CAIT Communication

Influence of changing peripheral geometry on electrical impedance tomography measurements

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Keywords—*Deformation, Impedance, Impedance tomography, Peripheral geometry, Source of error*

Med. & Biol. Eng. & Comput., 1996, **34**, 359–361

1 Introduction

WITH REGARD to dynamic imaging in electrical impedance tomography (EIT), theoretical deduction and practical measurements show that it is necessary to keep the peripheral geometry of the cross-section of the object under constant investigation during the reference and main measurements (*a* (WEBSTER 1990*a*, *b* HEIMBACK, 1990). This necessary condition, however, cannot generally be provided for in medical examination procedures. There are two reasons for this predicament; first it is almost impossible to keep the patient immobile during the measurement procedure as this is only possible with anaesthetised patients or patients with stabilised posture. Secondly, the peripheral geometry is susceptible to changes during the examination due to respiration, for example (ADLER *et al.*, 1994). This leads to the question of the extent to which the generated image is caused by the changed resistivity distribution in the cross-section under investigation on the one hand, or by the changes of the peripheral geometry on the other hand, e.g. during respiration.

2 Materials and methods

In order to gain an idea of the impact of an altered external shape on the generated image, we undertook the following simple experiment. We used a cylindrical tank, 220 mm in diameter and with a height of 180 mm, made of an elastic material. The tank was filled with a saline solution. At a height of 130 mm, 16 holes of 4·2 mm diameter were drilled at equal distances from each other. In front of these holes, 16 ECG electrodes were attached. EIT measurements were carried out with our multi-frequency tomograph (GERSING and OSYPKA, 1994), applying a frequency of 5 kHz. Images were reconstructed using a backprojection algorithm. The reference measurements were performed on the tank with the cylindrical cross-section. The tank cross-section (except for the rigid bottom) was progressively deformed elliptically, applying a corresponding radial force on the shell of the elastic tank near electrodes 5 and 13 (Fig. 1). Axis d_1 of the ellipse is situated in the direction of the force applied; axis d_2 is perpendicular to d_1. The relative changes D_1 in d_1 are

$$D_1 = (d_1 - d_o)/d_o$$

where d_o is the diameter of the circular cross-section of the undeformed tank.

We used a range of relative changes of d_1 from $+5\%$ to -10%.

In addition, in order to explore the phenomenon further, we carried out 4-pole impedance and trans-impedance (transfer impedance) measurements on the cylindrical and the deformed

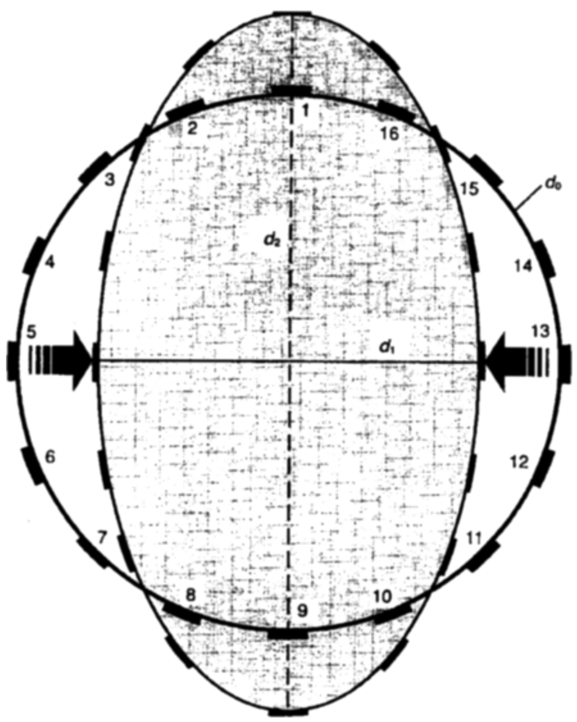

Fig. 1 *Cross-section of the tank at the height of the electrodes*

First received 12 June 1995 and in final form 15 July 1996.

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tank. As measuring equipment we used an Impedance/Gain-Phase Analyzer* with a special high-impedance probe which allows 4-pole measurements on a remote object (at 2 m distance).

We first measured the impedance using three different electrode patterns (Fig 1):

(a) electrodes 3 and 6 for current injection, and electrodes 4 and 5 for voltage sensing
(b) electrodes 5 and 16 for current injection, and electrodes 4 and 1 for voltage sensing
(c) eletrodes 6 and 13 for current injection, and electrodes 5 and 14 for voltage sensing.

We also measured the trans-impedance. Trans-impedance measurement on an object means that voltage is measured at a location remote from that of the current feeding. The measurement was carried out with the current supplied to electrodes 4 and 7 and the voltage between electrodes 12 and 15 at the opposite side of the tank.

3 Results and discussion

Fig. 2 shows an image produced from the date obtained from the tank with a relative change of axis d_l of 6·6%. The pixel values correspond to the relative differences of the reference and the main data sets. The colour scales provide information on the maximum positive and negative changes of the pixel values (dealing with the conductivities). Of course, the values depend on the weighting and filtering processes used in the image reconstruction algorithm.

Figs. 3 and 4 show images caused by a deformation of 4·4% and 2·2%, respectively. With increasing deformation of the tank, increasing inhomogeneities appeared in the image which do not actually exist in the medium under test. Considering the regions near electrodes 5 and 13 in the images, we find an increase in resistance with decreasing length of axis d_l. Fig. 5 shows the relative changes of pixel values R_p in the regions at the border in the neighbourhood of electrodes 5 and 13, depending on the relative changes D_l of axis d_l. (With respect to the location of the pixels near the border, the pixel

* Solartron 1260

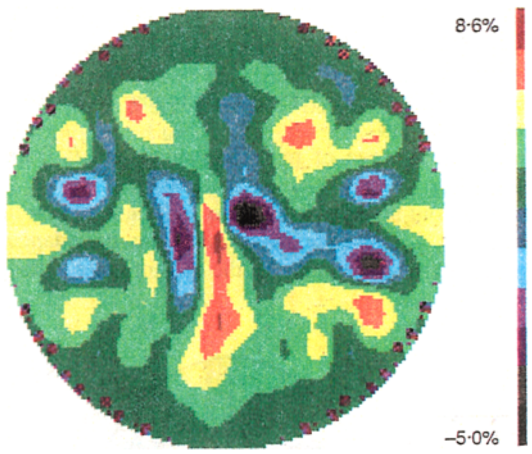

Fig. 2 *Changes in the resistivity distribution for a relative change of axis length D_l of −6·6%*

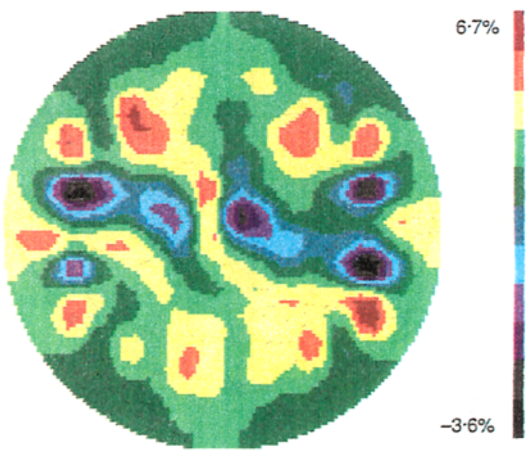

Fig. 3 *Relative change of axis length D_l of −4·4%*

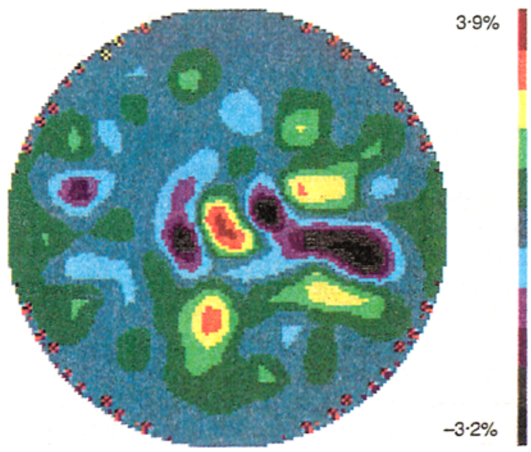

Fig. 4 *Relative change of axis length D_l of −2·2%*

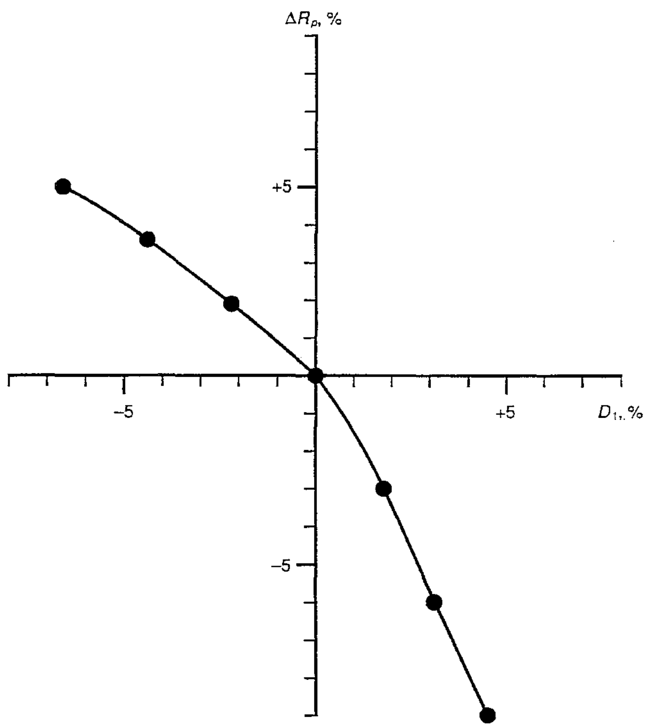

Fig. 5 *Maximum relative changes of pixel values R_p depending on relative changes D_l in the axis length*