Pediatric MRI: High-resolution Cardiovascular Imaging with Controlled Ventilation

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Background:

MR angiography is being increasingly used in children for non-neurological applications. Its safety and lack of radiation exposure make MRI a highly desirable alternative to CTA in the pediatric population. Because movement artifact can render MRI studies non-diagnostic, general anesthesia is frequently employed for pediatric MRI. However, the issue of breathing motion artifact is not addressed with standard anesthesia protocols, and with either spontaneous breathing or mechanical ventilation, image quality with CEMRA can be seriously compromised. The degree to which this occurs, and the degree to which suspended ventilation can improve diagnostic quality, has not been previously addressed [1,2].

Purpose:

The purpose of this study is to compare the image quality of Body MR Angiography in children with and without controlled apnea.

Method and Material:

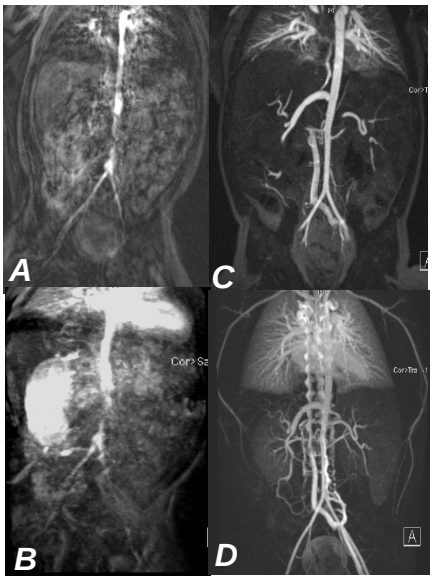
21 children (14 above 1 year old and 7 infants) underwent MRA of the chest and abdomen under general anesthesia and mechanical ventilation with high inspired oxygen concentration (FiO_2) at our institution since March 2004. In these children, ventilation was suspended during image acquisition, with intravenous injection of gadodiamide for CEMRA. The MRA studies in these children were compared to 27 control cases studied between Jan 2002 and March 2004 without controlled ventilation. All studies were performed on a 1.5 Tesla scanner (Siemens Sonata) using head, extremity or body phased array coil, as appropriate for size. Both groups were matched for age (mean age for breath-hold was 25 months and for non-breath-hold was 24 month; the medians retrospectively were 17.5 and 18 months) and age range was between 1 day to 8 years old. The mean weight of the children was 11.92 kg (range was 2.25- 23.4 kg). 9 pairs were evaluated for Abdominal MRA and 16 pairs were evaluated for Chest MRA. Contrast dose and infusion rate was adjusted on a body weight basis. (Mean contrast dose was 10.28 ml in both groups). Sequence parameter ranges were: TR 2.9-3.8/ TE 0.9-1.3; FOV 151x220- 400x400; FA 25; Matrix 125x160- 253x448; TA 10.17-27.67; BW 490-600; Slab thickness 1.2x40- 1.6x60. Partition MRA images and Maximum Intensity Projections (MIP) were assessed for overall image quality, vessel sharpness and motion artifacts.

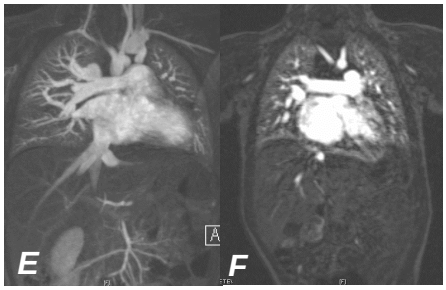
Subjective criteria for image quality was graded on a 4 point scale (1-4), vessel sharpness (i.e. pulmonary, celiac, common hepatic, right hepatic, mesenteric and renal arteries) were graded on a 4 point scale (0-3); and smaller abdominal branches were graded on a 3 point scale (0-2). The differences in above measurements were assessed using a Wilcoxon signed rank test.

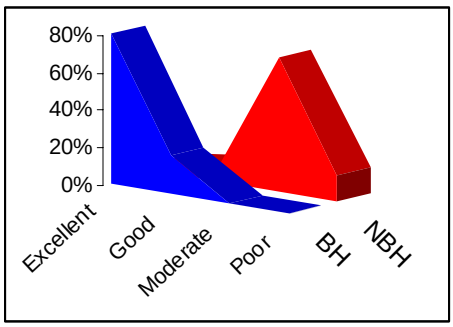
Results:

Image quality with controlled ventilation was rated as excellent in 80% versus only 5% in the control group (P<0.0001). Motion artifact was completely absent in 76% of patients with controlled apnea, while in the majority (67%) of non-breath-hold patients moderate motion artifact was present (P<0.0001). Vessel sharpness was rated significantly higher with apnea than in non-breath-hold studies.

Motion Artifact				
	Not seen	Minimal	Moderate	Severe
BH	76%	33.30%	0%	0%
NBH	5%	14%	67%	14%







Overall Image Quality

Figures:

A-Abdominal MRA of 22 months baby breathing spontaneously. Note the gross degradation in image quality and lack of vessel sharpness. **B-**Thin MIP reconstruction of case A

C-Abdominal MRA and venography of 2 y/o baby, status post liver transplant. Diagnostic impression in this case was made with high level of confidence on the patency of vessels. Breathing was suspended during image acquisition. Note the sharpness of the transplant hepatic artery and renal arteries. **D-**MIP ranges of baby c

E- Chest MRA of 20 months baby with controlled ventilation. Partial anomalous pulmonary venous return was present with a prominent left vertical vein draining into the left brachiocephalic vein. Right heart and pulmonary arterial enlargement due to APVR and ASD.

F-Chest MRA of 20 months baby, without controlled ventilation. Image quality is moderate, but vessel sharpness is inferior to E.

Conclusion:

Controlled ventilation can be used effectively in children to eliminate respiratory motion artifact from CEMRA studies, resulting in greatly improved diagnostic quality. Furthermore, by ventilating with 100% oxygen, prolonged apnea can be safely employed in a substantial proportion of patients. enabling use of more aggressive imaging parameters than would otherwise be possible. With the overhead in time, cost and specialist expertise inherent in performing general anesthesia for MRI, controlled ventilation can greatly increase the likelihood of successful studies.

References: **1**. Tsai-Goodman B et al. Amer J Cardiol 2004; **2**. Holmqvist C et al. Acta Radiologica 2001