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CASE REPORT

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Prenatal sirenomelia diagnosis in the first trimester: A case report and literature review

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Key Clinical Message

Sirenomelia is a lethal condition in the perinatal period. The sonographic examination in the first trimester can effectively detect sirenomelia with a high degree of accuracy. Furthermore, vascular examinations using color flow imaging and augmented imaging techniques such as 3D sonography can improve diagnostic accuracy. Parents should get advice from a multidisciplinary team concerning sirenomelia care and prognosis as soon as possible.

Abstract

Sirenomelia is a rare condition with an uncommon congenital malformation; its most remarkable feature is lower extremity fusion with multiple visceral anomalies. Accordingly, the appearance resembles a mermaid's tail, hence mermaid syndrome. Sirenomelia has an incidence rate of 1.5–4.2 per 100,000 births, a male-to-female 2.7:1 ratio, and shows no differences across races. The condition is generally associated with renal agenesis, exterior genitalia defects, a single umbilical artery, and an imperforate anus. Here, we describe the first sirenomelia case in our hospital; a 13-week-old fetus with conjoined lower limbs was identified by ultrasound in the first trimester. We discuss this rare case with reference to the literature and provide insights on diagnosing this condition by ultrasound.

KEYWORDS

caudal regression, fetal malformation, literature review, mermaid syndrome, sirenomelia

1 | INTRODUCTION

Sirenomelia is a rare, lethal congenital abnormality. It is distinguished by hypoplastic or atrophic inferior extremities with acute visceral malformations (genitourinary and gastrointestinal), vascular anomalies, and a single umbilical artery, which are manifested as multisystemic malformations associated with considerable phenotypic variability.[1] The incidence rate is reported to range from 1.5 to 4.2 per 100,000 births, with no differences between races, and a male-to-female 2.7:1 ratio. Approximately 2% of mothers have maternal diabetes, and the sirenomelia prevalence in monozygotic twins is 100–150 times higher when compared with single births.[1,2] Fetal survival predominantly relies on appropriate kidney function and adequate renal outflow.[3] However, for most fetuses with

sirenomelia, death typically occurs during pregnancy or immediately after delivery.

Sirenomelia can be identified at any gestational age; the earliest abnormalities identified in fetal limb structures were determined by transvaginal ultrasound at approximately 9 weeks.[4,5] In China, according to fertility policies, pregnant women must attend hospital between 11 and 13 weeks to test for first-trimester nuchal translucency (NT) thickness to screen for fetal deformities. Before the 11th week of gestation, we routinely observe for embryo or fetal viability, not for structural abnormalities. Here, we describe a case of sirenomelia diagnosed at the 13th week of gestation and characterize the condition with reference to the literature.

2 | CASE REPORT

A 26-year-old primigravida female attended the Fetal Medicine Department of Peking University Shenzhen Hospital for a prenatal consultation at 13 + 5 weeks of gestation. She and her husband were nonconsanguineous and reported no conditions or congenital abnormalities in their family history. No previous history of drug abuse or radiation exposure was also recorded. This was the first time a primigravida female had been referred to the Ultrasound Department for routine NT screening. During the ultrasonographic scan, the length of the crown-rump was 53 mm, which corresponded to a 12-week and 3-day gestation period, and the NT measured 3.2 mm, which exceeded the normal NT range (normal: 2.5–3.0 mm). Unusually, the fetus had a severe caudal malformation, with the ultrasound showing that the lower limbs were conjoined and moved in synchrony (Figure 1, right image). A single umbilical artery was detected by color flow imaging, and a single umbilical artery derived from the iliac vessel was identified (Figure 2). Also, renal tissue was not indicated, but amniotic fluid volume was normal, as were the four heart chambers and the stomach. The decision to terminate the pregnancy was proposed due to a mermaid malformation, and informed parental consent was obtained. After termination, an external examination of the fetus showed normal ears, tongue, and bilateral upper extremities with 10 thumbs, but the fetus lacked exterior genitalia and had a perforation of the anus. Following autopsy, bones in the lower limbs were fused below the knees, resulting in two complete feet that resembled a mermaid's tail (Figure 1, left image). A grayscale cross-sectional and midline sagittal ultrasound image showed the fetus had two femurs, two tibiae, and fibulae (Figures 3 and 4). Furthermore, a postmortem chromosomal spread was normal; the gender of the fetus was not revealed. For academic research purposes, the parents did not consent to a clinical autopsy.

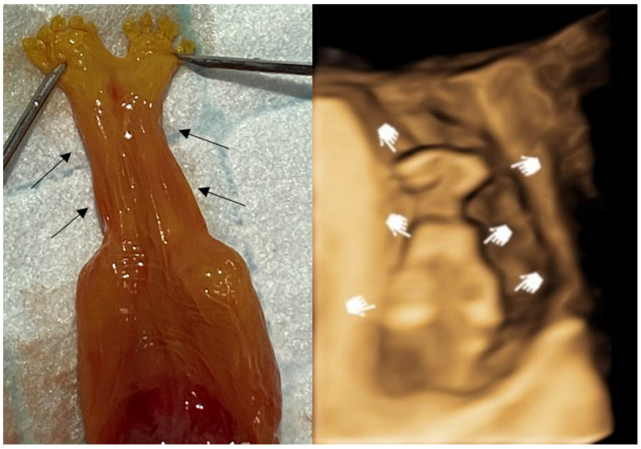


FIGURE 1 Autopsy showed that bones in the lower extremities below the knee had fused and ultimately formed two full feet, comparable to a mermaid's tail (left image, black arrows). A three-dimensional ultrasound scan showed the fused lower extremity (right image, white hands).

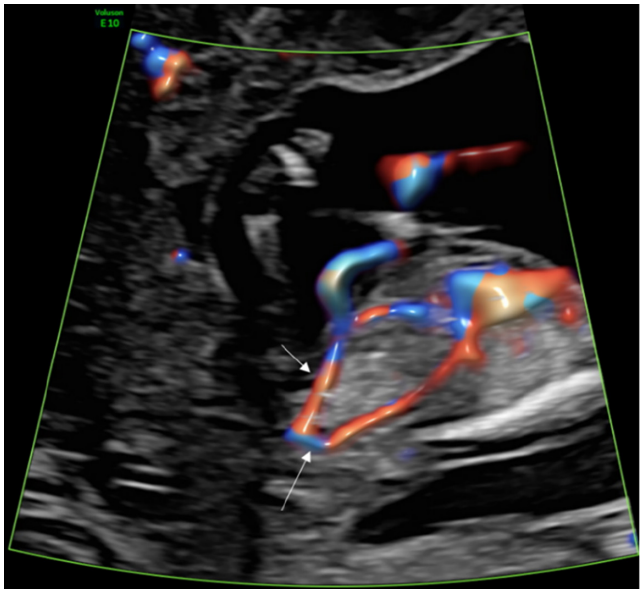


FIGURE 2 Color Doppler imaging of the fetus showing an umbilical artery (small arrow) emanating from the iliac artery (large arrow).

3 | DISCUSSION

Sirenomelia is a rare condition characterized by malformation of the gastrointestinal and genitourinary systems, fusion and skeletal abnormalities of the lower extremities, a single exceptional umbilical artery, and Potter's facies.[6] However, etiological mechanisms underlying this deformity remain unclear. Although several mechanisms have been proposed to explain mermaid syndrome, for example, maternal diabetes, genetic vulnerability, caudal mesoderm deficiency, lateral compression by amniotic folds,

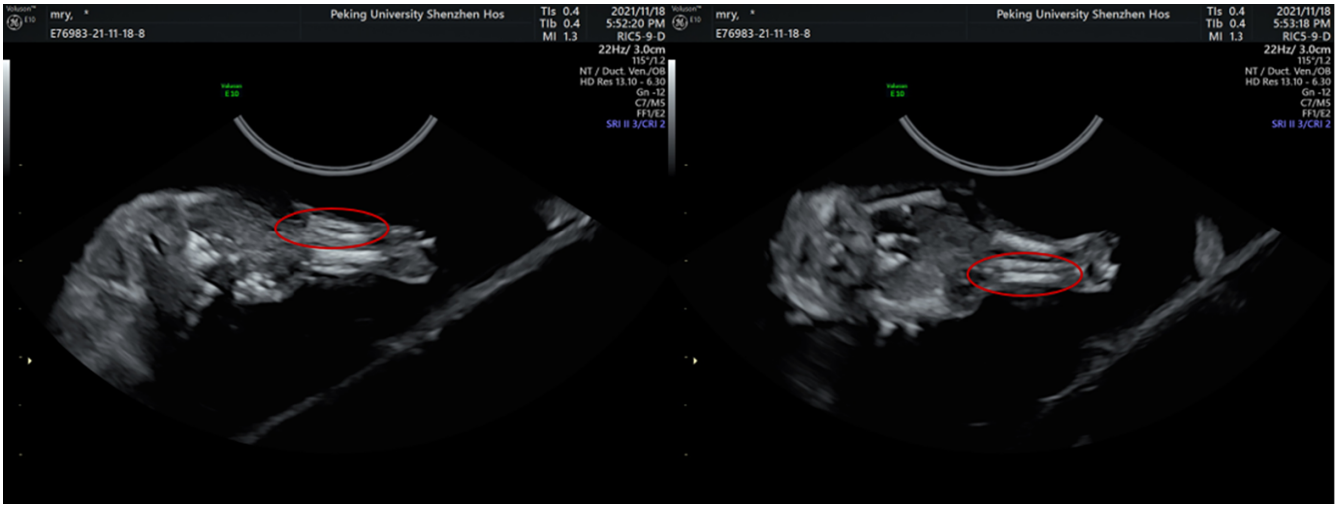
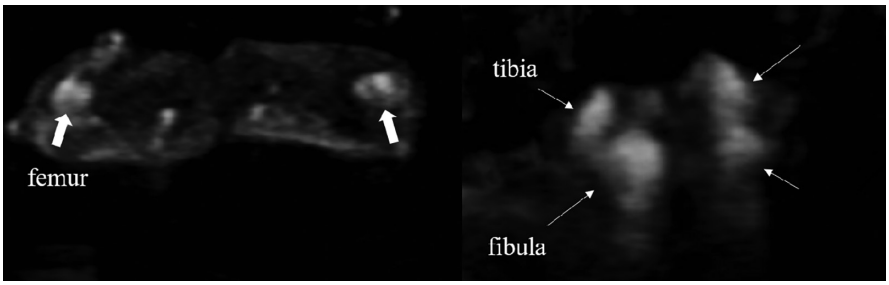


FIGURE 3 Grayscale midline sagittal ultrasound imaging performed using a vaginal probe showed on separate view that the fetus had two tibiae and fibulae (red circles).

FIGURE 4 Grayscale cross-sectional ultrasound imaging using a high-frequency probe showing the fetus had two femurs (bold arrow), two tibiae (small arrow), and fibulae (large arrow).



and a lack of blood supply in the posterior region leading to mechanical defects, the vascular theft hypothesis remains the most plausible.[7–9] It is believed that sirenomelia is caused by vitelline artery stealing in early embryonic development; the umbilical artery is directly attached to the higher-positioned abdominal aorta. Stealing blood vessels from the abnormal vitelline artery can result in decreased blood flow to the embryo tail, which inhibits embryonic development and causes embryonic malformation in the affected legs and organs.[9–12] Consequently, different visceral defects arise and are manifested as heart defects, lung hypoplasia, absence of genitalia, and anorectal anus.[13] However, unlike previous cases in the literature, our ultrasound observations showed that the umbilical artery was derived from the iliac artery and not from the high abdominal aorta. However, owing to parental disapproval of a clinical autopsy for academic research, our theory could not be corroborated. In sirenomelia cases without vascular theft, several studies have suggested other factors could be involved in sirenomelia pathogenesis.[14] Teratogens such as retinoic acid, cyclophosphamide, and cadmium have been identified in animal research.[15,16] Several genetic factors associated with sirenomelia, which contributed to caudal degeneration syndrome, were also reported, with possible multifactorial polygenic inheritance, dominant sex-linked inheritance, and autosomal dominant inheritance with variable expression and attenuated epistasis.[17]

Essentially, a sirenomelia diagnosis is difficult to establish during the second trimester due to diminished amniotic fluid volumes, which are linked to urinary tract agenesis or dysgenesis.[18] Insufficient amniotic fluid may limit the diagnosis of a lower limb deformity because renal hypoplasia results in anuria, which is critical for determining the amount of amniotic fluid, so severe oligohydramnios cases are diagnosed as malformations after birth.[4] In cases where oligohydramnios occurs due to bilateral renal hypoplasia, this may hinder the precise scanning of fetal malformations.[19] Color and power Doppler ultrasound are important for determining a prenatal diagnosis by showing a single greater vitelline artery, which arises from the proximal abdominal aorta, enters the iliac vessels without branches in the fetal pelvis, and enters the umbilical cord ventrally.[20] More importantly, two- or three-dimensional ultrasound has shown success in the first trimester, particularly the latter technique, as it provides practical clinical value for a sirenomelia prognosis.[21–23]

A sirenomelia diagnosis may be easier in the first trimester because amniotic fluid volume levels are comparatively normal and are secreted in the first trimester

from the amniotic membrane covering the placenta and umbilical cord.[24–26] The sirenomelia case reported here, which was diagnosed during the 13th week, was readily explored at this gestational age, fetus is enveloped by amniotic fluid, and the fetal head, heart, kidneys, umbilical cord, and extremities can be better displayed. Additionally, the most typical findings for sirenomelia include lower extremity fusion, thus our case was consistent with the literature.[27,28] Currently, the most widely used sirenomelia classification system is that proposed by Stocker and Heifetz[29] (Table 1); therefore, our case was assigned to category 1.

In terms of a differential diagnosis, it is vital to consider bilateral renal agenesis, megacystis, VACTER (vertebral, anal, cardiac, tracheal, esophageal, renal, and limb [congenital pattern]) association, and caudal regression syndrome (CRS).[6,30,31] Currently, the majority of studies perceive sirenomelia and CRS as different nosologic conditions that require exclusive genetic counseling.[32] In mermaid syndrome, the vagal blood vessels that arise from the vitelline artery in the fetus originate from the upper abdominal aorta and perform umbilical artery functions, transporting blood from the umbilical cord to the placenta, due to acute hypoperfusion of tissue in distal regions supplied by the abdominal aorta, resulting in extreme deformities of the spine, kidneys, lower gastrointestinal tract, genitourinary tract, and genitalia.[9] Additionally, some studies have proposed that mermaid syndrome is more serious than CRS, with both sharing common vascular features.[33] Sirenomelia manifests with more severe caudal hypoplasia when compared with CRS; it presents with a single abnormal umbilical artery, absence of an anus, and lower extremity fusion into a single limb, which causes the typical mermaid-like appearance. Additionally, acute renal hypoplasia contributes to oligohydramnion. In contrast, CRS manifests with two umbilical arteries, hypoplasia of both lower extremities, nonlethal kidney manifestations, and an imperforate or normal anus.[7,8,30,34,35]

Sirenomelia is a rare congenital anomaly, the prognosis of which depends on the extent of the deformity. A fetal prognosis may be improved as long as there are no severe cardio or neurological deficiencies. Additionally, survival and short-term prognosis depend largely on adequate renal functions and outflow.[3] Long-term problems incorporate bladder nerve dysfunction, progressive kidney damage, and paralysis caused by neuromuscular defects in the lower extremities.[36,37] Our case demonstrated that bone fusion below the knee and multiple absent pelvic organs were not compatible with postpartum life.

TABLE 1 Sirenomelia classification by Stocker and Heifetz.[29]

Type	Characteristics
I	All thigh and leg bones present
II	Single fibula
III	Absent fibula
IV	Partially fused femurs, fused fibula
V	Partially fused femurs, absent fibula
VI	Single femur, single tibia
VII	Single femur, absent tibia

4 | CONCLUSIONS

Mermaid syndrome is a rare disorder with a poor prognosis. Much debate has ensued on disease pathogenesis and the etiology that predispose to the condition. Ultrasound, although difficult, can be used to make an antenatal diagnosis. When combined with prenatal screening and related fertility policies in China, we conclude that the NT period is the most appropriate time to recognize the condition. Although not part of routine screening for six common lethal malformations, the conventional inspection of fetal extremities during this period could facilitate the earlier recognition of fused extremity malformations and provide clues for ultrasonographers to diagnose this rare condition. Similarly, a greater emphasis should be placed on proper prenatal diagnosis and care, with early termination recommended if sirenomelia is detected.

AUTHOR CONTRIBUTIONS

Xiaqing Shi: Writing – original draft. **Fengbei Kong:** Resources. **Guoru Wu:** Resources. **Yu Shi:** Supervision.

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CONFLICT OF INTEREST STATEMENT

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

CONSENT

Written informed consent was obtained from the patient to publish this report in accordance with the journal's patient consent policy.

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