

# An unnoticed variant of Sirenomelia with constellation of multiple anomalies

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## SUMMARY

Sirenomelia is a rare fatal congenital anomaly, characterized by a single midline lower limb, urogenital anomalies, Potter's facies and a single umbilical artery. Approximately 400 cases have been reported in the literature. Based on the number of feet and the degree of lower limb bone fusion, it is classified into seven different types. Sirenomelia has been reported with associated anomalies involving multiple systems mainly of urogenital, respiratory as well as the alimentary tract system. In the present case, the authors reported an unnoticed variation in the fusion of lower limbs and its rare association with tracheoesophageal fistula.

**Key words:** Sirenomelia – Mermaid syndrome – Tracheoesophageal fistula – Potter's facies

## INTRODUCTION

Sirenomelia, or Mermaid syndrome, is a rare fatal congenital anomaly, characterized by replacement of normally paired lower limbs by a fused, single midline lower limb with a single umbilical artery, anal atresia and urogenital abnormalities (Orioli et al., 2011). Urogenital abnormalities result in oligohydramnios lead to characteristic Potter facies and pulmonary hypoplasia (Al-Haggar et al.,

2010). Features of Potter facies comprise flattened nose, low set ears, epicanthal folds, receding chin and micrognathia. Oligohydramnios is also the limiting factor in the prenatal diagnosis of sirenomelia by ultrasound (US). The incidence of sirenomelia is 0.98 per 1,000,000 births, and approximately 400 cases of sirenomelia have been reported to date (Fadhlaoui et al., 2010; Orioli et al., 2011).

Although sirenomelia is traditionally considered a uniformly fatal syndrome, there are a few "rare" cases where patients survived with the help of multiple surgeries for the variable period of the lifetime; with a maximum up to the second decade (Orioli et al., 2011). Each of these rare cases documented the unilateral presence of one (or a partial) functioning kidney, and all had *sympus dipus* (fused lower limb with two feet) suggestive of less severe type. Sirenomelia reported with tracheoesophageal fistula is less than 6% (Orioli et al., 2011). In the present case, the authors reported an unnoticed variation of lower limb fusion in Sirenomelia with the rare association of tracheoesophageal fistula.

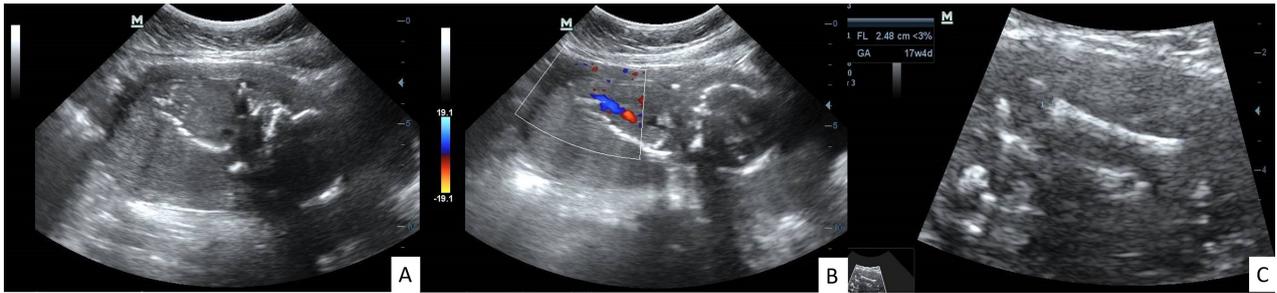
## CASE REPORT

A pre-natal US examination was performed on a 28-year-old primigravida female at 20-weeks of gestation. US examination demonstrated a single, live intrauterine fetus with anhydramnios, absent bilateral renal arteries, renal agenesis, absent urinary bladder, and the presence of only one-sided femur (Fig. 1). The fetus was aborted and sent for

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**Fig 1.** A) 2D ultrasonography showing grossly reduced liquor. B) Doppler ultrasonography showing absence of bilateral renal arteries (suggestive of renal agenesis). C) 2D ultrasonography showing a single femur, with femur length 2.48 cm, corresponding to 17 weeks 4 days of gestation.



**Fig 2.** A-B) Aborted fetus with placenta (P) showing Potter's facies; single, midline, externally rotated, flexed and fused lower limb (white arrow) with fused single foot having five toes; Outermost toes (yellow arrows) are bigger than middle toes; black arrows are showing syndactyly. C) Autopsy image showing tracheoesophageal fistula (Type C); black arrow showing reflected upper blind end of esophagus; yellow double-sided arrow showing fistulas communication between trachea (T) and distal esophagus (O); white circle shows laryngeal inlet; LL- Posterior aspect of left lung; RL - Posterior aspect of right lung; S - Stomach.

post-mortem examination.

The fetus weighed 206 grams and measured 22 cm in length. External examination showed (Fig. 2A, B):

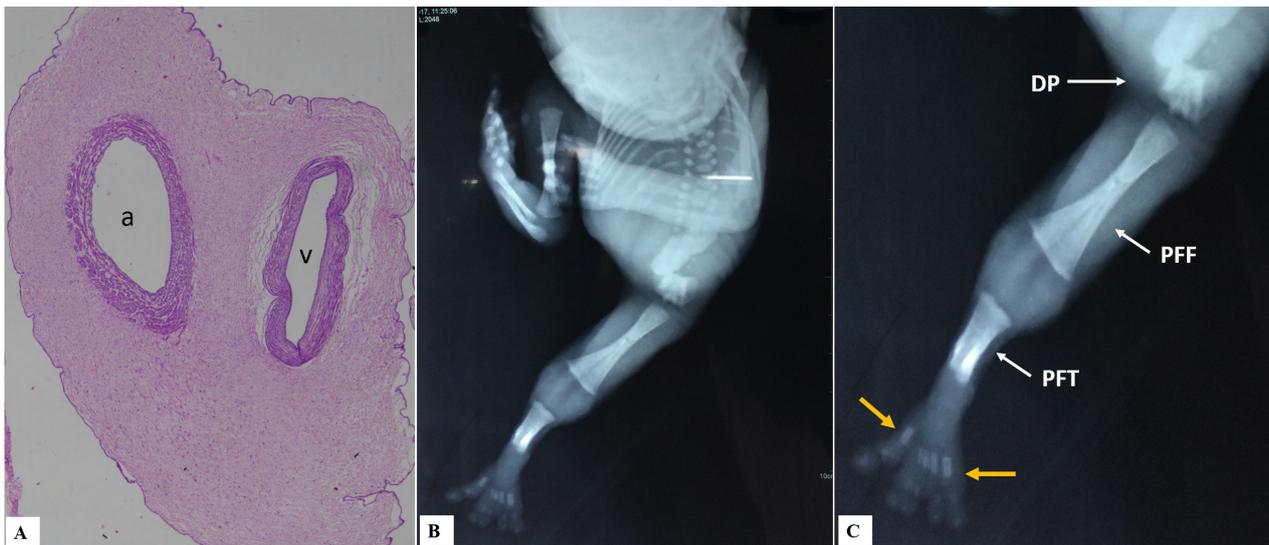
1. characteristic Potter's facies;
2. absent external genitalia;
3. imperforate anus;
4. single, midline, fused, externally rotated and flexed lower limb;
5. having a single fused foot with five toes

The first digit on either side of the foot was larger than middle toes, and this was suggestive of fusion of two inverted and externally rotated feet, articulating at the "former" lateral border. Two areas of syndactyly were noticed in this fused foot between the second-and-third toe and the fourth- and-fifth toe (numbering from the right side) (Fig. 2A, B). The placenta measured 10 cm in diameter and had a velamentous cord insertion. The umbilical cord measured 20 cm in length, and was found to

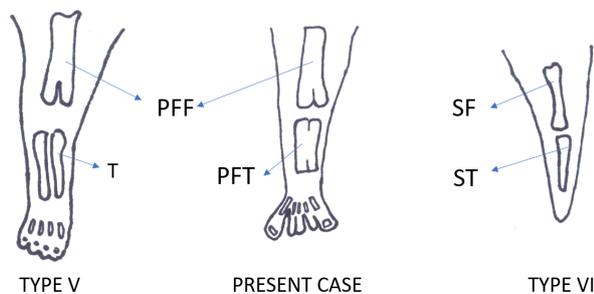
have a single umbilical artery.

Internal examination documented the presence of tracheoesophageal fistula at the mid-esophagus level communicating with the lower part of the trachea. The esophagus ended as a blind pouch just superior to the bifurcation of the trachea (Fig. 2C). The spleen was completely lobulated and attached to the tail of the pancreas and near the greater curvature of the stomach. Meckel diverticulum was found in the ante-mesenteric border of terminal ileum, measuring 0.4 cm, which was 7.5 cm away from the ileocecal junction. The proximal part of the sigmoid colon ended abruptly as a distended blind pouch that was filled with bile-stained contents. The distal part of the sigmoid colon, rectum, anal canal, bilateral kidneys, ureters and urinary bladder were absent. The corpus callosum was absent; however, all other gross anatomical structures of the brain appeared normal.

Histopathological examination of umbilical cord confirmed the presence of a single umbilical artery



**Fig 3.** A) Microscopic section of the umbilical cord confirming the presence of single umbilical artery (a) and umbilical vein (v). B-C) Radiograph of fetus showing dysplastic pelvis (DP), partially fused femurs (PFF), partially fused tibiae (PFT) and five metatarsals (yellow arrows).



**Fig 4.** Line diagram of present case showing partially fused femurs (PFF), partially fused tibiae (PFT), partially fused foot with absent bilateral fibulas; T – Tibia; SF – Single femur; ST – Single tibia.

(Fig. 3A).

Radiographic study of the fetus showed dysplastic pelvis with the absence of both ischium and pubis with fused ilium. In the lower limb, partially fused femurs and tibiae were observed with absence of bilateral fibulas. Two incompletely formed and fused foot showed five metatarsals, with the presence of larger metatarsal on lateral position. The thickness of the outermost metatarsal on either side of the foot was comparatively thicker than all others (Fig. 3B, C).

**DISCUSSION**

Sirenomelia may present with a diverse range of lower limb fusion. Based on the number of feet, sirenomelia was classified into three types, namely *sympus dipus* (two feet), *sympus monopus* (one foot) and *sympus apus* (without feet) (Orioli et al., 2011). In the present case, there is the single foot (*sympus monopus*) with five toes. The outermost toes on either side of the foot were comparatively larger than the medial toes, and radiograph of the foot showed outermost metatarsal on either side of

**Table 1.** Classification of Sirenomelia based on number of foot and pattern of fusion of lower limb bones (Stocker and Heifetz, 1987).

Based on no. of foot	Stocker and Heifetz Classification	
SYMPUS DIPUS (TWO FEET)	TYPE I	Paired femora, tibiae, and fibulae
	TYPE II	A single, fused fibula
	TYPE III	Absent fibula
SYMPUS MONOPUS (ONE FOOT)	TYPE IV	Partially fused femora and a single fibula
	TYPE V	Partially fused femora and absent fibulae
SYMPUS APUS (NO FOOT)	TYPE VI	A single femur and tibia
	TYPE VII	A single femur and absent tibiae and fibulae

the foot that were thicker than the medial metatarsals, similar to previously reported cases (Sharma and Singh, 2017). Collectively, the above features are suggestive of two inverted and externally rotated feet that were fused at the actual lateral borders of the feet to form a single foot having a great toe on either side and the dorsum of the foot facing posteriorly. A deep fissure near the right great toe indicates fusion of the single great toe of the right foot with three toes and a great toe of the left feet (Fig. 2A).

Stocker and Heifetz (1987) classified the sirenomelia based on a range of fusion of lower limb bones. In this classification, Type I is the mildest

form having paired femora, tibiae, and fibulae, and Type VII is the most severe form having a single femur and absent tibiae and fibulae (Table 1) (Stocker and Heifetz, 1987). In the present case, the authors noticed partially fused femurs, partially fused tibiae, absent fibulae with a fused foot showing five metatarsals. To the best of our knowledge after careful review of English literature, this pattern of lower limb fusion was not reported previously. It can be included in Type V with an additional subgroup. Type V comes under *sympus monopus* with partially fused femur, with absent fibulae and two tibiae. The case discussed herein falls under the description of *sympus monopus* and partially fused femur and partially fused tibia with absent fibulae (Fig. 4 and Table 1).

Sirenomelia is rarely associated with tracheoesophageal fistula. In 2011, the largest retrospective cohort study was conducted with the 40 years of data collected from 37 countries to study sirenomelia. This results of this study showed that out of 249 cases of sirenomelia reported from 25,290,172 births, only 16 cases were reported with associated tracheoesophageal fistula (Orioli et al., 2011). In the present case, there was a Type C tracheoesophageal fistula (Gross classification) (Brunicardi et al., 2015), which is the most common type of fistula, its association with sirenomelia was already reported in the literature (Sathe, 2014).

Risk of sirenomelia is increased with maternal age less than 20-years, maternal or gestational diabetes, and tobacco usage. The pathogenesis of sirenomelia was partially explained by two hypotheses: (1) insult to the caudal axial mesoderm and (2) vascular steal phenomenon during development. In former hypothesis, sirenomelia is thought to be the result of an abnormal insult to the caudal end of the axial mesoderm in the early embryogenesis, which leads to the defective formation of the lower part of the trunk and inferior extremities. In vascular steal phenomenon, it is suggested that the presence of single umbilical artery steals the blood to umbilical circulation from pelvic and inferior extremities leading to poor development (Orioli et al., 2011). However, neither of these hypotheses clearly explains cause and mechanism of sirenomelia. Several investigators have suggested that compression of the fetus secondary to amniotic band constriction (caused by entrapment of fetal parts in fibrous amniotic bands while in utero) or oligohydramnios leading to poor development and fusion of limbs; while others have reported that teratogens (i.e., cadmium, retinoic acid and irradiations) may lead to sirenomelia (Fadhlaoui et al., 2010; Bösenberg, 2005). Because the development of the distal part of the hindgut is in-part regulated by BMP4 (Bone Morphogenetic Protein) and Hoxd13, a defect in these genes may result in sirenomelia or some of the characteristics associated with its presentation. Support for this genetic

basis comes from a recent study that showed that a defect in BMP results in the fusion of two hind limb bud leading to sirenomelia (Zakin, 2005).

Although sirenomelia is a rare syndrome, most of the cases in the literature were diagnosed after the birth, unlike the case presented here that was diagnosed during gestational US. With the help of US and colored Doppler, sirenomelia can be diagnosed in the antenatal period as early as 13 weeks. However, the presence of oligohydramnios will limit the antenatal diagnosis (Kshirsagar et al., 2012).

In conclusion, sirenomelia (i.e., mermaid syndrome) is a rare fatal congenital anomaly with poor prognosis. Awareness of this rare syndrome is necessary to diagnose the sirenomelia in the early trimester by US and to perform the medical termination of pregnancy at the earliest possible time. This additional pattern of fusion of lower limb in sirenomelia should be included in Stocker and Heifetz classification for the better classification of patient presentations. Because there are limited cases reported in the literature, the authors hope that the present study will help by contributing new variant of fusion of lower limb and its associated anomalies.

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