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Use of Laparoscopic AI in Enhancing Production in Small Ruminants

AUTHORS DETAIL

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Abstract

Small ruminants like sheep and goats have a great impact on the agriculture system globally. Laparoscopic artificial insemination (LAI) is the assisted reproductive technology that enhances the production in small ruminants. Various factors that affect the success of LAI in small ruminants include quality and quantity of semen, preparation of females and environmental conditions. The post-thawed semen should have motility >40% and morphological abnormalities should be <15% for LAI. Fertility rates are different in different seasons through the use of LAI technique. By accurate insemination, enhancing pregnancy rate and better management of the flock at farm; LAI can enhance the production in small ruminants. LAI is different from conventional artificial insemination techniques (TVAI and TCAI). LAI bypasses the anatomical barrier of cervix but other two conventional artificial insemination techniques cannot bypass the barrier of tortuous cervix. Moreover, LAI requires a low dose of semen whereas TVAI and TCAI require higher dose of processed semen. However, LAI possess certain challenges and limitations including high cost, complications, technical difficulties and less experienced persons, which hinders the increased adoption of this technique. Despite these challenges, the LAI is the promising procedure for increasing production and genetic improvements in small ruminants.

Keywords: Fertility, Laparoscopic artificial insemination, Semen, Small ruminants, Trans-vaginal artificial insemination

1. Introduction

The animals like sheep and goats are known as small ruminants, having a great role in the global agriculture system. The first two domesticated animals are sheep and goat. The largest population of small ruminants is present in Asia as compared to other continents (Mazinani & Rude, 2020).

The sustainability of the agriculture system depends upon the small ruminants because small ruminants are playing a key role in the production of milk, meat and wool; thus contributing to food security and a source of earning for millions of farmers. Various assisted reproductive technologies (ART) have been used to enhance the production of small ruminants. Laparoscopic artificial insemination is one of the ART which has a potential of enhancing the production in small ruminants (Sathe, 2018). Laparoscopic AI is the intrauterine insemination of semen to bypass the unique anatomical barrier (the tortuous nature of cervix) in small ruminants (Faigl et al., 2012). There are many other methods of artificial insemination like conventional Vaginal Artificial Insemination (VAI) and trans-cervical artificial insemination but the pregnancy rate in ewes/does are less when bred by these methods. But the pregnancy rate in ewes/does are high when bred with processed semen through Laparoscopic artificial insemination (Birhan, 2019).

The pregnancy rate is higher (60-80%) when farmers use the laparoscopic artificial insemination technique to deposit the processed semen in ewes and does. The LAI technique in small ruminants requires on average 20 million live spermatozoa and

one entire frozen ejaculate can be used to inseminate an average 50 ewes. Thus through LAI, the semen can efficiently be used (Cseh et al., 2012). Thus the laparoscopic artificial insemination is more beneficial than conventional artificial insemination techniques in small ruminants. In this chapter, we will explore laparoscopic artificial insemination in small ruminants, principles of LAI, factors affecting LAI, benefits of LAI and comparison with other traditional AI methods. This chapter also includes various challenges and limitations of laparoscopic AI in small ruminants.

2. Principle of Laparoscopic AI:

The laparoscopic artificial insemination is a less invasive surgical procedure of depositing processed semen in the uterus of small ruminants. The principle of this technique revolves around the different steps like invasion, visualization and insemination of semen. In this technique small holes are made on the abdomen through incision and with the help of a telescope, the visualization is made and artificial insemination is done. After sedation and preparation of surgical site of animal, the two small incisions are made on the abdomen by using 11 number blade. The incisions are 2-4 cm away on the right and left side of midline. After making the incisions, the trocars and cannula are inserted into the peritoneum. There are two types of trocars used in the procedure i.e. sharp and blunt. When peritoneum is inserted then withdrawal of sharp trocars are done and blunt cannula are pushed into peritoneum (Toni et al., 2012). The abdomen is insufflated by the air which helps in differentiation of abdominal organs. After this, the visualization of the reproductive tract is done. For this purpose, the endoscope is passed into the cannula and real time visualization is done by using the endoscope and uterus is identified. After identification of the uterus, the stab incision is made by an insemination tip on the uterus to deposit the semen in uterine horns (Vallet et al., 1992).

EQUIPMENTS:

The laparoscopic artificial insemination technique requires special instruments like telescope, trocars and cannula, light source with halogens bulbs, air insufflation unit, video camera and screen, and laparoscopic AI cradle (Swanand, 2018).

Fig 1 Pictorial Description of Laproscopy

3. Factors affecting the success of laparoscopic artificial insemination:

There are various factors that affect the success of LAI in small ruminants. These factors include semen quality, preparation of female and environmental conditions. Anything that affects the semen quality also affects the success of laparoscopic artificial insemination. Semen quality refers to the capacity or ability of semen to accomplish conception. Different semen concentrations have different results (Rudresh, 2019). Semen quality is indicated by the sperm viability, motility and morphology. The post thawed semen should have motility >40% and morphological abnormalities should be < 15% for laparoscopic artificial insemination (Spanner et al., 2024). The sperm viability also affects the success of LAI. By different research the viability of sperm for fresh semen is suggested as 75% and for post thawed semen its suggested value is >40 % (Christensen, 2005). The quantity of semen also affects the laparoscopic artificial insemination. According to the study of Maxwell, 1986, the lambing rates are maximum when we use 20 million sperm doses through laparoscopic artificial insemination. The preparation of females affects the laparoscopic artificial insemination success. Major elements of preparation of females include (selection of females, estrous synchronization and timing of insemination) (Spanner et al., 2024).

The females that are having good health and having a good body condition score (BCS) are selected. The estrous synchronization is done at the farm for better management. So, for LAI estrous synchronization is done by using hormonal mechanisms. Various types of protocols are being used for estrus synchronization. According to Maxwell, the estrus synchronization is made by the administration of progestagen impregnated sponges through intravaginal route for 12 days. After the removal of sponges, the intramuscular administration of pregnant mare serum gonadotropin (PMSG) is given. This hormone induces the estrus in small ruminants. After this observe the estrus in small ruminants by using vasectomized ram and by observing the signs of estrus (Gourley & Riese, 1990). Environmental conditions like temperature, humidity and stress affect the success of LAI in small ruminants. The optimal temperature and humidity have a great impact on the quality of semen and on the health of animals. If the temperature of the environment is high it will negatively affect the health of animals. Moreover, due to high temperature the quality of semen deteriorates during handling of semen. Different seasons have different fertility rates in sheep on laparoscopic artificial insemination. In summer 54.16%, in winter 36.92%, in spring 64.28% and in autumn 32.14% fertility rates are observed on LAI (Tácia et al., 2022).

4. Benefits of Laparoscopic AI in Small Ruminants:

There are many benefits of laparoscopic AI in small ruminants like it increases reproductive efficiency by accurate insemination, improved pregnancy rates and less transmission of diseases (because laparoscopic artificial insemination is a less invasive procedure). Laparoscopic AI enhances the genetically superior animals in the flock. Through the use of LAI technique the higher recovery rates of embryos from small ruminants after superovulation can be obtained (Joanna et al., 2023). Through the use of higher concentration of sperm, it results in increased number of embryos produced (Fernando et al., 2012). Since the LAI technique bypasses the unique anatomical barrier in small ruminants and through this technique we can directly visualize the reproductive organ and semen is deposited in uterine horns. Laparoscopic AI preserved the endangered species of small ruminants by improving the use of limited genetic resources. Through LAI technique breeders can set mating plans by preventing inbreeding (Karaca et al., 2012). Laparoscopic artificial insemination is an alternative of the other conventional techniques such as trans- vaginal artificial insemination (TVAI) and trans-cervical artificial insemination (TCAI). LAI technique is much quicker than conventional artificial insemination techniques (Bianor, et al., 2020)

5. Comparison with Traditional AI Methods:

Laparoscopic artificial insemination is also known as the laparoscopic intrauterine artificial insemination (LIUAI). It is the alternative technique for low dose semen deposition. While other traditional techniques require higher doses of semen for artificial insemination. One of the major advantage of LAI is its unique characteristic of bypassing the anatomical barrier in small ruminants (Zemenu et al., 2020). In LAI lower dose of semen i.e. 20 million live sperms required, while the other traditional techniques such as TVAI and TCAI require higher doses (400 million, 200 million spermatozoa) respectively. LIUAI results in higher pregnancy rates (75 %) than traditional artificial insemination methods. In conventional artificial insemination methods the pregnancy rates are lower in sheep (35.7%), thus LAI is more beneficial for sheep breeders in enhancing the production (Gladys et al., 2015). LAI technique gives the real time visualization of the reproductive tract because this technique uses the video camera and screen to visualize the internal reproductive tract of animals (Sathe, 2018).

The fertilization rates are lower in traditional artificial insemination techniques because the tortuous nature of the cervix in small ruminants acts as a barrier in small ruminants and hinders the spermatozoa on reaching the fertilization site. As a result fewer numbers of embryos are produced. While fertilization rates are higher in laparoscopic AI technique because this technique bypasses the hindrance structure of cervix, thus leading to higher numbers of spermatozoa reaching at fertilization site in small ruminants. Hence a greater number of embryos are produced by utilizing the laparoscopic AI which enhances the production in small ruminants(Joanna et al., 2023).In traditional artificial insemination techniques, there are more chances of

disease transmission because in these techniques the reproductive tract of animals is more in contact with the inseminator, while in laparoscopic AI, there are less chances of disease transmission because the laparoscopic AI is less invasive procedure (Sándor et al., 2012).

6. Challenges and Limitations

Being a very efficient assisted reproductive technology (ART), the LAI also has some challenges and limitations like technical difficulties, availability of skilled personnel and cost of equipment. Various compilations also arise during the process of laparoscopic artificial insemination like rupturing of internal organs, bleeding of uterus, peritonitis and abscess formation. These complications offer a major challenge in the use of laparoscopic AI in small ruminants (Fausto et al., 2016). One the major challenge of laparoscopic AI is technical difficulties. Since this technique requires extensive training of the personnel to perform the LAI in small ruminants. But in the field there are less trained and experienced persons available to perform this technique. So this challenge limits the breeders to adopt laparoscopic AI (Dayane et al., 2014). This technique needs specific knowledge and skills to use the instrument used in laparoscopic AI, which results in less adoption of laparoscopic AI in the world (Fausto et al., 2016). Various instrument are required to perform LAI in small ruminants like telescope, video camera, screen and LAI cradle etc. These instruments are quite expensive and less available in local markets which limits the use of this technique (Purdy et al., 2009).

7. Future potential:

The future potential of LAI is highly promising in small ruminants. The advancement of various reproductive technologies , improved farm practices and advancement in robotic technology have shown an immense potential of the laparoscopic AI in small ruminants (Dovenski et al.,2012).With the development of Laparoscopic ovum pick-up (LOPU) technique the chances of future adaption of Laparoscopy are also increasing. By the use of LOPU technique many oocyte are recovered from sheep and goats and many embryos are produced by the use of in vitro-embryo production which leads to enhanced production in small ruminants and suggesting increasing applications of LAI in future (Hernan et al.,2021).
At present, the frozen semen of small ruminants is not available at large scale in the market but in future there are high chances that the more work will be done for the processing of semen of small ruminants and it will be available on large scale in the marke for the purpose of artificial insemination. This will leads to increased adoption of the laparoscopic AI in small ruminants (Milovanovic et al., 2013). The LAI technique have significant future potential because in future there will be more veterinarian and experienced person will be available for laparoscopic AI due to increasing awareness in the future.

8. Conclusion

In conclusion, small ruminants are playing a key role in maintaining the global agriculture system and small ruminants provide a good source of milk, meat and wool and thus maintaining food security. Laparoscopic artificial insemination (LAI) is one of the assisted reproductive technologies (ART) which enhances the production in small ruminants by increasing the pregnancy rates, decreasing lambing interval and higher embryos recovery rate in animals that are bred with laparoscopic AI. It increases the superior animals in the flock and also has a potential of conserving the endangered species of small ruminants. The principle of LAI revolves around minimum invasion, visualization and direct insemination of semen. Semen quality, preparation of females and environmental conditions are some factors that affect the success of LAI. Besides this age, nutrition and handling of semen also affect the success of LAI. TVAI and TCAI are conventional artificial insemination techniques. These techniques cannot bypass the anatomical barrier and require higher doses of processed semen while LAI is an advanced technique that has the ability to bypass the tortuous cervix of small ruminants and require low doses of processed semen to deposit in uterine horns. Besides having great efficiency of enhancing production in small ruminants, the laparoscopic AI possesses some challenges and limitations like technical difficulties and training, complications and high cost of the instrument. Considering all things, the LAI is a promising technique of enhancing production in small ruminants.

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