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Impact of bacterial translocation in calves with atresia coli

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Abstract

Objective – To identify whether enteric bacteria pass into the mesenteric lymph nodes (MLNs) and peritoneal cavity in calves with atresia coli and to evaluate whether the presence of bacterial translocation (BT) has an impact on the success of surgical treatment.
Design – Prospective clinical study.
Animals – Twenty-six client-owned calves.
Interventions – During laparotomy, swab samples were collected from the peritoneal cavity and MLNs using a sterile swab stick and were submitted for microbiological analysis.
Measurements and Main Results – Bacterial cultures of swab samples revealed that 65% ($n = 17$) of the calves experienced BT. Of these, 14 calves experienced BT to the MLNs, 9 to the peritoneal cavity, and 5 to both regions. Of the bacteria isolated from the MLNs, 72% ($n = 10$) were *Escherichia coli*. Of the samples isolated from the peritoneal fluid, 33% ($n = 3$) contained *E. coli* and 33% ($n = 3$) contained *E. coli* + coagulase-negative *Staphylococcus* (CNS). In calves with BT that were discharged ($n = 13$) and without BT that were discharged ($n = 7$), the median survival was 30 days; these data were found to be similar in the 2 groups.
Conclusions – This study revealed that BT is observed in the majority of atresia coli cases. *E. coli* is more common in BT, and translocation occurs primarily through the lymphatic route. These results suggest that the presence of BT is closely related to the success of the operation for correction of atresia coli.

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Keywords: atresia coli, bacterial translocation, calf, *E. coli*

Abbreviations

BT	bacterial translocation
CNS	coagulase-negative *Staphylococcus*
MLN	mesenteric lymph node

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Introduction

Atresia coli is a congenital anomaly that results in death in affected calves unless treated surgically.[1–3] Clinical signs include abdominal distension, absence of defecation, straining to defecate, lack of appetite, and poor health.[3] In cases of colonic atresia, clinical examination reveals an open anus, no defecation despite straining, and the presence of a yellowish mucus that sticks to a plastic catheter applied through the anus. In addition, radiography typically reveals that the intestines are filled with gas.[4–7] The survival rate of affected calves primarily depends on their physiological state at the time of admission to the clinic.[7] The leading causes of postoperative complications and mortality are believed to relate to altered hemodynamic parameters and sepsis due to bacterial translocation (BT), which may be related to the duration of the disease.[8]

Bacterial translocation is a process that occurs as a result of various etiological factors and is defined as the passage of bacteria that are normally found within the intestinal lumen through the stable intestinal wall,

followed by portal and systemic transport of these bacteria to the mesenteric lymph nodes (MLNs).[9–12] Bacterial translocation may be of clinical importance primarily in intestinal obstructions and other conditions such as hemorrhagic shock, severe burns, multiple trauma, immunosuppression, acute necrotic pancreatitis, and neutropenia.[9,13] Overgrowth of the intestinal flora, disruption of the mucosal barrier, and the patient's immunological state are the main factors believed to be involved in BT. Normal intestinal flora and anaerobic microflora control the colonization and translocation of pathogenic bacteria in the intestines. The villi on the apical surface of the intestinal epithelium are covered in a mucous membrane enshrouded by biofilms produced by anaerobes. These membranes prevent the overgrowth of gram-negative bacilli, primarily enterobacteria, and prevent them from sticking to enterocytes. An increase in the number of enteric aerobic gram-negative bacteria or a disruption in the anaerobic flora increases the predisposition to BT.[10,13–16]

In cases involving increased intraabdominal pressure, for example, in intestinal obstructions, BT can occur into the local MLN due to decreased intestinal perfusion, which plays an important role in the development of infection and sepsis in patients with intraabdominal hypertension.[11,17–19] We hypothesize that, as observed in people, calves with atresia coli develop intestinal obstruction leading to an increase in intraabdominal pressure over time, predisposing them to the translocation of enteric bacteria. Accordingly, in this study, we aimed to determine whether BT occurs in the peritoneal cavity and/or MLNs in calves with atresia coli, and, if so, the species distributions of the bacteria involved. In addition, we aimed to determine the effect of this condition on postoperative lifespan and prognosis in calves.

Materials and Methods

This study was performed on 26 newborn calves of different ages (1–10 days), breeds (22 Holstein, 2 Brown Swiss, and 2 Simmental), and sexes (22 males and 4 females) that presented to the Faculty of Veterinary Medicine of Selçuk University between December 2010 and December 2013 with the absence of feces since birth and diagnosed with atresia coli as a result of clinical, laboratory, radiological, and peri-operative examinations. The study protocol and all procedures were approved by the Animal Ethical Committee of the University of Selçuk (approval number 2012/019), and each case had informed client consent before enrolling in the study.

Clinical findings

Clinical signs such as pain (determined by frequent changes of position), unwillingness to suckle, or anorexia, dehydration, abdominal distension, and depression were detected. In some calves, gas-filled intestinal loops were observed by external abdominal palpation. Clear and blood-tinged mucus was detected during digital palpation or soft flexible catheterization of the rectum. Tachycardia and tachypnea were evident. Rectal temperatures were in the normal range.

Blood collection and analysis

Blood samples were collected from the jugular veins of calves using 2 mL heparinized injectors for blood gas analyses and K_3 EDTA tubes for hematological analyses. Blood gas analysis (including pH, pO_2, pCO_2, glucose, Na, K, lactate, BE, HCO_3, and $SatO_2$ levels) were measured immediately with a blood gas analyzer.[a] Hematological analysis (including WBC, RBC, HCT, Hg, and PLT) was conducted with a hematological cell counter.[b]

Surgical procedures

Following clinical evaluation, calves were considered to have atresia coli and were prepared for right midflank colostomy.[20] All colostomies were performed as described by Azizi et al[20] by the same surgeon (SA). Before colostomy, intravenous (IV) fluids were administered to correct acid–base and electrolyte imbalances and dehydration according to metabolic conditions. Each calf was placed in the left lateral recumbent position after preanesthetic administration of xylazine[c] (0.1 mg/kg, IV), followed by an inverted L-block was performed on the right flank with infiltration of 2% lidocaine[d] for anesthesia. After right midflank laparotomy, 1 swab sample from the peritoneal fluid and 1 swab sample from the MLNs near the colon (mesocolic lymph nodes) were collected in Stuart transport medium,[e] by stab incision with sterile scalpel blades. Then, the MLNs were sutured with 3-0 absorbable suture.[f] The samples were immediately transported to the microbiology laboratory of the hospital for bacterial isolation. After abdominal exploration, large amounts of yellowish peritoneal fluid and fibrin tags that were free or attached to the serosal surface of the intestines were observed in many calves. In addition, the cecum and proximal blind end of the colon were found to be distended with gas and meconium. For the colostomy, the blind end of the colon was exteriorized to the middle of the incisional area and bound to the peritoneum and abdominal muscles using a simple interrupted circular suture with Polyglactin 910[g] (No. 1). Then, the upper and lower parts of the abdominal wall incision were closed in layers. Finally, the blind of the colon was incised, meconium discharged, and the colon wall anchored to the skin using a simple interrupted suture with silk[h] (No. 1). During and following the surgery, calves were treated with IV fluids (eg, 0.9%

NaCl,[i] Ringer's lactate solution[j]), antimicrobials (20,000 IU/kg penicillin + 10 mg/kg dihydrostreptomycin,[k] IM, for 5 days, withdrawal period in beef 60 days), and analgesics (meloxicam,[l] 0.5 mg/kg, SC, for 2 days). Calves were discharged on postoperative day 3, and follow-up was performed through phone calls with their owners.

Systemic inflammatory response syndrome (SIRS) criteria

The diagnosis of SIRS was made based on the presence of 2 or more of the following abnormalities: temperature >39°C or <36°C, heart rate >120/min, respiratory rate >40/min, WBC count $>12 \times 10^3/\mu L$ or $<6 \times 10^3/\mu L$ or >10% band neutrophils, and hyperlactatemia >2 mmol/L. The diagnosis of sepsis was made if SIRS was present and if bacterial infection was confirmed by microbial culture.[21–25]

Bacterial culture isolation

Swab samples from MLNs and peritoneal fluid were cultured in MacConkey agar[m] and blood agar[n] (5% defibrinated sheep blood) for the isolation of bacteria, particularly *Enterobacteriaceae*. For *Salmonella* spp. isolation, samples were cultured in xylose lysine deoxycholate agar,[o] and isolated bacteria were identified using classical microbiological methods.[26,27]

Statistical analysis

Statistical analysis was performed using commercial software.[p] Venous blood gas analysis, hematological analysis, and age at admission data were compared using Student's *t*-tests. Lifespan analysis was performed with Kaplan–Meier survival analysis. Descriptive data from Student's *t*-tests are expressed as mean ± SD, while descriptive data from Kaplan–Meier analysis are expressed as median. A P value <0.05 was considered statistically significant.

Results

From December 2010 to December 2013, a total of 436 large animals (331 calves and 105 cattle) were admitted to the hospital for various reasons. Among these, atresia coli was detected in 39 of them. However, the owners of 13 calves did not consent to the surgery for reasons such as economic difficulties and the difficulty of postoperative nursing care. Therefore, a total of 26 calves were included in the study. During this period, the incidence of atresia coli in all admitted large animals was 9%, while the incidence in admitted calves was 12%.

Isolated bacterial cultures suggested that 65% ($n = 17$) of the calves experienced BT. Of these, 14 had BT to the MLNs, 9 to the peritoneal cavity, and 6 to both regions. Tachycardia (heart rate >120/min) was noted in 15 (88%) calves with BT and 7 (78%) calves without BT. Tachypnea (respiratory rate >40/min) was noted in 14 (82%) calves with BT and 3 (33%) calves without BT. Rectal temperature was normal (36–39°C) in calves with and without BT. Leukocytosis was noted in 11 (65%) calves with BT and 4 (44%) calves without. Leukopenia was noted in 1 (6%) calf with BT and 1 (11%) calf without BT. Hyperlactatemia was noted in 9 (54%) calves with BT and 4 (44%) calves without BT. Based on the presence of at least 2 of the SIRS criteria, 16 calves with BT and 9 calves without BT were considered to have SIRS. Among calves with BT, 4 cases met all 4 of the SIRS criteria, 9 cases met 3 of the SIRS criteria, and 3 cases met 2 of the SIRS criteria. Among calves without BT, 2 cases met all 4 of the SIRS criteria, 2 cases met 3 of the SIRS criteria, and 2 cases met 2 of the SIRS criteria. Animals with BT had significantly higher median respiratory rates compared to those without BT (48/min [36–64] and 41/min [36–52], respectively, $P < 0.05$).

In 16 of the 25 calves with atresia coli categorized as having developed SIRS, sepsis was confirmed by the isolation of bacteria from both the MLNs and peritoneal fluid, whereas in the remaining 9 cases, bacteria could not be isolated. The bacteria species isolated are presented. According to the blood gas analysis, venous pH, pO_2, pCO_2, glucose, Na, K, lactate, BE, HCO_3, and $SatO_2$ values were not significantly different between calves with BT and those without BT. The mean venous plasma lactate concentration was 3.4 ± 2.7 mmol/L among calves with BT ($n = 17$) and 3.3 ± 3.2 mmol/L among calves without BT ($n = 9$). The mean venous plasma lactate concentration of discharged calves ($n = 13$) was 3.3 ± 2.8 mmol/L among those with BT and 2.0 ± 0.6 mmol/L among those without BT ($n = 7$). In addition, the mean WBC count of calves with BT ($n = 17$) was $15.40 \pm 7.34 \times 10^3/\mu L$ ($15.40 \pm 7.34 \times 10^9/L$) and of calves without BT ($n = 9$) was $13.00 \pm 7.93 \times 10^3/\mu L$ ($13.00 \pm 7.93 \times 10^9/L$). The mean WBC count of calves with BT that were discharged ($n = 13$) was $15.25 \pm 8.38 \times 10^3/\mu L$ ($15.25 \pm 8.38 \times 10^9/L$), and that of calves without BT that were discharged ($n = 7$) was $9.28 \pm 3.29 \times 10^3/\mu L$ ($9.28 \pm 3.29 \times 10^9/L$). However, none of these differences were statistically significant (Table 1).

Survival of calves with BT and without BT was evaluated, and the Kaplan–Meier survival analysis data and curves are presented in Table 2 and Figure 1, respectively. The median lifespans of discharged calves with ($n = 13$) and without ($n = 7$) BT were 30 days, which was not statistically different. The mean age of calves with BT ($n = 17$) upon admission to the hospital was 3.3 ± 1.6 days, while the mean age of calves without BT

Table 1: Blood gas and hematological parameters in calves with colonic atresia with and without BT

PARAMETERS	Calves with BT ($n = 17$) Mean ± SD	Calves without BT ($n = 9$) Mean ± SD
pH	7.42 ± 0.43 ($n = 17$)	7.40 ± 0.28 ($n = 9$)
pCO_2 (mm Hg)	49.4 ± 6.8 ($n = 17$)	51.4 ± 8.6 ($n = 9$)
pO_2 (mm Hg)	22.5 ± 9.3 ($n = 17$)	20.8 ± 3.9 ($n = 9$)
Na^+ (mmol/L)	143 ± 3.4 ($n = 17$)	142 ± 2.1 ($n = 9$)
K^+ (mmol/L)	4.3 ± 0.9 ($n = 17$)	4.49 ± 0.7 ($n = 9$)
Ca^{+2} (mmol/L)	0.91 ± 0.18 ($n = 17$)	1.23 ± 0.83 ($n = 9$)
Glucose (mg/dL)	87 ± 23 ($n = 17$)	81 ± 14 ($n = 9$)
Lactate (mmol/L)	3.4 ± 2.7 ($n = 17$)	3.3 ± 3.2 ($n = 9$)
Lactate (mmol/L) (discharged calves)	3.3 ± 2.8 ($n = 13$)	2.0 ± 0.6 ($n = 7$)
HCO_3^- (mmol/L)	32.1 ± 4.3 ($n = 17$)	32.8 ± 4.2 ($n = 9$)
BE (mmol/dl)	7.6 ± 4.9 ($n = 17$)	7.6 ± 5.0 ($n = 9$)
O_2sat (%)	38.2 ± 19.1 ($n = 17$)	34.0 ± 14.2 ($n = 9$)
WBC ($10^3/\mu L$)	15.40 ± 7.34 ($n = 17$)	13.00 ± 7.93 ($n = 9$)
WBC ($10^3/\mu L$) (discharged calves)	15.25 ± 8.38 ($n = 13$)	9.28 ± 3.29 ($n = 7$)
RBC ($10^6/\mu L$)	8.02 ± 1.85 ($n = 17$)	7.34 ± 1.45 ($n = 9$)
HCT (%)	31.8 ± 8.8 ($n = 17$)	28.7 ± 5.3 ($n = 9$)
HGB (g/dL)	10.1 ± 1.8 ($n = 17$)	10.4 ± 0.6 ($n = 9$)
PLT count ($10^3/\mu L$)	365 ± 160 ($n = 17$)	362 ± 124 ($n = 9$)
Temperature (°C)	38.4 ± 0.4 ($n = 17$)	38.4 ± 0.3 ($n = 9$)
Respiration rate (breaths/min)	48 ± 7* ($n = 17$)	41 ± 6 ($n = 9$)
Heart rate (breaths/min)	143 ± 17 ($n = 17$)	134 ± 15 (n:9)
Age at admission (day)	3.3 ± 1.6* ($n = 17$)	4.3 ± 2.9 (n:9)

BT, bacterial translocation; * Statistically significant parameters ($P < 0.05$).

($n = 7$) was 4.3 ± 2.9 days. This difference was found to be statistically significant ($P < 0.05$) (Table 1).

According to the intraoperative observations, fibrinous peritoneal fluid and intestinal ischemia on the blind-end loop of the colon and cecum (cyanotic appearance) was observed in some calves (especially those referred late). Among the 17 calves with BT, 4 (24%) died during surgery or perioperatively. In addition, of the 9 calves without BT, 2 (22%) died during surgery or perioperatively. The mean age at the time of admission to the hospital of the 6 calves that died perioperatively was 5.2 ± 3.2 days. Of the calves that died, the mean age of those with BT ($n = 4$) was 3.3 ± 1.3 days, while the mean age of those without BT ($n = 2$) was 9 ± 1.4 days. Of the 4 calves with BT that died, 2 had BT to both the MLNs and peritoneal cavity, and in these 2 calves, WBC counts (33.5 and 24.8 × $10^3/\mu L$) (33.5 and 24.8 × $10^9/L$) and lactate concentrations (11.3 and 8.1 mmol/L) were higher than the reference values for healthy calves (6–12 × $10^3/\mu L$ or 6–12 × $10^9/L$ and < 2 mmol/L). Moreover, in the 2 calves without BT that died perioperatively, the WBC counts (27.21 and 24.8 × $10^3/\mu L$ or 27.21 and 24.8 × $10^9/L$) and lactate concentrations (4.6 and 11.3 mmol/L) were also higher than the reference intervals.

Of the bacterial samples isolated from the MLN, 72% ($n = 10$) contained *Escherichia coli*, 7% ($n = 1$) contained coagulase-negative *Staphylococcus* (CNS), 7% ($n = 1$) contained *Enterobacter* spp., 7% ($n = 1$) contained *E. coli* + *Staphylococcus aureus*, and 7% ($n = 1$) contained *E. coli* + *Enterobacter* spp. Of the bacterial samples isolated from the peritoneal fluid, 33% ($n = 3$) contained *E. coli*, 33% ($n = 3$) contained *E. coli* + CNS, 11% ($n = 1$) contained *E. coli* + *Klebsiella* spp., 11% ($n = 1$) contained *E. coli* + *Staphylococcus aureus*, and 11% ($n = 1$) contained *Proteus* spp. As a control, swab samples collected from the meconium of 3 calves that were 2, 5, and 10 days old were cultured. *E. coli* was detected in the meconium samples

Table 2: Data from survival time analysis (days) of the calves with atresia coli (Kaplan–Meier survival analysis)

	Median			
			95% Confidence Interval	
Prognostic factor	Estimate	Std. error	Lower bound	Upper bound
With BT	30.0	7.07	16.14	43.86
Without BT	30.0	22.26	0.00	73.63
Overall	30.0	6.40	17.46	42.54

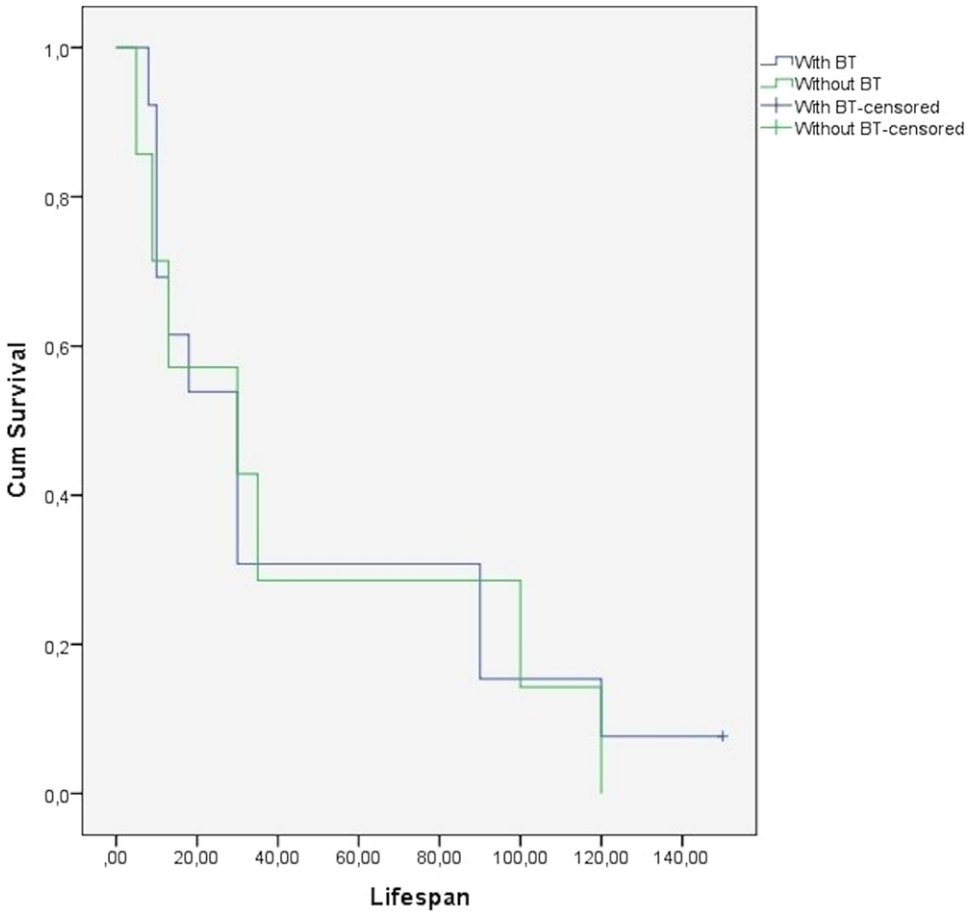

Figure 1: Comparison of Kaplan–Meier survival curves of calves with and without bacterial translocation.

of calves aged 5 and 10 days. However, BT was not detected in these calves.

Discussion

Atresia coli, which is one of the intestinal atresias, is an intestinal disorder that results in mortality caused by autointoxication within a few days unless treated.[2,28] In human intestinal atresia, the main cause of postoperative complications and mortality is sepsis, which is believed to be caused by BT, and disrupted hemodynamic equilibrium due to late admission to the hospital.[8] In calves with atresia coli, hematological values remain within the normal range during the first 48 hours following birth, and these levels change over time. In addition, bacterial overgrowth in the intestines occurs unidirectionally.[29] In the present study, 65% of calves ($n = 17$) experienced BT. In addition, the WBC count in the majority of calves was higher than the reference interval for healthy calves, suggesting that a unidirectional change occurred in the bacterial flora of the intestines and that bacteria passed from the intestinal lumen to the lymphatic and vascular circulation and/or peritoneal cavity.

Yellowish fibrinous peritoneal fluid in the abdomen and intestinal ischemia on the blind-end loop of the colon and cecum (cyanotic appearance) was observed in some calves (especially those admitted late). These findings are consistent with those of Smith et al.[30] However, bacteria were isolated in some samples taken from calves but not from others. In addition, in this study swab samples were taken only from the mesocolic lymph nodes. If we had sampled from random MLNs, our results may have changed. Thus, further research is required.

Enteric bacteria are important for animal health. These bacteria are numerous and belong to a variety of genera and species. The majority of these bacteria are important for the maintenance of the animal's health and are useful in utilizing nutrients and transforming them into metabolites. Many also have the ability to advantageously interact with the host, and even minor changes in these populations can lead to problems that can affect the well-being of the animal.[31] Congenital problems, such as short bowel syndrome or intestinal atresia, can

lead to the disruption of these bacterial populations and their unidirectional increase over time. This unidirectional bacterial overgrowth causes BT.[32] Compared to the intestinal flora, the most frequently translocated bacteria are gram-negative, facultative anaerobic *Enterobacteriaceae* (*E. coli*, *Klebsiella pneumoniae*, and *Proteus mirabilis*). In addition, gram-positive, oxygen-tolerant bacteria (eg, *Staphylococcus*) exhibit a moderate level of translocation. The translocation of obligate anaerobic bacteria (such as *Bacteriodes* and *Fusobacterium*) is rarely observed.[10,15] In an experimentally induced intestinal obstruction model in rats, the most commonly isolated bacteria from MLNs were found to be *E. coli*, *P. mirabilis*, and *Enterococcus* spp.[33] El Awady et al[19] reported that *E. coli* was the most commonly translocated bacteria. In the present study, consistent with the aforementioned studies,[10,15,19,33] bacteria isolated from swab samples from both the MLNs and peritoneal cavity included *E. coli* and *Staphylococcus*, *Enterobacter, Klebsiella*, and *Proteus* spp., while obligate anaerobes were not isolated.

One of the most important factors affecting BT pathogenesis is bacterial virulence. Some bacterial species such as *Pseudomonas aeruginosa* or *E. coli* have higher virulences than other bacteria.[13] In the present study, *E. coli* was isolated from both the swab and fecal samples of 12 of the 17 calves with BT, suggesting that *E. coli* dominates the bacterial microflora in calves with atresia coli. This could be attributed to the fact that *E. coli* is more virulent than other bacteria in the flora. This is also mostly related to its facultative nature and its fimbriated surface (a colonizing factor), thus supporting transport via the lymphatic and vascular route for BT.[19]

The aim of surgery in calves with colonic atresia is to reach an appropriate slaughter weight before the age of 6 months.[2] We also performed surgery with this intent. However, half of the calves died within the first 30 days due to various reasons. Surgical techniques such as colostomy, cecostomy, and intestinal anastomosis are thought to impact the survival rate of calves with atresia coli. Colostomy is superior to intestinal anastomosis regardless of the calf's condition in terms of reaching slaughter weight because the survival rate of colostomy is higher under poor physical conditions. However, weight gain is less than with intestinal anastomosis.[20,28] Azizi et al[20] achieved a 6-month calf survival rate of 73% with colostomy and found that calves exhibited less weight gain than their peers. However, some authors[30,34] have found that the survival rate of intestinal anastomosis ranges from 43% to 71%, and one advantage of anastomosis is the preservation of intestinal integrity, allowing normal absorption of nutrients. In this study, because only 1 calf survived to 6 months and she reached slaughter weight (150 kg), we were unable to draw general conclusions.

In a study in rats with an experimentally induced intestinal obstruction model, it was shown that *E. coli* inoculated into the intestinal content traveled to the intestinal submucosa in 11 min and to the muscular layer in 66 min.[17] The passage of the bacteria from the intestinal mucosa to the muscular layer in such a short time reveals the importance of initiating treatment for congenital intestinal obstructions such as atresia coli quickly. In addition, in the present study, the finding that 6 calves died perioperatively was remarkable, since the mean age of these calves at the time of admission was 5.2 ± 3.2 days and 4 of these calves had BT, which could be a sign of delayed initiation of treatment. This suggests that, although animals may undergo surgical intervention, their likelihood of survival may be reduced if the initiation of treatment is delayed. We believe that in these 4 calves with BT, because of delayed intervention, bacteria on the intestinal wall translocated to the peritoneal cavity and lymphatic or vascular system, causing sepsis and peritonitis[29,35] and eventually leading to death.

Plasma lactate concentration is a commonly used marker for evaluating the severity of diseases in people.[36,37] It was shown to be an important prognostic marker in newborn horses with critical illnesses and adult horses with colic, and its elevation is also associated with increased morbidity and mortality rates.[22,23,38] Hyperlactatemia, which is a sign of metabolic acidosis in acute shock, is a marker of cellular hypoxia.[23,39] When arterial plasma lactate concentrations exceed 5 mmol/L, the prognosis is usually poor, and when it is >10 mmol/L, the mortality rate is greater than 90%.[39] In the present study, venous plasma lactate concentrations in some calves with BT and without BT were high and, consistent with the above studies,[23,39] they died either during or following the surgery. Although the mean venous plasma lactate concentrations of calves with and without BT were not significantly different, it was higher in calves with BT than in calves without BT. Moreover, these values were above the normal reference interval in both groups. The increased plasma lactate concentrations in the calves without BT could have been due to the advanced ages of these 2 calves at the time of admission to the hospital, along with their high lactate concentrations. The mean plasma lactate concentration calculated after the exclusion of these 2 high values was 2.0 ± 0.6 mmol/L.

In calves with intestinal atresia (particularly over time), leukocytosis may develop owing to factors such as bacterial overgrowth, endotoxemia, peritonitis, and intestinal necrosis.[29] In this study, WBC counts were higher than reference intervals in most calves with BT ($n = 11/17$) and some calves without BT ($n = 4/9$). Moreover, there was no significant difference between the mean WBC counts of calves with and without BT,

although the value was higher in calves with BT than in those without BT. It is our opinion that the high WBC counts in the 2 calves without BT that were referred late to the hospital (at 8 and 10 days of age, respectively) caused this difference lose significance.

The clinical manifestation of the inflammatory response, SIRS, occurs in response to an infectious or noninfectious assault on the animal (eg, sepsis, burns, trauma), and it is considered to be present if 2 or more of the following occur: tachycardia, tachypnea (or respiratory alkalosis), hypothermia or hyperthermia, leukocytosis or leukopenia and neutrophilic left shift. A diagnosis of sepsis includes the presence of SIRS and the identification of infection.[22,24,25] In our study, most cases met at least 2 SIRS criteria at admission as well as yielding positive bacterial cultures. In 17 of the 26 calves with atresia coli diagnosed with SIRS, sepsis was confirmed via the isolation of bacteria from both the MLNs and peritoneal fluid, whereas in the remaining 9 cases, bacteria could not be isolated. The reason for this might be that the owners had used empirical antimicrobials before admission, and this may impacted results.[40] It is interesting that despite the fact that the SIRS criteria were met in the majority of cases, bacteria were isolated in only half of the cases. While this situation is not fully understood, it is clear that various factors are involved, including treatments applied to the patient before admission, immune competence of the patient, and other unknown causes. More detailed studies are warranted to establish the factors involved in this outcome.

The intestinal tract is colonized with various ingested environmental and maternal microflora immediately after birth.[41] In newborn calves during the first 24–36 hours of life, intestinal permeability is high because of the transfer of immunoglobulins from the colostrum to the bloodstream via the small intestinal epithelium. During this period, the intestinal walls of newborn calves are highly susceptible to BT, increasing the susceptibility to infections.[42] This study demonstrated that BT transfers bacteria to the MLNs and peritoneal cavity in most calves (65%) with atresia coli. However, whether this occurs directly or is mediated by other environmental and immune factors remains unknown. Because this study was a prospective clinical study, no control group could be generated from healthy animals, thus requiring further research. Adequate first colostrum is vital for passive protection in calves against microorganisms.[43] However, colostrum feeding early in life does not always assure the transfer of immunity, since approximately 10–30% of all newborn calves do not attain adequate levels of serum globulin, probably due to malabsorption and colostral contamination with microorganisms, which may suppress passive immune transfer.[29,43,44] However, if adequate ingestion of colostrum occurs at birth, immunoglobulin transfer usually proceeds normally.[29] In this study, owners were instructed to ensure adequate colostral feeding of the calves from their mothers, but there was no information regarding the colostral quality of each dam.

Intestinal atresia comprises 25% of cases of short bowel syndrome in people, and overgrowth of intestinal bacteria is observed in 60% of patients. Overgrowth of bacteria leads to BT and the production of toxic metabolites such as D- and L-lactate from carbohydrates.[32,45] D-lactate is a metabolite produced by microorganisms.[46] L-lactate is a metabolite associated with poor tissue perfusion caused by decreased hepatic clearance upon endotoxemia and subsequent anaerobic glycolysis.[22,23,47] The plasma lactate concentrations in our study were higher in calves with BT than in calves without BT. Although D-lactate levels are an important marker in the evaluation of microbial conditions,[47] circulating plasma lactate (L-lactate) is easier to measure, and can be also considered in the evaluation of BT in calves.

Several studies have shown that intestinal hypoperfusion and ischemia, which occur when the intraabdominal pressure increases, facilitate the development of BT.[16,19] In the present study, clinical signs of abdominal distension in colonic atresia and intestinal hypoperfusion and ischemia caused by the increased intraluminal pressure over time due to increased intestinal contents could have disrupted the intestinal mucosal barrier, thereby leading to the translocation of enteric pathogens. During the intraoperative period, intestinal ischemia of the colon (as indicated by cyanotic appearance) was clearly observed.

In conclusion, the development of BT in intestinal atresias such as atresia coli occurs primarily via the lymphatic route; however, passage to the peritoneum can occur in rare cases. If BT is not treated in time it can lead to death due to peritonitis and sepsis. In addition, delays in surgical intervention, even if BT is not observed, can increase the probability of perioperative death.

Footnotes

[a] GEM Premier Plus, Instrumentation Laboratory, MA.
[b] MS4 VET, Melet Schlosing Laboratories, France.
[c] Rompun, Bayer, Istanbul, Turkey.
[d] Vilcain, Vilsan, Ankara, Turkey.
[e] Cultiplast, LP Italiana Spa, Milano, Italy.
[f] PDS, Ethicon, NJ.
[g] Vicryl, Ethicon, NJ.
[h] Silk, Ethicon, NJ.
[i] Medifleks, Eczacıbaşı-Baxter, Istanbul, Turkey.
[j] Isolyte, Eczacıbaşı-Baxter, Istanbul, Turkey.
[k] Dipenisol, Bayer Animal Health, Istanbul, Turkey.
[l] Maxicam, Sanovel Pharmaceuticals, Istanbul, Turkey.
[m] Oxoid, Thermo Scientific, Hampshire, UK.
[n] Oxoid, Thermo Scientific, Hampshire, UK.
[o] Oxoid, Thermo Scientific, Hampshire, UK.
[p] SPSS v20.0 software, IBM Corp., Armonk, NY.

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