Preliminary Communication

REAL-TIME NUCLEAR MAGNETIC RESONANCE CLINICAL IMAGING IN PAEDIATRICS

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Summary Echo-planar imaging (EPI), a distinctive variant of nuclear magnetic resonance, needs only a fraction of a second for an image to be acquired and so is free from movement artifacts caused by respiration or heart beat. Clinical findings in the lungs, heart, and mediastinum of three children with high respiratory and heart rates who were examined by EPI are described.

INTRODUCTION

NUCLEAR magnetic resonance (NMR) echo-planar imaging (EPI) has been shown to have great promise as a dynamic imaging technique in thoracic studies on laboratory animals.[1,2] In this paper we report the first clinical use of real-time EPI to study the thoracic contents of infants and a young child. Neither sedation nor anaesthesia were used.

METHOD

Details of the EPI method are described elsewhere.[3] In the present work, cross-sectional snapshot images, with a slice thickness of 8 mm, comprising 32×32 pixels with 6 mm resolution are obtained in about 35 ms. These are linearly interpolated to 256×256 arrays for display. The imaging machine operates in either a free run or ECG gated mode. Both methods allow each image to be linked to the events in a cardiac cycle. Each patient examination comprises imaging in 32 contiguous transaxial slices with 16 gated or ungated pictures per slice. This procedure yields 512 separate images which constitute a four-dimensional data set (three spatial dimensions, plus time). From this data set, stills and movie sequences may be extracted for sagittal, coronal, and other arbitrary planes. The examination, for 512 images, takes about 4½ minutes. Spin-lattice relaxation time (T_1) maps are also obtained for an additional examination time of 30 s per selected slice. The static magnetic field used was 940 G, corresponding to a proton resonance frequency of 4·0 MHz.

CLINICAL FINDINGS

Patient 1, a 3-month-old infant, was examined during recovery from bronchiolitis and bronchopneumonia: clinically the heart was normal. Fig 1 shows transections through the midthorax during systole. No residual lung lesion can be detected. The arms are seen at the top of the picture.

In systole the cardiac chambers and great vessels are seen as dark regions, and in diastole such regions are bright. Fig 1a shows, in black, the right-ventricular outflow tract, ascending aorta, and superior vena cava. Blood at near standstill in the atria, which are in diastole, appears bright. Fig 1b, again in ventricular systole and 6 mm cephalad to fig 1a, shows the main pulmonary artery, aorta, and superior vena cava. Fig 1c, 12 mm cephalad to fig 1a, shows the bifurcation of the main pulmonary artery into right and left branches. The aorta is not seen in fig 1c because flow in the aorta and pulmonary artery is not synchronous throughout the cardiac cycle.

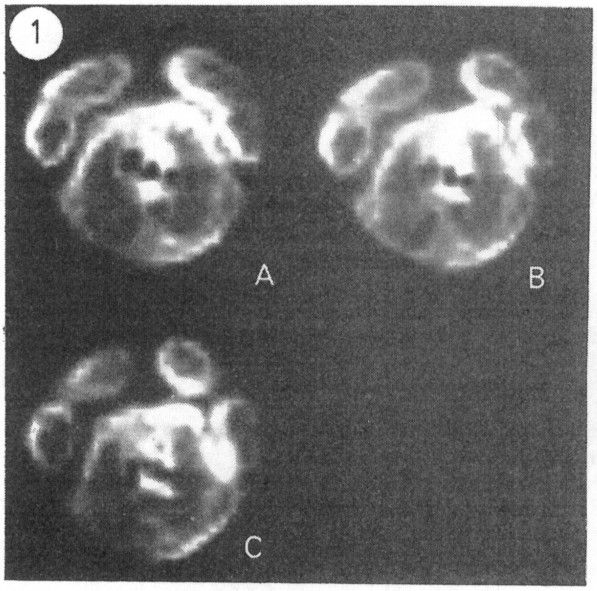

Fig 1—Snapshot EPI transections through thorax of a normal 3-month-old child.

Slice thickness 8 mm.

Patient 2 is a 14-month-old boy with type II truncus arteriosus. His left ventricle had not been detected on the angiocardiogram. Fig 2a shows a transection through the apex of the heart, and the apex of the left ventricle is seen as a dark zone in the left hemithorax. Fig 2b is a transection lying 6 mm cephalad to fig 2a and shows that the left ventricle is large. 24 mm cephalad to fig 2a is the transection shown in fig 2c: the left and right ventricles are demonstrated with the ventricular septum between. Fig 2d is a transection higher in

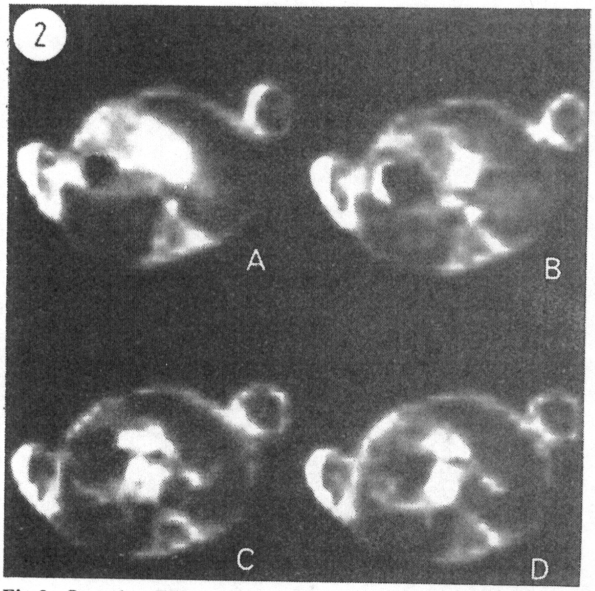

Fig 2—Snapshot EPI transections through thorax of 14-month-old infant with a type II truncus arteriosus.

Note enlarged left ventricle. Dark zones within heart mass are result of rapid blood flow through imaging plane. When blood is at standstill, in diastole, chambers and vessels yield high signals giving bright zones in the images.

the heart showing the conjoined right and left ventricles beneath the truncal valve, which is not shown on this transection.

Patient 3 is a 7-month-old oxygen-dependent infant with late bronchopulmonary dysplasia. The images were triggered from the ECG with the heart rate varying around 160/min. In both lungs (figs 3a and 3b) the bright zones are proton rich and poorly aerated. One especially large lesion is seen as a projection into the right lung from its posterior aspect. The extent of disease was clearly much greater than on plain chest X-ray and the idea of a possible lung resection was abandoned.

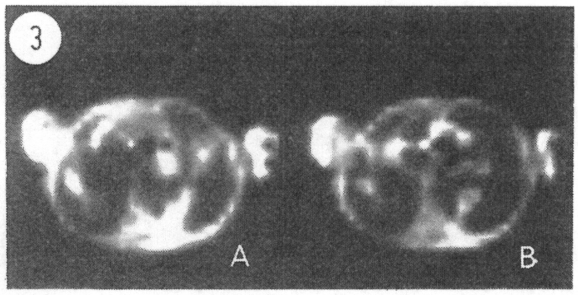

Fig 3—Snapshot EPI transections through thorax of 7-month-old child with bronchopulmonary dysplasia.

Images reveal widespread dysplastic lesions which show as static bright zones within lungs.

DISCUSSION

The three very young patients examined by EPI had high heart and respiratory rates. Such circumstances represent a severe test of an imaging technique. Good images which are free of movement artifact have been acquired. The images have been viewed either as static images or movie sequences of the lungs and heart. Clinically useful information has been obtained in all three patients.

This EPI technique is devoid of known hazard compared with methods entailing ionising radiation. Blood flow patterns may be observed without the injection of a potentially harmful contrast medium or radioisotope. EPI is quick and carries a prospect of a revolution in imaging methods in the thorax and elsewhere.

The clinical work has been carried out with benefit anticipated for the individual patient and in accord with Nottingham University Hospitals' ethical committees' requirements. These conform with National Radiological Protection Board guidelines for NMR clinical imaging.[4]

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Reviews of Books

Essentials of Human Biochemistry

C. R. Paterson, University of Dundee. London: Pitman. 1983. Pp 275. £8.95.

MOST biochemistry books are, naturally enough, written by biochemists for biochemists or other scientists. The subject has over the past few years assumed great importance in medicine, but the medical reader still has to rely largely on these books for the required knowledge. Most texts contain a considerable amount of material that is not relevant to medical studies, and omit much pertaining directly to endocrine or metabolic disease. Dr Paterson has, in writing this book specifically for a medical readership, made some progress in making things more satisfactory for them. He has obviously put a great deal of thought and work into this fairly concise volume, and has succeeded in producing an excellent introduction to physiological biochemistry that should not deter even the most "un-biochemical" from learning the fundamentals of the subject.

The chapters have been written in association with a number of other contributors to ensure a balanced and accurate view of each subject but, despite the number of authors, there is a uniformity of style and presentation. The print is easy to read, the drawings and diagrams are clear and understandable, and I came across only one printing error. The inclusion of photographs of patients gives the book a clinical feel which may prove attractive to preclinical students, but otherwise adds little to the content.

Much ground is covered, so many subjects are dealt with somewhat briefly and superficially, but this is inevitable. The interested reader will need to look to more comprehensive sources in order to study any subject in depth, and useful guidance is found in the short, but up-to-date reference sections at the end of each chapter. At £8.95 the book is good value for money. It will be useful not only for preclinical and clinical undergraduate students, but also for postgraduates studying for higher examinations in medicine, surgery, and pathology. I am sure that I will refer to it myself when I need to refresh my memory before teaching or writing.

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Cardiology

Vol III. The New Medicine. An Integrated System of Study. Edited by Hamish Watson, Unversity of Dundee. Lancaster: M.T.P. Press (in collaboration with Update Publications Ltd). Boston: Kluwer Academic Publishers Group. 1983. Pp 287. £9.95.

THE aim with this textbook, written mainly by members of the Dundee Medical School (with support from Edinburgh, Glasgow, and London), was to produce one that is different from the usual textbooks of cardiology and in this the authors have succeeded. It is very nicely produced and seems good value for money. Where the Hampton/Nottingham textbook (*Cardiovascular Disease*, Heinemann, see *Lancet* 1983; ii: 549) uses many photographs, this concentrates on clear line-drawings, which are very well annotated. This approach succeeds. The arrangement of the text is original. It is divided into five parts. The first part starts with a very useful background introduction to epidemiology, embryology, anatomy (a good section), cardiac physiology, and control mechanisms. This same chapter leads on to pathophysiology, the electrocardiogram, and radiology. Here photographs are used and they are clear and well produced. Sensibly, good line-drawings are used for the section on echocardiography. The next part deals with the history and physical examination, the third with the mode of presentation of cardiovascular disease and differential diagnosis, the fourth with specific diseases, and the fifth with the principles of management and treatment. There are some disadvantages with this arrangement. For instance, the view one gets of hypertension is fragmented and it is not easy to get a rapid and clear idea of the different options for care (incidentally, hypertension treatment is