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Invited Review Article

Interventional ultrasound in bovine medical practice - emerging clinical applications: A review

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Abstract

With India leading the World in milk production, many dairy farmers and compassionate owners of valuable dairy cows are demanding advanced clinical solutions to save their elite dairy cows from high morbid disorders. Hence the practice of Advanced Internal Medicine becomes highest necessity in Indian Bovine Practice. While Ultrasound is deployed for bovine practice in India, their current applications are limited to diagnostic applications. Unfortunately many novel applications of Ultrasound had not percolated into veterinary medical practice in general and bovine practice in particular. Interventional Ultrasound is one such paradigm. It has evolved over the last 3 decades in human medicine and is slowly gaining momentum in to animal medicine. Certain groups of large animal physicians had started deploying interventional ultrasound for large animal clinical applications. This paper reviews the current state of interventional ultrasound applications in bovine medical practice. The applications of interventional ultrasound in animals included image guided biopsy, aspiration and drainage techniques as well as intraoperative interventions. There is an unparalleled growth in the field of interventional ultrasound applications in small animals. New image guided interventional techniques such as cavity drainage, indwelling catheter placement, and intraoperative procedures were rapidly evolving for both large and small animals. Literature regarding Ultrasound guided percutaneous pericardiocentesis and drainage in cows with traumatic pericarditis was reviewed. Development of a Palliative Medical Therapy using Image guided Pericardial Lavage in cows was discussed in this review.

Key words: Interventional Ultrasound, Cows, Image guided Pericardial Lavage

Introduction

India is rapidly advancing on deploying cutting edge medical technologies for human health care and as a result the quality of life and longevity of human beings are getting enhanced. Certain newer medical technologies are finding their way in to veterinary medicine and vastly improved the quality of clinical care delivered for animals. While many advances have been made in the field of small animal medicine, there is no matching advancements made in the field of large animal clinical practice. Many factors like higher cost of equipment, limited availability of advanced medical infrastructure, lack of clinically skilled manpower and the higher procedure costs are stumbling block for mainstreaming modern medical technologies for bovine clinical practice.

With India leading the World in milk production, many dairy farmers and highly compassionate owners of highly valuable dairy cows are demanding advanced clinical solutions and are willing to pay a higher cost to save their elite dairy cows from high morbid disorders. Moreover considering the religious roles cows play in Indian cultural fabric, saving the life of the cows takes precedence over cost and other factors. Hence the practice of Clinical Medicine and Internal Medicine Principles is of the highest necessity for Indian Bovine Practice, while the herd health approach is the mainstay for bovine practice in the developed countries. Any advancement in Bovine Internal Medicine will have huge impacts for the developing and underdeveloped countries, where the small holder farms and few cows per family is the mainstay of livelihood for billions of poverty ridden people. Modern clinical technology and their deployments for bovine practice become essential now. This paper reviews one of the very promising medical tool – The Ultrasound, for advancing the quality of clinical care intended for the cows and ultimately the quality of life for such cows.

While Ultrasound is deployed for bovine practice in India, their current applications are limited to diagnostic applications as of now. But the number of veterinary institutions and hospitals delivering diagnostic ultrasound services are certainly limited and lots of scope exists there.

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Unfortunately many novel applications of Ultrasound had not percolated into veterinary medical practice in general and bovine practice in particular. Interventional Ultrasound – a cutting edge paradigm has evolved over the last 3 decades in human medicine. It is slowly gaining momentum in to small animal medicine. Certain groups of large animal physicians in different parts of the World had started deploying interventional ultrasound for large animal clinical applications. This paper reviews the current state of interventional ultrasound applications in bovine medical practice.

What is interventional ultrasound?

In addition to diagnostic applications, when we use the ultrasound image guidance to undertake treatment procedures, perform certain therapeutic or minimally invasive diagnostic procedures, then this practice is termed as Interventional Ultrasound. Ultrasound guided interventions is both diagnostic as well as therapeutic, minimally invasive clinical procedures, which are guided by real-time ultrasound imaging. Such interventional procedures are usually done by using attachable needle steering devices or such similar specialised devices. Image Guided Interventions may also include fine or coarse-needle biopsies of abnormalities, which were detected on ultrasound. Such image guided interventional procedures provide a firm basis for diagnosis and therapy.

In Human Medicine, multiple ultrasound guided drainage and catheterization procedures such as vascular access or central venous catheterizations, abscess drainages, nephrostomy, pleuracentesis and cholecystostomy etc., are routinely practiced as rapid and safe alternatives to conventional drainage methods which involves open surgery. Protocols, Devices and Methods for ultrasound guided minimally invasive focal tissue ablations are also rapidly developing. Focal treatment of malignant tumours in organs such as the liver and prostate, using a variety of ultrasound guided methods, are now routinely deployed in human applications. Known complications of interventional ultrasound are reportedly low with a 0.19% overall complication rate and a 0.04% mortality rate (Holm and Skjoldbye, 1996). It is now an established practice that interventional ultrasound provides a safe and cost-effective dynamic imaging modality for guidance of an increasing range of diagnostic and therapeutic interventional procedures.

Veterinary applications of interventional ultrasound

In 2005, Jacqueline Tanous Hage chronicled the applications of interventional ultrasound in small animal practice and observed that the advances in ultrasound technology combined with better understanding of biopsy, aspiration and drainage techniques, had produced unparalleled growth in the field of interventional ultrasound applications in small animals. Earlier, in 1998, Penninck and Finn-Bodner had reviewed the applications of Interventional ultrasonography, including their diagnostic, therapeutic, and intraoperative interventions, in veterinary medicine. They observed that the ultrasound-guided biopsy and fine-needle aspiration were common in small animals and new techniques such as cavity drainage, indwelling catheter placement, and intraoperative procedures were rapidly evolving.

There are three different methods for guidance of interventional procedures and they included indirect needle guidance, freehand technique and use of a needle guidance system. Indirect Method is being used for aspiration or drainage of large fluid collections and it is basically a blind technique; here the needle or catheter is not inserted using real-time guidance either through direct visualisations or through images. In the Freehand method, it allows direct needle visualization, where in the needle is placed with ultrasound guidance. The needle may be either adjacent to or remote from the ultrasound transducer, parallel or, less frequently, perpendicular to the scan plan. In the Needle Guidance Systems, most of the available systems are attached to the transducer. Such guidance systems are designed to have grooves and slots to allow the passage of different needles; some of these may be large enough to accompany small catheters. The angle, direction, or depth of the needle can be continuously monitored with real-time guidance. The guidance system holds the needle firmly along a predetermined course, which is displayed as a line or caliper on a video monitor or the ultrasound unit.

Common clinical techniques in veterinary interventional ultrasound

Aspiration is a common technique and here the aspiration of fluid depends on the amount of fluid to be aspirated and the consistency of the fluid. For example, a diagnostic thoracocentesis can be performed by placing the

needle into the fluid collection, removing the inner stylet, attaching a syringe directly to the needle and aspirating the fluid. Drainage is another technique; percutaneous drainage techniques are nowadays undertaken usually guided by ultrasound, CT, fluoroscopy or a combination of these. It is also recommended that, whenever possible, the drainage procedures must be done under ultrasound guidance. If a target area can be visualized under this technique, usually the drainage under the same technique can be done. The advantages of ultrasound are that it can be portable and that the initial needle puncture can be visualized in its entirety. Ultrasound can guide trocar catheter placement for procedures such as percutaneous abscess drainage also. Strikingly many of these newer techniques are commonly employed in small animal medicine and reports of their utility in bovine medical practice are very limited.

Ultrasound in bovine medical practice

Bovine practitioners often face challenges in arriving at a correct diagnosis and in choosing the optimal clinical management strategy. Use of advanced medical techniques like Ultrasound helps in diagnosis and management for various systemic disorders. These are also helpful for arriving prognosis of the conditions. It is essential that basic physical examination and procedures such as inspection, palpation, percussion, and auscultation shall be mandatorily done in any case, as they provide a preliminary diagnosis of digestive diseases in ruminants (Radostits *et al*., 1994). In the last few decades, special attention has been paid to advances in diagnostic methods and management of ruminant disorders especially ultrasound applications in cattle for diagnosis of cardiac disorders (Schweizer *et al*., 2003) and abdominal disorders (Braun 1998). The aim of this review is to describe the findings of the previous documented literature, on the diagnostic methods, current therapeutic and management aspects and prognosis of one of the most common high morbid disorder encountered in cattle throughout India – the traumatic pericarditis (TRP).

Diagnostic challenges in traumatic pericarditis

In the field practice, it is always challenging for the bovine practitioners to diagnose and manage bovine cardiac diseases. One such major cardiac disease is traumatic pericarditis. It has lots of complexities, as it involves pericardium, myocardium, and endocardium due to the piercing up of foreign body through reticular wall and diaphragm (Radostits *et al*., 2007). In recent years, Idiopathic pericarditis was also reported in cattle (Jesty *et al*., 2005; Saravanan *et al*., 2018). While such idiopathic pericarditis generally uncommon in cattle, it is commonly observed in humans, dogs and horses. In the diagnosis of traumatic pericarditis, besides signalment and history (Buczinski *et al*., 2010) and physical examination (Fig.1 &2), ancillary tests has to be performed; such testing includes cardiac auscultation, thoracic radiography, electrocardiography (Fig.3), ultrasound assessment, echocardiography, phonocardiography, peri-cardiocentesis for cell cytology or culture, blood gas analysis, lymph node aspirate and biopsy, blood cultures; abdominocentesis, complete blood count and cardiac catheterization (Chandan kumar singh *et al.,* 2019).

Fig.1and 2. Clinical signs in a non-descript cow and a crossbred affected with traumatic pericarditis (Brisket edema, distension of jugular vein and submandibular edema is apparent)

Fig. 3. Electrocardiography recording of cross bred cow with traumatic pericarditis Base- apex lead system. (Right arm leam placed on jugular vein and left arm lead on the chest behind the left olecranon process)

Ultrasonographic techniques & preparations: basic guidelines

1. Develop a protocol / system for ultrasonographic examination of the abdomen or of an individual organ and stick to it so that one don't miss things. A logical examination order includes starting the examination caudally and moving cranially on the left, then examining the ventral abdomen and then repeating the same procedure on the right.
2. Examination per rectum and trans-rectal ultrasound are both integral parts of the investigation.
3. Choose the most appropriate probe and frequency for the organ one wish to examine. In order to maximise visualisation of organs beneath the ribs, a convex, microconvex or phased-array probe is a logical choice. Linear or microconvex probes are most useful for ultrasonographic examination per rectum.
4. For examination of the rumen, reticulum and caecum, frequencies of 10-7.5 MHz are ideal whereas examination of the spleen, liver, small intestine and when examining deeper structures 5-2.5 MHz are required.
5. The lower frequencies (2.5MHz) are more likely to be required in large cattle where the musculature of the body wall is significant.
6. Never underestimate, however, what one can see with 10MHz linear probe if that is the only one available with him/her. They too will be useful and provide diagnostic clues.
7. Prepare the area of skin overlying the area of interest appropriately. In an ideal world all hair or wool would be removed, the skin would be cleaned and coupling gel would be applied. Preparation can take as long as or even longer than the ultrasonographic examination itself.
8. An alternative, which may not give such superior images, but is more practical in field situations includes soaking the skin with water or alcohol and using a coupling gel on the probe or parting the hair and coat using alcohol or gel directly on the skin.
9. Start the examination dorsally in the paralumbar fossa and move ventrally angling the probe cranially and caudally in order to maximise the area of visualisation.
10. Don't forget one need to constantly alter machine settings--gain and depth particularly in order to maximise the information that can be obtained from the ultrasound scan.

Ultrasound imaging windows in cattle

As would be expected, the rumen and reticulum make up the majority of the ultrasonographic anatomy of the left side of the abdomen, with the spleen also visible overlying the rumen in the mid abdominal area. Although the rumen is split physiologically into layers with gas, fluid and more solid ingesta, ultrasonographically there is enough gas throughout its structure not to be able to view anything but the wall in the near field. The same is true of the normal appearance of the reticulum.

- The rumen lies from the paralumbar fossa to the 8-9th rib space
- The reticulum is in the 5-7th rib space with the ventral blind sac of the rumen between these two structures (7th to 8th).
- The rumenal groove lies approximately equidistant between the dorsal and ventral body walls.
- The spleen lies between the body wall and the spleen is between the 11th and 9th rib spaces in the dorsal half of the abdomen--thus being larger than is usually described anatomically or seen at post-mortem.
- As we move further forward, more and more of the abdominal organs are obscured by the lung surface,

interference to abdominal organ visualization.

- Ventrally the rumen lies to the left of the midline, with a small amount of abomasum to the left of the midline.
- Abomasum and small intestine lie ventrally to the right of the midline, with some large intestine visible caudally.

Right side abdominal windows

- On the right, large intestine is visible in the paralumbar fossa, with small intestine in the most ventral segment. This is the most reliable place to find small intestine, although it is sometimes obscured by gas-filled large intestine.
- Kidney is visible just caudal to or beneath the liver between the 12th-10th rib spaces.
- Liver is visible in the 12th-7th rib spaces with the gallbladder most commonly seen in the 11th and 10th rib spaces.
- Omasum lies beneath the liver from the 11th-7th rib spaces and small intestine can be visualized ventrally from the paralumbar fossa to the 9th rib space.

Ultrasonography in the diagnosis of pericarditis

Ultrasonography of heart is performed on standing animals using 2.5 to 5.0 MHz sector or convex probes from 3th to 5th intercostal space of either sides of thoracic cavity (Mohamed and Oikawa, 2007; Braun, 2009 and Venkatesan *et al.* 2019). For better contact between the probe and the intercostal space the thoracic limbs has to be moved cranially. Ultrasound examination reveal would various forms of pathological changes namely anechoic pericardial effusion (Jesty *et al*., 2005), anechoic pericardial fluids with fibrin threads (Tharwat, 2011) (Fig.4 and 5), homogenous echoic pericardial effusion (Venkatesan *et al*., 2019) (Fig.6), and mixed echogenicities in pericardial sac (Sasikala *et al*., 2018) (Fig.7). While the ultrasound assessment can yield us a diagnosis, the farmers are interested mainly on the prognosis. Hence further prognostication efforts become essential. Without analysing the type of pericardial effusion, it would be difficult to arrive at a prognosis. The advent of interventional ultrasound is effectively helping here.

Ultrasonographic imaging of reticulum

Various studies investigated on the normal motility of the reticulum in dairy cattle and evaluated changes in these parameters in cattle with traumatic reticuloperitonitis. Motility studies are time-consuming and require patience. It has been shown that the reticulum has three biphasic contractions of which the first is incomplete. These occur over a three-minute period. In traumatic reticuloperitonitis there is a reduction or abolishment of reticular contractions, with a reduction in amplitude and increased duration of the length of contraction. A change in reticular contour is reported in traumatic reticulitis cases, but actual wall dimensions were not reported. Normal reticular wall thickness is approximately 0.4-0.55 cm in diameter in adult cattle and 0.2-0.35 cm in adult sheep and goats.

Conventional pericardiocentesis by blind techniques

Pericardiocentesis, which can be done under field conditions, was of primary importance for the diagnosis and management of cardiac tamponade in cattle (Seferović *et al*., 2006). Pericardiocentesis can be performed on the left 5th intercostal space, with an 18G spinal needle (Buczinski *et al*., 2011). Blunt metallic catheter or stillet guided flexible fenestrated PVC pipe fixed through subcutaneous tunnelling also can be adapted for pericardiocentesis (Simon *et al*., 2010). The shaved area at the ventral part of the left thorax has to be surgically prepared and the needle to be gently pushed in the direction of the contralateral elbow in the ventral part of the 5th intercostal space at a 5- to 8-cm depth. Local anesthesia with 2% Lignocaine hydrochloride of 5ml was found to be adequate for performing the pericardiocentesis (Premkumar *et al*., 2019). Before removing the stylet, the needle shall be observed for movement indicating heart beats, confirming the correct location of the needle.

Ultrasound guided percutaneous pericardiocentesis

In recent years, reports are emerging about the utility of Interventional Ultrasound in dairy animals. Ultrasound guided percutaneous pericardiocentesis and drainage was documented in many cows with traumatic pericarditis (Jesty *et al*., 2005; Selvaraj *et al*., 2013; Sasikala *et al*., 2018; Venkatesan *et al*., 2019). Under

Fig. 4. Ultrasonography of heart at left thoracic cavity 5th ICS, showing anechoic pericardial effusion with echoic fibrin materials in pericardium of traumatic reticlulo-pericarditis affected cow. Where PE – Pericardial effusion, LV- Left Ventricle, RV – Right ventricle.

Fig. 5. Ultrasonography of heart at left thoracic cavity 4th ICS, showing echoic pericardial effusion with echoic fibrin materials (Constrictive pericarditis) in traumatic reticlulo-pericarditis affected cow. Where PE – Pericardial effusion, LV- Left Ventricle, AO – Aorta.

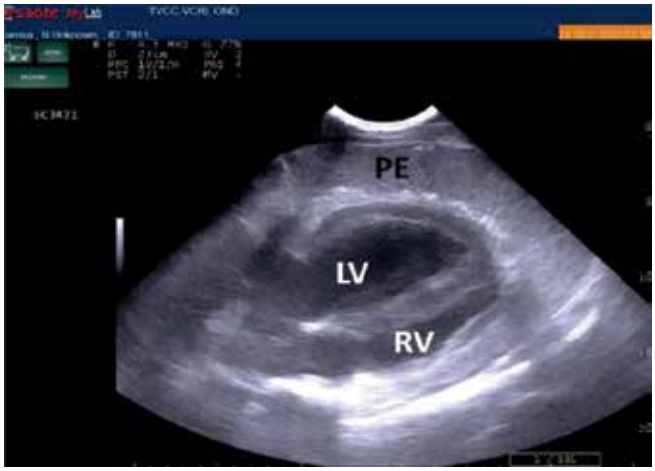

Fig. 6. Ultrasonography of heart at left thoraxic cavity 4th ICS, showing homogenous pericardial effusion in traumatic reticlulopericarditis affected cow. Where PE – Pericardial effusion, LV- Left Ventricle.

Fig. 7. Ultrasonography of heart at left thoracic cavity 4th ICS, showing turbid mixed echogenic pericardial effusion in traumatic reticlulopericarditis affected cow. Where PE – Pericardial effusion.

ultrasound guidance, percutaneous pericardio-centesis is being done using 18G needle at 4th or 5th intercostal space (Sasikala *et al*., 2018) (Fig.8a&b). Mainly such image guided centesis procedures serves as diagnostic ones. Various degrees of pathological effusions are encountered in the pericardial cavity and they differ based on the longevity of the clinical condition. In a study about one litre of foul smelling purulent brown effusion was drained (Saravanan *et al*., 2018) (Fig. 9c). In another study two litters of foul smelling serosanguinous pericardial fluid was drained out (Venkatesan *et al*., 2019) (Fig.9a), while in another study, 30 litres of fibrinopurulent exudative fluid were observed (Torki *et al*., 2010) (Fig.9b). These various levels of effusions need to be removed to provide some relief in such suffering animals. So far, such removal of accumulated fluid is done through surgical approaches or through blind techniques. Ultrasound-guided pericardiocentesis can be performed through the left fifth intercostal space by use of a trocar thoracic catheter (Jesty *et al*., 2005).

Ultrasound guided pericardial lavage as palliative medical therapy

Ultrasound guided pericardial drainage and lavage was recently documented as a useful palliative therapy in cows with traumatic pericarditis. Ultrasound guided, Therapeutic and Prognostic Percutaneous Pericardiocentesis was documented (Venkatesan *et al*., 2019) and it was done in a cow using 18G needle and an IV set. In this study, around 2 litres of foul smelling serosanguinous pericardial fluid was drained out. Subsequent to image guided pericardiocentesis, pericardial lavage was done with a mixture of 500 ml of Normal saline and 400 ml of Metronidazole by infusing it intra-pericardially, under the ultrasound guidance. Pericardial lavage with sterile saline solution is instrumental in removing debris from the pericardial space and preventing adhesions between the inflamed epicardial and visceral pericardial surfaces (Jesty *et al*., 2005). Post image guided drainage and lavage there was clinical improvement and cow was better in its activities than previous periods. However due to the recurrence of effusion, ultrasound guided drainage and lavage was repeated after two weeks. Subsequently it was done once every two weeks. With moderate clinical improvements, the procedure was done and the cow was followed up for one and half month's period. During this period, the cow was provided supportive care through parental routes with Inj. Procaine Penicillin - 5g, IM, Inj. Flunixine meglumine 2.2mg/kg b.wt. IV, Inj. Furosemide – 2 mg/kg b.wt. IV, Inj. Chlopheneramine maleate – 10 ml IM, inj. Vit B1B6 B12 – 10 ml IM for 3 days during each episode of the ultrasound guided centesis and drainage procedure. The effusion was reduced greatly by 3rd week and there was increase in the contractibility of the heart; clinical improvements were observed from day 18 onwards with reductions in jowl and brisket edema. There was improved, concentrate feed intake and the milk yield was found to be increased by 500 ml. The cow was found to be doing well even though it harboured metallic foreign body in its thoracic cavity. After one and half month of palliative medical care, ultrasonographic review confirmed the reduction of pericardial fluid coupled with clinical improvements. However, this technique has been found more useful when pericarditis occurs due to non traumatic causes i.e. through hematogenous route.

Advantage of interventional ultrasound techniques

The major advantage is that it alleviated the need for surgical interventions in affected cows. With farmers in India majorly unwilling for surgical interventions owing to the cost & socio-economic factors, interventional ultrasound techniques become the best options. While surgical techniques may have the disadvantage of mortalities, post-operative complications as well as other factors like limited availability of large animal surgical experts and lack of highly equipped facilities that can undertake thoracic surgery in large animals, especially in rural pockets. With the advent of portable ultrasound units, now it will be easier to perform procedures at field level or even at farm gates of dairy farmers. The only limiting factor is the skill sets of the veterinarians performing Ultrasound guided interventions, which can be improved through repeated trainings.

Another advantage is placement of indwelling catheters under ultrasound guidance. Indwelling catheters were fixed in cows and lavage was done with normal saline (Jesty *et al*., 2005; Venkatesan *et al*., 2019). Infusions of Metronidazole (1500 mg) in to pericardial sacs post lavage was also employed (Sasikala *et al*., 2018, and Venkatesan *et al*., 2019) and it was done either daily or at weekly interval for cows with traumatic pericarditis. Such interventional techniques also helped in the prognostication. As reduction in effusion volumes were assessed periodically. Such therapeutic and prognostic percutaneous pericardiocentesis were done using 28 FG thoracic catheters.

Conclusions

Interventional Ultrasound and its current applications in Bovine Medical Practice was reviewed. Image guided interventional techniques for applications in dairy cows are rapidly evolving and with the availability of ultraportable ultrasound machines, Point of Care Image guided Interventions had become reality in bovine practice. Ultrasound guided aspiration is a common technique in cows. Image guided diagnostic thoracocentesis is performed by placing the needle into the fluid collection, removing the inner stylet, attaching a syringe directly to the needle and aspirating the fluid. Ultrasound guided drainage is another technique routinely practiced in cows.

Fig.8 a. b. Ultrasound guided percutaneous pericardial drainage by 28 FG pericardial drainage catheter

a. Serosanguinous pericardial fluid b. Fibrinopurulent exudative fluid c. Foul smelling purulent brown effusion

Fig. 9. Pictures shows various Pericardial effusion drained from cows which affected with traumatic pericarditis.

Most promising results were observed with ultrasound guided percutaneous drainage techniques. Interventional Ultrasound also helped in development of palliative medical therapy for cows with traumatic pericarditis. It allowed the image guided placement of indwelling catheters under ultrasound guidance. Indwelling catheters were fixed in cows and pericardial sac lavage was done with normal saline. An infusion of Metronidazole in to pericardial sac post lavage was found to help in cows with traumatic pericarditis. Subsequent reductions in the effusion levels and concurrent improvement in quality of life of affected cows were observed. It is recommended that, whenever possible, the drainage procedures in thorax and abdomen can be done under ultrasound guidance. The advantages of ultrasound are that it can be very light weight and highly portable nowadays and that these interventional techniques can be employed at field level or as point of care services. Besides, interventional ultrasound techniques had totally reduced the need for surgical approaches and their associated complications.

References

Braun, U., Pusterla, N. and Anliker, H., 1998. Ultrasonographic findings in three cows with peritonitis in the left flank region. *Vet. Rec.* **142**: 338-40.

Braun, U. (2009). Traumatic pericarditis in cattle: clinical, radiographic and ultrasonographic findings. *Vet. J.* **182:**176-86.

Buczinski S., Rezakhani A. and Boerboom, D. 2010. Heart disease in cattle: Diagnosis, therapeutic approach and prognosis. *Vet. J.* **184:** 258-63.

Buczinski, S., Boulay, G. and Luc DesCôteaux. 2011. Repeated pericardiocentesis as palliative treatment for tamponade associated with cardiac lymphoma in a Holstein cow. Can *Vet. J.* **52**: 663–66.

Singh,C. K., Kumar A. and Singh, N. 2019. An overview on the diagnostic and therapeutic aspects of cardiac diseases in bovine. *J. Entomol. Zool. Stud.* 2019; **7(2):** 855-63.

Holm, H H and B Skjoldbye, (1996). Interventional ultrasound, Ultrasound Med Biol; **22(7)**:773-89. doi: 10.1016/0301-5629(96)00086-5, PMID: 8923697 DOI: 10.1016/0301-5629(96)00086-5.

Jacqueline Tanous Hage, 2005, Interventional Ultrasonography, World Small Animal Veterinary Association World Congress Proceedings, https://www.vin.com/apputil/content/defaultadv1.aspx?id=3854136&pid=11196

Jesty, S.A., Sweeney, R.W., Dolente, B.A and Reef, V.B. (2005). Idiopathic pericarditis and Cardiac tamponade in two cows. *J. Am. Vet. Med. Assoc.* **226(9)**:1555-58.

Mohamed T. and Oikawa S. 2007.Ultrasonographic characteristics of abdominal and thoracic abscesses in cattle and buffaloes. *J. Vet. Med.* **54**:512-17.

Penninck, D G and S T Finn-Bodner, (1998). Updates in interventional ultrasonography, Vet Clin North Am Small Anim Pract; **28(4)**:1017-40. doi: 10.1016/s0195-5616(98)50087-3.

Premkumar C., Dharmaceelan, S., Rajendran, N and Jagadeeswaran, A. 2019. Ultrasound Diagnosis and Pericardiocentesis under Local Analgesia for Traumatic Pericarditis in Cattle - A Clinical Study. *The Pharma Innovation Journal;* **8(3)**: 92-96.

Radostits, O.M., Blood, D.C., Gay, C.C., 1994. Veterinary Medicine. A text book of the diseases of cattle, sheep, pigs, goats and horses, 8th ed. Baillière Tindall, London. pp. 323.

Radostits, O. M., Gay, C. C., Blood, D. C., Hinchcliff, K. W. In: Radostits, O.M., Gay, C.C., Blood, D.C., Hinchcliff, K.W. (Eds.), 2007.Veterinary Medicine. A Textbook of the Diseases of Cattle, Sheep, Pigs, Goats and Horses. W.B. Saunders, London, pp. 443–51,

Tharwat M. (2011). Traumatic pericarditis in cattle: Sonographic, Echocardiographic and Pathologic findings. *Journal of Agri. Vet. Sci.;* **4(1)**:45-59.

Torki, E., Abdollahpour, G.H. Afshari, G.H., Rajabion M., Raeesian, M., Shahabi M. and Motaghinejad, M. (2010). Pleural effusion and cardiac displacement in a heifer: a case report. *Int. J. Vet. Res.* **4 (4)**: 269-71.

Saravanan M., Ranjithkumar,M., Yogeshpriya, S., Venkatesan M. and Arulkmar T. (2018). Idiopathic septic pericarditis in a pregnant cow. *Indian Vet. J.* **95(11)**: 61-63.

Sasikala, K., Vijayakumar, G., Sivaraman, S., and Balasubramaniam, G.A. 2018. Clinico Diagnostic Studies on Traumatic Reticulopericarditis in Cattle – A Review of 56 Cases. *Int. J. Curr. Microbiol. App. Sci* **7(5)**: 513-23.

Seferović PM, Ristić AD, Imazio M, et al. 2006. Management strategies in pericardial emergencies. *Herz;* **31**:891–900.

Selvaraj, P., Venkatesan, M., Nambi, A.P. and Srinivasan, S.R. 2013. Pericardiocentesis for prognostication of Traumatic reticulopericarditis in a cow. Proceeding off International clinical case conference, pp. 72.

Schweizer, T., Sydler, T., Braun, U., 2003. Cardiomyopathy, endocarditis valvularis thromboticans and pericarditis traumatica in cows – clinical and echocardiographical findings in three cases. *Schweiz Arch Tierheilk* **145**: 425-30.

Simon, M.J., William, B.J., Kumar, R.S. 2010. Surgical management of traumatic Reticulopericarditis in a cow, *Intas Polivet*, **2**: 202-03.

Venkatesan M., Selvaraj, P., Saravanan, M., Veeraselvam, M., Yogeshpriya, S. and Jayalakshmi, K. (2019). Palliative Management with Ultrasound Guided Percutaneous Pericardial Lavage for Cow with Pericarditis - A case Report. *The Indian Journal of Veterinary Sciences & Biotechnology*, **14 (3)**: 73-74.