

Clinical, hematological and biochemical findings in bovines with primary abomasal impaction

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Klinische, hämatologische und biochemische Befunde bei Rindern mit primärer Labmagenanschoppung

Die bisher beschriebenen biochemischen Veränderungen bei primärer Labmagenanschoppung (PAI) konzentrierten sich hauptsächlich auf Elektrolyte; die Veränderungen des C-reaktiven Proteins (CRP) und der Leberenzyme wurden bei erwachsenen Wasserbüffeln (*Bubalus bubalis*) bislang nicht speziell untersucht. Ziel dieser Studie war es, die Blutgaswerte, das CRP sowie die klinischen, hämatologischen und biochemischen Merkmale des PAI in einer prospektiven Studie zu beschreiben. Die Studie wurde an 15 Tieren (neun Büffeln und sechs Kühen) durchgeführt, bei denen eine primäre Labmagenanschoppung diagnostiziert wurde. Die Diagnose stützte sich auf die Konsistenz des Labmagens bei der Laparorumenotomie und/oder der Sektion. Das Alter der Tiere lag zwischen 2,5 und 10 Jahren, die seit 4 bis 15 Tagen erkrankt waren. Die Futterzusammensetzung war durch minderwertige Ballaststoffe (Weizenstroh) gekennzeichnet. Die häufigsten klinischen Symptome waren Anorexie, verminderte Wasseraufnahme, Lethargie, gerötete Schleimhäute, Dehydrierung, verminderte Pansenmotilität sowie spärlicher oder fehlender Kot mit oder ohne Schleim. Die hämatologischen Befunde waren in den meisten Fällen durch Neutrophilie, mit einer Linksverschiebung und einer toxischen Neutrophilie, gekennzeichnet. Die konsistenten biochemischen Veränderungen waren Hypochlorämie, Hypokaliämie, Hypokalzämie, Hypophosphatämie sowie erhöhte Werte des C-reaktiven Proteins, AST, GGT, Globulin, Triglyceriden, Glukose, Harnstoff, Kreatinin, Laktat, Magnesium und Chlorid in der Pansenflüssigkeit. Die Blutgasanalyse ergab eine schwere metabolische Alkalose mit kompensatorischer respiratorischer Azidose. Die Prognose der Erkrankung war schlecht. Der Grad der metabolischen Alkalose, der Hypochlorämie, der Hypokaliämie und der Hyperlaktatämie könnte bei der Unterscheidung

Summary

The reported biochemical changes in primary abomasal impaction (PAI) have mainly focused on electrolytes; the changes in C-reactive protein (CRP) and liver enzymes have not been evaluated particularly for adult buffaloes (*Bubalus bubalis*). The aim of this study was to describe the blood gas parameters, CRP, clinical, hematological, and biochemical characteristics of PAI in a prospective study. The study was conducted on 15 animals (nine buffaloes and six cows) diagnosed with PAI. The diagnosis was based on consistency of abomasum on laparo-rumenotomy and/or necropsy. The age of the animals was 2,5 to 10 years and had been ill for 4–15 days. The food composition was characterized by low quality fibres (wheat straw). Most frequent clinical signs were anorexia, reduced water intake, dullness, congested mucous membranes, dehydration, ruminal hypomotility, and scanty or absent feces with or without mucus. The hematological findings were neutrophilia, left shift and toxic neutrophils in most of the cases. The consistent biochemical changes were hypochloremia, hypokalemia, hypocalcemia, hypophosphatemia, and increased levels of C-reactive protein, aspartate aminotransferase, gamma-glutamyl transferase, globulin, triglycerides, glucose, urea, creatinine, lactate, magnesium and ruminal fluid chloride. Blood gas analysis revealed severe metabolic alkalosis with compensatory respiratory acidosis. Prognosis of the disease was poor. The degree of metabolic alkalosis, hypochloremia, hypokalemia and hyperlactatemia could be helpful in differentiating abomasal impaction from other abdominal disorders in bovines.

Keywords: Abomasal impaction, blood gas analysis, C-reactive protein, prognosis, ultrasonography

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Schlüsselwörter: Blutgasanalyse, C-reaktives Protein, Labmagenanschoppung, Prognose, Sonographie

Introduction

Abomasal impaction in adult bovines is an infrequently reported condition caused by accumulation of excess solid materials in the abomasum.²⁶ Due to the abnormal accumulation of solid matter in the abomasum there is enlargement of the abomasum and drying of the abomasal contents. This disease may occur as primary or secondary abomasal impaction. The primary abomasal impaction (PAI) occurs when poor quality fibrous feed (like straw) constitutes major portion of the diet^{5, 17} or due to the accumulation of sand and gravel in the abomasum.²³ The secondary abomasal impaction can occur in association with traumatic reticuloperitonitis/ pericarditis, abomasal ulceration and vagal indigestion.^{17, 26} The fixation of reticulum to the ventral abdominal wall due to the fibrinous peritonitis interferes with the normal cyclic motility of the reticulum leading to impaired sieving action of the reticulum and subsequent accumulation of large fibres in the abomasum leading to its distension and impaction.⁵

Despite the frequent use of dry and fibrous roughage for feeding of cows and buffaloes (*Bubalus bubalis*), especially during the dry season, impaction of abomasum has been poorly reported in India, probably because the condition is under diagnosed by the practitioners. In Punjab state it is usually confused with rumen impaction, omasal impaction and peritonitis, due to similar presenting complaint given by the owners i.e. absence of defecation.^{13, 18} Although the dietary abomasal impaction is well recognised in cattle, there is no or little published information on PAI in buffaloes.⁶ In a recent study, impaction of the abomasum has been primarily observed as secondary to other gastrointestinal disorders.¹⁷ The clinical signs reported in various studies are scanty or absent feces, anorexia, absence of rumination, reduced milk yield, depression, dehydration, tachycardia, hypomotile rumen, colic signs, and abdominal distension or bilateral ventral abdominal distension.^{1, 5, 23, 26–28} The reported laboratory changes in abomasal impaction are not consistent. The principal component analysis has revealed increased rumen fluid sedimentation time and chloride content, serum creatine phosphokinase, and blood neutrophil and eosinophil counts along with decreased blood lymphocyte proportion, potassium, and chloride as the greatest indicators for abomasal impaction in buffaloes.²⁷ The diagnosis of abomasal impaction is based on surgical or necropsy findings. However, a few studies has reported the utility of ultrasonography for the diagnosis of

abomasal impaction in cattle and buffaloes. One study has reported that scanning of bovine abomasum at the level of right elbow in the 8th to 10th intercostal spaces with dorsally displaced abomasum and positive liptak test is confirmatory for abomasal impaction/dilatation.² Another study observed increased abomasal size with no movement of the abomasal contents on ultrasonographic examination during abomasal impaction in buffaloes.²⁸ Most of the previous reports on the biochemical changes in bovine abomasal impaction have focussed on a few liver enzymes and other parameters, particularly, electrolytes.^{26, 27} Further, the blood C-reactive protein (CRP) concentration has not been evaluated previously in bovine abomasal impaction. This prospective study describes the blood gas parameters along with CRP, clinical, hematological and biochemical features of PAI in bovines.

Materials and methods

Signalment and physical examination

The study was performed in compliance with the institutional ethical guidelines. All owners gave their consent for the animals to be included in the study and testing procedures. Animal welfare and use of animals in research is regulated by the Committee for Control and Supervision of Experiments on Animals (CCSEA), a statutory body under India's Ministry of Fisheries, Animal Husbandry and Dairying, and through the Institutional Animal Ethics Committees (IAEC). All procedures have been conducted as per the guidelines by Guru Angad Dev Veterinary and Animal Science University IAEC constituted as per the article number 13 of the CCSEA rules laid down by the Government of India. The ethical clearance for the PhD study was granted by Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India, vide no. VMC/13/2187-2215, dated 02/05/2013.

The study was conducted on six Holstein-Friesian crossbred cows and nine buffaloes (three Murrah, two Nili-Ravi and four their crosses) suffering from PAI. The tentative diagnosis of the cases was on the basis of feeding history, clinical evaluation and laboratory analysis especially blood gas analysis. The diagnosis was confirmed by left flank laparo-rumenotomy (n = 6) and/or post-mortem examination (n = 9). No other cause of gastrointestinal dysfunction was observed on the physical examination, ancillary tests, and surgery or post-mortem examination. Detailed signalment

and history including species, age, sex, parity, duration of illness, pregnancy and lactation status were recorded in all the animals. A detailed history of feed and water intake, type of fodder, defecation, calving status, milk yield, tympany, symptoms of vomiting, fever and pain were noted in every case. All the animals were subject to a thorough clinical examination along with complete rectal examination.⁵ All animals were evaluated for the hydration status and vital physiological parameters. A focused gastrointestinal examination was conducted to assess abdominal conformation, ruminal consistency, rumen motility, the presence of intra-abdominal or intestinal fluid, and responses to pain-eliciting tests, including the withers pinch and palpation of the xiphoid region. During rectal examination, the amount of feces in the rectum, ruminal dimensions and degree of fill, ease of hand movement, and the condition of the intestinal tract were recorded.

Hematological, biochemical and blood gas analyses

The blood samples were taken for hematological and biochemical analysis as per our previously described procedures.¹⁵ Serum samples were utilized for the quantification of all biochemical analytes except glucose and fibrinogen. For the determination of glucose and fibrinogen concentrations, whole blood was collected in sodium fluoride and sodium citrate anticoagulated tubes (Accuvote Disposables, Quantum Biologicals Pvt. Ltd. Chennai, Tamil Nadu, India), respectively. Biochemical analyses were performed using the VITROS DT-II automated chemistry analyzer (Ortho-Clinical Diagnostics, Johnson & Johnson Company, New Brunswick, NJ, USA). Fibrinogen levels were measured by the heat-precipitation technique employing a handheld refractometer. The fibrinogen ratio was derived by subtracting the fibrinogen value from the total protein concentration and expressing the remainder relative to the total protein concentration.

Abdominocentesis was done in all the animals. The animals were restrained in standing position with hind limbs tied together. The sites were prepared aseptically and not infiltrated with any local anaesthetic. Free hand abdominocentesis, using 16–18G (1.5 inch long) sterilized needles, was done at the three sites. (i) Caudal to the xiphoid-sternum and 4–10 cm lateral to midline. (ii) Just anterior to the base of udder on the right side. (iii) Random tap at any site in the abdomen without puncturing the internal organs. The rumen liquor samples were taken for estimation of the rumen chloride concentration.¹³ For blood gas analysis, the blood samples were collected in heparinised syringes (1:1000) and care was taken to avoid entrance of atmospheric air into the samples. For this purpose, the tip of the needle was sealed immediately after venipuncture with a rubber stopper. The blood gas analysis was performed by Radiometer ABL 77 Series (ABL 77 v1.41, Analyser, produced by Radiometer- Denmark), within 5 minutes of collection.¹²

Anion gap was calculated by the difference of concentration of the major cations and major anions. Serum CRP was estimated by Bayer's diagnostic kits with the help of Micro-lab Autoanalyser (Merck).¹²

Radiography and laparorumenotomy

Reticular radiographs were taken in the right lateral recumbency (using ceiling mounted movable Seimen's 800 mA X-ray machine) to rule out foreign body syndrome.²¹ Left flank laparo-rumenotomy under local anesthesia was performed for diagnostic confirmation and flushing of impacted abomasum as per the protocol of the clinic. Post-operative treatment included intravenous administration of 5–10 L of normal saline and 5 L of dextrose normal saline for 3–4 days, 1 dose of intravenous calcium therapy (450 ml of Mifex®, Novartis India Limited, India), 200 ml of liquid Potklor® (containing 20 g of potassium chloride, twice daily) orally for 3 days, 10 ml intramuscular injection of rumeric (B complex and amino acids) for 3–5 days. The animals were discharged on the third day of treatment. Antibiotics (ampicillin and cloxacillin combination, and enrofloxacin) and analgesics (meloxicam) were administered at the standard doses for a period of four days. Normal feed/water intake and defecation, two to three days after the surgery, was regarded as recovery. The clinical outcome was defined as short- (discharged from hospital), medium- (20 days after discharge), and long-term outcome (3, 6, 12, and 24 months after discharge). Follow-up information was obtained by time-to-time telephonic conversation with the owners. For a period of 24 months, the owners were contacted on regular basis at intervals of 3 days for 15 days, every 15 days for the first 2 months, and then every 6 months. Detailed necropsy examination was carried out in the animals that died at our clinic.

Statistical analysis

The quantitative data were expressed as mean \pm standard deviation as well as median.

Results

Historical, clinical and radiographic findings

The study included 15 animals (9 buffaloes and 6 cattle) suffering from PAI. The affected animals were 2.5 to 10 years old (mean = 6 ± 2.81 years, median = 6 years) and had been ill for 4–15 days (mean = 8.73 ± 3.41 days, median = 8 days). All except one animal were females, two were heifers, seven were in first or second lactation, two were in third lactation, and three were in 5th - 6th lactation. Among the 14 females six were 3–8 months pregnant and the other had calved 1–6 months earlier. The food composition was characterized by low quality fibres i.e. wheat straw (exclusive wheat straw feeding in six cases). One case was presented in each of February, March, June, July and October, two cases each in April and November, and three cases each in May

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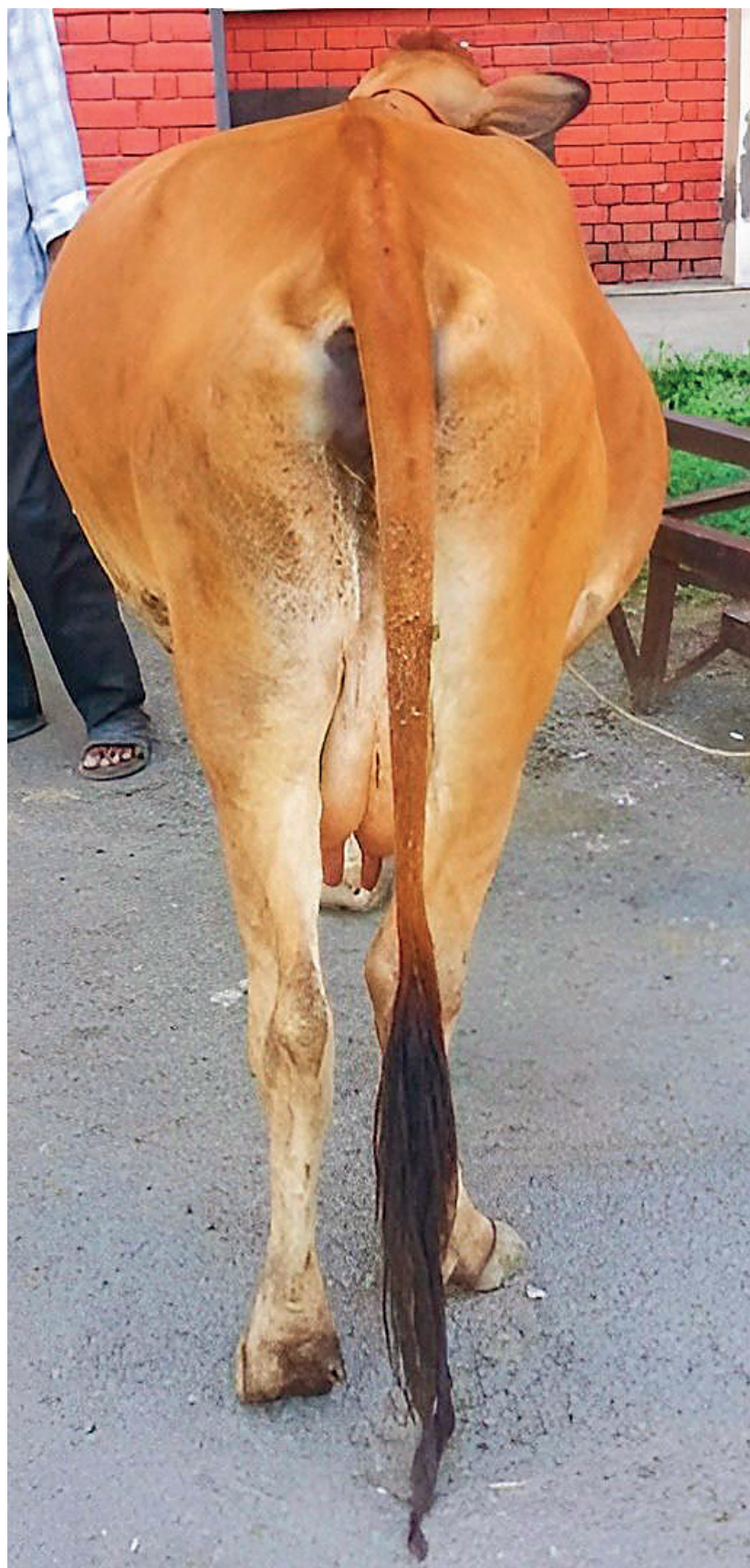


Figure 1: «Papple-shaped» abdomen in a cow suffering from primary abomasal impaction.

and December. Majority of the animals showed anorexia, reduced water intake, gradual or sudden drop in milk yield, dullness, congested mucous membranes, moderate to severe dehydration and scanty or absent feces with or without mucus. Tympany was observed in seven cases being persistent in five and recurrent in two. Five animals had a history of pain and two animals had a history of regurgitation. The pain was characterised by restlessness and occasional kicking at the abdomen. The rumen motility was absent in eleven, decreased in two and increased in two cases.

The rectal temperature, respiration rate and heart rate were within the reference interval but fever and tachycardia were observed in three and four cases, respectively. Moderate to severe left side abdominal distension was observed in eight cases, and bilateral distension and «papple-shaped» abdomen was observed in two cases (Figure 1). Rectal examination did not help in the diagnosis as impacted abomasum was not palpable in any of the cases. However, feces were black colored in six cases. Rectal examination was not performed in one animal as the animal was young and the animal became recumbent soon after presentation to the clinic. Swinging palpation revealed rebound effect of hard mass (impacted abomasum) in the lower right part of the abdominal wall in three animals. Radiography of reticular area was negative for foreign bodies and abdominocentesis did not reveal any peritoneal fluid.

Hematological, biochemical and blood gas findings

The mean values of hematological, biochemical and blood gas parameters are presented in table 1. The mean concentrations of hemoglobin, packed cell volume (PCV), total white blood cell (WBC) count and lymphocyte count were within the normal reference interval. The mean neutrophil count was increased. The WBC count was $<8000/\mu\text{L}$ in nine, $8000\text{--}12000/\mu\text{L}$ in two and $>12000/\mu\text{L}$ in four animals. Five animals had absolute neutrophilia, out of which four animals had neutrophilic leukocytosis. Toxic changes in neutrophils along with left shift were observed in seven animals, left shift without toxic changes in four, and toxic neutrophils without left shift were observed in one animal. The mean concentrations of total bilirubin, aspartate amino transferase (AST), gamma-glutamyl transferase (GGT), glucose, triglycerides, globulin, blood urea nitrogen (BUN), creatinine, lactate, magnesium and rumen chloride were increased while sodium, potassium, chloride, calcium and phosphorus were decreased. Alkaline phosphatase (ALP), cholesterol, total protein, albumin, fibrinogen and fibrinogen ratio were within the normal reference range. Blood gas analysis revealed increased mean values of pH, partial pressure of carbon dioxide (pCO_2), bicarbonate (HCO_3), standard bicarbonate (SBC), actual base excess (ABE), standard base excess (SBE) and increased anion gap. The acid base imbalances were interpreted on the basis of blood pH, pCO_2 and SBE as per the guidelines of Haskens.⁷ The higher blood

pH than the reference interval indicated alkalosis and higher pCO₂ indicated respiratory acidosis. The SBE > 4 indicated metabolic alkalosis. So the blood gas imbalance was primary metabolic alkalosis with compensatory respiratory acidosis. The overall disturbance was hypochloremic, hypokalemic metabolic alkalosis with compensatory respiratory acidosis. If the metabolic component of the acid base bal-

ance had been interpreted on the basis of HCO₃, SBC or ABE, the final interpretation was same as that of SBE. So, under clinical situations, any one of these parameters can be used for interpreting metabolic component of acid base balance. The serum CRP ranged from 0–2,6 mg/dL (mean = 1,41 ± 0,87 mg/dL), being elevated in 10 animals.

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Table 1: Hematological, biochemical and blood gas analytes from bovines with primary abomasal impaction.

Measurement	Mean ± SD	Median	Reference range	Number of animals with values below the reference range	Number of animals with values above the reference range
Hemoglobin (g/L)	107,5 ± 28,9	102	85–122	02	05
PCV (L/L)	0,35 ± 0,10	0,33	0,22–0,33	01	07
WBC (×10 ⁹ /L)	9,5 ± 4,9	7,3	4,9–12,0	01	04
Neutrophils (×10 ⁹ /L)	6,9 ± 4,4	5,8	1,8–6,3	0	05
Lymphocytes (×10 ⁹ /L)	2,6 ± 8,9	2,7	1,6–5,6	02	0
Total Bilirubin (µmol/L)	18,1 ± 24	8,55	0,17–8,55	0	06
AST (U/L)	221,7 ± 88,1	234	78–132	0	14
ALP U/L)	93,5 ± 25,9	91	0–200	0	0
GGT (U/L)	59,3 ± 33,1	45	6,1–17,4	0	15
Glucose (mmol/L)	7,28 ± 4,23	8,1	2,5–4,2	01	10
Cholesterol (mmol/L)	1,70 ± 0,86	1,35	1–5,6	11	0
Triglycerides(mmol/L)	0,43 ± 0,36	0,28	0–0,2	02	13
Total protein (g/L)	72,1 ± 9,7	73	57–81	0	03
Albumin (g/L)	29,6 ± 4,9	30	21–36	0	01
Globulin (g/L)	42,5 ± 7,2	45	30–35	01	10
Fibrinogen (g/L)	3,8 ± 1,5	3,5	2–7	0	0
Fibrinogen ratio	20,91 ± 10,68	16,8	>15	0	06
BUN (mmol/L)	18,4 ± 8,6	18,6	2–7,5	0	12
Creatinine (µmol/L)	364 ± 328	274	67–175	0	10
Lactate (mmol/L)	12,64 ± 4,17	10,8	0,6–2,2	0	15
Sodium (mmol/L)	132,6 ± 11,46	135	132–152	08	0
Potassium (mmol/L)	2,37 ± 0,39	2,2	3,9–5,8	15	0
Chloride (mmol/L)	62,46 ± 13,34	58	95–110	15	0
Calcium (mmol/L)	1,92 ± 0,55	1,85	2,43–3,10	14	0
Phosphorus (mmol/L)	1,58 ± 0,60	1,48	1,08–2,76	13	02
Magnesium (mmol/L)	1,34 ± 0,47	1,19	0,74–1,10	0	12
Rumen Chloride(mmol/L)	67,33 ± 7,86	66,0	<30	0	15
Blood pH	7,617 ± 0,071	7,595	7,35–7,5	0	15
pCO ₂ (mmHg)	51,58 ± 11,92	51,5	34–45	0	11
HCO ₃ (mmol/L)	53,61 ± 14,32	50,4	20–30	0	15
SBC (mmol/L)	52,51 ± 14,32	48,55		0	15
ABE(mmol/L)	16,81 ± 9,11	18,5	-4 to +4	0	15
SBE (mmol/L)	15,45 ± 10,11	17,8		0	15
Anion Gap (mmol/L)	29,62 ± 32,2	19,45	14–26	02	07

PCV=packed cell volume, WBC= total white blood cells, AST= aspartate aminotransferase ALP= alkaline phosphatase, GGT= gamma-glutamyl transferase, BUN=blood urea nitrogen, pCO₂ =partial pressure of carbon dioxide, HCO₃=bicarbonate, SBC =standard bicarbonate, ABE=actual base excess, SBE=standard base excess.

Reference ranges: from Constable et al. (5).

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Surgical and necropsy findings

Laparo-rumenotomy was performed in six animals. In all six animals the reticulum was free and reticular foreign bodies were absent. Rumen was distended with frothy and drier contents in one animal. Abomasum was impacted in all the six cases. Omasum was impacted in two cases. Abomasum (omasum also, if impacted) was evacuated and thoroughly flushed with water under moderate pressure, kneaded and most of the impacted contents were flushed back into the rumen. Three animals recovered successfully 4–6 days after the surgery and the other three died after 1–5 days of the surgery. The three recovered animals remained productive members of their herds; two became pregnant, and delivered healthy calves. After recovery from surgery, there was no significant effect on the milk yield in the current or subsequent lactation. One recumbent animal that had severe bilateral abdominal distension underwent rumenostomy. Due to deterioration in the condition, this animal was euthanized with owners consent on 4th day. Necropsy revealed severe omasal and abomasal impaction.

The owners of three animals were not willing for the surgery and these animals were treated with intravenous fluids, antibiotics and other supportive care. There was no response to the medical treatment and eventually these three animals perished after 2–4 days. Another five animals died before the surgery. The necropsy of all these eight cases revealed dilated and impacted abomasum. The rumen contents were watery or slightly dry and no reticular foreign bodies could be recovered on post-mortem examination. Omasum was impacted in four cases. One animal had severe abomasal impaction and dilatation (size of almost rumen) (Figure 2) along with omasal dilatation, and abomasal wall was excessively thin which was so friable that it ruptured on touch. Epicardial hemorrhages were observed in one case and intestinal mucosa was hyperemic in another case. Type 1b and 1a abomasal ulcers were observed in five cases.



Figure 2: Photograph showing severe primary abomasal impaction on necropsy.

Discussion

In this prospective study historical findings, clinical signs, hemato-biochemical findings, blood gas alterations, treatment and outcome were investigated in a series of cases of PAI in bovines. The reported causes of scanty or absent feces in bovines of Punjab (India) include rumen impaction, omasal impaction, intestinal obstruction, abomasal ulcers, peritonitis, caecal dilatation, reticular diaphragmatic hernia, and late pregnancy indigestion. The diagnosis was established as PAI after these disorders were ruled out by the procedures as described by the previous authors. Further, no other cause of gastrointestinal dysfunction could be established on laparo-rumenotomy and/or necropsy.

In present study, the 15 cases of PAI were observed over a period of three years, suggesting a low prevalence of PAI in cattle and buffaloes. In a recent retrospective study, the prevalence of abomasal impaction was 0,35 percent, being similar for cattle and buffaloes.¹⁰ Another necropsy based study has reported prevalence 8,2% but that study included both primary and secondary cases of abomasal impaction.¹⁷ The main causes for secondary abomasal impaction in that study were traumatic reticuloperitonitis/pericarditis and abomasal ulceration.¹⁷ We believe that feeding of wheat straw was the possible cause for PAI in this study. Wheat straw feeding has been implicated as a cause of stomach impaction in cattle and buffaloes in the previous studies.^{13,19,25} The contributory factors for dietary abomasal impaction include advanced pregnancy, high energy demands of the growing heifers and cold weather.⁵ In this study four cases were observed during the winter months (December-February) and two were heifers, but none of the animals was in advanced stage of pregnancy.

The clinical signs of PAI were non-specific and resembled other abdominal disorders like rumen and omasal impaction. The main complaint by the owners was gradual reduction or sudden absence of defecation. The clinical signs in the present study resembled the earlier reported signs of abomasal impaction except the abdominal pain. The dilatation and impaction of the abomasum could have resulted in decreased rumen motility through inhibition of the acid receptors in the abomasum. In this study the per-rectal findings were non-specific and impacted abomasum was not palpable. Further, there was no evidence of abomasal displacement. It is reported that the impacted abomasum is usually located in the lower right cranial part of the abdominal cavity and deep ballotment together with strong percussion of the region may demonstrate presence of a hard mass and pain.²³ The hard mass was felt in three cases of the present study but it was not painful. Melena observed in 40% cases was ascribed to secondary type 1 abomasal ulcers; these ulcers were confirmed in the cases that underwent necropsy. The secondary type 1 abomasal ulcers have been reported in many gastrointestinal diseases including

PAI.¹⁸ Radiography and abdominocentesis ruled out the possibility of traumatic reticuloperitonitis and peritonitis due to other causes. Further, peritonitis was not observed on laparotomy (n=6) or necropsy (n=9).

The increase in neutrophil count may be attributed to potential inflammatory complications of impacted feed material.^{1,28} The impacted feed material has also been implicated as the cause of inflammation in rumen and omasal impactions.^{13,19} The type 1 abomasal ulcers could have also contributed to the inflammatory response. The differential leukocyte cell count was a better indicator of the associated inflammation than WBC, as in some cases, left shift and toxic changes were observed without increase in the WBC count. Similarly, in previous studies differential cell count of blood has been suggested to be a better indicator of inflammation in bovine abdominal disorders like peritonitis¹³ and abomasal ulcers.¹⁵

The increased AST and GGT activities may be attributed to secondary cholestasis and presence of type 1 abomasal ulcers. The increased activity of these enzymes may be also due to the cellular disturbances in the liver parenchyma. The increase in glucose level may be attributed to stress caused by the impaction. Holtenius et al.⁸ observed that hyperglycemia, at a clamped level of insulin, reduced the rate of abomasal outflow in cattle. The mechanisms mediating the effect of hyperglycemia on the rate of abomasal outflow were not understood. Similarly increased glucose levels in the present study could have further reduced the abomasal outflow rate and aggravated the impaction. Similar to our results, elevated globulin, uremia and normal fibrinogen have been reported in abomasal impaction of cattle.^{1,4,24} Hyponatremia and hypophosphotemia were in agreement to findings of Yasaswini et al.²⁸ Uremia and increased blood lactate concentration were consistent with dehydration. Hypocalcemia was in agreement to earlier findings.^{26,28} and it was likely secondary to reduced food intake and metabolic alkalosis.

Hypochloremic, hypokalemic metabolic alkalosis with compensatory respiratory acidosis in the present study may be attributed to abomasal reflux. The abomasal reflux was confirmed by elevated rumen chloride concentration. The metabolic alkalosis, hypochloremia and hypokalemia and hyperlactatemia were more severe than reported for other bovine abdominal disorders like intestinal obstruction,¹² and traumatic reticuloperitonitis/ pericarditis.^{9,16} So we suggest that the degree of metabolic alkalosis, hypochloremia, hypokalemia and hyperlactatemia might have a diagnostic potential and could be helpful in differentiating abomasal impaction from the other abdominal disorders.

CRP, being one of the abundant acute phase proteins in the serum, is rapidly synthesised by liver during disease or stress conditions. The serum CRP concentration in healthy bo-

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vines in one study is reported as $0,23 \pm 0,09$ mg/dl.¹² In present study, the mean CRP concentration was about six times higher than that reported for healthy bovines¹² and comparable to the CRP levels reported in mastitic cattle.²⁰ However, it was lower than the CRP values reported in bovine intestinal obstruction.^{3, 12} The individual variation in levels can be explained on the basis that despite unequivocal evidence of active inflammatory disease and/or tissue damage, some conditions are often associated with only minor (or no) elevation of CRP concentration and also there is often no correlation between CRP concentration and disease severity.²²

The flushing of impacted abomasum and omasum^{2, 13} resulted in recovery of 50 % of operated cases. Abomasal impaction sometimes leads to tear of the abomasal wall¹ and such tear occurred during the necropsy of two cases in the present study. Further the concurrent impaction/dilation of omasum in about 50 % cases was similar to the earlier reported findings.^{1, 17} Similar to our results, type 1 ulcers have been reported in primary bovine abomasal impaction.¹⁸ In one case report, perforated abomasal ulcers have been observed with abomasal impaction in cattle.¹¹

Strength and limitations of the study

The study employed a combination of clinical examination, laboratory alterations, radiography, and confirmatory laparo-rumenotomy or necropsy. This extensive diagnostic panel increases the reliability and depth of the clinical characterization of PAI. All cases were confirmed by either surgical exploration or necropsy, eliminating diagnostic uncertainty and strengthening the validity of the clinical and laboratory changes observed. Further, the study integrates acid-base disturbances, biochemical alterations, providing a holistic understanding of the metabolic consequences of PAI.

Most studies possess limitations, which may be recognized by researchers during the course of the investigation or become evident later as scientific understanding and technological capabilities advance. Our study also had limitations. First, although detailed, the limited number of animals restricts the statistical power and the broader generalizability of the findings to wider populations and different production systems. Second, surgical confirmation was performed in only six animals. This limits the ability to evaluate the clinical predictors of surgical outcomes. Third, all animals originated from a single veterinary clinical facility, which may limit the ability to extrapolate the results to different geographic regions, management systems, or feeding practices. Serial CRP monitoring could provide stronger insights into the inflammatory progression and prognostic value, but this was not performed.

Future research should focus on larger, controlled studies to explore the potential of laboratory and rumenotomy find-

ings for predicting the prognosis of PAI in cattle and buffaloes. Species-specific analyses comparing cattle and buffaloes may also clarify potential physiological differences in susceptibility and metabolic response to PAI. Prospective studies with serial monitoring of laboratory parameters including CRP could help to elucidate the temporal progression of systemic changes during the development and resolution of PAI. Such data may improve prognostic indicators and guide the treatment decisions. Multi-center studies across different management systems and feeding practices would improve the external validity of the findings.

Conclusions

The PAI is primarily associated with the feeding of wheat straw and causes significant hemostatic and biochemical dysfunctions. The clinical signs of PAI were non-specific and resembled other gastrointestinal disorders. Differential leukocyte cell count was better indicator of the associated inflammation than total white blood cell count. The degree of metabolic alkalosis, hypochloremia, hypokalemia and hyperlactatemia could be helpful in differentiating abomasal impaction from the other abdominal disorders in cattle and buffaloes. The prognosis of the disease is poor.

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Conflict of interest

None.

Constatations cliniques, hémato- logiques et biochimiques chez les bovins atteints d'une impaction primaire de la caillette

Les modifications biochimiques mentionnées dans le cadre d'une impaction primaire de la caillette (PAI) ont principalement porté sur les électrolytes ; les variations de la protéine C-réactive (CRP) et des enzymes hépatiques n'ont pas été évaluées spécifiquement chez les buffles adultes (*Bubalus bubalis*). L'objectif de cette étude était de décrire les paramètres des gaz sanguins, la CRP, ainsi que les caractéristiques cliniques, hématologiques et biochimiques de la PAI dans le cadre d'une étude prospective.

L'étude a été menée sur 15 animaux (neuf buffles et six vaches) chez lesquels une impaction abomasale primaire avait été diagnostiquée. Le diagnostic reposait sur la consistance de l'abomasum observée lors d'une laparo-rumenotomie et/ou d'une autopsie. Les animaux étaient âgés de 2,5 à 10 ans et étaient malades depuis 4 à 15 jours. La composition alimentaire était caractérisée par des fibres de mauvaise qualité (paille de blé).

Les signes cliniques les plus fréquents étaient l'anorexie, une diminution de la consommation d'eau, une apathie, une congestion des muqueuses, une déshydratation, une hypomotilité ruminale et des selles rares ou absentes, avec ou sans mucus. Les résultats hématologiques ont montré une neutrophilie avec un déplacement vers la gauche et des neutrophiles toxiques dans la plupart des cas. Les modifications biochimiques constantes comprenaient une hypochlorémie, une hypokaliémie, une hypocalcémie, une hypophosphatémie et des taux élevés de protéine C-réactive, d'AST, de GGT, de globuline, de triglycérides, de glucose, d'urée, de créatinine, de lactate, de magnésium ainsi que du chlorure dans le liquide ruminal.

L'analyse des gaz sanguins a révélé une alcalose métabolique sévère avec acidose respiratoire compensatoire. Le pronostic de la maladie était mauvais. Le degré d'alcalose métabolique, d'hypochlorémie, d'hypokaliémie et d'hyperlactatémie pourrait être utile pour différencier l'obstruction de la caillette d'autres troubles abdominaux chez les bovins.

Mots clés: Impaction de la caillette, analyse des gaz sanguins, protéine C-réactive, pronostic, échographie

Riscontri clinici, ematologici e biochimici nei bovini con impattamento abomasale primario

Le alterazioni biochimiche riportate finora nell'impattamento abomasale primario (PAI) si sono concentrate principalmente sugli elettroliti; le variazioni della proteina C-reattiva (CRP) e degli enzimi epatici non sono state valutate in modo specifico, in particolare nei bufali adulti (*Bubalus bubalis*). L'obiettivo di questo studio era descrivere i parametri dei gas ematici, la CRP, nonché le caratteristiche cliniche, ematologiche e biochimiche del PAI in uno studio prospettico.

Lo studio è stato condotto su 15 animali (nove bufali e sei bovini) con diagnosi di impattamento abomasale primario. La diagnosi si basava sulla consistenza dell'abomaso rilevata mediante laparorumenotomia e/o necroscopia. L'età degli animali variava da 2,5 a 10 anni e la durata della malattia era compresa tra 4 e 15 giorni. La dieta era caratterizzata da fibre di bassa qualità (paglia di frumento).

I segni clinici più frequenti erano anoressia, ridotta assunzione di acqua, abbattimento, mucose congestizie, disidratazione, ipomotilità ruminale e feci scarse o assenti, con o senza muco. I reperti ematologici includevano neutrofilia, deviazione a sinistra e neutrofilii tossici nella maggior parte dei casi. Le alterazioni biochimiche più costanti erano ipocloremia, ipokaliemia, ipocalcemia, ipofosfatemia e aumento dei livelli di proteina C-reattiva, AST, GGT, globuline, trigliceridi, glucosio, urea, creatinina, lattato, magnesio e cloruri nel fluido ruminale.

L'analisi dei gas ematici ha evidenziato una grave alcalosi metabolica con acidosi respiratoria compensatoria. La prognosi della malattia era sfavorevole. Il grado di alcalosi metabolica, ipocloremia, ipokaliemia e iperlattatemia può essere utile per differenziare l'impattamento abomasale da altri disturbi addominali nei bovini.

Parole chiave: Impattamento abomasale, analisi dei gas ematici, proteina C-reattiva, prognosi, ecografia

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