



Traumatic reticuloperitonitis in cattle and buffalo: Recent advances in understanding of etiopathogenesis, diagnosis and treatment

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ABSTRACT

Traumatic reticuloperitonitis (TRP) is one of the common ailments caused by ingestion of foreign bodies in adult large ruminants. It is mostly reported in stall fed animals or in animals of industrial areas and has huge economic importance. Its clinical signs are obvious but are obscured in the advanced chronic cases. Diagnosis of the condition is better done through the imaging techniques, although other ancillary tests like haemato-biochemical or physico-clinical examination aides in its confirmation. Treatment is undertaken either as conservative (medicine and magnets) or invasive (surgical) with the former options considered initially. Failure of the conservative treatment is followed by the surgical option and/ or the euthanasia or slaughter. Considering the importance of TRP and its limited know how in this part of the world, the current review details about the disease etio-pathogenesis, clinical signs, diagnosis and treatment. Finally, a conclusive statement over the disease is provided.

Keywords: Buffalo, Cattle, Radiography, Traumatic reticulo-peritonitis, Treatment, Ultrasonography

Traumatic reticuloperitonitis (TRP) or hardware disease is one of the common diseases reported in adult cattle and buffalo and is caused by the ingestion of foreign bodies that perforate their foregut. Cattle and buffalo have unique mouth anatomy and due to their long prehensile tongue, they grasp feed without any selection of the feed items. Due to their unselective feeding habit, foreign bodies, metallic or non-metallic, mixed with the feed often make entry into their stomach. The risk and sequelae of TRP syndrome are considerably higher in buffalo than in cattle and extremely common within developing countries, possibly due to less organized small-scale farming and the low standards of animal management and feeding regimes (Misk *et al.* 2001). As stomach of these animals is also a complex organ divided into 4 chambers, the main chambers commonly involved in the TRP are rumen and reticulum. The potential foreign bodies are of variable types and usually of ferromagnetic nature (Jagos 1969, Ryzhakov and Lazarev 2008, Braun *et al.* 2009a, Warislohner 2017), citing the potential role magnets can play in localizing the foreign bodies. The foreign body may affect organs like liver, spleen, heart or lungs and sometimes the nerves leading to the clinical conditions like vagal indigestion (Braun *et al.* 2021).

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TRP in large ruminant continues to remain an important condition despite reduction in its incidence. It is a devastating condition for farmer as it makes animal unproductive and economically burden, unless treated early. Usually adult dairy animal are more often affected, although affection in yearlings cannot be ruled out. Decades back higher incidence of the syndrome would be reported though it has reduced to a great extent. Available literature shows incidence to reduce from as high as 80% decades ago (Maddy 1954) to the lowest of 2–3% (Starke and Rehage 2000) in recent years, although others have reported incidence of 8% (Waldner *et al.* 2009) and 10% (Cramers *et al.* 2005) in more recent times. The incidence remains high in stall fed animals wherein feed is contaminated with the foreign bodies, although animals grazing outside in the industrial areas are not less commonly affected (Braun *et al.* 2020).

Initially, TRP would be diagnosed primarily after the slaughter/ upon post-mortem but recent advances in diagnostic imaging techniques especially the radiography and ultrasonography has made it possible to diagnose the condition at an earliest (Braun *et al.* 2020). Such an early diagnosis has made it possible to make early prognosis of the case and thereby reduces the loss of animal and thereby economic burden. The current review provides a detailed account of the condition with respect to the etio-pathogenesis, symptoms, diagnosis and treatment in cattle and buffalo.

Etio-pathogenesis

The main cause of TRP is a combination of a lapse in good management and the non-selective eating habits of large ruminants (Mousavi *et al.* 2007). Bovines are more likely to ingest foreign bodies than small ruminants since they do not use their lips for prehension and thus food taken into mouth by out-swept curling action of tongue aided by backward pointing tongue papillae and very little mastication will ingest foreign bodies in feedstuffs which will fall directly in reticulum and is unlikely to be forced to rumen (Misk *et al.* 2001). The foreign bodies get lodged into the honey comb pattern of reticulum which may puncture or perforate the reticulum (Roth and King 1991, Braun *et al.* 2018). Normal physiological contractions of reticulum are sufficient to facilitate foreign body's

penetration through the wall. Reticular motility play an important role in mixing of ingesta (primary contraction cycle) and eructation of gases (secondary contraction cycle), and additionally facilitate piercing of foreign body. Metallic foreign bodies like nails, wires and nets are often heavy enough to settle down in the fore stomach. Due to the fore gut contractions, some of these foreign bodies pierce its wall (potential foreign body) and lead to complications. The foreign body penetration is also aided by the pressure of the fetus in advanced pregnancy and uterine contractions at the time of delivery (Ghanem 2010, Anteneh and Ramswamy 2015, Ibrahim and Gomaa 2016). Most of the lesions are caused by wires followed by nails and other sharp objects as detailed in Table 1.

Greater than 99% of foreign bodies injure the reticulum,

Table 1. Overview of TRP diagnosis and foreign body types reported

Diagnostic basis	Foreign body	Animal number	Reference
Slaughter	Baling wire (75%), nails (20%), foreign bodies composed of other materials (5%)	79.6% of 42,892 cattle slaughtered	Maddy 1954
–	2140 foreign bodies were found wire (51.6%), were nails (30.6%), were metallic fragments (9.9%), were strips of tin (5.5%), other objects (1.7%)	600 cattle	Jagos 1969
Slaughter	18.4% of 430 cattle had metallic foreign bodies (210 fixed and 212 loose), most of which were magnetic. Nails and pieces of wire (69%) of magnetic foreign bodies. 2.2% of all cattle had a cage magnet in the reticulum	13.4% of 2337 slaughtered cattle had sharp foreign bodies in reticulum	Neuman 1979
Slaughter	120 cows (23.7%) of 507 cattle had lesions due to lodged or dislodged foreign bodies. About 36% of all cattle had lesions caused by sharp objects.	41.2% of the 507 cattle	Andersen and Gillund 1980
–	59 cases out of 60 cases caused by fragments of wire. 1 animal had a nail.	Traumatic reticulitis in 60 cattle	Roth and King 1991
Radiography	Non-magnetic copper foreign bodies with contact to magnet.	4 cattle affected	Braun <i>et al.</i> 2003c
-	Cut tire wires.	7 cows in 200 became ill after ingestion of tire wires	Harwood 2004
-	Tire wires	11 cattle were ill	Monies 2004
Slaughter	286 foreign bodies retrieved from 1,491 cows. Tire wires (11%), fencing wires (14%), screws (5%), nails (9%), mixed pieces of metals (37%), copper (2%), remnants of boluses containing antiparasitic drugs (22%).	1,491 cows	Cramers <i>et al.</i> 2005
	Metal components of a mixer wagon.	9 cattle from a 270-cow dairy herd became ill	Daniel and Smith 2008
Clinical diagnosis	Wire bristles from a brush attachment used to clean the runways.	32 cows suffered TRP and 4 suffered traumatic pericarditis in (airport area	Ryzhakov and Lazarev 2008

(Table 1. Contd...)

Diagnostic basis	Foreign body	Animal number	Reference
Clinical investigation	Brush wire-bristle.	All cows from a herd of 31 had to be slaughtered or euthanized because of TRP	Braun 2009a
Clinical examination, ultrasonography, laboratory examination, post-mortem examination	Pieces of wires and nails.	22 buffalo affected with TRP	El-Ashker <i>et al.</i> 2013
Clinical examination and rumenotomy (radiography and ultrasonography inconclusive)	Coins, nails, needles, plastic and rubber materials.	2 cattle and 4 buffaloes	Devi Prasad <i>et al.</i> 2017
Clinical examination, radiography, ultrasonography, laboratory examination	–	Acute pericarditis in 10 buffalo and chronic suppurative pericarditis in 17 buffalo	Khalphallah <i>et al.</i> 2017
Clinical investigation	Fencing wire pieces (141), nails (121), screws (13), flat pieces of metal (8), barbed wire (5), eye glasses (4 arms), staples (2), hair clip (1), aluminium (1), fence insulator (1), belt buckle (1), nail clippers (1 set). 273 foreign bodies were ferromagnetic. Foreign bodies size ranged from 1.5 to 18 cm in length (median, 6 cm).	299 foreign bodies retrieved from 271 cattle diagnosed for TRP	Braun <i>et al.</i> 2018
Clinical examination, radiography and ultrasonography (ultrasonography more accurate than radiography)	Foreign bodies, penetrating and non-penetrating.	35 buffalo affected with TRP	Pal <i>et al.</i> 2018

and although rare, injury to the abomasum (Murray *et al.* 1991, Nuss *et al.* 2004), duodenum (Mullowney and Whitlock 1978) and jejunum (Egle *et al.* 2007) cannot be ruled out. TRP and pica are correlated with the latter considered a potential factor for TRP development (Ocal *et al.* 2008).

The contaminated penetrated foreign body may result in local or diffuse peritonitis and may also reach into the thoracic cavity and the adjacent abdominal anatomic structures including the liver and spleen (Abdelaal *et al.* 2009, Braun 2020). The most important complications of TRP are traumatic pericarditis (Braun 2009), hepatic inflammation or abscesses (Dirksen 2002), splenic inflammation or abscesses (Nuss *et al.* 2009), pleuropneumonia (Dirksen 2002), vagal indigestion (Rehage *et al.* 1995) and generalised peritonitis (Dirksen 2002). There also have been reports of cardiac tamponade following foreign body induced perforation of a coronary artery (Awadhiya *et al.* 1974), fatal reticular haemorrhage after puncture of the reticular vein by a foreign body (Constable *et al.* 2017), thrombosis of the cranial venacava (Gerspach *et al.* 2011) and aortic thromboembolism (Du Preez *et al.* 1995).

The non-potential foreign bodies lie harmlessly in the

reticulum, but the vigorous contractions of the reticulum aided by the movement of diaphragm make the thin sharp hard objects to penetrate through the reticular wall at different sites in various directions and the most common site of foreign body penetration is antero-ventral wall, ventral wall or anterior wall of reticulum. Foreign bodies can remain in a fixed site for a prolonged period or can lie freely in reticulum after 72 h due to necrosis around the object and corroded away in a 6 week to 1 year period (Radiostitis 2000). The foreign body can penetrate mucosal fold or reticular wall and if foreign body does not penetrate up to serosal surface, generally there is no illness. Foreign body, if reaches serosal layer establishes a local infective focus. Foreign bodies which penetrate ventrolateral wall of reticulum result in reticular fistula. The medial wall of reticulum is abundant of low threshold tension receptors, so any insult to medial reticular wall musculature lead to dysfunction of these receptors which result in diminished and hypomotility of rumeno-reticulum. There could be a complete atony of rumeno-reticulum with variable degree of tympany. Acute localized peritonitis commences 24 h after the penetration of foreign body, leading to high fever increased pulse and rigor particularly in abdomen muscles

which causes tucked up appearance. Infected tissues release cytokines, including interleukin (IL)-1, IL-6, and tumor necrosis factor- α . Such proinflammatory cytokines induce local and systemic reactions, typically pyrexia, leukocytosis, hormonal variations, and muscle protein depletion and stimulate the hepatic release of acute phase proteins. Acute diffuse peritonitis may be associated with leukopenia with a degenerative left shift due to migration of circulating neutrophils to the site of inflammation combined with reduced bone marrow response (Tornquist and Rigas 2010). Non-metallic foreign bodies like sand, ropes, polythene bags or plastic items are often non-potential but due to the fore gut contractions these foreign bodies may stack together and block ingesta movement within the gut leading to the obstruction (Braun *et al.* 2020).

Clinical signs

Animals with TRP show a variety of symptoms which depend on whether the condition is acute or chronic and the body structure penetrated.

Acute condition

Acute condition is characterized by sudden onset of anorexia as a result of stasis of forestomach and a drop in the milk yield. Because of the moderate systemic reaction, elevated rectal temperature, heart rate and respiratory rate may be recorded. Presence of pain causes reluctance in walking and if the animal is moved downhill, grunting may be noticed. Animals prefer to stand for long periods; however some animals may become recumbent and are reluctant to stand. Arching of back may be noticed, along with tense abdomen leading to a tucked-up appearance (Abdelaal *et al.* 2009, Braun *et al.* 2018). Defaecation and urination elicits pain and as such are reduced in frequency. Initially, arched back, ruminal tympany and spontaneous grunting are considered characteristic clinical findings. These are relatively rarely observed in delayed cases whereas bruxism, a subtle sign of pain, is more frequent and needs careful clinical evaluation (Braun 2020). Rumination and rumen motility is decreased or absent. Distension of left paralumbar fossa occurs due to moderate free-gas bloat and rumen contents are doughy on palpation. Animals pass poorly digested faeces whereas in some cases constipation or diarrhoea may occur. Pressure on xiphoid elicits pain and forms the basis of poll test diagnosis. Pinching of withers causes depression of back and a grunt is elicited (Wither Pinch test), however, this test is difficult to perform in large adult ruminants. Although the grunt may be audible however, it is best detected by auscultation of trachea. By 3rd or 4th day, the clinical signs subside and spontaneous recovery may occur as a result of localization of the inflammatory process. The early signs of TRP in buffaloes are less evident than cattle; therefore it may be difficult to differentiate it from other diseases (Macedo *et al.* 2021).

Chronic condition

In chronic cases, the appetite and milk yield do not return

to normal even after prolonged medical management and animal lose its body condition. Rumen motility is decreased and chronic recurrent bloat occurs. Faeces are reduced in quantity and undigested faeces become more common. Poll test or wither pinch test may not elicit any response, but gait may be stiff. The complications are usually seen in chronic cases. Cows and buffaloes with thoracic abscesses and pericarditis have respiratory signs of cough, dyspnoea and abnormal lung sounds (Abdelaal *et al.* 2009).

In traumatic pericarditis, tachycardia is the primary clinical sign. Heart rate may be mildly elevated at 80–100 bpm, however the heart rate as high as 130 bpm have been recorded (Braun *et al.* 2007). The severity of tachycardia is directly proportional to the degree of compression of the heart by pericardial effusion. Pericardial effusion causes the heart sounds to be muffled and asynchronous. Depending on the type of lesions, the sounds are of a rubbing, squeaking or scratching nature with predominantly fibrinous changes. With fluid splashing or gurgling sounds (vary continuously in pitch), loudness, duration and point of maximal intensity are recorded. Distension of the jugular veins, oedema of the submandibular region, brisket and ventral abdomen has been reported (Jesty *et al.* 2005, Braun *et al.* 2007a). Animal stands with abducted elbows with oedema and jugular vein distension, although absence of these signs does not rule out pericarditis. Pericardial fluid may drain into the reticulum through a patent foreign body tract (Gründer 2002).

Apart from dairy cattle and buffalo, TRP has also been reported in a bull having history of weight loss, mild tachycardia and reduced rumen motility with multiple masses/abscess in submandibular, retropharyngeal and cervical region. Confirmation of reticular foreign body was made at necropsy (Harvey 2008).

Diagnosis

Traumatic reticulo-peritonitis is diagnosed primarily on the basis of physical examination and diagnostic imaging, and is aided by laboratory work in less obvious cases. In absence of an accurate history and when the condition has been present for several days, diagnosis becomes more difficult. Peritonitis arising with other causes particularly perforated abomasal ulcers becomes difficult to distinguish from TRP (Constable 2015). As mentioned above, TRP can also result from foreign penetrating abomasum, duodenum and jejunum.

Abdominocentesis: Abdominocentesis, performed blindly or under ultrasound guidance, offers a valuable diagnostic aid in evaluation of peritoneal fluid (Constable *et al.* 2017, Solcan *et al.* 2018). Peritoneal fluid amount, colour, transparency, odour, consistency and presence or absence of other materials is assessed (Braun 2016). Elevated total solids and white blood cell numbers supports peritonitis. In 80% peritonitis cases, nucleated cell count remains above 6000 cells/ μ L and total protein above 3 g/dL. Using a differential cell count, a relative neutrophil count more than 40% and a relative eosinophil count less than 10% was frequently associated with the diagnosis of

peritonitis (Constable *et al.* 2017). Furthermore, estimation of glucose in the peritoneal fluid is considered as an important criterion for (specificity=90.2%, sensitivity=47.1%) the diagnosis of septic peritonitis. A low concentration of glucose in cases of septic peritonitis is usually found in peritoneal fluid of cattle (Wittek *et al.* 2010b). D-dimer concentration is considered the best parameter for the diagnosis of peritonitis since it has both high sensitivity (96.2%) as well as high specificity (94.1%) (Wittek *et al.* 2010a, b).

Haemato-biochemical findings

The leukogram, plasma protein and fibrinogen concentrations provide an aid in the diagnosis of TRP in cattle (Francoz and Guard 2015). However, they may or may not be helpful because many patients with traumatic reticuloperitonitis have normal CBCs, although almost all have elevated plasma fibrinogen levels (Fubini and Divers 2008).

Some patients of traumatic reticuloperitonitis with acute localized peritonitis and most patients with acute diffuse peritonitis will show a degenerative left shift in the leukogram (Fubini and Divers 2008), however, the leukocyte count may vary in inflammatory disease from severely decreased to severely increased (Weiser 2012). A differential leukocyte count is a better diagnostic indicator for acute peritonitis than the total leukocyte count. In acute local peritonitis, a neutrophilia (mature neutrophils above 4000 cells/ μ L) and a left shift (immature neutrophils above 200 cells/ μ L) are common while as in case of acute diffuse peritonitis a leucopenia (total count below 4000 cells/ μ L) with a greater absolute number of immature neutrophils than mature neutrophils (degenerative left shift) occurs, which suggests an unfavourable prognosis, if severe (Constable *et al.* 2017).

In chronic (longer than 10 days) hardware disease, serum globulin is often elevated (5.7 mg/dl), and the leukogram

may be normal or confirm mature neutrophilia (Fubini and Divers 2008). Animals with peracute diffuse septic peritonitis caused by hardware disease may have hypoproteinemia as a result of fluid and protein loss into the peritoneal cavity, but this does not occur as commonly as with abomasal perforation. In severe diffuse peritonitis, the fibrinogen levels may be increased up to 10 to 20 g/L (Constable *et al.* 2017). Because of forestomach and abomasal hypomotility or stasis, patients with hardware disease have a hypochloremic, hypokalemic, metabolic alkalosis that varies in severity in direct proportion to the degree of stasis (Fubini and Divers 2008).

Cattle with active peritonitis caused by TRP have an acute phase response, manifested as an increased plasma concentration of serum amyloid A and haptoglobin, and a decreased plasma albumin concentration (Constable *et al.* 2017). Affected cattle have prolonged prothrombin time, thrombin time, and activated partial thromboplastin time and thrombocytopenia, indicating the presence of abnormal coagulation (Gokce *et al.* 2007).

Ferroscore

Scanning of the ventral and lateral thoracic and abdominal wall with a metal detector can provide information regarding the presence of ferromagnetic foreign bodies (Sawandkar *et al.* 2009). Ferroscore has been found to be more effective in diagnosis of metallic foreign bodies than radiography (Hussain *et al.* 2018). However, other authors have reported that the instruments (metal detectors) are of limited use because most dairy cows eating chopped forages are positive for metal over the reticular area (Constable *et al.* 2017).

Diagnostic imaging

The most helpful ancillary tests for TRP are abdominal ultrasonography (Fig. 1) and reticular radiography (Fig. 2) as detailed in Tables 2 and 3.

Table 2. Ultrasonographic findings of TRP

Echogenic deposits between reticulum, ruminal atrium and abdominal wall were detected by placing the transducer just behind the xiphoid cartilage representing acute local peritonitis, corrugated appearance of reticular wall in chronic case. Acute diffuse peritonitis was characterized by extensive echogenic strands and hypoechoic septated peritoneal fluid in the ventral abdomen between xiphoid and pelvic region.	Abdelaal <i>et al.</i> 2009
Displaced reticular wall away from abdominal wall with an anechoic fluid without margin and which was not restricted around reticular area in cases of diffuse peritonitis.	Athar <i>et al.</i> 2010b
Echogenic deposits, with or without hypo- or anechoic fluid pockets, and structures of various shapes and echogenicities with central echogenic fluid collections, reflect foreign body-related inflammatory changes of the peritoneum that include fibrinous deposits and abscesses.	Braun 2009, Braun <i>et al.</i> 2018
Corrugated reticulum with reduction or absence of reticular motility was considered characteristic ultrasonographic feature of TRP in buffaloes.	Gouda 2015
Movement of reticulum with each respiration and sliding of reticular wall along skin and muscle layer and at no time reticulum contracted away from the transducer in B-mode ultrasonography in cases of reticulophrenic adhesion.	Kumar <i>et al.</i> 2007
Free flowing echogenic bands of fibrin seen in anechoic fluid between abdominal wall and the reticular wall along with displacement of reticular wall due to presence of fluid in the peritoneum.	Pal <i>et al.</i> 2018
Thick corrugated reticular wall with echogenic deposits between reticulum and abdominal wall and anechoic fluid compartment with hyperechoic fibrin strands was observed in buffaloes suffering from TRP.	Tharwat <i>et al.</i> 2012

Table 3. Radiographic findings of TRP

An abnormal FB position on a radiograph was a good predictor of FB perforation. Foreign body fully attached to the magnet was unlikely to be perforating the reticular wall. Abnormal reticulum size, location, and gas shadows adjacent to the reticulum were found simultaneously on a radiograph, hepatic or perireticular abscess was likely.	Fubini <i>et al.</i> 1990
Large unattached metallic foreign bodies outside the reticular outline Large perireticular gas accumulation without foreign body. Large metallic foreign bodies unattached to magnets within the reticular outline.	Partington <i>et al.</i> 1991
A typically positioned foreign bodies, abnormal gas shadows in the region of the reticulum, and depressions in the cranioventral margin of the reticulum. Accumulation of gas or a gas-fluid interface outside the gastrointestinal tract, and intra-abdominal masses were typical findings in cattle with traumatic reticuloperitonitis.	Braun <i>et al.</i> 1993
Abnormal contour, position or shape of the reticulum, foreign body penetrating the reticulum or gas shadows or a gas-fluid interface.	Braun <i>et al.</i> 1994
Foreign bodies that are partly or completely outside of the outer contour of the reticulum have perforated the reticular wall.	Braun <i>et al.</i> 2020

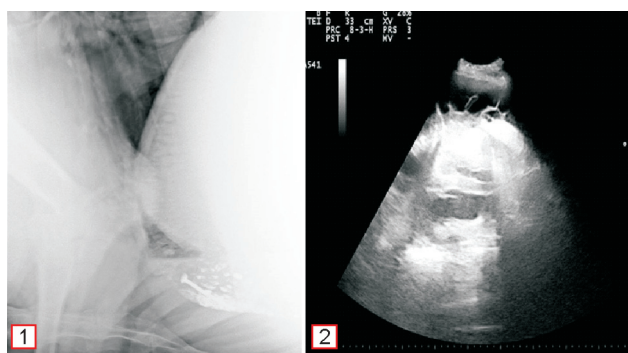
Ultrasound is an ideal tool for the diagnosis of TRP in bovines (Braun 2009, Athar *et al.* 2010b, Khalphallah *et al.* 2015, Braun *et al.* 2018). In bovines suspected with traumatic reticuloperitonitis, the contour and motility pattern of the reticulum are assessed first and when abnormalities are detected, the examination should extend to the neighbouring areas to determine the extent of the lesion (Braun and Rauch 2008, Braun *et al.* 2020). The amplitude, frequency and velocity of reticular contractions are affected in almost all cattle with TRP; most often there was partial reticular motility, movement of reticulum with each respiration or there was complete reticular atony (Kumar *et al.* 2007, Athar *et al.* 2010b, Gouda 2015, Braun *et al.* 2020). Abdominal ultrasound should reveal echogenic deposits with an abnormal pocket of hypo or anechoic fluid pocket and structures of various shapes and echogenicities with central echogenic fluid collections, reflect foreign body-related inflammatory changes of the peritoneum that include fibrinous deposits and abscesses (Fubini and Divers 2008, Braun 2009, Braun *et al.* 2018). Reticular abscess, a frequent complication of the TRP in bovines is present in about 20% of the cases with TRP and is characterized by an echogenic capsule of varying thickness and a cavity with

hypoechoic to moderately echogenic, homogeneous or heterogeneous content (Braun *et al.* 2020). In pericarditis, initially small fluid column in pericardial sac may be seen while in advanced cases, fluid and fibrinous strands are seen (Fig. 1).

Radiography is the best test for confirming metallic foreign body, the current location or its penetration of the reticulum or rarely rumen, the presence and size of perireticular abscesses (Fubini and Divers 2008). The sensitivity and specificity of radiography in detecting TRP was 83% and 90%, respectively (Partington and Biller 1991).

A linear foreign body that is at least 1 cm long is considered clinically relevant (Partington and Biller 1991). Foreign bodies in the reticulum that do not contact the ventral aspect of the reticulum or those at an angle of greater than 30 degrees to the ventral aspect of the reticulum are most likely penetrating (Fig. 2) (Partington and Biller 1991, Farrow 1999).

Bovine abdominal radiographs with a high probability of TRP is usually presented with readily recognized lesions, including large unattached metallic foreign bodies outside the reticular contour (Partington and Biller 1991). A perireticular gas shadow or gas fluid interface strongly suggests a perforating foreign body and infection with gas-producing and pyogenic bacteria (Braun *et al.* 2020). These foreign objects may or may not be adjacent to focal perireticular gas collections which represent a partially gas filled abscess (Partington and Biller 1991). These gas collections may be present ventrally in the cranial reticular area adjacent to the diaphragmatic line or superimposed over the reticulum (Partington and Biller 1991, Athar *et al.* 2010a). However, radiography isn't considered as a reliable tool for the diagnosis of reticular abscess in bovines (Saini *et al.* 2005, Kumar *et al.* 2008, Athar *et al.* 2010a). Ancillary aids therefore help determine the need or approach for surgery, and prognosticate more specifically than possible without this ancillary aid (Fubini and Divers 2008).



Figs 1–2. 1. Radiographic image showing the potential foreign body in the ventral abdomen of a cattle suffering from TRP. 2. Ultrasonographic image showing fibrinous pericarditis in cattle suffering from TRP.

Treatment

TRP can be treated conservatively as well as surgically which depends on location of the foreign body, financial condition of the owner and facilities available (Dirksen *et al.* 2002, Francoz and Guard 2015). Before surgical intervention animals should be treated medically by giving basic supportive care through antimicrobial drugs, anti-inflammatory and pain killers through NSAIDs and replenishing electrolytes and fluids.

Conservative treatment

Antibiotic: In acute cases bacteraemia and likely endotoxemia will occur due to be broad host of GI origin, whereas in chronic cases are more often of *Trueperella pyogenes*. Tetracyclines and β -lactams are good choices against the broad spectrum of primarily anaerobes.

Pain killers: In order to treat toxemia, inflammation, and pain, steroidal or nonsteroidal anti-inflammatory drug (NSAID) therapy should be instituted early and to limit fibrin deposition and adhesion formation in later stages (Miesner and Repper 2017).

Confinement: Restricting animal's movements is essential to prevent further cranial migration of foreign body like wires (Orpin and Harwood 2008). The animal can be confined in a box stall or tied for several days. The front feet should be elevated about 25 cm above the floor (Radostits *et al.* 2002).

Magnet: In TRP, administration of a magnet is a preventive tool rather than therapeutic but still it is first line of treatment (Braun *et al.* 2003) and its response to treatment is considered positive when eating and rumination improves and the rectal temperature normalises (Braun *et al.* 2017) and can also be confirmed radiographically. In a radiographic study of 90 cows with reticuloperitonitis, 85% of the magnets were found in the reticulum one to four days after administration. Amongst, 92% non-penetrating and 32% penetrating foreign bodies were attached to the magnets (Braun *et al.* 2003). The magnets were most efficacious (in about 75% cases) with foreign bodies in an upright position on the ventral aspect of the reticulum (Braun *et al.* 2018).

Surgery

Surgery is indicated when there is no response to the conservative treatment within 3 to 4 days and foreign body that has penetrated or perforated the reticulum, fails to fully attach to the magnet. The cows are re-evaluated using radiography. Removal of a foreign body by surgery provides clear evidence of the diagnosis and indicates what type of material is present within the reticulum. Surgery is considered as a 'gold standard' treatment for traumatic reticulitis (Orpin and Harwood 2008). Immediate surgery will offer the best results as there is less risk of penetration in the cardiac area. It has been reported that the success rates of conservative and surgical treatment were 82 and 90%, respectively but recovery with regard to general health, appetite and rectal temperature after the start of

treatment did not differ between the two groups (Braun *et al.* 2018). Hartnack *et al.* (2015) reported that after rumenotomy for TRP, 26% were productive members of the herd, 40% had been sold based on production criteria, and 34% had either died or were euthanized 5 months to 5 years after surgery which were more commonly due to concurrent disease complications like vagal indigestion and preoperative peritonitis rather than rumenotomy. In another study, 17 of 25 cattle with type II vagal indigestion due to peri-reticular abscessation survived and were productive following rumenotomy and intrareticular abscess drainage (Fubini *et al.* 1988).

Surgical procedure: A left flank exploratory laparotomy is performed to evaluate the extent of peritonitis and peri-reticular/rumen adhesions and rumenotomy to attempt retrieval of intraluminal foreign bodies, and lance peri-reticular abscesses into the lumen of the reticulum. To perform rumenotomy, the site of laparorumenotomy incision, size of the animal, and length of the surgeon's arm should be considered to ensure that the surgeon's arm has maximum reach (Horney and Wallace 1984). In peritoneal cavity, gentle manipulation is recommended to explore the rumeno-reticular adhesions. Due care must be taken to avoid break down in adhesions in order to minimize the spreading of infection in animals. Breakdown of recent adhesion is not advised because it may mask and surround an abscess (Weaver *et al.* 2005). The inspection of exterior of the reticulum may reveal the site of penetration and whether there is any peritonitis. In the absence of any signs of penetration, the wound should be closed.

Rumenotomy: The portion of the dorsal rumen sac is sutured to the skin or to the specialist rumenotomy set like weingarth's set while performing the rumenotomy (Fig. 3).

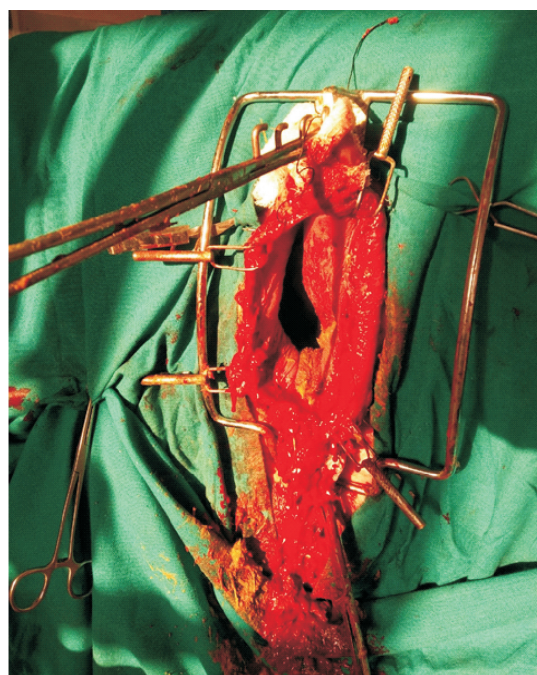


Fig. 3. Rumenotomy done (Weingarth set applied) for removal of foreign body from reticulum.

The stoma should be sufficient for arm access maintaining several centimetres from the cut edge of the rumen to the sutured skin edge, as it will be necessary for closure. Suture (No. 3) should be non-absorbable and soft so that it won't pull through the rumen wall. The rumen is sutured to the skin in combination of continuous connell suture pattern for skin placement and cushioning for rumen placement. The sutures should be far from the edges of the skin so that the skin edges will invert under the rumen to minimize contamination. The dorsal and ventral apex of the incision should receive special care to ensure that a seal is formed, often sutured separately (Miesner and Repper 2017). In Weingarh's technique, a Weingarh's frame is fixed to the dorsal commissure of the skin incision by its thumb screw. The rumen is incised and its wall fixed to the frame by multiple hooks (Orpin and Harwood 2008).

A protective shroud or drape is also recommended with either technique which will give extra protection from contamination and prevent rumen trauma or suture disruption. The rumen is incised a few centimetres from the dorsal and ventral extent of the sutured seal. At this point a rumen shroud or drape can be. Comparison of suture and clamp techniques demonstrate that a complete rumen skin suture technique is superior to intermittent stay sutures for preventing contamination but will take the surgeon longer to perform (Dehghani and Ghadrani 1995).

Reticulum is explored following the dorsal rumen wall cranially to the reticulum identified by the honeycomb-shaped mucosa meticulously to ensure that the foreign object is not missed. Objects lying on the superficial mucosa are palpated and removed followed by brushing the surface for fixed or protruding foreign bodies. Reticular abscesses may be drained through an ultrasound-guided transcutaneous paracentesis or via rumenotomy into the rumen. Goal is to identify a location of soft, smooth, possibly bulging reticular mucosa and suspected areas should be gently grasped. Intraluminal ultrasound can be performed to confirm abscesses, or needle and syringe aspiration can help confirm abscesses. Once surgeons have identified an abscess and determined adequate adhesion to the reticulum, the abscess can be lanced into the lumen of the reticulum (Miesner and Repper 2017). After exploration, remove the shroud and lavage the surgical site. Suture the rumen with a with absorbable suture material in a double layer of inverting Cushing pattern, flush it with sterile saline and repair the surgical abdominal wound in a standard manner (Orpin and Harwood 2008).

Treating Septic pleuritis, pyothorax, or pericarditis can be approached through thoracotomy. A fifth or sixth partial rib resection can provide more thorough drainage of the area than trocar or catheter placement. Unilateral septic pleuritis and pyothorax have a more favorable, yet guarded, prognosis than animal with likely grave septic and restrictive pericarditis (Ducharme *et al.* 1994). Cattle and buffalo can ventilate sufficiently with a hemothorax throughout the surgery and during second-intention healing of the wound unless infection has compromised complete mediastinum.

Therefore, the procedure can be performed standing under local anaesthesia. However general anaesthesia can also be used but because of already existing reduction in cardiac output and hemodynamic derangements, general anaesthesia may carry a poorer chance of surgical survival than when done standing (Ducharme *et al.* 1994).

Traumatic pericarditis may be surgically managed with three therapeutic options. Sobti *et al.* (1989) described pericardiocentesis and pericardial lavage as a therapeutic option that proved to be ineffective. The pericardiotomy along with pericardial lavage, then closure of the pericardium with a passive drain in the pericardial cavity has also been described (Sobti *et al.* 1989, Gavali *et al.* 2003) although 0% success rate in animal survival was achieved. Pericardiostomy with 5th rib resection has been mentioned as a therapeutic option in different case series or case reports (Ducharme *et al.* 1992, Grisneaux and Fecteau 2001, Gavali *et al.* 2003). Grisneaux and Fecteau (2001) reported that the cow had a normal productive life and was culled 6 years after the pericardiostomy. In the study of Gavali *et al.* (2003), one of the four cows treated by pericardiostomy had calved normally and was normal 3 months later. Constrictive pericarditis is one of the late complications of pericarditis with fibrosis of the pericardium and fibrin (Nigam and Manohar 1973) as mentioned in humans (Braunwald 1998).

Braun (2009) suggests that under normal circumstances, cattle with traumatic pericarditis should be humanely euthanized as quickly as possible. A treatment can be attempted only in a high valuable animal or in an animal carrying a high valuable embryo. The long-term antimicrobial administration can be a problem in milking cows with prolonged withdrawal times. Therefore, treatment is not cost effective in commercial cows.

Conclusion

TRP is a common ailment in cattle and buffalo with higher incidence in adult dairy animals. It has huge economic impact on farmer's economy. The disease has diverse symptoms but is more convincing in diagnosis of the condition. The condition is better diagnosed in early stages when it has good prognosis. Earlier disease was diagnosed after post mortem or slaughter but now-a-days TRP can be diagnosed through clinical symptoms, haemato-biochemical tests and through ancillary diagnostic imaging tests. Its treatment can be initiated through conservative means and if failed invasive surgical procedures may be ensued. The condition if diagnosed and treated early has good prognosis that reduces as the time gap increases.

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