

EXPERIMENTALLY INDUCED TORSION OF SPLEEN AND ITS TREATMENT IN CANINES

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "EXPERIMENTALLY INDUCED TORSION OF SPLEEN AND ITS TREATMENT IN CANINES" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other university or society.

Mannuthy,
10-10-88


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CERTIFICATE

Certified that this thesis, entitled "EXPERIMENTALLY INDUCED TORSION OF SPLEEN AND ITS TREATMENT IN CANINES" is a record of research work done independently by Sri. Mohinder Singh Bhadwal under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.



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*To
The oldest friend
of mankind.*

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Introduction

EXPERIMENTALLY INDUCED TORSION OF SPLEEN AND ITS TREATMENT IN CANINES

INTRODUCTION

Spleen is the largest lymphoid organ in the body and it forms part of the reticuloendothelial system. In dogs, it serves as a reservoir of blood. It is regarded as a graveyard for ageing erythrocytes. However, spleen is not essential for life, as its functions are taken up by liver, lymphnodes and bone marrow in its absence.

Splenomegaly is associated with bacterial infections, protozoan diseases, tumours and abscess of the spleen, splenic torsion and gastric dilatation-volvulus syndrome. Splenic torsion is comparatively a rare condition. It is most often described as part of a gastric-volvulus syndrome, although it may occur independently (Stevenson *et al.*, 1981). The incidence is more in large, deep-chested breeds of dogs such as Great Dane, St. Bernard, Alsatian and others.

Etiology of torsion of the spleen is unknown. Usually it occurs after a heavy meal followed by exercise. Most of the reports on splenic torsion are based on clinical cases. The condition is usually fatal due to absence of pathognomonic clinical symptoms making it difficult to diagnose the condition.

Hence the present work was taken up to study the pathophysiology and clinical manifestations of torsion of spleen

induced in experimental dogs. It was also contemplated to evaluate the efficacy of the two methods of treatment viz., (i) detorsion of the spleen and (ii) splenectomy.

Review of Literature

REVIEW OF LITERATURE

McNish et al. (1967) reported a case of splenic torsion in a 12 month-old female Deerhound. The animal had been fed a few hours before the onset of the symptoms and had a previous history of gastric dilatation and torsion. The animal was dull and in a state of shock with a painful swelling in the middle of the abdomen. On exploratory laparotomy stomach was found to be tympanitic. The dog vomited during manipulation of the stomach. The spleen was found to be grossly enlarged and the splenic pedicle twisted. The torsion was corrected and the spleen was removed. The recovery was uneventful.

Jubb and Kennedy (1970) stated that torsion of the spleen occurred in dogs in association with torsion of the stomach. There was severe congestion and haemorrhagic infarction due to occlusion of the vein. When the artery was occluded, the organ became necrotic. When the distal portion was twisted, only the veins were occluded, causing haemorrhagic infarction and congestion.

Maxie et al. (1970) reported three cases of torsion of spleen in Great Dane. Anorexia, vomiting and splenodynia with palpable splenomegaly were observed in two cases while polyuria and polydipsia were observed in the other. Neutrophilia, haemoglobinuria and increased serum alkaline phosphatase were detected in all the three cases. Radiographically detectable splenomegaly was observed in two cases. The

diagnostic interval varied from five days to 11 days. All the animals survived after splenectomy.

Orman and Lorenz (1972) reported a case of the torsion of the splenic pedicle in a male Great Dane aged 18 months, with the previous history of vomiting. The animal was depressed, weak, anorectic, with grey mucous membrane, but the rectal temperature was normal. The abdomen was tender when palpated and revealed an enlarged spleen. Leucocytosis and reticulocytosis were detected in blood smears. A large homogenous mass was visible in radiographs of the mid-abdominal region. Exploratory laparotomy revealed an enlarged, dark red, congested spleen covered with gastrosplenic omentum that was thickened, dark red and firm. Torsion of the splenic pedicle with thrombosis of splenic vessels was seen. The stalk was untwisted and splenic artery, vein and omental vessels proximal to the level of the thrombosis were ligated. Splenectomy and gastropexy were performed. After surgery, the dog was bright and alert, mucous membrane was pink and the capillary refilling time improved. The animal recovered uneventfully.

Brodie (1974) reported a case of splenic torsion in a 12 month old female Alsatian dog. The animal was showing symptoms of acute abdominal discomfort and was stretching its body. The dog had a rectal temperature of 102°F. The mucous membrane was normal but the pulse and respiration rates were increased. The abdominal muscles were relaxed and a

large firm mass was palpable from the costal margin to the pelvic inlet. Exploratory laparotomy revealed that the spleen was twisted 180° on its pedicle and had a horse-shoe shape. The organ was congested and firm with splenic veins grossly engorged. The spleen was removed. There was no evidence of anaemia or haemoperitoneum. The dog made an uneventful recovery.

Kipnis (1974) reported torsion of the splenic pedicle and gastric volvulus in an eight-year-old female German Shepherd dog. The dog had an acute episode of retching and progressive abdominal distension. The rectal temperature was 39°C, mucous membrane was dark and capillary refilling time was slow. A soft tissue mass was palpable in the ventral portion of the abdomen in level with the umbilicus. Heart and respiratory rates were normal and the pulse was regular and strong. A lateral abdominal radiograph showed dilatation of the stomach and bowel. Exploratory laparotomy revealed serosanguineous fluid in the peritoneal cavity. The spleen was rounded and congested and the splenic mesentery was twisted around the splenic vessels. The spleen was removed after untwisting the splenic pedicle. The abdominal cavity was flushed with physiologic saline solution. Immediately after surgery, the capillary refilling time was normal and mucous membrane was pink. The recovery was uncomplicated.

Howenstein et al. (1975) reported a case of torsion of the splenic pedicle in a four-year-old, male St. Bernard dog.

The dog was whining and avoiding sternal recumbency and had a history of emesis. The dog was alert, with a rectal temperature of 102°F and normal mucous membrane. The abdomen was very firm and palpation elicited signs of discomfort. Lateral and ventrodorsal radiographs of the abdomen revealed a large mass in the left cranial aspect of the abdomen. Exploratory laparotomy revealed an enlarged, congested spleen, twisted on its pedicle several times in a counter-clockwise direction. The gastrosplenic omentum was thickened, congested, twisted and adherent. The splenic vessels were engorged and contained clots and hence splenectomy was performed. Recovery was satisfactory. Sections of the spleen, the omentum and splenic pedicle revealed congestion and haemorrhage.

Iverson (1976) reported a case of torsion of splenic pedicle and complete splenic separation in a two-and-a-half-year-old female St. Bernard dog. The animal was initially presented for lethargy, loss of appetite and diarrhoea. The rectal temperature was 105°F. In spite of treatment the dog continued to have poor appetite. A week later the rectal temperature was 103.5°F, mucous membrane was pale, hematocrit value was 23 and total white cell count was 48,000 with a left shift in the differential cell count. Radiographs gave evidence of fluid in the peritoneal cavity. Exploratory laparotomy revealed large volume of serosanguineous fluid in the peritoneal cavity. A normal-sized, degenerated spleen without

attachment to any other structure was removed from the abdomen, and a necrotic splenic pedicle, apparently rotated 720° was excised. The abdomen was drained of the fluid. The dog recovered without serious complications.

Lipowitz et al. (1977) reported splenic torsion in a six-year-old intact male Chesapeake Bay Retriever. The dog had a history of lethargy, anorexia and emesis. Symptomatic treatment gave good results but there was recurrence. The white blood cell count was 16,700/mm³, packed cell volume was 32 per cent, creatinine 0.5 mg/dl, SGPT 7 IU/L and blood glucose 85 mg/dl. The rectal temperature was 39.1°C, respiration 20/minute and heart rate was 84/minute. Oral mucous membrane was pale. Packed cell volume, haemoglobin content, red blood cell count and white blood cell count decreased during hospitalization. Differential leucocytic count showed increase in segmented neutrophils and eosinophils, whereas non-segmented neutrophils and lymphocytes decreased. There was no change in monocyte count. Serum sodium, potassium, creatinine and total protein values were within normal limits. Radiography revealed two poorly demarcated soft-tissue masses in the abdomen, one in the caudal mid-abdomen and the other in the cranial right quadrant. A large firm mass was readily palpable in the cranial portion of the abdomen. Exploratory laparotomy revealed greatly enlarged spleen with its vascular and mesenteric pedicle twisted. The splenic veins appeared to be thrombosed. The splenic pedicle was untwisted and

splenectomy was performed. Recovery was satisfactory. In a similar case of splenic torsion presented earlier, vascular embarrassment to the intestine was observed on necropsy.

Barton (1981) stated that torsion of spleen produced congestive splenomegaly. The condition occurred either as an acute surgical emergency as part of the gastric dilatation-volvulus complex or a subacute debilitating disease with vague gastrointestinal signs like anorexia and emesis. Abdominal pain was variable, ranging from excruciating pain in the cranial abdomen in acute cases to a virtual absence of pain on palpation in more chronic cases. Prognosis after splenectomy was dependent on the degree of vascular embarrassment in the other abdominal organs such as intestine. Thrombosis of hilar splenic vessels was a constant finding.

Moreau and Henley (1981) reported a fatal case of clostridial splenitis secondary to splenic torsion in a three-and-a-half year old, spayed female Great Dane. The dog had a history of depression, anorexia, emesis and loss of weight. The dog was anorectic but normal bowel movements were observed. The rectal temperature was 41°C, heart rate, 148/minute and respiratory rate, 32/minute. The dog was in lateral recumbency and dehydrated. Mucous membranes was pale and capillary refilling time was prolonged. Abdomen was soft, doughy and distended without detectable pain or tympany. Results of the haemogram indicated anemia, marked leucocytosis with a regenerative left shift. Splenomegaly was appreciable

in radiograph. On exploratory laparotomy brownish-black peritoneal fluid was seen in the abdominal cavity. The spleen was found to be congested, greatly enlarged, necrotic and rotated 360° about its pedicle. Splenectomy was performed and during the procedure, thrombi were seen in splenic vessels. The dog died, eight hours after splenectomy. Microscopic examination of the spleen revealed necrosis and many colonies of bacteria.

Stevenson et al. (1981) reported the incidence of splenic torsion in seven dogs aged three to 12 years. The clinical signs included anorexia (6/7) and vomiting (5/7). Two dogs had blood in urine and one had passed very dark coloured urine. Abdominal pain was detected by palpation or by postural gait. Splenomegaly or enlargement of an intra-abdominal structure was detected upon initial physical examination in six of the seven cases, but a definite radiographic diagnosis of splenic torsion was offered in only one case. Pallor of the mucous membrane was noted initially in two cases and five dogs developed detectable pallor later. Hæmograms revealed neutrophilia (6/7) and anemia initially in two cases and after hospitalization in five. Serum sodium and potassium revealed little abnormality. Laparotomy was performed in all the animals. The spleen was left twisted and the vessels double clamped and ligated with 2-0 silk. The spleen was removed. Two of the dogs survived and the remaining died during the post-operative period.

Stead et al. (1983) described clinical and radiographic signs of torsion of the splenic pedicle in three German Shepherd dogs. Vomiting, dullness, anorexia, restlessness and pallor of mucous membrane were observed in two cases whereas vomiting and diarrhoea were seen in one case. One of these animals was recumbent and another had a history of gastric torsion. Pulse was elevated in two cases. Distension of abdomen and pain on palpation of the abdomen were noticed in two cases. On radiographic examination splenomegaly with distinct edges was a characteristic finding in the three dogs. Splenic veins were thrombosed and splenic artery was patent in two cases whereas in the third case the splenic veins were only partially blocked. In each case the spleen lay along the mid-abdominal floor causing displacement of adjacent viscera. Splenectomy was performed in all the three cases. Two dogs survived and the third died during surgical procedure.

George et al. (1984) reported splenic torsion in a seven-and-a-half-year-old male Alsatian dog presented with the history of anorexia, frequent emesis and depression of one week duration. The animal had congested conjunctival mucous membrane and mucopurulent discharge from both the eyes. The abdomen was distended. Plain and contrast radiograph did not reveal any specific diagnostic lesion. Urinalysis revealed the presence of bile pigments (+++). Haemogram showed increased total leucocyte count. Differential

leucocyte count revealed increase in number of band cells. At autopsy, the spleen was found to be enlarged, congested and covered with thick gastr^splenic omentum. Four complete twists of the splenic pedicle could be noticed without involvement of the stomach.

O'Neill (1985) reported splenic torsion in a three-year-old spayed Great Dane presented with the history of depression and anorexia. A large, firm mass was palpable in the anterior abdomen. Radiograph revealed the presence of a mass which displaced the intestine caudally. The packed cell volume was 28 per cent. Exploratory laparotomy revealed an enlarged spleen and a mesentery with haemorrhagic necrotic foci. Normal blood vessels were difficult to identify. Splenectomy was performed and the recovery was uneventful. The spleen and adherent tissue weighed approximately eight pounds. Histopathological examination revealed arterial and venous thrombosis with extensive haemorrhage of the mesentery. Congestion and infarction of the spleen were also found.

Wright and Callahan (1987) reported splenic torsion in a six-year-old spayed Blood hound with the history of emesis and listlessness. The mucous membrane was pale and the body temperature was 100.8°F. Listlessness and dehydration were noted. A large, painless, mid-abdominal mass was palpated. Radiograph revealed a uniformly enlarged spleen. The white blood cell count was 7300/ul. The packed cell volume, plasma protein and differential leucocyte count were normal. There

was a thrombocytopenia and a rapid sedimentation rate and rouleaux formation. Exploratory laparotomy revealed 180° torsion of the spleen about its pedicle and the spleen was seven times its normal size. The capsule was seen ruptured. Splenectomy was performed and the abdomen was lavaged to remove blood clots. Histopathology indicated lymphoid depletion, lympholysis and extramedullary hematopoiesis. The recovery was uneventful.

Materials and Methods

MATERIALS AND METHODS

Experimental animals

Eighteen apparently healthy dogs of either sex, aged one to five years and weighing 10-15 kg were used for the study. All the dogs were dewormed and examined for the presence of blood parasites if any. They were housed separately in cages under identical conditions of feeding and management and kept under observation for 10 days before the experiment.

The animals were divided into two groups as detailed below:

Group A: consisting of six animals numbered serially, viz., A(1), A(2), A(3), A(4), A(5) and A(6) and

Group B: consisting of 12 animals divided into two subgroups of six animals each and numbered serially, viz., B1(1), B1(2), B1(3), B1(4), B1(5) and B1(6) and B2(1), B2(2), B2(3), B2(4), B2(5) and B2(6).

In the animals of group A, laparotomy was performed and torsion of the spleen was brought about.

The observations made in this group served:

- i) to assess the clinico-pathological changes, and
- ii) to arrive at appropriate time for the commencement of treatment in group B.

In the animals of group B, effectiveness of treatment, following experimentally induced torsion of spleen was studied. In the subgroup B1, detorsion of the spleen was done, while in the subgroup B2, splenectomy was performed.

Food and water were withheld for 12 hours prior to the experiment. The left mid-cervical region and the mid-ventral abdominal region were prepared for aseptic surgery by clipping, shaving and painting with Tr. Iodine.

Procedure

The animals were controlled in right lateral recumbency. Local anaesthesia of the left mid-cervical region was brought about by linear infiltration of 3-5 ml of two per cent lignocaine hydrochloride* solution for catheterization of the carotid artery and the jugular vein. A cutaneous incision, 4 cm long, was made at the inferior border of the jugular furrow. The left carotid artery and the left jugular vein were exteriorised by blunt dissection. A polythene catheter was introduced into the carotid artery and fixed in situ by ligation. The catheter was connected to an aneroid manometer by means of a three-way valve, for measuring the arterial blood pressure. Another polythene catheter was introduced into the anterior venacava through the jugular vein and fixed in situ by ligation. The catheter was connected to a water manometer by means of a three-way valve, for recording central

* Gasicain - SG Pharmaceuticals, Baroda.

venous pressure, administration of anaesthetic solution and collection of blood samples (Fig. 1 & 2). After a period of stabilization (20 minutes) the initial values were recorded and the blood samples were collected.

Five per cent solution of thiopentone sodium* at the rate of 15 mg/kg body weight was administered intravenously through the venous catheter. Local anaesthesia of the mid-ventral abdominal region was brought about by linear infiltration of 5-10 ml of two per cent lignocaine hydrochloride solution. The animals were secured in dorsal recumbency.

Group A.

A 8-10 cm long mid-ventral laparotomy incision was made between xiphoid cartilage and the umbilicus, incising through skin, subcutaneous tissue, linea alba and peritoneum. The spleen was exteriorised (Fig. 3). The gross measurements of the spleen were recorded. The splenic pedicle was isolated and two complete twists (720°) were made in the clock-wise direction (Fig. 4 & 5) and the spleen was returned to the abdominal cavity. The laparotomy wound was closed by suturing the peritoneum, linea alba and subcutaneous tissue by simple continuous sutures using 2-0 chromic catgut. The cutaneous incision was closed by horizontal mattress sutures using monofilament nylon. The wound was dressed with Tr. Benzoin.

Subgroup B1.

In the six animals of the subgroup B1, torsion of the

* Intraval sodium - May and Baker (India) Ltd., Bombay.

spleen was brought about as in group A. Detorsion of the spleen was the treatment adopted in this subgroup. The time for commencing the treatment was fixed on the basis of the observations on group A. Five per cent solution of thiopentone sodium was administered through the venous catheter and the laparotomy wound was opened again by removing the sutures. The spleen was exteriorised (Fig. 6), detected and returned to the abdominal cavity. The laparotomy wound was closed. Five per cent solution of dextrose-saline at the rate of 10 ml/kg body weight with 4.0 mg betamethasone sodium phosphate* was administered intravenously through the venous catheter and repeated at six and 12 hours after detorsion. Chloramphenicol sodium succinate** was administered intravenously at the rate of 30 mg/kg body weight daily for three consecutive days after detorsion.

Subgroup B2.

In the six animals of the subgroups B2, torsion of the spleen was brought about as in group A. Splenectomy was the treatment adopted in this subgroup. The time for commencing the treatment was fixed on the basis of the observations in group A. Five per cent solution of thiopentone sodium was administered through the venous catheter and the laparotomy wound was opened by removing the sutures. The spleen was exteriorised and splenectomy was performed after ligating the

* Betnesol - Glaxo Laboratories, Bombay.

** Chlorotin - Sterfil Laboratories, Bombay.

splenic pedicle, using 2-0 chromic catgut. The laparotomy wound was closed in the routine manner. Administration of dextrose-saline, betamethasone and chloramphenicol was done in the animals as in subgroup B1.

Administration of fluids and antibiotic was continued in all the animals under subgroups B1 and B2 till the abdominal wound healed up or till death, whichever was earlier. The animals which survived were sacrificed on the tenth post-operative day and autopsy was done.

Blood samples were collected just before bringing about torsion of the spleen and afterwards at intervals of three hours, till 72 hours or until death of the animals in group A. Other clinical observations were recorded at the same intervals. In subgroups B1 and B2, blood samples were collected just before bringing about torsion of the spleen and afterwards at intervals of three hours till the treatment was started. After the commencement of the treatment, blood samples were collected and the observations were recorded at six, 12, 18, 24, 48, 96 and 168 hours. The arterial and venous catheters were withdrawn after 24 hours in all the animals and the vessels were ligated to arrest haemorrhage. The cutaneous incision was closed by simple interrupted sutures using monofilament nylon. After the withdrawal of the catheters, blood samples were collected from the peripheral veins.

The following parameters were studied.

1. Clinical signs, viz.,

Behavioural change
Colour of mucous membrane
Capillary refilling time
Temperature
Heart rate
Respiration rate

2. Haemodynamic factors viz.,

Arterial blood pressure
Central venous pressure

3. Electrocardiogram (ECG)

4. Haemogram viz.,

Erythrocyte sedimentation rate
Packed cell volume
Haemoglobin content
Differential leucocyte count

5. Serum constituents viz.,

Total serum protein
Serum sodium
Serum potassium

6. Radiographic studies

7. Period of survival

8. Autopsy findings

9. Morphological and histopathological studies of the spleen

Methods.

1. Clinical signs.

Behaviour of the animals was observed post-operatively. Conjunctival mucous membrane was observed for any change in its colour. Capillary refilling time was studied by pressing the gums/tongue and the time required for reappearance of the original colour was recorded. The rectal temperature was recorded using a clinical thermometer. Heart rate and respiration rate were recorded by auscultation.

2. Haemodynamic factors.

a) Arterial blood pressure: The systolic pressure (SP) and diastolic pressure (DP) were recorded directly from the aneroid manometer.

Mean arterial pressure ($MAP = \frac{SP + 2 DP}{3}$) and pulse pressure ($PP = (SP - DP)$) were derived from the recorded values of arterial blood pressure.

b) Central venous pressure: The central venous pressure was recorded from the water manometer calibrated from -150 to + 300 mm.

3. Electrocardiogram (ECG).

ECG was recorded using a base apex lead system, at a paper speed of 25 mm per second at three hours after torsion in all the animals of group A and B. In subgroups B1 and B2, ECG was again recorded at three hours after the treatment.

4. Haemogram.

Erythrocyte sedimentation rate and packed cell volume were estimated following the method of Wintrobe (1961). Haemoglobin content and differential leucocyte count were estimated as per the technique described by Schalm (1975).

5. Serum constituents.

Total serum protein was estimated using Biuret method of Inchiosa (1964). Serum sodium and potassium were determined by flame photometry (Oser, 1971).

6. Radiographic studies.

Lateral radiographs of the abdomen were taken 12 hours after the induction of torsion in group A.

7. Period of survival.

The time of death was recorded and the period of survival was calculated.

8. Autopsy.

Autopsy was performed on all the animals which died during the study. The animals which survived were sacrificed on the tenth post-operative day and autopsy was done. The organs were examined and gross lesions if any, were recorded.

9. Morphological and histopathological studies of the spleen.

The gross measurements of the spleen were recorded before bringing about torsion of the spleen in all the animals, at the time of detorsion and splenectomy in subgroups B1 and B2

respectively and at the time of autopsy in group A and subgroup B1. The spleen was weighed in group A and subgroup B1 at the time of autopsy and in subgroup B2 after the splenectomy.

Representative samples of the spleen were collected and fixed in 10 per cent buffered neutral formalin and were processed by routine paraffin embedding technique (Armed Forces Institute of Pathology, 1968). Paraffin sections of four micron thickness were stained with hematoxylin and eosin method (Sheehan and Hrapchak, 1980).

Statistical analysis

Mean values were compared using student's 't' test (Snedecor and Cochran, 1967).

Fig. 1 & 2. Animal prepared for the experiment with the Arterial and venous catheters secured in situ.

Fig. 3. Normal spleen, when exteriorised after laparotomy.

Fig.1



Fig.2

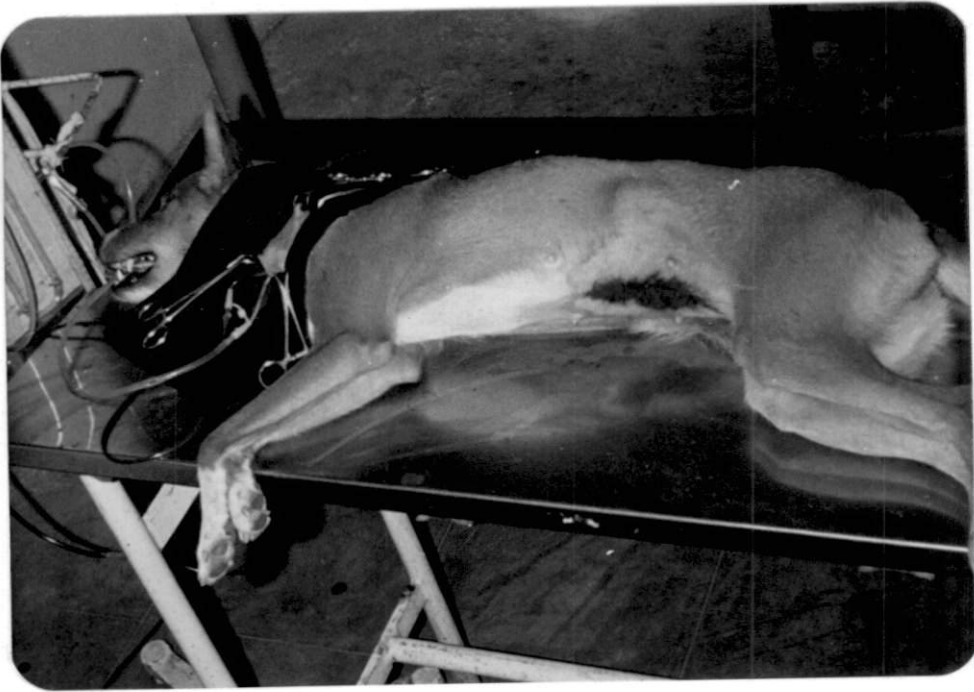


Fig.3



Fig. 4 & 5. Spleen - After inducing torsion.

Fig. 6. Enlarged spleen - Immediately after detorsion.

Fig. 4

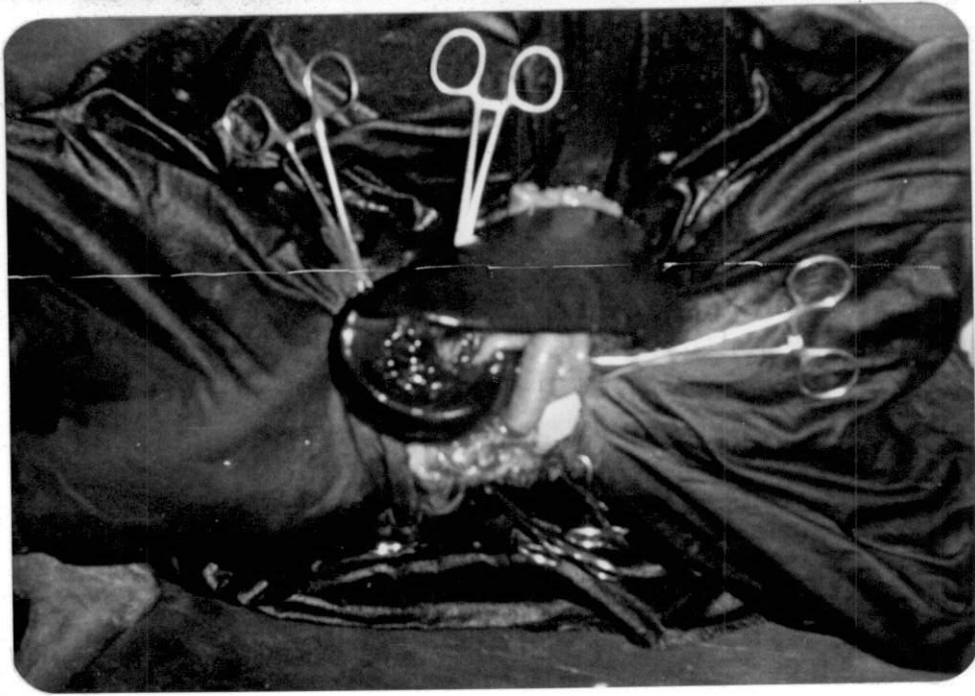


Fig. 5



Fig. 6



Results

RESULTS

Group A

The average body weight of the animals in this group was 12.92 ± 0.74 kg. The recovery from anaesthesia was uneventful in all the animals. The observations are presented in tables 1 to 4.

Clinical signs.

After torsion.

Within three hours after torsion of the spleen, there was appreciable abdominal distension in all the animals except in one animal (A5). Pain on abdominal palpation was noticed in all the animals except in two animals (A2 and A3). Straining was observed in three animals, (A3, A5 and A6). Mucous membrane was pale in four animals (A1, A2, A3 and A4) and light pink in two animals (A5 and A6). The capillary refilling time was prolonged in all the animals.

Within six hours, all the animals were dull and recumbent. Extremities were cold in all the animals except in two animals (A1 and A6). Blood was dark and thick in two animals (A5 and A6). Abdominal distension reduced in two animals (A1 and A2). One animal (A6) vomited and showed signs of dehydration. Mucous membrane was pale in all the animals except in one animal (A1) which had light pink mucous membrane. The capillary refilling time was prolonged in all the animals.

Within nine hours, all the animals were dull and recumbent. Extremities were cold in all the animals. Signs

of dehydration were observed in two animals (A5 and A6). Heart beat was feeble and pulse was weak in one animal (A3) and this animal died by the eighth hour. Capillary refilling time was prolonged in all the animals.

Within 12 hours all the animals were recumbent and did not show any variation in clinical signs.

The animals which survived after 12 hours remained recumbent till death. By 16th hour, the animal number A4 died. By 21st hour, the animal number A1 died. Animal number A5 died by 22.45 hours. The animal number A6 passed light-brown urine and died by 23.30 hours. Animal number A2 died by 38.45 hours.

Rectal temperature ($^{\circ}\text{F}$) was 101.57 ± 0.16 at 0 h, 102.10 ± 0.26 at 3 h, 100.91 ± 0.45 at 6 h, 101.00 ± 0.52 at 9 h, 101.40 ± 0.64 at 12 h, 101.48 ± 0.66 at 15 h, 101.45 ± 0.73 at 18 h and 102.00 ± 0.00 at 21 h. In the animal (A2) which survived after 21 h, it was 102.00 at 24 h, 102.00 at 27 h, 102.40 at 30 h, 102.80 at 33 h and 101.80 at 36 h. It showed a slight reduction at 6 h followed by a gradual increase. The values were within the normal range and not significant.

Heart rate (per min.) was 108.00 ± 5.24 at 0 h, 133.33 ± 9.33 at 3 h, 127.33 ± 12.57 at 6 h, 149.60 ± 5.46 at 9 h, 163.20 ± 8.98 at 12 h, 154.00 ± 6.87 at 15 h, 167.50 ± 10.01 at 18 h and 162.67 ± 10.41 at 21 h. In the animal (A2) which survived after 21 h, it was 135.00 at 24 h, 150.00 at 27 h,

134.00 at 30 h, 136.00 at 33 h and 122.00 at 36 h. It showed a gradual increase and the increase was significant ($P < 0.05$) at 3 h, 9 h, 12 h, 15 h, 18 h and 21 h.

Respiration rate (per min.) was 22.67 ± 1.43 at 0 h, 19.83 ± 1.45 at 3 h, 20.67 ± 0.95 at 6 h, 20.00 ± 1.41 at 9 h, 20.60 ± 2.18 at 12 h, 20.20 ± 1.36 at 15 h, 24.00 ± 0.82 at 18 h and 27.00 ± 3.51 at 21 h. In the animal (A2) which survived after 21 h, it was 24.00 at 24 h and 27 h, 23.00 at 30 h, 33 h and 36 h. It showed a slight reduction at 3 h, followed by a gradual increase. The values were within the normal range and the variations were not significant.

Hæmodynamic factors.

The systolic pressure (mmHg) was 132.50 ± 5.44 at 0 h, 111.67 ± 13.03 at 3 h, 108.67 ± 8.89 at 6 h, 85.40 ± 10.79 at 9 h, 83.20 ± 13.40 at 12 h, 70.60 ± 8.85 at 15 h, 71.75 ± 7.62 at 18 h and 74.67 ± 6.36 at 21 h. In the animal (A2) which survived after 21 h, it was 64.00 at 24 h, 60.00 at 27 h, 84.00 at 30 h, 80.00 at 33 h and 70.00 at 36 h. It showed a gradual decrease and the decrease was significant ($P < 0.05$) at 6 h, 9 h, 12 h, 15 h, 18 h and 21 h.

The diastolic pressure (mmHg) was 112.17 ± 2.95 at 0 h, 101.67 ± 13.03 at 3 h, 98.67 ± 8.29 at 6 h, 77.80 ± 11.39 at 9 h, 74.80 ± 12.78 at 12 h, 61.60 ± 8.07 at 15 h, 61.25 ± 7.18 at 18 h and 66.00 ± 4.00 at 21 h. In the animal (A2) which survived after 21 h, it was 60.00 at 24 h, 55.00 at 27 h,

80.00 at 30 h, 70.00 at 33 h and 60.00 at 36 h. It showed a gradual decrease and was significant ($P < 0.05$) at 9 h, 12 h, 15 h, 18 h and 21 h.

The mean arterial pressure (mmHg) was 113.39 ± 6.46 at 0 h, 104.50 ± 13.05 at 3 h, 102.00 ± 8.48 at 6 h, 80.33 ± 11.16 at 9 h, 77.60 ± 12.97 at 12 h, 64.60 ± 8.32 at 15 h, 64.75 ± 7.33 at 18 h and 68.89 ± 4.78 at 21 h. In the animal (A2) which survived after 21 h, it was 61.33 at 24 h, 55.67 at 27 h, 81.33 at 30 h, 73.33 at 33 h and 63.33 at 36 h. It showed a gradual decrease and the decrease was significant ($P < 0.05$) at 9 h, 12 h, 15 h, 18 h and 21 h.

The pulse pressure (mmHg) was 20.33 ± 4.91 at 0 h, 10.00 ± 0.00 at 3 h, 10.00 ± 0.89 at 6 h, 7.60 ± 1.60 at 9 h, 8.40 ± 1.60 at 12 h, 10.00 ± 0.63 at 15 h, 10.50 ± 0.50 at 18 h and 8.67 ± 2.40 at 21 h. In the Animal (A2) which survived after 21 h, it was 4.00 at 24 h, 5.00 at 27 h, 4.00 at 30 h, 10.00 at 33 h and 10.00 at 36 h. It showed a gradual decrease and the decrease was significant ($P < 0.05$) at 9 h.

The central venous pressure (mm H₂O) was 28.30 ± 8.60 at 0 h, -2.30 ± 12.70 at 3 h, -4.10 ± 13.10 at 6 h, -24.00 ± 5.30 at 9 h, -26.00 ± 6.60 at 12 h, -30.00 ± 6.30 at 15 h, -28.80 ± 8.50 at 18 h and -23.30 ± 6.00 at 21 h. It showed a gradual decrease and the decrease was significant ($P < 0.05$) at 9 h, 12 h, 15 h, 18 h and 21 h.

Electrocardiogram.

Electrocardiogram showed tachycardia after torsion in

all the animals. Spiking of P-wave was seen in one animal (A3). One animal (A6) showed inverted P-wave. One animal (A5) developed sinus arrhythmia in the beginning, the TP interval increased and P-wave was biphasic in later stages. Spiking of T-wave was seen in three animals (A4, A5 and A6) and increased amplitude of T-wave was seen in two animals (A3 and A6) (Fig. 7).

Hæmogram.

Erythrocyte sedimentation rate (mm/1 h) was 10.00 ± 2.77 at 0 h, 10.67 ± 2.19 at 3 h, 8.83 ± 2.29 at 6 h, 11.60 ± 3.22 at 9 h, 11.40 ± 4.08 at 12 h, 10.60 ± 6.15 at 15 h, 14.00 ± 9.35 at 18 h and 19.00 ± 14.00 at 21 h. In the animal (A2) which survived after 21 h, it was 4.00 at 24 h, 3.00 at 27 h and 2.00 at 30 h, 33 h and 36 h. It showed a decrease upto 6 h followed by a gradual increase upto 21 h. The variations were not significant.

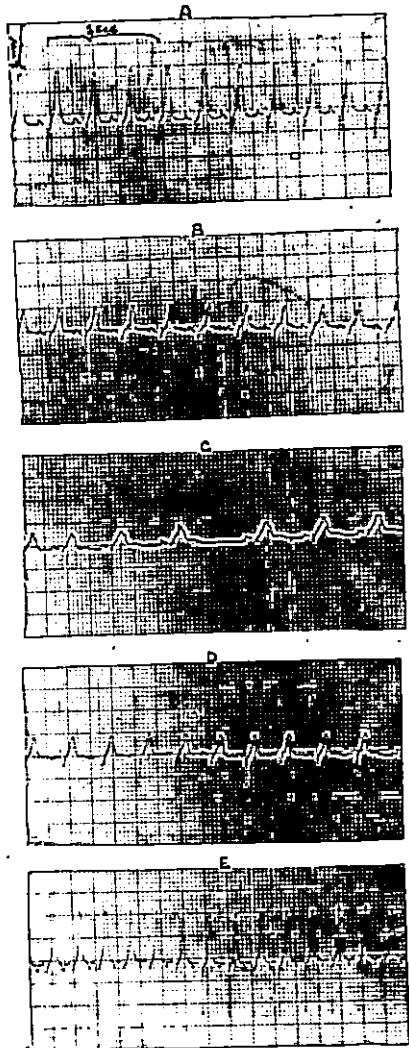
Packed cell volume (%) was 38.67 ± 1.91 at 0 h, 36.83 ± 1.56 at 3 h, 36.33 ± 1.76 at 6 h, 37.00 ± 2.10 at 9 h, 37.40 ± 1.60 at 12 h, 38.20 ± 2.13 at 15 h, 36.50 ± 3.48 at 18 h and 32.00 ± 2.52 at 21 h. In the animal (A2) which survived after 21 h, it was 37.00 at 24 h, 39.00 at 27 h, 41.00 at 30 h and 33 h and 40.00 at 36 h. The values remained within the normal range and the variations were not significant.

Hæmoglobin content (g/dl) was 10.93 ± 0.70 at 0 h, 9.20 ± 0.55 at 3 h, 9.28 ± 0.40 at 6 h, 9.08 ± 0.33 at 9 h, 9.02 ± 0.53 at 12 h, 9.04 ± 0.69 at 15 h, 8.40 ± 0.53 at 18 h

Fig. 7. Electrocardiogram, three hours after torsion.

- A. Tachycardia, spiking of T-wave, increased amplitude of T-wave.
- B. Tachycardia, spiking of T- wave
- C. Tachycardia, biphasic P-wave, arrhythmia.
- D. Tachycardia, biphasic P-wave
- E. Tachycardia, inverted P-wave.

Fig. 7.



and 8.13 ± 0.47 at 21 h. In the animal (A2) which survived after 21 h, it was 9.60 at 24 h, 9.80 at 27 h, 10.20 at 30 h, 11.20 at 33 h and 11.6 at 36 h. It showed a gradual decrease and the decrease was significant ($P < 0.05$) at 18 h and 21 h.

Segmented neutrophil count (%) was 70.80 ± 4.50 at 0 h, 81.33 ± 4.16 at 3 h, 81.67 ± 2.27 at 6 h, 81.60 ± 5.41 at 9 h, 77.20 ± 2.99 at 12 h, 77.00 ± 1.95 at 15 h, 78.25 ± 4.37 at 18 h and 71.33 ± 12.44 at 21 h. In the animal (A2) which survived after 21 h, it was 83.00 at 24 h, 85.00 at 27 h and 30 h, 79.00 at 33 h and 80.00 at 36 h. It showed an increase upto 9 h, followed by a decrease upto 21 h. The variations were not significant.

Band cell count (%) was 0.33 ± 0.33 at 0 h, 1.50 ± 1.15 at 3 h, 6.50 ± 2.64 at 6 h, 7.20 ± 2.40 at 9 h, 10.20 ± 3.87 at 12 h, 11.00 ± 3.33 at 15 h, 8.75 ± 4.78 at 18 h and 12.33 ± 6.49 at 21 h. In the animal (A2) which survived after 21 h it was 3.00 at 24 h and 27 h, 5.00 at 30 h, 4.00 at 33 h, 7.00 at 36 h. It showed a gradual increase and the increase was significant ($P < 0.05$) at 9 h, 12 h, 15 h and 21 h.

Lymphocyte count (%) was 26.83 ± 4.39 at 0 h, 14.83 ± 4.32 at 3 h, 10.17 ± 3.69 at 6 h, 10.80 ± 1.43 at 9 h, 15.80 ± 2.27 at 12 h, 10.60 ± 2.06 at 15 h, 11.25 ± 1.65 at 18 h and 14.33 ± 7.83 at 21 h. In the animal (A2) which survived after 21 h, it was 11.00 at 24 h, 12.00 at 27 h, 10.00 at 30 h, 15.00 at 33 h and 13.00 at 36 h. It showed a decrease and the decrease was significant ($P < 0.05$) at 6 h, 9 h, 15 h and 18 h.

Eosinophil count (%) was 2.67 ± 0.95 at 0 h, 1.17 ± 0.40 at 3 h, 0.50 ± 0.34 at 6 h, 0.20 ± 0.20 at 9 h, 0.60 ± 0.40 at 12 h, 1.00 ± 0.55 at 15 h, 0.75 ± 0.25 at 18h and 2.00 ± 2.00 at 21 h. In the animal (A2) which survived after 21 h, eosinophils could not be detected. It showed a decrease and the decrease was significant ($P < 0.05$) at 9 h.

Serum constituents.

Total serum protein (g/dl) was 5.55 ± 0.37 at 0 h, 5.07 ± 0.32 at 3 h, 5.23 ± 0.37 at 6 h, 5.49 ± 0.23 at 9 h, 5.61 ± 0.19 at 12 h, 5.85 ± 0.22 at 15 h, 5.76 ± 0.27 at 18 h and 5.44 ± 0.17 at 21 h. In the animal (A2) which survived after 21 h, it was 4.57 at 24 h, 5.65 at 27 h, 5.51 at 30 h, 5.24 at 33 h and 4.29 at 36 h. The values were within the normal range and not significant.

Serum sodium (meq/L) was 140.87 ± 7.54 at 0 h, 133.45 ± 9.75 at 3 h, 135.00 ± 8.90 at 6 h, 139.29 ± 9.23 at 9 h, 134.52 ± 8.80 at 12 h, 139.39 ± 7.51 at 15 h, 128.52 ± 6.31 at 18 h and 130.58 ± 16.58 at 21 h. In the animal (A2) which survived after 21 h it was 134.78 at 24 h, 142.89 at 27 h, 136.42 at 30 h, 151.66 at 33 h and 144.35 at 36 h. The variations were marginal except at 18 h (125.52 ± 6.31) and 21 h (130.58 ± 16.58) when it showed a decrease. The variations were not significant.

Serum potassium (meq/L) was 5.57 ± 0.17 at 0 h, 6.83 ± 0.36 at 3 h, 7.45 ± 0.56 at 6 h, 7.32 ± 0.64 at 9 h, 7.01 ± 0.70 at 12 h, 7.32 ± 0.81 at 15 h, 7.06 ± 0.51 at 18 h and

7.31 \pm 1.00 at 21 h. In the animal (A2) which survived after 21 h it was 5.64 at 24 h and 27 h, 5.72 at 30 h, 5.98 at 33 h and 36 h. It showed a gradual increase and the increase was significant ($P < 0.05$) at 3 h, 6 h, 9 h, 15 h, 18 h and 21 h.

Radiographic studies.

Radiograph revealed a dense shadow with distinct borders representing the spleen in the anterior part of the abdomen (Fig. 8).

Period of survival.

The maximum and the minimum survival period in this group was 38.45 hours and 8.00 hours respectively. The average survival period was 21.53 \pm 4.10 hours.

Autopsy findings.

Dark coloured fluid (50-200 ml) was detected in the peritoneal cavity in all the animals except in one animal (A2). Spleen was enlarged and dark in all the animals except in one animal (A2), where it was reddish-grey. The spleen was ruptured, fragmented and separated in one animal (A4). Small foci of rupture were noticed in two other animals (A1 and A5). Congestion of splenic pedicle, splenic vessels and blood clots in the splenic vessels were seen in three animals (A1, A4 and A6) whereas blood clots alone were seen in two animals (A1 and A3). Intestine and stomach were distended and pale in three animals (A1, A3 and A6). In one animal (A5) stomach alone was distended. Congestion of

Fig. 8. Skiagram of the abdomen - 12 hours after inducing torsion of the spleen.

The mass occupying the anterior part of abdomen has distinct borders (arronation).

Fig. 8.



gastric mucosa along with dark coloured fluid in the stomach was observed in one animal (A2). Congestion of the liver, lungs and kidneys was noticed in three animals (A1, A2 and A5). About 50 ml of light-brown urine was detected in urinary bladder in one animal (A6).

Morphological and histopathological studies of the spleen.

Spleen was firm in consistency and was dark-red in three animals (A1, A2 and A3) and bright-red in the other three animals (A4, A5 and A6) before torsion. On autopsy, the spleen was found to be dark in all the animals except in one animal (A2) where it was reddish-grey. The consistency was soft in three animals (A2, A3 and A5), very soft in two animals (A1 and A6) and in one animal (A4), the spleen was found to be ruptured, fragmented and separated.

The length (cm) of the spleen was 21.57 ± 1.39 before torsion and 24.50 ± 1.70 at the time of autopsy. There was an increase in the length but the increase was not significant.

The maximum width (cm) of the spleen was 8.83 ± 0.62 before torsion and 10.22 ± 0.89 at the time of autopsy. There was an increase in the maximum width but the increase was not significant.

The minimum width (cm) of the spleen was 4.87 ± 0.40 before torsion and 6.76 ± 1.41 at the time of autopsy. There was an increase in the minimum width but the increase was not significant.

The average weight of the spleen at autopsy was 232.00 \pm 21.54 grams.

Histopathological changes in the spleen included extensive congestion, haemorrhage and thrombi in the vessels. There was hyalinization and necrosis of the trabeculae, lymphoid depletion and the lymphoid tissue was replaced with red blood cells.

The animals became dull and recumbent by six hours after the experimentally induced torsion of the spleen. They remained recumbent till death. The mucous membrane was pale and the capillary refilling time was found to be prolonged. A significant ($P < 0.05$) increase in the heart rate, band cell count and serum potassium and a significant ($P < 0.05$) decrease in systolic pressure, diastolic pressure, mean arterial pressure, pulse pressure, central venous pressure, lymphocyte count and eosinophil count was observed by the ninth hour after torsion.

From the above observations, it could be seen that the period from the sixth to the ninth hour after torsion of the spleen would be critical. Hence the appropriate time to commence the treatment was fixed as six hours after torsion.

Group-A

Table 2. Length, maximum width, minimum width and physical characters of the spleen, before torsion and at the time of autopsy (Mean \pm S.E), n=6

Animal No.	Body weight (kg)	Before torsion					At the time of autopsy					
		Colour	Length (cm)	Width (cm)		Consistency	Colour	Length (cm)	Width (cm)		Consistency	Weight (g)
				Max.	Min.				Max.	Min.		
A1	10.50	Dark red	25.40	10.90	6.30	Firm	Dark	28.50	9.50	7.30	Very soft	300
A2	12.00	Dark red	20.00	7.50	4.30	Firm	Reddish grey	21.50	7.60	4.50	Soft	220
A3	15.00	Dark red	21.00	7.50	5.00	Firm	Dark	26.00	11.00	5.50	Soft	180
A4	13.00	Bright red	19.50	8.60	4.60	Firm	Dark	Spleen ruptured, fragmented and separated.				
A5	15.00	Bright red	26.00	10.50	5.50	Firm	Dark	27.00	13.00	12.00	Soft	260
A6	12.00	Bright red	17.50	8.00	3.50	Firm	Dark	19.00	10.00	4.50	Very soft	200
Mean	12.92		21.57	8.83	4.87			24.50	10.22	6.76		232.00
\pm S.E.	\pm 0.74		\pm 1.39	\pm 0.62	\pm 0.40			\pm 1.70	\pm 0.89	\pm 1.41		\pm 21.54

Group B

Subgroup B1.

The average body weight of the animals in this subgroup was 12.33 ± 0.80 kg. The recovery from anaesthesia was uneventful in all the animals. In these animals, detorsion of the spleen was done six hours after splenic torsion. The observations are presented in tables 5 to 8.

Clinical signs.

After torsion.

Within three hours after torsion of the spleen, there was appreciable abdominal distension and pain on abdominal palpation in three animals (B1(1), B1(3) and B1(5)). Straining was observed in three animals (B1(1), B1(4) and B1(6)). Extremities were cold in one animal (B1(2)). Two animals (B1(4) and B1(6)) were recumbent. Retching and staring at the flank region was observed in one animal (B1(6)). The mucous membrane was pale in three animals (B1(1), B1(2) and B1(4)), light-pink in B1(3), pink in B1(5) and congested in B1(6). The capillary refilling time was prolonged in all the animals.

Within six hours, all the animals were dull and recumbent. Extremities were cold in two animals (B1(1) and B1(3)). Blood was dark and thick in three animals (B1(2), B1(3) and B1(4)). Three animals (B1(1), B1(2) and B1(6)) vomited. Signs of dehydration were seen in two animals (B1(3) and B1(6)).

The mucous membrane was pale in all the animals except one animal (B1(5) which had pink mucous membrane. The capillary refilling time was prolonged in all the animals.

After detorsion.

All the animals were recumbent except one animal (B1(1) which was able to stand up within one hour. Two animals (B1(3) and B1(5) were able to stand up within six hours. Extremities remained cold in all the animals throughout the period of observation, but in one animal (B1(1) the extremities returned to normalcy after 24 hours. Blood was dark and thick in two animals (B1(1) and B1(4). All the animals were dull and did not take food and water, except two animals (B1(1) and B1(5) which started feeding after 24 hours. One animal (B1(3) vomited by 96 hours and on the sixth day and one animal (B1(5) passed dark-yellow urine by 48 hours. One animal (B1(2) showed hiccups by one-and-a-half-hours and died. There was no change in the colour of the mucous membrane of all the animals except in two animals, B1(5) which was pink initially, became pale later and in B1(1) it was light pink. The capillary refilling time was prolonged in all the animals except in one animal (B1(1) which showed improvement after 24 hours.

Rectal temperature ($^{\circ}\text{F}$) was 101.30 ± 0.11 at 0 h, 101.70 ± 0.61 at 3 h and 101.27 ± 0.94 at 6 h after torsion. The values were within the normal range and not significant. After detorsion, it was 100.13 ± 0.58 at 6 h, 100.47 ± 0.74 at 12 h,

99.80 \pm 1.40 at 18 h, 100.33 \pm 0.77 at 24 h, 102.20 \pm 0.42 at 48 h and 101.53 \pm 0.29 at 96 h. In the animal B1(1) which survived after detorsion, it was 101.60 at 168 h. It showed a decrease upto 18 h, followed by a gradual increase. The variations were not significant.

Heart rate (per min.) was 116.67 \pm 5.41 at 0 h, 168.67 \pm 5.41 at 3 h, and 155.17 \pm 9.35 at 6 h after torsion. It showed an increase and was significant ($P < 0.05$) at 3 h and 6 h. After detorsion, it was 164.67 \pm 13.48 at 6 h, 161.33 \pm 12.72 at 12 h, 154.67 \pm 18.81 at 18 h, 143.00 \pm 18.50 at 24 h, 149.33 \pm 23.45 at 48 h and 136.00 \pm 28.00 at 96 h. In the animal B1(1) which survived after detorsion, it was 98.00 at 168 h. It showed an increase at 6 h, followed by a gradual decrease. The variations were not significant.

Respiration rate (per min.) was 19.00 \pm 2.57 at 0 h, 49.50 \pm 19.27 at 3 h and 31.33 \pm 3.82 at 6 h after torsion. It showed an increase and increase was significant ($P < 0.05$) at 6 h. After detorsion, it was 33.33 \pm 9.61 at 6 h, 28.33 \pm 6.98 at 12 h, 27.67 \pm 6.33 at 18 h, 28.00 \pm 6.11 at 24 h, 28.00 \pm 4.62 at 48 h and 21.67 \pm 1.20 at 96 h. In the animal B1(1) which survived after detorsion, it was 18.00 at 168 h. It showed an increase at 6 h, followed by a gradual decrease. The variations were not significant.

Hæmodynamic factors.

The systolic pressure (mmHg) was 136.67 \pm 6.15 at 0 h,

116.83 \pm 13.61 at 3 h and 98.33 \pm 7.03 at 6 h after torsion. It showed a significant ($P < 0.05$) decrease at 6 h. After detorsion, it was 69.00 \pm 5.00 at 6 h, 76.00 \pm 9.00 at 12 h, 80.00 \pm 10.00 at 18 h and 95.00 \pm 5.00 at 24 h. It showed a decrease at 6 h, followed by a gradual increase upto 24 h. The variations were not significant.

The diastolic pressure (mmHg) was 120.00 \pm 6.83 at 0 h, 106.33 \pm 12.13 at 3 h and 89.17 \pm 6.89 at 6 h after torsion. It showed a significant ($P < 0.05$) decrease at 6 h. After detorsion, it was 62.00 \pm 4.00 at 6 h, 69.50 \pm 10.50 at 12 h, 70.00 \pm 10.00 at 18 h and 85.00 \pm 5.00 at 24 h. It showed a decrease at 6 h, followed by a gradual increase upto 24 h. The variations were not significant.

Mean arterial pressure (mmHg) was 125.56 \pm 6.54 at 0 h, 109.83 \pm 12.61 at 3 h, and 92.22 \pm 6.92 at 6 h after torsion. It showed a significant ($P < 0.05$) decrease at 6 h. After detorsion, it was 64.34 \pm 4.33 at 6 h, 71.67 \pm 10.00 at 12 h, 73.33 \pm 10.00 at 18 h and 88.33 \pm 5.00 at 24 h. It showed a decrease at 6 h, followed by a gradual increase upto 24 h. The variations were not significant.

The pulse pressure (mmHg) was 16.67 \pm 2.11 at 0 h, 10.50 \pm 1.96 at 3 h and 9.17 \pm 0.83 at 6 h after torsion. It showed a significant ($P < 0.05$) decrease at 6 h. After detorsion, it was 7.00 \pm 1.00 at 6 h, 6.50 \pm 1.50 at 12 h, 10.00 \pm 0.00 at 18 h and 24 h. It showed a decrease at 6 h, followed by an increase upto 24 h. The variations were not significant.

The central venous pressure (mm H₂O) was 31.70 ± 4.80 at 0 h, -5.80 ± 10.90 at 3 h and -12.50 ± 8.60 at 6 h after torsion. It showed a significant ($P < 0.05$) decrease at 3 h and 6 h after torsion. After detorsion, it was 0.00 ± 13.20 at 6 h, -7.50 ± 2.50 at 12 h, -7.20 ± 2.50 at 18 h and 5.00 ± 30.00 at 24 h. It showed an increase at 6 h, followed by a decrease upto 18 h and then again an increase at 24 h. The variations were not significant.

Electrocardiogram.

Electrocardiogram showed tachycardia after torsion in all the animals. P-wave was biphasic and inverted in three animals (B1(2), B1(5) and B1(6)). In two animals (B1(1) and B1(4)) flattening of T-wave was observed. After detorsion there was increase in amplitude and spiking of T-wave in one animal (B1(1)) and tachycardia in four animals (B1(1), B1(3), B1(4) and B1(5)) (Fig.9).

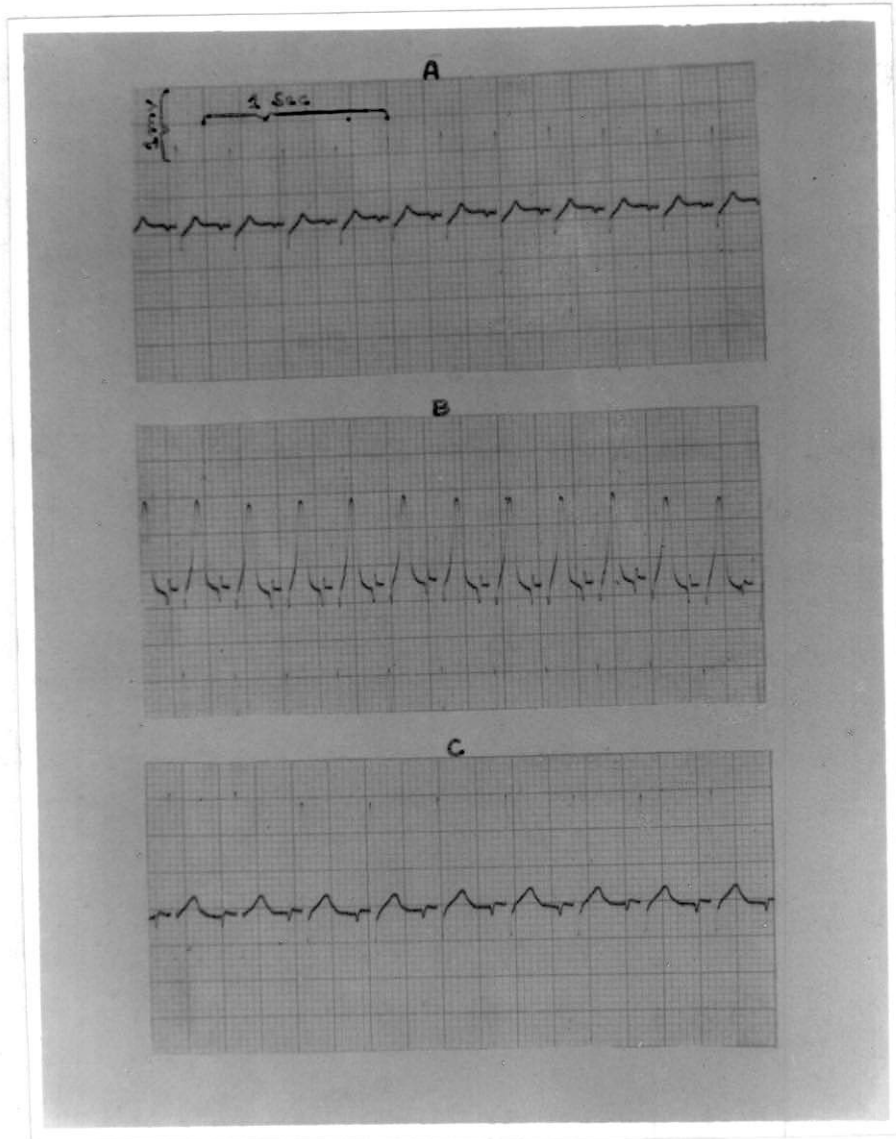
Hæmogram.

Erythrocyte sedimentation rate (mm/1 h) was 10.83 ± 2.73 at 0 h, 5.50 ± 2.14 at 3 h and 5.33 ± 2.38 at 6 h after torsion. It showed a decrease but the variations were not significant. After detorsion it was 3.00 ± 1.53 at 6 h, 7.67 ± 6.17 at 12 h, 12.33 ± 9.87 at 18 h, 3.50 ± 1.50 at 24 h, 26.00 ± 24.00 at 48 h and 32.33 ± 19.46 at 96 h. In the animal B1(1) which survived after detorsion, it was 5.00 at 168 h. It showed a decrease at 6 h, followed by an increase at 12 h and 18 h. It again decreased by 24 h,

Fig. 9. Electrocardiogram, three hours after torsion and three hours after detorsion.

- A. Tachycardia, inverted P-wave.
- B. Tachycardia, increased amplitude and spiking of T-wave, biphasic P-wave.
- C. Tachycardia, flattening of T-wave, inverted/biphasic P-wave.

Fig. 9.



followed by an increase at 48 h and 96 h. The variations were not significant.

Packed cell volume (%) was 44.50 ± 3.95 at 0 h, 42.00 ± 3.10 at 3 h and 40.67 ± 3.42 at 6h after torsion. The values remained within the normal range and not significant. After detorsion, it was 42.00 ± 2.65 at 6 h, 39.00 ± 5.35 at 12 h, 36.00 ± 6.16 at 18 h, 35.00 ± 5.29 at 24 h, 36.00 ± 8.08 at 48 h and 25.00 ± 5.72 at 96 h. In the animal B1(1) which survived after detorsion, it was 25.00 at 168 h. Packed cell volume showed a slight increase at 6 h after detorsion followed by a gradual decrease upto 96 h. The variations were not significant.

Hæmoglobin content (g/dl) was 12.47 ± 0.54 at 0 h, 11.00 ± 0.93 at 3 h and 10.80 ± 1.04 at 6 h after torsion. It showed a gradual decrease, but the variations were not significant. After detorsion, it was 10.73 ± 0.93 at 6 h, 10.33 ± 1.17 at 12 h, 9.80 ± 0.57 at 18 h, 9.47 ± 0.47 at 24 h, 8.53 ± 1.62 at 48 h and 8.20 ± 1.21 at 96 h. In the animal B1(1) which survived after detorsion it was 6.60 at 168 h. It showed a gradual decrease upto 96 h and the decrease was significant ($P < 0.05$) at 24 h and 96 h.

Segmented neutrophil count (%) was 66.83 ± 2.17 at 0 h, 83.33 ± 1.89 at 3 h and 84.33 ± 1.86 at 6 h after torsion. It showed a significant ($P < 0.05$) increase at 3 h and 6 h. After detorsion, it was 76.33 ± 2.03 at 6 h, 77.67 ± 3.18

at 12 h, 78.00 ± 2.05 at 18 h, 78.00 ± 3.61 at 24 h, 81.33 ± 4.81 at 48 h and 68.00 ± 1.70 at 96 h. In the animal B1(1) which survived after detorsion it was 73.00 at 168 h. The decrease was significant ($P < 0.05$) at 6 h and 96 h.

Band cell count (%) was 0.00 ± 0.00 at 0 h, 2.67 ± 1.26 at 3 h and 2.00 ± 1.53 at 6 h after torsion. It showed an increase but the variations were not significant. After detorsion, it was 10.67 ± 4.91 at 6 h, 7.33 ± 2.03 at 12 h, 5.00 ± 2.08 at 18 h, 5.67 ± 0.33 at 24 h, 6.67 ± 0.67 at 48 h and 7.00 ± 4.36 at 96 h. In the animal B1(1) which survived after detorsion it was 2.00 at 168 h. It showed an increase at 6 h, followed by a gradual decrease upto 18 h and then a gradual increase upto 96 h. The increase was significant ($P < 0.05$) at 48 h.

Lymphocyte count (%) was 30.33 ± 1.76 at 0 h, 12.83 ± 1.58 at 3 h and 13.33 ± 3.18 at 6 h after torsion. The decrease was significant ($P < 0.05$) at 3 h and 6 h. After detorsion it was 12.00 ± 6.51 at 6 h, 14.33 ± 5.21 at 12 h, 17.00 ± 3.21 at 18 h, 16.00 ± 3.05 at 24 h, 11.00 ± 4.04 at 48 h and 21.00 ± 2.08 at 96 h. In the animal B1(1) which survived after detorsion it was 24.00 at 168 h. It showed a gradual increase upto 24 h, a decrease at 48 h, followed by an increase at 96 h. The variations were not significant.

Eosinophil count (%) was 2.50 ± 0.62 at 0 h, 0.50 ± 0.34 at 3 h and 0.33 ± 0.33 at 6 h after torsion. The decrease

was significant ($P < 0.05$) at 3 h. After detorsion it was 0.33 ± 0.33 at 6 h and 12 h, 0.00 ± 0.00 at 18 h, 0.33 ± 0.33 at 24 h, 0.67 ± 0.33 at 48 h and 1.67 ± 1.20 at 96 h. In the animal B1(1) which survived after detorsion it was 1.00 at 168 h. There was no change in eosinophil count upto 12 h after detorsion. After 18 h, it showed a gradual increase upto 96 h. The variations were not significant.

Serum constituents.

Total serum protein (g/dl) was 5.72 ± 0.23 at 0 h, 5.60 ± 0.12 at 3 h and 5.60 ± 0.23 at 6 h after torsion. The values were within the normal range and the variations were not significant. After detorsion it was 5.75 ± 0.05 at 6 h, 5.72 ± 0.07 at 12 h, 5.74 ± 0.13 at 18 h, 5.65 ± 0.20 at 24 h, 5.72 ± 0.26 at 48 h and 5.88 ± 0.14 at 96 h. In the animal B1(1) which survived after detorsion it was 4.50 at 168 h. The values were within the normal range and the variations were not significant.

Serum sodium (meq/L) was 148.84 ± 1.47 at 0 h, 149.84 ± 2.11 at 3 h and 148.51 ± 1.46 at 6 h after torsion. It showed an increase initially but the values were within the normal range and the variations were not significant. After detorsion it was 147.69 ± 2.41 at 6 h, 147.67 ± 2.96 at 12 h, 147.60 ± 2.59 at 18 h, 147.63 ± 2.98 at 24 h, 146.92 ± 3.86 at 48 h and 146.77 ± 3.86 at 96 h. In the animal B1(1) which survived after detorsion it was 147.98 at 168 h. The

values were within the normal range and the variations were not significant.

Serum potassium (mEq/L) was 5.05 ± 0.15 at 0 h, 5.46 ± 0.38 at 3 h and 7.94 ± 0.28 at 6 h after torsion. The increase was significant ($P < 0.05$) at 6 h. After detorsion it was 7.62 ± 0.26 at 6 h, 7.42 ± 0.16 at 12 h, 7.29 ± 0.27 at 18 h, 7.18 ± 0.08 at 24 h, 7.10 ± 0.08 at 48 h and 6.89 ± 0.27 at 96 h. In the animal B1(1) which survived after detorsion, it was 6.21 at 168 h. It showed a gradual decrease upto 96 h and the decrease was significant ($P < 0.05$) at 96 h.

Period of survival.

Five animals of this subgroup died after detorsion at various time intervals (Table No.5). The animal number B1(1) which survived, was sacrificed on the 10th day and autopsy was conducted.

Autopsy findings.

The spleen was in its normal position and of normal size, colour and consistency in the animal B1(1) which was sacrificed. A few, small branches of splenic vessels contained blood clots. The lungs were pale and kidneys showed congestion. Among the other five animals which died at various time intervals, dark fluid in the peritoneal cavity was detected in three animals (B1(2), B1(4) and B1(6)). Rupture of splenic capsule was seen in two animals (B1(2) and B1(6)). Congestion of splenic pedicle was seen in three

animals (B1(2), B1(3) and B1(5) and it was adherent to stomach, the spleen and intestine in two animals (B1(3) and B1(5). Intestine was perforated at the point of adhesion in one animal (B1(3) . Spleen was dark-brown and separated in two animals (B1(3) and B1(5). Congestion of splenic vessels was seen in animal number B1(2) and blood clots in splenic vessels were seen in three animals (B1(3), B1(4) and B1(6). Intestine and lungs were pale in four animals (B1(2), B1(3), B1(4) and B1(5). Congestion in kidneys and liver was seen in animal number B1(2) and B1(4) respectively. Stomach contained dark semi-solid material and the pancreas was brown in one animal (B1(3).

Morphological and histopathological studies of the spleen.

The spleen was bright-red in all the animals before torsion except in one animal(B1(1) where it was reddish-brown. It was soft in consistency in all the animals except one animal (B1(6), where it was firm. After detorsion it was dark in all the animals. It was firm in consistency in all the animals except two animals (B1(4) and B1(6), where it was soft. At the time of autopsy, it was dark in three animals (B1(2), B1(4) and B1(6) and reddish-brown in one animal (B1(1). In two animals (B1(3) and B1(5) the spleen was dark-brown and separated. It was soft in consistency in all the animals.

The length (cm) of the spleen was 20.67 ± 0.56 before torsion, 26.92 ± 2.21 immediately after detorsion and 25.25 ± 4.18 at the time of autopsy. There was a significant ($P < 0.05$) increase in the length after torsion.

The maximum width (cm) of the spleen was 8.50 ± 0.63 before torsion, 10.97 ± 0.61 immediately after detorsion and 8.00 ± 1.37 at the time of autopsy. There was a significant ($P < 0.05$) increase in the maximum width after torsion. There was no significant difference between the value before torsion and at the time of autopsy.

The minimum width (cm) of the spleen was 5.67 ± 0.21 before torsion, 7.03 ± 0.46 immediately after detorsion and 5.13 ± 0.69 at the time of autopsy. There was a significant ($P < 0.05$) increase in the minimum width after torsion. After detorsion there was a significant ($P < 0.05$) decrease in the minimum width. There was no significant difference between the value before torsion and at the time of autopsy.

The average weight of the spleen at the time of autopsy was 181.25 ± 14.49 grams.

Histopathological changes in the spleen included extensive congestion, thrombosis of vessels, lymphoid depletion and lympholysis. Focal areas of necrosis, edema and hyalinization of the trabeculae were also seen.

Subgroup B2.

The average body weight of the animals in this subgroup was 13.50 ± 0.96 kg. The recovery from anaesthesia was uneventful in all the animals. In these animals, splenectomy was performed six hours after splenic torsion. The observations are presented in the tables 9 to 12.

Clinical signs.

After torsion.

Within three hours after torsion of the spleen, there was appreciable abdominal distension and pain on abdominal palpation in all the animals except one animal (B2(1) which was recumbent and moaning. One animal (B2(5) vomited. The mucous membrane was light-pink in three animals (B2(2), B2(5) and B2(6), pale in two animals (B2(3) and B2(4) and congested in one animal (B2(1). The capillary refilling time was prolonged in all the animals.

Within six hours, all the animals were dull, recumbent and the extremities were cold. Blood was dark and thick in three animals (B2(1), B2(4) and B2(6). One animal (B2(5) vomited and another two animals (B2(3) and B2(6) showed retching. There was no change in the colour of the mucous membrane and the capillary refilling time was prolonged in all the animals.

After splenectomy.

All the animals were recumbent for varying periods from

six to 12 hours. The extremities which were previously cold regained normalcy when the animals stood up. The blood was watery after 12 hours. All the animals started taking food and water and were active and alert at varying intervals after 12 hours. One animal (B2(3)) vomited during the first six hours and passed light-brown urine after 24 hours. One animal (B2(1)) passed loose faeces after 48 hours. The mucous membrane was light-pink in four animals (B2(1), B2(2), B2(3) and B2(4)) and pink in two animals (B2(5) and B2(6)). The capillary refilling time showed improvement in all the animals.

Rectal temperature ($^{\circ}\text{F}$) was 101.50 ± 0.30 at 0 h, 101.57 ± 0.54 at 3 h and 101.40 ± 0.30 at 6 h after torsion. The values were within the normal range and the variations were not significant. After splenectomy, it was 101.17 ± 0.36 at 6 h, 101.23 ± 0.31 at 12 h, 101.10 ± 0.28 at 18 h, 101.53 ± 0.19 at 24 h, 101.33 ± 0.18 at 48 h, 101.40 ± 0.15 at 96 h and 101.63 ± 0.10 at 168 h. The values were within the normal range and the variations were not significant.

Heart rate (per min.) was 108.67 ± 3.92 at 0 h, 152.67 ± 5.31 at 3 h and 156.33 ± 8.49 at 6 h after torsion. It showed an increase and was significant ($P < 0.05$) at 3 h and 6 h. After splenectomy, it was 151.00 ± 2.82 at 6 h, 145.67 ± 5.85 at 12 h, 136.00 ± 9.47 at 18 h, 116.00 ± 7.66 at 24 h, 105.33 ± 4.09 at 48 h and 101.67 ± 8.83 at 96 h and 104.33 ± 7.60 at 168 h. It showed a gradual decrease and was significant ($P < 0.05$) at 24 h, 48 h, 96 h and 168 h.

Respiration rate (per min.) was 25.67 ± 2.80 at 0 h, 51.00 ± 17.95 at 3 h and 41.50 ± 15.95 at 6 h after torsion. It showed an increase but the variations were not significant. After splenectomy it was 22.33 ± 1.96 at 6 h, 21.67 ± 1.96 at 12 h, 21.83 ± 1.83 at 18 h, 43.17 ± 17.35 at 24 h, 39.00 ± 16.29 at 48 h, 28.67 ± 5.28 at 96 h and 24.87 ± 3.57 at 168 h. It showed a decrease at 6 h, followed by a gradual increase upto 24 h and then a gradual decrease upto 168 h. The variations were not significant.

Haemodynamic factors.

The systolic pressure (mmHg) was 135.00 ± 7.19 at 0 h, 122.67 ± 8.61 at 3 h and 122.50 ± 8.34 at 6 h after torsion. It showed a decrease but the variations were not significant. After splenectomy it was 96.67 ± 9.19 at 6 h, 102.50 ± 9.80 at 12 h and 110.00 ± 10.00 at 18 h and 24 h. It showed a decrease at 6 h, followed by a gradual increase upto 24 h. The variations were not significant.

The diastolic pressure (mmHg) was 121.67 ± 8.72 at 0 h, 113.33 ± 7.60 at 3 h and 6 h after torsion. It showed a decrease but the variations were not significant. After splenectomy, it was 85.00 ± 8.47 at 6 h, 92.50 ± 7.50 at 12 h and 95.00 ± 5.00 at 18 h and 24 h. It showed a decrease at 6 h, followed by a gradual increase upto 24 h. The decrease was significant ($P < 0.05$) at 6 h.

The mean arterial pressure (mmHg) was 126.11 ± 8.18 at 0 h, 116.44 ± 7.92 at 3 h and 116.67 ± 7.90 at 6 h after

torsion. It showed a decrease but the variations were not significant. After splenectomy, it was 88.89 ± 8.68 at 6 h, 95.83 ± 7.50 at 12 h, 100.00 ± 6.67 at 18 h and 24 h. It showed a decrease at 6 h, followed by a gradual increase upto 24 h. The decrease was significant ($P < 0.05$) at 6 h.

The pulse pressure (mmHg) was 13.33 ± 2.11 at 0 h, 9.33 ± 1.45 at 3 h and 9.17 ± 0.83 at 6 h after torsion. It showed a decrease but the variations were not significant. After splenectomy it was 11.67 ± 1.67 at 6 h, 10.00 ± 0.00 at 12 h, 15.00 ± 5.00 at 18 h and 24 h. It showed an increase upto 24 h. The variations were not significant.

The central venous pressure (mm. H₂O) was 36.70 ± 4.90 at 0 h, 21.70 ± 4.00 at 3 h and 18.00 ± 2.00 at 6 h after torsion. It showed a significant ($P < 0.05$) decrease at 3 h and 6 h. After splenectomy it was 8.00 ± 11.10 at 6 h, 10.00 ± 7.10 at 12 h, 25.00 ± 11.70 at 18 h and 30.00 ± 10.00 at 24 h. It showed a decrease at 6 h, followed by a gradual increase upto 24 h. The variations were not significant.

Electrocardiogram.

Electrocardiogram showed tachycardia after torsion in all the animals. Biphasic and inverted P-wave and spiking of T-wave was seen in three animals (B2(2), B2(4) and B2(5)). After splenectomy tachycardia was seen in all the animals. P-wave was inverted in two animals (B2(2) and B2(4) (Fig.10).

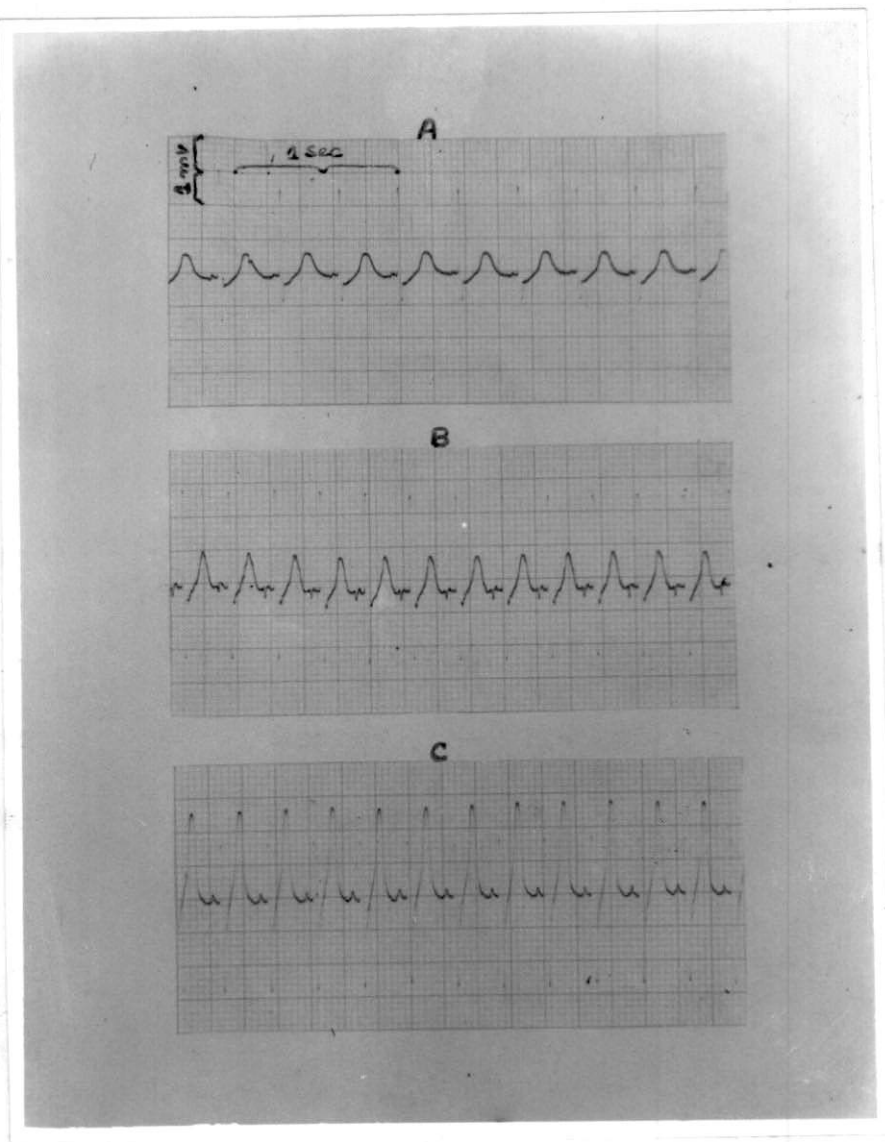
Hæmogram.

Erythrocyte sedimentation rate (mm/1 h) was 12.83 ± 2.30

Fig. 10. Electrocardiogram, three hours after torsion and three hours after splenectomy.

- A. Tachycardia, biphasic P-wave.
- B. Tachycardia, inverted/biphasic P-wave.
- C. Tachycardia, spiking of T-wave, increased amplitude of T-wave.

Fig. 10.



at 0 h, 14.67 ± 5.00 at 3 h and 13.17 ± 4.32 at 6 h after torsion. It showed an increase but the variations were not significant. After splenectomy it was 14.00 ± 5.59 at 6 h, 14.67 ± 5.66 at 12 h, 18.33 ± 6.99 at 18 h, 18.50 ± 6.90 at 24 h, 25.33 ± 9.77 at 48 h, 23.33 ± 10.31 at 96 h and 24.50 ± 10.87 at 168 h. It showed an increase upto 48 h, followed by a decrease. The variations were not significant.

Packed cell volume (%) was 37.50 ± 3.02 at 0 h, 37.00 ± 4.30 at 3 h and 38.83 ± 3.67 at 6 h after torsion. The values were within the normal range and the variations were not significant. After splenectomy it was 35.00 ± 3.19 at 6 h, 34.17 ± 2.87 at 12 h, 34.00 ± 2.74 at 18 h, 29.33 ± 2.20 at 24 h, 29.66 ± 2.29 at 48 h, 28.00 ± 1.69 at 96 h and 29.33 ± 2.08 at 168 h. It showed a gradual decrease and was significant ($P < 0.05$) at 96 h.

Hæmoglobin content (g/dl) was 11.37 ± 0.35 at 0 h, 10.40 ± 0.72 at 3 h and 10.23 ± 0.56 at 6 h after torsion. It showed a gradual decrease but the variations were not significant. After splenectomy it was 8.77 ± 0.78 at 6 h, 8.27 ± 0.64 at 12 h, 8.03 ± 0.66 at 18 h, 8.27 ± 0.67 at 24 h, 7.30 ± 0.93 at 48 h, 7.26 ± 0.84 at 96 h and 7.67 ± 0.79 at 168 h. It showed a gradual decrease and the decrease was significant ($P < 0.05$) at 18 h, 96 h and 168 h.

Segmented neutrophil count (%) was 70.20 ± 4.03 at 0 h, 85.50 ± 2.39 at 3 h and 79.40 ± 4.40 at 6 h after torsion. It showed a significant ($P < 0.05$) increase at 3 h. After

splenectomy it was 78.67 ± 7.36 at 6 h, 88.33 ± 0.33 at 12 h, 93.25 ± 1.65 at 18 h, 79.33 ± 9.21 at 24 h, 80.50 ± 6.11 at 48 h, 74.33 ± 6.06 at 96 h and 76.00 ± 6.04 at 168 h. It showed a gradual increase upto 18 h, after which the values were not much different from the value at 6 h after torsion. The increase was significant ($P < 0.05$) at 18 h.

Band cell count (%) was 0.40 ± 0.40 at 0 h, 1.33 ± 0.95 at 3 h and 2.00 ± 0.95 at 6 h after torsion. It showed an increase but the variations were not significant. After splenectomy, it was 4.33 ± 1.86 at 6 h, 4.00 ± 1.73 at 12 h, 3.00 ± 0.91 at 18 h, 2.00 ± 0.58 at 24 h, 1.00 ± 0.71 at 48 h, 7.00 ± 2.31 at 96 h and 2.20 ± 0.86 at 168 h. It showed an increase at 6 h, then a gradual decrease upto 48 h, followed by an increase at 96 h and then again a decrease at 168 h. The variations were not significant.

Lymphocyte count (%) was 26.40 ± 4.28 at 0 h, 11.50 ± 2.47 at 3 h and 17.40 ± 4.84 at 6 h after torsion. The decrease was significant ($P < 0.05$) at 3 h. After splenectomy it was 16.33 ± 8.51 at 6 h, 7.33 ± 1.45 at 12 h, 3.25 ± 1.38 at 18 h, 15.67 ± 7.17 at 24 h, 16.75 ± 5.02 at 48 h, 16.00 ± 6.93 at 96 h and 20.00 ± 4.63 at 168 h. It showed a decrease upto 18 h, followed by a gradual increase upto 168 h. The decrease was significant ($P < 0.05$) at 18 h.

Eosinophil count (%) was 2.40 ± 0.81 at 0 h, 1.17 ± 0.48 at 3 h and 0.20 ± 0.20 at 6 h after torsion. The decrease was significant ($P < 0.05$) at 6 h. After splenectomy it was

0.67 \pm 0.33 at 6 h, 0.00 \pm 0.00 at 12 h, 0.25 \pm 0.25 at 18 h, 2.33 \pm 0.88 at 24 h, 1.50 \pm 0.65 at 48 h, 2.00 \pm 1.00 at 96 h and 1.60 \pm 1.36 at 168 h. It showed an increase after 12 h and significant ($P < 0.05$) at 24 h.

Serum constituents.

Total serum protein (g/dl) was 5.79 \pm 0.05 at 0 h, 5.81 \pm 0.08 at 3 h and 6 h after torsion. The values were within the normal range and the variations were not significant. After splenectomy it was 5.81 \pm 0.09 at 6 h, 5.78 \pm 0.05 at 12 h, 5.76 \pm 0.12 at 18 h, 5.80 \pm 0.12 at 24 h, 5.79 \pm 0.05 at 48 h, 5.77 \pm 0.05 at 96 h and 5.87 \pm 0.08 at 168 h. The values were within the normal range and the variations were not significant.

Serum sodium (meq/L) was 152.33 \pm 1.64 at 0 h, 155.07 \pm 1.49 at 3 h and 154.99 \pm 1.11 at 6 h after torsion. It showed an increase but the variations were not significant. After splenectomy it was 154.18 \pm 0.59 at 6 h, 150.61 \pm 0.94 at 12 h, 150.94 \pm 2.44 at 18 h, 151.83 \pm 1.99 at 24 h, 150.76 \pm 2.09 at 48 h, 152.79 \pm 2.00 at 96 h and 152.40 \pm 2.05 at 168 h. It showed a decrease upto 12 h followed by a gradual increase upto 168 h. The decrease was significant ($P < 0.05$) at 12 h.

Serum potassium (meq/L) was 5.55 \pm 0.25 at 0 h, 6.41 \pm 0.41 at 3 h and 7.98 \pm 0.23 at 6 h after torsion. The increase was significant ($P < 0.05$) at 6 h. After splenectomy it was 7.72 \pm 0.24 at 6 h, 7.56 \pm 0.09 at 12 h, 7.83 \pm 0.24 at 18 h,

8.01 \pm 0.30 at 24 h, 7.49 \pm 0.21 at 48 h, 7.72 \pm 0.39 at 96 h and 7.33 \pm 0.37 at 168 h. It showed a slight decrease and the variations were not significant.

Period of survival.

All the animals survived in this subgroup and they were sacrificed on the 10th day.

Autopsy findings.

There was no gross change in any of the abdominal organs. Adhesion was noticed between the splenic pedicle and the intestine in two animals (B2(2) and B2(5)). There was no damage to the intestine.

Morphological and histopathological studies of the spleen.

The spleen was bright-red in all the animals before torsion. It was firm in consistency in three animals (B2(1), B2(4) and B2(6)) and soft in the other three animals (B2(2), B2(3) and B2(5)). At the time of splenectomy, it was dark in four animals (B2(1), B2(4), B2(5) and B2(6)), dark-red in two animals (B2(2) and B2(3)) and very soft in consistency in all the animals.

The length (cm) of the spleen was 26.07 \pm 0.69 before torsion and 30.23 \pm 0.83 at the time of splenectomy. There was a significant ($P < 0.05$) increase in the length of the spleen after torsion.

The maximum width (cm) of the spleen was 9.57 \pm 0.92 before torsion and 11.77 \pm 0.86 at the time of splenectomy.

There was an increase in maximum width of the spleen after torsion, though not significant.

The minimum width (cm) of the spleen was 6.65 ± 0.43 before torsion and 7.76 ± 0.36 at the time of splenectomy. There was an increase in minimum width of the spleen after torsion, though not significant.

The average weight of the spleen after splenectomy was 196.67 ± 5.11 grams.

Histopathological changes in the spleen included extensive congestion, haemorrhage, thrombosis of vessels and lymphoid depletion. Haemosiderosis and histiocyte reaction were seen. There was necrosis and hyalinization of the trabeculae.

Subgroup B₂Table 10. Length, maximum width, minimum width and physical characters of the spleen, before torsion and after splenectomy (Mean \pm S.E.), n=6.

Animal No.	Weight (kg)	Before torsion					After splenectomy					
		Colour	Length (cm)	Width (cm) Maxi- mum	Mini- mum	Consis- tency	Colour	Length (cm)	Width (cm) Maxi- mum	Mini- mum	Consis- tency	Weight (g)
B2(1)	15.0	Bright red	25.0	9.1	5.9	Firm	Dark	28.0	9.9	8.0	Very soft	175
B2(2)	15.0	Bright red	27.0	9.0	6.2	Soft	Dark red	32.0	11.0	8.0	Very soft	205
B2(3)	10.0	Bright red	29.0	12.5	8.5	Soft	Dark red	30.0	13.0	9.0	Very soft	200
B2(4)	11.0	Bright red	26.0	6.0	5.5	Firm	Dark	33.0	9.0	7.0	Very soft	210
B2(5)	15.0	Bright red	24.8	11.4	6.9	Soft	Dark	28.0	14.0	8.0	Very soft	190
B2(6)	15.0	Bright red	24.6	9.4	6.9	Firm	Dark	30.4	13.7	6.5	Very soft	200
Mean \pm S.E.	13.50 \pm 0.96		26.07 \pm 0.69	9.57 \pm 0.92	6.65 \pm 0.43			30.23* \pm 0.83	11.77 \pm 0.86	7.76 \pm 0.36		196.67 \pm 5.11

* Significant at 5% level

Discussion

DISCUSSION

Group A

The average body weight of the animals in this group was 12.92 ± 0.74 kg. Recovery from anaesthesia was uneventful.

Clinical signs.

Following experimentally induced torsion of the spleen, appreciable abdominal distension was observed in five animals within three hours of torsion. Kipnis (1974), Moreau and Henley (1981), Stead et al. (1983) and George et al. (1984) have recorded abdominal distension in clinical cases of splenic torsion in dogs.

Pain on abdominal palpation was observed in four animals within three hours. Barton (1981) had reported that the abdominal pain was variable ranging from excruciating pain in acute cases to virtual absence of pain in chronic cases. Stevenson et al. (1981) have reported pain on abdominal palpation in three out of seven clinical cases of splenic torsion in dogs.

Straining was observed in three animals within three hours. Brodie (1974) had reported straining as a symptom in a case of splenic torsion in a dog.

Conjunctival mucous membrane became pale in four animals within three hours and in five animals within six hours of splenic torsion. This is in agreement with the earlier observations made by Moreau and Henley (1981); Stevenson et al.

(1981); Stead et al. (1983) and Wright and Callahan (1987). In one animal the mucous membrane remained normal rosy pink in colour. Brodie (1974) had reported normal mucous membrane in a clinical case of splenic torsion.

Capillary refilling time was found to be prolonged in all the animals, which continued to be so till death. This is in agreement with the findings of Kipnis (1974) and Moreau and Henley (1981) in clinical cases of splenic torsion.

All the animals became dull within six hours after torsion. A similar observations was made by Orman and Lorenz (1972), Iverson (1976), Lipowitz et al. (1977), Moreau and Henley (1981), Stead et al. (1983), George et al. (1984) and O'Neill (1985) in clinical cases of splenic torsion in dogs. However, Howenstein et al. (1975) have reported alert appearance in a case of splenic torsion in a dog.

Following splenic torsion all the animals assumed a position of lateral recumbency within six hours and remained so till death. Moreau and Henley (1981) and Stead et al. (1983) have reported recumbency as a symptom in torsion of spleen.

In all the animals, symptoms such as, extremities becoming cold and dark and thick blood were observed within nine hours.

Signs of dehydration were seen in two animals within nine hours. Dehydration has been reported in splenic torsion by Moreau and Henley (1981) and Wright and Callahan (1987).

Emesis was observed only in one animal. Emesis had been reported as a symptom in splenic torsion by Maxie et al. (1970), Orman and Lorenz (1972), Howenstein et al. (1975), Lipowitz et al. (1977), Moreau and Henley (1981), Stevenson et al. (1981), George et al. (1984) and Wright and Callahan (1987).

The rectal temperature, showed a slight reduction at the sixth hour followed by a gradual increase but remained within normal range. The variations were not significant. Iverson (1976) and Moreau and Henley (1981) reported a rise in rectal temperature in clinical cases of splenic torsion, while Orman and Lorenz (1972), Brodie (1974) and Howenstein et al. (1975) reported that rectal temperature was normal.

The heart rate showed a significant increase ($P < 0.05$) from the third hour which persisted till the end. Increase in the heart rate had been recorded in clinical cases of splenic torsion by Brodie (1974), Moreau and Henley (1981) and Stead et al. (1983).

The respiration rate showed a slight reduction by the third hour, followed by an increase towards the terminal stages, the respiration rate remaining within the normal range. However, the variations were not significant. Lipowitz et al. (1977) reported normal respiration rate, while Brodie (1974) and Moreau and Henley (1981) observed an increase in respiration rate in clinical cases of splenic torsion.

Haemodynamic factors.

A significant ($P < 0.05$) decrease in the systolic pressure

was observed by sixth hour after torsion, which persisted throughout.

The diastolic pressure and mean arterial pressure showed a decrease which was significant ($P < 0.05$) from the ninth hour onwards.

The pulse pressure showed a decrease in value throughout, but it was significant ($P < 0.05$) only at the ninth hour.

The central venous pressure showed a decrease in value throughout, which was significant ($P < 0.05$) from the ninth hour onwards.

These results could not be compared with any other work for want of data in the literature available. The exact cause of the variations in the physiological norms cannot be explained because it requires more detailed experimentation.

Electrocardiogram.

ECG showed tachycardia in all the animals. Conduction abnormalities were not seen at any stage of observation. One animal developed sinus arrhythmia but became normal spontaneously.

Haemogram.

Erythrocyte sedimentation rate showed a decrease upto sixth hour followed by a gradual increase. The variations were not significant. Rapid sedimentation rate and rouleaux formation had been reported by Wright and Callahan (1987).

Packed cell volume showed only marginal variations, the values remaining within the normal range and not significant. Wright and Callahan (1987) have reported normal packed cell volume in a clinical case of splenic torsion in a dog.

Haemoglobin content showed a decreasing trend which was significant ($P < 0.05$) by the 18th hour. Lipowitz et al. (1977) observed a reduction in haemoglobin content in a clinical case of splenic torsion in a dog.

Segmented neutrophil count showed an increase upto ninth hour after torsion followed by a decrease upto 21 hours, though the variations were not significant. Maxie et al. (1970), Lipowitz et al. (1977), Moreau and Henley (1981) and Stevenson et al. (1981) reported neutrophilia as a common finding in clinical cases of splenic torsion in dogs.

Band cell count showed a gradual increase and the increase was significant ($P < 0.05$) after ninth hour. Increase in number of immature neutrophil was reported by Iverson (1976), Moreau and Henley (1981) and George et al. (1984) while Lipowitz et al. (1977) recorded a decrease in number of immature neutrophils.

The lymphocyte count showed a decrease and the values were significant ($P < 0.05$) from the sixth hour onwards. Lymphopenia was reported by Lipowitz et al. (1977) and Moreau and Henley (1981).

Eosinophil count showed a decrease and it was significant ($P < 0.05$) at the ninth hour. Lipowitz et al. (1977) recorded an increase in eosinophil count.

Serum constituents.

Total serum protein values remained within the normal range, the variations were not significant. Lipowitz et al. (1977) also had made a similar observation in a clinical case of splenic torsion in a dog.

The serum sodium level varied within the normal range but showed a decrease from the 18th hour, eventhough the variations were not significant. Lipowitz et al. (1977) and Moreau and Henley (1981) observed a slight rise in serum sodium level, but the values were within the normal range.

The serum potassium level showed a significant ($P < 0.05$) increase from the third hour onwards. Lipowitz et al. (1977) observed serum potassium level at the lower limit of the normal range in a clinical case of splenic torsion in a dog. Moreau and Henley (1981) reported a low level of serum potassium on the third day of hospitalization of a dog suffering from splenic torsion.

Radiographic studies.

Radiographic examination, 12 hours after torsion of the spleen, positioning the animal in left lateral recumbency, could reveal a dense shadow representing the spleen in the anterior abdomen. Splenomegaly as a radiographic finding was reported by Marie et al. (1970), Howenstein et al. (1975), Moreau and Henley (1981), Stevenson et al. (1981), Stead et al. (1983), O'Neill (1985) and Wright and Callahan (1987).

Period of survival.

The average survival period was 21.53 ± 4.10 hours, the range being 8.00 hours to 38.45 hours.

Autopsy findings.

On autopsy dark coloured fluid in the peritoneal cavity in varying quantities was seen in five animals. Presence of fluid in the peritoneal cavity on exploratory laparotomy in clinical cases of splenic torsion was reported by Kipnis (1974), Iverson (1976) and Moreau and Henley (1981). Spleen was enlarged and dark coloured in five animals. Spleen was found to be ruptured, fragmented and separated in one animal, and small foci of rupture were noticed in two animals. Congestion of splenic pedicle, splenic vessels and blood clots in splenic veins were observed in three animals, whereas clots in the splenic vessels alone were seen in two animals. Thrombosis of splenic vessels was reported by Orman and Lorenz (1972), Lipowitz et al. (1977), Moreau and Henley (1981), Stead et al. (1983) and O'Neill (1985). Intestine and stomach were dilated and pale in three animals. Lipowitz et al. (1977) stated that vascular embarrassment to the intestine occurs due to torsion of large abdominal organ. Acute mesenteric vessel occlusion and early degenerative intestinal changes may occur. Congestion of gastric mucosa and presence of dark fluid in the stomach in one animal and congestion of liver, lungs and kidneys was seen in three

animals. About 50 ml of light-brown urine was detected in the urinary bladder in one animal.

Morphological and histopathological studies of the spleen.

Normal spleen was firm in consistency and was dark-red in three animals and bright red in the other three animals. At the time of autopsy the spleen was found to be dark in five animals and reddish-grey in one animal. The consistency was soft to very soft in five animals and it was fragmented in one animal.

The length, maximum width and minimum width were on the increase eventhough the values were not significant.

Splenomegaly as a radiographic finding was reported by Maxie et al. (1970), Howenstein et al. (1975), Moreau and Henley (1981), Stevenson et al. (1981), Stead et al. (1983), O'Neill (1985) and Wright and Callahan (1987).

Palpable splenomegaly was reported by Maxie et al. (1970), and Stevenson et al. (1981). Splenomegaly as reported by the earlier workers on the basis of radiography and on palpation are confirmed by the autopsy findings during the present study.

Histopathological changes in the spleen included extensive congestion, haemorrhage and thrombi in the vessels. This is in agreement with the findings of Howenstein et al. (1975) and O'Neill (1985). There was hyalinization and necrosis of trabeculae, lymphoid depletion and lymphoid tissue was replaced with red blood cells. Similar changes had been reported by Wright and Callahan (1987).

From the above observations it was found that the animals became dull and recumbent by six hours after experimentally induced torsion of the spleen and remained recumbent till death. The mucous membrane was pale and the capillary refilling time was prolonged. A significant increase in the heart rate, band cell count and serum potassium and a significant decrease in systolic pressure, diastolic pressure, mean arterial pressure, pulse pressure, central venous pressure, lymphocyte count and eosinophil count was observed by the ninth hour after torsion. It could be seen that the period from sixth to the ninth hour after torsion of the spleen would be critical and hence the appropriate time to commence the treatment was fixed at six hours after torsion.

Group B

Subgroup B1. (Detorsion of spleen was undertaken six hours after torsion)

The average body weight of the animals in this subgroup was 12.33 ± 0.80 kg. The recovery from anaesthesia was uneventful.

After torsion.

Clinical signs.

Following experimentally induced torsion of the spleen, appreciable abdominal distension and pain were observed in three animals within three hours. Straining was observed in three animals. Conjunctival mucous membrane was pale in

three animals, pink in two and congested in one animal. Capillary refilling time was prolonged in all the animals.

All the animals became dull and assumed a position of lateral recumbency within six hours. Symptoms such as extremities becoming cold (two animals), signs of dehydration (two animals) and blood becoming dark and thick (three animals) were observed within six hours. Emesis was noticed in three animals.

The above observations were similar to those in group A.

The rectal temperature remained within the normal range, the variations were not significant.

The heart rate showed a significant ($P < 0.05$) increase at third hour and sixth hour.

The respiration rate showed a significant ($P < 0.05$) increase by the sixth hour.

The observations on rectal temperature, heart rate and respiration rate were similar to those in group A.

Haemodynamic factors.

The systolic pressure, diastolic pressure, mean arterial blood and pulse pressure showed a significant ($P < 0.05$) decrease by the sixth hour after torsion.

The central venous pressure showed a significant ($P < 0.05$) decrease at third hour and sixth hour.

The observations on haemodynamic factors were similar to those in group A.

Electrocardiogram.

ECG showed tachycardia in all the animals. Conduction abnormalities were not seen.

Haemogram.

Erythrocyte sedimentation rate showed a decrease upto sixth hour though not significant.

Packed cell volume showed only marginal variations, the values remaining within the normal range and not significant.

Haemoglobin content showed a decreasing trend, but not significant.

Segmented neutrophil count showed a significant ($P < 0.05$) increase at third hour and sixth hour.

Band cell count showed an increase, but not significant.

Lymphocyte count showed a significant ($P < 0.05$) decrease at third hour and sixth hour.

Eosinophil count showed a decrease and it was significant ($P < 0.05$) at third hour.

The observations on haemogram were similar to those in group A.

Serum constituents.

Total serum protein values remained within the normal range, the variations were marginal and not significant.

The serum sodium level showed an increasing trend initially but the variations were marginal and not significant.

The serum potassium showed an increase and was significant ($P < 0.05$) at sixth hour.

The observations on serum constituents were similar to those in group A.

Morphological study of spleen.

Normal spleen was bright-red in colour in five animals and reddish-brown in one animal. It was soft in consistency in five animals while it was firm in one animal.

After detorsion.

Clinical signs.

After detorsion all the animals assumed the position of lateral recumbency, except one animal, which stood up within one hour. Two animals could stand up within six hours. Extremities were cold in all the animals except in one animal that survived. Blood was dark and thick in two animals. Four animals were dull and did not accept food and water, while the rest started feeding after 24 hours. There was no change in the colour of the mucous membrane in four animals, while it was pale in one animal and light-pink in another. The capillary refilling time was prolonged in five animals, while the animal that survived showed improvement after 24 hours.

The rectal temperature showed a decrease upto 18 hours and thereafter a gradual increase. The variations were not significant.

The heart rate and the respiration rate exhibited an

increasing trend by the sixth hour, followed by a gradual decrease, though the variations were not significant.

Haemodynamic factors.

The systolic pressure, diastolic pressure and mean arterial pressure decreased at six hours and then gradually increased upto 24 hours. The variations were not significant.

The pulse pressure decreased upto 12 hours followed by a gradual increase upto 24 hours. The variations were not significant.

The central venous pressure showed an increase at six hours followed by a decrease upto 18 hours and then an increase at 24 hours, though the variations were not significant.

Electrocardiogram.

ECG showed tachycardia in four animals. Conduction abnormalities were not seen at any stage of observation.

Haemogram.

Erythrocyte sedimentation rate showed fluctuations at different time intervals, though not in the normal range. However, the variations were not significant.

Packed cell volume showed a slight increase at six hours followed by a gradual decrease thereafter, with no significant variation.

Haemoglobin content showed a gradual decrease which was significant ($P < 0.05$) at 24 hours and 96 hours.

Segmented neutrophil count showed a decrease which was significant ($P < 0.05$) at six hours and 96 hours.

The band cell count was high and the increase was significant ($P < 0.05$) at 48 hours.

The lymphocyte count showed fluctuations during the observation period with no significant variation in the values.

The eosinophil count did not show any change upto 12 hours, but recorded a gradual increase afterwards, the variation being not significant.

Serum constituents.

Total serum protein values remained within the normal range, the variations were not significant.

Serum sodium showed a decreasing trend. The values remained within the normal range, the variations were not significant.

Serum potassium showed a gradual decrease and the decrease was significant ($P < 0.05$) at 96 hours.

Period of survival.

One animal in this subgroup survived the period of observation of seven days. Remaining five animals died at varying time intervals, viz., one hour 30 min (one animal), two hour 30 min. (one animal), five hours 25 min. (one animal) and six days (two animals).

Autopsy findings.

Of the five animals which died at different intervals, dark fluid in peritoneal cavity was present in three animals. Rupture of splenic capsule was seen in two animals. Splenic pedicle was congested in three animals and it was adherent to stomach, spleen and intestine in two animals. Intestine was perforated at the point of adhesion in one animal. Spleen was dark-brown in colour and separated in two animals. Splenic vessels were found to be congested in one animal and blood clots were seen in the splenic vessels in three animals. Intestine and lungs were pale in four animals. Congestion in the kidneys and the liver was seen in one animal each. Stomach contained dark semi-solid material and the pancreas was found to be brown in colour in one animal. In the animal that survived the period of observation and when sacrificed on the 10th day, the spleen was found to be in its normal position and of normal size, colour and consistency. Some of the small branches of splenic vessels contained blood clots. The lungs were pale and the kidneys showed congestion.

Morphological and histopathological studies of the spleen.

At the time of detorsion the spleen was dark in all the animals. It was firm in consistency in four animals and soft in two animals. At the time of autopsy it was dark in three animals, reddish-brown in one animal, while in two animals, the spleen was dark-brown in colour and separated. It was soft in consistency in all the animals.

There was a significant ($P < 0.05$) increase in the length of the spleen at the time of detorsion, which showed a decrease at the time of autopsy. However, it was more than the value before torsion, but not significant.

There was a significant ($P < 0.05$) increase in the maximum width of the spleen at the time of detorsion, which showed a decrease at the time of autopsy. However, it was not significant.

There was a significant ($P < 0.05$) increase in the minimum width of the spleen at the time of detorsion, which showed a significant ($P < 0.05$) decrease at the time of autopsy. The measurements at the time of autopsy did not show any significant variation when compared to the initial value.

Histopathological changes in the spleen included extensive congestion, thrombosis of vessels, lymphoid depletion and lympholysis. Focal areas of necrosis, edema and hyalinization of trabeculae were also seen. Jubb and Kennedy (1970) stated that spleen becomes necrotic when the artery is occluded.

Subgroup B2. (Splenectomy was performed, six hours after torsion)

The average body weight of the animals in this subgroup was 13.50 ± 0.96 kg. The recovery from anaesthesia was uneventful.

After torsion.

Clinical signs.

Following experimentally induced torsion of the spleen,

appreciable abdominal distension and pain were observed in five animals within three hours and one animal was recumbent and moaning. Blood was dark and thick in one animal. Emesis was noticed in one animal. Mucous membrane was light-pink in three animals, pale in two and congested in one animal. Capillary refilling time was prolonged in all the animals.

All the animals became dull and assumed a position of lateral recumbency within six hours. Symptoms such as extremities becoming cold and blood becoming dark and thick (three animals) were observed within six hours. One of the animal vomited off and on. Retching was seen in two animals. There was no change in the colour of the mucous membrane. Capillary refilling time was prolonged in all the animals.

The above observations were similar to those in group A and subgroup B1.

The rectal temperature remained within the normal range, the variations were not significant.

The heart rate showed a significant ($P < 0.05$) increase at third hour and sixth hour.

The respiration rate showed an increase, though not significant.

The observations on rectal temperature, heart rate and respiration rate were similar to those in group A and subgroup B1.

Haemodynamic factors.

The systolic pressure, diastolic pressure, mean arterial pressure and pulse pressure showed a decrease after torsion, though not significant.

The central venous pressure showed a significant ($P < 0.05$) decrease at third hour and sixth hour.

The observations on haemodynamic factors were similar to those in group A and subgroup B1.

Electrocardiogram.

ECG showed tachycardia in all the animals. Conduction abnormalities were not seen.

Haemogram.

Erythrocyte sedimentation rate showed a slight increase at third hour followed by a decrease at sixth hour, however these values were within the normal range and the variations were not significant.

Packed cell volume showed only marginal variations, the values remaining within the normal range and not significant.

Haemoglobin content showed a decreasing trend, but not significant.

Segmented neutrophil count showed a significant ($P < 0.05$) increase at third hour.

Band cell count showed an increase, but not significant.

Lymphocyte count showed a significant ($P < 0.05$) decrease at third hour.

Eosinophil count showed a decrease and it was significant ($P < 0.05$) at third hour. The observations on haemogram were similar to those in group A and subgroup B1, except for the erythrocyte sedimentation rate values, which showed a slight increase initially.

Serum constituents.

Total serum protein values remained within the normal range, the variations were not significant.

The serum sodium level showed an increasing trend initially, but the variations were not significant.

The serum potassium showed an increase and was significant ($P < 0.05$) at sixth hour.

The observations on serum constituents were similar to those in group A and subgroup B1.

Morphological study of spleen.

Normal spleen was bright-red in colour in all the animals. Consistency was firm in three animals and soft in the other three animals.

After splenectomy.

Clinical signs.

After splenectomy all the animals were recumbent for varying periods from six to 12 hours. The extremities which were previously cold regained normalcy after splenectomy,

when the animals stood up. The blood was watery 12 hours after splenectomy. All the animals started taking food and water and were active and alert at varying intervals after 12 hours. One animal vomited during the first six hours and passed light-brown urine after 24 hours. One animal passed loose faeces after 48 hours. The mucous membrane was light pink in four animals and pink in two animals. The capillary refilling time improved in all the animals. Orman and Lorenz (1972) and Kipnis (1974) reported a change in the colour of the mucous membrane to pink and improvement in capillary refilling time after splenectomy in clinical cases of splenic torsion in dogs.

The rectal temperature remained within the normal range, the variations were marginal and not significant.

The heart rate showed a gradual decrease which was significant ($P < 0.05$) from 24 hours.

The respiration rate showed a decrease at six hours followed by a gradual increase upto 24 hours and a gradual decrease again. The variations were not significant.

Haemodynamic factors.

The systolic pressure, showed a decrease at six hours followed by a gradual increase upto 24 hours.

The diastolic pressure and mean arterial pressure showed a significant ($P < 0.05$) decrease at six hours followed by a gradual increase upto 24 hours.

The pulse pressure showed an increase upto 24 hours. The variations were not significant.

The central venous pressure showed a decrease at six hours followed by a gradual increase upto 24 hours. The variations were not significant.

Electrocardiogram.

ECG showed tachycardia in all the animals. The conduction abnormalities were not seen.

Haemogram.

Erythrocyte sedimentation rate showed an increase upto 48 hours followed by a decrease. The variations were not significant.

Packed cell volume showed a gradual decrease which was significant ($P < 0.05$) at 96 hours.

Haemoglobin content showed a gradual decrease which was significant ($P < 0.05$) at 18 hours, 96 hours and 168 hours.

Segmented neutrophil count showed an increase upto 18 hours and thereafter the values were almost the same as at the time of splenectomy. The increase was significant ($P < 0.05$) at 18 hours.

Band cell count showed fluctuations during the period of observation but the variations were not significant.

Lymphocyte count showed a decrease upto 18 hours followed by a gradual increase upto 168 hours. The decrease was significant ($P < 0.05$) at 18 hours.

Eosinophil count showed an increase after 12 hours and the increase was significant ($P < 0.05$) at 24 hours.

Serum constituents.

Total serum protein values remained within the normal range, the variations were not significant.

Serum sodium showed a decrease upto 12 hours followed by a gradual increase upto 168 hours. The decrease was significant ($P < 0.05$) at 12 hours. After 12 hours the variations were not significant.

Serum potassium level showed slight decrease, the variations were not significant.

Period of survival.

All the animals in this subgroup survived the period of observation of seven days. Splenectomy as a treatment in clinical cases of splenic torsion has been reported by McNish (1967), Iverson (1976), Lipowitz et al. (1977), O'Neill (1985) and Wright and Callahan (1987) in a single case each. All these animals survived after splenectomy.

Moreau and Henley (1981) reported a case of splenic torsion in a dog which did not survive after splenectomy. Stevenson et al. (1981) reported incidence of splenic torsion in seven dogs. Out of the seven dogs only two survived after splenectomy and the remaining died post-operatively. Stead et al. (1983) reported three cases of splenic torsion, out of which two survived after splenectomy and the third died.

Autopsy findings.

There were no gross changes in any of the abdominal organs. Adhesion was noticed between the cut end of the splenic pedicle and the intestine in two animals. There was no damage to the intestine.

Morphological and histopathological studies of the spleen.

At the time of splenectomy, the spleen was dark in four animals, dark-red in two animals and very soft in consistency in all the animals.

There was a significant ($P < 0.05$) increase in the length of the spleen after torsion.

There was an increase in maximum width and minimum width of the spleen after torsion but the increase was not significant.

The above results could not be compared with any other work for want of data in the literature available. The exact cause of the variations in physiological norms cannot be explained because it requires more detailed experimentation.

Histopathological changes in the spleen included extensive congestion, haemorrhage, thrombosis of vessels and lymphoid depletion. Haemosiderosis and histiocyte reaction were seen. There was necrosis and hyalinization of the trabeculae.

Three out of the six animals in subgroup B1 remained recumbent after detorsion whereas all the six animals in subgroup B2 stood up within 12 hours. Extremities remained cold

in five animals in subgroup B1, throughout the period of observation whereas in subgroup B2, the extremities regained normalcy when the animals stood up. Four out of the six animals in subgroup B1 did not take food and water after detorsion whereas all the six animals in subgroup B2 started feeding and were active and alert after 12 hours. The mucous membrane remained pale and the capillary refilling time was prolonged after detorsion in subgroup B1, whereas in subgroup B2, the mucous membrane turned light pink or pink and the capillary refilling time improved. The rectal temperature showed a decreasing trend upto 18 hours after detorsion, whereas it remained within the normal range after splenectomy. Heart rate showed a decreasing trend in both the subgroups but the decrease was significant after splenectomy in subgroup B2 after 24 hours. Respiration rate showed an increase at sixth hour after detorsion, followed by a gradual decrease, whereas it showed a decrease at sixth hour after splenectomy, followed by a gradual increase upto 24 hours and then a gradual decrease.

Blood pressure decreased at sixth hour followed by an increase upto 24 hours in both the subgroups. The central venous pressure showed an increase at the sixth hour after detorsion, followed by a decrease upto 18 hours and then again an increase at 24 hours, whereas it showed a gradual increase after splenectomy.

Electrocardiogram showed tachycardia in both the subgroups.

Erythrocyte sedimentation rate showed fluctuations after detorsion in subgroup B1. It showed an increase at 48 hours and 96 hours. In subgroup B2, it increased gradually upto 48 hours followed by a decrease. Packed cell volume decreased in both the subgroups except for a slight increase at the sixth hour after detorsion in subgroup B1. Haemoglobin content showed a significant decrease at 24 hours and 96 hours after detorsion in subgroup B1 and at 18, 96 and 168 hours after splenectomy in subgroup B2. Differential leucocyte count gradually returned to normal in both the subgroups after treatment except for band cell count which remained above normal in subgroup B1.

Total serum protein and serum sodium values remained almost within the normal range in both the subgroups but serum potassium showed a gradual decrease after detorsion in subgroup B1 which was significant at 96 hours. In subgroup B2, only a slight decrease was observed after splenectomy.

One animal in subgroup B1 survived after detorsion. Remaining five animals died at varying time intervals after detorsion, viz., one hour 30 min. (one animal), two hours 30 min. (one animal), five hours 25 min. (one animal) and six days (two animals). All the animals in subgroup B2 survived after splenectomy.

In the present study there was no incidence of the spleen getting itself detorted when twisted around its pedicle to 720° in a clock-wise direction.

Summary

SUMMARY

Eighteen apparently healthy dogs of either sex, aged one to five years and weighing 10-15 kg were used for the study. The animals were divided into two groups, A and B consisting of six and 12 animals respectively. The animals of group B were further divided into two subgroups, B1 and B2 consisting of six animals each. In group A, laparotomy was performed and torsion of the spleen was brought about. In group B, torsion of the spleen was brought about as in group A. Six hours later, detorsion of the spleen was done in subgroup B1 and splenectomy was performed in subgroup B2. All the animals were observed for a period of seven days or death, whichever was earlier.

Group A.

Within three hours of experimentally induced torsion of the spleen, appreciable abdominal distension, pain on abdominal palpation and straining were observed. The mucous membrane became pale, the capillary refilling time was prolonged and the extremities became cold. The rectal temperature and respiration rate remained within the normal range but heart rate showed a significant increase.

The animals assumed a position of lateral recumbency within six hours. There was gradual fall in systolic pressure which became significant from sixth hour. The diastolic pressure, mean arterial pressure and central venous pressure decreased steadily but significant decrease was observed from

the ninth hour onwards. The pulse pressure recorded a gradual fall which was significant at the ninth hour. Signs of dehydration were seen in two animals and emesis was noticed in one animal.

Electrocardiogram, three hours after torsion showed tachycardia.

Erythrocyte sedimentation rate showed a decrease upto sixth hour followed by a gradual increase. Packed cell volume remained within the normal range. The haemoglobin content showed a decrease. Differential leucocyte count revealed neutrophilia, lymphopenia and eosinopenia.

Total serum protein and serum sodium values remained within the normal range, whereas serum potassium showed a significant increase from the third hour onwards.

The radiograph taken at 12th hour revealed a dense shadow with distinct borders in the anterior part of the abdomen.

All the animals in this group died and the average survival period was 21.53 ± 4.10 hours.

Autopsy revealed dark coloured fluid in the peritoneal cavity. The spleen was dark, soft and enlarged. It was found to be ruptured, fragmented and separated in one animal. Blood clots in the splenic vessels were also seen.

Histopathological changes in the spleen included congestion, haemorrhage and thrombosis.

Group B.

After experimentally induced torsion of the spleen, the clinical symptoms, haemodynamic factors, haemogram and serum constituents upto six hours were almost identical to those in group A.

Subgroup B1.

After detorsion only one animal survived the period of observation of seven days. The remaining five animals died at varying time intervals, viz., one hour 30 min. (one animal), two hours 30 min. (one animal), five hours 25 min. (one animal) and six days (two animals).

The three animals which died within six hours were recumbent till death. After detorsion the extremities were cold, the mucous membrane was pale and the capillary refilling time was prolonged. Most of the animals did not take food and water. In the three animals which survived for more than six hours, the variations in rectal temperature, heart rate and the respiration rate were not significant.

The blood pressure and central venous pressure returned to normal.

Electrocardiogram, three hours after detorsion showed tachycardia.

Erythrocyte sedimentation rate remained within the normal range whereas packed cell volume and haemoglobin content decreased. Differential leucocyte count did not show marked variations except for a significant decrease in segmented



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neutrophil count at sixth and 96 hours and a significant increase in band cell count at 48 hours.

Total serum protein and serum sodium values were within the normal range. Though a significant decrease was observed in serum potassium level, yet the value remained above normal.

Autopsy revealed presence of dark coloured fluid in the peritoneal cavity, rupture of splenic capsule, congestion of splenic pedicle and clots in splenic vessels. Separation of the spleen and adhesion of the splenic pedicle to the stomach and intestine were also seen.

Histopathological changes in the spleen included congestion, thrombosis of vessels, lympholysis and focal areas of necrosis.

Subgroup B2.

After splenectomy all the animals survived the period of observation of seven days.

After splenectomy, all the animals stood up within 12 hours, the extremities regained normalcy and they started taking food and water. The mucous membrane was light pink or pink and the capillary refilling time improved. The blood was watery 12 hours after splenectomy. The rectal temperature remained within the normal range. Fluctuations in the respiration rate were not significant. The heart rate returned to normal range.

The blood pressure and central venous pressure returned to normal.

Electrocardiogram, three hours after splenectomy showed tachycardia.

Variations in erythrocyte sedimentation rate were not significant whereas packed cell volume and haemoglobin content decreased. Differential leucocyte count did not show marked variations. There was an increase in eosinophils and segmented neutrophils and decrease in lymphocytes.

The total serum protein and serum sodium showed only slight variations. Serum potassium level which was high showed a decreasing trend, the values remaining above normal.

Autopsy after sacrificing the animals revealed adhesion between the cut end of the splenic pedicle and the intestine in two animals.

Histopathological changes in the spleen included congestion, thrombosis, haemosiderosis and histiocyte reaction.

The following conclusions could be drawn from the present study:

1. Clinical signs such as abdominal distension, pain on abdominal palpation, straining, recumbency, cold extremities, emesis, tachycardia, hypotension, neutrophilia, increased serum potassium and a dense shadow with distinct borders in the anterior part of the abdomen on radiography are diagnostic.
2. The period from sixth to the ninth hour after torsion of the spleen would be critical and hence the appropriate time to commence the treatment.

3. After detorsion of spleen five out of the six animals died and hence detorsion does not appear to be the satisfactory treatment.
4. After splenectomy all the six animals survived and hence is recommended as the treatment in splenic torsion.

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ABSTRACT

Eighteen apparently healthy dogs of either sex, aged one to five years and weighing 10-15 kg were used for the study. All the dogs were dewormed and examined for the presence of blood parasites if any. They were housed separately in cages under identical conditions of feeding and management and kept under observation for 10 days before the experiment.

The animals were divided into two groups as detailed below:

Group A: Consisting of six animals numbered serially, viz., A(1), A(2), A(3), A(4), A(5) and A(6) and

Group B: Consisting of 12 animals divided into two subgroups of six animals each and numbered serially, viz., B1(1), B1(2), B1(3), B1(4), B1(5) and B1(6) and B2(1), B2(2), B2(3), B2(4), B2(5) and B2(6).

In the animals of group A, laparotomy was performed and torsion of the spleen was brought about. The observations made in this group served (i) to assess the clinico-pathological changes and (ii) to arrive at appropriate time for the commencement of treatment in group B. In the animals of group B, effectiveness of treatment, following experimentally induced torsion of the spleen was studied. In the subgroup B1, detorsion of the spleen was done while in subgroup B2, splenectomy was performed.

The animals became dull and recumbent by six hours after experimentally induced torsion of the spleen and remained recumbent till death. The mucous membrane was pale and the capillary refilling time was prolonged. A significant increase in the heart rate, band cell count and serum potassium and a significant decrease in blood pressure, central venous pressure, lymphocyte count and eosinophil count was observed by the ninth hour after torsion. It could be seen that the period from sixth to the ninth hour after torsion of the spleen would be critical and hence the appropriate time to commence the treatment was fixed at six hours after torsion.

In group B, where effectiveness of the treatment was studied, only one animal survived after detorsion in subgroup B1 whereas all the animals survived after splenectomy in subgroup B2. In subgroup B1, after detorsion most of the animals were recumbent, the extremities were cold and they did not take food and water, whereas in subgroup B2, after splenectomy all the animals were able to stand and they took food and water. The heart rate showed a decreasing trend in both the subgroups. Blood pressure showed a decrease at sixth hour followed by an increase in both the subgroups. Central venous pressure showed an increase at sixth hour followed by a decrease upto 18 hours and then an increase at 24 hours in subgroup B1, whereas in subgroup B2, it increased gradually. Packed cell volume and haemoglobin content decreased in both the subgroups. The serum potassium level remained high in both the subgroups.