2024, Scienceline Publication
World's Veterinary Journal
World Vet J, 14(1): 1-7.
ISSN 2322-4568

DOI: https://dx.doi.org/10.54203/scil.2024.wvj1
PII: S232245682400001-14

Diagnosis and Management of Ringwomb in Sheep: Challenges and Approaches

Mojtaba Kafi, Asghar Mogheiseh*, and Abdolah Mirzaei

Department of Clinical Sciences, School of Veterinary Medicine, Shiraz University, Shiraz, Fars, Iran

*Corresponding author's Email: mogheiseh@yahoo.com

REVIEW ARTICLE
Received: January 03, 2024
Revised: February 18, 2024
Accepted: February 20, 2024
Published: March 25, 2024

ABSTRACT

Small ruminants, including sheep and goats, constitute a major part of the livestock population in different countries of the world. About 15-32% of sheep dystocia are due to incomplete dilation of the cervix which is often called ringwomb. This disorder typically occurs during the lambing process, prompting farmers to possibly seek veterinary assistance due to delayed labor. Different causes, such as calcium and phosphorus deficiency, uterine inertia, and fetal inability to enter the cervical canal, could all lead to incomplete dilation of the cervix. In the meantime, many cases of ringwomb occur as idiopathic. Some factors, such as genetics, nutrition, and imbalance of estrogen to progesterone concentration may also contribute to incomplete dilation of the cervix. In practice, it is important to differentiate the ringwomb with similar conditions such as false dilation of the cervix, early dilation syndrome, and vaginal prolapse associated with ringwomb. In this review, the definition of ringwomb in sheep, an exploration of the structure of the sheep's cervix, the normal process of cervix dilation during lambing, etiology and symptoms of ringwomb, differential diagnosis, and different treatments are discussed.

Keywords: Cervix, Collagen, Dystocia, Sheep, Ringwomb

INTRODUCTION

Incomplete dilation of the cervix is one of the most common causes of dystocia in sheep and goats. This abnormal condition is specifically called ringwomb in sheep and goats (Voigt et al., 2021). This condition usually occurs in ewes older than three years (multiparous) and sometimes with polytocous pregnancies (Parkinson et al., 2019; Cowley et al., 2023). The prevalence of ringwomb varies in different seasons and between sheep breeding units (Mavrogianni, 2017). Breed and body condition scores do not have a strong relationship with the incidence of ringwomb. Most literature considers 15-32% of sheep dystocia due to ringwomb; however, some researchers report a much higher prevalence (Kerr, 1999; Parkinson et al., 2019). The first scientific report describing ringwomb dates back to the 1930s (Kerr, 1999). Later, in the 1950s, a more detailed description of the condition was published (Mackinnon and Bayliss, 1952). Ringwomb occurs without a specific cause. Multiple and different causes can lead to this situation. Although the precise cause of ringwomb in the ewes is not clear, there may be a significant percentage of this condition along with vaginal prolapse (Mostefai et al., 2018). In the present review, the authors aim to discuss different approaches and challenges for the diagnosis and treatment of ringwomb in sheep. The content of this review is based on the available literature and the authors' clinical experiences and observations on ringwomb in sheep at the Department of Clinical Sciences School of Veterinary Medicine, Shiraz University.

Uterine cervix anatomy

The cervical structure varies among different breeds of ewes (Kershaw et al., 2005; Naqvi et al., 2005). In Iran, a study in the Zel breed, different shapes of protrusion of the external os of the cervix into the vaginal fornix, such as duckbill, papilla, flap, slit, and rose were reported (Marzban Abbasabadi et al., 2017). Further, the papilla shape was found to be the most common among Afshari and Kurdish breeds, while the flap shape was the most commonly reported shape of the external os of the cervix among the Makuei breed (Soufyeh et al., 2014). In Iranian native breeds, the average cervical length in the luteal phase is not much different, compared to the follicular phase (6.3 cm versus 6.1 cm) (Marzban Abbasabadi et al., 2017). The average cervical length in the Afshari, Kurdish, and Makuei breeds is 4.11, 4.02, and 4.05 cm, respectively (Soufyeh et al., 2014). Additionally, in Sanjabi breed the average cervical length is 5.5 cm (Habibizad et al., 2015). The average cervical diameter in Afshari, Kurdish, and Makuei breeds is 0.95, 0.95, and 0.96 cm, respectively (Soufyeh et al., 2014). However, the average cervical diameter in the Merinos (Australian brees), Costelasta, and Assaf (south-west Asia) breeds stands at 1.03 cm (Kaabi et al., 2006). In Afshari, Kurdish, and Makuei breeds of Iran, the average number of folds is 7.4, ranging from 5 to 10 folds in each cervix. The size and distance between the folds, from the outer part of the cervix (the vaginal side) to the inner part (the uterus body side), decrease.

To cite this paper: Kafi M, Mogheiseh A, Mirzaei A (2024). Diagnosis and Management of Ringwomb in Sheep: Challenges and Approaches. *World Vet. J.*, 14 (1): 1-7. DOI: https://dx.doi.org/10.54203/scil.2023.wvj1

The distance between the first and second folds is greater than the intervals between the other folds. The interior space of the cervix is a funnel-like shape. The number of cervical folds in Afshari, Kurdish, and Makuei breeds has been reported as 5.65, 5.62, and 5.5 on average, respectively (Soufyeh et al., 2014).

Normal cervical dilation

The cervix is closed after the establishment of pregnancy, and the external os is gradually covered with secretions from the cervical mucosa. This process plays an important role in maintaining pregnancy and keeping the uterus nearly sterile. Over time, these secretions become more viscous and harder, causing complete obstruction of the cervical canal (Menzies, 2007). As the delivery approaches, however, the mucosal substance softens and gradually exits through the cervical external os. Following the hormonal changes that occur before and during parturition, the cervix and pelvic ligaments as well as the perineal area are relaxed. The alterations in the cervix are a consequence of various mechanical, hormonal, neural, and biochemical mechanisms (Jackson, 2004). Reducing progesterone and increasing estrogen, relaxin, and prostaglandins have a significant role in softening and dilating the cervix. Biochemical changes, such as a decrease in the concentration of collagen, proteoglycan, and hyaluronidase, and a small but significant increase in tissue hydration, also occur in the cervical tissues following these hormonal changes. These changes serve to soften and relax the cervical tissue. The activity of leukocyte-specific enzyme, myeloperoxidase, and changes in leukocyte concentration in cervical tissue could participate in the reorganization of cervical connective tissue (Menzies, 2007). Although much of the cervical tissue is composed of connective tissue, about 20-30% of it consists of smooth muscle, which plays an important role in opening the cervix during delivery (Marzban Abbasabadi et al., 2017). Disruption of hormonal changes near delivery can cause incomplete dilation of the cervix. The exact processes involved in the dilation of the cervix are not yet well understood in sheep. For example, the effect of relaxin on the cervix has been proven in all species, as it softens the cervix before delivery; however, in sheep, cervical relaxation may not be dependent on the blood relaxin changes (Taverne and Noakes, 2019).

Lambing stages

Natural lambing occurs in three stages, including preparation of the birth canal (relaxation and opening), preparation of the fetus for exit, and expulsion of the fetus and placenta. During the preparatory stage, regular contractions of the longitudinal and circular muscles of the uterus and the dilation and opening of the cervix occur. This stage is completed in 2-6 hours. In the second stage of labor, the amniotic membrane, head, and forelegs or hind legs enter the birth canal (Taverne and Noakes, 2019). Uterine contractions intensify as a result of the activation of the Ferguson reflex. This occurs when the fetal membranes and fluids apply pressure to the internal os of the cervix, stimulating sensory neurons. As a result, more oxytocin is released from the posterior pituitary gland, increasing the intrauterine pressure and gradually pushing the fetus into the cervix. Additionally, voluntary abdominal contractions commence due to the activation of the pelvic reflex. This occurs when the fetal membranes and fetus are present in the pelvic cavity. This stage typically lasts 30-120 minutes. The third stage is the expulsion of the placenta, which takes between 5-8 hours (Menzies, 2007).

Etiology of incomplete dilation of cervix

Although calcium and phosphorus deficiency, uterine inertia, and fetal inability to enter the cervical canal have been reported among the causes of ringwomb in sheep and goats, none of them may be the main cause of this condition. The genetic basis for the occurrence of ringwomb is likely due to the occurrence of this condition in consecutive generations of affected ewes (Jacobson et al., 2020). The profile of estrogen and progesterone secretion in the affected ewes does not provide a clear interpretation of the occurrence of ringwomb. However, a set of studies suggests that the increasing ratio of estrogen to progesterone at parturition may be a contributing factor in the development of ringwomb (Mavrogianni, 2017). Accordingly, the consumption of estrogenic diets by pregnant ewes can disrupt the physiological process of cervical dilation by disrupting the hormonal balance of estrogen and progesterone immediately before and during parturition (Srinivas and Sreenu, 2009). An imbalance in estrogen to progesterone ratio disrupts the synthesis and secretion of prostaglandins E and F in the cervical tissue, consequently causing failure in the depolymerization of cervical collagen tissue. Changes in collagen tissue are necessary for the progress of the first stage of parturition. Although no reports confirm the possibility of experimentally creating ringwomb in ewes, the injection of stilbestrol in the near stages of parturition has created a state similar to incomplete cervical dilatation (Hindson et al., 1967). Additionally, the daily injection of progesterone in the last week of pregnancy has disrupted the dilation of the cervix (Kerr, 1999).

Clinical symptoms

Incomplete dilation of the cervix may be seen during normal or delayed deliveries. On veterinary examination, the most obvious clinical feature is the placenta hanging from the vulva in ewes with incomplete cervical dilation and

without labor straining (Khan and Erdoğan, 2019). However, this definition encompasses a range of cases, from those in which the cervix has not opened at all to those in which a fetal organ has passed through the cervix. Many clinicians accept this description, but cases of an incomplete abortion (where the fetus remains in the uterus, the cervix is partially open, and the fetal membranes are outside the birth canal and hanging from the vulva) must be distinguished from ringwomb (Mavrogianni, 2017). Like ewes in a normal lambing process, affected ewes are not typically separated from the herd. Swelling and softening of the vulva and pelvic structure may not be noticeable, and mammary gland growth and colostrum accumulation may be slower than in normal conditions. The affected ewe may not enter the second stage of lambing after a period of restlessness and abdominal straining (Kerr, 1999). Leaving the animal in such a condition can lead to detachment of the placenta from the uterus, resulting in the death of the fetus. Upon examination of the birth canal, the cervix may be closed or partially open to the extent of one or two fingers. If the membranes of the fetus are intact and inside the uterus, it may be advisable to wait for the next stages of lambing. However, if the cervix is partially open and the membranes of the fetus are torn in the vagina or hanging from the vulva, then this is a case of ringwomb with no doubt (Khan and Erdoğan, 2019). After a two-hour period of examination for the progress of cervical dilation, if there is no significant change, treatment should not be delayed. Experiences have shown that the cervix will not open by simply waiting in cases of ringwomb. Some researchers believe that ringwomb does not usually occur in two consecutive lambing seasons in the same ewe, unless the cervix was damaged during the previous parturition. Ewes with ringwomb may be found recumbent on the ground with both hind legs outstretched and having difficulty breathing (Jacobson et al., 2020).

Differential diagnosis

Incomplete dilation of the cervix with similar clinical signs may occur, which must be carefully investigated to distinguish one from the other during the clinical examination. False dilation of the cervix, early dilation syndrome (EDS), vaginal prolapse associated with ringwomb, and failure to initiate lambing can all lead to incorrect diagnosis and treatment (Mavrogianni, 2017).

False dilation of the cervix

Sometimes the farmer dilates the cervix by digital manipulation before the end of the first stage of natural parturition. Depending on when the intervention takes place, the cervix may open and the lamb may be removed, or it may not be possible to open the cervix (Jacobson et al., 2020). The authors' experiences show that the cervix eventually closes in cases where it is not possible to fully open it. In some cases, due to the abnormal positioning of the fetus inside the uterus, the necessary pressure from the fetus is not applied to the cervix and therefore the cervix remains closed (Kerr, 1999).

Early dilatation syndrome

The clinical symptoms of this syndrome are largely similar to ringwomb, the main difference is that early dilatation syndrome (EDS) of the cervix is usually seen in primiparous ewes. This syndrome occurs in the last two to three weeks of pregnancy leading to natural lambing. In this situation, the mammary gland has not grown much and there is no colostrum, while in some animals, significant changes occur in a very short time, for example, overnight, and the mammary gland grows. Many cases of EDS suggest that an abortion is taking place (Kerr, 1999). On examination, fetal membranes are often hanging from the vulva and the lamb inside the uterus is either dead or crushed and macerated. If the lamb is alive, it is generally weak and premature. In these ewes, the cervix is open by one to two fingers, and in cases of maceration of the lamb in the uterus, the vaginal discharge is usually foul-smelling. Attempting to open the cervix with massage is usually futile and can cause rupture of the cervix, peritonitis, and death of the ewe. Early dilation syndrome of the cervix does not appear to have a genetic basis. If an infectious agent is responsible for the occurrence of early dilation syndrome of the cervix followed by an abortion, 5 to 30% of the herd may be affected (Kerr, 1999).

In order to accurately diagnose cases that have not yet entered the first stage of lambing, and where the ewe may have shown transient symptoms similar to parturition (such as brief straining or the discharge of vaginal-mucosal secretions), ultrasound examination can be used to determine the gestational age based on indices such as the diameter of the fetal kidney, evaluation of uterine contractions using a tocodynamometer, and measurement of blood progesterone concentration (Lye and Freitag, 1990; Mukasa-Mugerwa and Viviani, 1992). Among these methods, ultrasound examination is more convenient and practical, and if progesterone measurement kits are available, levels of progesterone above 1-2 ng/ml in the blood will indicate the absence of labor (Mukasa-Mugerwa and Viviani, 1992; Kalkan et al., 1996). In a hospital or veterinary clinic where it is possible to check the uterine contractions using a tocodynamometer, the uterus is expected to have the lowest uterine contractions in the pregnancy period, if it has not yet entered the first stage of labor.

Diagnosis and treatment of incomplete dilation of cervix

Considering the available facilities, the authors suggest two strategies for the diagnosis and treatment of ringwomb. In the first strategy, epidemiological information, clinical symptoms, and an ultrasound machine (Figure 1) are used for diagnosis and treatment. This solution can be used under farm conditions.

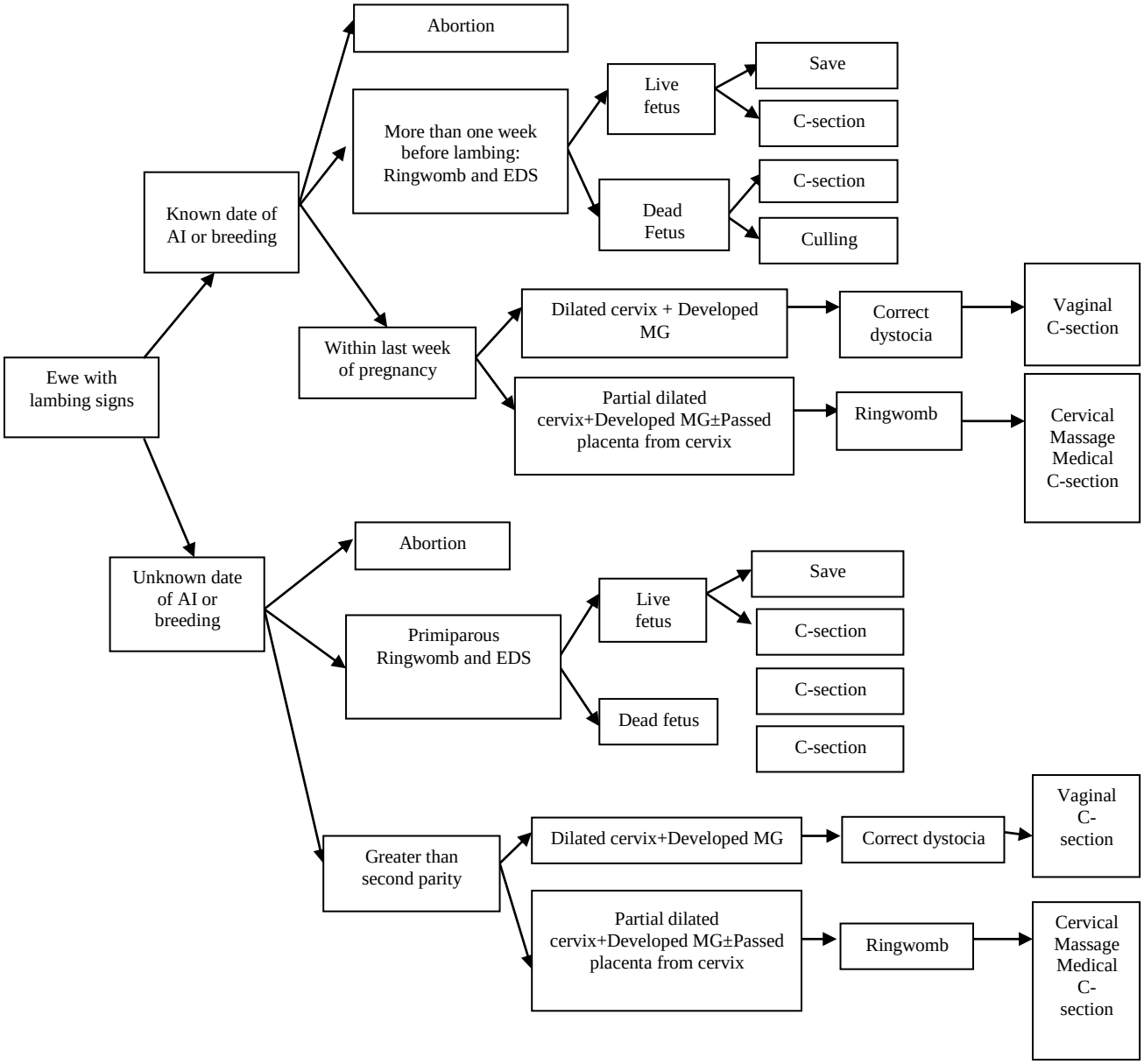

Figure 1. Diagnosis and treatment of ewes affected by ringwomb. General health of ewes needs to be considered in all cases. EDS: Early dilation syndrome; C-section: Cesarean section; AI: Artificial insemination; MG: Mammary gland.

In the second strategy, ultrasonography, tocodynamometery, and blood progesterone measurement can be used in veterinary clinics or hospital conditions (Figure 2). With these tools, along with history and clinical symptoms, it is possible to make a reliable differential diagnosis of incomplete dilation of the cervix. In the first stage, gestational age is determined by measuring the diameter of the fetus's kidney, rib bone, and aorta, and further viability of the fetus is evaluated by assessing the heart rate, fetal movements, fetal fluids, and placenta via the abdominal ultrasound examination. Abortion may be the case if there are signs of labor with a gestational age lower than normal or if the fetus is dead. In these cases, the farmer should be informed of the possibility of abortion and the necessary investigations should be carried out regarding the history and cause of abortion. Additionally, the farmer should be advised on the possibility of culling the affected ewe as it may approach abortion. To maximize the economic profit of the farmer, a valid and reliable prognosis should be given. An intra-vaginal examination can be performed using a hand covered with a glove and lubricated with a water-soluble gel. The vaginal examination provides valuable information about the degree of relaxation and dilation of the cervix and the opening of the birth canal, as well as the contents inside the vagina. Using a tocodynamometer, it is possible to measure the number and intensity of uterine contractions. In the normal course of pregnancy, uterine contractions in the range of 10 mm Hg can be distinguished from the first stage of labor with uterine contractions at regular intervals up to 40-50 mm Hg (Lye and Freitag, 1990). It is important to mention that uterine inertia may cause a wrong diagnosis. In these conditions, by considering the history, clinical symptoms, and the results of clinical and ultrasound examinations, a more correct diagnosis can be made. If it is possible to measure blood progesterone using animal-side kits, the concentration of progesterone can indicate the normal or abnormal pregnancy process. A blood progesterone level of less than 1-2 ng/ml indicates the beginning of lambing or the early stages of abortion (Mukasa-Mugerwa and Viviani, 1992).

Treatment

The following options are suggested for the treatment of ringwomb in farm conditions. Manual dilation of the cervix, injection of muscle relaxants, and cesarean section can be used (Mavrogianni, 2017; Khan and Erdoğan, 2019). From an economic perspective, the farmer may also be advised with the option of culling in specific cases. Some veterinarians have considered the treatment of ringwomb using cervical massage with fingers in some cases. However, many practitioners believe that if the cervix opens with this method, the cause of dystocia may have not been necessarily ringwomb. Cervical massage can be done carefully for 20 to 30 minutes. Care must be taken; the cervix of an ewe with incomplete dilation of the cervix is very vulnerable. It is crucial to exercise caution to avoid any tearing of the cervix of an ewe with incomplete dilation. Based on the above reasons and clinical experiences, it appears that the only approach to address ringwomb is conducting a cesarean section.

The use of muscle relaxants alone in cases of ringwomb has not resulted in high success. Muscle relaxants such as hyoscine do not have the ability to open the cervix selectively. Hormone products such as estradiol, oxytocin, and prostaglandin E2 have been used alone or in combination, but no significant success has been achieved (Padilha-Nakaghi et al., 2020). Hyoscine can be helpful when administered during the first stage of lambing as it relaxes the smooth muscle of the cervix.

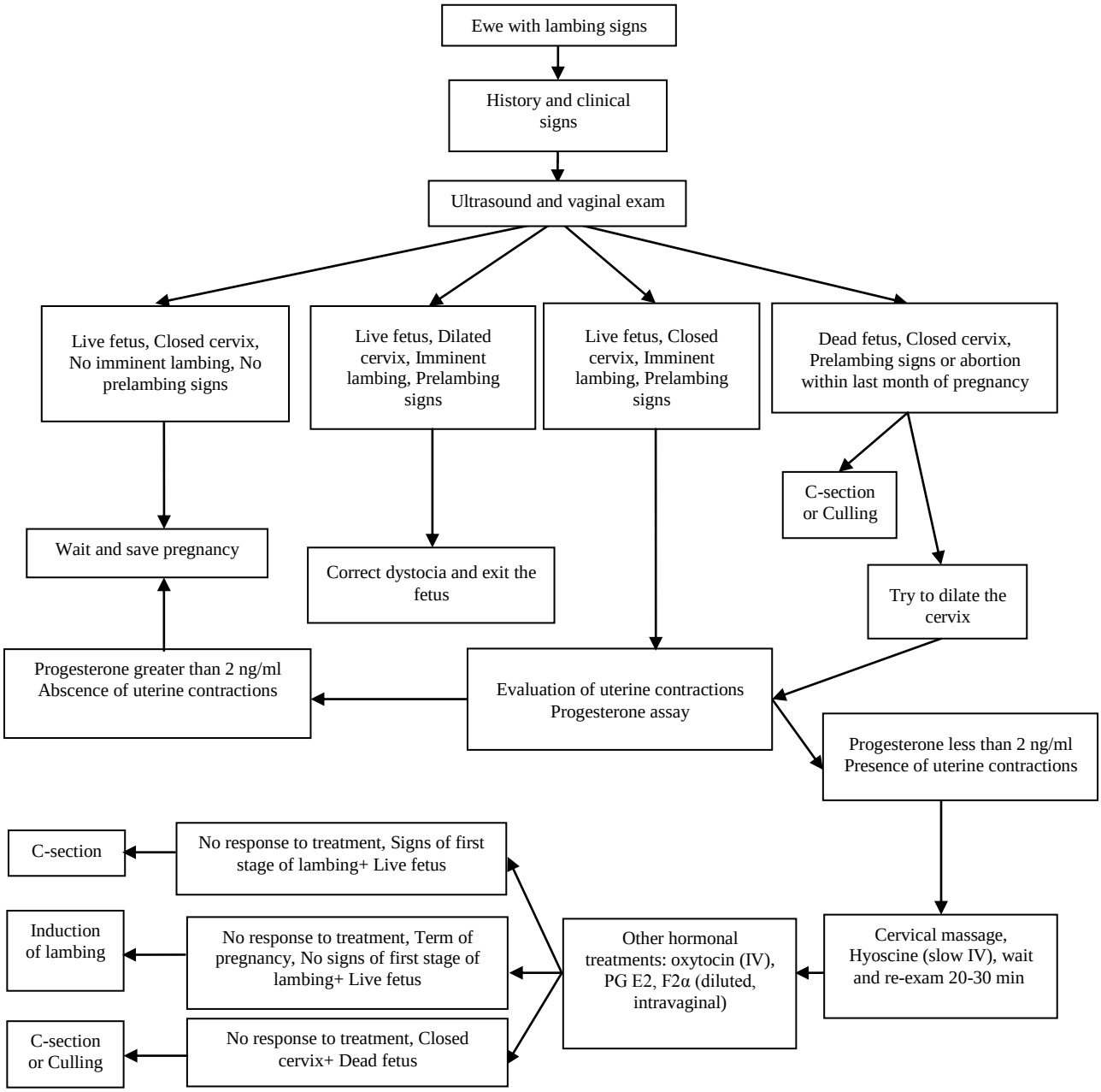

Figure 2. Differential diagnosis, treatment, and management of ewes affected with ringwomb using vaginal examination, ultrasound exam, progesterone measurement, and evaluation of uterine contractions in pregnant ewes with imminent signs of lambing. C-section: Cesarean section; IV: Intravenous; PG: Prostaglandin.

CONCLUSION

To diagnose the causes of incomplete dilation of the cervix in ewes, it is important to employ the history, clinical symptoms, and birth stages, as well as using methods including ultrasonography, tocodynamometery, and on-farm progesterone assay. Meanwhile, to maximize the economic profit of the farmer, a valid and reliable prognosis should be given considering the cost-benefit of treatment and the possibility of culling the affected ewes. Two different approaches for the diagnosis and treatment of ringworm were presented in this review. It is necessary to conduct studies aiming to identify the risk factors associated with the occurrence of ringwomb and genetic predispositions in different breeds.

DECLARATIONS

Funding
The authors would like to thank the Research Council of Shiraz University, for the financial support of this review.

Ethical considerations
Ethical issues, such as data fabrication, double publication and submission, redundancy, plagiarism, consent to publish, and misconduct, have been checked by all the authors before publication in this journal.

Acknowledgments
The authors would like to thank the Research Council of Shiraz University, School of Veterinary Medicine, Shiraz University.

Authors' contributions
All authors equally contributed to writing and editing this manuscript. The authors confirmed the last content of article before publication.

Availability of data and materials
The data of the current study are available according to the reasonable request.

Competing interests
We would like to confirm that there are no known conflicts of interests associated with this publication, and there has been no significant financial support for this work that could have influenced its outcome.

REFERENCES

Cowley J, Stockler J, and Maxwell H (2023). A review of small ruminant cesarean section: Case selection, surgical techniques, care of the neonates, and postoperative care of the dam. Clinical Theriogenology, 15: 70-81. DOI: https://www.doi.org/10.58292/ct.v.9620

Habibizad J, Karami-Shabankareh H, and Muhaghegh-Dolatabady M (2015). Influence of age and cervical grade on anatomy, morphology and depth of cervical penetration in sanjabi ewes. Journal of Livestock Science and Technologies, 3(2): 33-38. DOI: https://www.doi.org/10.22103/jlst.2015.1056

Hindson JC, Schofield BM, and Turner CB (1967). The effect of a single dose of stilboestrol on cervical dilation in pregnant sheep. Research in Veterinary Science, 8(3): 353-360. DOI: https://www.doi.org/10.1016/S0034-5288(18)34622-8

Jackson PGG (2004). Dystocia in the ewe. In: P. G. G. Jackson (Editor), Handbook of veterinary obstetrics, 2nd Edition. W.B. Saunders., Oxford, Chapter 6, pp. 105-124. Available at: https://vetbooks.ir/handbook-of-veterinary-obstetrics-2nd-edition/

Jacobson C, Bruce M, Kenyon PR, Lockwood A, Miller D, Refshauge G, and Masters DG (2020). A review of dystocia in sheep. Small Ruminant Research, 192: 106209. DOI: https://www.doi.org/10.1016/j.smallrumres.2020.106209

Kaabi M, Alvarez M, Anel E, Chamorro C, Boixo J, De Paz P, and Anel L (2006). Influence of breed and age on morphometry and depth of inseminating catheter penetration in the ewe cervix: A postmortem study. Theriogenology, 66(8): 1876-1883. DOI: https://www.doi.org/10.1016/j.theriogenology.2006.04.039

Kalkan C, Cetin H, Kaygusuzoglu E, Yilmaz B, Ciftçi M, Yildiz H, Yildiz A, Deveci H, Apaydin AM, and Ocal H (1996). An investigation on plasma progesterone levels during pregnancy and at parturition in the ivesi sheep. Acta Veterinaria Hungarica, 44(3): 335-340. Available at: https://pubmed.ncbi.nlm.nih.gov/9055457/

Kerr NJ (1999). Occurrence, etiology and management of ringwomb in ewes. Graduate Theses, West Virginia University, United States. Available at: https://researchrepository.wvu.edu/cgi/viewcontent.cgi?article=1984&context=etd

Kershaw CM, Khalid M, McGowan MR, Ingram K, Leethongdee S, Wax G, and Scaramuzzi RJ (2005). The anatomy of the sheep cervix and its influence on the transcervical passage of an inseminating pipette into the uterine lumen. Theriogenology, 64(5): 1225-1235. DOI: https://www.doi.org/10.1016/j.theriogenology.2005.02.017

Khan S and Erdoğan G (2019). A review: Obstetrical emergencies in small ruminants. Alexandria Journal of Veterinary Sciences, 62: 1-16. DOI: https://www.doi.org/10.5455/ajvs.40558

Lye S and Freitag C (1990). Local and systemic control of myometrial contractile activity during labour in the sheep. Reproduction, 90(2): 483-492. DOI: https://www.doi.org/10.1530/jrf.0.0900483

Mackinnon M and Bayliss J (1952). Caesarean section in the ewe. Veterinary Record, 64: 512.

Marzban Abbasabadi B, Kochakzadeh H, and Kaveh Aski A (2017). Evaluating gross anatomy of cervix in zel sheep. Anatomical Sciences Journal, 14(3): 115-120. Available at: https://www.sid.ir/paper/711178/en#downloadbottom

Mavrogianni VS (2017). Ringwomb in ewes and does. Journal of the Hellenic Veterinary Medical Society, 54(4): 321-328. DOI: https://www.doi.org/10.12681/jhvms.15341

Menzies PI (2007). Lambing management and neonatal care. Current therapy in large animal theriogenology, Chapter 91, pp. 680-695. DOI: https://www.doi.org/10.1016/b978-072169323-1.50094-5

Mostefai EC, Kouidri M, and Ammar S (2018). Causes of sheep dystocia in djelfa area (algeria). Revue Marocaine des Sciences Agronomiques et Vétérinaires, 7(2): 284-287. Available at: https://www.agrimaroc.org/index.php/Actes_IAVH2/article/download/760/765

Mukasa-Mugerwa E and Viviani P (1992). Progesterone concentrations in peripheral plasma of menz sheep during gestation and parturition. Small Ruminant Research, 8(1): 47-53. DOI: https://www.doi.org/10.1016/0921-4488(92)90006-P

Naqvi S, Pandey G, Gautam K, Joshi A, Geethalakshmi V, and Mittal J (2005). Evaluation of gross anatomical features of cervix of tropical sheep using cervical silicone moulds. Animal Reproduction Science, 85(3-4): 337-344. DOI: https://www.doi.org/10.1016/j.anireprosci.2003.10.007

Padilha-Nakaghi LC, Uscategui RAR, Oliveira MEF, Nociti RP, Macente BI, Coutinho LN, Nakaghi EYO, Motta GA, Santos VJC, Maciel GS et al. (2020). Local α1-adrenergic blockers: An alternative for sheep cervix dilation?. Animal Reproduction Science, 222: 106609. DOI: https://www.doi.org/10.1016/j.anireprosci.2020.106609

Parkinson TJ, Vermunt JJ, and Noakes DE (2019). Maternal dystocia: Causes and treatment. In: D. E. Noakes, T. J. Parkinson, G. C. W. England (Editors.), Veterinary reproduction and obstetrics, 10th Edition. Elsevier., St. Louis, W.B. Saunders, pp. 236-249. DOI: https://www.doi.org/10.1016/B978-0-7020-7233-8.00013-6

Soufyeh K, Rezaei H, and Kohram H (2014). Studying the anatomy of the sheep cervix and its influence on the transcervical passage of an inseminating pipette into the cervix. Iranian Journal of animal Science, 45(4): 317-325. DOI: https://www.doi.org/10.22059/ijas.2014.54346

Srinivas M and Sreenu M (2009). A retrospective study on assisted lambings. Veterinary Practitioner, 10(1): 81-83. Available at: https://www.cabidigitallibrary.org/doi/full/10.5555/20093343455

Taverne M and Noakes DE (2019). Parturition and the care of parturient animals and the newborn. In: D. E. Noakes, T. J. Parkinson, G. C. W. England (Editors), Veterinary reproduction and obstetrics, 10th Edition. Elsevier, Ltd., Amsterdam, The Netherlands, pp. 115-147. Available at: https://www.sciencedirect.com/book/9780702072338/veterinary-reproduction-and-obstetrics

Voigt K, Najm NA, Zablotski Y, Rieger A, Vassiliadis P, Steckeler P, Schabmeyer S, Balasopoulou V, and Zerbe H (2021). Factors associated with ewe and lamb survival, and subsequent reproductive performance of sheep undergoing emergency caesarean section. Reproduction in Domestic Animals, 56(1): 120-129. DOI: https://www.doi.org/10.1111/rda.13855