Optimising oral contrast agents for interactive neonatal gut imaging

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Introduction: Imaging the neonatal gut to investigate embryological rotational abnormalities is performed using X-ray fluoroscopy techniques (upper gastrointestinal contrast studies) which carry a significant radiation burden. We are developing an MR equivalent of the X-ray base upper GI contrast study in neonates, using an interactive real-time multi-contrast pulse sequence [1, 2]. The optimal contrast medium for neonatal use or whether this should use a T1w or T2w imaging strategy is unclear [3]. Ideally a contrast medium is required which can be easily visualised on either T1w or T2w sequences, well tolerated by the neonate, but readily distinguishable from the fluid which may already be within small bowel segments (a mixture of milk, water and other contrast media). Currently, there are no gadolinium-based contrast agent licensed or optimised for oral use in children, but several commercial fruit juices have a short T1 (high in manganese) and may be suitable as oral contrast agents [4]. Concentrated pineapple juice (PJ), for example, has been used as a negative contrast agent for long T2w imaging in MRCP in children [5]. Our initial evaluation of these fruit juices yielded insufficient signal on interactive T1w sequences (FSPGR) but relatively high signal on T2w sequences (SSFSE). However, fruit juices can cause increased neonatal gut transit time, which can be uncomfortable and distressing: this is due to the inability of the immature gut to deal with complex carbohydrate loads of >10%. In this work we investigate the ability of several different dilute contrast media to provide optimal signal. We also investigated use of an inversion prep pulse in-vivo to null any existing bowel fluid whilst retaining the conspicuity of the contrast medium.

Methods: 1. The T1 of different contrast media was measured and compared using a SSFSE sequence with variable Inversion Recovery time (TI). 7 different contrast media were tested (Figure 1): water, 0.5% dilute gadolinium (Gadovist, Bayer; 0.005mmol/ml), Iopamidol (Gastromiro, Bracco), used for X-ray fluoroscopy procedures), Neocate (Nutricia, Gaithersburg, MD) and pineapple juice diluted to 75% original strength from three UK supermarkets (A-C) to give carbohydrate concentrations of < 10%, following neonatal dietician advice. Many neonates referred have food intolerances and are therefore fed on an amino-acid based milk formula, Neocate.

2. We tested the optimal solution during an upstream GI MR study using the interactive IR-SSFSE sequence, as part of an ethically approved study to evaluate using interactive MR as an alternative to X-ray upper GI contrast studies for suspected malrotation [1].

Results: 1. The T1 relaxation times of the different contrast media were: dilute Gadovist 50ms, Gastromiro 810ms, Neocate milk 900ms, PJ-A 290ms, PJ-B 285ms, and PJ-C 240ms (Figure 2). A TI of 500 ms effectively suppressed the signal from Gastromiro and milk whilst the various PJs (A - C) and the dilute gadolinium gave the highest signals (Figure 3). In vivo, an interactively adjusted TI of 1000ms provided optimal suppression of bowel fluid and high signal for PJ-C in a neonatal male (Figure 4).

Conclusion: In vitro, pineapple juice - C gave the highest signal relative to milk, using a TI of 500ms, whilst in vivo, pre-existing bowel contents were effectively nullled using a TI of 1000ms. The ability to interactively optimise the TI allows relatively long T1 bowel contents to be suppressed, whilst short T1 PJ acts as a positive contrast medium to allow accurate delineation of the gut. This strategy may allow the examination to be tailored to the individual, allowing discrimination of an orally administered contrast agent from the background signal generated by pre-existing gut contents.


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