Efficacy of a novel veterinary argon plasma coagulation device in treating teat canal stenosis

NEVZAT SAAT[1], ALI RISVANLI[2,3], HALEF DOGAN[4], TARIK SAFAK[5], OZNUR YILMAZ[6], BURAK YUKSEL[2], M. AKIF KILINC[7], MUSTAFA TASKIN[8]

[1] Balikesir University, Faculty of Veterinary Medicine, Department of Obstetrics and Gynecology, 10100 Balikesir, Turkey
[2] Firat University, Faculty of Veterinary Medicine, Department of Obstetrics and Gynecology, 23100 Elazig, Turkey
[3] Kyrgyz-Turkish Manas University, Faculty of Veterinary Medicine, Department of Obstetrics and Gynecology, Bishkek, Kyrgyzstan
[4] Tekirdag University, Faculty of Veterinary Medicine, Department of Obstetrics and Gynecology, Tekirdag 59110, Turkey
[5] Kastamonu University, Faculty of Veterinary Medicine, Department of Obstetrics and Gynecology, 37100 Kastamonu, Turkey
[6] Siirt University, Faculty of Veterinary Medicine, Department of Obstetrics and Gynecology, 56100 Siirt, Turkey
[7] Bingol University, Faculty of Veterinary Medicine, Department of Obstetrics and Gynecology, Bingol, Turkey
[8] Mersin University, Faculty of Engineering, Department of Metallurgical and Materials 33100 Mersin, Turkey

SUMMARY

Teat canal stenosis is a significant factor that impedes milking and can lead to cows being unable to rear. Because the methods applied in the treatment of teat canal stenosis are mostly unsuccessful, animals with the disease are usually removed from breeding. In this case, it causes great damage to the livestock economy in the world. This study aimed to determine the efficacy of the veterinary argon plasma coagulation device, a newly developed treatment for teat canal stenosis. A two-stage study was conducted for this purpose. In the first stage, as a material, 30 teats from 30 cows of varying ages and breeds were selected. The cows were randomly divided into three groups. The first group (n=10) underwent closed operations using instruments such as occult mammary scalpels, papillomas, and udder probes, depending on the severity and condition of their teat stenosis. The second group (n=10) received a preparation containing 8 mg chemotrypsin, 8 mg trypsin, 4 mg papain, 100,000 IU retinol palmitate, and 120 mg tocopherol acetate per ml without any operation. The preparation, containing 4 mg chemotrypsin, 4 mg trypsin, and 10 mg papain in each ml, was administered intramammary three times at 12-hour intervals once a day at a dose of 0.4 ml/10 kg intramuscularly for three days. The third group (n=10) received veterinary argon plasma coagulation device through the teat canal. In the second stage, veterinary argon plasma coagulation device was utilized to treat 104 stenosed teat canals. Based on the findings, the group in which veterinary argon plasma coagulation device was applied exhibited the best recovery rate (90%) at the end of the third week in the study's first phase. In the study's second phase, 89.42% of the nipples treated with veterinary argon plasma coagulation device were completely healed. In both stages of the study, it was established that the recovery criteria could not be detected as stenosis and that the milk flow was continuous due to weekly ultrasonographic and clinical examinations. Therefore, it can be concluded that the newly developed veterinary argon plasma coagulation device is a portable device that can be used to treat teat canal stenosis.

KEY WORDS

Veterinary, Argon, Plasma, Coagulation, teat canal, cow.

INTRODUCTION

Teat stenosis refers to conditions that impede or entirely halt the normal output of milk in cows, with an incidence rate ranging from 3-10% [1-5]. The obstruction of milk outflow from the udder in cows can result from congenital or acquired disorders, usually treated with surgical intervention. However, the primary issue with both closed and open operations is the formation of bleeding in the lesioned areas during or after the operation and the development of severe adhesions during healing. Additionally, since most of the tissues resected during operations are tumoral structures, procedures performed may cause hypertrophy or hyperplasia of such structures, resulting in conditions such as further exacerbation of occlusions [1,3, 6-12].

Recent advancements in endoscopy techniques have allowed

Corresponding Author:
Ali Risvanli (arisvanli@firat.edu.tr)

for removing these stenoses through the teat or teat incisions using theloresektoscopy tools [13-17].
Frequent udder expression, teat rubbing between fingers to prevent adhesions, and using materials such as polyethylene glycol after the operation to prevent adhesions are recommended. However, these methods yield unsatisfactory results [1,3]. Enzymes such as trypsin and chymotrypsin have also been investigated as an alternative to operative methods for teat stenosis treatment. Nevertheless, success rates with such applications are generally limited [1].
The argon plasma coagulation technique is widely employed in human medicine, particularly for treating lung cancers that obstruct the bronchi, polyps in the intestines, and prostatic hypertrophy. This electrocoagulation method is applied without tissue contact. The argon-plasma coagulation device functions by ionizing argon gas, which conducts electric current. As the coagulated tissue does not conduct electricity, the risk of perforation and bleeding is low. The device enables limited and controlled penetration of 2-3 mm depth, preventing perforation in thin-walled tissues. Controlled coagulation reduces vaporization and carbonization, leading to faster lesion healing without sequelae. Due to its flexible probes, the device can be utilized in flexible and rigid endoscopic procedures, making it a preferred choice over most electrosurgery methods in human medicine [9,18,19].
This study aims to evaluate the efficacy of the argon plasma coagulation technique for treating teat stenosis, a significant udder health concern, particularly in dairy cow farming.

MATERIALS AND METHOD

The animal material required for the research was obtained from cows brought to the Department of Obstetrics and Gynecology at the Faculty of Veterinary Medicine, Fırat University, Turkey. The material consisted of 130 animals of various ages and breeds with complaints of teat canal stenosis. The study was conducted after receiving an Ethics Committee Report (08.05.2019 - 2019/68) from the Fırat University Experimental Animals Local Ethics Committee.

Animals, housing, and trial groups

The study was designed in two stages.
For this study stage, 30 teats from 30 cows of varying ages and breeds were selected. The cows were randomly divided into three groups. The first group (n=10) underwent closed operations using instruments such as occult mammary scalpels, papillomas, and udder probes, depending on the severity and condition of their teat stenosis. The second group (n=10) received a preparation containing 8 mg chemotrypsin, 8 mg trypsin, 4 mg papain, 100,000 IU retinol palmitate, and 120 mg tocopherol acetate per ml (Masti Veyxym Veyx-Pharma GMBH Schwarzenborn, Germany) without any operation. The preparation, containing 4 mg chemotrypsin, 4 mg trypsin, and 10 mg papain in each ml, was administered intramammary three times at 12-hour intervals (Nekro Veyxym Veyx-Pharma GMBH Schwarzenborn GERMANY) once a day at a dose of 0.4 ml/10 kg intramuscularly for three days. The third group (n=10) received veterinary argon plasma coagulation device through the teat canal. Intramammary antibiotics were administered to all groups of animals before and after the application to prevent mastitis. Ultrasonographic examination of the teats of all groups of animals was performed before and after the application. Additionally, the udders of the animals in each group were checked at least three times, at one-week intervals after treatment, regarding milk output.
One-hundred-four teats from 100 cows of varying ages and breeds with teat stenosis complaints were used as material to achieve this goal. Veterinary argon plasma coagulation device was applied to all teats via the teat canal. After the application, intramammary antibiotics were administered to all animals to prevent mastitis. Ultrasonographic examination of the teats of all animals was performed before and after the application. Additionally, the udders of the animals in each group were checked at least three times, at 1-week intervals after treatment, regarding milk output.

Ultrasonographic examination of the teats

USG examinations were conducted after the applications using an 8 MHz linear probe (IBEX, USA). The teats were immersed in a container filled with warm water using the water bath technique before the examinations. During the measurements related to the teat, the probe was applied vertically and parallel to the teat canal [20,21].

Application of veterinary argon plasma coagulation device

Veterinary argon plasma coagulation device was developed for the treatment of teat stenosis with the support of TÜB TAK-TEYDEB (Scientific and Technological Research Council of Turkey) project number 2170002 (Turkish Patent Submission Number: 2018/06089/Application Number: 2018-GE- 251737 and PCT International Application Submission Number: 050045/Application Number: PCT/TR2019/050045). The product has since been implemented on live animals.
Veterinary argon plasma coagulation device can be applied while the animal stands or lies down during labor. After identifying the location and severity of the disorder causing teat canal stenosis using ultrasonography and palpation, the teat was aseptically prepared, and 10 ccs of local anesthetic was injected at the base of the teat. After administering anesthesia, the probe part of the Veterinary argon plasma coagulation device was inserted through the ostium papillare, and Argon Plasma Coagulation was applied to remove the growth causing the stenosis. The application was continued until the growth disappeared and normal milk flow was restored. Ultrasonography was performed to examine the condition of the teat again, and the relief of the obstruction was confirmed (Figure 1). After the application, a plastic cannula was inserted into all teats, and various types of intramammary antibiotics were administered for 5 days.

Statistical analysis

The data were analyzed using the SPSS 22.0 statistical software package (SPSS 22.0 Edition for Windows, Chicago, Illinois, USA).
The normality of the recovery rate data for each group was visually examined using histogram and probability plots and by conducting the Kolmogorov-Smirnov test. The data were determined to be non-normally distributed and did not meet the assumptions for parametric tests. Therefore, the Kruskal-Wallis test - a non-parametric test used for multi-group comparison - was employed to compare the groups. Post-hoc pairwise group comparisons were conducted using the Bonferroni corrected Mann-Whitney-U test after Kruskal-Wallis.

Figure 1 - Application of veterinary argon plasma coagulation device to the bovine teat.

RESULTS

In both phases of the study, it was acknowledged that the recovery criteria could not be identified through weekly ultrasonographic and clinical examinations and that milk flow remained continuous (Figure 2).

The results from the first phase of the study are summarized in Table 1. Based on the weekly assessments, the highest recovery rate at the end of the third week was observed in the group where veterinary argon plasma coagulation device was applied.

The findings from the second phase of the study are presented in Table 2. Teat canal stenosis was eliminated in all teats treated with the application. However, based on the weekly assessments, the recovery rate at the end of the third week was 89.42% for the teats and 90% for the cows. After applying 14 udders, mastitis developed and was treated at various times.

During the first and second phases of the study, no complications other than mastitis occurred in any of the teats treated with veterinary argon plasma coagulation device. The affected udders, which developed mastitis, were treated, and the cows continued to lead normal lives.

Table 1 - Group-wise distribution of results from the first stage of the study.

	Week 1 Recovery	Week 2 Recovery	Week 3 Recovery
Group 1 (n=10)	3[b]	0[b]	0[b]
Group 2 (n=10)	0[b]	0[b]	0[b]
Group 3 (n=10)	10[a]	10[a]	9[a]
P	*	*	**: P 0.001

a,b: The difference between groups with different superscripts in the same column is statistically significant, (P 0.01)

DISCUSSION

Stenosis, which affects milk outflow from the breast, is caused by congenital or acquired disorders [1,22]. Typically, such disorders are treated with surgical intervention. The operation's success depends on the correct diagnosis, complete asepsis, appropriate anesthesia, and preventive antibiotic treatment. Surgical interventions are often unsuccessful, and the prognosis is poor in cases of complete occlusion of the teat canal, narrowing of the nipple canal due to overgrown tissue, growths due to chronic breast edema (subcutaneous fibrosis), and excessive lipoid and granulomatous proliferation in the milk cavities [1,2]. It has frequently been emphasized that an effective treatment method for udder obstruction in cows should prevent recurrences, be inexpensive, portable, require little expertise, and not require an operating room environment.

Recently, there has been an intense effort to transfer some treatment techniques and devices from human medicine to the veterinary field. However, there are some challenges in successfully using techniques to treat human diseases for animal health. The primary concern in farm animal husbandry is economics, as spending more money on diseases is not viable than the profit expected from an animal with commercial value. Therefore, it is necessary for devices developed for animal health to be cost-effective. There is no reason to develop expensive devices for animal health.

Another critical point to consider in animal health is that the physician goes to the patient, unlike in human medicine, particularly farm animal husbandry. Therefore, the tools or techniques used must be portable. Thanks to the veterinary argon plasma coagulation device, which forms the basis of the presented project, a device missing in treating teat stenosis in the veterinary field for years has been developed to be both low-cost and portable. The argon plasma coagulation device for veterinary purposes was designed by modifying the argon plasma coagulation device used for various purposes in human medicine. With the studies carried out, significant modifications (2-3 mm following the cow udder hole), especially on the probes applied to the patient, were made to the existing human-purpose argon plasma coagulation device veterinary argon plasma coagulation device was developed. As a result, it is now usable, portable, and inexpensive for animals.

The superiority of QESD in terms of hemostasis efficiency in partial hepatectomies performed in rabbits has been demonstrated with the QESD (Quantum Energy Surgical Device), which was designed based on the principle of applying argon gas atoms heated to a high temperature by providing kinetic energy, to tissues in the veterinary field [23]. There is no in-

Table 2 - Group-wise distribution of results from the second stage of the study.

VAPCD* is applied	Recovery negative		Recovery positive	
	n	%	n	%
Teat (n=104)	11	10.58	93	89.42
Cow (n=100)	10	10	90	90

* Veterinary argon plasma coagulation device

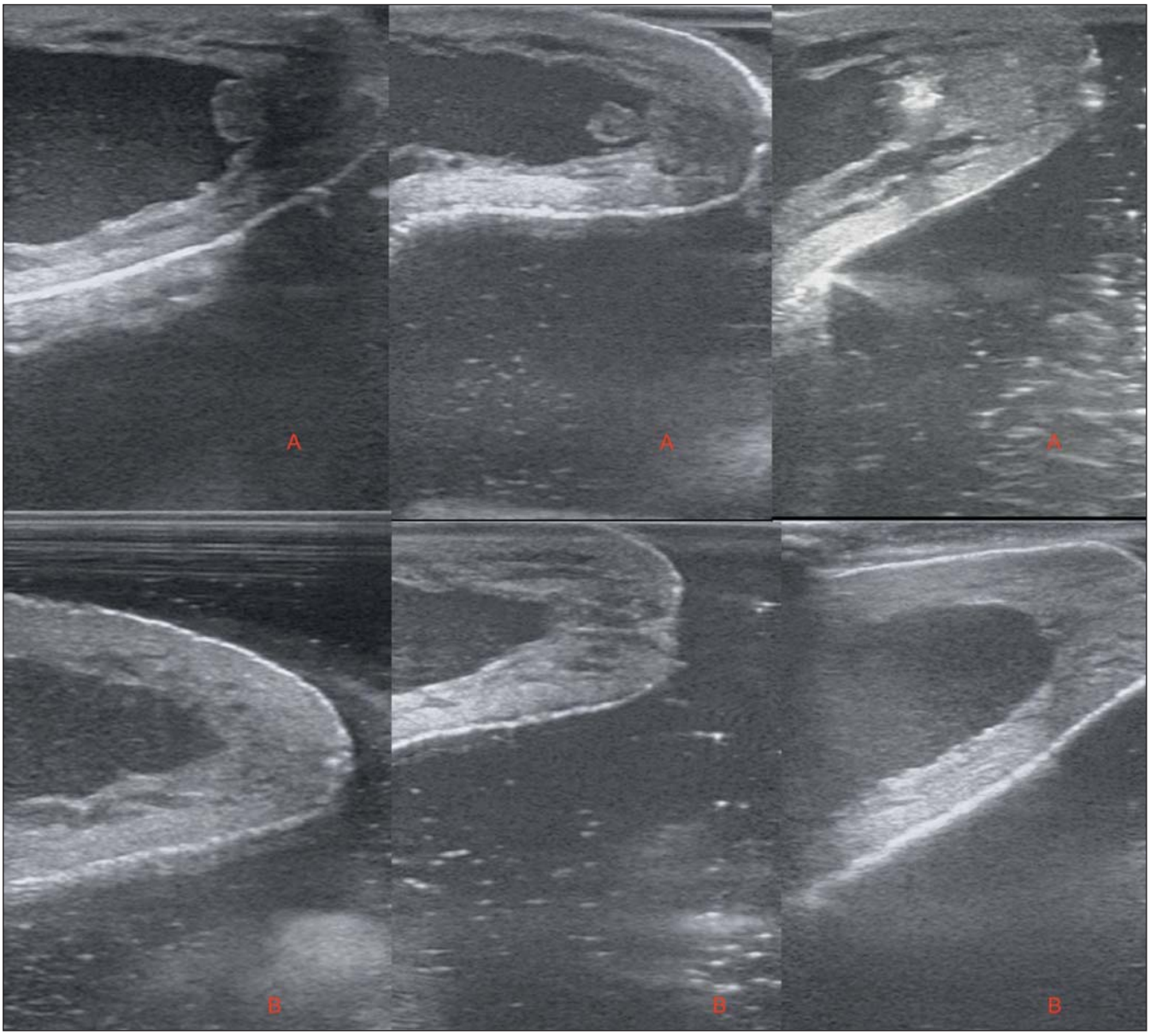

Figure 2 - Ultrasonographic view of the teats before and after the application. A. The teats before application. B. The same teats after application.

formation about using the argon plasma coagulation technique in treating teat canal stenosis. In the first phase of the presented study, the group in which the veterinary argon plasma coagulation device was applied showed the best recovery rate at the end of the third week (90%). In the study's second phase, 89.42% of the teats were applied with veterinary argon plasma coagulation device, and 90% of the animals were completely healed. The theloscopy technique developed for milk flow disorders is particularly useful in diagnosing issues in the teat cistern, as it can improve visibility [16]. However, this application requires an incision at the teat, which raises some questions. For teat canal disorders, it is essential to have methods that prevent recurrences without causing bleeding, trauma, or adhesions in the canal. Mastitis is frequently seen after closed operation techniques that worsen the situation [16]. Mastitis developed at different times after the application in 14 of 104 teats to which veterinary argon plasma coagulation device was applied. After treating the mastitis-shaped udders differently, the animals returned to normal lives.

As a result, the team in this study has developed an inexpensive and portable technique, the veterinary argon plasma coagulation device, which can be effectively used to treat teat canal stenosis. The certification and regulatory processes for the developed device are ongoing, and upon completion of these processes, activities will be initiated to promote its use.

Acknowledgements

All authors have read and approved this manuscript for submission and declare substantial contributions through conception and design of the study, acquisition of data, interpretation/analysis of data, drafting of article and revising for intellectual content. None of the authors have a conflict of interest.

Funding

This study was supported by the Scientific and Technological Research Council of Turkey (TUBITAK TEYDEB-1512, 2170002). This device was supported by program called «Leaders in Innovation Fellowship" supported by the Newton Fund, organized by the Royal Academy of Engineering.

References

1. Deveci, H., Apaydin, A.M., Kalkan, C., and Ocal, H. 1994. Mammary diseases in domestic animals. Firat Univ. Press Elazig, Türkiye,
2. Edler, B., and Grunert, E. 1994. Teat amputation in cattle: indications, surgical results and economy. *Berl. Munch. Tierarztl. Wochenschr*., 107:397-400.
3. Jarett, J.A. 1984. The veterinary clinics of North America. First Ed. Pages 86-91. W.B. Saunders Com, Philadelphia, USA
4. Abd-El-Hady, A.A.A. 2015. Clinical observations on some surgical udder and teat affections in cattle and buffaloes. *Sch. J. Agric. Vet. Sci.,* 4A: 270-281.
5. Uddin, M.A., Kamal, M.M., and Haque, M.E. 2009. Epidemiological study of udder and teat diseases in dairy cows. *Bangl. J. Vet. Med.,* 7:332-340
6. Philpot, W.N., and Nickerson, S.C. 1991. Mastitis: counter attack. Babson Bros Co, Illinois, USA.
7. Trent, A.M. 1993. Teat surgery. *Agri-pratice -Surg.,* 14:6-8.
8. Schmit, K.A., Arighi, M., and Dobson, H. 1994. Post operative evaluation of the surgical treatment of acessory teat and gland cistern complexes in dairy cows. *Can. Vet. J.,* 35:30-35.
9. Mennel, H.D., Riegel, T., Lonic, D., and Bertalanffy, H. 2002. Helium (argon) plasma coagulation in neurosurgery. Morphology of tissue damage and reparation. *Exp. Toxic. Pathol.,* 54:255-263.
10. Venkatesan, M., Selvaraj, P., Sumathi, D., and Arun, R. 2017. Teat ultrasonographic assessment of milk flow disorders in hand milked dairy cows. *Indian J. Vet. Med.,* 37: 17-23.
11. Seeh, C., Hospes, R., and Bostedt, H. 1996. Use of visual methods (Sonography/Endoscopy) for the diagnosis of a webbed teat in cattle: a case report. Tierarztl. Prax., 24:438-442.
12. Couture, Y., and Mulon, P.Y. 2005. Procedures and surgeries of the teat. *Vet. Clin. North. Am. Food Anim. Pract*., 21:173- 204.
13. Jonh, H., Sicher, D., Puterla, J.B., Gobet, D., Stocker, H., Jaeger, P., Rusch, P., and Hassig, M. 1998. Video-assisted thelescopic eletroincision of a high teat stenosis. *Schweiz. Arch. Tierheilkd.,* 140:282-286.
14. Medl, M., Querengasser, K., Wagner, C., Paarmann, S. and Rusch, P. 1994. Clarification and treatment of teat stenosis using endoscopy. *Tierarztl. Prax.,* 22:532-537.
15. Geishauser, T., Querengässer, K. and Querengässer, J. 2005. Teat endoscopy (theloscopy) for diagnosis and therapy of milk flow disorders in dairy cows. *Vet. Clin. North. Am. Food Anim. Pract*.,21: 205-225.
16. Geishauser, T., and Querengasser, K. 2001. Using teat endoscopy (theloscopy) to diagnose and treat milk flow disorders in cows. *Bov. Pract.,* 156-164.
17. Querengässer, J., Geishauser, T., Querengässer, K., Bruckmaier, R., and Fehlings, K. 2002. Investigations on milk flow and milk yield from teats with milk flow disorders. *J. Dairy Sci.,* 85:810-817.
18. Platt, R.C. 1997. Argon plasma electrosurgical coagulation. *Biomed. Sci. Instrum.,* 34: 332-337.
19. Raiser, J., and Zenker, M. 2006. Argon plasma coagulation for open surgical and endoscopic applications: state of the art. *J. Phys. D. Appl. Phys.*, 39;3520-3523.
20. Sekmen, G., Safak, T., Yilmaz, O., Yuksel, B.F., Risvanli, A., and Seker, I. 2020. The relationship between ultrasonographic measurements of teat canal and mastitis in cows. *Erciyes Univ. J. Fac. Vet. Med.,* 17:131-137.
21. Seker, I., Risvanli, A., Yuksel, M., Saat, N. and Ozmen, O. 2009. The relationship between cmt scores and ultrasonographic teat measurements in dairy cows. *Aust. Vet. J.,* 87:480-483.
22. Riedl, J., Kiossis, E., Muller, M., Seidl, S., Stolla, R., and Hermanns, W. 2004. Endoscopic, pathologic-anatomic and histologic findings in the bovine teat. 2. Changes in the area of Fürstenberg's rosette. *Dtsch. Tierarztl. Wochenschr.,* 111:423-429.
23. Perk, C., Mutlu, Z., Gurel, A., and Haktanir, D. 2006. Comparison of electrocautery and quantum energy surgical devices in experimental partial hepatectomies. *Turkish J. Vet. Anim. Sci.,* 30:77-82.