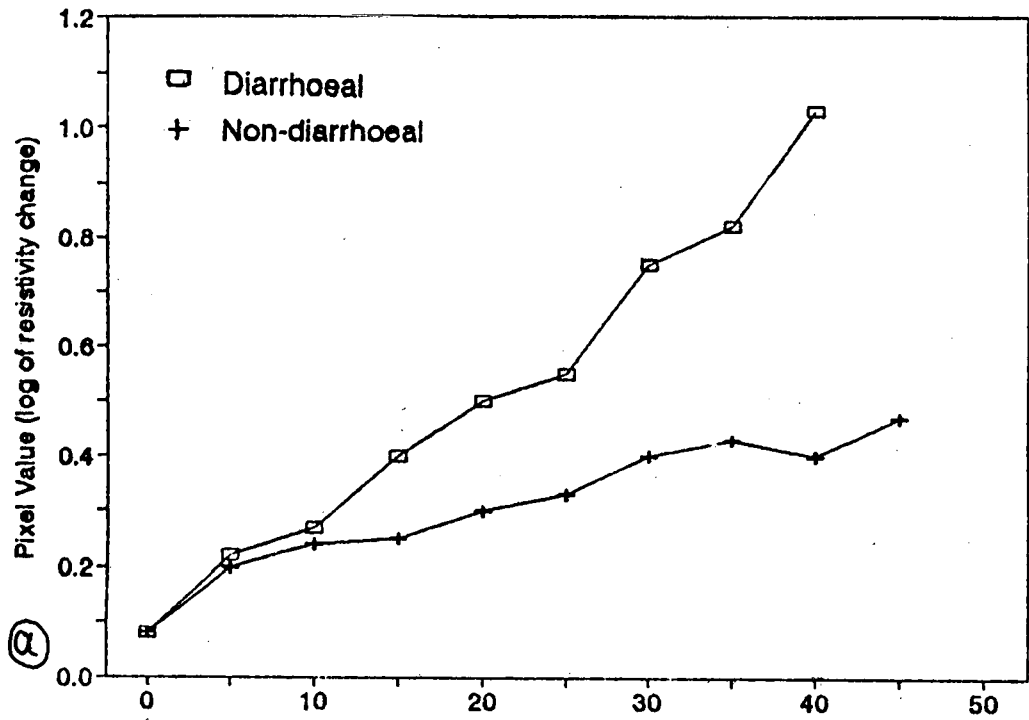


Fig. 2. Contd.

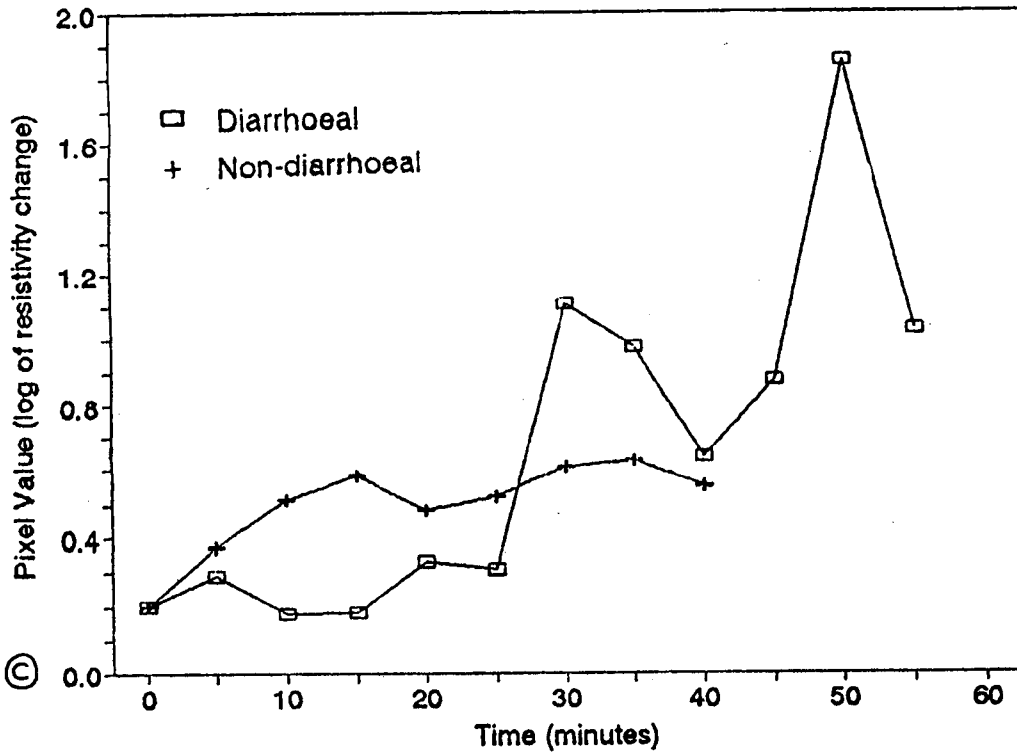


Fig. 2. Gastric emptying rates under diarrhoeal and non-diarrhoeal conditions for three subjects. Rate is higher in diarrhoeal condition.

As can be observed from the above curves, the rate of stomach emptying is slower when the subjects are in non-diarrhoeal condition compared to the situation when they have diarrhoea. The overall trend is similar in all the three subjects though there are minor variations within the curves. This seems to imply that the gastric emptying rate is higher when the subject have diarrhoea.

Discussion

The new EIT technique offers a unique method for studying gastric emptying non-invasively which was not possible before⁵. the measurement, however, is slightly difficult in children, particularly malnourished ones. Electrodes had to be trimmed to accommodate around the slender trunk of the subjects. Besides, under diarrhoeal conditions, disconnecting

and reconnecting electrodes on demands of the subject posed a problem. Sometimes electrode contacts become less than satisfactory due to movement. However, the equipment has a check against faulty electrodes and by careful monitoring it is possible obtain meaningful results.

The results obtained in the present pilot study shows that the gastric emptying rates are higher when the children have diarrhoea compared to the condition when they do not have diarrhoea. As mentioned earlier, this diarrhoea do not have any pathogenic origin and hence an understanding of the physiological system will help in combating the disorder. The consistent results of the present study justifies further study using a larger sample size. If these results are born out then it may be possible to control diarrhoea during nutritional rehabilitation of malnourished children using antimotility drugs and thus reduce hospitalisation time.

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Summary

The purpose of present study was to use this new EIT technique for investigation of stomach emptying rates of children with malnutrition in two regimes. The results shows that the gastric emptying rates are higher when the children have diarrhoea compared to the condition when they do not have diarrhoea. The consistant results of the present study indicates that if these results are borne out then it may be possible to control diarrhoea during nutritional rehabilitation of malnourished children using anti-motility drugs and thus reduce the treatment time, which also justifies further study using largar sample.

Acknowledgement

This study was supported by a grant from the Bose center from the Bose Center of Advanced Studies, University of Dhaka. The British Council, under ODA assisted link programme, provided funds for acquisition of EIT equipment from Seffield University.

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