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Congenital Right-side Rib Agenesis in a Male Lamb: A Rare Case Report

K. Vijayakaran [a++*], D.T. Kaarthick [a++], N. Arunmozhi [b#], K. Jayalakshmi [a++], P.K. Ramkumar [a++], R. Lakshmi [a++] and A. Vijayarajan [a†]

[a] Veterinary Clinical Complex, Veterinary College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Orathanadu, Tamil Nadu-614 625, India.
[b] Department of Clinics, Madras Veterinary College, Chennai, Tamil Nadu Veterinary and Animal Sciences University, Tamil Nadu-600 007, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Case Report

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ABSTRACT

Sheep play a vital role in agriculture, contributing to Gross Domestic Product (GDP) through meat, wool, and leather. The number of ribs in sheep is an important economic trait, particularly for meat production, as a higher rib count correlates with increased mutton yield. However, the congenital absence of ribs is a rare condition scarcely documented in veterinary field. This report presents the first known case of rib aplasia in a lamb, highlighting its clinical presentation, diagnosis, and

[++] Assistant Professor;
[#] Professor;
[†] Professor and Head;
**Corresponding author: Email: vkkvijay36@gmail.com;*

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implications. A two-day-old male co-twin lamb exhibited symptoms of ataxia, anorexia, and dyspnea. Physical examination revealed missing ribs on the right side and scoliosis at the thoracic vertebrae level. Chest X-rays confirmed the absence of the 9th and 10th ribs and thoracic scoliosis. Despite explanations of the poor prognosis, the lamb collapsed after two days, and no post-mortem examination was conducted. This case underscores the need for further research to identify genetic factors contributing to congenital rib agenesis in lambs, given its economic importance in the sheep industry.

Keywords: Congenital rib agenesis; genetic factors; ataxia; thoracic scoliosis.

1. INTRODUCTION

Sheep hold significant economic importance in agriculture, contributing to the Gross Domestic Product (GDP) through the provision of meat, wool, and leather. In the sheep industry, the number of ribs is a crucial economic trait, especially for sheep raised for meat production. A higher rib count is associated with increased mutton yield due to the larger body size, and ribs are particularly valued in the mutton market. Therefore, breeders frequently select larger sheep to fulfill production requirements [1]. In vertebrates, the number of rib pairs is determined by the count of thoracic vertebrae [2].

Congenital absence of ribs is a rare condition that is seldom documented in veterinary literature. Numerous cases have been reported in humans, either as isolated anomalies or as part of congenital conditions like Poland syndrome [3]. Although reports of vertebral aplasia have been noted in dogs [4], neonatal calves [5] and partial agenesis of rib plate [6]. However, there have been no previous reports of rib aplasia in lambs. This report presents a case of a lamb born with missing ribs.

2. PRESENTATION OF CASE

A two-day-old male co-twin lamb was brought to the Veterinary Clinical Complex, Veterinary College and Research Institute, Orathanadu, exhibiting symptoms of ataxia, anorexia, and dyspnoea since birth. It was noted that the other lamb was normal. Upon physical examination, the lamb appeared dull, depressed, recumbent, and unable to walk properly when forced to walk. The lamb had a rectal temperature of 37.9ºC, a respiration rate of 60 breaths per minute indicating tachypnoea, and a heart rate of 140 beats per minute indicating tachycardia. A depression was observed on the right side of the rib cage (Fig. 1). Palpation revealed intact skin and subcutaneous tissue on both sides, but some ribs were absent in the area of depression. Physical examination of the vertebral column revealed scoliosis at the level of the thoracic vertebrae (Fig. 2). Lung auscultation showed asymmetrical respiratory movement with forceful inspiration, though no abnormalities were detected in the abdomen and limbs upon palpation.

Fig. 1. Lamb showing depression on the right side of the ribcage

Fig. 2. Lamb showing the curvature of the spine at the level of thoracic vertebrae

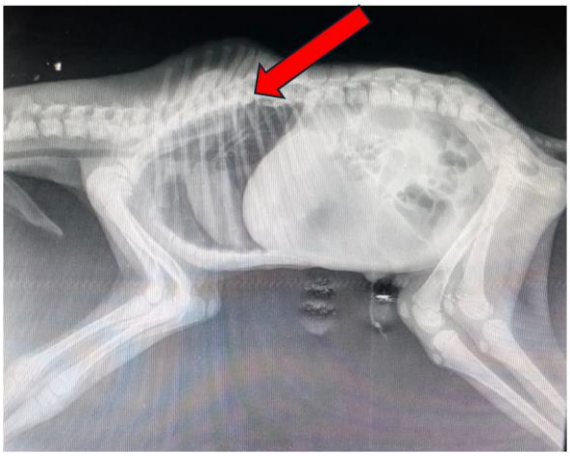

Fig. 3. Plain X-ray of thorax showing the missing of 9th and 10th rib (Lateral view)

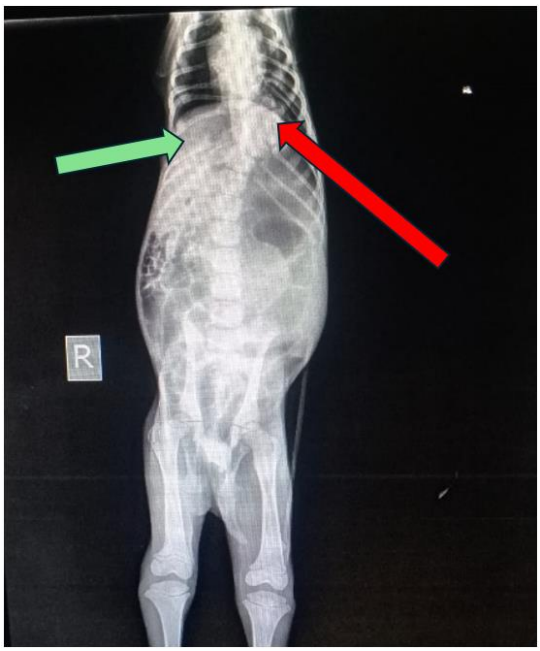

Fig. 4. Plain X-ray of thorax showing absence of the 9th and 10th rib on right side of the thorax with increased intercostal space along with scoliosis (Dorsoventral view)

A plain chest X-ray (lateral and dorsoventral views) showed normal lung fields but a complete absence of the 9th and 10th ribs on the right side with increased intercostal space as well as scoliosis of the vertebral column at the thoracic vertebrae level (Figs. 3 & 4), The other ribs were normal, and no lung anomalies were found. Based on these examinations, the lamb was diagnosed with congenital rib aplasia of the 9th and 10th ribs along with scoliosis, marking the first report of such a condition in lambs. The prognosis was thoroughly explained to the owner. Unfortunately, the lamb collapsed after two days, as there was no proven treatment for this condition and the owner declined a postmortem examination.

3. DISCUSSION

Congenital malformations in sheep have been reported to range from 0.2% to 2% in Australia, New Zealand, and the United States, with 50% of

these malformations involving the musculoskeletal system [7,8]. These anomalies can arise from genetic factors, infections, consumption of teratogenic plants or toxic substances [9], drug administration during pregnancy [10], and nutritional deficiencies [11].

Lambs typically have 13 pairs of ribs. Congenital rib anomalies are rare in veterinary species but have been previously documented in dogs [12] and calf [6]. Such congenital rib defects can occur as isolated malformations or alongside other abnormalities [13]. While various causes for rib agenesis have been proposed in humans, these have not been extensively studied in animals. In humans, rib agenesis may be due to impaired blood supply during the embryonic period, and the absence may involve a segment or the entire rib [3]. Congenital rib absence is usually unilateral and can affect a single rib, multiple ribs, or the entire thoracic cage [3]. In the current case, the condition of the lamb mirrors the previous reports in a calf [6] and in humans [3] with a unilateral agenesis of ribs.

Bulld et al. [14] and McDowell [15] noted that vitamin A deficiency can led to disorganized bone growth in various animals and humans due to osteoblast and osteoclast dysfunction. Additionally, Giadinis et al. [16] reported that hypovitaminosis A caused vertebral aplasia or agenesis in lambs. Although vitamin A deficiency could be a factor in the rib agenesis observed in the present case, however, serum vitamin A levels were not measured.

Congenital rib anomalies in animals are closely tied to disruptions in rib development during embryogenesis [17]. Homeobox gene family (Hox genes), crucial in developmental biology, encode transcriptional regulators that guide development along the head-to-tail axis. These genes' specific regional functions depend on their expression patterns, with disruptions causing developmental defects [18]. In vertebrates, Hox genes provide positional information to embryonic tissues from the three germ layers. Loss-of-function mutations in Hox genes can alter tissue identity within their expression domains, affecting structures derived from endoderm or mesoderm-like ribs [19,20]. HoxPG10 genes, for instance, suppress rib formation, with ectopic expression leading to rib-less animals [21]. HoxPG9 genes influence the development of sternal versus floating ribs [22]. Apart from that, HoxPG6 and HoxPG5 also play critical roles in rib development indicating that no single Hox gene inactivation causes complete rib loss, indicating multiple Hox groups or other genes are involved in rib formation [23,22]. Additionally, the SYNDIG1L gene and SFRP4 gene have been linked to thoracic vertebral and rib number in sheep [1,24].

Congenital absence of ribs is a rare condition with uncertain etiology and typically involves other developmental defects in the vertebral column, thoracic wall muscles, and pleura, often accompanied by scoliosis [25]. In this case, the lamb exhibited scoliosis at the thoracic vertebrae along with congenital absence of the right 9^{th} and 10^{th} ribs. In human beings, it was reported that the absence of superior ribs can lead to thoracic scoliosis, affecting motor coordination and appearance, while the absence of inferior ribs can result in more severe complications like poor cardiac ejection fraction and lung herniation, leading to recurrent chest infections, tachypnoea, and dyspnoea with poor prognosis [26]. In animals, the ribs were divided into anterior and posterior ribs. In the present case, the missing right 9^{th} and 10^{th} ribs (posterior ribs) along with increased intercostal space in this lamb likely impacted respiratory and cardiovascular functions and symmetry of the ribcage, as well as conversely caused thoracic scoliosis. Widening of the intercostal space in the left anterior chest wall can increase the risk of vital organ injury and intercostal herniation of the lung. This change may result in abnormal attachment of intercostal muscles, hampering lung expansion and causing localized lung secretion accumulation, which could lead to recurrent infections. It also affects breathing mechanics, requiring intercostal muscles to adapt. Significant widening can cause rib cage deformities, leading to discomfort, pain, and potential posture issues [27,28].

The symmetrical rib cage plays a crucial role in maintaining the vertebrae in the body's midline, preventing rotation due to its dual articulating surfaces on each side. The intercostal muscles, which connect the ribs, prevent them from separating on the convex side during spinal bending. As a result, any curvature of the thoracic spine necessitates vertebral rotation and rib deformation. Thus, the rib cage significantly impacts the biomechanics of the thoracic spine by creating a strong external framework, which enhances the thoracic spine's moment of inertia, particularly in the transverse plane [29,30,31]. In this case, the congenital absence of ribs along with widened intercostal space likely affected the symmetry of the rib cage which in turn might

have affected the respiratory mechanics as well the biomechanics of the thoracic vertebrae by providing uneven load to the vertebrae during the development of the fetus, leading to scoliosis, which is consistent with the findings of Gogala [31].

The diagnosis of congenital rib absence in this lamb was established through clinical examination and chest X-ray. In humans, 3D-CT, which is more effective than plain radiography for detecting such abnormalities, is typically used, but economic constraints prevented its use in this case. After two days, the lamb collapsed, likely due to the deformity of the lower (posterior) ribs, which usually leads to recurrent respiratory infections and paradoxical respiratory movements. These issues subsequently might have caused secondary tachypnoea, dyspnoea, hypercarbia, and reduced cardiac ejection capacity, resulting in a poor prognosis. However, a postmortem was not conducted because the owner declined it.

In this case, the cause of rib aplasia remains uncertain, aligning with Esfandiari and Dehghan [11] assertion that investigating the causes of congenital anomalies in animals is challenging.

4. CONCLUSION

In conclusion, while the absence of vertebrae in lambs has been documented, there are no studies, to my knowledge, reporting the absence of ribs in lambs. In this case, the lamb exhibited complications such as tachypnea and tachycardia that could be responsible for the poor prognosis. Further molecular-level research is needed to identify the genes responsible for this congenital rib agenesis in lambs, as it is an economically significant trait in the sheep industry.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors at this moment declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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