# An 8-Channel Array Adapted for Pediatric Cardiac Imaging

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**Introduction:** Aside from great functional and viability information, cardiac MRI in children is of particular relevance as many of these patients suffer from congenital abnormalities that require pre- and post surgical imaging work-up and monitoring over time. MDCT scanning is often considered a rapid alternative but leads to considerable radiation dose accumulation throughout a patient's lifetime. One of the major shortcomings of pediatric cardiac MRI is the lack of appropriate coils leading to makeshift solutions with adult coils that yield suboptimal SNR and mediocre parallel imaging support. In fact, it is not uncommon that the size of one element of an adult array coil is larger than the width of the chest of a pediatric patient. That said, the availability of parallel imaging would be of utmost importance for these exams as these patients usually have significantly higher heart rates, are less compliant for breath-hold scans or should not be kept too long under general anesthesia due to their already very unstable clinical condition. The objective of this work was therefore to develop and test an 8-channel array coil dedicated specifically to pediatric cardiac imaging.

**Methods:** An 8-channel cardiac/upper torso array tailored for 3-6 years old children was constructed for improved imaging of the heart and the major vessels at 1.5T (GE Signa 14.0), reaching from the aortic arch and the subclavian artery down to the renal arteries (see Figure 1). One of the key issues in the design of this coil array was focusing on the coil layout, which of course should be optimally supporting the targeted FOV whilst providing minimum mutual coupling and g-factor-related noise enhancement. Another important parameter (frequently overlooked in parallel imaging coil design) was baseline SNR. Do note that even if the g-factor noise enhancement can be very little for a particular configuration, overall SNR can be much less than for an array with a less ideal g-factor behavior. To identify a preliminary coil arrangement with regard to baseline SNR and g-factor enhancement, we first performed numerical simulations using quasi-static methods to compute the noise correlation matrix and $B_1$ field distributions of an array with square coil elements [1]. Here, a potentially optimal configuration was found by overlapping the coil elements and by rotating the whole array by 45 degrees with respect to the z-axis. This configuration was then built on an acrylic coil former that was shaped to fit the upper chest area tightly. To determine the dimensions of the former, the average chest size was determined from CT and MR scans in consecutive series of children in the targeted age group. Coil element decoupling was performed by inductive decoupling of nearest neighbors and additional capacitive decoupling between diagonal elements when possible.

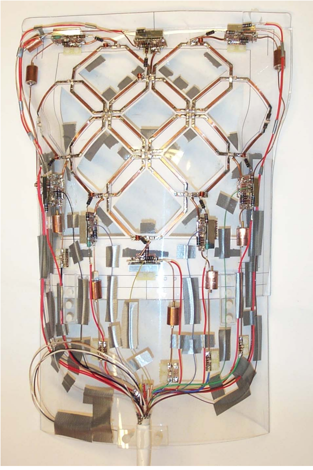
***Fig. 1** – 8-channel cardiac/upper torso array for 3-6 years old children with on-coil preamplifiers. The coil layout is optimized for best possible SNR in accelerated imaging.*

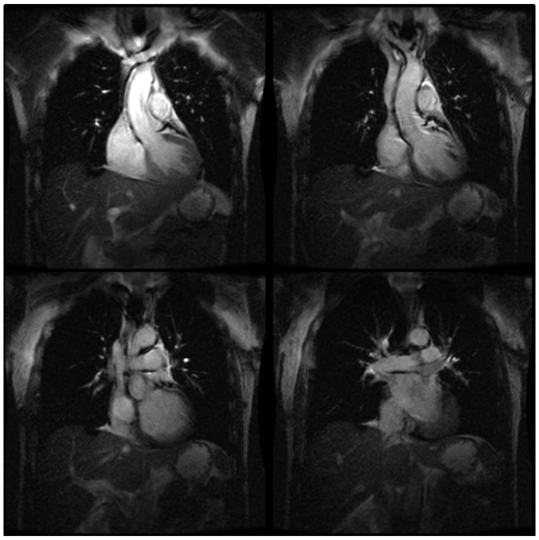
***Fig. 2** – Coronal views of a cine FIESTA acquisition in a healthy volunteer. The coverage of the coil can be well appreciated. Excellent SNR could be achieved over the heart. Despite the rather distinct coil sensitivity profile of individual coils, the sum-of-squares reconstruction yielded rather homogeneous images, whilst parallel imaging greatly benefited from the larger number of coils across the small FOV. No residual reconstruction artifacts were seen.*

Low-resolution calibration scans were performed in conductive homogeneous phantoms and volunteers to estimate coil sensitivity distribution and potential mutual coupling. Moreover, balanced SSFP scans were performed in 15sec breath-hold and cine mode (TR/TE=2.1/1.1ms, thickness/section gap =6mm/0mm, matrix=256x256, FOV=30cm, 50deg, GRAPPA x 2). All experiments were approved by the institutional review board and informed consents were obtained from all participating subjects prior to scanning them.

**Results:** Elements that are neither inductive nor capacitively decoupled relied solely on preamplifier decoupling. With on-coil preamplifiers, a blocking impedance of about 50 Ohms was achieved. The loaded to unloaded Q-ratio of a single element was1:4. This ratio changed to 1:2.5 in the presence of all other elements and components attached. Coil sensitivity maps revealed adequate sensitivity variations for parallel imaging and no significant coupling between channels. Figure 2 demonstrates the excellent SNR of the coil and the spatial coverage from the cervico-thoracic junction down to the renal pelvis. No residual parallel imaging reconstruction artifacts were observed.

**Discussion:** A dedicated 8-channel pediatric cardiac coil has been developed and tested. Compared to similar adult coils a significant increase in image quality could be achieved. The drop in the Q-ratio seen when attaching further elements is primarily due to imperfect preamplifier decoupling performance and also due to screening effects from other elements. Future work will focus on increased preamplifier-decoupling performance achievable with substantially zero input impedance preamplifiers that reflect negative impedance into the matching network [2], reducing overall coil weight, robust packaging, and placing some of the electronic components more in the cranial direction to shorten the cranio-caudal extent of the coil former.

**References:** [1]J. Wang, IEEE Trans. on Biomed. Eng. 42(9), p. 908, 1995; [2]X. Lou, US Patent #6,369,550 B1

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