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Prenatal diagnosis of bowel malposition using T2-weighted fetal MRI sequences

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KEYWORDS
Fetal MRI;
Fetal ultrasound;
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Abstract
Objective: The goal of this study was to investigate the capability of T2-weighted magnetic resonance imaging (MRI) in revealing fetal bowel malposition.
Materials and methods: All fetal MRI examinations (excluding central nervous system MRI examinations) performed in our department from January 2005 to January 2014 were retrospectively studied by 2 independent observers for situs, stomach and jejunum location on T2-weighted images. Patients data were also reviewed for results of ultrasound examinations, MRI indication, and gestational age. Abnormally positioned jejunums were classified into 3 groups: intrathoracic (A), extra-fetal (B) and abnormal intra-fetal (C). Prenatal data were compared to postnatal imaging, surgery or autopsy findings that served as standard of reference.
Results: A total of 709 fetal MRI examinations were analyzed. In 64 fetus (9%), the jejunum was not present in the left subgastric area on T2-weighted MR images. In these 64 fetuses, proximal jejunum was intrathoracic (41/64, 64%, group A), extra-fetal (11/64, 17%, group B), or intra-abdominal but abnormally positioned (12/64, 19%, group C). Interobserver agreement was 100%. All diagnoses for fetuses in groups A and B (52 cases) were confirmed postnatally (41 cases) or at autopsy (11 cases). In group C, bowel malposition was suspected after ultrasound in only 2/12 fetuses (16.6%); it was confirmed postnatally in 1 fetus but not confirmed in the remaining one. In the 10 remaining fetuses (83%), malposition was confirmed postnatally although not initially suspected.
Conclusion: T2-weighted fetal MR images are useful for the prenatal diagnosis of bowel malposition, even when they are unsuspected on ultrasound examination.

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The normal process of midgut rotation during embryo development determines the normal position of the gastrointestinal tract with the stomach to the left, the angle of Treitz (duodenojejunal angle) to the left of the spine (more specifically to the left of L2 left pedicle), a left-sided jejunum under the stomach and the cecum in the right iliac fossa. Bowel malposition refers to a wide range of conditions including both intestinal malrotations due to abnormal rotation of the mesenteric root, and lateralization disorders or heterotaxy (situs inversus and isomerism) [1].

Prenatal screening for bowel position abnormalities is by no means a priority due to the rarity of these isolated abnormalities. However, second-line investigation to diagnose potential bowel malposition becomes important in the presence of other defects with which it is known to be associated, especially since complications can be serious (midgut volvulus) and have been reported in fetuses and neonates.

Due to its low contrast resolution, ultrasound does not perform well for diagnosing abnormal jejunum positions, especially for the morphology ultrasound around 20—22 weeks of gestation (WG).

The aim of this study was to assess the capability of fetal MRI, independently from ultrasound data, to reveal bowel malposition.

Material and methods

Patients

Our retrospective study included all the fetal neck-chest-abdomen (non-brain) MRI examinations performed between January 2005 and January 2014 in the pediatric and prenatal imaging department of our hospital. MR examinations were performed on a 1.5-T equipment (Philips Intera™, Philips, Best, The Netherlands), using the same protocol, i.e. single shot HASTE T2-weighted sections (4-mm slice thickness; TR/TE, 11753/120 ms; voxel size, 1.52 × 2.19 mm; flip angle, 90°), true fast imaging with steady-state precession (TrueFISP) T2-weighted sections (3 mm slice thickness; TR/TE, 5.9/3 ms; voxel size, 1.78 × 1.34 mm; flip angle, 65°) and three-dimensional (3D) spin-echo T1-weighted sections (TR/TE, 7/3.4 ms; voxel size, 1.8 × 1.97 × 2 mm; flip angle, 15°), acquired in the three fetal anatomical planes. Maternal sedation was not required for these examinations. Fetuses with omphalocele were not included in this study due to the rarity of this birth defect, its frequent association with other syndromes and chromosomal defects, and the fetal MRI signal abnormalities often observed for the small intestine (5 cases).

Images analysis

Jejunal location was assessed by two independent observers. They were a senior physician with 10 years of experience in fetal MRI, and a junior operator who had been learning the basics of fetal MRI interpretation for 6 months. The following data were analyzed: potential suspected bowel malposition by ultrasound, indication for MRI, gestational age at the time of MRI examination, situs, location of the stomach and jejunum on T2-weighted images.

The normal location for the jejunum on T2-weighted images was defined as being the left side, under the stomach (Fig. 1), or the right side under the stomach for fetuses with heterotaxy syndrome. The position of the jejunum was considered as nonassignable in fetuses with a midline stomach. Abnormally jejunum positions (i.e. proximal jejunal loops absent from the subgastric region on the left side on T2-weighted MR images) were classified into 3 groups:

- group A — extra-abdominal, intrathoracic jejunum (diaphragmatic hernia) (Fig. 2)
- group B — extra-abdominal, extra-fetal jejunum (gastroschisis) (Fig. 3);
- group C — abnormally positioned intra-abdominal jejunum.

Standard of reference

MR imaging findings were compared to prenatal ultrasound data, and then with neonatal data that include clinical records, ultrasound and upper GI series, and/or surgical findings depending on their respective availability or autopsy findings if applicable (termination of pregnancy).

Results

Overall, 709 fetal MRI examinations were analyzed retrospectively. The mean gestational age at the time of MRI examination was 30 WG (range: 22—37 WG). MR imaging was performed for fetuses suspected to have urinary disease (220/709; 31%), chest deformities (134/709; 19%), digestive system abnormalities (106/709; 15%), cystic lesions (106/709; 15%) and miscellaneous disorders (143/709; 20%). On analysis of the MR images, the position of the bowel was considered normal (i.e. under the stomach on the left side) in 645/709 fetuses (91%). Due to the long period the retrospective study covered, it was not possible to contact all these ''normal'' children and request they attend a paraclinical examination; their clinical records indicated the absence of complications during the neonatal period.

MRI revealed an abnormal position of the proximal small intestine for 64 of the patients of the whole population (64/709; 9%) that is the proximal jejunal loops were absent from the subgastric region on the left side on T2-weighted images. In the subpopulation with an abnormally positioned jejunum, diaphragmatic hernia was showed in 41/64 fetuses (64%; group A) with intrathoracic herniation of the jejunum on the left side. For 11/64 fetuses of this subpopulation (17%; group B), the jejunum was extra-abdominal and protruded into the amniotic fluid due to gastroschisis. For other 12/64 fetuses (19%; group C), the jejunum was located within the abdomen but at an abnormal position.

All the conditions diagnosed with MRI in groups A and B (52 fetuses) were confirmed by postnatal examination (41 fetuses) or at autopsy (11 fetuses). The agreement in reading for the diagnosis and group classification was 100%.

In group C, the abnormal jejunum positions observed in 10/12 fetuses (83%) was not suspected at the time of prenatal ultrasound; they were associated with prune belly syndrome ($n = 1$), pouch colon ($n = 1$), small bowel atresia ($n = 1$), atrioventricular canal defect ($n = 1$), left isomerism ($n = 1$), abdominal situs inversus ($n = 2$) (Fig. 4), and isolated

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