Preliminary Communication

REAL-TIME NUCLEAR MAGNETIC RESONANCE CLINICAL IMAGING IN PEDIATRICS

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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\(\times\)32 pixels with 6 mm resolution are obtained in about 35 ms. These are linearly interpolated to 256\(\times\)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 un gated 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 (T1) 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 transsections 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.

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 transsection 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 transsection lying 6 mm cephalad to fig 2a and shows that the left ventricle is large. 24 mm cephalad to fig 2a is the transsection shown in fig 2c: the left and right ventricles are demonstrated with the ventricular septum between. Fig 2d is a transsection higher in
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.

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**REFERENCES**