

Inversion Recovery and Early Contrast Studies in the Brain:

A Brief History

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Note: Only first authors are named in references and their locations are given only in some instances.

Introduction:

When MRI of human subjects began, there was no data available about the NMR properties of living tissues. Odeblad and colleagues had measured the time constants of many body fluids (1955,1966), and Damadian (1971) had observed changes in small pieces of excised tumour. The only certain sources of contrast were the differences in tissue water content, though early head images showed little promise in this respect. The need to obtain better data led to trials of IR and SE sequences before the end of January 1980. These experiments showed positive results for IR – though SE was disappointing.

Learning about Contrast:

When imaging was performed at 0.3T (during the fall of 1980) contrast achieved at 0.1T could not be reproduced. Finally the magnet field was lowered, before being raised again – to determine how the time constants might change. However, clinical work began at 0.15T, and the machine field had to remain there. Bottomley et al's seminal paper discussing how the time constants might change with B_0 was not published until 1984 (1).

It should be noted that the first three papers describing the clinical use of MRI depended on the use of IR – and heavy T_1 -weighting (2,3,4). Unlike T_1 dependency, T_2 -weighting seemed unproductive until clinicians replaced physicists in determining imaging targets. Arising from the impact of the UCSF group with its enormous technical and clinical strength (Crooks (1982)), T_2 -weighting was widely preferred for a few years following 1982.

In the brain, initial work concentrated on tumours and multiple sclerosis and it was MRI's success in showing more MS lesions than CT that first demonstrated its potential (4). The sensitivity that IR delivered is illustrated by its success in observing blood oxygenation through changes in T_1 in volunteer hearts (5).

Initially, IR was regarded as a difficult, awkward sequence. This was largely due to the RF configuration of most MRI machines which used combined transmit/receive RF coils. The trade-off between sensitivity on the one hand, and RF field homogeneity on the other was invariably decided in favour of the former. Some groups were fortunate in separating the two coils –as they could then be optimised for their respective functions and IR is much more sensitive to errors in RF flip angle than other sequences. Its saviour was the birdcage coil with its combination of homogeneity and sensitivity (6). IR's value was emphasised again by the arrival of the first contrast agent (Gd-DTPA) (Weinmann 1984) which was primarily T_1 -sensitive (7).

Variations on the IR Theme:

STIR was the first targeted IR variant, though it was developed to eliminate peripheral lipid signals in abdominal imaging so as to reduce motion artefacts. Its applications in orthopaedic imaging came later, and it has never been of great use in the CNS even though its magnitude images have additive T_1 and T_2 contrast.

FLAIR was a fortuitous development. Double inversion recovery (including cancellation of CSF) had been demonstrated by the mid 1980s (8) but seemed to have no real purpose. It was seven years later before its value in eliminating CSF-based motion artefact was demonstrated, and its clinical importance determined (Bydder 1992).

Summarizing Contrast in the Brain:

Surprisingly, the majority of the contrast mechanisms now in use in the brain were developed in the 1980s or start of the 1990s. MTC imaging (Balaban 1989), DWI (Le Bihan 1986), followed by diffusion anisotropy (Moseley 1991), chemical shift control (Dixon 1984), angiography (Dumoulin 1989, Laub 1990) susceptibility mapping (Young 1987), $T_{1\rho}$ imaging (Sepponen (1985), contrast agents (Carr 1984), BOLD (Ogawa 1990) all arrived before 1992, leaving only clinical UTE imaging (Bydder 2003) developed in the last 20 years. Hopefully other contrast mechanisms will soon be found to join this isolated example.

References:

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