Clinical and ultrasonographic findings, diagnosis and treatment of pyelonephritis in 17 cows

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Abstract

The goal of the present study was to describe the clinical, haematological and ultrasonographic findings and treatment of 17 cattle with pyelonephritis. Fifteen cattle had an abnormal general condition, which varied in severity; five animals had signs of colic. The urine was brownish-red in 11 animals and cloudy in 13. Clumps of purulent material were seen in the urine of nine animals and clots of blood in two. The specific gravity was lower than normal in 13 animals and ranged from 1.005 to 1.020. A urine test strip revealed protein in 16 animals, blood in 16 and leukocytes in 12. Bacteriological examination of urine yielded Corynebacterium renale in 11 animals, Arcanobacter pyogenes in two and Escherichia coli in one. Rectal examination revealed abnormalities of the urinary tract in 11 animals; there was dilatation of the left ureter and/or enlargement of the left kidney in eight cases, and dilatation of the right ureter and/or enlargement of the right kidney in three others. The most frequent abnormal haematological finding was an increase in the serum concentrations of total protein, fibrinogen, urea and creatinine, a decreased haematocrit and a positive glutaraldehyde test. In 13 animals, ultrasonography via the rectum and right flank using a 5.0MHz transducer revealed dilatation of the right or left ureter, cystic lesions in one or both kidneys and dilatation of the renal sinus. Eight animals were euthanased or slaughtered at the owners' request or because of a poor prognosis. Nine (53%) animals were successfully treated; five received antibiotics and four underwent unilateral nephrectomy and antibiotic therapy. The treated animals were clinically healthy when discharged from the clinic 10-21 days after admission. A follow-up via telephone 8-24 months later revealed that none had experienced complications and all were in full production. In cattle with severe unilateral pyelonephritis, unilateral nephrectomy is the treatment of choice.
CLINICAL FINDINGS AND DIAGNOSIS OF THROMBOSIS OF THE CAUDAL VENA CAVA IN CATTLE

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ABSTRACT

This paper describes the causes, clinical findings and diagnosis of caudal vena caval thrombosis in cattle. Occlusion of the vein is caused by a “white” thrombus, and typical clinical signs include chronic weight loss, poor general condition and intermittent fever. Most affected cattle have respiratory signs; in some, pulmonary hemorrhage, ascites and sudden death occur. Hematologic analyses, endoscopy of the respiratory tract and ultrasonographic examination of the pleura, liver and abdomen should be carried out in cattle suspected of having thrombosis of the caudal vena cava. The most important diagnostic finding is dilatation of the caudal vena cava seen via ultrasonography. Normally the caudal vena cava appears triangular in cross section but in cattle with thrombosis, it is oval or circular. The prognosis is poor and there is no treatment.

Keywords: Cattle, caudal vena cava, thrombosis, ultrasonography.

NATURE OF THE DISEASE

Comprehensive descriptions of vena caval thrombosis in cattle have been published (Rubarth, 1960; Stöber, 1966; Selman et al., 1974; Breeze et al., 1976; Jensen et al., 1976; Gudmundson et al., 1978; Rebhun et al., 1980; Ikawa et al., 1987; Mills and Pace, 1990; Braun et al., 1992, 2002, 2003, 2005). With vena caval thrombosis, there is partial or complete obstruction of the vein by a white thrombus (Fig. 1; Braun, 2002). The caudal vena cava is most commonly affected, although occasionally the cranial vena cava is the site of obstruction (Wyssman, 1932; Breeze and Petrie 1977). This problem affects mainly adult cattle and only rarely younger cattle.

CAUSES
The most frequent cause of vena caval thrombosis is liver abscess (Rubarth, 1960; Stöber, 1966; Selman et al., 1974; Rebhun et al., 1980; Ikawa et al., 1987; Mills and Pace, 1990; Radostits et al., 2000; Braun et al., 2002). Abscesses sit adjacent to and rupture into the caudal vena cava. The resultant white thrombus is attached to the intima and may partially or completely occlude the lumen. Thrombi are usually located in the hepatic portion of the caudal vena cava but sometimes are found in the perirenal, subphrenic or intrathoracic portion of the vessel (Braun, 2002). Vena caval thrombosis can also be caused by emboli from inflammatory processes in other organs such as the udder, uterus or claws (Smith, 1996). Umbilical infection is suspected to be a cause of vena caval thrombosis in calves. Cases of vena caval thrombosis have been described in which no focus of infection was found (Selman et al., 1974). The most important infectious agents associated with this disease are *Fusobacterium necrophorum* and *Arcanobacter pyogenes* (Ikawa et al., 1987). Streptococci, staphylococci and *Escherichia coli* may be concomitant pathogens. Thrombosis of the cranial vena cava is uncommon and is usually attributable to thrombophlebitis of the jugular vein.

**CLINICAL SIGNS OF CAUDAL VENA CAVAL THROMBOSIS**

In cattle with a primary abscess and an early stage of thrombus formation, the clinical signs are usually vague. With time however, the main signs may vary. Generally, there is chronic weight loss, moderately to severely abnormal general condition, reduced appetite or anorexia and no ruminal motility (Stöber, 1966; Mills and Pace, 1990; Radostits et al., 2000; Braun et al., 2002). The heart and respiratory rates are often increased, affected animals have intermittent fever and many cattle have respiratory signs (Selman et al., 1974; Rebhun et al., 1980). In most cases, vena caval thrombosis manifests as metastatic chronic purulent bronchopneumonia that is resistant to treatment and sometimes accompanied by pulmonary hemorrhage. Ascites is rarely a lead symptom (Adams 1963, Braun et al., 1992). Sudden death sometimes occurs (Stöber, 1966; Rebhun et al., 1980; Radostits et al., 2000). In 12 cows with thrombosis of the caudal vena cava (Table 1), the most important sign was a
moderately to severely abnormal general condition (Braun et al., 2002). Appetite was reduced or absent, and body condition was moderate to thin in all the cows. The heart rate was higher than normal in seven cows, and the rectal temperature was above normal in eight. In seven cows, the mucous membranes were very pale. Ruminal motility was markedly reduced or absent in 11 cows, and one or more tests for a reticular foreign body were positive.

**Metastatic chronic suppurative bronchopneumonia**

Metastatic chronic suppurative bronchopneumonia is caused by dissemination of emboli, which may lodge in the pulmonary artery causing embolism, endarteritis, multiple pulmonary abscesses and chronic suppurative bronchopneumonia. Clinical signs include abnormal lung sounds, tachypnea and coughing (Stöber, 1966; Selman et al., 1974; Mills and Pace, 1990). Treatment with antibiotics and expectorants results in transient or no improvement. In advanced cases, there is expiratory dyspnea often with open-mouth breathing and expiratory grunting. Of 12 cows with thrombosis of the caudal vena cava, 11 had serous to suppurative nasal discharge (Braun et al., 2002). The respiratory rate was elevated in eight cows, and three had dyspnea. Eight cows had pulmonary wheezes; one of these had a pleural friction rub and one crackles. Seven cows had a spontaneous cough, and three others coughed after forced breath holding.

**Pulmonary hemorrhage**

Erosion of a pulmonary vessel may result in massive intrapulmonary or intrabronchial hemorrhage (Fig. 2). This usually occurs in the terminal stages of the disease (Selman et al., 1974; Rebhun et al., 1980, Mills and Pace, 1990). Clinical signs include bilateral epistaxis, bleeding from the mouth and hemoptysis (Fig. 3). The pulmonary hemorrhage usually subsides quickly but generally recurs. The amount of blood seen in the vicinity of the animal is not a reliable indicator of
the severity of the hemorrhage because some of the blood is swallowed and forms large clots in the
rumen. The feces of cattle that have swallowed expectorated blood are sometimes dark and pasty and
a test for occult blood is positive. In the terminal stages, there is usually peracute circulatory and/or
pulmonary failure. The animal may be found dead in a pool of blood (Fig. 4). Of 12 cows with
thrombosis of the caudal vena cava, two had bilateral epistaxis and one of these also had bleeding
from the mouth (Braun et al., 2002). The feces of three cows were dark and contained blood. The ru-
men juice of these three cows was also dark and positive for occult blood (Hemofec®, Boehringer
Mannheim).

Hepatic congestion and ascites

Hepatic congestion and ascites develop only when the thrombus is located cranial to the liver
and occludes at least half of the vena caval lumen (Adams, 1963; Selman et al., 1974). Otherwise,
blood flow to the heart is afforded by collateral routes, which include the udder vein, internal thoracic
vein, cranial vena cava and the azygous veins. In one cow with vena caval thrombosis, severe ascites
occurred because both udder veins were inflamed following intravenous infusions and no longer pro-
vided an alternate circulatory pathway (Braun et al., 1992). In a young heifer with thrombosis of the
caudal vena cava, the poorly developed and narrow udder veins were assumed to be unable to provide
a collateral route, thus leading to ascites (Braun et al., 2005). In most cattle, the ascites is not severe
enough to cause visible abdominal enlargement, although in a few cases the abdomen may become
pear shaped.

Sudden death

Acute or peracute disease with death is usually attributable to embolization of a large throm-
bus or rupture of a massive amount of purulent material into the vena cava (Stöber, 1966). Similarly,
small pieces of a thrombus may become embolic resulting in small pulmonary abscesses; subsequent embolization of the same microbes, possibly because of allergic sensitization, can lead to severe dyspnea, coughing fits and death (Stöber, 1966). Affected animals are found dead, usually after having non-specific clinical signs or a period of fever and indigestion.

Other complications

In ten per cent of cattle with vena caval thrombosis, endocarditis develops. In these cases, the lungs are always involved. Septic thrombi may also travel to the kidneys causing suppurative nephritis.

DIAGNOSTIC APPROACH

In cattle suspected of having thrombosis of the caudal vena cava, a glutaraldehyde clotting test should be performed first, followed by hematologic and biochemical analyses (complete blood cell count and differential, concentrations of total protein and fibrinogen and activities of liver enzymes). Also important are endoscopic examination of the respiratory tract, radiography of the lungs and ultrasonographic examination of the pleura, liver and abdomen. The most important diagnostic procedure is ultrasonography of the caudal vena cava in the 11th or 12th intercostal space on the right side near the liver. Abdominocentesis should be carried out in cattle with ascites.

HEMATOLOGIC AND BIOCHEMICAL ABNORMALITIES

The results of hematologic and biochemical analyses are non-specific in cattle with thrombosis of the caudal vena cava. Mild anemia and increased concentrations of total protein and fibrinogen occur as a result of chronic inflammation. The clotting time of the glutaraldehyde test is shorter than normal because of the increased levels of total solids and fibrinogen. Moderate to severe
anemia may occur in cattle with pulmonary hemorrhage. Obstruction of the caudal vena cava results in liver congestion. Thus, the activities of the liver enzymes, particularly the bile duct enzyme $\gamma$-glutamyl transferase ($\gamma$-GT), and in advanced cases also the parenchymal enzymes, are elevated.

Of 12 cows with thrombosis of the caudal vena, eight had a markedly decreased hematocrit and leukocytosis with a left shift (Braun et al., 2002; Table 2). In nine cows, total solids were elevated, and in six, the concentration of fibrinogen was higher than normal. In the glutaraldehyde test, the clotting time was shorter than normal in all the cows; in 11 of the 12 cows, the time was less than 3 minutes. The activity of $\gamma$-GT was elevated in seven cows, and that of glutamate dehydrogenase (GLDH) was increased in two.

**ENDOSCOPIC FINDINGS**

Endoscopic examination of the respiratory tract and cytologic and bacteriologic evaluation of tracheal secretions confirm a diagnosis of chronic suppurative bronchopneumonia. Massive numbers of erythrocytes seen microscopically in the tracheal secretions and/or blood visible in the trachea indicate pulmonary hemorrhage. Of 12 cows with thrombosis of the caudal vena cava, the tracheal secretions were hemorrhagic in two and purulent in three (Braun et al., 2002). Cytological examination of tracheal secretions revealed a moderate to large number of degenerated neutrophils in six cows. In three of these cows, erythrocytes were seen and in the other three bacteria. Of the three cows with erythrocytes in the tracheal secretion, only one had epistaxis and bleeding from the mouth.

**RADIOGRAPHIC FINDINGS**

Radiographs of the lungs frequently show an irregular increase in lung density (Breeze et al., 1976); there may also be bullae (Rebhun et al., 1980), cavernous areas and abscesses (Rebhun et al.,
1980; Braun et al., 2002). An area of increased density near the caudal vena cava at the level of the diaphragm indicates an abscess, possibly involving the liver, and in cattle with concomitant respiratory signs, is a reliable indicator of vena caval thrombosis (Fig. 5).

Of 12 cows with thrombosis of the caudal vena cava, the radiographs of 11 showed interstitial densities of varying severity in the lungs, which indicated bronchopneumonia (Braun et al., 2002). In six cows, lesions seen in the diaphragmatic lung lobes were interpreted as one or multiple abscesses. In four cows, the lesions were located caudodorsally near the diaphragm and caudal vena cava and supported a tentative diagnosis of vena caval thrombosis.

ULTRASONOGRAPHIC FINDINGS

The introduction of ultrasonographic examination of the caudal vena cava near the liver was a major step forward in the diagnosis of thrombosis of this vessel (Table 3). Ultrasonography from the 11th and 12th intercostal spaces reveals that the caudal vena cava in healthy cattle is triangular in cross section (Fig. 6, Braun, 1990). Obstruction of the caudal vena cava by a thrombus results in congestion of the vessel (Braun, 1990 1997, 2002; Braun et al., 2002, 2003, 2005). Consequently, the diameter of the caudal vena cava increases resulting in an oval to circular appearance when imaged in cross section (Fig. 7). The thrombus can rarely be seen via ultrasonography (Fig. 8) because it is usually situated more cranially and obscured by the lungs. In addition, with congestion of the caudal vena cava, the liver veins that join it, particularly the right hepatic vein, are markedly dilated and prominent (Fig. 9), the liver borders are blunt and there is edema of the gallbladder wall. Sometimes a liver abscess and ascites can be seen. Ultrasonographic examination of the thorax may reveal signs of suppurative bronchopneumonia such as comet-tail artifacts and lung abscesses.
In all the cows with thrombosis of the caudal vena cava that we examined (Braun et al., 1992; Braun et al., 2002, 2003, 2005), the caudal vena cava appeared abnormal. In cross section it was oval or circular and dilated. In one cow, the thrombus could be seen and appeared as an echogenic structure within the vascular lumen (Braun et al., 2003). Three cows had severe ascites. In a report from Japan, echogenic thrombi could be seen via ultrasonography in the caudal vena cava as well as in the right hepatic vein (Mohamed et al., 2004).

ABDOMINOCENTESIS

The ascites can be mild to severe. The fluid is typically a modified transudate.

DIAGNOSIS

In most cases, a definitive diagnosis in the live animal cannot be made based on clinical signs alone. Vena caval thrombosis is suspected in cattle with severe respiratory signs and liver disease as well as other symptoms that cannot be attributed to other diseases. With concomitant pulmonary hemorrhage or ascites, thrombosis of the caudal vena cava is very likely. Hematological evaluation provides information about chronic inflammation and radiography allows a diagnosis of chronic bronchopneumonia. A radiographic density in the region of the caudal vena cava near the diaphragm is a strong indication of thrombosis. The most reliable method for diagnosing thrombosis of the caudal vena cava is ultrasonography. Normally, the caudal vena cava appears triangular in cross section but with thrombosis, the vein is oval to circular and dilated. Although a rare occurrence, detection of a thrombus via ultrasonography is diagnostic.

DIFFERENTIAL DIAGNOSIS
A differential diagnosis must include diseases with similar symptoms such as suppurative bronchopneumonia, aspiration pneumonia, endocarditis, suppurative nephritis and other conditions associated with ascites. In addition, all diseases associated with epistaxis must be ruled out. Right-sided heart failure and compression of the caudal vena cava by a space-occupying lesion in the thorax or subphrenic region must be considered when congestion of the caudal vena cava is seen via ultrasonography. In right-sided heart failure, there is also congestion of the jugular veins. Space-occupying lesions in the thorax may be detected via radiography. In cattle with ascites caused by portal hypertonia, the caudal vena cava and right hepatic veins are not dilated. A sample of abdominal fluid from cattle with uroperitoneum contains higher concentrations of urea and creatinine than a blood sample (Radostits et al., 2000). Abdominocentesis yields bloody fluid in cases of hemoperitoneum. Peritoneal tumors may be detected by ultrasonography (Braun et al., 2004). Ileus has an acute course and is associated with dilated loops of small intestine seen via ultrasonography (Braun et al., 1995). In inflammatory ascites, the abdominal fluid is an exudate with inflammatory cells.

PROGNOSIS

Cattle with vena caval thrombosis have a poor prognosis and should be slaughtered or euthanased.

POSTMORTEM FINDINGS

In cattle suspected of having thrombosis of the vena cava, examination of the caudal vena cava should be done before the liver is removed. When postmortem examination is carried out after the carcass has been further processed, a thrombus is easily missed because the caudal vena cava is severed during slaughter and parts of it discarded. During slaughter, the lungs, heart and diaphragm
are usually placed on a hook. In this position, the diaphragm hangs over the caudal vena cava and obscures it. Therefore, to detect a thrombus in the subphrenic part of the vena cava, one must lift the diaphragm and inspect, palpate and incise the vein (Braun, 2002). A thrombus appears as an elongated whitish-yellow structure (Fig. 1). Another characteristic finding is abscesses in the liver, kidney or thorax that sit immediately adjacent to the caudal vena cava (Fig. 2). The lungs often have multiple abscesses, and there may be thrombosis of pulmonary vessels and pulmonary hemorrhage. In cattle with the latter, the bronchi and trachea contain clotted blood, and in some cases there is clotted blood in the rumen. In addition, septic emboli may have involved the heart and/or kidneys, and there may be liver congestion, ascites and mesenteric edema.

Of 12 cows with caudal vena caval thrombosis, a thrombus was found in the thoracic region in four, in the subphrenic region in one and in the abdominal region near the liver in seven (Braun et al., 2002). In one cow, the thrombus in the thoracic region of the caudal vena cava extended into the right atrium. The thrombi varied in length from 6.0 to 15.0 cm with a diameter of 1.5 to 6.0 cm. The thrombus was situated where a liver abscess had ruptured into the caudal vena cava in three cows and where a diaphragmatic abscess had ruptured into the vein in one other. Eleven cows had bronchopneumonia and multiple pulmonary abscesses. In three cows, the lungs also had blood-filled sinuses, and in two, there was severe pulmonary emphysema.

CONCLUSIONS

Ultrasonography is currently the only method of diagnosing congestion of the caudal vena cava caused by thrombosis. In cows with chronic bronchopneumonia, ultrasonography of the caudal vena cava from the 11th and 12th intercostal spaces on the right side should be carried out in addition to other diagnostic procedures such as endoscopy of the respiratory tract and radiography of the
lungs. Thrombosis of the caudal vena cava has a poor prognosis, and a diagnosis allows affected cattle to be culled right away.

REFERENCES


Legend to figures

Figure 1: A “white” thrombus that has been removed from the subphrenic region of the caudal vena cava. Reprinted from U. Braun, in: Innere Medizin und Chirurgie des Rindes, Parey Buchverlag, Berlin.

Figure 2: Intrapulmonary hemorrhage attributable to erosion of the pulmonary artery by a lung abscess in a cow with vena caval thrombosis. Immediately adjacent to this, purulent material is seen exiting a lung abscess that has been cut open (arrow). Reprinted from U. Braun, in: Innere Medizin und Chirurgie des Rindes, Parey Buchverlag, Berlin.

Figure 3: Epistaxis and bleeding from the mouth in a cow with pulmonary hemorrhage.

Figure 4: A Holstein-Friesian cow that died of pulmonary hemorrhage during transport to the clinic. The cow is lying in a pool of blood. The cow was referred because of chronic bronchopneumonia. There was massive bleeding (light red blood) from the mouth.

Figure 5: Radiograph of the thorax of a cow with thrombosis of the caudal vena cava. A radiodense area is evident caudodorsally in a diaphragmatic lung lobe. 1 Lung, 2 Pulmonary vessel, 3 Radiodense area, 4 Diaphragm, 5 Caudal vena cava, 6 Caudal border of the heart, Cr Cranial, Cd Caudal. Reprinted from U. Braun, Vet Rec 150, 209-213 (2002).

Figure 6: Ultrasonogram of liver and normal caudal vena cava imaged from the 11th intercostal space using a 3.5 Mhz linear transducer. The caudal vena cava has a triangular shape on cross section. 1 Abdominal wall, 2 Liver, 3 Caudal vena cava, Ds Dorsal, Vt Ventral.
Figure 7: Ultrasonogram of liver and congested caudal vena cava, imaged from the 11th intercostal space using a 3.5 Mhz linear transducer. The caudal vena cava has an oval shape on cross section. 1 Abdominal wall, 2 Liver, 3 Caudal vena cava, Ds Dorsal, Vt Ventral

Figure 8: Ultrasonogram of liver and congested caudal vena cava containing an echogenic thrombus, imaged from the 11th intercostal space using a 3.5 Mhz convex transducer. The caudal vena cava has an oval shape on cross section and contains an echogenic thrombus. 1 Abdominal Wall, 2 Liver, 3 Caudal vena cava, 4 Thrombus in the caudal vena cava, 5 Portal Vein, Ds Dorsal, Vt Ventral. Reprinted from U. Braun, Schweizer Archiv für Tierheilkunde 145, 340-341, 2003

Figure 9: Ultrasonogram of liver and congested right hepatic vein imaged from the 11th intercostal space using a 3.5 Mhz linear transducer. The right hepatic vein is dilated. 1 Abdominal wall, 2 Liver, 3 Right hepatic vein, 4 Portal vein, Ds Dorsal, Vt Ventral
Table 1: Breed, age and history in 12 cows with thrombosis of the caudal vena cava (Braun et al., 2002)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Findings</th>
<th>Number of cows</th>
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<tbody>
<tr>
<td>Breed</td>
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<tr>
<td></td>
<td>Swiss Braunvieh</td>
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<td></td>
<td>Simmental</td>
<td>3</td>
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<tr>
<td></td>
<td>Holstein Friesian</td>
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<tr>
<td>Age</td>
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<td>History</td>
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<tr>
<td></td>
<td>Ill for more than 14 days</td>
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</tr>
<tr>
<td></td>
<td>Pretreated for pyrexia, indigestion, foreign bodies</td>
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<tr>
<td></td>
<td>History of epistaxis</td>
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Table 2: Haematological and biochemical findings in 12 cows with thrombosis of the caudal vena cava (Braun et al., 2002)

<table>
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<th>Variable</th>
<th>Finding</th>
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<td>Haematocrit (21.7 ± 4.23 %)</td>
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<td></td>
<td>Decreased (15 - 23)</td>
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<tr>
<td>Leukocyte count (10516 ± 3166/μL)</td>
<td>Normal (4200 – 9,000)</td>
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<td></td>
<td>Increased (10,400 – 18,400)</td>
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<td>Total solids (90.5 ± 7.92 g/L, n = 11)</td>
<td>Normal (63 - 86)</td>
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<td></td>
<td>Increased (88 - 106)</td>
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<tr>
<td>Fibrinogen (8.5 ± 2.94 /L, n = 11)</td>
<td>Normal (4 - 7)</td>
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<td></td>
<td>Increased (6 - 13)</td>
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<td>Glutaraldehyde test (2.2 ± 1.14 min.)</td>
<td>Decreased (1 - 5.5)</td>
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<td>γ-GT (69.3 ± 67.31/L)</td>
<td>Normal (12 - 23)</td>
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<tr>
<td>GLDH (23.2 ± 26.80 U/L, n = 10)</td>
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<td>Braun et al. (2005)</td>
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<td></td>
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<td>Mohamed et al. (2004)</td>
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<tr>
<td>Echogenic thrombus in the caudal vena cava</td>
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<td>Braun et al. (2003)</td>
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<td>Hepatic abscesses</td>
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<td>Ascites</td>
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<td>Braun (1990)</td>
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Table 4: Synopsis of the typical clinical signs, haematological findings, pathological changes and useful diagnostic approaches in cattle with thrombosis of the caudal vena cava

<table>
<thead>
<tr>
<th>Variable</th>
<th>Findings</th>
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| Clinical signs            | - General signs: Abnormal general condition, moderate to thin body condition, reduced appetite, fever, reduced ruminal motility, positive reticular foreign body tests  
- Metastatic chronic suppurative bronchopneumonia including abnormal lung sounds, tachypnea and coughing  
- Bilateral epistaxis, bleeding from the mouth and hemoptysis due to pulmonary hemorrhage  
- Ascites  
- Sudden death |
| Haematological findings   | Mild anemia, leukocytosis, increased concentrations of total protein and fibrinogen, reduced clotting time of the glutaraldehyde test, elevated activities of the bile duct enzyme \( \gamma \)-glutamyl transferase |
| Pathological changes      | - Thrombus in the caudal vena cava  
- Abscesses in the liver, kidney or thorax that sit immediately adjacent to the caudal vena cava  
- Multiple abscesses in the lungs, pulmonary hemorrhage  
- Liver congestion, ascites and mesenteric edema |
| Diagnostic approaches     | - Ultrasonographic examination of the caudal vena cava in the 11th or 12th intercostal space on the right side near the liver, pleura, liver and abdomen  
- Glutaraldehyde test  
- Endoscopic examination of the respiratory tract  
- Radiography of the lungs |