A 8+4-Channel Receive Phased Array for Imaging Newborns and Premature Infants at 1.5T

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1. Introduction

In this study a phased array for optimized MRI of newborns and premature infants at 1.5T was developed. State of the art MRI coils are mostly designed for adults and suitable to only a limited extent for pediatric and newborn imaging, except special designed prototypes [1]. However, especially imaging of newborns and premature infants is needed for early diagnostics of e.g. cardiac defects. Several challenges occur when a dedicated array is designed. A very fast variation of biometrical parameters in the first six months, meaning very different electrical loading conditions, a very small anatomy and a relatively high heart rate (>100bpm) with respect to adult imaging. Two of the requirements, imaging of small objects with high resolution and accelerated imaging to prevent motion artifacts, can be met by using phased array technology. It provides high signal-to-noise-ratio [2] and the possibility for accelerated imaging with well established imaging techniques like SENSE or GRAPPA [3, 4]. Besides minimizing the acquisition time, a minimization of environmental stress, i.e. transport, temperature and oxygen level is absolutely necessary. To achieve these goals, we aimed for the implementation of a phased array in a special MR safe incubator (Lammers Medical Technology GmbH, Luebeck, Germany).

2. Methods

The phased array system consists of two parts (see figure 1). The upper part is thermo baked in foam, flexible and has four overlapping receive elements (combined 125mm x 175mm) to minimize mutual inductance [2]. The preamplifiers are placed directly in the receive elements to optimize the geometry and performance of the array. RF interferences caused by preamplifier oscillations were prevented by precisely adjusted cable traps and proper shielding of single components.

The bottom part is a small patient table. It houses eight receive elements. These eight elements are arranged in two rows with four overlapping elements, which are additionally overlapping in z-direction. The preamplifiers are placed outside of the elements and connected via coaxial cable and cable traps. To assure maximum patient safety, every receive element is equipped with an active and passive detuning circuit. In the unlikely case of a malfunction of both detuning circuits, a fuse is implemented as a third safety feature.

All phantom measurements were performed on a 1.5T clinical MRI system (Magnetom Avanto TIM, Siemens Medical Solutions, Erlangen, Germany). T1 weighted images (Spoiled gradient echo, TR/TE/α = 100ms/10ms/24°, FOV = 300mm, $1.2mm^2$, 5mm slice) were acquired for the phantom analysis. The phantom was a standard 2 liter PE plastic bottle filled with aqua dist. and 1,25g $NiSO_4$ x $6H_2O$, 5g NaCl per 1000g H_2O.

First in vivo imaging was performed on a 6.5kg lamb. Gradient echo cine series (0.6mm x 0.6mm, 4mm slice thickness, TR/TE/α = 40ms/1.2ms/52°) of 4 chamber and 2 chamber slices were acquired at an average heart rate of 180bpm (see figure 4).

Fig. 1: Photograph showing the coil setup with a phantom bottle in the middle.

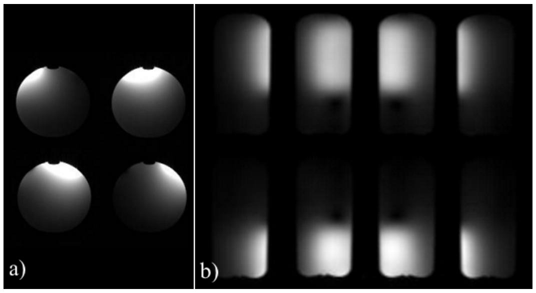

Fig. 2: a) Four single channel enlarged magnitude images of the flexible upper phased array. b) Eight single channel enlarged magnitude images of a phantom loading acquired with the bottom phased array.

3. Results and discussion

Magnitude images from each single channel of the flexible and bottom phased array (see figure 2) show only minor couplings in diagonal opposed located elements of the bottom array. The noise correlation (NC) matrix (figure 3), as an indicator for electrical coupling, shows a NC <0.4 for every coil pair. The bottom phased array had no value > 0.2. First in vivo images (cf. figure 4) show the very good SNR performance, which can be achieved with the array. The very compact design allows the radiologist to use the 8+4-channel array system in a MR safe incubator. These geometrical limitations are not matched by any other phased array available so far. Due to this combination of phased arrays and the MR safe incubator, the newborn patient can be provided with optimal environment conditions. Only minimal stress through the examination process is experienced while high resolution images of the chest and spine can be acquired.

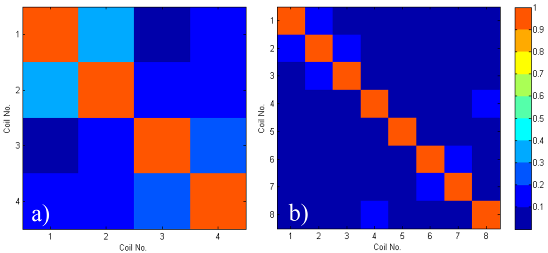

Fig. 3: Noise correlation of a) the flexible four-channel and b) the bottom eight-channel phased array.

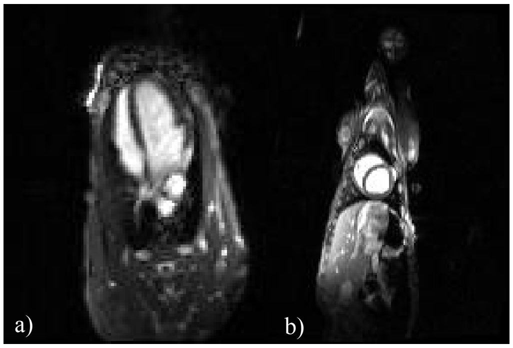

Fig. 4: In-vivo cine images with a) four chamber and b) short axis view of an anesthetized lamb. Courtesy of Dr. Sohrab Fratz, German Heart Centre Munich, Germany.

4. Acknowledgement

BMWi ZIM - KF2048801UL8 for financial support, Dr. Sohrab Fratz, German Heart Centre Munich, Germany for providing the in-vivo images.

5. References

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