Postmortem fetal imaging: a prospective blinded comparison study of 2-dimensional ultrasound with MR imaging

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Short title: Postmortem MRI vs. US of human fetuses.

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Abstract

Objective: To compare the diagnostic rate and diagnostic accuracy of 3 Tesla (T) postmortem magnetic resonance imaging (PMMRI) and postmortem ultrasound (PMUS) in an unselected population.

Methods: In a blinded manner, we prospectively performed 3T PMMRI and PMUS on 160 unselected fetuses at 13-41 weeks of gestation. All imaging was reported according to a pre-specified template, for 5 anatomical regions: brain, thorax, heart, abdomen and spine. McNemar test for paired proportion was used to compare the non-diagnostic results rates of PMUS and PMMRI. When diagnostic, sensitivity, specificity and concordance rates for each anatomical region were calculated, using conventional autopsy as the reference standard.

Results: 3T PMMR performed significantly better than PMUS overall. Specifically, for the brain (7 non-diagnostic vs 43/160; 4.4% vs 26.9%; p<0.001), thorax (8 non-diagnostic vs 27/155; 5.2% vs 17.4%; p<0.001), heart (6 non-diagnostic vs 48/157; 3.8% vs 30.6%; p<0.001) and abdomen (5 non-diagnostic vs 37/157; 3.2% vs 23.6%; p<0.001). However, when diagnostic, we found similar accuracy for PMUS and PMMRI, with no difference in sensitivity or specificity, and similar concordance (PMUS 81.8-96.5%; PMMRI 81.6-99.1%).

Conclusion: PMMRI performed significantly better than PMUS in this population, mainly due to a lower non-diagnostic study rate. PMMRI remains the first line imaging investigation for perinatal autopsy, but PMUS could be considered where MRI is not available, accepting a higher non-diagnostic rate.

Introduction

Despite improvements in prenatal imaging, fetal post-mortem examination after termination of pregnancy (TOP) remains the reference standard. Post mortem assessment or "autopsy" provides a definitive diagnosis, or additional clarification for the prenatally suspected diagnosis[1–3]. Despite the benefit of autopsy for counselling regarding recurrence, bereaved parents often decline to consent to an invasive procedure[4,5]. In the past decade, post-mortem imaging with MRI (PMMRI) and post-mortem ultrasound (PMUS) have emerged as an alternative to autopsy as they are less invasive and more readily accepted[4–11].

Standard field PMMRI (1.5 Tesla (T)), was the first validated alternative to autopsy, with sensitivities and specificities of 33.3-88% and 70.5-95.2% for the thoraco-abdominal organs and higher diagnostic accuracy for brain lesions[9,12–15]. Fetal brain PMMRI can provide a diagnosis in about 80% of cases when classic autopsy fails due to severe autolysis[9,15,16]. 3.0T PMMRI may have a better concordance rate with classical autopsy as compared to 1.5T PMMRI mainly for smaller fetuses, however not for fetuses above 20 weeks of gestation[16]. Acceptable diagnostic rates have been achieved using high-field (9.4T) PMMRI or other techniques such as microfocus computerized tomography (micro-CT), which are not currently available for clinical practice[17–19]. We also recognize that whilst MRI machines are increasingly available in the hospitals of developed countries, MRI examination remains expensive, which potentially limits its access.

Ultrasound is a much less expensive and more accessible imaging tool even for developing countries. Fetal PMUS with a high frequency probe has shown promising results, with a sensitivity of 74.7% and a specificity of 83.3% for all organs irrespective of GA, suggesting a potential advantage for fetuses < 20 weeks GA, compared to PMMRI[11]. As yet, no direct comparison in the same patients has been conducted between 3T PMMRI and PMUS.

In this blinded study, we compared the diagnostic rate and diagnostic accuracy of 3T PMMRI and PMUS, using autopsy as the reference standard.

Method

Study participants and design

This was a prospective single-center study conducted at the Fetal Medicine Unit of the University Hospital Brugmann, Université Libre de Bruxelles, Brussels, Belgium. The local ethics committee approved the study (CE2012/116) and all patients signed a written informed consent. Between March 2014 and January 2018, PMMRI, PMUS and classic autopsy were offered to all parents who suffered a fetal loss by miscarriage, TOP or stillbirth. PMMRI and PMUS were performed in a random order depending on the availability of the operators. Fetuses were stored in a refrigerated compartment at 4°C before the post-mortem imaging and autopsy.

Among the 160 PMMRI and PMUS collected for this study, the results of 79 (49.4%) MRI and 103 (64.4%) PMUS were previously reported respectively in a study comparing 3T against 1.5T PMMRI[16] and in a study that compared PMUS against conventional autopsy[11]. However, none of these studies compared the results of PMUS to PMMRI.

The study design followed the requirement of STARD guidelines for reporting diagnostic accuracy[20].

PMMRI - acquisition

Whole-body high-resolution T2-weighted sequences were obtained using a 3.0-T magnet (Philips Achieva, Best, Netherlands) according to previously published acquisition parameters[16] . Axial and coronal views of the head and body were acquired. An 8-ch wrist coil or a body coil was chosen depending on the size of the fetus. Very small fetuses of GA less than 14 weeks were imaged in a 60 cc syringe with saline solution.

PMMRI - reporting

Two radiologists with more than 10 years' experience in PMMRI, assessed the PMMRI images. They were only informed of the GA and the manner of death (miscarriage, stillbirth or TOP) but no further clinical data.

Twenty anatomical structures were analyzed and a diagnosis was given as normal, abnormal or non-diagnostic for each structure. They were then grouped in 5 anatomical regions: brain (corpus callosum, thalamus, cerebral ventricles, cortex and cerebellum), thorax (thymus, trachea and lungs), heart (ventricles, atria, cardiac septum and great arteries), abdomen (liver, spleen, stomach, bowels, adrenals, kidneys, and bladder) and spine for further analysis. The anatomic region was considered normal when every organ was normal, or abnormal if at least one organ was abnormal and non-diagnostic when at least one organ was non-diagnostic and the others were normal. If the results of one anatomical structure were missing, the results of the whole anatomical region were considered as missing. The results were entered into an independent database prior to further investigation.

PMUS – acquisition

Four fetal medicine specialists with more than 5 years' experience at the beginning of the study performed the post-mortem ultrasound. Two-dimensional and 3-dimensional images were acquired using a Voluson E8 (GE Medical Systems, Zipf, Austria) machine, equipped with the transducers as previously described[11] . The operators were blinded to the prenatal imaging results and other clinical data except for the GA and the cause of death (miscarriage, stillbirth or TOP).

PMUS - reporting

The same 20 anatomical structures as PMMRI were analyzed and a diagnosis was given as normal, abnormal or non-diagnostic. The results were entered immediately after the PMUS into an independent database and before the fetuses were sent for autopsy. The anatomical structures were grouped in the same 5 anatomical regions

as PMMRI and the diagnoses were given following the same method as previously described for PMMRI.

Conventional autopsy

Conventional autopsy was performed by one pathologist with more than 15 years of experience in fetal autopsy, who was informed of the prenatal diagnosis in order to provide the most detailed clinical report for parental counseling. The pathologist was blinded to all the post-mortem imaging diagnoses except in one case of suspected diplomyelia on post-mortem imaging leading to specifically dissect the spine in this case. Autopsy results were entered into an independent database for the same 20 anatomical structures and then grouped into 5 anatomical regions following the same method as PMMRI and PMUS.

Statistical analysis and sample size

Study recruitment was based on non-diagnostic results of 10% for PMMRI and 20% for PMUS according to previously published data. To be conservative, we estimated that when PMMRI was non-diagnostic, PMUS would be non-diagnostic in only 50% of cases. Consequently, we determined that a sample size of 150 cases would provide a power of 80% to determine a difference in non-diagnostic results between the 2 imaging techniques, at significance level of 5%.

McNemar test for paired proportions was used to compare the non-diagnostic results of PMUS and PMMRI for the 5 anatomical regions. For each region, McNemar test was also used to study the non-diagnostic examination rate of PMUS compared to PMMRI within the different strata of the cause of death (IUD, TOP or miscarriage), the presence of maceration (yes or no) and GA (< 20 or ≥ 20 weeks).

We calculated the sensitivity, specificity, concordance rate, discordance rate and their 95% confidence intervals for each anatomical region when a diagnosis was given by both imaging techniques and conventional autopsy. We excluded all non-

diagnostic cases in order to compare the accuracy of both techniques and not their success rate. McNemar test for paired proportions was selected to compare the differences between PMUS and PMMRI for each anatomical region.

Data were analyzed with the statistical software G*Power version 3.1.9.2 (Heinrich-Heine-Universität Düsseldorf, Germany)[21], R version 3.0.2 (The R Foundation for Statistical Computing, Vienna, Austria). Excel version 9.0 (Microsoft, Redmond, WA, USA) was used. A two-sided $P<0.05$ was considered to be statistically significant.

Results

We included 160 fetuses of GA ranging from 13 to 41 weeks. PMUS, PMMRI and autopsy when consented were performed with a median delay of respectively 1 (range; 0-5), 1 (range; 0-7) and 4 days (range; 0-7) from birth. The STARD flow diagram of the 160 cases is illustrated in Fig 1. Classic autopsy was accepted in 118 cases, 92 of which also underwent brain autopsies. Autopsy was diagnostic in 118 (100%) cases for the examination of thoraco-abdominal organs and in 59 (64.1%) out of 92 cases for the examination of the brain.

The performance of PMMRI and PMUS are summarized in Table1. Overall, PMMRI performed significantly better than PMUS providing fewer non-diagnostic studies for the brain (4.4% vs 26.9%; $p<0.001$), thorax (5.2% vs 17.4%; $p<0.001$), heart (3.8% vs 30.6%; $p<0.001$) and abdomen (3.2% vs 23.7%), in particular for fetuses ≥ 20 weeks of GA. For the spine, both techniques showed equal success rate (0% vs 1.9%; NS). For fetuses < 20 weeks of GA, the difference was not significant except for the brain for which PMMRI showed an advantage with 11.1% of non-diagnostic examination vs 37% for PMUS ($p<0.05$).

The performance of PMMRI was also better than PMUS irrespective of the state of maceration except for the abdomen for which no significant difference was observed for macerated fetuses.

However, when both imaging modalities were diagnostic, we found no statistical difference in diagnostic accuracy for PMUS and PMMRI, with no difference in sensitivity or specificity (Table 2) and similar concordance (PMUS 81.8-96.5%; PMMRI 81.6-99.1%) (Table 2). The abnormalities that were not seen on PMUS and PMMRI are listed in Table 3.

Moreover, when a diagnostic full autopsy was achieved, PMUS and PMMRI gave the correct final diagnosis of major malformations in respectively 67.8% (40/59 CI 95% [54.4%-79.4%]) vs 78.0% (46/59 CI 95% [65.3%-87.7%](NS) of cases.

Examples of images obtained with diagnostic PMMRI and PMUS are illustrated in Fig 2 to 11.

Discussion

Main findings

Our blinded prospective study found that PMMRI was more frequently diagnostic than PMUS for all anatomical regions except for the spine, particularly for fetuses of GA ≥ 20 weeks, regardless the degree of maceration. For fetuses of GA <20 weeks, diagnostic rates were similar, except for the brain for which PMMRI performed better than PMUS. Overall, when a diagnosis was made, both techniques showed similar accuracy.

Comparison with previous studies

Ultrasound is a relatively economical and widely available imaging technique. In previous observational studies of its application to post-mortem imaging, PMUS had a success rate of 95% when a single sonographer knew the prenatal diagnosis[10] and a success rate of 74.8–82.8% when multiple observers were blinded to prenatal diagnosis[11]. Our study in an independent population confirms the latter results and suggests that the true diagnostic rate for PMUS in common clinical settings is about 70-80% when multiple observers are blinded to the prenatal information.

While PMMRI at 3T might be limited by its access and its cost, our study confirmed a high success rate with only 3-5% of non-diagnostic examination[16]. We have now demonstrated a performance advantage over PMUS, regardless of maceration.

The sensitivity of PMUS and PMMRI observed in our study was similar to that reported in previous publications, but the specificity of both techniques was slightly higher than the reported data[11,16]. This difference is explained by the fact that we excluded the non-diagnostic cases for the accuracy analysis, which were considered as false positive in previous studies. Yet no difference in accuracy was detected between PMUS and PMMRI. This suggests that the main difference between PMUS

and PMMRI was their ability to obtain images of sufficient quality for a confident diagnosis.

Clinical implications

The loss of an unborn fetus at any GA is a devastating event for any parents. To explain and persuade the parents of the benefits of an invasive autopsy at such a time is also challenging to medical practitioners[21]. Non-invasive post-mortem imaging appears to be a comforting alternative for parents, as suggested by its high acceptance rate[4,5]. Therefore, although the observed sensitivity of 40-70% of PMUS and PMMRI might seem unacceptable for clinical practice at first glance, the benefit of having any post-mortem examination performed instead of none is undeniable. Additionally, we have included all abnormalities found at autopsy, including minor abnormalities such as abnormal lung lobulation or Meckel's diverticulum, which may have very limited clinical relevance. Moreover, in our study, all sonographers and radiologists were blinded to the prenatal diagnoses and to the findings of ancillary examinations such as placental pathology or genetic tests. Higher sensitivity may be anticipated when this is used in a clinical setting, relating findings to antenatal data and when other ancillary test results (e.g. placental examination) are added[9].

Another reported advantage of PMMRI is the examination of the brain, for which a diagnosis remains possible even if autolysis results in the failure of classic autopsy[9,14–16]. Our data confirm this result with a 95.6% of success rate for PMMRI, whereas autopsy was diagnostic in only 64.1% of cases. Although fetal brain PMUS was more frequently non-diagnostic than PMMRI, a diagnosis was also possible in 73.1% of cases. Therefore, PMMRI could be used as a first-line diagnostic method for brain abnormalities. If MRI is not available, PMUS is an acceptable alternative.

When the GA is < 20 weeks, the examination of fetuses is challenging for conventional autopsy and PMMRI and requires delicate and precise handling in the first case and high-resolution images in the second. Sufficient image resolution may be obtained with 9.4-T MRI and has been obtained more recently with microfocus computerized tomography (micro-CT)[17,19]. However, these technologies are not available for current clinical practice. Previous data on PMUS suggested a benefit for fetuses < 20 weeks[10,11]. Unfortunately, on direct comparison, PMUS did not ameliorate the success rate of PMMRI and was even more likely non-diagnostic, though this difference was not significant. Therefore, considering the comparable accuracy of PMUS and PMMRI, both techniques might be an option for fetuses < 20 weeks if conventional autopsy is refused.

Finally, we should emphasize the high success rate of both imaging techniques for spinal cord abnormalities. In our study, one case of diplomyelia was not seen on prenatal imaging but was suspected on post-mortem imaging by both techniques (figure 10). This led to the dissection of the spinal cord at classic autopsy to confirm this finding, which is not done routinely in our center in the absence of a clinical indication.

Strength and limitations of the study

Our study is the first to compare the performance of PMUS and PMMRI with autopsy as standard. While we recruited a large number of fetuses with abnormal prenatal diagnosis, the abnormalities per anatomical region remained low and limited the generalization of the accuracy test results. Another limitation is the delay between fetal birth and classic autopsy, which was performed up to 7 days afterwards in some cases, which was the consequence of having to perform 2 types of post-mortem imaging examinations. This may have accentuated the effect of autolysis, particularly for the examination of the brain. However, the progress of autolysis is limited in refrigerated chambers at 4°C and its severity is more related to the interval between fetal death and delivery when the fetus was immersed in 37°C amniotic fluid. Finally, our study was conducted in a tertiary referral center for fetal abnormalities, and all

sonographers and radiologists had lengthy experience in fetal medicine or post-mortem imaging. Therefore, generalization to common clinical practice should be prudent regarding the possible learning curve for PMMRI and PMUS reporting[23].

Conclusion

3T PMMRI performed better than PMUS for all anatomical regions except for the spine, particularly for fetuses of GA ≥ 20 weeks, and the brain in fetuses <20 weeks. The main difference between PMUS and PMMRI was due to their respective ability to obtain images of sufficient quality for a confident diagnosis. PMMRI remains the first line imaging investigation for perinatal autopsy, but PMUS could be considered where MRI is not available, accepting a higher non-diagnostic rate.

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Figures:

Figure 1. STARD flow diagram of the cases included in this study.

Figure 2. Axial view images of normal brain structures in a 21 week-fetus using 3D PMUS compared to 3T MRI T2-weighted turbo spin-echo images.

Figure 3. Axial view images in a 33-week fetus presenting semilobar holoprosencephaly using 3D PMUS compared to 3T MRI T2-weighted turbo spin-echo images.

Figure 4. Axial view images in a 29-week fetus with severe bilateral ventriculomegaly (*) using 3D PMUS compared to 3T MRI T2-weighted turbo spin-echo images.

Figure 5. Axial view images of normal thoracic structures in a 21-week fetus using 2D PMUS compared to 3T MRI T2-weighted turbo spin-echo images.

Figure 6. Coronal view images of normal thoracic structures in a 19-week fetus using 3D PMUS compared to 3T MRI T2-weighted turbo spin-echo images showing the trachea and the bifurcation into the 2 principal bronchi (arrow).

Figure 7. Normal four-chamber view and coronal view images of the heart in a 21-week fetus using 3D PMUS compared to 3T MRI T2-weighted turbo spin-echo images.

Figure 8. Axial and coronal view images of the heart in a 23-week fetus presenting tetralogy of Fallot using 3D PMUS compared to 3T MRI T2-weighted turbo spin-echo images. The ventricular septal defect (VSD), the pulmonary atresia and the right-sided aorta are observed with both techniques. The thymus (*) and the thyroid (Δ) are also shown.

Figure 9. Coronal view images of normal abdominal structures in a 21-week fetus using 3D PMUS compared to 3T MRI T2-weighted turbo spin-echo images.

Figure 10. Coronal view images of normal kidneys in a 21-week fetus using 3D PMUS compared to 3T MRI T2-weighted turbo spin-echo images.

Figure 11. Axial and coronal view images using 3D PMUS and 3T MRI T2-weighted turbo spin-echo sequences in a 26-week fetus spinal cord showing diplomyelia compared with the spinal cord at classical autopsy.

Table 1. Comparison of non-diagnostic examination rate between PMUS and PMMRI. * p<0.05. **p< 0.001.

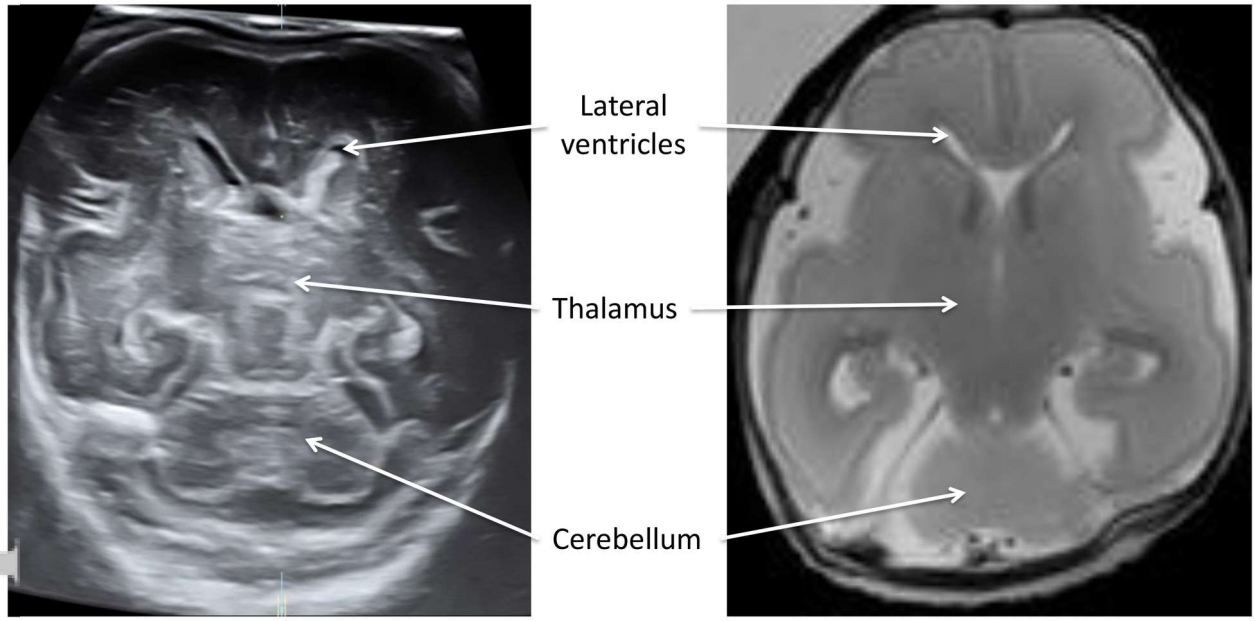
Variable		Total number of fetuses (%)	Non-diagnostic PMUS (%)	Non-diagnostic PMMRI (%)
Brain				
Overall		160 (100)	43 (26.9)**	7 (4.4)**
Cause of death	**Stillbirth**	28 (17.5)	17 (60.7)**	5 (17.9)**
	TOP	109 (68.1)	21 (19.3)**	1 (1)**
	Miscarriage	23 (14.4)	5 (21.7)	1 (4.3)
Maceration	**Yes**	36 (22.5)	16 (44.4)*	7 (19.4)*
	No	124 (77.5)	27 (21.8)**	0 (0)**
Gestational age	**<20 weeks**	27 (16.9)	10 (37.0)*	3 (11.1)*
	≥20 weeks	133 (83.1)	33 (24.8)**	4 (3.0)**
Thorax				
Overall		155 (100)	27 (17.4)**	8 (5.2)**
Cause of death	**Stillbirth**	26 (16.8)	8 (30.8)	5 (19.2)
	TOP	106 (68.4)	17 (16.0)**	2 (1.9)**
	Miscarriage	23 (14.8)	2 (8.7)	1 (4.3)
Maceration	**Yes**	32 (20.6)	10 (31.3)*	3 (9.4)*
	No	123 (79.4)	17 (13.8)*	5 (4.1)*
Gestational age	**<20 weeks**	54 (17.4)	10 (37.0)	7 (25.9)
	≥20 weeks	256 (82.6)	17 (13.3)**	1 (0.8)**
Heart				
Overall		157 (100)	48 (30.6)**	6 (3.8)**
Cause of death	**Stillbirth**	27 (17.2)	13 (48.1)	1 (3.7)
	TOP	107 (68.2)	31 (19.0)**	1 (0.9)**
	Miscarriage	23 (14.6)	4 (17.4)	1 (4.3)
Maceration	**Yes**	34 (21.7)	19 (55.9)**	4 (11.8)**
	No	123 (78.3)	29 (23.6)**	2 (1.6)**
Gestational age	**<20 weeks**	27 (17.2)	11 (40.7)	5 (18.5)
	≥20 weeks	130 (82.8)	37 (28.5)**	1 (0.8)**
Abdomen				
Overall		157 (100)	37 (23.6)**	5 (3.2)**
Cause of death	**Stillbirth**	27 (17.2)	10 (37.0)	3 (11.1)
	TOP	107 (67.7)	20 (18.7)**	1 (1.0)**
	Miscarriage	23 (14.6)	7 (30.4)*	1 (4.3)*
Maceration	**Yes**	34 (21.7)	9 (26.5)	3 (8.8)
	No	123 (78.3)	28 (22.8)**	2 (1.6)**
Gestational age	**<20 weeks**	27 (17.2)	9 (33.3)	4 (14.8)
	≥20 weeks	130 (82.8)	28 (21.5)**	1 (0.8)**
Spine				
Overall		156 (100)	2 (1.3)	0 (0.0)

Table 2. Accuracy test comparison of PMUS and PMMRI when both techniques were diagnostic. * Exact CI.

	PMUS	PMMRI	p
Brain n=49			
Sensitivity (%)	70.8 (17/24) [48.9-87.4]	79.2 (19/24) [57.9-92.0]*	NS
Specificity (%)	100 (25/25) [86.3-100]*	84.0 (21/25) [63.9-95.5]*	NS
Concordant (%)	85.7 (42/49) [72.8-94.1]*	81.6 (40/49) [68.0-91.2]*	NS
Discordant (%)	14.3 (7/49) [5.9-27.2]*	18.4 (9/49) [8.8-32.0]*	NS
Thorax n=93			
Sensitivity (%)	31.8 (7/22) [13.9-54.9]*	40.9 (9/22) [20.7-63.7]*	NS
Specificity (%)	98.6 (70/71) [95.9-100]*	98.6 (70/71) [95.9-100]*	NS
Concordant (%)	82.8 (77/93) [75.1-90.5]	85.0 (79/93) [77.7-92.2]	NS
Discordant (%)	17.2 (16/93) [9.5-24.9]	15.1 (14/93) [7.8-22.3]	NS
Heart n=80			
Sensitivity (%)	69.6 (16/23) [47.1-86.8]*	65.2 (15/23) [42.7-83.6]*	NS
Specificity (%)	93.0 (53/57) [83.0-98.1]*	100 (57/57) [93.7-100]*	NS
Concordant (%)	86.3 (69/80) [78.7-93.8]	90.0 (72/80) [81.2-95.6]*	NS
Discordant (%)	13.8 (11/80) [6.2-21.3]	10.0 (8/80) [4.4-18.8]*	NS
Abdomen n=88			
Sensitivity (%)	61.5 (16/26) [40.6-79.8]*	57.7 (15/26) [38.7-76.7]	NS
Specificity (%)	85.5 (53/62) [74.2-93.1]*	91.9 (57/62) [82.2-97.3]*	NS
Concordant (%)	79.5 (70/88) [71.1-88.0]	81.8 (72/88) [73.8-89.9]	NS
Discordant (%)	20.5 (18/88) [12.0-28.9]	18.2 (16/88) [10.1-26.2]	NS
Spine n=113			
Sensitivity (%)	83.3 (5/6) [35.9-99.6]*	83.3 (5/6) [35.9-99.6] *	NS
Specificity (%)	97.2 (104/107) [92.0-99.4]*	100 (107/107) [96.6-100]*	NS
Concordant (%)	96.5 (109/113) [91.2-99.0]*	99.1 (112/113) [95.2-100]*	NS
Discordant (%)	3.5 (4/113) [9.7-8.8] *	0.9 (1/113) [0.0-4.8] *	NS

Table 3. Abnormalities not seen on diagnostic PMUS and PMMRI compared to autopsy.

	Missed diagnosis on PMUS and PMMRI		Missed diagnoses on PMUS but not PMMRI		Missed diagnoses on PMMRI but not PMUS	
	n	**Diagnosis**	**n**		**n**	
Brain	1	Thin lateral ventricular wall from probable ventriculomegaly	2	Tumors	0	
	2	Increased cirvonvolutions without sign of micropolygyria				
	1	Olfactory bulb agenesia				
	1	Thin corpus callosum				
Thorax	10	Abnormal lung lobulations	1	Absent thymus	0	
	1	Big thymus	1	Esophageal atresia with fistula in the trachea		
	2	Hypoplasic lungs				
Heart	1	Atrial septal defect	1	Tetralogy of Fallot	1	Small rhabdomyoma confirmed by histology
	1	Transposition of the great vessels with ventricular septal defect			1	Pulmonary artery stenosis
	3	Dilated cardiac cavities				
	1	Increased cardiac weight				
Abdomen	3	Meckel diverticulum	1	Volvulus	1	Asplenia
	2	Malrotation				
	1	Abnormal organ volume				
	3	Polysplenia/ asplenia				
	1	Bowel agenesia/absent of anus				
Spine	1	Spina bifida occulta	0		0	



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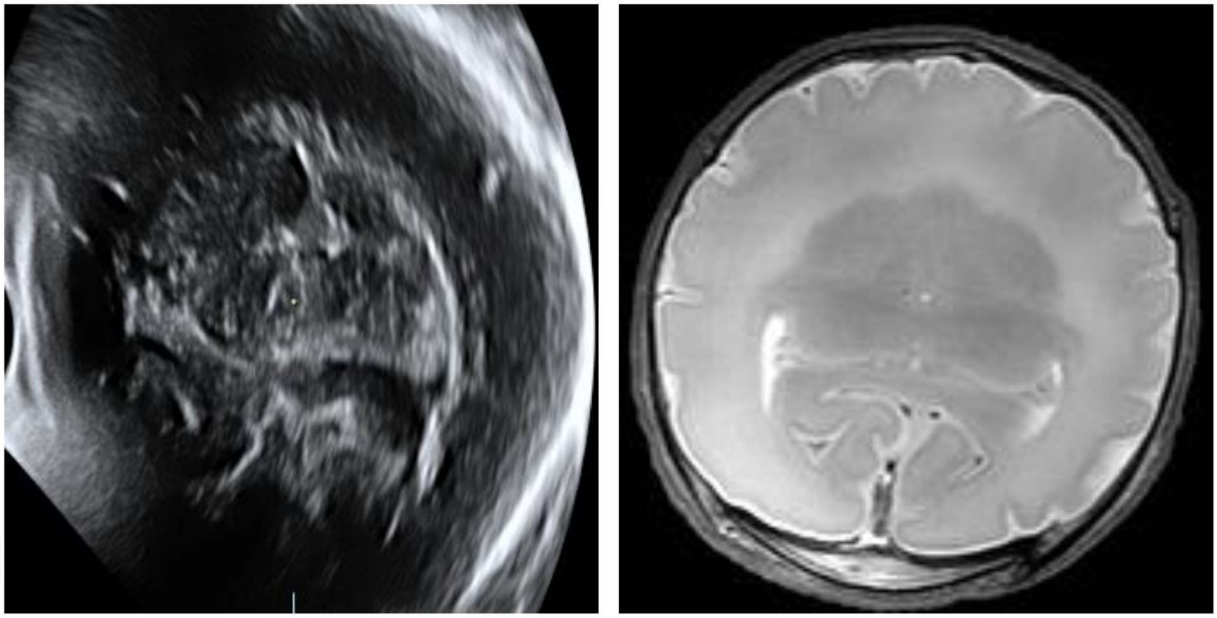

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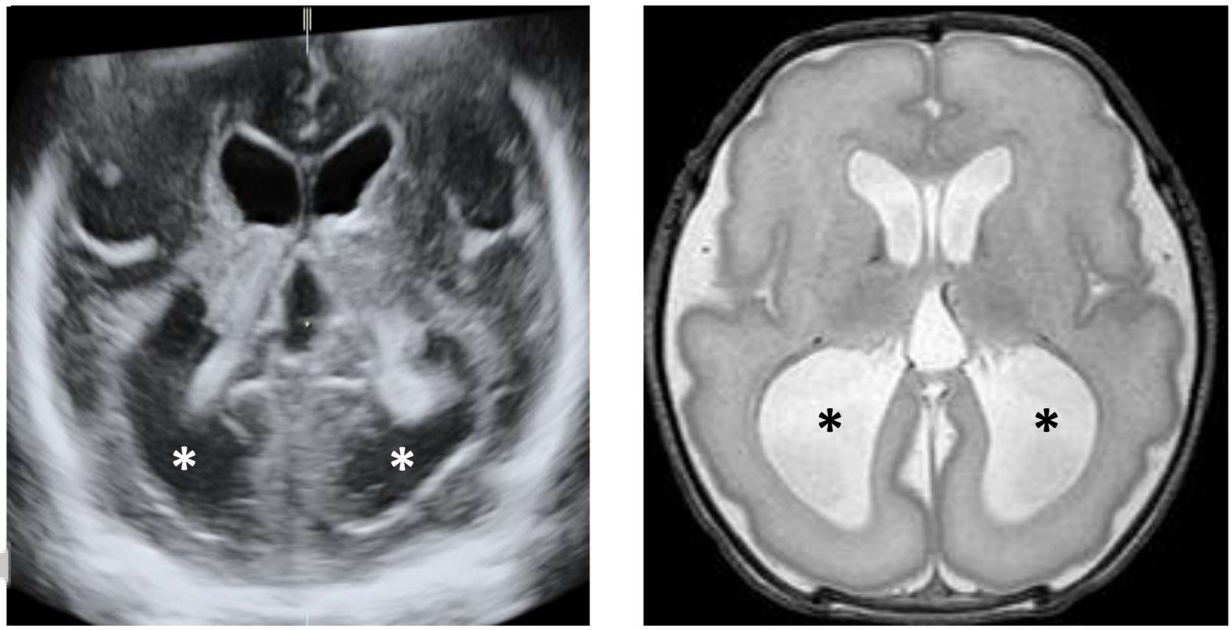

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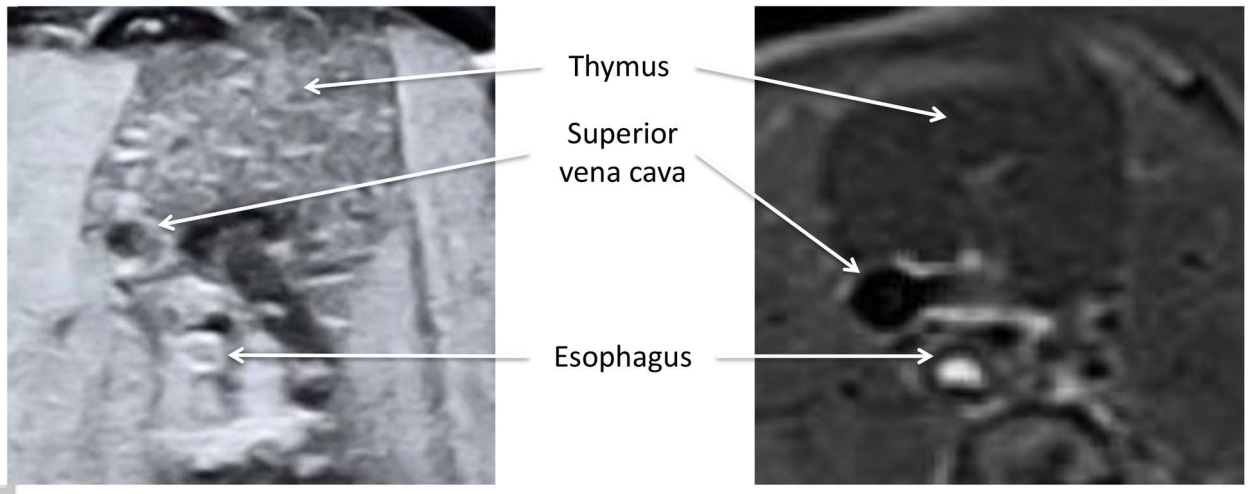

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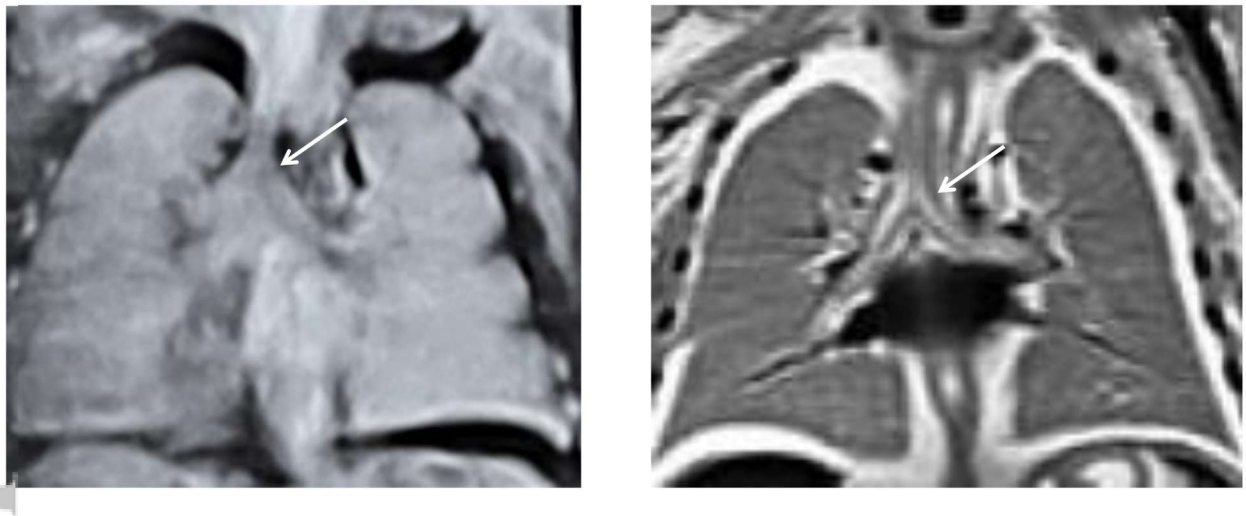

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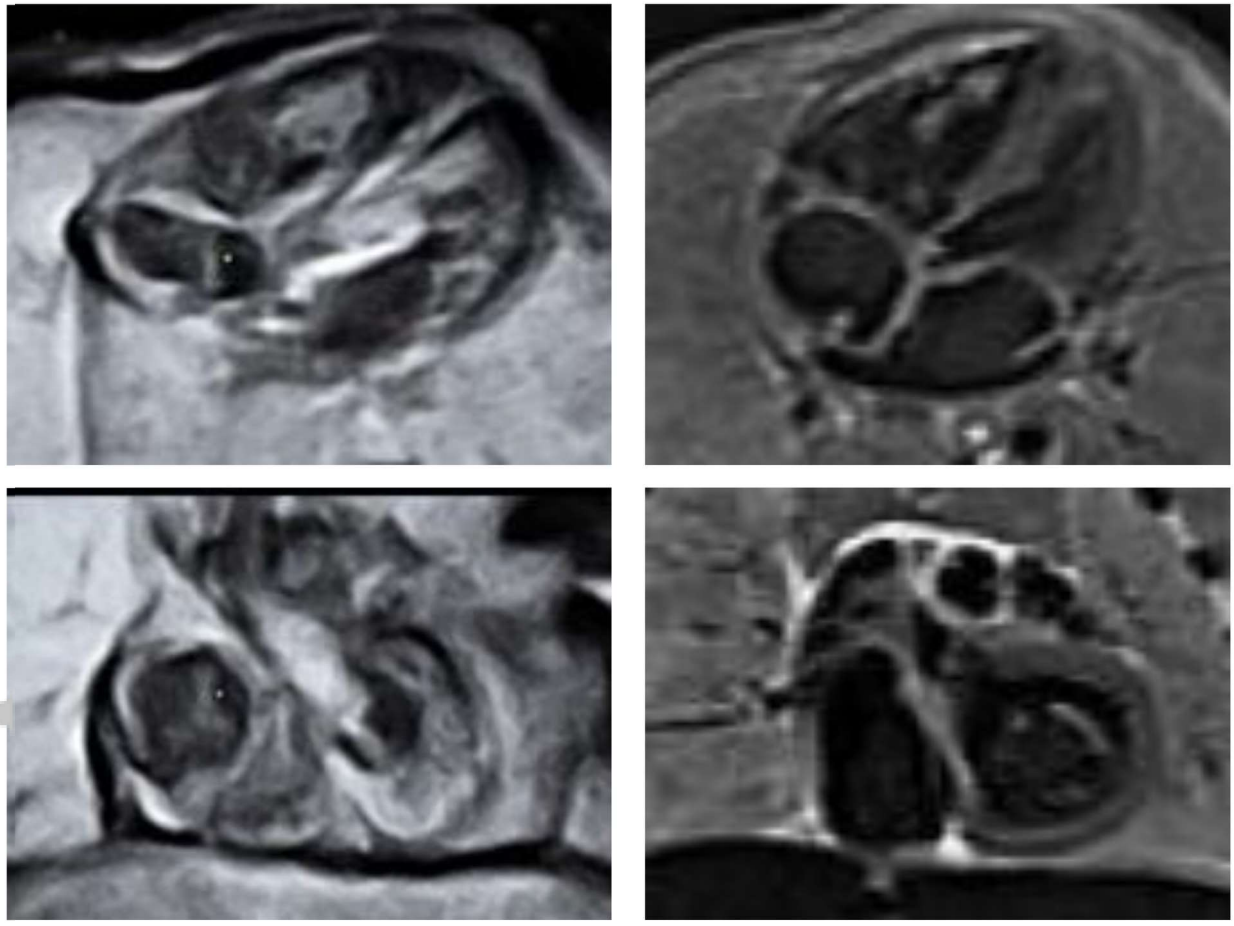

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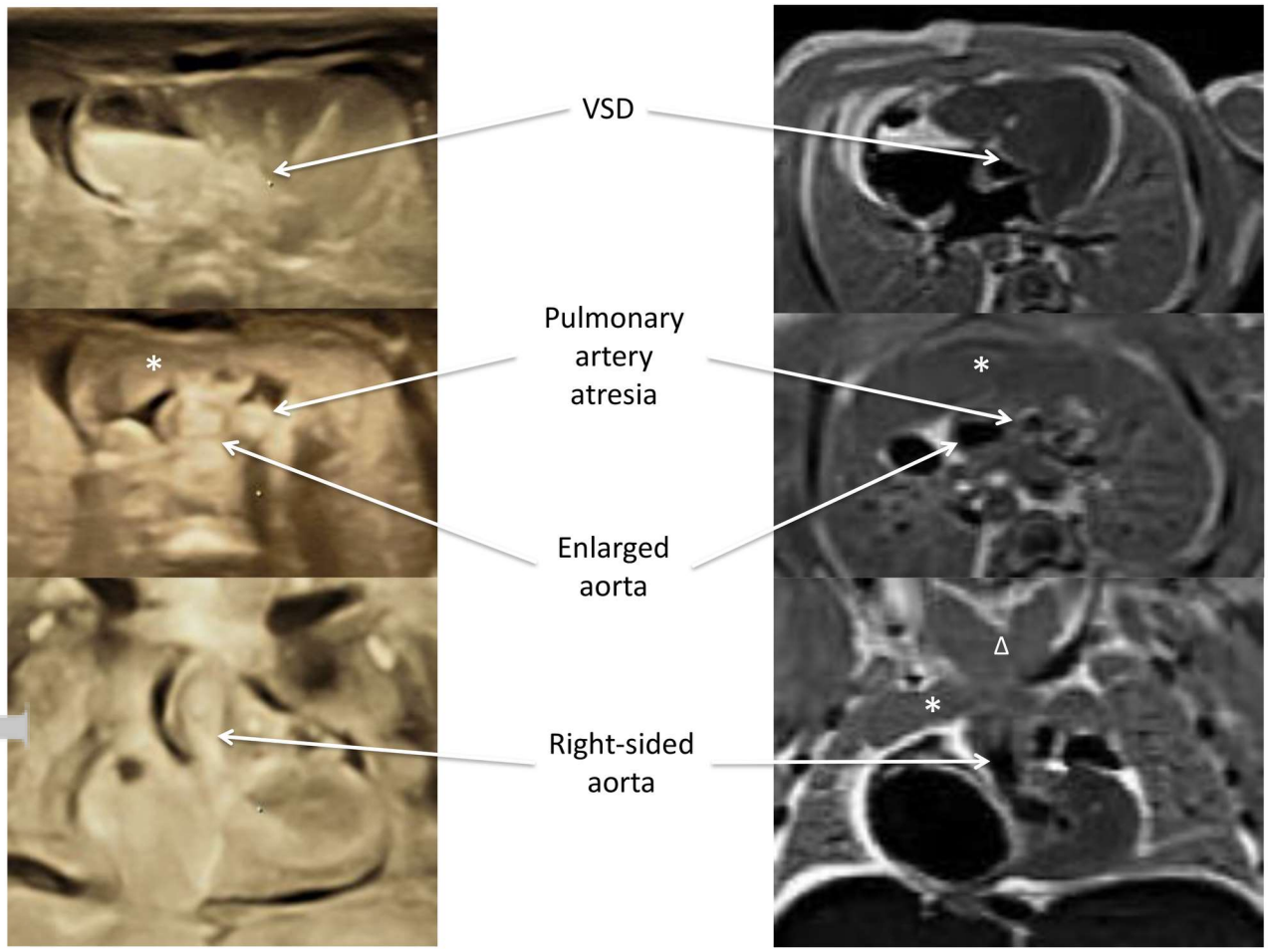

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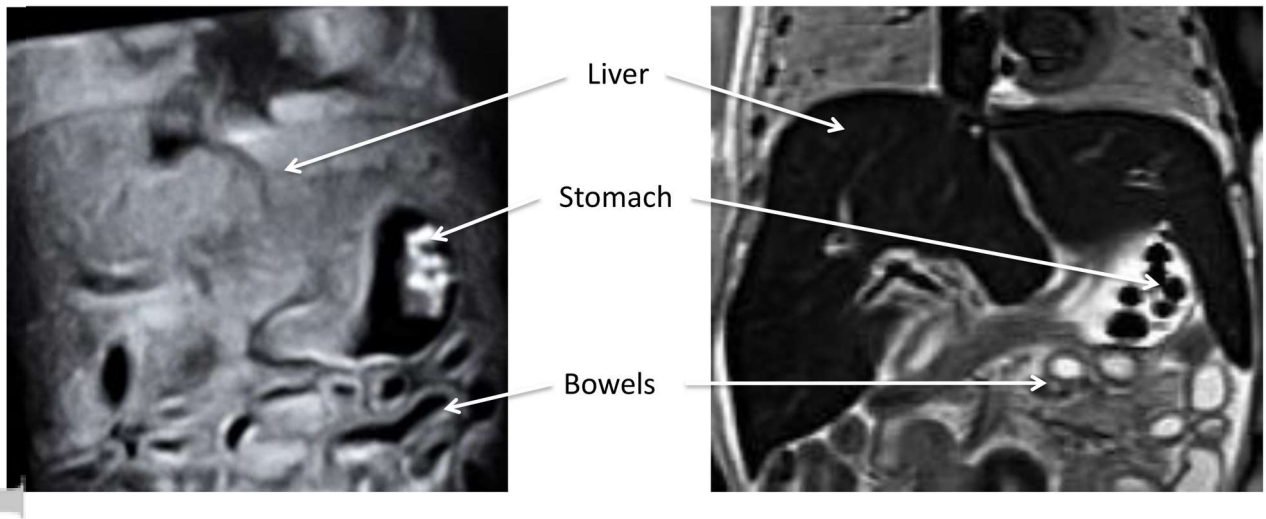

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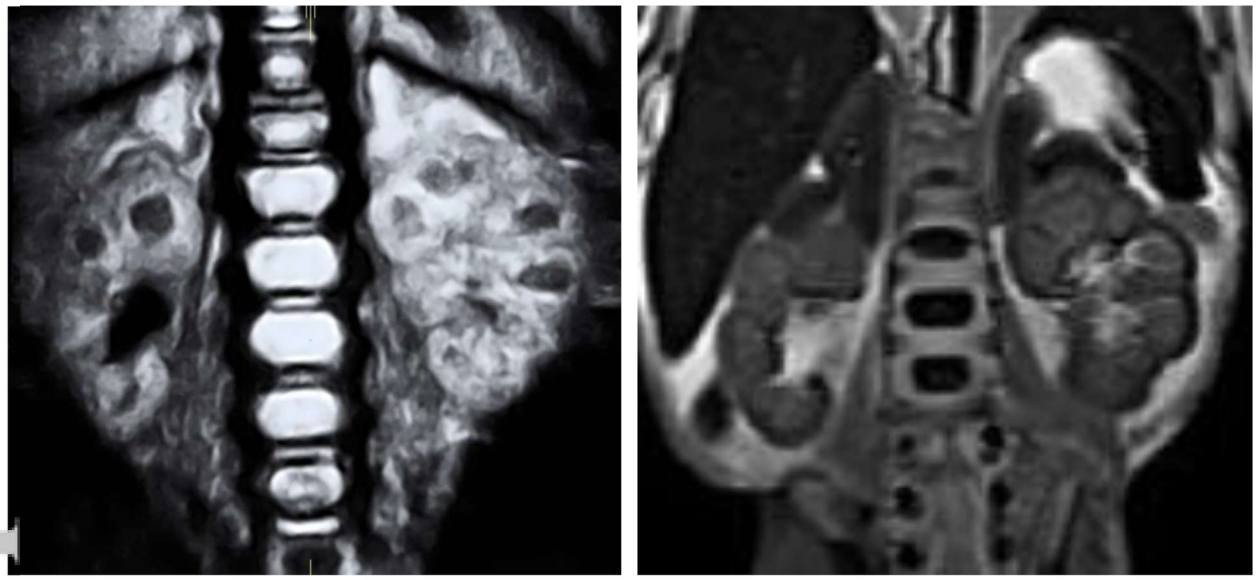

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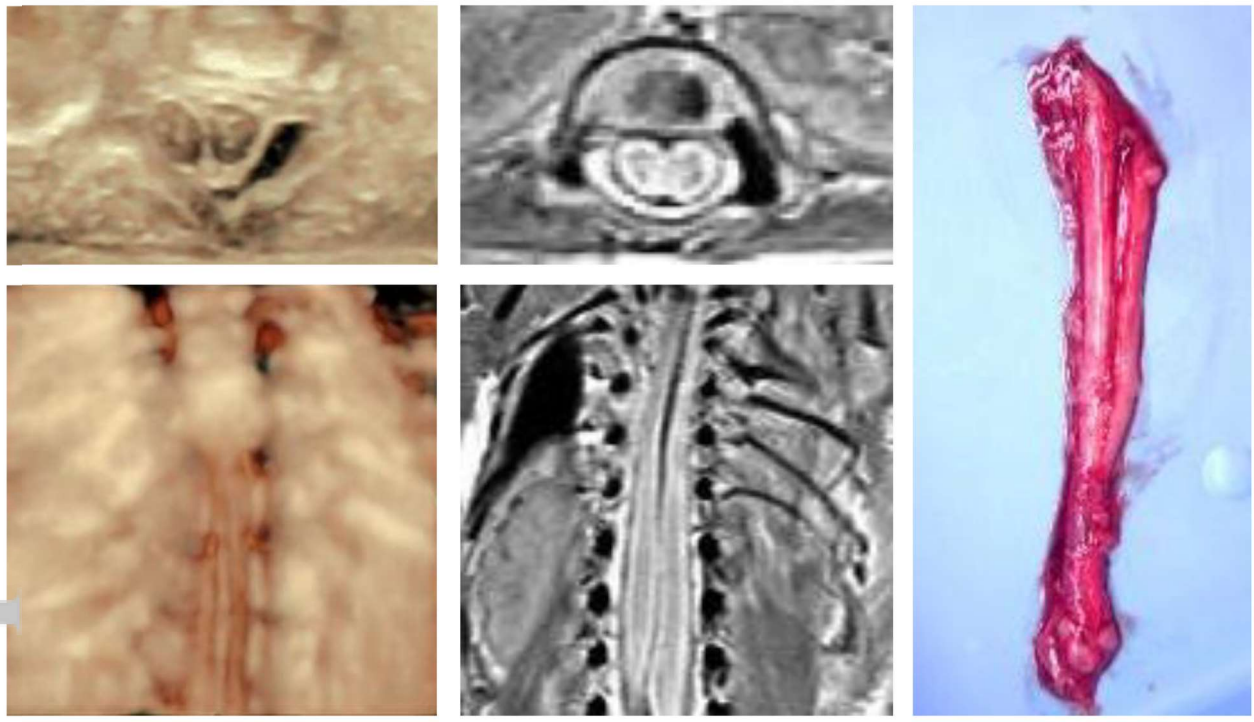

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