

REVIEW ARTICLE

Impact of ruminal impaction syndrome on ruminant livestock productivity: Evaluation of protocols for rapid diagnosis and treatment

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ABSTRACT

Ruminal impaction syndrome (RIS) is an emerging, severe, and potentially fatal gastrointestinal disorder affecting ruminants in urban, semi-urban and peri-urban settlements, with increasing spread into rural communities in developing regions. RIS arises from ingestion of indigestible objects that accumulate in the rumen and obstruct the flow of ingesta through the lower digestive tract; resulting in severe impaction, indigestion, persistent tympany, protracted morbidity, lethargy, and, in severe cases, death. Additionally, RIS results in animal losses, reduced milk and meat production, and costly, often ineffective treatments. Moreover, RIS exhibits a high prevalence propagated via a vicious cycle. Definitive diagnosis and treatment often rely on exploratory rumenotomy. Affected animals are frequently presented in a terminal condition, limiting therapeutic options. Surgical outcomes are often poor and are commonly associated with postoperative complications. Furthermore, microplastics, nanoplastics, xenobiotic chemicals and heavy metals leach into ruminal fluid, bioaccumulate in tissues and enter food chain through milk and meat products to exert detrimental toxic effects in animals and humans. Despite its high incidence and severe strain on economy and animal health, there are no established government regulations or standardized guidelines governing the diagnosis and treatment of RIS, making it a major yet neglected disorder that is often managed empirically by veterinarians. Integrating rumenoscopies alongside nanotechnology, diagnostic markers and modified abdominal ballottement technique can advance accurate diagnosis, while therapeutic laparoscopy may facilitate prompt treatment. This review evaluates the profound impact of RIS on the health and productivity of ruminant livestock. Ultimately, it aims to establish effective diagnostic pathways and therapeutic protocols that can be adopted by veterinarians and policymakers to restore livestock health, improve animal welfare, and ensure sustainable productivity of ruminant livestock systems.

Keywords: Diagnosis, impaction, productivity, ruminal, treatment

INTRODUCTION

Ruminal Impaction Syndrome (RIS) (also known as Non-Penetrating Foreign Body Syndrome, Plastic-Induced Ruminal Impaction or Ruminal Impaction Disease Syndrome) is a major emerging threat to health and welfare of ruminants, including free-range and semi-intensively reared livestock in developing regions (Bokko et al., 2025). The rapid growth of plastic production and the expansion of “take-make-dispose” consumption patterns generate enormous amounts of plastic waste that litter the environment, thereby contributing to the incidence of RIS (Adane and Muleta, 2011). Ruminal impaction syndrome remains a challenging high prevalence gastrointestinal disorder, primarily driven by ingestion and accumulation of indigestible, non-biodegradable materials in the rumen, leading to severe secondary metabolic disturbances and high mortality if left untreated (Jyothi et al., 2025). Ruminal impaction syndrome rapidly degrades the body condition of affected animals and consequently undermines farmers’ livelihoods, representing a significant impediment to ruminant livestock productivity. Moreover, sustainable ruminant livestock production remains crucial for attainment of global food security and safeguarding the livelihoods of many households in low- and middle-income countries where RIS is endemic (Kamalakar et al., 2021).

Beyond its detrimental effects on animal health, plastic debris, particularly microplastics and nanoplastics, together with xenobiotic chemicals and heavy metals leached from ingested plastics, may enter the human food chain via meat and milk, posing a risk of irreversible metabolic, endocrine, and developmental abnormalities (Allen et al., 2022; Coffin et al., 2022; Walker et al., 2022). Thus, RIS exerts multi-dimensional impact on animal and human health. Traditional diagnostic procedures like clinical examination, ruminal fluid analysis, and biochemical screening have significant limitations due to non-specificity of assay outcomes (Lakhpatri et al., 2019; Jyothi et al., 2025; Marzok and Tharwat, 2025). Radiography and ultrasonography are used only as complementary diagnostic tools, as neither modality provides a definitive diagnosis of RIS. Modern diagnostic protocols need to evolve to overcome these barriers by employing multimodal approaches that

provide greater diagnostic accuracy and improve overall survival rates (Sagar et al., 2024). This review appraises the impact of RIS in ruminants and explores emerging diagnostic frameworks and therapeutic strategies, including laparoscopy, nanotechnology, putative diagnostic markers and modified abdominal ballottement techniques, to identify the most effective protocols for restoring animal health, enhancing welfare, and safeguarding livestock productivity.

AN OVERVIEW OF RUMINAL IMPACTION SYNDROME (RIS)

ETIOLOGIC AGENTS OF RIS

The incidence of RIS begins with the indiscriminate ingestion of indigestible materials by ruminants. The principal etiologic agent, polyethylene or polythene (IUPAC name: polyethene or poly[methylene]; abbreviated PE) accounts for 79.2% of the foreign mass associated with RIS (Negash et al., 2015). The ethylene double bond allows untrammelled polymerization into Low-Density Polyethylene (LDPE), a soft, flexible, lightweight thermoplastic polymer that can be easily melted, moulded and reshaped through the application of heat and pressure into a wide range of consumer plastic products (plastic bags, films, sheets, wraps, films, membranes) primarily used for food packaging (Achilias et al., 2007; Araújo et al., 2008; Adane and Muleta, 2011). LDPE is noted for its low temperature flexibility, water resistance, durability, corrosion resistance and transparency (Adane and Muleta, 2011). Plastic originates from fossil fuels buried deep beneath the Earth’s surface and ultimately ends up as deadly anthropogenic debris in landfills, refuse dumps, and aquatic ecosystems. While the foreign mass is predominantly composed of polythene intertwined with feed particles, it may also contain other indigestible materials, such as synthetic ropes and cords, fabric, leather, rubber, stone, trichobezoars and metals (Tiruneh and Yesuwork, 2010), which make up 20.8% of the foreign mass content (Mushonga et al., 2015; Negash et al., 2015; Duresa et al., 2022). The tangled polythene network acts as an ever-present matrix that traps other indigestible items in the rumen.

PROPENSITY OF RUMINANT LIVESTOCK TO RIS

Numerous factors play imperative roles in the predisposition of ruminants to RIS. These include:

Breed, Age and Sex Predisposition

Ruminants are prone to RIS, with cattle more susceptible than sheep and goats. This is attributable to cattle having least sensitive prehensile organs (lips and tongues) to distinguish feed from inedible items and having more indiscriminate, non-selective feeding habits (Uzal et al., 2016). Crossbred cattle are also more vulnerable than indigenous breeds owing to higher nutritional and energy demands (Mendonça et al., 2019). Sheferaw et al. (2014) showed that the prevalence of polythene masses in slaughtered animals was significantly higher in cattle (41.8%) than in sheep (20.6%) and goats (11.9%). Similarly, post-mortem prevalence of ruminal polythene mass at Addis Ababa abattoir was 35.7% in cattle, 18.6% in sheep and 15.3% in goats (Mekuanint et al., 2017; Kamalakar et al., 2021).

Furthermore, cattle older than 10 years and sheep and goats older than 4 years exhibit a higher prevalence (46.7%) than younger age groups (12.9%) (Duresa et al., 2022). This is attributable to the continual ingestion and cumulative load of indigestible material in the rumen over their lifespan. Additionally, the absence of diagnostic signs exacerbates the occurrence of higher prevalence of RIS in older animals (Mekuanint et al., 2017; Priyanka and Dey, 2018; Kamalakar et al., 2021).

RIS are more prevalent in cows, ewes and does than in bulls, rams and bucks (Tiruneh and Yesuwork, 2010; Mekuanint et al., 2017). For instance, the frequency of recovered plastic at Batna slaughterhouse in Algeria was 79.06% in cows and 23.92% in bulls (Zahra et al., 2022). Female animals show higher propensity to RIS due to greater nutritional demand, negative energy balance and susceptibility to mineral deficiency aggravated by gestation and lactation (Remi-Adewumi et al., 2004; Tiruneh and Yesuwork, 2010; Mekuanint et al., 2017).

Ruminant Livestock Rearing System

Ruminant livestock reared under free range or semi-intensive farming are at a higher risk of developing RIS. They roam waste-polluted open areas and refuse dumps, where they indiscriminately scavenge or freely graze any feed matter, including erratic ingestion of predominantly polythene garbage laced with residual salt, sugar and seasoning mistaken for feed. The repeated ingestion of

such indigestible materials leads to their accumulation in the rumen. In contrast, ruminant livestock reared by intensive systems without access to indigestible material rarely develop RIS (Bokko et al., 2025).

Nutritional Imbalances

Fodder scarcity, poor nutritional supplementation and deficiencies of essential minerals like calcium, phosphorus and other micronutrients can lead to *pica* and increased energy requirement with resultant negative energy balance status (Otsyina et al., 2015). Such ruminants resort to ingesting indigestible items resembling feed in an attempt to offset energy deficits (Otsyina et al., 2017). Additionally, the RIS cycle is propagated in a “vicious cycle” as a self-perpetuating, negative feedback loop that links malnutrition to compulsive, indiscriminate ingestion of indigestible materials. Nutritional buffering with mineral licks and supplementary feeding minimizes consumption of non-feed items.

Industrialization and Urbanization

Since the 1950s, global plastic industry has experienced exponential growth. For instance, plastic production reached 390.7 million metric tons in 2021, from 2 million tons in 1950, generating \$609.2 billion with attendant enormous polythene wasteland (Kamalakar et al., 2021). Plastic waste generation exacerbated by population explosion, “take-make-dispose” consumer actions, and urbanization, has resulted in a global plastic pollution crisis, outpacing the global waste management systems and exerting adverse effects on the environment, climate and public health (Borrelle et al., 2020; Sequeira et al., 2020; Walker, et al., 2022; Kibria et al., 2023). Plastic waste, together with poor animal husbandry, aggravates the incidence of RIS and consequently represses productivity and profitability of the free range or semi-intensive ruminant livestock systems (Borrelle et al., 2020; Lau et al., 2020). The high preponderance of RIS is a direct reflection of poor waste management practices and environmental plastic pollution, highlighting a broader public health failure in waste disposal systems, particularly in urban areas of developing countries. The issue underscores the interconnectedness of environmental, animal and human health.

Furthermore, rapid urbanization through extensive haphazard constructions has diminished natural grazing lands while discarded anthropogenic debris, principally

plastic waste, is ingested by ruminants (Bokko et al., 2025). Moreover, the free range and semi-intensive rearing methods have not been synchronized with the urban growth trends.

PREVALENCE OF RUMINAL IMPACTION SYNDROME

Slaughterhouse prevalence of RIS in ruminant livestock in developing regions has been extensively reported.

Studies have shown that abattoir prevalence rates range from 19.3% to 87.32%; while the hospital RIS detection rates are 0.4% to 13.5% (Table 1). The vast disparity in detection of RIS with up to 90% prevalence post-mortem compared to under 14% in veterinary hospitals/clinics highlights a high disease overall incidence that is severely masked by poor clinical detection of active cases in living animals; a critical flaw in clinical diagnostics.

Table 1 Prevalence rates of RIS in ruminant livestock in veterinary hospitals or abattoir post-slaughter in selected developing countries

Country	Abattoir postmortem prevalence	Prevalence in hospitals/clinics	Source reference
Algeria	52.24%	No data	Zahra et al., 2022
Ethiopia	30.73% – 79.2%	0.44% - 13.22%	Hussain & Uppal, 2012 Tesfaye and Chanie, 2012 Nugusu et al., 2013 Negash et al., 2015 Kamalakar et al., 2021 Ame et al., 2022 Duresa et al., 2022 Vakare et al., 2022
Kenya	72.3%	0.5 – 13.5%	Otsyina et al., 2015
Malawi	80.7%	7.8%	Airs et al., 2024
Nigeria	19.3% – 87.32%	0.7 – 11%	Aminu et al., 2024 Igbokwe et al., 2003 Rabana et al., 2022
Rwanda	65.5%	0.4% - 3.2%	Mushonga et al., 2015

The massive gap between the high prevalence of RIS observed post-slaughter (up to 90%) and the low number of cases documented in veterinary hospitals and clinics (<14%) indicates that the condition is widespread but frequently undetected in the field. The lowest RIS prevalence post-slaughter was more than the highest prevalence detected in the veterinary hospitals and clinics in all countries. Despite a high incidence of RIS, the majority of cases go undetected in clinical settings.

ECONOMIC IMPACT OF RIS ON RUMINANT LIVESTOCK

Ruminal impaction syndrome severely impedes animal health and production in several ways. The physical presence of foreign mass in the rumen reduces functional capacity, obstructs fermentation and hinder production and absorption of volatile fatty acids (VFA), leading to low milk yield, poor weight gain, reduced draft ability and microbiota dysbiosis (Ali et al., 2024). Ruminants experiencing RIS exhibit increased susceptibility to other diseases (Martin Martel et al., 2021). In severe or

untreated cases, RIS may lead to mortality rates as high as 100% (Bokko et al., 2025).

Furthermore, RIS impedes ruminant productivity. Its high prevalence results in substantial economic losses for livestock farmers. For instance, the prevalence of $67.46 \pm 7.32\%$ translates to an estimated US\$538.75 million (₦820.675 billion) loss annually amongst the 152.48 million cattle, sheep and goats in Nigeria alone (Rabana et al., 2022; Aminu et al., 2024; Bokko et al., 2025). The losses arise from infertility, foetal loss, low milk yield, stagnated weight gain, emaciation, poor meat quality, high morbidity, high health costs and high mortality (Remi-Adewunmi et al., 2004; Bokko, 2011). Ruminal impaction syndrome can also result in “phantom” live weight inclusive of the foreign mass and rumen distension masking actual body mass.

Untreated RIS negatively impact animal welfare causing significant distress and protracted suffering amongst ruminants (Terra and Reynolds, 2020). RIS also puts significant strain on potentials for international trade since contaminated milk and meat products as export commodity fall short of the global WTO agreement standards (Tibebu et al., 2024).

EFFECTS OF RIS IN RUMINANTS

Plastic forms (megaplastics >50mm and macroplastics >25mm – 50mm) in the rumen exposed to churning, ruminal contractions, microbial action, oxidation, mechanical degradation and enzyme activity, undergo continual subtle disintegration into mesoplastics (>5mm – 25mm), microplastics (1µm – <1mm), nanoplastics (1nm – <1µm) or plastic nanoparticles (≤100 nm), even into monomeric forms (Walker et al., 2022; Ali et al., 2024). Microplastics and nanoplastics are the key breakdown forms that cross into circulation and enter tissues. At the same time, plastic polymerization additives, including xenobiotic chemicals such as bisphenol A (BPA), di-(2-ethylhexyl) phthalate (DEHP), polychlorinated biphenyl's (PCBs), triphenyl phosphate (TPP), dioxins, per- and polyfluoroalkyl substances (PFASs), and heavy metals (lead, mercury, chromium, radium, copper, cobalt, barium, arsenic, cadmium) are uncoupled and continually leached into the ruminal fluid, absorbed into the bloodstream, eventually bioaccumulating in tissues and body fluids (Vandenberg et al., 2012; Wiesinger et al., 2021; Dey et al., 2022; Ali et al., 2024). Microplastics and nanoplastics as well as xenobiotic chemicals and heavy metals have been detected in sheep faeces (Beriot et al.,

2021), cow follicular fluid (Grechiet et al., 2023), blood, ruminal fluid, milk, liver, kidney, and muscle tissues of ruminants (Kunisue et al., 2004; Muleke et al., 2013; Da Costa Filho et al., 2021; Glorio Patrucco et al., 2024). Microplastics, nanoplastics, xenobiotic chemicals and heavy metals are highly toxic, non-biodegradable, and eventually cause lethal effects in ruminants (Allen et al., 2022; Leslie et al., 2022; Walker et al., 2022). Such include immunosuppression, endocrine dysfunction, metabolic insufficiencies, disrupted neurodevelopment, increased reactive oxygen species production and DNA damage, infertility, carcinogenicity and teratogenicity (Matthews, 2021). Microplastics, nanoplastics, xenobiotic chemicals and heavy metals may exert putative, yet to be determined, toxic synergism in livestock with RIS.

IMPACT OF RIS ON HUMAN HEALTH

The RIS carries significant public health importance. RIS itself is not contagious, infectious or zoonotic, but microplastics, nanoplastics, xenobiotic chemicals and heavy metals pose long-term threat to human health. Although humans are vulnerable to exposure through multiple routes, such as inhalation and skin contact dietary ingestion has been recognized as a major sources of exposure. Ingestion is principally the route of exposure to microplastics, nanoplastics, xenobiotic chemicals and heavy metals in water supplies, the environment and food chain including meat and milk products from ruminants with RIS. Humans unknowingly consume 39,000 – 52,000 microplastics annually (Cox et al., 2019). Additionally, airborne particulates originate from synthetic textiles, rubber tyres, landfills and waste incineration are inhaled into the lungs (Kole et al., 2017; Prata, 2018). The vast and thin (<1 µm) alveolar surface area of the lungs is permeated by plastics and chemicals to enter blood stream and reach the entire body (Lehner et al., 2019). Inhalation of plastic particles can push up the figures to 74,000 – 121,000 particles per year (Cox et al., 2019). Similarly, dermal exposure occur where plastic particles and chemicals in personal care products pass through the skin barrier, skin wounds, sweat glands or hair follicles (Schneider et al., 2009).

Microplastics, nanoplastics, xenobiotic chemicals and heavy metals have the inclination for widespread dispersal, non-biodegradability, persistence and high toxicity (Kolandhasamy et al., 2018; Wang et

al., 2020; Yee et al., 2021). Bioaccumulation and biomagnification occur in vital organs with potential to cause an array of adverse, irreversible and severe health damage over time (Adane and Muleta, 2011; Muleke et al., 2013; Priyanka and Dey, 2018). These toxic agents have been detected in liver, spleen, lungs (Amato-Lourenço, 2021; Horvatits, 2022), kidneys, heart, gonads, blood (Leslie et al., 2022; Walker et al., 2022; Codrington et al., 2025) and human placenta (Ragusa et al., 2021). Each of these agents have been reported to cause discrete deleterious effects that mirror the other; such that microplastics and nanoplastics cause effects analogous to xenobiotic chemicals and/or heavy metals. For instance, *in vitro* and *in vivo* studies have shown that microplastics and nanoplastics induced myocardial pyroptosis, mitochondrial damage and adverse immune response in humans (Matthews, 2021). Additionally, they cause endocrine dysfunction, infertility, metabolic insufficiencies, disrupted neurodevelopment (Deng et al., 2017; Lu et al., 2018; Goodes et al., 2022) and tumours of the liver, testes, prostate, breast, ovaries and increased cardiovascular disease risk (Oskam et al., 2005; Vandenberg et al., 2012; Yee et al., 2021). Furthermore, exposure can trigger the release of reactive oxygen species (ROS) production that can set off DNA damage (Srinivas et al., 2019; Ali et al., 2024). Similarly, continuous long-term exposure to picomolar to nanomolar doses of xenobiotic chemicals or heavy metals have been linked to infertility, birth defects, growth and cognitive impairment (Oskam et al., 2005; Vandenberg et al., 2012; Rani et al., 2015; Ali et al., 2024), immunosuppression, increased cardiovascular disease risk, stroke, as well as hepatocellular carcinoma, testicular carcinoma, prostate, breast and ovarian tumors (Oskam et al., 2005; Vandenberg et al., 2012; Priyanka and Dey, 2018).

The adverse human health effects of microplastics, nanoplastics, xenobiotic chemicals and heavy metals due to RIS remain largely undefined owing to lack of definitive evidence-based data. While microplastics, nanoplastics, and associated leached chemicals or heavy metals are known to be harmful individually, they likely act in combination to produce additive or synergistic toxic effects that amplify overall risks to human health. Currently, there is no comprehensive data to distinguish standalone detrimental effects attributable to individual agent. Further research is required to determine the distinct toxicological effects of xenobiotic chemicals, heavy metals, and plastic particles (microplastics/

nanoplastics) on the human physiology. Deciphering the discrete effects of plastic particles, heavy metals and other xenobiotic chemicals is a critical research challenge, as these pollutants rarely occur in isolation and often act synergistically. Moreover, microplastics and nanoparticles pose greater threat by acting as vectors for chemical contaminants (xenobiotic chemicals and heavy metal) adsorbed on their surfaces.

SIGNS AND SYMPTOMS OF RIS

Ruminants harboring little quantities of indigestible materials, most notably polythene waste in the rumen, remain asymptomatic. Once the intraruminal load attains significant threshold, clinical signs start to appear. Although such animals initially appear healthy, they gradually develop a range of nonspecific, low grade, non-diagnostic clinical signs starting out as mild forms of depression, inappetence, indigestion, recurrent bloat, ruminal stasis, ruminal impaction, weight loss, reduced fecal output (Kamalakar et al., 2021; Vakare et al., 2022) or even dyschezia (Babayani and Nyange, 2019). As RIS assumes a more severe form, exhibited signs increase in severity as anorexia, persistent impaction, doughy to firm rumen on palpation, suspended rumination, reduced or absent rumen motility, recurrent severe tympany, distended abdomen, progressive emaciation, dehydration, constipation, lethargy and death (Otsyina et al., 2017; Sasikala et al., 2018; Matthews, 2021). In severely protracted RIS, the actual muscular wall of the rumen can become shrunk or atrophied because the walls remain adhered to the foreign material. The severity of RIS varies greatly depending on the quantities, location and duration of the foreign mass in the rumen, and the extent of interference of ingesta flow (Otsyina et al., 2017). These also produce the variation in duration of clinical RIS of 31 ± 1.24 days (Kamalakar et al., 2021) and 3.7 ± 4.6 months (0.5 to 24 months) in the affected animal (Ismail et al., 2007). The resulting abdominal distension in RIS is frequently misdiagnosed as pregnancy especially amongst female small ruminants (Navarre et al., 2012).

Additionally, rumen movement against the polythene mass lead to mechanical injuries on the ruminal mucosae and papillae (Martin Martel et al., 2021) causing a significant reduction of rumen papillae length (1.243 units) in comparison to the long, slender, regular, white to grey, healthy rumen papillae (3.097 units) (Uzalet al., 2016), thereby reducing rumen functionality. Rumenitis, thinning of ruminal wall, (Martin Martel et al., 2021),

erosion, dystrophy, ulceration, sloughing of ruminal papillae, as well as vacuolar degeneration (spongiosis), increased keratinocytic layers and intense acanthosis of the squamous epithelium of the ruminal mucosae have also been reported (Sheferaw et al., 2014; Mahadappa et al., 2020).

CURRENT PROTOCOLS FOR DIAGNOSIS AND TREATMENT OF RIS

Unlike other diseases, RIS offers no pathognomonic or signature clinical signs. Diagnosis in living animals is difficult because the symptoms are often non-specific or obscure. Instead, RIS is frequently an accidental finding during rumenotomy, necropsy, identified at “the fag end” (Priyanka & Dey, 2018) or as incidental finding during routine abdominal surgeries. Even the inadvertent diagnosis only occurs when a substantial quantity of foreign mass is already present in the rumen and the animal is mortally ailing (Bokko et al., 2025).

Diagnosis of RIS relies on a combination of primary diagnostic procedures including clinical examination and laboratory tests; and complementary imaging techniques (ultrasonography and radiography).

Primary Diagnostic Methods

Clinical Indicators: The animal’s history, rearing methods, such as free range or semi-intensive rearing systems, access to plastic waste, other indigestible materials and garbage dumps, or consumption of poor-quality fibrous feed, are crucial indicators. Chronic progressive anorexia, considerable left abdominal distension, “doughy” to hard mass felt on deep abdominal palpation, chronic recurrent bloat, ruminal stasis and/or constipation with scanty or dry feces are key signs.

Evaluation of Rumen Fluid

Methylene Blue Reduction Time (MBRT) in RIS is significantly prolonged due to the disrupted microbial activity and fermentation processes (Bayne and Edmondson, 2020; Jyothi et al., 2025). Reduction in protozoal (Entodiniomorphs such as *Entodinium* and Holotrichs like *Isotricha*) count and activity are suggestive of RIS (Ivan et al., 2000). Reduced Total Volatile Fatty Acid (TVFA) concentration indicates impaired digestion and fermentation (Ivan et al., 2000). The indicators used today are a measure of function and activities in the rumen. These tests neither confirm

presence or size of polythene mass and other indigestible material, nor the duration, location or severity of RIS.

Complementary Diagnostic Methods

Utility of Non-Invasive Diagnostic Imaging

Radiography and ultrasonography are frequently employed to visualize foreign bodies in the rumen. Their effectiveness, however, is limited as primary diagnostic methods as detailed below:

Ultrasonography

Ultrasonographic scanning of the rumen utilizes linear or convex transducer with a 3.5 to 5.0 MHz on a B-mode to acquire the echogenicity of rumen, its morphology and contents (Li et al., 2018). The rumen topography, motility, wall thickness and contents are visualized in the 8th through 12th intercostal spaces (ICS) and flank on the left; and from 12th ICS and flank on the right (Bayne and Edmondson, 2020). The rumen wall appears as thick, distinct, hyperechoic, smooth line (Marzok and Tharwat, 2025). The gas cap is hyperechoic, characterized by reverberation artifacts that run parallel to the rumen wall, the fiber mat appears as an echogenic, heterogeneous mass with gas inclusions, while fluid phase appears anechoic to hypoechoic (Bayne and Edmondson, 2020; Marzok and Tharwat, 2025). The gas content often creates acoustic shadowing, making it difficult to properly assess the contents or the far wall (Gomaa and Abdelaal, 2015).

In RIS cases, significant reduction in wall thickness has been observed (Gomaa and Abdelaal, 2015). The stratification of ruminal contents (gas, fiber mat, fluid layers) is often not clearly visible with contents appearing as a heterogeneous mixture of echogenic material (Wong et al., 2024). Entangled plastic mass appears as hyperechoic band with characteristic “dirty” acoustic shadowing mostly observed at ventro-lateral aspect of left 11th-12th ICS and lower left paralumbar fossa (Abdelaal and EL-Maghawry, 2014; Gomaa and Abdelaal, 2015; Li et al., 2018; Kamalakar et al., 2023; Wong et al., 2024). Ultrasonography may not reveal characteristic differences in the size or appearance of the polythene or other indigestible materials. Detecting specific materials like plastics can be difficult as they often lack a distinct sonographic signature.

Radiography

Radiography is a valuable diagnostic tool for ruminal impaction caused by radio-opaque (e.g., metallic) foreign bodies (Makhdoomi et al., 2018). Radiography

of the abdomen may also demonstrate the displacement, distortion, distention or superimposition of abdominal structures, as well as the presence of soft tissue opacities, gas-fluid interfaces, or abnormal gas inclusions (Bayne and Edmondson, 2020). In cases where foreign bodies can be seen, radiography serves as a definitive diagnostic method, precluding exploratory surgeries. However, it has limitations for diagnosing RIS caused by plastics; non-radio-opaque (radiolucent or low radiopacity) material, not readily evident on standard radiographs (Lakhpati et al., 2019). The polythene material often appears as non-discrete, non-specific radiolucent or low radiopacity areas, that often merge with existing fluid and soft tissue densities, making them difficult to distinguish between the fluid and soft tissue in the rumen. The radiographs might show generalized dilated

rumen with fluid shadows but cannot specifically identify the foreign material itself. Radiography can also confirm a dilated stomach distended with food material, which may displace other abdominal organs, such as the intestines caudally (Navarre et al., 2012). The use of radiography for RIS diagnosis in pregnant dams, especially during the first trimester, poses radiation hazard to the fetus. Radiography may be supportive but not highly diagnostic, often inconclusive for RIS (Lakhpati et al., 2019). Other methods are necessary for a definitive diagnosis. This significantly limits the utility of radiography alone.

Current Treatment Protocols

Treatment of RIS with anti-bloat agents, laxatives or purgatives intended to aid the passage of polythene



Figure 1 Foreign mass recovered via rumenotomy from a 5 year old Sahel Buck (32kg bodyweight). The recovered mass was washed to reveal the composition. A). A 3.8kg foreign mass with feed material (yellowish), B). Polythene weighing 3.1 kg accounting for 81.6 % of the mass, C). Indigestible plant fibres, D). Fabric/Cloth (red), E). Synthetic cords and F). Polyester mesh.

or other indigestible materials is not successful in resolving RIS. Moreover, polythene or other indigestible materials cannot be excreted, hence remain as such. Rumenotomies and probiotics may help restore rumen microflora and motility, but only after the removal of the foreign mass (Dagnaw Fenta et al., 2023). At the moment, rumenotomy is the sole therapeutic protocol that guarantees resolution of RIS, where the rumen is surgically opened to physically remove the accumulated indigestible material with a good prognosis for recovery if addressed in time. In practice, the affected animal will mostly be terminally ill with a huge quantity of the foreign material and surgical intervention success rate is very low.

Foreign mass recoveries via rumenotomy weighed as much as 5.5kg in sheep and goats with 12 liter rumen capacity (Martin Martel et al., 2021; Bokko et al., 2025). This is a considerable load for small ruminants with a bodyweight range of 18–52kg. Similarly, a team of veterinarians in Vepery, Tamil Nadu, India recovered 52kg of foreign mass from a 150 liter sized rumen of a 600kg cow via rumenotomy (Sasikala et al., 2018). The foreign mass is typically large, hard, compact, irregular, roughly spherical to oblong shaped; and conforming to the ruminal environment - usually the ventral sac, composed of tightly intertwined materials with polythene as the main component (Figure 1).

Rumenotomy in animals with poor body condition is frequently associated with complications like severe peritonitis, abscessation, hemorrhage, seromas, infection, dehiscence of suture lines and adhesions between the rumen and abdominal wall. The exteriorization of the rumen, *per se* a tremendous stressor may culminate in hypovolaemic shock (Bokko et al., 2025). These are exacerbated by pre-existing conditions (severe emaciation, dehydration or chronic impaction) before intervention. Furthermore, foreign body mass is typically substantial, frequently exceeding 1kg in small ruminants (Figure 1) and above 10kg in cattle. These loads reduce rumen functional volume; interfering with ruminal movements and inhibiting fermentation and VFA production. Moreover, their sudden removal can trigger physiological imbalances predisposing to emergencies. Even after removal of the foreign bodies, the damage to the rumen wall (atrophy of papillae) or chronic impairment of absorption may not be reversed, leading to poor productivity. Furthermore, the animal requires intensive care following rumenotomy, including antibiotics and potential transfaunation to re-

establish the flora and accelerate recovery. These are rarely performed.

These challenges reinforce the necessity for developing efficient protocols for early diagnosis of RIS where the indigestible material load is detected before occurrence of any damage to the rumen architecture, function and contents. Although rumenotomy is valuable as treatment, it has setbacks as a diagnostic tool for early stage RIS, including the cost, expediency and skill.

NEWER PROPOSITIONS FOR DIAGNOSIS AND TREATMENT OF RIS

Advances in science, medicine and biotechnology have led to higher degree of accuracy in diagnosing and treating intra-abdominal masses. However, not much progress has occurred in the rapid diagnosis and treatment of RIS in ruminants, despite its high incidence and the untoward impact on the livestock economy. Endeavours are mainly about reportage of prevalence and quantization of economic losses from repressed ruminant livestock productivity. Today, emerging technologies can be harnessed to develop early and definitive diagnostic techniques and expeditious therapeutic approaches for RIS in the ruminants (Figure 2). Such interventions will help prevent ruminants from going through deleterious, debilitating and even fatal course of RIS, while enhancing welfare and restoring ruminant health.

In this review, laparoscopy, nanotechnology, putative diagnostic markers and modified abdominal ballottement techniques are appraised. Laparoscopy and nanotechnology offer twofold roles for diagnosis and treatment for RIS (Figure 2). Diagnostic markers and abdominal ballottement provide only a presumptive diagnosis (Figure 2). The multi-faceted modalities constitute a comprehensive framework for the contemporary diagnosis and management of RIS.

DUAL ROLE OF LAPAROSCOPY FOR DIAGNOSIS AND TREATMENT OF RIS

The advent of laparoscopy (syn: minimally invasive procedure, band-aid surgery, keyhole surgery) represents a milestone in surgery that initiated a shift from the open abdominal operation era to minimally invasive surgery revolution (Kelley, 2008). Laparoscopy, a cornerstone of minimally invasive surgery, has emerged as a gold standard and versatile technique offering numerous benefits over conventional surgery. Moreover, laparoscopy is handy for diverse applications

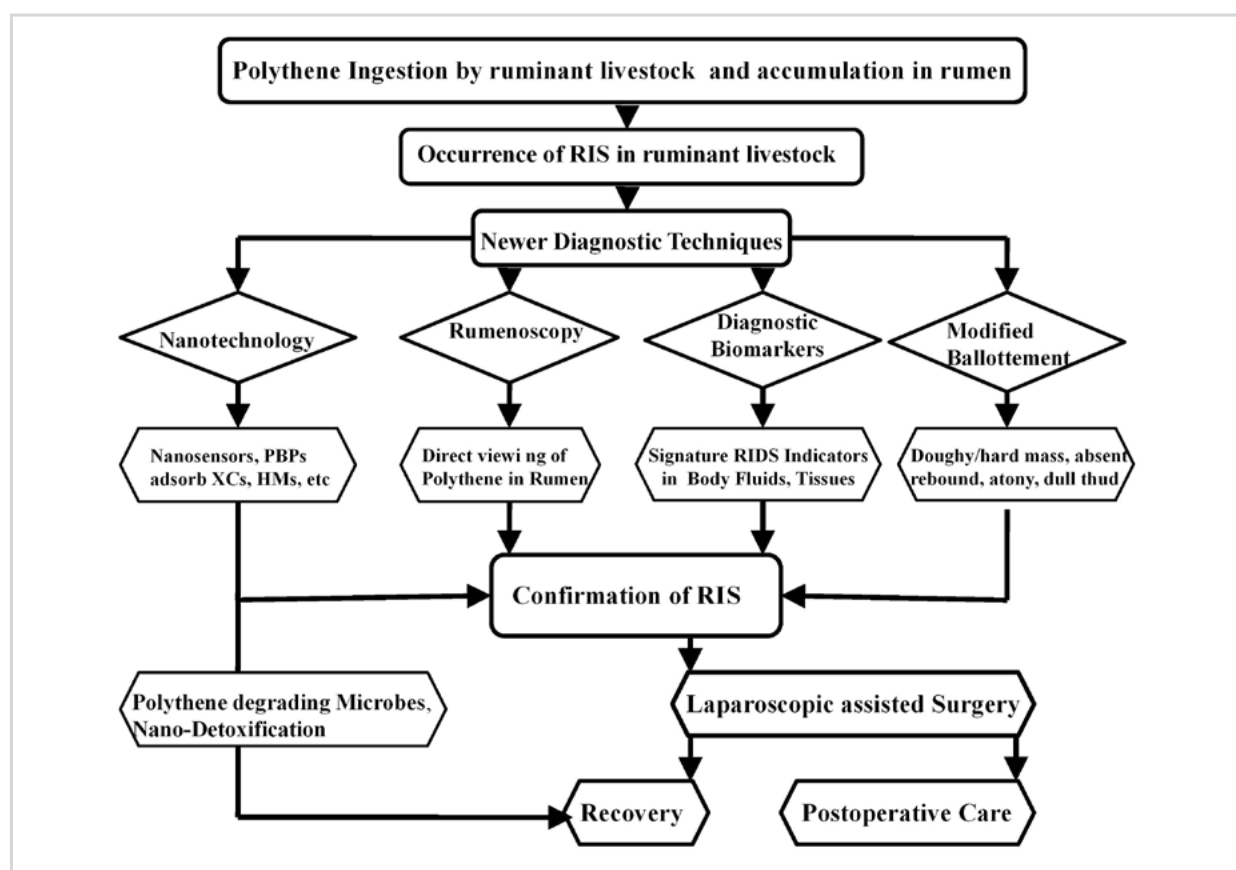


Figure 2 Flowchart of non-invasive diagnosis and minimally invasive treatment of RIS in ruminant livestock. Nanotechnology and laparoscopy offer both diagnostic and therapeutic prospects. Diagnostic markers and abdominal ballottement afford diagnosis. HMs – heavy metals, PBPs – plastic-binding peptides, RIS – ruminal impaction syndrome, XC's – xenobiotic chemicals.

in diagnosis, therapeutic interventions, and/or biopsy of organs of the abdominal cavity without the need for laparotomy.

Laparoscopy is accomplished with the aid of the cardinal tool, the laparoscope, either through the conventional telescopic rod lens system or the digital ("chip-on-the-tip") laparoscope, representing two distinct imaging technologies to visualize the abdomen (Sinha et al., 2017; Alkatout et al., 2021). The rod-lens-based laparoscopes dominate in practice for their fine optical resolution (50µm objective lens), trim contrast, better image quality and brightness (Soper et al., 2005). Also, the rod lens system has high-definition (HD) video camera (single- or three Charge-Coupled Device (CCD)) attached, with single chip cameras offering higher image sharpness (Soper et al., 2005). Equally, the digital laparoscope has a miniature digital video camera (CCD or Complementary Metal-Oxide-Semiconductor

- CMOS) attached at the distal tip of the laparoscope, eliminating the rod lens system (Soper et al., 2005). Digital laparoscope offers ergonomically superior, often focus-free, lightweight and flexible imaging that provides enhanced resolution, finer color and, in many cases, HD grade images (Sinha et al., 2017; Singla et al., 2022). The digital laparoscopes are becoming standard for complex, precision surgeries, providing depth perception and faster procedure times. Furthermore, 3D laparoscopy employs either dual-channel rods or two sensors at the tip, that significantly improve depth perception, spatial orientation and precision, critical for identifying tissue planes, particularly for suturing (Sinha et al., 2017).

In this review, rumenoscopy (syn: diagnostic laparoscopy, exploratory laparoscopy) denotes to explore, visualize and diagnose conditions, while laparoscopic rumenotomy (laparoscopy-assisted

surgery; therapeutic/operative laparoscopy) implies minimally invasive surgery to treat, repair or remove diseased tissue or organs in the abdomen or pelvic area. Laparoscopy offers diagnosis and treatment (Figure 2). Often, a procedure begins as a diagnostic laparoscopy to determine the problem and continue as therapeutic laparoscopy during the same session.

Rumenoscopy is performed through multiple (2 - 5) elective 3-5cm stab incisions in selected regions of the abdomen, creating a minimally invasive access route that allows the placement of laparoscopic instruments (scissors, dissector, probes, hooks, retractors, etc.) (Figure 3). The real time view of the operating field, assessment of abdominal contents and digital recording is enhanced by pneumoperitoneum via CO₂ gas insufflation (Sinha et al., 2017; Yu et al., 2017). The navigation system permits two directional movement (180° upward and 100° downwards) to produce 2D viewing (Jayender et al., 2018) and the irrigation system facilitates rumen lavage (Sasikala et al., 2018). Larger incisions (>10 mm) may be employed for colectomy, nephrectomy, cholecystectomy or large specimen biopsy (El-Sharkawy et al., 2019).

Rumenoscopy (Diagnostic Laparoscopy)

Rumenoscopy allows direct visualization and inspection of the abdominal cavity for diagnosing disorders like appendicitis, intra-abdominal adhesions, ascites, hernias, cirrhosis, bleeding, cancers or foreign body masses (Buia et al., 2015; Yaghobian et al., 2024). Laparoscopy also provides enhanced precision, surpassing physical examination or other imaging tests (radiography, computed tomography, ultrasonography, magnetic resonance imaging scans) to clarify pathologies (Allen et al., 2016; Bokko, 2018; Haruna et al., 2021). Laparoscopy has been shown to be more accurate than radiography for staging cancers of the digestive system (Kooby, 2006). Additionally, laparoscopy not only minimizes patient discomfort, but also allows for repeated examinations if required, providing a practical approach to ongoing abdominal assessments (Yaghobian et al., 2024). Thus, laparoscopy is well suited to evaluate the rumen for the presence of plastic masses and lesions associated with RIS by placement of the laparoscope alone (Yaghobian et al., 2024). Moreover, rumenoscopy is safe, quick and effective for establishing a conclusive diagnosis.

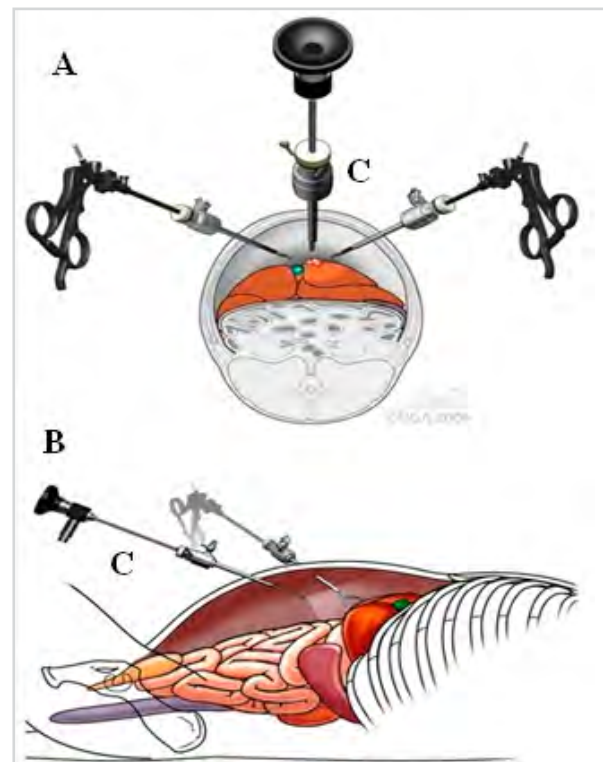


Figure 3: The laparoscopic image with triangulation depth perception of instruments orientation in the transverse (A), sagittal planes (B) and laparoscope (C)

The laparoscope illuminates the operation field view for correct lap instruments placement through the stab incisions while pneumoperitoneum with carbon dioxide gas elevates the abdominal wall to enhance visualization (<https://veteriankey.com/laparoscopy>).

Laparoscopic Rumenotomy (Laparoscopy-Assisted Surgery, Therapeutic/Operative Laparoscopy)

In addition to rumenoscopy, laparoscopy can double as a tool for removal of polythene and other indigestible materials from the rumen. Laparoscopic techniques have been widely employed for procedures such as herniorrhaphy, ovariectomy, hysterectomy, removal of certain cancers (including those affecting the colon, prostate, ovaries, liver), and the management of ectopic pregnancies in both humans and animals, while providing real-time visualization of the operative field (Sasikala et al., 2018).

Laparoscopy also reduces surgical trauma, bleeding, post-operative morbidity, pain and recovery time

compared to open surgery (Li et al., 2017). In addition, it provides superior cosmetic outcomes and facilitates a more rapid return to normal activity (Wang et al., 2017). Laparoscopic surgery for RIS treatment can significantly prevent complications like postoperative infections, risks to internal organs, fewer chances of wound dehiscence, peritonitis and postoperative hemorrhage (Martin Martel et al., 2021). Keyhole surgery also translates to shorter hospital stays, reduced cost and providing views of internal organs on a monitor (Yi et al., 2017; Yaghobian et al., 2024). Complications such as aspiration pneumonia are avoided with laparoscopy (Sasikala et al., 2018).

The future of laparoscopy in veterinary medicine looks promising, with advancements in robotic surgery, advanced imaging, instruments accessibility and precision (Buia et al., 2015; Yaghobian et al., 2024). These innovations will improve surgical outcomes and expand the range of procedures that can be performed. The dual role of laparoscopy can therefore be a boon to veterinary surgery and ruminant animal practice for early, accurate diagnosis and instant treatment of RIS.

NANOTECHNOLOGY TOOLS FOR RIS DIAGNOSIS AND TREATMENT

Nanotechnology offers a wide range of highly sensitive advanced tools for early-stage diagnosis and precise, targeted treatment options operating at atomic or molecular scale (1–100nm) for RIS (Figure 2). Nanotechnological approaches are primarily driven by the inadequacies of existing diagnostic and therapeutic methods, which currently remain the only available options. Early detection of RIS is crucial for preventing severe structural and functional damage to the rumen.

Nanotechnology in RIS Diagnostics

Nanoparticles may be developed into diagnostic tools such as nanosensors/nanobiosensors that enable accurate, faster, low-cost and ultra-sensitive detection of indicators (Mekonnen, 2021). Nanosensors are high-precision tools that can be used for real-time, on-site monitoring of ruminal distress and early recognition of specific diagnostic markers for RIS in biological samples like blood, rumen liquor or saliva (Danchuk et al., 2023; Sharma et al., 2025). Prompt diagnosis via nano-sensors allows intervention before RIS becomes a clinical disease. Additionally, nanoparticles can be used as contrast agents in digital imaging to visualize non-penetrating foreign bodies within the rumen, replacing the need for invasive, exploratory rumenotomy.

Nanotechnology in RIS Treatment

Treatments focus on breaking down foreign matter, preventing secondary infections, and repairing damaged tissues. Nanoparticles can also be engineered into Nano-Detoxification Systems as high-affinity binders to adsorb, bind, neutralize, or remove toxins within the rumen by leveraging high surface area and specific affinities, preventing their absorption into the animal's system and the entry into food chain (Pashirova et al., 2023). In addition, prokinetic drugs or bioengineered nano-enzymes can be delivered directly into the rumen to target and break down polymeric plastics or fiber-based blockages that lead to impaction. Emerging research indicates that the use of nanoparticles enhances the ability of rumen microorganisms to degrade polythene by re-engineering their metabolic cycles (Graham et al., 2011). Furthermore, metal-based nanoparticles such as zinc oxide (ZnO-NPs) and selenium (Se-NPs) can be used to treat metabolic disorders associated with RIS and re-stabilize the ruminal microflora, which is often severely disrupted in RIS (Michalak et al., 2022; Kholif et al., 2025).

Nanotechnology, alongside other advanced techniques such as digital non-invasive imaging and laparoscopy, may form a comprehensive strategy to manage RIS more effectively (Figure 2). Overall, nanotechnology could offer significant improvements over existing diagnostic and treatment options for RIS.

DECIPHERING PUTATIVE DIAGNOSTIC MARKERS FOR RIS

Diagnostic markers are signature molecules that detect or confirm the presence of a disease or condition of interest. To date, there are no established signature molecules or diagnostic biomarkers for RIS in ruminants. Developing diagnostic markers for RIS focuses on identifying physiological, haematological and biochemical molecules arising from the chronic accumulation of polythene in the rumen. Putative diagnostic markers to identify RIS *in vivo* are emerging through research into metabolic, inflammatory, and molecular changes. The putative diagnostic marker that may provide a definitive diagnosis can be any of the polythene forms, plastic micropellets in the rumen fluid, rumen content or faecal material (Figure 2). Potential diagnostic markers may include polythene monomers, microplastics and nanoplastics, xenobiotic chemicals, heavy metals, biological agents, degradation products, reporter molecules, and enzymes, which may be triggered by RIS or by ingestion of polythene and other indigestible materials. These markers may be detectable

in blood, milk, urine, tissues, and ruminal fluid, and could potentially serve as indicators of RIS (Figure 2). Their concentration is expected to be directly or indirectly proportional to the state of RIS.

The diagnostic markers can be characterized, re-engineered or labeled, and then developed into a reliable, rapid, cost-effective and easy to use kit for early and spot-on diagnosis of RIS. Utility of specific diagnostic markers aid the early diagnosis of RIS and helps ensure timely treatment.

MODIFIED ABDOMINAL BALLOTTEMENT TECHNIQUE FOR DIAGNOSIS OF RIS

The term “Ballottement” derived from the French word *balloter* (“to toss” or “to shake” or “to move about”) originated in the 1830s (Cockcroft and Jackson, 2004). Traditional abdominal ballottement is a specialized physical palpation technique of a “push and feel” that relies on the principle of rapidly displacing fluid causing the underlying solid object to float away and then “rebound” or “bounce” back to tap the examiner’s hand.

Conventional abdominal ballottement has been subjected to a variety of refinements to accurately decipher complex scenarios where the simple push and feel does not yield desired outcome or when such adjustments offer decisive conclusion. These refinements transform the technique into a more systematic, multi-step or positional maneuvers (Abdisa, 2017). Modifications or specialized versions of ballottement technique significantly enhance diagnostic accuracy particularly in complex clinical situations—such as pregnancy diagnosis, enlarged organs (kidney, liver), ascites or sizeable foreign mass in the rumen (Abdisa, 2017). Such modified techniques include a specialized bimanual ballottement technique executed using one hand to apply sudden pressure to produce “milking” motion or “toss” or displace internal structures against a stationary, feeling hand acting as a stabilizer on the opposite side to detect the “bounce” from enlarged organs (e.g. kidneys) or masses within an ascites-filled abdomen (Abdisa, 2017). Additionally, Ballottement and Simultaneous Auscultation (BSA) technique combines physical pushing with auscultation (stethoscope) to detect fluid-splashing sounds as in traumatic reticuloperitonitis or left-displaced abomasum (LDA) (Cockcroft and Jackson, 2004). Furthermore, Ballottement Percussion (Tactile Percussion) involves a “firm and interrupted” push, creating a wave-like fluid movement that allows the detection of organ enlargement (e.g., liver), masses,

or pregnancy in small ruminants that cannot be felt through either method alone.

Modified abdominal ballottement enhances accuracy of RIS diagnosis, even in field situations or remote communities. The Modified Ballottement Technique involves locating the rumen, typically in the left paralumbar fossa and the region caudal to an imaginary line drawn from the point of the elbow to the top of the last rib (Bayne and Edmondson, 2020; Petzl et al., 2026). The technique involves applying deep, firm-pushing stroke, inward thrust using a clenched fist into the left paralumbar fossa, and upward pressure against the left flank, where foreign bodies are frequently located (Karadaev, 2015). Crucially, the hand should remain in contact with the abdomen after the initial push (Abdisa, 2017). The goal is to specifically detect the presence of dense, solid mass that is “doughy” to “hard” in consistency, which would indicate compacted foreign material in the rumen; distinct from normal rumen contents that can feel soft and soggy (Table 2). RIS will typically exhibit a lack of rebound, feeling solid and heavy against the hand from tightly packed palpable hard or doughy mass in the mid-to-caudal left abdomen that does not “bounce” or produce a fluid wave (Table 2). The key diagnostic finding for RIS therefore is the sensation of a solid hard or doughy mass of heavily impacted rumen (Figure 2). The polythene masses indicative of RIS usually occupy the flank and the lower quadrants (Terra and Reynolds, 2020).

Modified abdominal ballottement, a refined, low-cost technique has shown high accuracy rates—ranging from 80% to 95% of field cases, especially small ruminants, allowing for earlier detection of impacted masses before irreversible systemic damage occurs (Petzl et al., 2026). As a physical, manual technique, it requires no specialized equipment, making it highly suitable for field conditions and small holder farmers.

Modified ballottement technique serves a “triad of purpose”. First, it can be utilized for the benefit of remote areas and rural communities to diagnose RIS in their ruminants, as most of the livestock are kept on a semi-intensive rearing. Second, this technique can be used in cases where equipment such as imaging devices, laparoscopy and diagnostic marker assay are not freely accessible. Third, ballottement can be employed by trained community-based animal health workers, veterinary nurses, veterinary technicians, field veterinary assistants or paraprofessionals to detect and report RIS in ruminant livestock.

Table 2 Findings following abdominal ballottement tests on healthy and RIS ruminants: distinctions between normal and RIS rumen reactions upon abdominal ballottement in the mid-to-caudal left flank. Succussion technique refers to vigorous shaking of the left flank by rocking side to side. Typical result is a splashing or fluid-sloshing sound on auscultation. In RIS, succussion yields a dull thud or lack of splashing sounds due to mass

Feature	Normal Rumen	RIS Rumen
Consistency	Dorsal resilient gas cap, mid doughy fiber mat of firmer fibrous material and bottom with rumen fluid.	Uniformly firm: hard mass or a very doughy in the mid-to-ventral abdomen
Rebound	Soft, elastic rebound or resilient “bounce”. Rumen walls yield to pressure and returns quickly.	Indistinct, reduced or absent rebound. Mass moves as a single, sluggish unit.
Sound	Splashing or “tinkling” fluid wave	Dull or absent fluid wave/splashing
Rumen Motility	Normal, Regular, consistent ruminal contractions cycles (typically 1-3 per minute) in the left paralumbar fossa.	Reduced or absent (rumen stasis/atony) due to the heavy, static mass.
Abdominal Contour	Normal symmetrical or slight filling of the left flank within a normal range.	Ventral left abdomen often visibly distended (bilateral in severe cases).
Succussion splash	a “slushy” or splashing sound	dull thud
Pain Response	Generally non-painful.	May show signs of abdominal discomfort during deep palpation.

CONCLUSION

Ruminal impaction syndrome (RIS) resulting from the ingestion of polythene materials remains an emerging and serious gastrointestinal disorder that threatens ruminant health, welfare, and sustainable production, particularly in developing regions where environmental plastic pollution is widespread. The high prevalence, neglect and “vicious cycle” continually and severely hamper the efficiency of extensive and semi-intensive ruminant livestock production systems, with colossal economic loss to livestock stakeholders and considerable health hazards to humans in endemic regions. Current identification and treatment methods have significant deficiencies. Laparoscopy, nanotechnology, establishment of specific diagnostic markers will provide non-invasive, high precision diagnosis and instant minimally invasive treatment of RIS. The integration of modified abdominal ballottement with the analysis of putative markers provides an effective field-

level diagnostic framework to allow early detection of RIS. The multi-tiered, technology-driven approach for the management of RIS in ruminants represents the new standard of care to maximize long-term livestock health, improve individual survival rates and safeguard the economic viability of livestock production systems.

CONFLICT OF INTEREST

The authors declare no competing interests regarding the authorship, content or publication of this article.

CONTRIBUTORS

All content herein in this article is solely by the authors. PBB conceptualized and wrote the initial review manuscript draft. PBB also generated data on laparoscopy, nanotechnology, diagnostic markers prospects and the economics of RIS. AAH,

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Utjecaj sindroma ruminalne impakcije na produktivnost preživara: Evaluacija protokola za brzu dijagnostiku i liječenje

SAŽETAK

Sindrom ruminalne impakcije (RIS) je novonastali, težak i potencijalno smrtonosan gastrointestinalni poremećaj koji pogađa preživare u urbanim, poluurbanim i periurbanim naseljima, sa sve većim širenjem u ruralne zajednice u zemljama u razvoju. RIS nastaje uslijed ingestije neprobavljivih predmeta koji se akumuliraju u buragu i ometaju prolaz ingesta kroz donji probavni trakt, što dovodi do teške impakcije, poremećaja probave, perzistentnog timpanizma, produženog morbiditeta, letargije, a u teškim slučajevima i smrti. Dodatno, RIS dovodi do gubitaka životinja, smanjene proizvodnje mlijeka i mesa te skupih i često neefikasnih tretmana. Nadalje, RIS pokazuje visoku prevalenciju koja se održava kroz začarani krug. Definitivna dijagnoza i liječenje često se oslanjaju na eksplorativnu rumenotomiju. Pogođene životinje nerijetko dopijevaju u terminalni stadij bolesti, što ograničava terapijske mogućnosti. Hirurški ishodi su često nepovoljni i najčešće povezani sa postoperativnim komplikacijama. Nadalje, mikroplastika, nanoplastika, ksenobiotičke hemikalije i teški metali mogu dospjeti u ruminalnu tečnost, bioakumulirati se u tkivima i ući u prehrambeni lanac putem mlijeka i mesa, gdje ispoljavaju štetne toksične efekte kod životinja i ljudi. Uprkos visokoj učestalosti i značajnom ekonomskom i zdravstvenom opterećenju, ne postoje uspostavljeni državni propisi niti standardizirane smjernice za dijagnostiku i liječenje RIS-a, što ga čini važnim, ali zanemarenim poremećajem kojeg veterinari često tretiraju empirijski. Integracija rumenoskopije zajedno sa nanotehnologijom, dijagnostičkim markerima i modificiranom tehnikom abdominalne palpacije (ballotement) može unaprijediti tačnu dijagnostiku, dok terapijska laparoskopija može omogućiti pravovremeno liječenje. Ovaj pregledni članak procjenjuje značajan utjecaj RIS-a na zdravlje i produktivnost preživara. Konačno, cilj je uspostaviti učinkovite dijagnostičke puteve i terapijske protokole koji se mogu primijeniti od strane veterinara i donosilaca politika, kako bi se poboljšalo zdravlje životinja, unaprijedila dobrobit i osigurala održiva produktivnost sistema uzgoja preživara.

Ključne riječi: Burag, dijagnostika, impakcija, liječenje, produktivnost.