EVALUATION OF THE EFFICACY OF DIAPHRAGMATIC AND OMENTAL TRANSPLANTS AT THE GASTROESOPHAGEAL JUNCTION IN DOGS

By
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THESIS

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requirement for the degree

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DECLARATION

I hereby declare that the thesis entitled "**EVALUATION OF THE EFFICACY OF DIAPHRAGMATIC AND OMENTAL TRANSPLANTS AT THE GASTROESOPHAGEAL JUNCTION IN DOGS**" 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
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CERTIFICATE

Certified that the thesis entitled "**EVALUATION OF THE EFFICACY OF DIAPHRAGMATIC AND OMENTAL TRANSPLANTS AT THE GASTROESOPHAGEAL JUNCTION IN DOGS**" is a record of research work done independently by **Smt. T. Sarada Amma**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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T. SARADA AMMA

Dedicated

To My Teachers

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Introduction

INTRODUCTION

Surgery at the gastroesophageal region in dogs is employed in conditions like achalasia, cardiospasm and stricture of oesophagus that may delay or prevent oesophageal emptying into the stomach and lead to the development of a paralytic condition, megaoesophagus. Megaoesophagus is found in most of the breeds of dogs but are reported to be more frequent in German Shepherd, Dobermann Pinscher and Great Dane (Harvey *et al.*, 1974 and Thilagar *et al.*, 1994).

Megaoesophagus is considered to be irreversible and most of the affected dogs suffer from aspiration pneumonia and malnutrition. Hence treatment is directed towards emptying of the oesophagus into the stomach to improve the nutritional status of the animal. Though spontaneous remission in idiopathic and congenital megaoesophagus (Morgan and Lumb, 1964 and Kipnis, 1978) and symptomatic relief in condition associated with myasthenia gravis with the administration of parasympathomimetic agents (Miller *et al.*, 1983) have been observed. Prolonged medication, special feeding and management were reported necessary.

The surgical treatment have been recommended with the objective of widening or dilatation of the lower oesophageal sphincter and cardia by bougienage (Stack *et al.*, 1957)

retrograde dilatation (Knecht and Eddy, 1959) or cardioplasty (Kipperman and Straw 1988) to facilitate oesophageal emptying.

Ellis *et al.* (1967) experimentally evaluated the myotomy techniques in dogs and recommended short Heller myotomy. Modified Hellers oesophagomyotomy reduced the lower oesophageal sphincter pressure and allowed the emptying of the oesophagus with less pressure, but retained its capacity to prevent gastric reflux (Hoffer *et al.*, 1980). However the techniques employed in many instances were accompanied by complications like pneumothorax, pneumonia, pleuritis, adhesions and hiatal hernia after thoracotomy (Hofmeyr, 1966, Lammerding *et al.*, 1976 and Boothe, 1978) stricture, reapproximation of myotomy edges and reflux oesophagitis associated with myotomy (Ellis *et al.*, 1967) and gastroesophageal intussusception, inability to restore antireflux barrier and gastric dilatation (Burrows and Merrit, 1992).

Successful reinforcement of the gastroesophageal myotomy site with a pedicle graft of diaphragm was reported in man (Petrovsky, 1961) and transplantation of diaphragm graft for replacement of a segment of esophagus in dogs (Lammerding *et al.*, 1976). The effect of omentum transplantation on healing at the site of oesophageal anastomosis was studied in dog (Mukerjee *et al.*, 1973).

Because of the limitations on therapeutic management and the demerits of surgical techniques, a modified surgical approach in treating achalasia and cardiospasm in dogs, was felt necessary.

Hence the present study was undertaken with the following objectives.

1. To design a surgical approach to the gastroesophageal region in dogs.

2. To compare and evaluate the efficacy of gastroesophageal myotomy combined with transplantation of diaphragm and omentum at the gastroesophageal junction in dogs.

Review of Literature

REVIEW OF LITERATURE

Heller (1913) was the first to report successful surgical correction of chronic cardiospasm in man. The technique adopted was double oesophagomyotomy at the cardia and the esophagus to permit expansion of esophageal lumen.

Hofmeyr (1956) reported two techniques for surgical correction of achalasia of oesophagus in dogs. Through left intercostal thoracotomy, the oesophagus was incised either by severing the muscle fibres without injuring the mucosa or by incising through all the layers of the oesophageal wall, exposing the lumen. In both the methods, the incisions were closed by suturing transversely with a single layer suture and the stomach wall was fixed to the edges of diaphragm to prevent cicatrical contraction.

Stack *et al.* (1957) reported successful correction of oesophageal achalasia in an eight month old pup by repeated dilatation with bougies of different sizes.

Knecht and Eaddy (1959) treated a case of oesophageal achalasia and megaoesophagus by retrograde dilatation of lower oesophageal sphincter through a gastrotomy incision, using human uterine dilator. Radiographs taken four months later

revealed normal structures, and the animal had attained body weight more than its litter mates.

Petrovsky (1961) reported the use of diaphragm grafts in man for surgical correction of cardiospasm, tumors, cysts, aneurysms and fistula and to support cardiac sphincter. In cardiospasm, the scarred muscular area of the lower oesophagus was resected and the defect was closed with a triangular pedicle graft of diaphragm. The edges of the graft was sutured to the edges of oesophageal wound and the base of the graft was sutured to the medial and lateral surfaces of the diaphragm. Results obtained with the technique was excellent.

Knight (1963) carried out a survey of 75 cases of transthoracic oesophagotomy in dogs. Recovery was 85 per cent and the complications encountered were pleurisy, wound infection, pneumothorax, pneumonia, cardiospasm and cardiac arrest.

Maksic and Small (1964) illustrated the radiographic appearance of various congenital and acquired conditions of the canine oesophagus like stenosis, obstructions, vascular ring anomalies and persistant ductus arterioses.

Morgan and Lumb (1964) reported a case of spontaneous remission of oesophageal dilatation in a German Shepherd pup. At sixth week of age, x-ray and fluoroscopy revealed greatly

dilated oesophagus with a pouch anterior to the heart. The terminal oesophagus was conical and allowed only a small portion of contrast medium to enter the stomach. The animal was maintained on a feeding schedule of 4 to 5 times a day upto the fourth month of age. At 18th week of age, free passage of barium meal into the stomach except for slight pooling anterior to the heart was noticed and at 13th month, barium meal passed freely into the stomach.

Hall (1966) suggested that any anaesthetic technique was satisfactory for gastroesophageal surgery and recommended the use of muscle relaxant drugs along with anaesthetics for oesophageal surgery.

Hofmeyr (1966) evaluated cardioplasty techniques in the treatment of achalasia of oesophagus in dogs. Out of 37 cases diagnosed, 18 animals were operated upon through a 9th intercostal thoracotomy. The oesophageal hiatus was exposed, part of diaphragmatic attachment to the oesophagus was dissected to expose the stomach and a small part of stomach was drawn into the thorax. An incision was made on the dorsolateral aspect of the oesophagus to the gastric wall incising through constricting muscle fibres of the cardia without opening the mucosa. The wound was sutured in a transverse manner. Tension on the suture line was avoided by suturing the stomach wall to the diaphragm. Out of the 18

cases, complications like herniation of stomach into thorax, pleuritis and aspiration of ingesta were observed in seven dogs.

Lawson and Pirie (1966) reported that the surgical conditions affecting the oesophagus in dogs were vascular rings, achalasia, tumors and perioesophageal lesions. Surgical management of achalasia using bougies, cardiomyotomy and oesophagocardioplasty were recommended. The authors concluded that left side thoracotomy was better for surgical procedures of the lower oesophagus.

Clifford *et al.* (1967) performed oesophagomyotomy (Hellers') for relief of achalasia of the lower oesophageal sphincter in three dogs, aged 12 to 16 weeks. Oesophagomyotomy through eighth intercostal thoracic approach was performed in two dogs and through the abdominal approach, in one dog. Myotomy of full extent of the achalasia was performed and the edges of the incision were spread to let the mucosa bulge out. Transabdominal approach to the lower oesophagus was reported to be time consuming and exposure of the surgical site was poor.

Earlam *et al.* (1967) conducted experiments to study the effects of ischemia of lower oesophagus and oesophagogastric junction on canine oesophageal motor function. In 15 dogs, the lower end of the oesophagus and upper part of the stomach

were made ischaemic for four hours. The oesophagus became dilated in majority of the animals but became normal afterwards. Definite motility disturbance occurred in the early postoperative period. The ganglion cells in the Auerbach's plexes were damaged and their numbers were seen reduced. It was observed that the lower oesophagus and the oesophagogastric junction functioned normally even in the absence of normal number of ganglion cells in Auerbach's plexes.

Ellis *et al.* (1967) evaluated oesophagomyotomy as the treatment of choice for oesophageal achalasia and observed that the high incidence of gastroesophageal reflux and oesophagitis following oesophagomyotomy was probably due to the failure of selection of appropriate surgical technique for the correction. Three techniques of myotomy were studied in experimental dogs viz. (i) a classic Heller anterior and posterior extra mucosal myotomy extending 3 cm on either side of the oesophagogastric junction, (ii) a long Heller myotomy of single anterior extramucosal myotomy extending 3 cm on either side of oesophagogastric junction and (iii) a short Heller myotomy, where a single anterior extramucosal myotomy, 3 cm from gastroesophageal junction, extending a few millimetre on to the stomach. After surgery the sphincter function was studied by roentogenoscopy, oesophagoscopy and determination of oesophageal motility. Spontaneous

oesophagitis was observed only with classic Heller's procedure. A comparable degree of sphincter pressure reduction was observed in all the three groups.

Osborne *et al.* (1967) reported a hereditary pattern of oesophageal achalasia in inbred Wire Fox Terriers, compared to other breeds. Special diet, oesophageal myotomy or both were employed to reduce the severity of the disease. It was observed that complete restoration of oesophageal motility was not possible by these techniques.

Pearson (1970) described the differential diagnosis of various oesophageal conditions causing persistant vomiting in young dogs and found that megaoesophagus (achalasia) was the highest in incidence. The condition was seen in most of the breeds of dogs but was found more common in Alsations, Labradors and Irish Setters.

Clifford *et al.* (1971) reported congenital achalasia of the oesophagus in four cats of common ancestry. In one cat the dilated oesophagus with fibrous ring constricting near the gastroesophageal region was exposed and oesophagomyotomy was performed.

Gourley and Leighton (1971) described a technique for myotomy in oesophageal achalasia. The myotomy incision was extended to both thoracic and abdominal portions of caudal

oesophageal sphincter and was sutured in an open position into the phrenoesophageal ligament. The complications encountered were reflux oesophagitis, subsequent stricture and gastroesophageal intussusception.

Pass (1971) reported methods for surgical repair of various oesophageal defects in dogs and recommended oesophagomyotomy for oesophageal achalasia, either through 8th or 9th intercostal approach or abdominal approach. The myotomy incision commencing from one centimetre distal to the cardia on the stomach, extended cranially along the narrowed portion of the oesophagus. Ventral mid line incision from xiphoid to umbilicus was employed in abdominal approach.

Clifford *et al.* (1972) treated congenital oesophageal achalasia in four Miniature Schnazers. Based on the age, physical status and nature of lesion, the dogs were treated with (1) normal feeding (2) feeding from elevated containers and (3) oesophagomyotomy and tube feeding with liquid diet. The animals showed gradual symptomatic relief but radiography after five years revealed moderate enlargement of the oesophagus.

Guffy (1972) conducted radiographic examination of the oesophagus of the dog and cat by plain survey radiography and contrast radiography for detection of abnormalities. Barium sulphate oesophageal cream was found ideal for the first half

of oesophagus and barium sulphate mixed with food for the second half to avoid chances of missing small strictures.

Lorenz *et al* (1972) reported a case of neostigmine responsive weakness affecting the whole axial and appendicular skeletal muscles with marked dilatation of the entire oesophagus. The animal responded to injections of 15 mg of neostigmine thrice daily for three days and once daily afterwards for 30 days. Sixth day radiograph revealed disappearance of dilatation of oesophagus.

Sokolovsky (1972) observed two types of oesophageal achalasia in dogs. One type was characterised by dilated hypertrophied oesophagus, often sigmoid in shape with a dilated thin atonic lower portion and normal cardia. This type responded to oesophagoplasty. The second type was characterised by dilated, hypertrophied oesophagus, the lower portion being fusiform in shape with the circular muscle fibres hypertrophied to a marked degree. Such conditions responded to Heller's oesophagomyotomy in reducing pressure with in the sphincter, but the peristalsis of the diseased oesophagus was not restored because the changes were irreversible.

Mukerjee *et al*. (1973) conducted an experimental evaluation of free omental graft in the healing of oesophageal anastomosis in dogs. With the use of omental graft, healing

was more effective, leakage through the anastomotic site was minimum and the bursting pressure was higher.

Diamant *et al.* (1974) reported five cases of idiopathic megaoesophagus and its spontaneous improvement. All the cases were diagnosed from the symptom of persistent regurgitation and by radiological examination. Oesophageal pressure manometry and assessment of motor activity by cineradiography were also carried out. Swallowing reflex was greater than 80 per cent in asymptomatic dogs and lesser than 60 per cent in dogs with symptoms. The oesophageal motor activity improved with age in animals with megaoesophagus and in apparently asymptomatic dogs. Continuous improvement with return of function was apparent in the first six months with maximum improvement by 12th month. Megaoesophagus in dogs was found to represent developmental immaturity of innervation and/or musculature which may have continued upto 12th month.

Gray (1974) demonstrated the neuroeffector function in canine achalasia by vagal stimulation. Cervical vagal stimulation elicited weaker intraoesophageal pressure in dogs with achalasia. Stimulation of either the right or left vagus produced transient abrupt increase in the thoracic intraoesophageal pressure.

Harvey *et al.* (1974) carried out a clinical survey of 79 cases of megaoesophagus in dogs. Age, breed and sex relations

were studied and reported that German Shepherd and Great Danes were more affected and the incidence was more between sixth to tenth week of age. Out of 79 cases, 22 were treated surgically along with diet recommendations, 23 with diet recommendations alone, 11 with surgery alone, one with bougienage and 22 were not treated. Cardiomyotomy was performed in thirty dogs, and cardioplasty in one. Death due to complications were more in surgically treated animals, with an overall mortality rate of 74 per cent.

Lammerding *et al.* (1976) conducted experiments in dogs for the repair of distal oesophageal defect. Esophageal defects were created in two groups of dogs and were repaired with diaphragmatic pedicle grafts of suitable size. Simple suturing for apposition of the same sized defects were evaluated in two other groups. For smaller defects both the techniques were successful but in larger defects, simple suturing caused mediastinitis and pleuritis.

Strombeck and Troya (1976) evaluated the lower motor neuron function in two dogs with megaoesophagus. Fluoroscopic examination of the oesophagus after a barium swallow revealed no evidence of oesophageal motility, but it reached the stomach by gravitation. The function of the oesophagus was studied by oesophageal manometry after stimulation of vagus and measuring the pressure from cardia towards the pharynx.

Boothe (1978) reported successful surgical correction of acquired achalasia in a dog aged two and half years. The dog had persistent vomiting and productive cough. Radiography revealed dilatation of both cervical and thoracic portion of oesophagus. Achalasia was confirmed by fluoroscopy. Myotomy of the gastroesophageal region was performed from the dilated end to the cardia, allowing the mucosa to bulge out. The oesophageal hiatal incision was closed by suturing the diaphragm to the ventral aspect of incised oesophagus. Post operative radiography revealed retraction of left caudal lung lobe, reduction of the dilatation of oesophagus and absence of constriction at the gastroesophageal region. Radiography and fluoroscopy after six months revealed that the size of the oesophagus was not reduced but oesophageal emptying was much more rapid than when observed prior to surgery.

Kipnis (1978) reported spontaneous remission of megaoesophagus in two pups after the initiation of gravity feeding of liquid diet to maintain the nutritional and caloric requirements. Gravity feeding was recommended as an important management consideration in achalastic patients.

Hoffer *et al.* (1979) studied management of acquired achalasia, confirmed by fluoroscopy, in 11 dogs. Seven animals were treated conservatively and four animals by modified Heller's oesophagomyotomy. It was concluded that

acquired achalasia was characterised by lack of progressive peristalsis in the body of the oesophagus with asynchronous function of the lower oesophageal sphincter in the mature dogs. The modified Heller procedure resulted in improvement in the clinical status of the patient with acquired achalasia but did not restore synchronised oesophageal function.

Hugh *et al.* (1979) conducted experimental evaluation of gastric patch oesophagoplasty in dogs. Pedicled gastric antrum and pedicled parietal cell area of the stomach were utilised for suturing the oesophageal incision cranial to the diaphragm. The pedicles were prepared from stomach, passed into the thorax through a lateral incision in the diaphragm and sutured to the oesophageal incision with the mucosal surface facing the lumen. Oesophagitis was observed in dogs with parietal cell patches within the first month of operation.

Cox *et al.* (1980) studied a hereditary pattern of oesophageal dysfunction as megaoesophagus or achalasia in a colony of Miniature Schnauzers. All animals were evaluated by contrast radiography of the oesophagus. At four to eight months of age, all the affected dogs except one had recovered clinically, and radiographic evidence of dysfunction was greatly reduced. None of the animals received any special feeding regimen.

Gaynor *et al.* (1980) studied the physiological features of the canine oesophagus. The muscular coat of oesophagus in dog consisted of striated muscle, having a helical configuration and blended with the smooth muscle of the stomach at the gastroesophageal junction. The lower oesophageal sphincter act as an intrinsic physiologic sphincter. It was observed that the conditions which interfered with the passage of a bolus or a normal synchronised opening and closing of the lower oesophageal sphincter resulted in the retension of material in the oesophagus.

Hoffer *et al.* (1980) studied the effects of modified Heller's oesophagomyotomy on the oesophageal pressure and the function of the lower oesophageal sphincter. Oesophagomyotomy of the lower oesophagus was performed, from distal to the cardia and extending over the gastroesophageal junction. Interrupted sutures were placed between the cranial edge of oesophagus and the hiatal incision starting from the centre, with additional sutures on either side to appose the phreno oesophageal ligament with the oesophageal musculature. The animals were maintained for more than 18 months. The intra luminal pressure, time of contraction and relaxation of middle and distal oesophagus and the lower oesophageal sphincter were evaluated. The surgical procedure lowered most of the pressure values and shortened the duration of changes in

pressure. Despite the decrease in the intraluminal pressure and the changes in the time required for relaxation and contraction, the lower oesophageal sphincter retained its ability to contract and prevent reflux oesophagitis.

Leighton (1982) reported the technique of oesophagomyotomy of the lower oesophageal spincter for the treatment of canine megaoesophagus. The oesophagus was exposed through thoracotomy and the oesophageal hiatus was incised to locate the cardia and stomach. A longitudinal incision on the oesophagus was made over the achalasic area upto the cardia, cutting through the muscularis, to allow the mucosa to bulge out. The oesophageal hiatal incision was sutured to the oesophageal musculature, to relocate the exposed mucosal area abdominally. This procedure reduced the reflux of gastric acid into the distal oesophagus.

Bright and Thacker (1983) described a technique for preparation of omental pedicle flap for use in diaphragmatic repair. The omentum was mobilised after ligating the right gastroepiploic artery, close to the pancreas. The small gastroepiploic arteries which coursed along the greater curvature of stomach were isolated and ligated, preserving the gastroepiploic arcade in the cranial border of omentum. The left gastroepiploic artery was not disturbed. The remaining splenic and pancreatic attachments were carefully dissected

out from the omentum, to free the flap sufficiently long for use.

Leighton (1983) described the surgical procedures of gastroesophageal cardiomyotomy for the relief of congenital or acquired megaoesophagus, variably referred as achalasia, oesophageal dilatation, cardiospasm, hypomotility, aperistalsis and oesophageal paralysis. In animals with megaesophagus, the cardia failed to open because of the lack of a stimulating contractile wave from the oesophagus. Myotomy of the cardia caused it to open and the bolus of food entered the stomach more readily. The effect became more marked when fed from an elevated position. Out of 38 cases of surgery reviewed, the results were satisfactory in 21.

Boudrieau and Rogers (1985) reviewed the treatment of 50 (18 congenital and 32 acquired) cases of megaoesophagus. Due to the large number of therapeutic failures, encountered with medicinal therapy and food management, the authors suggested further evaluation of surgical treatment or combined treatment.

Gourley and Vasseur (1985) studied the incidence of megaoesophagus, its symptoms and treatment. The incidence was high in German Shepherd dogs. Dogs with generalised hypomotility, dilatation and achalasia responded to myotomy of the thoracic portion of caudal oesophageal sphincter

(Sphincterotomy). The technique improved the oesophageal drainage and did not cause reflux oesophagitis.

Manderino (1987) reported the incidence of megaoesophagus secondary to hiatal hernia in a German Shepherd pup. The condition was diagnosed by radiography and endoscopy.

Kipperman and Straw (1988) performed cardioplasty combined with resection of oesophageal sacculation detected at the cranial and caudal thoracic oesophagus in the treatment of megaoesophagus in a 14 month old German Shepherd dog. Thoracotomy was performed on the left side, the dialated oesophagus was exposed and the phrenoesophageal ligament was incised to expose the cardia and stomach. A three centimetre long incision was taken caudal to the cardia and was extended three centimetre cranially on the oesophagus. The cranial and caudal ends of the incisions were brought together and sutured, so that the plane of closed incision was perpendicular to the original incision. Oesophageal sacculations were resected and sutured. No regurgitation was observed post operatively and radiography on the fourth day revealed normal emptying of the oesophagus. No improvement in oesophageal motility was observed. The animal was without symptoms 18 months after surgery.

Bojrab *et al.* (1990) evaluated the use of pedicle grafts from pericardium, omentum, diaphragm and gastric wall, for

patching the oesophageal defects or for correction of oesophageal stricture. Left lateral thoracotomy through the 8th or 9th intercostal space was recommended for surgery of the distal oesophagus and a ventral abdominal laparotomy and gastrotomy for removal of the foreign bodies lodged in the lower oesophagus.

Harvey *et al.* (1990) reported that stricture of the lower oesophageal sphincter was usually acquired and sometimes occurred following anaesthesia, due to reflux oesophagitis. They recommended baloon catheter dilatation at 7 to 14 day intervals, along with corticosteroid therapy in between. In unsuccessful dilatation, oesophagoplasty, with a longitudinal incision closed transversely, was adopted. For acquired megaoesophagus cardiomyotomy was recommended to allow the oesophagus to empty more quickly.

Satchell (1990) experimentally produced megaoesophagus and peripheral neuropathy in dogs by administering a neurotoxin, acrilamide. Sequential radiographic and manometric studies demonstrated a progressive decrease in the proportion of swallows that initiates peristalsis and a gradual increase in oesophageal calibre. Regurgitation, failure of peristalsis and oesophageal dilatation appeared in three days. When the administration of toxin was discontinued, the abnormalities disappeared quickly but

oesophagus remained dilated for longer. The abnormalities exhibited was considered to be due to the damage to the proprioceptive elements.

Anderson (1992) reported the functional and morphological abnormalities of the caudal oesophagus in animals, their symptoms and treatment. Iatrogenic chalasia following myotomy of the caudal oesophageal sphincter was rare in adult animals.

Burrows and Merrit (1992) suggested radiography (plain and contrast), fluoroscopy, endoscopy and biopsy for assessment of the function of oesophagus. Functional studies, were conducted with oesophageal manometry. In surgical management of lower oesophageal sphincter, complications like pneumothorax, inadequate reestablishment of antireflux barrier, gastric dilatation and gastroesophageal intussusception were reported.

Hopkins (1992) observed that the muscular weakness in myasthenia gravis was due to decreased acetylcholine receptor content of the neuromuscular junction. Immune mediated mechanisms account for the acquired defect while decreased membrane insertion of receptor, leads to the congenital disorder. Congenital forms presented within the first few weeks of life showed general weakness as the predominant sign. Acquired myasthenia occur between 8 months to 13 years of age and were presented as megaoesophagus alone or with excercise

related weakness. Aspiration pneumonia was a major cause of mortality in such cases.

Smith and Clark (1992) reported the occurrence of post anaesthetic oesophageal stricture in a dog and its correction by baloon catheter dilatation. It was found that during anaesthesia, the reflux of gastric juice into the oesophagus occurred and was the probable cause of stricture inspite of thorough lavage and cemetidine treatment.

Willard and Delles (1993) reported successful baloon catheter dilatation of the stricture of the lower oesophagus in a dog.

Thilagar *et al.* (1994) conducted a clinical survey of megaoesophagus in dogs, its incidence with reference to breed, sex and age and found higher incidence in Doberman Pinscher, followed by German Shepherd . The incidence was higher in males than in females and 29 per cent cases were in animals over seven years of age.

Willard *et al.* (1994) reported the incidence of iatrogenic tear of oesophagus in two dogs associated with endoscopic balooning of oesophageal stricture.

Balagopalan *et al.* (1995) reviewed six cases of megaoesophagus in dogs. The condition was confirmed by

contrast radiography. Gravitational feeding of liquid diet along with vitamin supplements was recommended.

Orton and McCracken (1995) found the use of diaphragmatic pedicle graft for patching the caudal thoracic oesophagus. The diaphragmatic pedicle grafts were used as an onlay graft to reinforce an oesophageal incision and as an inlay graft for oesophagoplasty for relief of oesophageal stricture.

Whitley (1995) reported a case of megaoesophagus with glucocorticoid deficient hypoadrenocorticism in a seven year old German Shephered dog. Rapid resolution of megaoesophagus was observed following appropriate supplementation.

Guilford and Strombeck (1996) found that many anatomical features of the gastroesophageal junction are important for normal function of the gastroesophageal sphincter, although the sphincter function is controlled by nerves and peptide hormones. The role of the short abdominal oesophagus, oblique entry of the oesophagus into the stomach, the crura of diaphragm, the phrenoesophageal membrane and the mucosal folds of the cardia in maintaining the normal function of the gastroesophageal sphincter were studied. The etiopathogenisis of megaoesophagus was discussed and observed that surgery (Heller's esophagomyotomy) caused permanent reduction in gastroesophageal sphincter tone and avoided continuous administration of anticholinergic drugs.

Rusbridge *et al.* (1996) suggested the treatment for acquired myasthenia gravis associated with thymoma in two German Shephered dogs. Thymoma was surgically removed. Satisfactory control over clinical signs was observed with anticholinesterase and corticosteroid therapy.

Vonwerthern *et al.* (1996) successfully treated a case of gastroesophageal intussusception along with megaoesophagus in a six week old, female German Shephered pup. Eighteen months later the dog was found in good condition with no clinical signs despite the presence of megaoesophagus.

Yam *et al.* (1996) observed that the underlying problem in a large proportion of cases of acquired megaoesophagus was focal myasthenia gravis. Fifteen dogs with confirmed adult onset of idiopathic megaoesophagus without generalised muscle weakness were tested for the presence of acetylcholine receptor antibodies. Six dogs were found to have values greater than the levels determined for myasthenia gravis, indicating that a significant proportion of dogs with megaoesophagus suffer from myasthenia gravis.

Materials and Methods

MATERIALS AND METHODS

The experimental study was conducted in 30 apparently healthy, adult nondescript dogs of either sex. They were randomly divided into five groups of six animals each. viz., Group I, Group II, Group III, Group IV and Group V and numbered serially as

Group I - A1 to A6

Group II - B1 to B6

Group III - C1 to C6

Group IV - D1 to D6

Group V - E1 to E6

The dogs were dewormed, treated for ectoparasites and were kept under observation for one week. All the dogs were maintained under identical conditions of feeding and management.

The programme of experiment was:

Group I

Myotomy of the gastroesophageal region was performed through a left side thoracotomy incision, with resection of eighth rib.

Group II

Myotomy of the gastroesophageal region was performed through a left side laparotomy incision at the twelfth intercostal space along with resection of twelfth rib.

Based on the results obtained from group I and Group II, the abdominal approach as in Group II was adopted for surgery in Groups III, IV and V.

Group III

Myotomy of the gastroesophageal region was performed and the wound edges were sutured to the overlying portion of diaphragm.

Group IV

Myotomy of the gastroesophageal region was performed and the wound edges were sutured to a deflected portion of diaphragmatic pedicle graft prepared from the dome of the diaphragm.

Group V

Myotomy of the gastroesophageal region was performed and the wound edges were sutured to omental pedicle graft.

Preoperative considerations

All the animals were kept off feed for 18 hours prior to surgery and a warm soap water enema was given one hour prior to anaesthesia.

In animals of Group I the chest extending from the sixth rib to the 10th rib on the left side and in animals of Groups II, III, IV and V, the region from the 10th rib to the middle of the left lateral abdominal wall was shaved and prepared for aseptic surgery.

The animals were controlled on the operation table in the right lateral recumbent position.

Surgical technique

Preparation of the site

The surgical site was washed with soap and water, mopped, applied 70 per cent alcohol and painted Tr. iodine. The site was suitably draped.

Anaesthesia

All the animals were premedicated with atropine sulphate* at a dose of 0.04 mg per kilogram body weight intramuscular.

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* Atropine sulphate - Rayan Pharma Limited, Anaparty, AP.

After five minutes, xylazine* at the dose of 0.5 mg per kilogram body weight was administered intramuscular. Ten minutes later five per cent solution of thiopentone sodium** was administered intravenous, for anaesthesia to effect. A cuffed endotracheal tube was introduced, inflated the cuff and was secured in position. To maintain anaesthesia, five per cent solution of thiopentone sodium was administered intravenous, whenever the animals showed signs of recovery during the course of surgery. During surgery, five per cent dextrose normal saline*** solution was infused intravenously.

Surgical procedure

Surgery of the gastroesophageal region through left side thoracic approach with resection of eighth rib was adopted in group I animals. In animals of group II, left side abdominal approach was adopted through 12th intercostal space, with resection of the 12th rib. The abdominal approach as in group II was adopted for groups III, IV and V.

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* Xylaxin - Xylazine hydrochloride 23.22 mg/ml (equivalent to 20 mg of xylazine) Indian Immunologicals, Hyderabad

** Intraval sodium - Thiopentone sodium injection IP - Rhone - Poulenc (India) Ltd., Bombay

*** Dextrose normal saline - Sodium chloride 0.9% and dextrose 5% W/V injection IP South Indian Parenterals (P) Ltd., Binanipuram, Ernakulam.

Thoracic approach (Group I)

A skin incision was made over the eighth rib, starting four centimetre distal to the vertebral articulation and extending upto the costochondral junction. The incision was deepened through the cutaneous trunci and lattissimus dorsi muscles to expose the rib. The attachments of serratus caudalis and obliquous externus abdominis muscles to the rib were retracted. The periosteum on the lateral surface of the rib was incised longitudinally. The edges of the periosteal incision were separated with a periosteal elevator. A curved artery forceps was used to completely separate the periosteum from the rib on its deeper surface. The narrow jaw of the rib shear was then passed underneath the vertebral end of the exposed portion of the rib and the rib was severed transversely. The distal end of the rib was disarticulated at the costochondral junction and was removed. Haemorrhage was controlled by ligation with 3-0 silk. The animal was connected to the respiration pump and/or Boyles' Tec anaesthetic apparatus through the endotracheal tube. During deflation of the lungs the periosteum and the parietal pleura were incised through the centre and the incision was extended on either side with scissors to complete the thoracotomy incision. The wound edges were kept retracted.

Gastroesophageal myotomy

The caudal lobe of lung was displaced cranially. The mediastinal pleura was opend with scissors. The oesophagus was held lifted with a babcock forceps and a sterile pliable rubber tube was passed underneath the oesophagus. The babcock forceps was released and the oesophagus was lifted to the wound edges with cranial traction applied by the tube. The oesophageal hiatus was exposed along with the oesophagus.

The dorsolateral side of the oesophagus was then separated from its phrenoesophageal membraneous attachment to create a rent between the oesophagus and diaphragm. Traction on the oesophagus cranially exposed the abdominal portion of oesophagus, cardia and the anterior part of stomach. A babcock forceps was applied distal to the cardia, on the stomach wall and the stomach was held lifted.

An incision of four centimetre length was made starting from the stomach just behind the cardia and extending cranially to the oesophagus, incising the musculature, leaving the submucosa and mucosa intact. The edges of the incisions on either side were undermined to allow protrusion of the oesophageal mucosa (Fig.1). Bleeding points were ligated with 3-0 braided silk. The babcock forceps, holding the stomach was released.

Closure of the oesophageal hiatal incision of diaphragm

The first suture was applied at the cranial most end of the oesophageal incision using 3/0 silk. The suture starting from the submucosa, was passed through the muscularis and was taken out through the tunica adventitia. The suture was then passed through the wound edge of the diaphragm, at the centre of the hiatal incision. The suture thread on either side was adjusted to equal length and knotted. This suture converted the longitudinal incision on the oesophagus above the level of diaphragm, into a transverse wound (Fig.2). With one end of the suture thread, continuous apposition sutures were placed between the oesophageal wound edge and the edge of the diaphragm ventral to the first suture applied. Using the other end of suture thread, continuous apposition sutures were placed between the oesophageal wound edge and the edge of diaphragm dorsal to the first suture, to complete the suturing. On completion of suture the exposed portion of the oesophageal mucosa, became intraabdominal in position and increased the width of the abdominal portion of the oesophagus and cardia The rubber tube holding the oesophagus anteriorly was removed and the oesophagus was repositioned.

Closure of the thoracotomy wound

The incised edges of pleura and the edges of periosteal incisions were apposed by simple continuous suture using

1-0 silk. Before closure of the wound at the costochondral junction, a sterilised rubber tube was kept at the lower commissure and a purse string suture was applied around it. The lungs were then inflated fully, to expell the air from the thoracic cavity. The rubber tube was closed before deflation of the lungs and opened during inflation of the lungs. The inflation of the lung was done thrice. The tube was removed when the lung was in full inflation and the purse string suture was tightened and knotted. The first layer of suture was completed and knotted at the costochondral junction. A second layer of suture using 1-0 silk was applied fixing the obliquous abdominis externus, serratus caudalis, serratus ventralis and the lattissimus dorsi. A subcuticular suture was taken and the skin wound was closed by vertical mattress sutures using monofilament nylon. Healex spray* was applied over the suture line.

Abdominal approach (Group II)

A skin incision was made over the 12th rib starting from four centimetre distal to its vertebral articulation and extended downward upto the costal arch. The incision was deepened through the cutaneous trunci and lattissimus dorsi

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Healex spray - An aerosol spray dressing for local use. Rallis India Limited, Andheri, Bombay

muscle to expose the 12th rib. The attachment of serratus caudalis and the obliquous abdominis externus muscles were reflected. A longitudinal incision was made on the periosteum to the exposed length of the rib, the periosteum was separated and the rib was cut and removed.

The wound edges were kept retracted. The incised edges of cutaneous trunci and the lattissimus dorsi muscles caudal to the incision were reflected to the 12th intercostal space. The incision was then continued through the centre of the intercostal space, cutting through the external and internal intercostal muscles. The deeper fibrous attachments of the diaphragm to the 13th rib and the parietal peritoneum were incised taking care to avoid opening of the thoracic cavity.

Gastroesophageal myotomy

The greater curvature of the stomach was brought to the laparotomy site by gentle traction and was held in position to expose the oesophageal hiatus, the abdominal oesophagus and the cardia. The attachment of the phrenoesophageal ligament on the dorsolateral aspect of the oesophagus was incised and widened to expose the thoracic portion of the lower oesophageal sphincter (Fig.3). Immediately after incising the oesophageal hiatus, the animal was connected to the respiration pump or Boyle's Tec anaesthetic apparatus.

A stay suture was applied a little above the border of the diaphragm at the centre of hiatal incision and the two ends of the thread were held together and the diaphragm was lifted to expose the site.

An incision, four centimetre long, was made starting from the stomach a little behind the cardia and extending cranially to the esophagus incising the oesophageal musculature, leaving the submucosa and mucosa intact. The edges of the oesophageal incision were undermined on either side to cause protrusion of the mucosa through the myotomy incision (Fig.4). Haemorrhage was controlled by ligation with 3-0 silk.

Closure of the oesophageal hiatal incision of diaphragm

The first suture was applied at the most cranial end of the oesophageal incision using 3-0 silk. The suture starting from the submucosa and passing through the muscularis was taken out through the tunica adventitia. The suture was then taken through the edge of the diaphragm, at the centre of the hiatal incision. The suture thread on either side was adjusted to equal length and was knotted. This suture converted the longitudinal incision on the oesophagus above the level of diaphragm into a transverse wound. With one end of the thread, continuous apposition sutures were placed between the oesophageal wound edge and the edge of the diaphragm ventral to the first suture. Using the other end of

the suture thread, continuous apposition sutures were placed between the oesophageal wound edge and the edge of diaphragm, dorsal to the first suture. Before tightening the last suture, the jaw of a curved artery forceps was introduced into the mediastinal space. The lung was inflated fully by pressing the rebreathing bag and the jaws of the forceps were widened to expell the air in the mediastinum. The jaws of the forceps were held closed during deflation of the lung. The procedure was repeated twice and during the third inflation the forceps was withdrawn and the suture was tightened and knotted to complete the closure of hiatal incision. On completion of suture, the exposed portion of the oesophageal mucosa became intraabdominal in position with increased width of the abdominal portion of the oesophagus and cardia. The stay suture on the diaphragm was released and the stomach was repositioned.

Closure of the laparotomy wound

The parietal peritoneum and the edges of the intercostal muscles were apposed by simple continuous suture using 1-0 silk. The edges of the periosteal incision and the reflected edges of the serratus caudalis and obliquous abdominis externus muscles were sutured together in simple continuous pattern using 1-0 braided silk. A subcuticular suture was applied and the skin wound was closed by vertical mattress

sutures using monofilament nylon. Healex spray was applied over the suture line.

The merits and demerits of both thoracic and abdominal approaches were assessed and abdominal approach was found more suitable for the experimental procedures in group III, IV and V.

Group III

Myotomy of the gastroesophageal region was done and the hiatal incision was sutured as in group II. The wound edges of the myotomy incision were sutured to the overlying diaphragm in simple continuous pattern using 3-0 braided silk, so that the diaphragm formed an outer covering for the exposed mucosa at the gastroesophageal region.

Closure of the laparotomy wound was performed as in group II.

Group IV

After myotomy at the gastroesophageal region and suturing of oesophageal hiatal incision as in Group II, a pedicle graft from the dome of the diaphragm was prepared and was sutured to the myotomy edges to form an outer covering for the exposed mucosa at the gastroesophageal region.

Preparation of diaphragmatic pedicle graft

A pouch of diaphragm above the level of its tendinous attachment was held by a babcock forceps and a doyen's bowel clamp was applied at the base in such a way to isolate a pouch, approximately measuring four centimetre in length and three centimetre in width (Fig.5). The babcock forceps was removed. Two babcock forceps were applied on the isolated part of diaphragm, one cranial and one caudal to the doyen's bowel clamp and held the portion lifted. Running mattress sutures, overlapping each bite, was applied on the diaphragm at the base of doyens' clamp, leaving a small area at the distal end. The isolated portion of diaphragm was severed over the doyen's clamp leaving the distal end attached to the tendinous portion. The clamp was removed and the wound edges on the diaphragm were reinforced with simple continuous suture using 1-0 silk. The pedicle graft was held by forceps (Fig.6) and the babcock forceps holding the diaphragm were released. The lung was fully inflated to check leakage of air through the suture line.

Suturing of the diaphragmatic pedicle graft with myotomy wound

The cardia, myotomy wound and the oesophageal hiatus were exposed by caudal traction of stomach. The edges of the myotomy wound were held by forceps. The diaphragmatic pedicle

graft was placed over the myotomy site to cover the exposed mucosa, with the apex directed towards the stomach. Sutures were applied between the pedicle graft and the wound edges on all three corners of the wound with 3-0 silk. Simple continuous apposition sutures were then applied between the pedicle graft and the suture line of hiatal incision. The other two sides of the pedicle graft were sutured to the oesophagomyotomy edges on either side, in simple continuous pattern using 3-0 silk (Fig.7). The forceps holding the wound edges were released and the stomach was repositioned.

Closure of the laparotomy wound was performed as in group II.

Group V

After myotomy of the gastroesophageal region, and suturing of oesophageal hiatal wound as in Group II, a pedicle graft prepared from the greater omentum was used for covering the exposed mucosa at the gastroesophageal region.

Preparation of omental pedicle graft

A pedicle of omentum, four centimetre in width was prepared from the cranial attachment of greater omentum to the greater curvature of stomach (Fig.8). Omentum was torn from the free border to its attachment with the stomach without

injuring the major blood vessels. The free omental pedicle graft with its blood supply was drawn over the myotomy site.

Suturing of the omental pedicle graft with myotomy wound

The cardia, myotomy wound and the oesophageal hiatus were exposed by caudal traction of the stomach. The edges of the myotomy wound were held by forceps. The omental pedicle graft was drawn over the wound with its free border in line with the myotomy incision, on the ventral side, to cover the exposed mucosa. Sutures were applied with 3-0 silk, between the pedicle graft and wound edges, on all three corners of the wound. Simple continuous apposition sutures were then applied between the pedicle graft and the suture line of hiatal incision. The other two sides of the pedicle graft were sutured to the oesophagomyotomy edges on either side in simple continuous pattern, using 3-0 silk, each side being sutured separately. This caused spreading of a double folded omental flap over the exposed mucosa at the myotomy site (Fig.9). The forceps holding the wound edges were released. The torn end of the greater omentum was sutured by interrupted apposition sutures. The stomach was repositioned.

Closure of the laparotomy wound was performed as in group II.

Blood smears were prepared and venous blood samples were collected in EDTA* before anaesthesia, immediately after surgery and on 7th, 14th and 21st day of surgery for haematological studies.

Electrocardiographic recordings were made with a base apex lead system before surgery, during surgery, immediately after completion of surgery, 24 hour after surgery and on 7th, 14th and 21st day of surgery.

Contrast radiography of the distal oesophageal region and stomach was done before surgery, 24 h after surgery and on 7th, 14th and 21st day of surgery, after administration of barium sulphate** through a stomach tube.

Post surgical management

The dogs were kept under observation for a period of 21 days after surgery. Streptopenicillin*** 0.5 g was administered intramuscular in all the animals for three

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* EDTA-EDTA-Disodium salt (Nice Laboratory reagent), New India Chemical Enterprises, Kochi

** Microbar - Barium sulphate IP 95% W/V. Eskay fine chemicals, Navi Mumbai.

*** Dicrysticin-S - Streptopenicillin for suspension, Sarabhai Chemicals, Baroda.

consecutive days post operatively and Benzathene Penicillin G* 600,000 IU intramuscular on the fourth day of surgery. The skin wound was dressed daily with framycetin** skin cream. The skin sutures were removed on the eighth to tenth day of surgery.

Milk was offered to the animals, four hours after surgery and were maintained on liquid diet upto 48 h after surgery. There after the animals were fed on routine solid diet throughout the period of observation. All animals were sacrificed at the end of the period of observation, conducted autopsy, recorded gross lesions, if any, in the caudal thoracic and cranial abdominal regions, diaphragm, lungs, oesophagus and stomach. Barium meal contrast radiography of the distal oesophagus and stomach of the autopsy specimens were made in one animal each from group I and group II. The specimen from the gastroesophageal region was collected for histo-morphological studies, from two animals each from all the five groups.

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* Penidure LA6 - Benzathine penicillin G 600,000 IU, John Wyeth (India) Ltd., Bombay

** Soframycin - Framycetin skin cream - Roussel India Ltd. - Thane

Main items of observation

The following parameters were recorded.

1. Time for induction of anaesthesia

It was calculated as the time interval between the injection of thiopentone sodium and the disappearance of palpebral reflex, on touching at the level of inner canthus of the eye.

2. Duration of anaesthesia

It was calculated as the time interval between the disappearance of palpebral reflex and reappearance of palpebral reflex.

3. Time for recovery from anaesthesia

It was calculated as the time from reappearance of palpebral reflex to the time when the animal was able to raise its head.

4. Type of respiration during surgery

The changes if any observed in the character of respiration during surgery was recorded.

5. Physiological observations

Physiological parameters such as rectal temperature (°C), pulse rate (per minute), respiration rate (per minute) were observed before anaesthesia, at 30 min., 90 min. and 24 h after surgery and on 7th, 14th and 21st day of surgery.

6. Clinical signs

Various clinical signs exhibited by the animals, including the general condition and feed intake were recorded.

7. Haemogram

Blood samples collected were used for estimation of the total erythrocyte count, total and differential leucocyte counts, erythrocyte sedimentation rate (ESR), packed cell volume (PCV) (Schalm, 1975) and haemoglobin concentration (Cyanmethemoglobin method, Jain, 1986).

8. Electrocardiogram (ECG)

Electrocardiographic recording was made before surgery, during surgery, immediately after the completion of surgery, 24 h after surgery and on 7th, 14th and 21st day of surgery using a base apex lead system, at a paper speed of 25 mm per second.

9. Radiography

Barium meal radiography of the distal oesophagus and stomach (Lateral) were recorded out before surgery, 24 h after surgery and on 7th, 14th and 21st day of surgery to study abnormalities if any, in shape and size of distal oesophagus and stomach, and for leakage, during the post operative days. After sacrificing the animals, radiograph of the barium filled distal oesophagus and stomach was taken in one animal each from group I and group II.

10. Autopsy findings

The animals were sacrificed at the end of the period of observation and autopsy was performed. Gross lesions and changes in the lungs, pleural cavity, distal oesophagus oesophageal hiatus, diaphragm, stomach and adhesions, if any, were recorded.

The specimens of distal oesophagus, cardia and adjacent portion of stomach were collected and observed for gross changes.

11. Histomorphological examination

Two random specimens of gastroesophageal region from each group, were subjected to histomorphological examination. The specimen collected from gastroesophageal region was fixed in

buffered formol saline (Humason, 1979). The tissues were processed, longitudinal sections at 5 μ thickness were prepared and stained with hematoxylin and eosin (Bancroft and Cook, 1984).

The data obtained in all the groups were analysed using analysis of co-variance test and the means were compared with presurgical values (Snedecor and Cochran, 1967).

Fig.1. Photograph of the schematic representation of gastroesophageal myotomy (Group I)

Fig.2. Photograph of the schematic representation of the first suture applied for closure of the hiatus oesophageus (Group I)

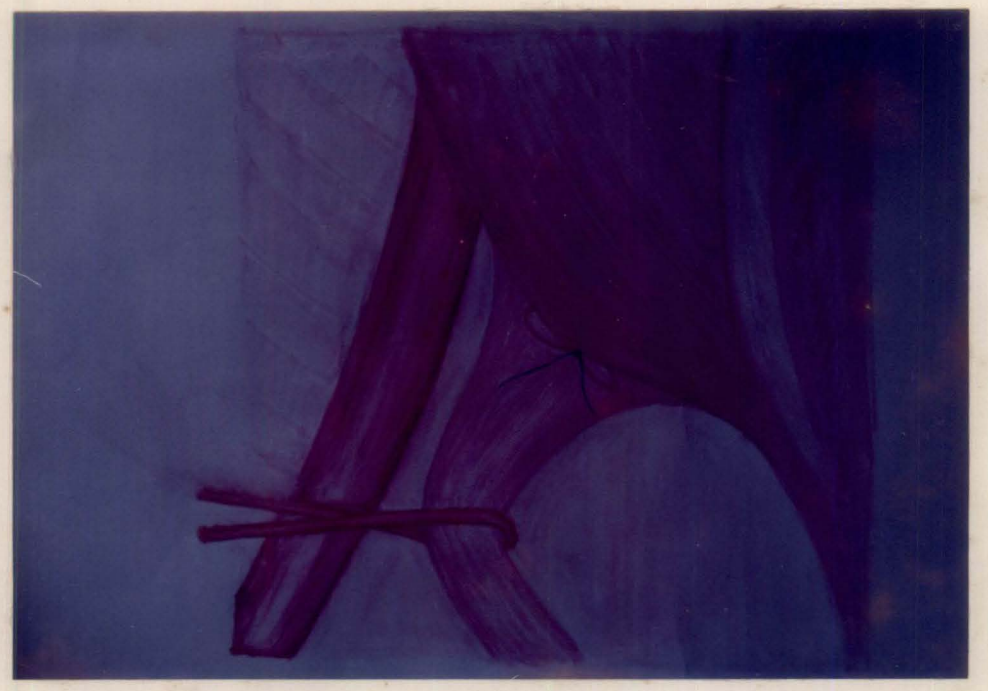
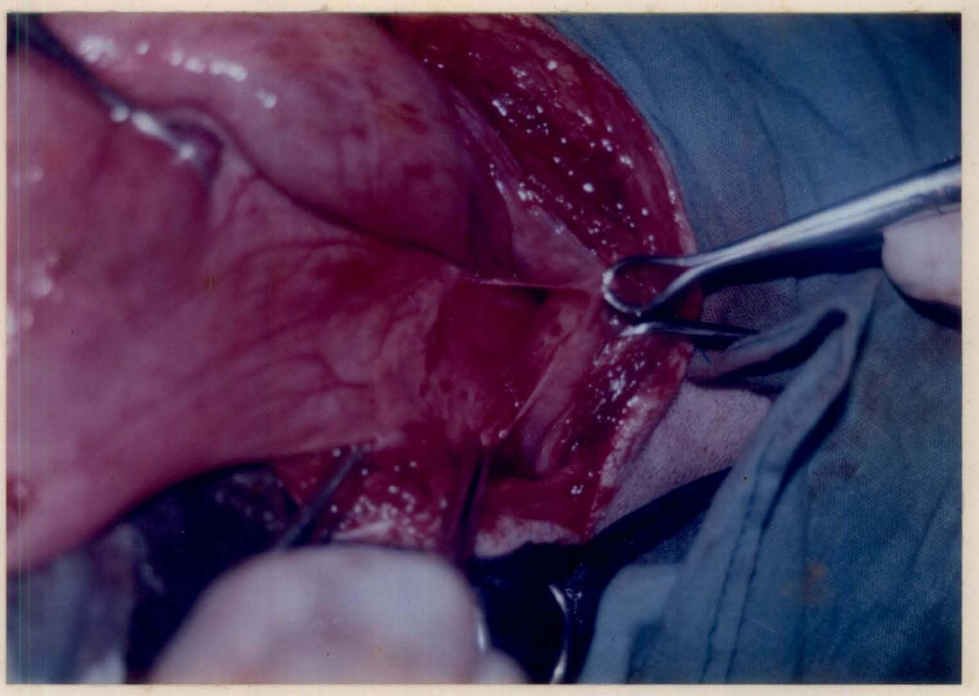


Fig.3. Photograph of the gastroesophageal region showing the oesophageal hiatal incision (Group II)

Fig.4. Photograph of the gastroesophageal region (Group II) showing the exposed mucosa through myotomy site



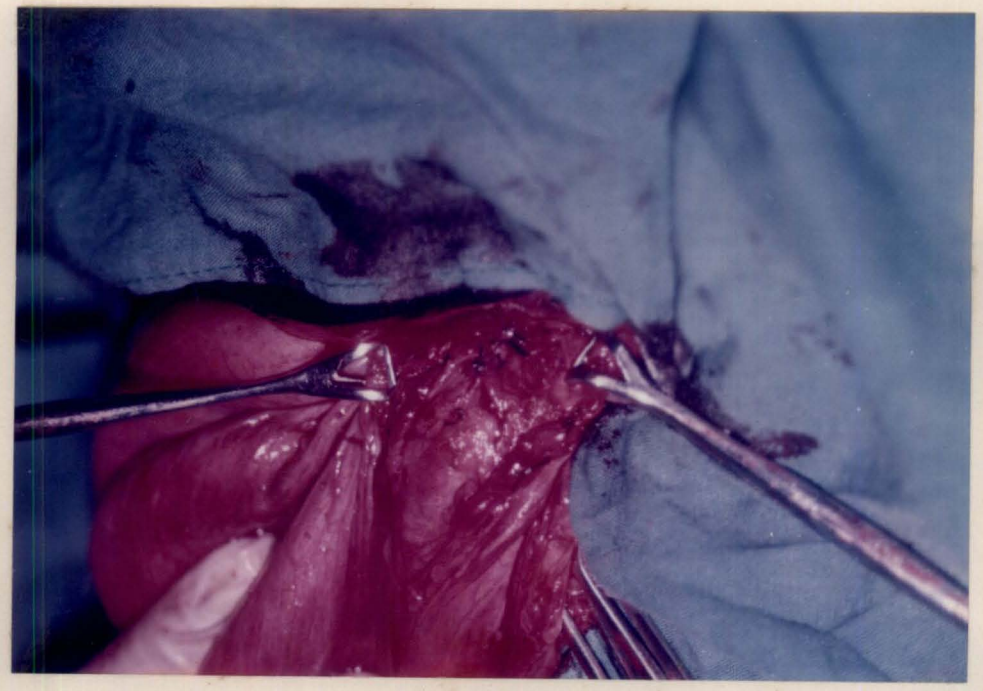
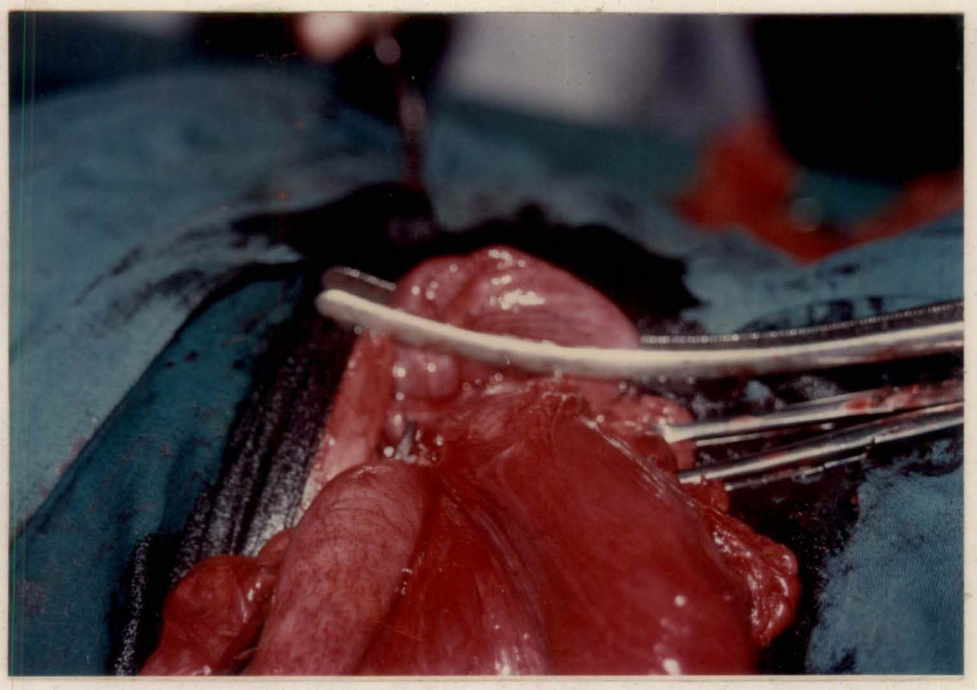


Fig.5. Photograph showing the isolated diaphragm pouch (Group IV) for pedicle graft preparation

Fig.6. Photograph showing the isolated diaphragm pedicle graft for suturing at the myotomy site (Group IV)



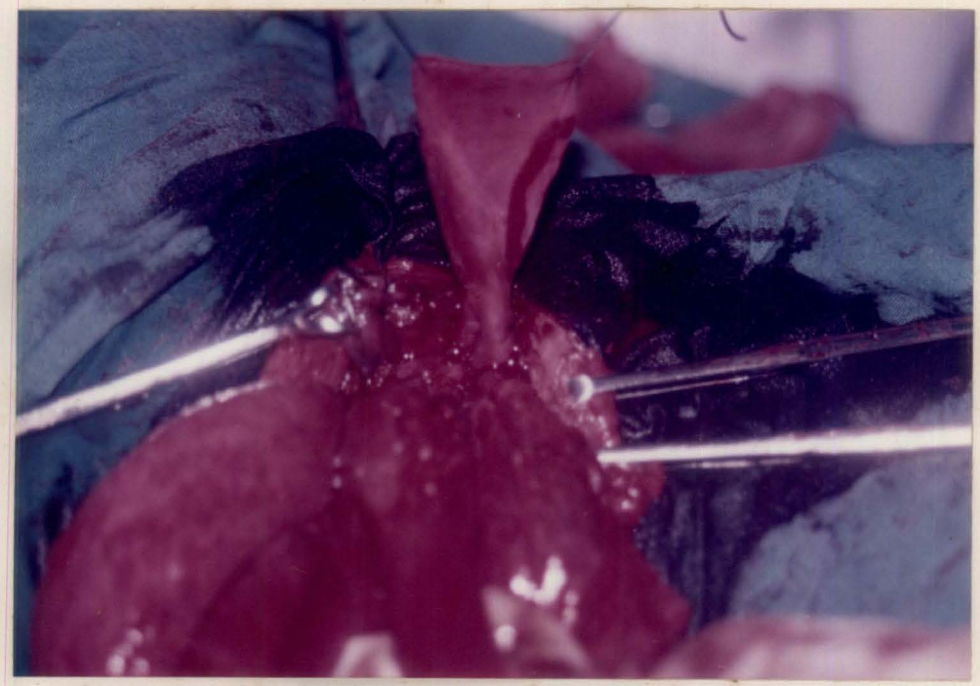


Fig.7. Photograph showing the diaphragm pedicle graft sutured to the myotomy wound edges (Group IV)

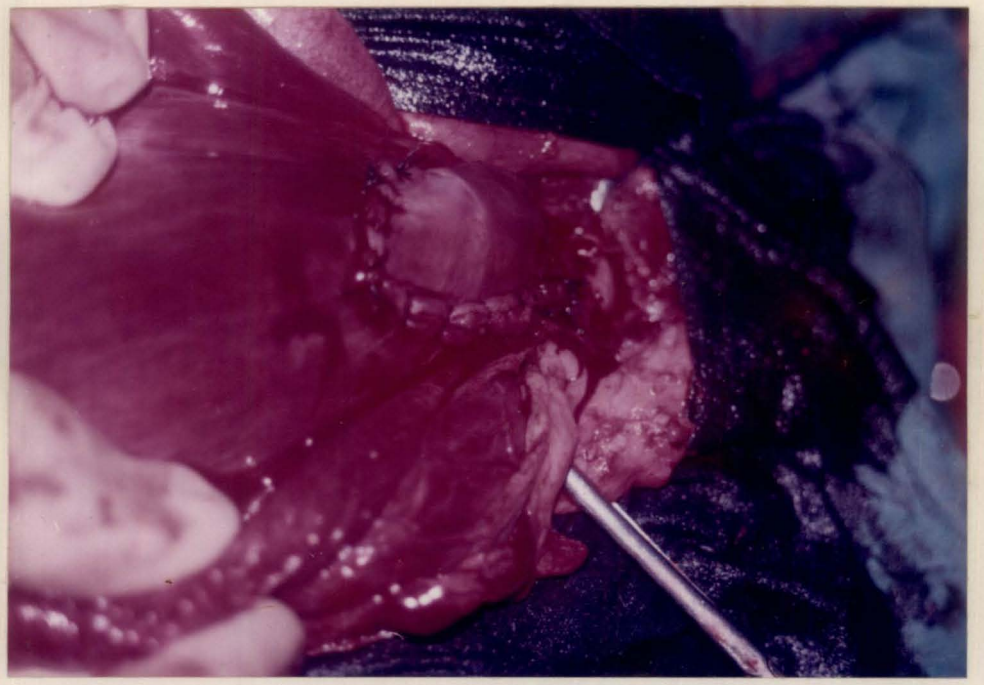
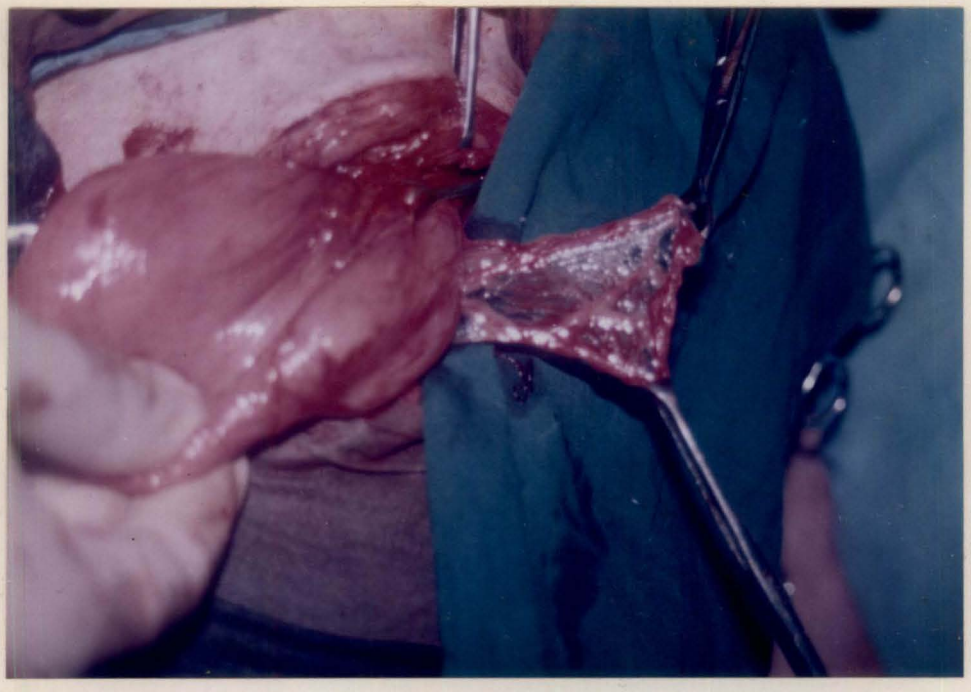
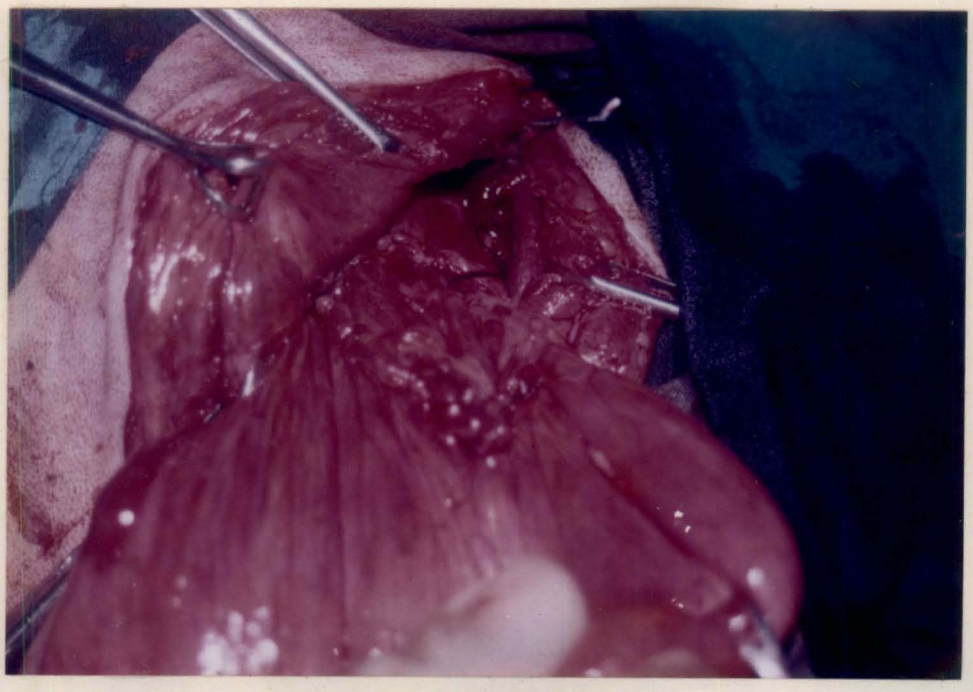


Fig.8. Photograph of the isolated omental pedicle graft for suturing at the myotomy site (Group V)

Fig.9. Photograph of the omental pedicle graft sutured in position at the myotomy site (Group V)





Results

RESULTS

The study was conducted in 30 apparently healthy adult nondescript dogs of either sex, randomly divided into five groups of six animals each viz.,

Group I (A1 to A6)
Group II (B1 to B6)
Group III (C1 to C6)
Group IV (D1 to D6)
Group (V) (E1 to E6)

The average body weight (kilogram) of the animals was 9.67 ± 0.49 in Group I, 11.50 ± 0.62 in Group II, 11.83 ± 1.01 in Group III, 12.33 ± 1.12 in Group IV and 10.50 ± 0.76 in Group V animals.

Anaesthesia (Table 1)

In all the groups, the animals were premedicated with atropine sulphate at the rate of 0.04 mg/kg body weight followed by xylazine @ 0.5 mg/kg body weight. Anaesthesia was induced with five per cent solution of thiopentone sodium intravenously to effect.

Atropine sulphate (mg) was administered in an average dose of 0.39 ± 0.28 in Group I, 0.46 ± 0.02 in Group II, 0.47

± 0.04 in Group III, 0.49 ± 0.04 in Group IV and 0.42 ± 0.03 in Group V animals.

Xylazine (mg) was administered in an average dose of 4.83 ± 0.25 in Group I, 5.75 ± 0.31 in Group II, 5.92 ± 0.51 in Group III, 6.67 ± 0.65 in Group IV and 5.25 ± 0.38 in Group V animals.

Thiopentone sodium (mg) was administered in an average dose of 195.83 ± 17.58 in Group I, 233.33 ± 21.08 in Group II, 239.17 ± 16.85 in Group III, 325.00 ± 38.73 in Group IV and 258.33 ± 27.89 in Group V animals.

The average time (min) for induction was 2.92 ± 0.08 in Group I, 3.50 ± 0.34 in Group II, 3.33 ± 0.17 in Group III, 4.00 ± 0.26 in Group IV and 4.08 ± 0.33 in Group V animals.

The average duration of anaesthesia (min) was 47.83 ± 2.95 in Group I, 49.17 ± 3.01 in Group II, 93.08 ± 16.17 in Group III, 93.08 ± 12.51 in Group IV and 98.42 ± 13.12 in Group V animals.

The average time taken for recovery (min) was 50.83 ± 5.38 in Group I, 35.83 ± 6.11 in Group II, 43.33 ± 12.00 in Group III, 65.00 ± 11.51 in Group IV and 43.33 ± 3.80 in Group V animals.

Respiratory arrest during induction/maintenance of anaesthesia was observed in one animal each in Groups I (A3), II (B6) and V (E2) and two animals each in Groups III (C3 and C6) and IV (D3 and D6). Respiration could be revived with artificial respiration in all these animals except one (D6) in which respiratory arrest was followed by cardiac arrest and death.

Muscle relaxation

In all the groups, muscle relaxation was adequate and the anaesthesia was maintained with i/v administration of thiopentone sodium during surgery to obtain satisfactory muscle relaxation and anaesthesia.

Table 1. Dose of atropine sulphate, xylazine and thiopentone sodium administered and the time of induction, duration and recovery from anaesthesia in animals of group I, II, III, IV and V (Mean±SE)

n=6

Group No.	Body weight (kg)	Atropine (mg)	Xylazine (mg)	Thiopentone sodium (mg)	Time of		
					Induction (min)	Duration (min)	Recovery (min)
I	9.67± 0.49	0.39± 0.28	4.83± 0.25	195.83± 17.58	2.92± 0.08	47.83± 2.95	50.83± 5.38
II	11.50± 0.62	0.46± 0.02	5.75± 0.31	233.33± 21.08	3.50± 0.34	49.17± 3.01	35.83± 6.11
III	11.83± 1.01	0.47± 0.04	5.92± 0.51	239.17± 16.85	3.33± 0.17	93.08± 16.17	43.33± 12.00
IV	12.33± 1.12	0.49± 0.04	6.67± 0.65	325.00± 38.73	4.00± 0.26	93.08± 12.51	65.00± 11.51
V	10.50± 0.76	0.42± 0.03	5.25± 0.38	258.33± 27.89	4.08± 0.33	98.42± 13.12	43.33± 3.80

GROUP I

The observations are presented in Tables 2 to 6.

In this group of animals myotomy of the gastroesophageal junction was performed through left side thoracic approach, with resection of eighth rib.

Observation during surgery (Table 2)

The respiration was regular smooth and shallow in four animals (A2, A4, A5 and A6). Dyspnea followed by exaggerated respiration was noticed towards the end of surgery in two animals (A1 and A3), which caused difficulty to expose oesophagus.

Electrocardiogram revealed a decrease in the amplitude of R wave in all the animals. A variation in the amplitude of R wave manifested by a gradual decrease followed by a gradual increase to normal in a regular manner, was observed in two animals (A1 and A6).

Physiological parameters (Table 3)

Rectal temperature (°C)

The rectal temperature (°C) was 39.26 ± 0.15 before anaesthesia. Significant decrease ($P<0.05$) in rectal

temperature was observed at 30 min and 90 min. It became normal at 24 h and was within normal range thereafter during the of period observation.

Pulse rate (per minute)

The pulse rate (per min) was 114.50 ± 4.96 before anaesthesia. Increase in pulse rate observed at 30 min, 90 min and at 24 h was significant ($P<0.05$). Pulse rate was within normal range by 7th day and remained in the normal range there after during the period of observation.

Respiration rate (per minute)

The respiration rate (per min) was 32.00 ± 1.71 before anaesthesia. Significant increase in respiration rate ($P<0.05$) was observed at 30 min and 90 min after surgery. It started declining at 24 h and became normal by 7th day. A reduction in respiration rate within normal range was observed on 21st day.

Clinical signs (Table 4)

General condition

All the animals except animal A3 were alert and active by 24 h after surgery. Animal A3 was recumbent for first four

post operative days and was dull and weak. It aborted on the 8th day of operation.

On auscultation abnormal sounds were not audible except in animal A5, in which muffling of the heart sound and whistling sound on the operated side was audible upto 24 h after surgery.

Appetite

Appetite was normal in all the animals throughout the period of observation except in one animal (A3) where poor feed intake was observed during the first three post operative days.

Swallowing was normal in all the animals throughout the period of observation.

Regurgitation and vomiting

Regurgitation and vomiting was not observed in any of the animals in this group.

Skin wound

Skin wound showed normal healing in all the animals and the sutures were removed on the eighth day except in one animal (A2) where swelling of the suture line and presence of

serosanguineous fluid was observed on the 6th day. The wound was dressed with framycetin skin cream and has healed by 10th day.

Other changes

Animal A3 had abortion on the eighth day.

Haemogram (Table 5)

The haemoglobin concentration (g/dl) was 16.85 ± 0.39 before anaesthesia and the variations noticed in the post operative period were marginal and within normal range.

Erythrocyte sedimentation rate (mm/h) was 2.25 ± 1.22 before anaesthesia and the variations noticed in the post operative period were marginal and within normal range.

The packed cell volume (per cent) was 42.17 ± 1.30 before anaesthesia and the variations noticed in the post operative period were marginal and within normal range.

The total erythrocyte count ($10^6/mm^3$) was 6.51 ± 0.09 before anaesthesia and the variations noticed in the post operative period were marginal and within normal range.

The total leucocyte count ($10^3/mm^3$) was 10.36 ± 0.48 before anaesthesia and the variations noticed in the post operative period were marginal and within normal range.

The neutrophil count (per cent) was 70.33 ± 0.33 before anaesthesia and the variations noticed in the post operative period were marginal and within normal range.

The lymphocyte count (per cent) was 21.50 ± 0.43 before anaesthesia and the variations noticed in the post operative period were marginal and within normal range.

The monocyte count (per cent) was 2.33 ± 0.21 before anaesthesia and the variations noticed in the post operative period were marginal and within normal range.

The eosinophil count (per cent) was 5.83 ± 0.48 before anaesthesia. Significant decrease in eosinophil count was observed at 30 min, 7th day and on 21st day ($P<0.05$) of the period of observation.

Basophil was not observed in any of the blood samples.

Electrocardiogram (ECG)

Increase in heart rate was observed immediately after surgery in one animal (A1), upto 24 h in one animal (A3), upto

7th day in two animals (A2 and A5) and throughout the period of observation in two animals (A4 and A6).

Decrease in the amplitude of `R' wave was observed during surgery in all the animals and immediately after surgery in three animals (A2, A4 and A5). In animal A3 it persisted upto 7th day and in animal A4 upto 14th day.

An increase in the amplitude of `T' wave with spiking was observed immediately after surgery in one animal (A6), at 24 h in two animals (A3 and A4) and on 7th day in one animal (A4).

Radiographic observation

Barium meal contrast radiography during the post operative period showed normal emptying of the oesophagus into the stomach, in all the animals. Signs of oesophagitis, hiatal hernia, leakage of contents and narrowing of the oesophageal lumen were not observed in any of the animals.

Barium meal filled distal oesophagus and the stomach from the autopsy specimen of one animal A3 (Fig.10) showed normal size of the oesophageal lumen and widening of the gastroesophageal region and cardia. An outpouching of the wall of the stomach with an increase in the curvature at the

greater curvature along with normal mucosal folds was also observed.

Terminal findings

All the animals were sacrificed at the end of the period of observation and gross morphological changes in and around the region of surgery was studied. Specimens collected from the gastroesophageal region from two animals (A4 and A5) were subjected to histomorphological studies.

Gross morphological observations (Table 6)

Caudal thoracic oesophagus

The caudal thoracic oesophagus was found normal in size and shape. In animals, A1 and A3, adhesion of the diaphragmatic lobe of the lung with the oesophagus was noticed. Fibrous tissue, for a length of four centimetre from the hiatus anteriorly, was seen on the surface of the caudal oesophagus (Fig.11) in two animals (A3 and A5).

Diaphragm

Diaphragm was normal and intact in all the animals.

Lungs

Congestion and consolidation of both the diaphragmatic lobes of the lung was observed in one animal (A3). Collapse of right diaphragmatic lobe of lung was observed in one animal (A2) and collapse of the diaphragmatic lobe on the operated side was observed in one animal (A1).

Adhesion of lung with oesophagus was observed in two animals (A1 and A3), with the thoracic wall (pleura) on the operated side in three animals (A2, A3 and A4) and with the diaphragmatic pleura in one animal (A5).

Pleura

Mediastinal pleuritis and adhesion with pericardium was observed in one animal (A3).

Oesophageal hiatus

The oesophageal hiatus was intact in all the animals. The hiatal incision has healed completely.

Gastroesophageal region and cardia

Increase in the width of gastroesophageal region and cardia was observed in all the animals. The oesophageal wall

and cardia at the myotomy region was thin and the mucosa was smooth with normal folds (Fig.12).

Stomach

The stomach was normal in size in all the animals. An outpouching of the stomach at the greater curvature, was also observed (Fig.13).

Peritoneum and omentum

No sign of peritonitis or adhesion with omentum was observed in any of the animals.

Histomorphological observations

Histomorphological examination of the longitudinal sections of the gastroesophageal region from animals A4 and A5 revealed complete healing of the myotomy site with proliferation of fibrovascular connective tissue (Fig.14). The region was devoid of muscular layers. The Gastroesophageal junction revealed the normal transition of stratified squamous epithelium of the oesophagus to the columnar epithelium of the stomach.

Table 2. Observations on respiration, difficulties encountered in surgery and ECG changes during surgery in dogs (Group I)

Animal No.	Respiration	Difficulties encountered in surgery	ECG
		Thoracotomy	
A1	Dyspnea followed by exaggerated respiration	Movement of lungs caused difficulty to expose the oesophagus	Variation in the amplitude of R waves
A2	Regular, smooth and shallow	-	Decrease in the amplitude of R wave
A3	Dyspnea followed by exaggerated respiration	Movement of lungs caused difficulty to expose the oesophagus	Decrease in the amplitude of R wave
A4	Regular, smooth and shallow	-	Decrease in the amplitude of R wave
A5	Regular, smooth and shallow	-	Decrease in the amplitude of R wave
A6	Regular, smooth and shallow	-	Variation in the amplitude of R waves

Table 3. Rectal temperature, pulse rate and respiration rate before surgery and on different post operative periods in dogs (Group I) (Mean±SE)

n=6

Physiological parameters	0 min	30 min	90 min	24 h	7 d	14 d	21 d
Temperature (°C)	39.26± 0.15	36.91*± 0.61	37.96*± 0.33	39.35± 0.23	39.21± 0.18	38.93± 0.05	39.11± 0.18
Pulse (per minute)	114.50± 4.96	130.00*± 4.46	131.03*± 4.45	128.66*± 6.98	113.33± 2.17	112.00± 2.13	106.66± 3.92
Respiration (per minute)	32.00± 1.71	56.16*± 10.80	57.00*± 8.92	42.33± 5.42	31.33± 1.33	28.66± 0.42	27.00± 1.43

* Significant at 5 per cent level as compared to value at 0 min

Table 4. Clinical observations during the post operative period in dogs (Group I)

Animal No.	General condition	Appetite	Swallowing	Regurgitation/ vomition	Skin wound	Others
A1	Good	Normal	Normal	Absent	Normal healing	--
A2	Good	Normal	Normal	Absent	Swelling of suture line 6th to 9th day	
A3	Weak and dull	Poor for first 3 days	Normal	Absent	Normal healing	Aborted on the 8th day
A4	Good	Normal	Normal	Absent	Normal healing	--
A5	Good	Normal	Normal	Absent	Normal healing	Muffling of heart sound and whistling sound on the operated side upto 24 h
A6	Good	Normal	Normal	Absent	Normal healing	--

Table 5. Haemogram before surgery and on different postoperative periods in dogs (Group I) (Mean±SE)

n=6

Parameters and units	0 min	Post operative intervals			
		Immediately after	7th day	14th day	21st day
Haemoglobin concentration (g/dl)	16.85± 0.39	16.43± 0.56	16.68± 0.40	16.35± 0.33	16.19± 0.36
Erythrocyte sedimentation rate (mm/h)	2.25± 1.22	2.17± 0.86	1.83± 0.74	0.92± 0.24	0.92± 0.24
Packed cell volume (%)	42.17± 1.30	40.00± 0.82	40.50± 0.68	39.67± 1.23	41.50± 0.73
Total erythrocyte count ($10^6/mm^3$)	6.51± 0.09	6.19± 0.28	6.56± 0.12	6.03± 0.20	6.55± 0.10
Total leucocyte count ($10^3/mm^3$)	10.36± 0.48	* 11.68± 0.55	11.23± 0.43	11.53± 0.16	11.15± 0.34
Neutrophil count (%)	70.33± 0.33	72.83± 1.28	73.00± 1.46	72.83± 2.27	72.83± 1.11
Lymphocyte count (%)	21.50± 0.43	21.33± 1.47	21.50± 1.06	21.00± 2.10	21.00± 1.29
Monocyte count (%)	2.33± 0.21	2.17± 0.40	1.33± 0.42 *	1.66± 0.17	2.33± 1.02 *
Eosinophil count (%)	5.83± 0.48	* 3.67± 0.33	* 4.00± 0.36	4.50± 0.43	3.53± 0.70
Basophil count (%)	0.00	0.00	0.00	0.00	0.00

* Significant at 5 per cent level as compared to value at 0 min

Table 6. Gross morphological changes observed during autopsy in dogs (Group I)

Animal No.	Caudal thoracic oesophagus	Lungs	Pleura	Oesophageal hiatus	Gastro-oesophageal region and cardia	Stomach
A1	Adhesion with a portion of diphragmatic lobe of lung	Collapse of lung, adhesion of a portion of diaphragmatic lobe with oesphagus and on the operated side with the diaphragmatic pleura	No abnormality detected	Intact	Widened and thin	Outpouching of greater curvature
A2	No abnormality detected	Diaphragmatic lobe collapsed on the right side and left side was adhered with diaphragm and chest wall	No abnormality detected	Intact	Widened and thin	Outpouching of greater curvature
A3	Adhesion with diaphragmatic lung lobe. Fibrous tissue proliferation for 4 cm from the hiatus over the surface	Diaphragmatic lobes were congested and consolidated	Mediastinal pleuritis and adhesion with peri-cardium	Intact	Widened and thin	Outpouching of greater curvature
A4	No abnormality detected	Adhesion with chest wall on the side of operation	No abnormality detected	Intact	Widened and thin	Outpouching of greater curvature
A5	Fibrous tissue proliferation for 4 cm from the hiatus over the surface	Diaphragmatic lobe adherent with diaphrag-matic pleura on the operated side	No abnormality detected	Intact	Widened and thin	Outpouching of greater curvature
A6	No abnormality detected	No abnormality detected	No abnormality detected	Intact	Widened and thin	Outpouching of greater curvature

Fig.10. Contrast radiograph of the autopsy specimen of caudal oesophagus and stomach (Group I) showing increased width of gastroesophageal region and an out pouching of greater curvature of stomach

Fig.11. Photograph of the autopsy specimen of stomach and caudal oesophagus (Group I) showing the fibrous tissue covering over the surface of caudal oesophagus


G1-3-21d

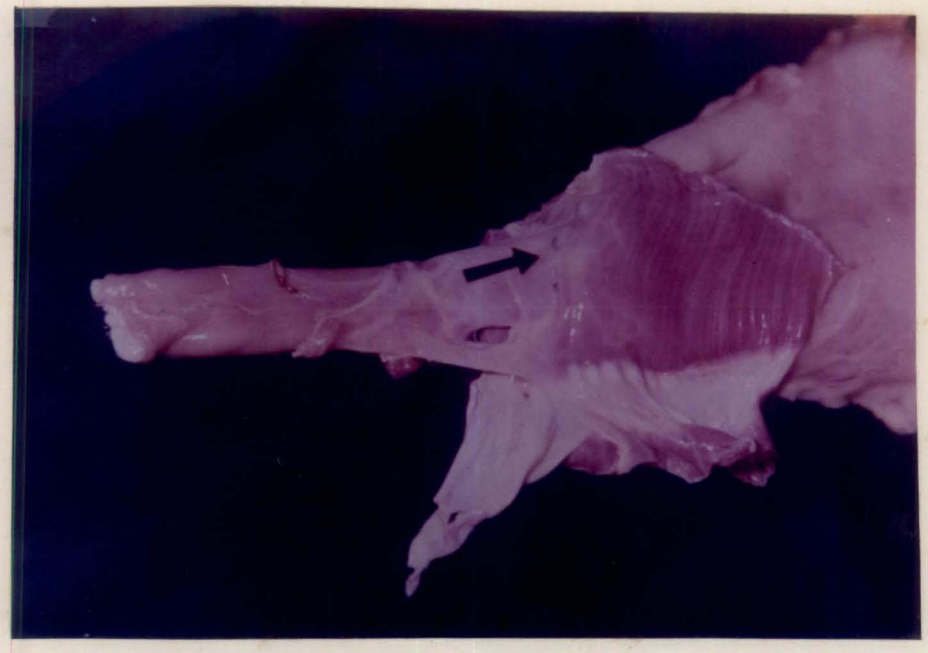
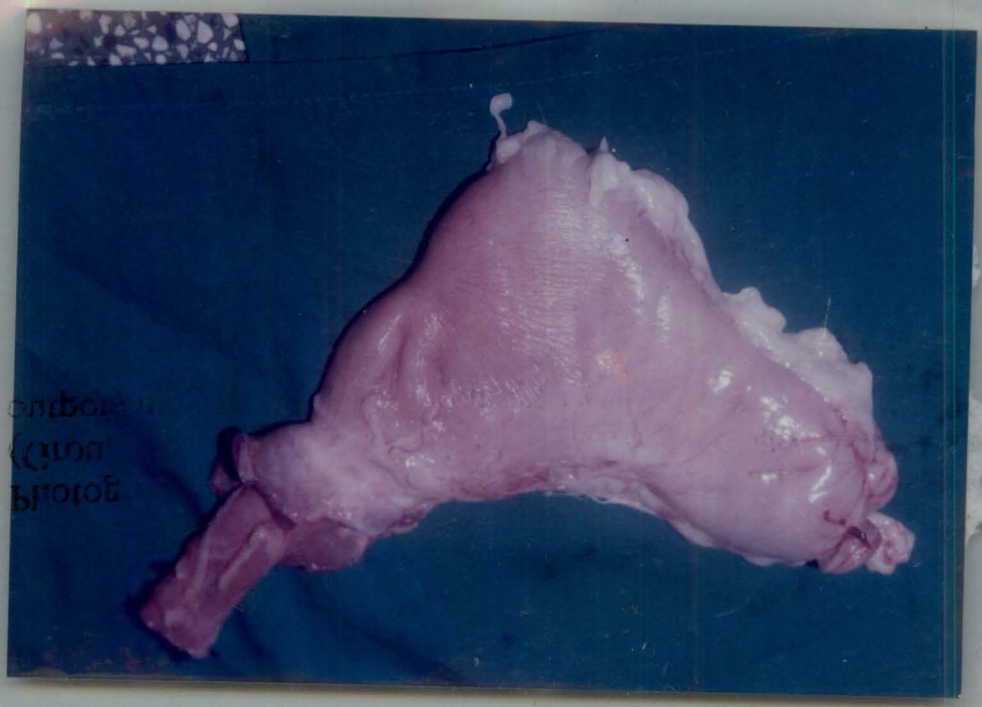


Fig.12. Photograph of the oesophagus and stomach (Group I) showing the normal mucosal surface

Fig.13. Photograph of the caudal oesophagus and stomach (Group I) showing the healed myotomy site and an outpouching at the greater curvature



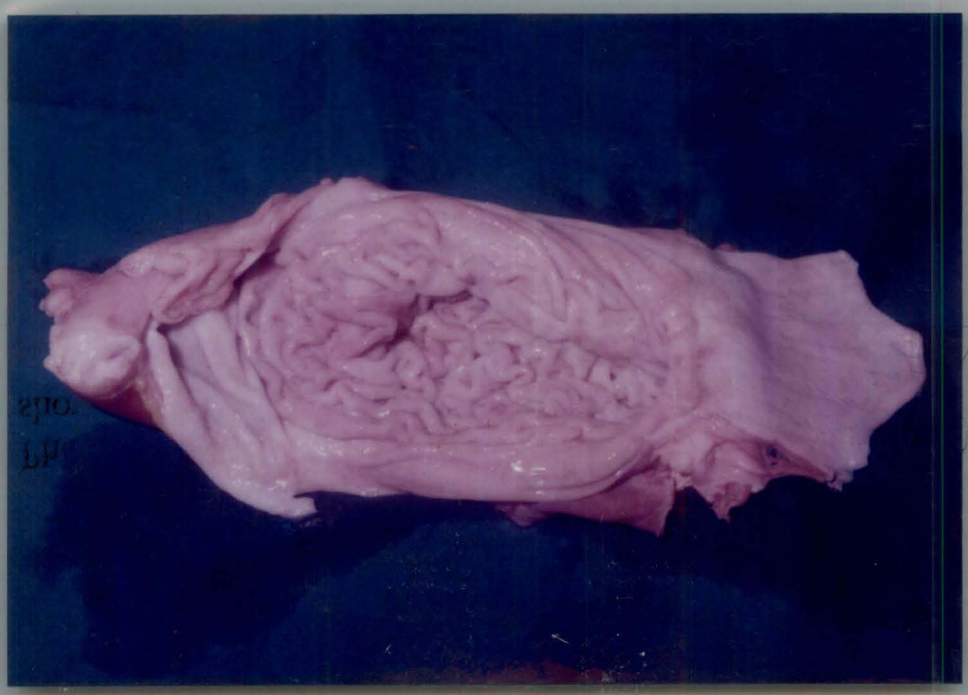
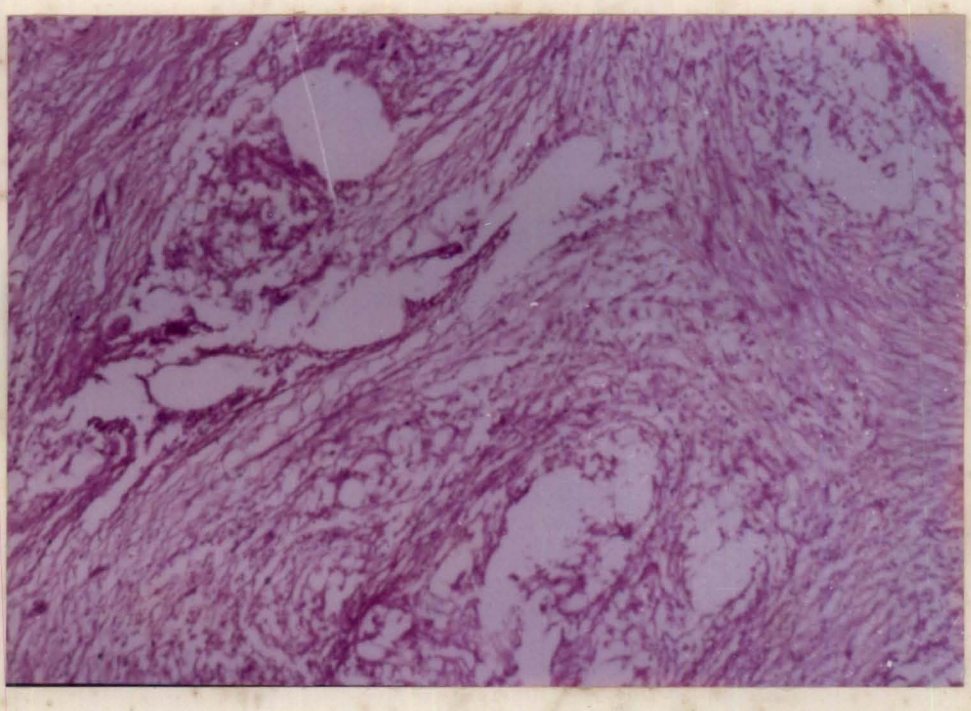


Fig.14. Photomicrograph of the gastroesophageal junction (Group I) showing the fibrovascular tissue proliferation at the myotomy site. (H&Ex250)



GROUP II

The observations are presented in Tables 7 to 11.

In this group of animals myotomy of the gastroesophageal junction was performed by a left side laparotomy approach through the 12th intercostal space along with resection of 12th rib.

Observation during surgery (Table 7)

Respiration was regular, smooth and shallow in two animals (B1 and B2) and rapid and shallow in three animals (B3, B4 and B5). Respiratory arrest for a short period during maintenance of anaesthesia was observed in one animal (B5). Dyspnea towards the end of surgery was observed in one animal (B6).

During laparotomy accidental opening into the thorax occurred in one animal (B6) and was sutured immediately. Oesophageal mucosa was penetrated in one animal (B6) during myotomy and was sutured.

Electrocardiogram revealed a decrease in the amplitude of R wave in five animals (B2, B3, B4, B5 and B6) and decrease in the heart rate in one animal (B1).

Physiological parameters (Table 8)

Rectal temperature (°C)

The rectal temperature (°C) was 39.30 ± 0.17 before anaesthesia. Significant decrease in rectal temperature ($P<0.05$) was observed at 30 min and 90 min after surgery but it became normal by 24 h and remained within the normal range there after during the period of observation.

Pulse rate (per minute)

The pulse rate (per minute) was 112.00 ± 0.53 before anaesthesia. The variations observed during the post operative period were within normal range.

Respiration rate (per minute)

The respiration rate (per minute) was 29.33 ± 1.51 before anaesthesia. Increase in respiration rate observed at 30 min, 90 min and at 24 h after surgery was significant ($P<0.05$). Respiration rate was within normal range from 7th day onwards.

Clinical signs (Table 9)

All the animals were alert and active by 24h after surgery and during the post operative period of observation except animal B5, which developed aspiration pneumonia after

administration of barium meal for radiography on the 14th day and died on the 16th day.

Appetite

Appetite was normal in all the animals throughout the period of observation.

Swallowing

Swallowing was normal in all the animals throughout the period of observation.

Regurgitation and vomiting

Regurgitation and vomiting was not observed in any of the animals.

Skin wound

Skin wound showed normal healing in all the animals and sutures were removed on the eighth day, except in two animals (B3 and B6), where swelling of the suture line with serosanguineous fluid was observed on the 6th day. The fluid was drained out and the wound was dressed with framycetin skin cream and it healed by 12th day.

Haemogram (Table 10)

The haemoglobin concentration (g/dl) was 12.72 ± 0.98 before anaesthesia. The variations observed during the post-operative period were marginal and within the normal range.

The erythrocyte sedimentation rate (mm/h) was 4.33 ± 3.14 before anaesthesia. The variations observed during the post operative period were marginal and within normal range.

The packed cell volume (per cent) was 37.50 ± 2.43 before anaesthesia. The variations observed during the post operative period were marginal and within normal range.

The total erythrocyte count ($10^6/mm^3$) was 5.72 ± 0.22 before anaesthesia. The variations observed during the post operative period were marginal and within normal range.

The total leucocyte count ($10^3/mm^3$) was 10.52 ± 0.60 before anaesthesia. The variations observed during the post operative period were marginal and within normal range.

The neutrophil count (per cent) was 65.17 ± 1.42 before anaesthesia. The variations observed during the post operative period were marginal and within normal range.

The lymphocyte count (per cent) was 27.67 ± 1.52 before anaesthesia. The variations observed during the post operative period were marginal and within normal range.

The monocyte count (per cent) was 2.00 ± 0.49 before anaesthesia. The variations observed during the post operative period were marginal and within normal range.

The eosinophil count (per cent) was 5.17 ± 0.70 before anaesthesia. The variations observed during the post operative period were marginal and within normal range.

The basophil was not observed in any of the blood samples.

Electrocardiogram

Decrease in heart rate was observed during surgery in animal B1 but immediately after surgery it increased to above normal and was within normal range by 24 h. An increase in heart rate was observed at 24 h in four animals (B3, B4, B5 and B6) and on 7th day in two animals (B1 and B4).

Decrease in the amplitude of R wave was observed, immediately after completion of surgery in four animals (B2, B3, B4 and B6) and it persisted upto 7th day in B2 and 14th day in B3.

An elevation of ST segment with spiking of T wave was observed at 24 h in two animals (B1 and B3) and on 14th day in one (B3). Increase in the amplitude of T wave was observed on the 7th and 14th day in two animals (B1 and B6).

Radiographic observation

Contrast radiography of the distal oesophagus and the stomach using barium meal showed normal emptying of the oesophagus into the stomach in all the animals. Signs of oesophagitis, hiatal hernia, leakage of contents and narrowing of the oesophageal lumen were not observed in any of the animals.

Contrast radiography of the distal oesophagus and the stomach from the autopsy specimen of animal No. B2 showed normal size of the oesophageal lumen, widening of the gastroesophageal region and the cardia. An outpouching of the stomach with an increase in the greater curvature with normal mucosal folds, was observed (Fig.15).

Terminal findings

All the animals were sacrificed at the end of the period of observation and gross morphological changes in and around the region of surgery were studied. Specimens collected from

two animals (B3 and B4) were subjected to histomorphological studies.

Gross morphological observations (Table 11)

Caudal thoracic oesophagus

Caudal thoracic oesophagus was normal in size and shape in all the animals.

Diaphragm

Diaphragm was normal and intact in all the animals.

Lungs

The lungs were normal in colour and consistency except in animal B5 where the lung lobes were congested, oedematous and contained whitish particles of barium sulphate inside.

Pleura

The pleura was normal in all the animals.

Oesophageal hiatus

The oesophageal hiatus was intact in all the animals. The hiatal incision has healed completely.

Gastroesophageal region and cardia

Increase in the width of the gastroesophageal region and cardia was observed in all the animals. The wall at the region of myotomy was thin. The myotomy incision at the level of cardia was adherent with the dome of diaphragm in one animal (B6) and with the abdominal wall in two animals (B1 and B4). The mucosa was smooth, with normal folds (Fig.16).

Stomach

The stomach was normal in size in all the animals. An outpouching of the wall of the stomach at the greater curvature was seen in all the animals (Fig.17) except in B5, which died on the 16th day of operation.

Peritoneum and omentum

Peritoneum was normal in all the animals. Adhesion of a small portion of greater omentum with the abdominal wall was seen in one animal (B4).

Histomorphological observations

Histomorphological examination of longitudinal sections prepared from the gastroesophageal region from animals B3 and B4 revealed healing of the myotomy site with fibrovascular connective tissue (Fig.18). The region was devoid of muscular

layers. The gastroesophageal junction revealed the normal transition of stratified squamous epithelium of the oesophageal mucosa to the columnar epithelium of the stomach. Oesophageal and gastric glands were normal. Remnants of the suture material were seen at the hiatal region.

Comparative evaluation of the two techniques indicated that

1. Approach to gastroesophageal region was satisfactory through the 12th intercostal abdominal approach with resection of 12th rib.

2. The abdominal approach provided exposure of the thoracic part of oesophageal sphincter without opening into the pleural cavity.

3. The exposed myotomy wound remained intraabdominal in position after closure of the hiatus, in both the groups.

4. Maintenance of respiration with respiration pump or Boyles' Tec anaesthetic apparatus was essential during surgery in thoracic approach.

5. Adhesion of lungs with chest wall or other thoracic organs were noticed in thoracic approach. Complications were minimum in abdominal approach.

Hence the abdominal approach through the 12th intercostal incision with resection of 12th rib was chosen for the surgical techniques in Groups III, IV and V.

Table 7. Observations on respiration, difficulties encountered in surgery and ECG changes during surgery in dogs (Group II)

Animal No.	Respiration	Difficulties encountered in surgery		ECG
		Laparotomy	Myotomy	
B1	Regular, smooth and shallow	-	-	Decrease in the heart rate
B2	Regular, smooth and shallow	-	-	Decrease in the amplitude of R wave
B3	Rapid and shallow towards the end	-	-	Decrease in the amplitude of R wave
B4	Rapid and shallow towards the end	-	-	Decrease in the amplitude of R wave
B5	Rapid and shallow towards the end	-	-	Decrease in the amplitude of R wave
B6	Rapid and shallow towards the end	Accidental opening into thorax	Accidental penetration of oesophageal mucosa	Decrease in the amplitude of R wave

Table 8. Rectal temperature, pulse rate and respiration rate before surgery and on different post operative periods in dogs (Group II) (Mean±SE)

n=6

Physiological parameters	0 min	30 min	90 min	24 h	7 d	14 d	21 d
Temperature (°C)	39.30± 0.17	* 36.69± 0.42	* 37.59± 0.65	39.30± 0.25	39.11± 0.23	38.93± 0.11	39.05± 0.17
Pulse (per minute)	112.00± 2.53	105.33± 5.13	118.67± 8.54	127.33± 5.31	114.33± 2.33	112.00± 4.62	106.40± 4.11
Respiration (per minute)	29.33± 1.51	* 56.33± 10.70	* 63.33± 12.30	* 57.33± 11.81	33.00± 2.17	29.33± 1.68	28.40± 2.22

* Significant at 5 per cent level as compared to value at 0 min

Table 9. Clinical observations during the post operative period in dogs (Group II)

Animal No.	General condition	Appetite	Swallowing	Regurgitation/ vomition	Skin sound	Others
B1	Good	Normal	Normal	Absent	Normal healing	-
B2	Good	Normal	Normal	Absent	Normal healing	-
B3	Good	Normal	Normal	Absent	Normal healing	-
B4	Good	Normal	Normal	Absent	Swelling of the suture line on 6th day	-
B5	Good	Normal	Normal	Absent	Normal healing	Aspirated barium meal on 14th day and died on the 16th day
B6	Good	Normal	Normal	Absent	Swelling of the suture line on 6th day	-

Table 10. Haemogram before surgery and on different postoperative periods in dogs (Group II) (Mean±SE)

n=6

Parameters and units	0 min	Post operative intervals			
		Immediately after	7th day	14th day	21st day
Haemoglobin concentration (g/dl)	12.72± 0.98	12.94± 0.77	12.97± 0.58	13.05± 0.79	12.90± 0.81
Erythrocyte sedimentation rate (mm/h)	4.33± 3.14	5.08± 2.30	3.92± 1.32	2.50± 1.12	1.20± 0.20
Packed cell volume (%)	37.50± 2.43	39.50± 2.24	35.67± 1.86	35.17± 2.40	36.60± 1.40
Total erythrocyte count (10^6/mm^3)	5.72± 0.22	5.37± 0.37	6.11± 0.34	5.75± 0.17	5.95± 0.18
Total leucocyte count (10^3/mm^3)	10.52± 0.60	10.41± 0.75	9.81± 0.67	11.10± 0.64	9.89± 1.17
Neutrophil count (%)	65.17± 1.42	64.33± 2.75	63.00± 2.40	66.50± 2.42	65.00± 2.75
Lymphocyte count (%)	27.67± 1.52	30.33± 2.97	28.83± 2.43	27.33± 2.51	28.80± 2.53
Monocyte count (%)	2.00± 0.49	1.33± 0.33	1.83± 0.30	1.67± 0.49	1.40± 0.40
Eosinophil count (%)	5.17± 0.70	5.67± 0.66	5.33± 0.62	4.33± 0.33	4.80± 0.86
Basophil count (%)	0.00	0.00	0.00	0.00	0.00

Table 11. Gross morphological changes observed during autopsy in dogs (Group II)

Animal No.	Caudal thoracic oesophagus	Lungs	Oesophageal hiatus	Gastro-oesophageal region and cardia	Stomach	Omentum
B1	No abnormality detected	No abnormality detected	Intact	Widened and thin. Adhesion of cardia at myotomy site with abdominal wall	Out pouching of greater curvature	No abnormality detected
B2	No abnormality detected	No abnormality detected	Intact	Widened and thin	Out pouching of greater curvature	No abnormality detected
B3	No abnormality detected	No abnormality detected	Intact	Widended and thin	Out pouching of greater curvature	No abnormality detected
B4	No abnormality detected	No abnormality detected	Intact	Widened and thin. Adhesion of cardia at myotomy site with abdominal wall	Out pouching of greater curvature	Adhesion of greater omentum with abdominal wall
B5	No abnormality detected	Congested and oedematus, contained whitish deposits of barium inside	Intact	Widened and thin	Normal size and shape	No abnormality detected
B6	No abnormality detected	No abnormality detected	Intact	Widened and thin, portion of myotomy site was adherent with diaphragm	Out pouching of greater curvature	No abnormality detected

Fig.15. Contrast radiograph of the autopsy specimen of caudal oesophagus and stomach (Group II) showing increased width at the gastroesophageal region

Fig.16. Photograph of the gastroesophageal region (Group II) showing the normal mucosal folds

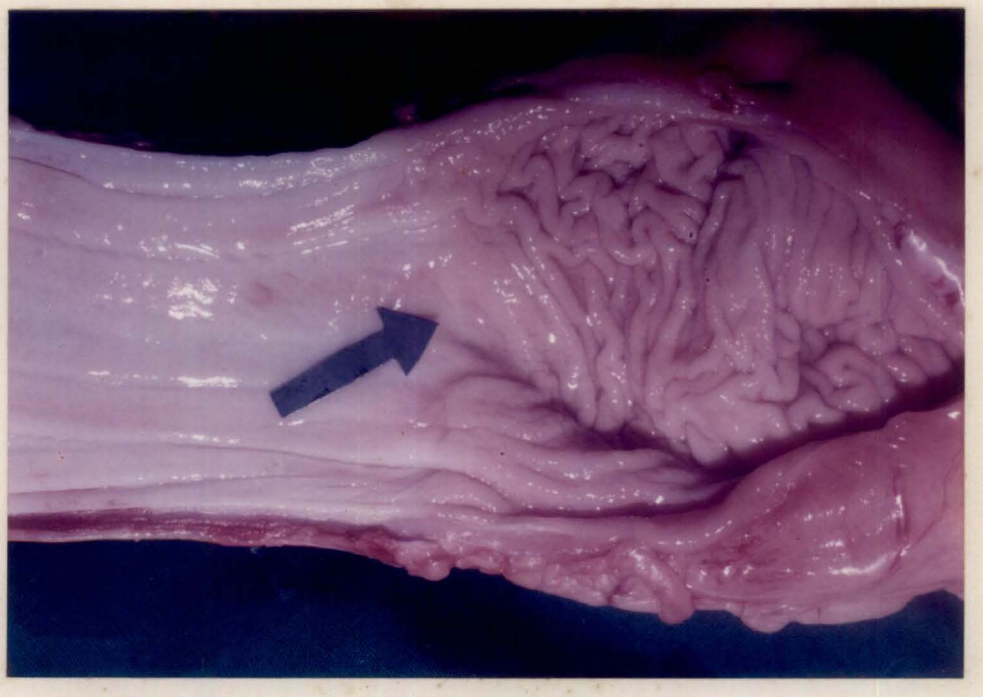
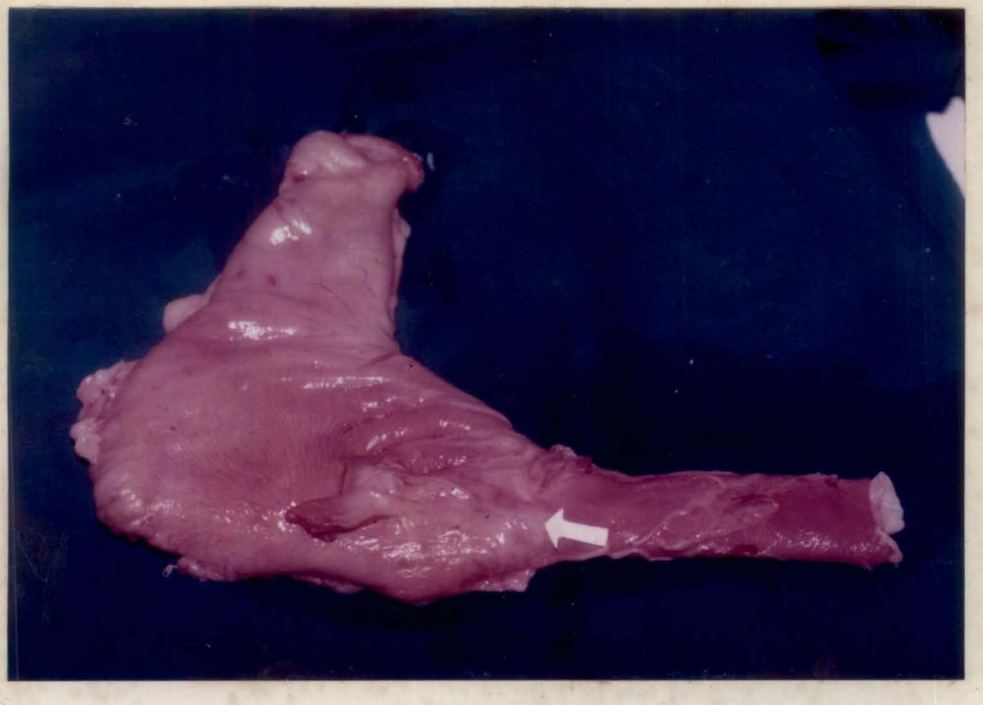
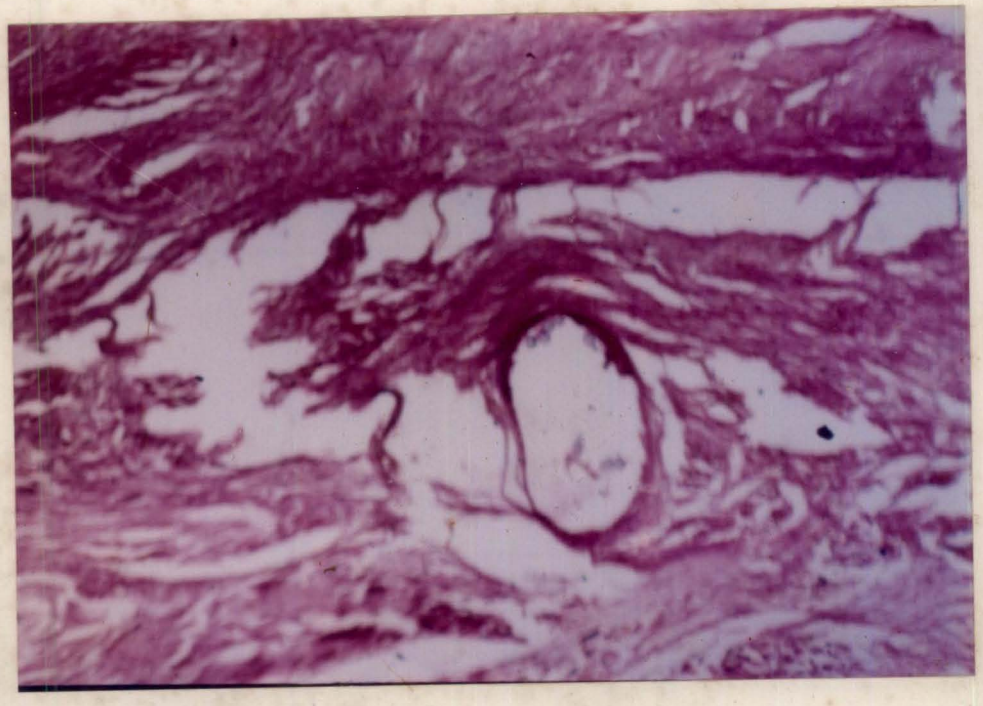


Fig.17. Photograph of the caudal oesophagus and stomach (Group II) showing the healed myotomy site and an outpouching at the greater curvature

Fig.18. Photomicrograph of the gastroesophageal junction (Group II) showing the fibrovascular proliferation at the myotomy site (H&Ex400)





GROUP III

The observations are presented in Tables 12 to 15.

In this group of animals myotomy of the gastroesophageal junction was performed by left side laparotomy through the 12th intercostal space along with resection of 12th rib. The myotomy wound was sutured with the overlying portion of diaphragm, along the wound edges.

Observation during surgery (Table 12)

Respiration was regular, smooth and shallow in four animals (C2, C3, C4 and C5). In one animal (C1) dyspnea was noticed towards the end of surgery and in one animal (C6), rapid shallow respiration was observed. Dyspnea was corrected by administration of oxygen and rapid shallow respiration was controlled by administration of anaesthestic.

During laparotomy thorax was opened accidently in animals C1 and C5 and during myotomy oesophagus was penetrated into the lumen in one animal (C3).

Electrocardiogram revealed decreased amplitude of R wave in three animals (C1, C3 and C6) and elevated T wave in animal C5. A variation in the amplitude of R wave manifested by a

gradual decrease in amplitude for three followed by a gradual increase to normal for three were observed in one animal (C6).

Physiological parameters (Table 13)

Rectal temperature (°C)

The rectal temperature (°C) was 39.15 ± 0.16 before anaesthesia Significant decrease ($P<0.05$) in rectal temperature was observed at 30 min and 90 min. It became normal by 24 h and remained within the normal range thereafter during the period of observation.

Pulse rate (per minute)

The pulse rate (per minute) was 117.00 ± 8.23 before anaesthesia. Significant increase ($P<0.05$) in pulse rate was observed at 30 min and 90 min after surgery. Pulse rate was within normal range from 24 h after surgery and remained in the normal range thereafter during the period of observation.

Respiration rate (per minute)

The respiration rate (per minute) was 35.33 ± 5.10 before anaesthesia, and an increase in respiration rate within normal range was observed at 30 min and 90 min after surgery. It was within the normal range by 24 h and remained in the normal range thereafter during the period of observation.

Clinical signs (Table 14)

General condition

All the animals were alert and active from 24 h after surgery.

Appetite

Appetite was normal in all the animals throughout the period of observation.

Swallowing

Swallowing was normal in all the animals throughout the period of observation.

Regurgitation and vomiting

Regurgitation and vomiting was not observed in any of the animals.

Skin wound

Skin wound showed normal healing in all the animals. The sutures were removed on the eighth day in four animals. In two animals (C4 and C6), swelling of the suture line and presence of serosanguineous fluid was observed from 6th to 12th day and the wound has completely healed by 14th day.

Haemogram (Table 15)

The haemoglobin concentration (g/dl) was 11.66 ± 0.96 before anaesthesia and the variations noticed in the post operative period were marginal and within the normal range.

The erythrocyte sedimentation rate (mm/h) was 3.50 ± 2.68 before anaesthesia and the variations noticed in the post operative period were marginal and within normal range. Diphasic ESR was noticed in one animal (C3) throughout the period of observation including the preanaesthetic period with a minimum reading on 21st day.

The packed cell volume (per cent) was 34.33 ± 2.68 before anaesthesia and the variations noticed during the post operative period were marginal and within normal range.

The total erythrocyte count ($10^6/mm^3$) was 5.70 ± 0.42 before anaesthesia and the variations observed during the post operative period were marginal and within normal range.

The total leucocyte count ($10^3/mm^3$) was 10.33 ± 0.7[illegible] before anaesthesia and the variations noticed during the post operative period were marginal and within normal range.

The neutrophil count (per cent) was 70.17 ± 2.52 before anaesthesia and the variations noticed during the post operative period were marginal and within normal range.

The lymphocyte count (per cent) was 25.33 ± 2.29 before anaesthesia and significant decrease ($P<0.05$) in the count was observed on 14th day but it was within normal range by 21st day.

The monocyte count (per cent) was 2.17 ± 0.40 before anaesthesia and the variations noticed in the post operative period were marginal and within normal range.

The eosinophil count (per cent) was 2.33 ± 0.33 before anaesthesia and the variations noticed in the post operative period were marginal and within normal range.

Basophil was not observed in any of the blood samples.

Electrocardiogram

An increase in heart rate was observed immediately after surgery in two animals (C1 and C3). In animal No.C3 increased rate was also observed on 7th and 14th day. A variation in the amplitude of R wave manifested by a gradual decrease in amplitude for three beats followed by a gradual increase for three beats, was observed immediately after surgery in animal C2.

Decrease in the amplitude of R wave was observed immediately after surgery in two animals (C1 and C3) but became normal at 24 h.

Increase in the amplitude of T wave was observed, immediately after surgery and at 24 h in one animal (C5)and only at 24 h in animals C1 and C2. In animal C3 elevated spiked T wave was observed on 7th and 14th day.

Radiographic observation

Barium meal contrast radiography of the distal oesophagus and the stomach revealed normal emptying of the eosophagus into the stomach in all the animals. In one animal (C2) slight dilatation of the stomach was observed on 21st day. Signs of oesophagitis, hiatal hernia, leakage of contents and narrowing of the oesophageal lumen were not observed in any of the animals.

Terminal findings

All the animals were sacrificed at the end of the period of observation and gross morphological changes in and around the region of surgery was studied. Specimens collected from two animals (C3 and C4) were subjected to histomorphological studies.

Gross morphological observation (Table 16)

Caudal thoracic oesophagus

The caudal thoracic oesophagus was normal in size and shape in all the animals. In animal C2 the caudal end of the

oesophagus, just above the level of hiatus, showed a clear demarcation of the mucosa with thickening for a length of two centimetres and a few Spirocerca nodules.

Diaphragm

Diaphragm was normal and intact in all the animals and the sutured portion with the myotomy wound was firmly adherent with the myotomy site (Fig.19).

Lungs

The lungs were normal in colour and consistancy in all the animals.

Pleura

The pleura was normal in all the animals.

Oesophageal hiatus

The oesophageal hiatus was intact in all the animals. The hiatal incision has healed completely.

Gastroesophageal region and cardia

In all the animals, an increase in the width of the gastroesophageal region and cardia were observed. The myotomy

edges sutured with diaphragm were firmly adherent and the mucosal surface was normal.

Stomach

Stomach was normal in size and an outpouching of the greater curvature was noticed in all the animals except in one (C2). In animal C2, slight dilatation and flaccidity of the stomach was noticed.

Peritoneum and omentum

The peritoneum was normal in all the animals. In two animals (C1 and C5) a portion of omentum was adherent with abdominal wall at the suture line.

Histomorphological observations

Histomorphological examination of the gastroesophageal junction in animals C3 and C4 revealed normal mucosa, submucosa and submucosal glands. The myotomy site was devoid of oesophageal muscular layers. The myotomy site showed proliferation of fibrovascular connective tissue over which diaphragmatic muscle fibrils were seen in fascicles (Fig.20). Remnants of suture materials were also observed.

Table 12. Observations on respiration, difficulties encountered in surgery and ECG changes during surgery in dogs (Group III)

Animal No.	Respiration	Difficulties encountered in surgery		ECG
		Laparotomy	Myotomy	
C1	Dyspnea towards the end	Accidental opening into the thorax	-	Decrease in the amplitude of R wave
C2	Regular, smooth and shallow	-	-	Normal
C3	Regular, smooth and shallow	-	Accidental penetration of oesophageal mucosa	Decrease in the amplitude of R wave
C4	Regular, smooth and shallow	-	-	Normal
C5	Regular, smooth and shallow	Accidental opening into the thorax	-	Increase in the amplitude of T wave
C6	Rapid, shallow towards the end	-	-	Variation in the amplitude of R wave

Table 13. Rectal temperature, pulse rate and respiration rate before surgery and on different post operative periods in dogs (Group III) (Mean±SE)

n=6

Physiological parameters	0 min	30 min	90 min	24 h	7 d	14 d	21 d
Temperature (°C)	39.15± 0.16	36.57± 0.49 *	37.65± 0.51 *	38.85± 0.23	38.82± 0.02	38.83± 0.02	38.83± 0.02
Pulse (per minute)	117.00± 8.23	146.00± 14.78 *	150.33± 12.97 *	127.67± 10.46	111.00± 6.00	111.00± 3.44	108.67± 4.43
Respiration (per minute)	35.33± 5.10	46.67± 8.04	49.67± 9.88	42.00± 5.93	37.67± 7.73	35.00± 6.60	30.67± 2.28

* Significant at 5 per cent level as compared to value at 0 min

Table 14. Clinical observations during the post operative period in dogs (Group III)

Animal No.	General condition	Appetite	Swallowing	Regurgitation/ vomition	Skin wound
C1	Good	Normal	Normal	Absent	Normal healing
C2	Good	Normal	Normal	Absent	Normal healing
C3	Good	Normal	Normal	Absent	Normal healing
C4	Good	Normal	Normal	Absent	Swelling on the suture line seen on the 6th day
C5	Good	Normal	Normal	Absent	Normal healing
C6	Good	Normal	Normal	Absent	Swelling on the suture line seen on the 6th day

Table 15. Haemogram before surgery and on different postoperative periods in dogs (Group III) (Mean±SE)

n=6

Parameters and units	0 min	Post operative intervals			
		Immediately after	7th day	14th day	21st day
Haemoglobin concentration (g/dl)	11.66± 0.96	11.49± 0.47	11.11± 0.56	11.77± 1.02	11.59± 0.55
Erythrocyte sedimentation rate (mm/h)	3.50± 1.80	1.67± 0.56	2.00± 0.45	1.83± 0.40	1.50± 0.48
Packed cell volume (%)	34.33± 2.68	33.33± 1.76	31.83± 1.62	32.17± 1.04	33.67± 1.87
Total erythrocyte count (10^6/mm^3)	5.70± 0.42	5.28± 0.32	5.30± 0.31	5.50± 0.34	5.66± 0.27
Total leucocyte count (10^3/mm^3)	10.33± 0.77	11.16± 0.66	11.78± 0.61	12.29± 0.72	11.22± 1.02
Neutrophil count (%)	70.17± 2.52	74.33± 2.28	75.67± 1.42	76.67± 1.20	72.33± 1.20
Lymphocyte count (%)	25.33± 2.29	22.17± 2.36	20.33± 1.33	19.01*± 1.28	22.83± 1.11
Monocyte count (%)	2.17± 0.40	1.50± 0.22	2.33± 0.38	2.50± 0.43	2.67± 0.49
Eosinophil count (%)	2.33± 0.33	2.00± 0.36	1.67± 0.33	1.83± 0.40	2.17± 0.37
Basophil count (%)	0.00	0.00	0.00	0.00	0.00

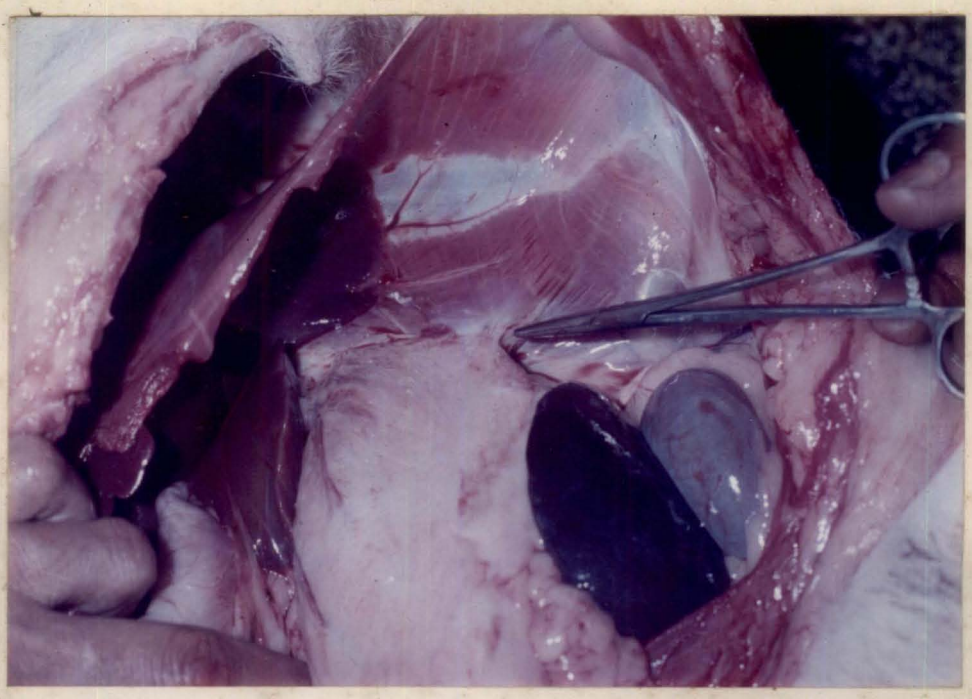
* Significant at 5 per cent level as compared to value at 0 min

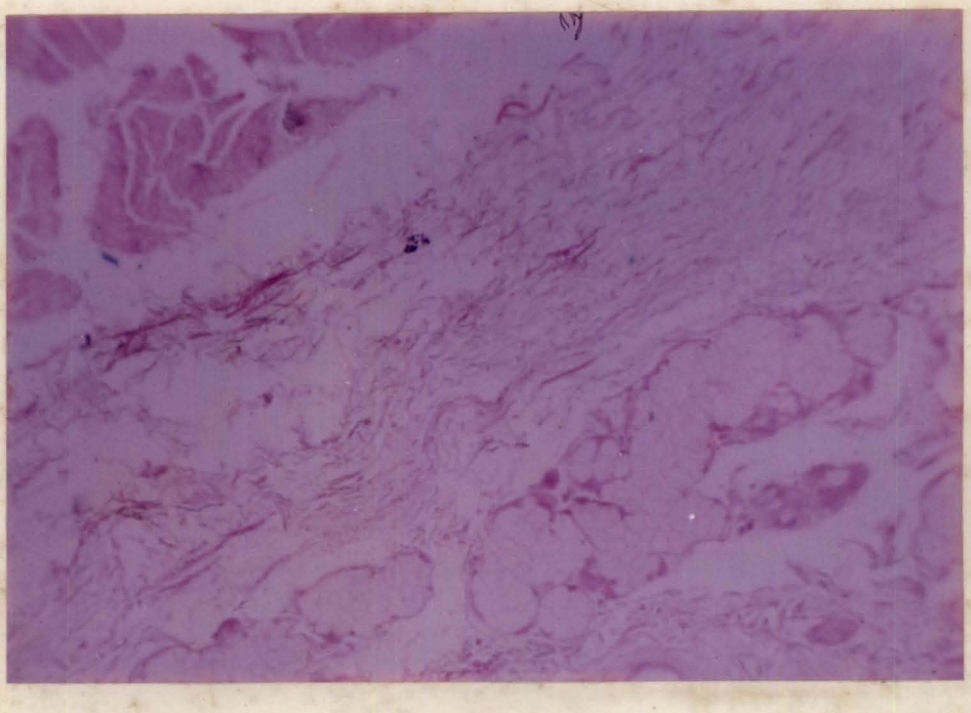
Table 16. Gross morphological changes observed during autopsy in dogs (Group III)

Animal No.	Caudal thoracic oesophagus	Diaphragm	Oesophageal hiatus	Gastro-oesophageal region and cardia	Stomach	Omentum	Others
C1	No abnormality detected	Normal and sutured portion with myotomy site healed completely	Intact	Widened and myotomy site firmly adherent with sutured diaphragm	Outpouching of greater curvature	A small portion adhered with abdominal wall	-
C2	Size and shape normal but mucosa showed a clear demarcation for 2 cm long from the hiatus anteriorly	Normal and sutured portion with myotomy site healed completely	Intact	Widened and myotomy site firmly adherent with sutured diaphragm	Slight dialatation and flaccidity	Normal	Spirocerca nodules in the oesophagus
C3	No abnormality detected	Normal and sutured portion with myotomy site healed completely	Intact	Widened and myotomy site firmly adherent with sutured diaphragm	Outpouching of greater curvature	Normal	-
C4	No abnormality detected	Normal and sutured portion with myotomy site healed completely	Intact	Widened and myotomy site firmly adherent with sutured diaphragm	Outpouching of greater curvature	Normal	-
C5	No abnormality detected	Normal and sutured portion with myotomy site healed completely	Intact	Widened and myotomy site firmly adherent with sutured diaphragm	Outpouching of greater curvature	A small portion adhered with abdominal wall	-
C6	No abnormality detected	Normal and Sutured portion with myotomy site healed completely	Intact	Widened and myotomy site firmly adherent with sutured diaphragm	Outpouching of greater curvature	A small portion adherent with abdominal wall	-

Fig.19. Photograph of the autopsy specimen of gastroesophageal region and stomach in situ, showing the adhesion between diaphragm and myotomy site (Group III)

Fig.20. Photomicrograph of the myotomy site at the gastroesophageal junction (Group III) showing the diaphragmatic muscle fibrils over the fibrovascular layer (H&Ex320)





GROUP IV

The observations are presented in Tables 17 to 22.

In this group of animals, myotomy of the gastroesophageal junction was performed by a left side laparotomy through the 12th intercostal space, along with resection of 12th rib. The myotomy wound was sutured to diaphragmatic pedicle graft.

Observation during surgery (Table 17)

Respiration was regular, smooth and shallow, in four animals (D1, D3, D4 and D5) during surgery. In two animals (D1 and D6) respiration was regular and shallow, followed by exaggerated type. Animal D6 has not recovered from anaesthesia administered for maintenance and died immediately after surgery.

During myotomy, oesophageal mucosa was penetrated in one animal (D4).

Electrocardiogram revealed decreased amplitude of R wave in all the animals except D6, an elevation of ST segment in animal D5 and an elevated T wave in animal D4. Tachycardia with arrhythmia was observed in animal D6.

Physiological parameters (Table 18)

Rectal temperature (°C)

The rectal temperature (°C) was 39.07 ± 0.12 before anaesthesia. Significant decrease in rectal temperature ($P<0.05$) noticed at 30 min and 90 min after surgery became normal by 24 h and remained in the normal range thereafter during the period of observation.

Pulse rate (per minute)

The pulse rate (per minute) was 106.67 ± 5.02 before anaesthesia and the significant increase in pulse rate ($P<0.05$) observed at 30 min and 90 min after surgery was with in normal range at 24 h and remained in the normal range thereafter during the period of observation.

Respiration rate (per minute)

The respiration rate (per minute) was 30.00 ± 1.78 before anaesthesia. Significant increase in respiration rate ($P<0.05$) observed at 30 min and 90 min after surgery, was with in normal range at 24 h and remained in the normal range thereafter during the period of observation.

Clinical signs (Table 19)

General condition

All the animals were alert and active by 48h except one (D6) which did not recover from anaesthesia after surgery. Animals D1, D3 and D4 were dull upto two days.

Heart sounds and respiratory sounds were normal by 48 h in all the animals except one (D6). In animal D4 moist rales and occasional cough were observed during the second week of observation.

Appetite

Appetite was normal in all the animals throughout the period of observation, except in one (D4) where poor feed intake was noticed for the first three days.

Swallowing

Swallowing was normal in all the animals.

Regurgitation and vomiting

Regurgitation and vomiting was not observed in any of the animals except in animal D4 where vomiting was noticed once on the 2nd day after surgery.

Skin wound

Skin wound showed normal healing in all the animals and sutures were removed on the eighth day.

Haemogram (Table 20)

Haemoglobin concentration (g/dl) was 11.77 ± 0.82 before anaesthesia and the variations noticed during the post operative period were marginal and within the normal range.

The erythrocyte sedimentation rate (mm/h) was 0.83 ± 0.40 before anaesthesia and the variations noticed during the post operative period were marginal and within normal range.

The packed cell volume (per cent) was 35.00 ± 2.56 before anaesthesia and the variations observed during the post operative period were marginal and within normal range.

The total erythrocyte count ($10^6/mm^3$) was 5.90 ± 0.35 before anaesthesia and the variations observed during the post operative period were marginal and within normal range.

The total leucocyte count ($10^3/mm^3$) was 10.85 ± 1.10 before anaesthesia and the variations observed during the post operative period were marginal and within normal range.

The neutrophil count (per cent) was 70.17 ± 0.98 before anaesthesia and the variations observed during the post operative period were marginal and within normal range.

The lymphocyte count (per cent) was 25.83 ± 1.07 before anaesthesia and the variations noticed during the post operative period were marginal and within normal range.

The monocyte count (per cent) was 2.67 ± 0.33 before anaesthesia and the variations observed during the post operative period were marginal and within normal range.

The eosinophil count (per cent) was 1.33 ± 0.33 before anaesthesia and the variations observed during the post operative period were marginal and within normal range.

Basophil was not observed in any of the blood samples.

Electrocardiogram (ECG)

An increase in heart rate was observed in two animals (D3 and D5) immediately after completion of surgery.

Decrease in the amplitude of R wave was observed immediately after surgery in three animals (D2, D3 and D4) and till the completion of surgery in 2 animals (D1 and D5).

An elevation of ST segment was observed in one animal (D5) during surgery.

Elevated and spiked T wave was observed upto the 14th day of observation in one animal (D4).

Radiographic observation

Barium meal contrast radiography of the distal oesophagus and the stomach showed normal emptying of the oesophagus into the stomach in all the animals. In two animals (D1 and D3) the abdominal portion of the oesophagus showed an upward curvature, (Fig.21) by which it appeared to be joining the stomach more vertically, in the lateral view. The size of oesophagus and stomach was found normal, in all the animals. Signs of esophagitis, hiatal hernia, leakage of contents and narrowing of the oesophageal lumen were not observed in any of the animals.

Terminal findings

All the animals were sacrificed at the end of the period of observation and gross morphological changes in and around the region of surgery were studied. Specimens collected from two animals (D3 and D4) were subjected to histomorphological studies.

Gross morphological observations (Table 21)

Caudal thoracic oesophagus

The caudal end of the oesophagus was normal in size and shape with normal mucosal folds in all the animals.

Diaphragm

The diaphragm was intact in all the animals. The suture line in the diaphragm has healed completely and the diaphragm pedicle graft sutured to the myotomy site was firmly adherent with the oesophagus (Fig.22).

The suture line in the diaphragm at the thoracic side was adherent with the thoracic wall, in four animals (D1, D2, D3 and D4).

Lungs

Lungs were normal in colour and consistency in all the animals except in animals D4 and D6. In D4, it contained greyish white patches on the surface and gritty particles along the border. In animal D6 the lung was completely collapsed.

Pleura

Pleura was normal in all the animals.

Oesophageal hiatus

The oesophageal hiatus was intact in all the animals. The hiatal incision has healed completely. In animal D6, the sutures in the oesophageal hiatus was intact.

Gastroesophageal region and cardia

Gastroesophageal region and cardia showed an increased width. The diaphragm pedicle sutured to the myotomy site has healed and was adherent with myotomy site in all the animals. The dorsal portion of diaphragmatic pedicle graft was adherent with the dome of diaphragm in two animals (D1 and D3). The sutured area of the mucosal penetration showed an elevation of the mucosal surface around the suture in animal D4.

Stomach

Stomach was normal in size and an outpouching of the greater curvature was observed in all the animals.

Peritoneum and omentum

The peritoneum was normal in all the animals. In two animals (D1 and D2) a portion of omentum was adherent with abdominal wound.

Other changes

In animal D6 the spleen was granular in appearance with greyish white patches at the middle region.

Histomorphological observations

Histomorphological examination of the gastroesophageal junction in animal D3 revealed normal mucosa, and submucosa. In animal D4 hypertrophy of the mucosal surface was observed, at the region of mucosal penetration. In both the animals, the myotomy site was devoid of oesophageal musculature. A thin layer of fibrovascular connective tissue was observed peripheral to submucosa (Fig.23). The diaphragmatic muscle fibrils in fascicles were seen over the fibrovascular connective tissue (Fig.24). No cellular infiltration was observed.

Table 17. Observations on respiration, difficulties encountered in surgery and ECG changes during surgery in dogs (Group IV)

Animal No.	Respiration	Difficulties encountered in surgery	ECG
		Myotomy	
D1	Regular, smooth and shallow	-	Decrease in the amplitude of R wave
D2	Exagerated towards the end	-	Decrease in the amplitude of R wave
D3	Regular, smooth and shallow	-	Decrease in the amplitude of R wave
D4	Regular, smooth and shallow	Accidental penetration of oesophageal mucosa	Decrease in the amplitude of R wave and increase in the amplitude of T wave
D5	Regular, smooth and shallow	-	Decrease in the amplitude of R wave and elevation of ST segment
D6	Exagerated towards the end	-	Tachycardia with arrhythmia

Table 18. Rectal temperature, pulse rate and respiration rate before surgery and on different post operative periods in dogs (Group IV) (Mean±SE)

n=6

Physiological parameters	0 min	30 min	90 min	24 h	7 d	14 d	21 d
Temperature (°C)	39.07± 0.12	36.44± 0.44 *	37.64± 0.11 *	38.44± 0.22	38.80± 0.66	38.82± 0.14	38.87± 0.06
Pulse (per minute)	106.67± 5.02	136.67± 23.76 *	154.00± 3.99 *	119.60± 3.48	108.40± 5.30	105.60± 4.06	111.20± 6.27
Respiration (per minute)	30.00± 1.78	62.40± 6.16 *	55.20± 3.37 *	41.20± 1.62	38.40± 5.73	46.40± 10.90	41.60± 7.18

* Significant at 5 per cent level as compared to value at 0 min

Table 19. Clinical observations during the post operative period in dogs (Group IV)

Animal No.	General condition	Appetite	Swallowing	Regurgitation vomition	Skin wound	Others
D1	Dull and unsteady for 2 days	Normal	Normal	Absent	Normal healing	-
D2	Good	Normal	Normal	Absent	Normal healing	-
D3	Dull and weak for 2 days	Normal	Normal	Absent	Normal healing	Muffling of heart sound upto 24 h
D4	Dull for first 2 days	Poor during the first 3 days	Normal	Vomitted once on the 2nd day of surgery	Normal healing	Moist rales on auscultation of lung during the 2nd week and occasional cough
D5	Good	Normal	Normal	Absent	Normal healing	-
D6	Not recovered from anaesthesia	-	-	-	-	-

Table 20. Haemogram before surgery and on different postoperative periods in dogs (Group IV) (Mean±SE)

*n=6, ** n=5

Parameters and units	Post operative intervals				
	* 0 min	** Immediately after	** 7th day	** 14th day	** 21st day
Haemoglobin concentration (g/dl)	11.77± 0.82	11.72± 1.30	11.48± 0.82	11.98± 0.52	11.67± 0.89
Erythrocyte sedimentation rate (mm/h)	0.83± 0.40	0.80± 0.37	1.20± 0.70	1.20± 0.20	0.80± 0.20
Packed cell volume (%)	35.00± 2.56	34.60± 4.50	33.20± 2.33	37.60± 1.94	33.20± 2.84
Total erythrocyte count ($10^6/mm^3$)	5.90± 0.35	5.71± 0.64	5.70± 0.39	5.57± 0.34	5.54± 0.44
Total leucocyte count ($10^3/mm^3$)	10.85± 1.10	11.99± 0.62	12.84± 1.12	12.38± 0.51	12.19± 0.98
Neutrophil count (%)	70.17± 0.98	72.40± 0.81	74.40± 2.94	69.40± 4.87	71.80± 4.32
Lymphocyte count (%)	25.83± 1.07	24.40± 0.39	22.20± 2.70	26.80± 5.25	24.80± 4.29
Monocyte count (%)	2.67± 0.33	2.00± 0.31	1.80± 0.37	3.20± 0.49	2.60± 0.24
Eosinophil count (%)	1.33± 0.33	1.20± 0.20	1.60± 0.39	0.60± 0.24	0.80± 0.37
Basophil count (%)	0.00	0.00	0.00	0.00	0.00

Table 21. Gross morphological changes observed during autopsy in dogs (Group IV)

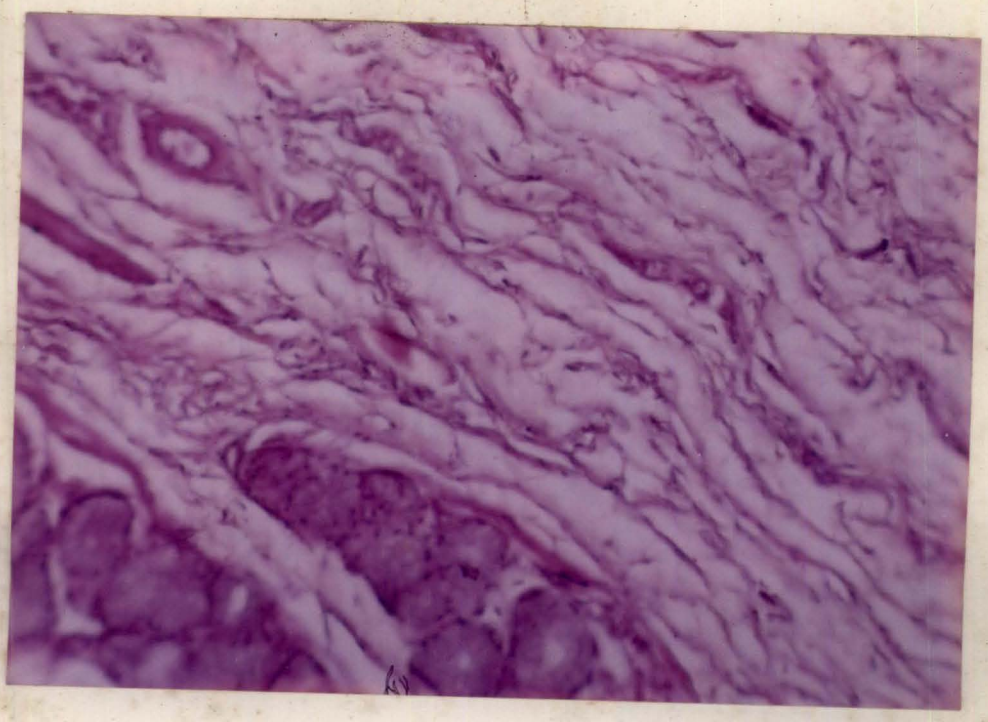
Animal No.	Caudal thoracic oesophagus	Diaphragm	Lungs	Pleura	Oesophageal hiatus	Gastro-oesophageal region and cardia	Stomach	Omentum
D1	No abnormality detected	Suture line healed and adherent with chest wall at thoracic side	Normal	No abnormality detected	Intact	Widened and diaphragm pedicle healed with myotomy wound, and adherent with diaphragm above	Outpouching of greater curvature	A portion adherent with abdominal wound
D2	No abnormality detected	Suture line healed and adherent with chest wall at thoracic side	Normal	No abnormality detected	Intact	Widened and diaphragm pedicle healed with myotomy wound	Outpouching of greater curvature	A portion adherent with abdominal wound
D3	No abnormality detected	Suture line healed and adherent with chest wall at thoracic side	Normal	No abnormality detected	Intact	Widened and diaphragm pedicle healed with myotomy wound and adherent with diaphragm above	Outpouching of greater curvature	No abnormality
D4	No abnormality detected	Suture line healed and adherent with chest wall at thoracic side	Contained greish white patches throughout and gritty particles at the border	No abnormality detected	Intact	Widened and diaphragm pedicle healed with myotomy wound. Mucosal surface raised around the site of penetration	Outpouching of greater curvature	No abnormality
D5	No abnormality detected	Suture line healed well	Normal	No abnormality detected	Intact	Widened and diaphragm pedicle healed with myotomy wound	Outpouching of greater curvature	No abnormality
D6	No abnormality detected	Normal, suture line intact	Collapsed	No abnormality detected	Intact	Widened and diaphragm pedicle intact at myotomy site	Outpouching of greater curvature	No abnormality

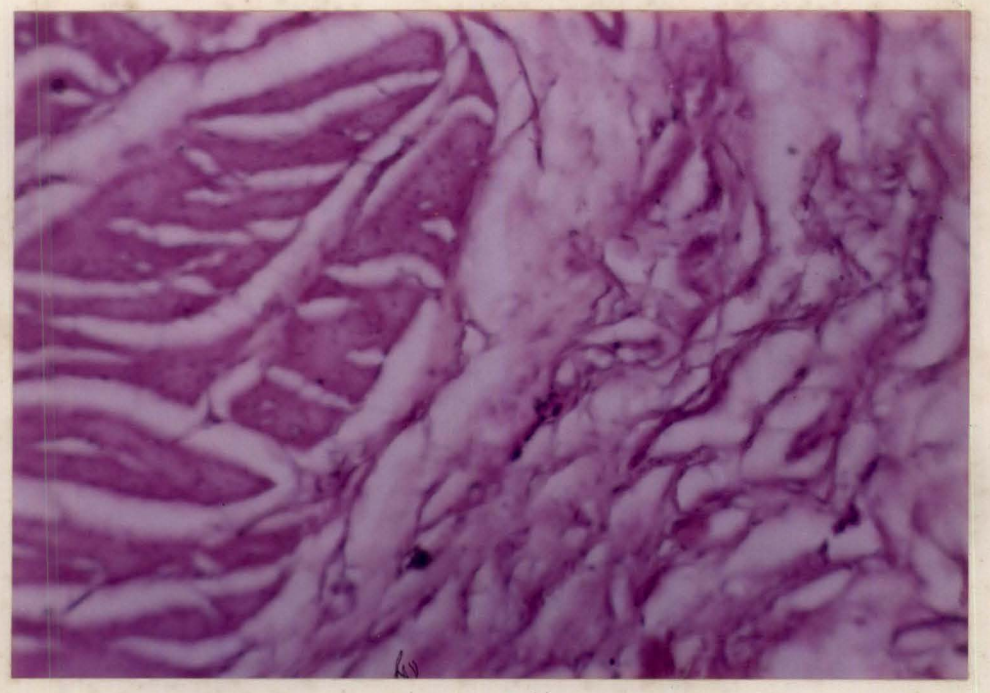
Fig.21. Contrast radiograph of the oesophagus and stomach showing the elevation of the caudal end of oesophagus (Group IV)

Fig.22. Photograph of the gastroesophageal region showing the adhesion of diaphragm pedicle graft at the myotomy site (Group IV)

Fig.23. Photomicrograph of the myotomy site (Group IV) showing the fibrovascular layer over the submucosa at the gastroesophageal junction (H&Ex400)

Fig.24. Photomicrograph of the myotomy site (Group IV) showing the fibrovascular layer with the muscle fibrils of diaphragm towards the periphery (H&Ex400)





GROUP V

The observations are presented in Tables 22 to 26.

In this group of animals, myotomy of the gastroesophageal junction was performed by a left side laparotomy through the 12th intercostal space, along with resection of 12th rib. The myotomy wound was sutured to a deflected pedicle graft of omentum.

Observation during surgery (Table 22)

Respiration was regular, smooth and shallow in all the animals. During laparotomy, thorax was opened accidently in animal E5 and during myotomy oesophageal mucosa was penetrated in animals E3 and E5. Electrocardiogram revealed decreased amplitude of R wave in two animals (E1 and E2) and an elevation of T wave in two animals (E2 and E6).

Physiological parameters

Rectal temperature (°C)

The rectal temperature (°C) was 39.19 ± 0.10 before anaesthesia. Significant decrease in rectal temperature ($P<0.05$) observed at 30 min and 90 min became normal by 24 h and remained in the normal range thereafter during the period of observation.

Pulse rate (per minute)

The pulse rate (per minute) was 113.33 ± 1.60 before anaesthesia. Significant increase in pulse rate ($P<0.05$) was observed at 30 min and 90 min after surgery. It became normal at 24 h and remained in the normal range thereafter during the period of observation.

Respiration rate (per minute)

The respiration rate (per minute) was 28.00 ± 1.03 before anaesthesia. Significant increase in respiration rate ($P<0.05$) was observed at 30 min and 90 min after surgery. It became normal at 24 h and remained in the normal range thereafter during the period of observation.

Clinical signs (Table 24)

All the animals were alert and active by 24h after surgery except one (E5) which was dull and weak upto 36 h and showed rise in body temperature from 8th to 10th day. It was having vesicular lesions on the ventral abdomen from 10th to 21st day.

Appetite

Appetite was normal in all the animals throughout the period of observation.

Swallowing

Swallowing was normal in all the animals.

Regurgitation and vomiting

Regurgitation and vomiting was not observed in any of the animals.

Skin wound

The skin wound showed normal healing in all the animals and sutures were removed on the eighth day.

Haemogram (Table 25)

The haemoglobin concentration (g/dl) was 10.43 ± 0.49 before anaesthesia. The variations observed during the post operative period were marginal and within the normal range.

The erythrocyte sedimentation rate (mm/h) was 4.33 ± 1.38 before anaesthesia and the variations observed during the post operative period were marginal and within normal range. Diphasic ESR was observed throughout the period of observation including the pre anaesthetic period in animals E3, E5 and E6 with its minimum reading on 21st day. In animal E1, it was observed upto 7th day.

The packed cell volume (per cent) was 30.17 ± 1.27 before anaesthesia. The variations observed during the post operative period were marginal and within normal range.

The total erythrocyte count ($10^6/mm^3$) was 4.88 ± 0.21 before anaesthesia. The variations observed during the period of observation were marginal and within normal range.

The total leucocyte count ($10^3/mm^3$) was 9.21 ± 0.49 before anaesthesia and the significant increase in lekcocyte count ($P<0.05$) observed during the 7th and 14th day of observation became normal by 21st day.

The neutrophil count (per cent) was 67.83 ± 0.79 before anaesthesia. Significant increase in neutrophil count ($P<0.05$) was observed on 7th and 14th day after surgery and it became near normal by 21st day.

The lymphocyte count (per cent) was 26.67 ± 0.84 before anaesthesia. Significant decrease in lymphocyte count ($P<0.05$) observed on the 7th day was within normal range by 14th day.

The monocyte count (per cent) was 3.00 ± 0.25 before anaesthesia. The variations observed during the post operative period were marginal and within normal range.

The eosinophil count (per cent) was 2.33 ± 0.08 before anaesthesia and The variations observed during the post operative period were marginal and within normal range.

Basophil was not observed in any of the blood samples.

Electrocardiogram (ECG)

Tachycardia observed in three animals (E1, E2 and E6) immediately after surgery became normal by 24 h. An irregular rhythm manifested by a pause after each three beats was observed on the 7th day and 14th day in one animal (E3).

A decrease in the amplitude of R wave was observed immediately after surgery in one animal (E5).

An elevation of ST segment was observed in one animal (E1), throughout the period of observation.

An increase in the amplitude of T wave with spiking was noticed in two animals (E2 and E5) upto 14th day of observation.

Radiographic observation

Contrast radiography of the distal oesophagus and the stomach with barium meal during the period of observation revealed normal emptying of the oesophagus into the stomach in

all the animals. No sign of oesophagitis, hiatal hernia leakage of contents and dilatation was observed in any of the animals. In animal E1 slight narrowing of the caudal end of thoracic oesophagus with dilatation of the stomach (Fig.25) and in animal E6, dilatation of the stomach were observed on the 21st day.

Terminal findings

All the animals were sacrificed at the end of the period of observation and gross morphological changes in and around the region of surgery was studied. Specimens collected from the gastroesphageal region of two animals (E2 and E3) were subjected to histomorphological studies.

Gross morphological observations (Table 26)

Caudal thoracic oesophagus

The caudal thoracic oesophagus was normal in size and shape except in one animal (E1) where slight narrowing of the lower end of thoracic oesophagus was noticed. Mucosal folds were normal in all animals.

Diaphragm

Diaphragm was normal and intact in all the animals.

Lungs

Lung lobes were normal in all the animals.

Pleura

Pleura was normal in all the animals.

Oesophageal hiatus

The oesophageal hiatus was intact in all the animals. The hiatal incision has healed completely.

Gastroesophageal region and cardia

The gastroesophageal region and cardia were widened in all the animals. The omental pedicle sutured to the myotomy site has healed completely (Fig.26) and was indistinguishable from the site except in one animal (E2) where fatty deposits could be identified on the periphery. The gastroesophageal region and cardia at the myotomy site were thin in all the animals. In animal E5 an elevation of the mucosal surface, around the sutured area of mucosal penetration was observed. The mucosal surface was smooth and mucosal folds were flattened in animals E1, E3, E5 and E6.

Stomach

Stomach was normal in size in all the animals except E1 and E6 where the stomach was slightly dialated and flaccid. An outpouching of stomach at the greater curvature was observed in four animals and there was gastric dilatation in two (E1 and E6). The mucosal folds were normal in two animals, more flattend and less towards the cardia in four (Fig.27).

Peritoneum and omentum

The peritoneum was normal in all the animals. The omental pedicle sutured to the myotomy site was firmly adherent with the wound and was indistinguishable except in animal E2, where omental fat was present at the region.

In one animal (E2) a portion of omentum was adherent with the abdominal wound.

Histomorphological observations

Histomorphological examination of the gastroesophageal junction in animal E2 and E3 revealed normal mucosa and submucosa. The myotomy site was devoid of eosophageal muscular layers.

At the gastroesophageal junction the normal abrupt transition of oesophageal squamous epithelium to columnar epithelium of the stomach was observed. The portion of submucosa was devoid of glands in animal E2. The myotomy site was infiltrated with a few neutrophils, plasma cells, lymphocytes and macrophages. The cellular infiltration extended upto the stroma and lamina propria (Fig.28). Immediately adjacent to this zone a thin layer of fibro vascular connective tissue was observed. Fibrous connective tissue was observed as the outer most layer and it contained a few fat cells in animal E2 (Fig.29).

Table 22. Observations on respiration, difficulties encountered in surgery and ECG changes during surgery in dogs (Group V)

Animal No.	Respiration	Difficulties encountered in surgery		ECG
		Laparotomy	Myotomy	
E1	Regular, smooth and shallow	-	-	Decreased amplitude of R wave
E2	Regular, smooth and shallow	-	-	Decreased amplitude of R wave and increased amplitude of T wave
E3	Regular, smooth and shallow	-	Accidental penetration of oesophageal mucosa	-
E4	Regular, smooth and shallow	-	-	-
E5	Regular, smooth and shallow	Acidental opening into the thorax	Accidental penetration of oesophageal mucosa	-
E6	Regular, smooth and shallow	-	-	Increased amplitude of T wave

Table 23. Rectal temperature, pulse rate and respiration rate before surgery and on different post operative periods in dogs (Group V) (Mean±SE)

n=6

Physiological parameters	0 min	30 min	90 min	24 h	7 d	14 d	21 d
Temperature (°C)	39.19± 0.10	* 36.24± 0.29	* 36.89± 0.42	38.70± 0.10	38.91± 0.11	38.85± 0.05	38.82± 0.04
Pulse (per minute)	113.33± 1.60	* 139.67± 10.83	* 141.33± 8.43	119.67± 3.51	108.00± 2.57	100.00± 1.55	101.33± 4.78
Respiration (per minute)	28.00± 1.03	* 47.00± 6.16	* 48.00± 5.75	39.33± 2.76	29.67± 1.66	27.67± 0.95	27.33± 0.66

* Significant at 5 per cent level as compared to value at 0 min

Table 24. Clinical observations during the post operative period in dogs (Group V)

Animal No.	General condition	Appetite	Swallowing	Regurgitation/ vomition	Skin wound	Others
E1	Good	Normal	Normal	Absent	Normal healing	-
E2	Good	Normal	Normal	Absent	Normal healing	-
E3	Good	Normal	Normal	Absent	Normal healing	-
E4	Good	Normal	Normal	Absent	Normal healing	-
E5	Dull and weak upto 36 h	Normal	Normal	Absent	Normal healing	Vesicular lesions on the ventral abdominal wall
E6	Good	Normal	Normal	Absent	Normal healing	-

Table 25. Haemogram before surgery and on different postoperative periods in dogs (Group V) (Mean±SE)

n=6

Parameters and units	0 min	Post operative intervals			
		Immediately after	7th day	14th day	21st day
Haemoglobin concentration (g/dl)	10.43± 0.49	10.53± 0.33	10.82± 0.82	11.05± 0.54	11.49± 0.74
Erythrocyte sedimentation rate (mm/h)	4.33± 1.38	6.17± 3.98	2.50± 0.34	2.17± 0.30	2.33± 0.21
Packed cell volume (%)	30.17± 1.27	30.33± 2.45	33.83± 2.46	33.00± 1.63	34.00± 2.23
Total erythrocyte count ($10^6/mm^3$)	4.88± 0.21	4.96± 0.39	4.55± 0.35	5.45± 0.28	5.56± 0.35
Total leucocyte count ($10^3/mm^3$)	9.21± 0.48	10.36± 0.49	* 11.43± 0.48	* 11.20± 0.85	10.40± 0.35
Neutrophil count (%)	67.83± 0.79	71.83± 1.92	* 75.67± 1.28	* 73.00± 0.68	71.83± 0.95
Lymphocyte count (%)	26.67± 0.84	23.17± 2.24	* 18.83± 1.10	22.67± 0.92	22.83± 0.79
Monocyte count (%)	3.00± 0.25	3.33± 0.42	3.17± 0.30	3.00± 0.36	3.00± 0.04
Eosinophil count (%)	2.33± 0.08	2.67± 0.49	2.33± 0.49	1.50± 0.34	2.33± 0.49
Basophil count (%)	0.00	0.00	0.00	0.00	0.00

* Significant at 5 per cent level as compared to value at 0 min.

Table 26. Gross morphological changes observed during autopsy in dogs (Group V)

Animal No.	Caudal thoracic oesophagus	Lungs	Oesophageal hiatus	Gastro-oesophageal region and cardia	Stomach	Omentum
E1	Slight narrowing at the hiatus	No abnormality detected	Intact	Widened and thin omental pedicle healed well with myotomy wound and mucosa was smooth and folds more flattened	Slight dilatation, walls thin and flaccid	No abnormality
E2	No abnormality detected	No abnormality detected	Intact	Widened and thin omental pedicle healed well with myotomy wound and indistingushable	Out pouching of the greater curvature	A portion adherent with abdominal wall
E3	No abnormality detected	No abnormality detected	Intact	Widened and thin omental pedicle healed well with myotomy wound Mucosal folds more flattened	Out pouching of the greater curvature	No abnormality
E4	No abnormality detected	No abnormality detected	Intact	Widened and thin omental pedicle healed well with myotomy wound and indistingushable	Out pouching of the greater curvature	No abnormality
E5	No abnormality detected	No abnormality detected	Intact	Widened and thin Oomental pedicle healed well with myotomy wound and indistingushable, mucosal folds more flattened Raised mucosal surface around sutured area	Out pouching of the greater curvature	No abnormality
E6	No abnormality detected	No abnormality detected	Intact	Widened and thin Omental pedicle healed well with myotomy wound. Mucosal folds more flattened.	Dilated, walls thin and flaccid, mucosal folds less	No abnormality

Fig.25. Contrast radiograph of the oesophagus and stomach on the 21st day showing the narrowing of the caudal end of oesophagus with dilatation of the stomach (Group V)

Fig.26. Photograph of the stomach showing the omental graft healed in position at myotomy site and the outpouching at the greater curvature (Group V)

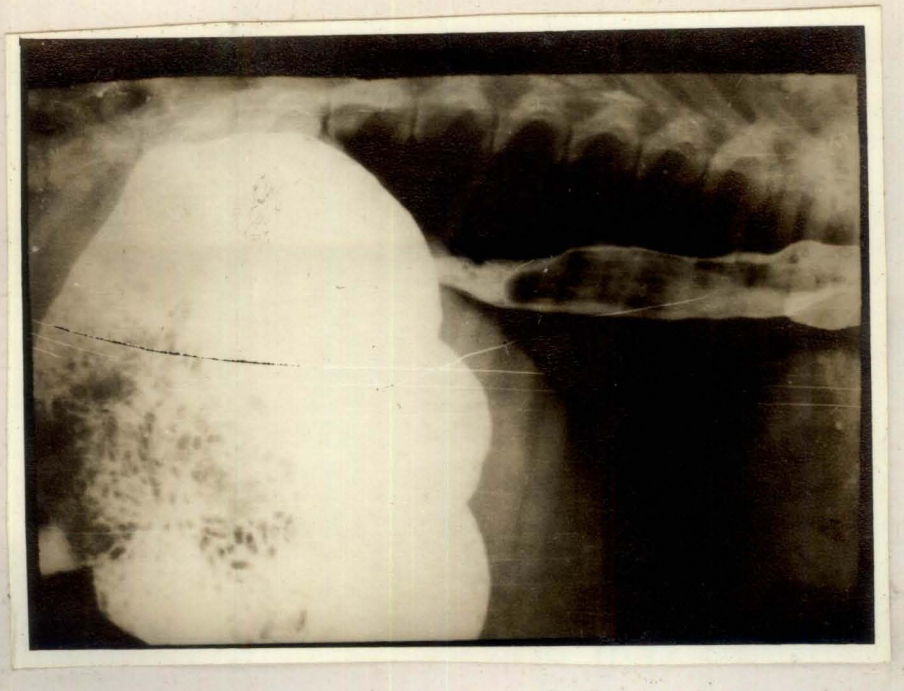
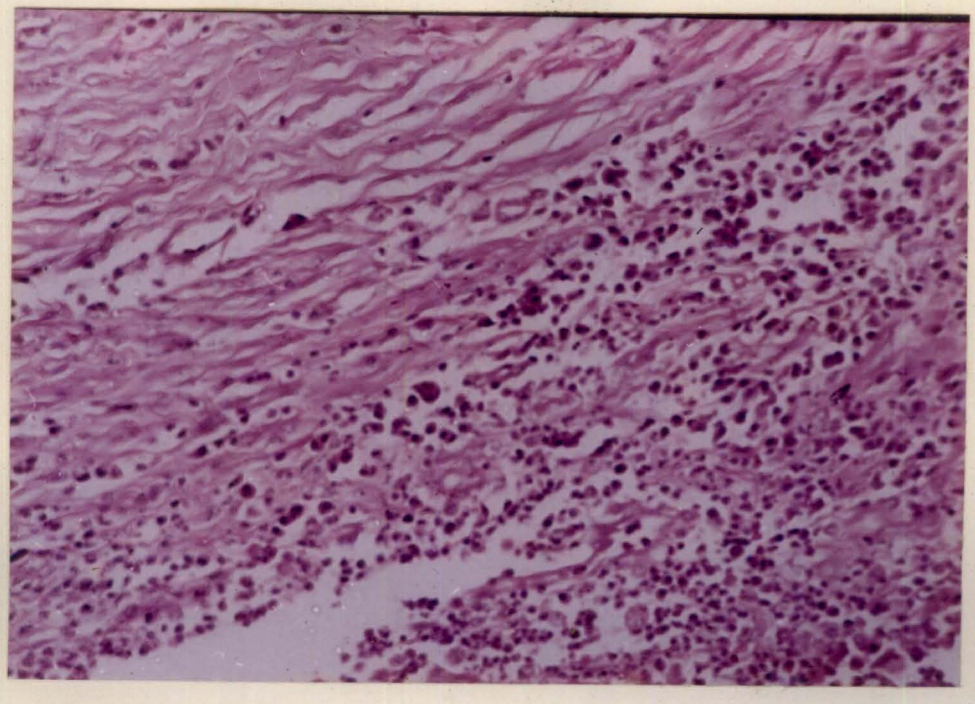
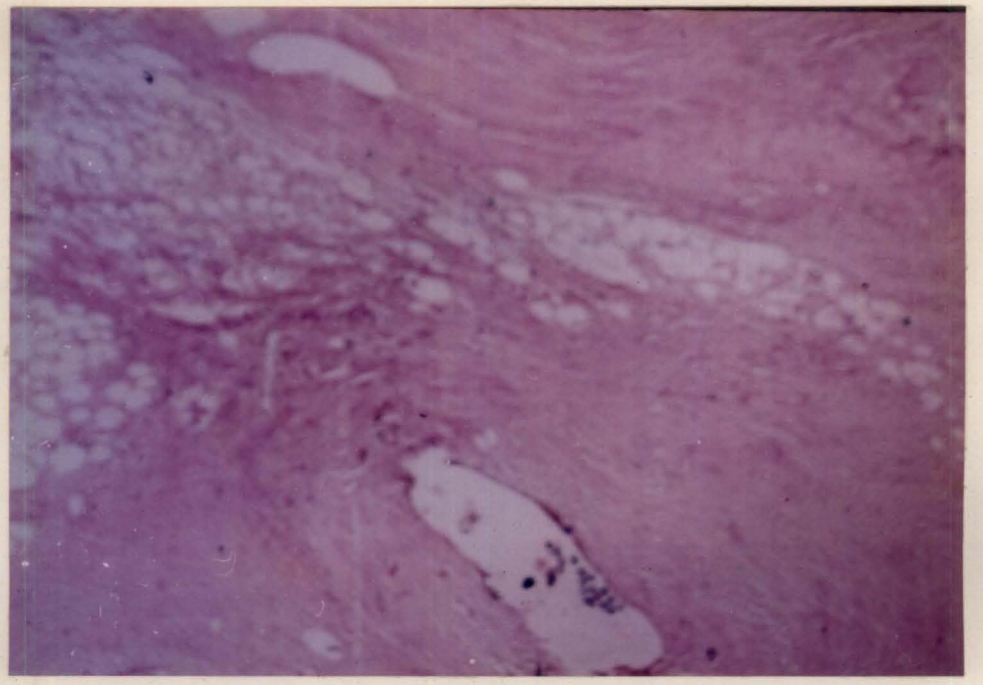


Fig.27. Photograph of the mucosal surface of the gastroesophageal region (Group V) showing slight narrowing and flattened mucosal folds

Fig.28. Photomicrograph showing the cellular infiltration and fibrous tissue proliferation at the myotomy site (Group V) (H&Ex320)

Fig.29. Photomicrograph at the gastroesophageal region showing the fibrous tissue proliferation at the myotomy site and vaccules of fat cells (Group V) (H&Ex250)





Discussion

DISCUSSION

The experimental study was conducted in dogs with the objective of evolving techniques to bring about relief of achalasia and dilatation of oesophagus by widening the gastroesophageal region. The experimental plan included (a) designing an approach to the gastroesophageal region and (b) evaluating gastroesophageal myotomy with transplantation of diaphragmatic and omental grafts. 30 apparently healthy adult nondescript dogs of either sex were used in the study, divided into five groups (Groups I, II, III, IV and V) of six animals each.

Anaesthesia

The animals were anaesthetised by premedicating with atropine sulphate (0.04 mg/kg body weight) followed by xylazine (0.5 mg/kg body weight) intramuscular and intravenous administration of five per cent solution of thiopentone sodium to effect. Anaesthesia was maintained whenever necessary with intravenous administration of thiopentone sodium.

The combination of anaesthetic agents produced smooth induction, adequate duration and smooth recovery. Respiratory arrest during anaesthesia was observed in seven out of 30

animals. Of the seven, all the animals except one could be revived by administration of oxygen/artificial ventillation.

The average time for induction was 2.92 ± 0.08 min in Group I, 3.50 ± 0.34 min in Group II, 3.33 ± 0.17 min in Group III, 4.00 ± 0.26 min in Group IV and 4.08 ± 0.33 min Group V animals.

The average duration of anaesthesia was 47.83 ± 2.95 min in Group I, 49.17 ± 3.90 min in Group II, 93.08 ± 16.17 min in Group III, 93.08 ± 12.51 min in Group IV and 98.42 ± 13.12 min in Group V animals.

The time taken for recovery was 50.83 ± 5.38 min in Group I, 35.83 ± 6.11 min in Group II, 43.33 ± 12.00 min in Group III, 65.00 ± 11.51 min in Group IV and 43.33 ± 3.80 min in Group V animals.

The anaesthesia was satisfactory for the myotomy of the gastroesophageal region in thoracic and abdominal approaches. Muscle relaxation and anaesthesia was adequate with single injection of anaesthetic in animals of group I and II. In animals of groups III, IV and V anaesthesia had to be maintained for prolonged surgical intervention by repeated administration of anaesthetic.

Hall (1966) stated that any type of anaesthesia is satisfactory for oesophageal surgery but the use of a relaxant drug is more ideal. Hall (1985) recommended the use of atropine and xylazine as pre anaesthetic in small animal anaesthesia, because the anticholinergic action of atropine minimised the side effects of xylazine on the heart. In dogs Sharma *et al.* (1983a&b)obtained short duration of anaesthesia of 11.75 ± 0.8 min, when thiopentone alone (25 mg/kg) was administered and 14.75 ± 4.27 min when atropine (0.02 mg/kg) and thiopentone sodium (25 mg/kg body weight) were administered and xylazine (0.15 mg/kg body weight) was used for maintenance. In the present study the minimum duration of anaesthesia obtained was 47.83 ± 2.95 min, which was satisfactory for the major surgical procedures. The increased duration obtained was probably due to the sedative, muscle relaxant and analgesic property of xylazine.

In group I and in group IV animals, the recovery time was prolonged due to the added surgical stress on the patient because of exposure of thoracic viscera, preparation of pedicle graft of diaphragm and closure of the rent in diaphragm.

Respiration during surgery was regular smooth and shallow in most of the animals. Dyspnea noticed in a few animals were managed by administration of oxygen. During the course of

surgery rapid shallow respiration observed in a few animals were due to anaesthetic recovery and were managed by deepening anaesthesia with intravenous administration of thiopentone sodium.

The electrocardiogram changes observed during surgery was depression of R wave in most of the animals. Elevation of ST segment and T wave were observed in a few animals. Reduction in the heart rate was observed in one animal. These changes were transient and was probably due to the effect of anaesthetic on the myocardium.

Surgical technique

Gastroesophageal myotomy was performed through thoracotomy in group I and through laparotomy in group II. Based on the results obtained, the abdominal approach was adopted for surgery in animals of groups III, IV and V.

Gastroesophageal myotomy was performed in animals of group III and the wound edges were sutured to the overlying portion of diaphragm. In group IV the wound edges of gastroesophageal myotomy were sutured to a diaphragmatic pedicle graft prepared from the dome of the diaphragm and in group V, the wound edges were sutured to an omental pedicle graft.

All the animals were kept under observation for a period of 21 days post operatively.

The physiological parameters, clinical signs exhibited during the period of observation, haematological parameters, electrocardiogram and radiographs taken were studied to evaluate the experimental procedures. Gross morphological changes at the time of autopsy and histomorphological changes of two random samples from each groups were also studied.

Approach to the gastroesophageal region

Surgical approach by thoracotomy through eighth intercostal space (Lawson (1966), Hofmeyr (1966), Clifford *et al.* (1967), Pass (1971), Boothe (1978) and Leighton (1982 and 1983)) or ninth intercostal space (Hoffer *et al.*, 1980) were recommended for gastroesophageal myotomy in dogs. Experimentally Ellis *et al.* (1967) performed myotomy of gastroesophageal region through eighth intercostal space in dogs. Thoracotomy through the eighth/ninth intercostal space was recommended for cardioplasty also (Hofmeyr, 1956, Harvey *et al.*, 1974, Kipperman and Straw, 1988 and Harvey *et al.*, 1990).

In the present study, thoracic approach through the left side was adopted in group I. After resection of the eighth rib, the deeper periosteum and pleura were incised to enter

the thorax. The technique provided satisfactory exposure of the gastroesophageal region but required exposure of the thoracic viscera and handling of the lung. Controlled respiration was necessary to maintain respiration and to get proper visualisation of the gastroesophageal region. The technique was accompanied by complications like congestion and consolidation of the lungs, collapse of the lungs, mediastinal pleuritis and adhesion of lungs with oesophagus, diaphragm, pericardium and chest wall in a few animals. Adhesion of lungs to diaphragm, pleuritis and pneumonia were observed as complications after thoracotomy and myotomy in dogs (Ellis *et al.*, 1967). Lammerding *et al.* (1976) reported adhesion of lungs with oesophagus and mediastinal pleuritis in thoracic oesophagoplasty using diaphragm grafts in dogs.

Clifford *et al.* (1967), Pass (1971) and Clifford *et al.* (1972) performed myotomy through abdominal approach in treatment of oesophageal achalasia. Clifford *et al.* (1967 and 1972) preferred the abdominal approach when pyloromyotomy along with oesophageal myotomy was to be performed. Ventral midline incision extending from the sternum to the unbilicus was recommended to expose and incised the diaphragm ventral to the hiatus to exteriorise the caudal end of oesophagus and to perform myotomy without incising the hiatus. The technique was reported to be time consuming, exposure of the myotomy

site was poor and required suturing of the diaphragmatic incision.

The abdominal approach (Group II) in the present study was performed through the 12th intercostal space after resection of the 12th rib. There was better exposure and space for handling the gastroesophageal region during surgery. Caudal traction of the stomach and severing the phrenoesophageal ligament exposed the caudal portion of the thoracic oesophagus. Since the pleural cavity was not opened, simple procedure for management of respiration was sufficient during surgery and the risk involved in opening the thorax was avoided. The complications were accidental penetration of the diaphragm during laparotomy and adhesion of a portion of omentum with abdominal wall or diaphragm and the myotomy site with diaphragm observed in a few animals.

The technique provided very good exposure of the gastroesophageal region and myotomy could be performed without opening the pleural cavity. Since the myotomy wound became intraabdominal in position abdominal approach was advantageous in grafting of the myotomy site with diaphragm and omentum. The status of stomach and abdominal viscera could be ascertained for better evaluation of the patient.

Gastroesophageal myotomy

The myotomy of the gastroesophageal region commencing a few millimetre from behind the cardia, was extended for a length of four centimetre cranially into the oesophagus. In thoracic approach, the cardia was pulled into the thorax for performing myotomy. In abdominal approach the caudal end of thoracic oesophagus was drawn into the abdomen for myotomy. Ellis *et al.* (1967) evaluated three types of myotomy and preferred short Heller myotomy since it was devoid of complications like reflux oesophagitis.

Accidental penetration of mucosa during myotomy was reported by Clifford *et al.* (1967) and Boothe (1978). Leighton (1983) stated that accidental opening into the lumen may be closed by inversion sutures to avoid leakage whereas Harvey *et al.* (1990) recommended to widen the opening and to suture the whole wound in a horizontal direction, as was done for cardioplasty. In the present study during myotomy accidental penetration of oesophageal mucosa happened only in five out of the 30 animals.

Myotomy of the lower oesophageal sphincter for treatment of oesophageal achalasia was successfully carried out by Clifford *et al.* (1967), Gourley and Leighton (1971), Pass (1971), Clifford *et al.* (1972), Boothe (1978), Leighton (1982 and 1983). Clifford *et al.* (1971) performed oesophageal

myotomy for relieving a constricting fibrous ring at the lower oesophageal sphincter in a cat.

Myotomy caused the lower oesophageal sphincter to open with less force to allow the passage of food from the oesophagus into the stomach. After myotomy of the gastroesophageal region, Hoffer *et al.* (1980) observed (a) decrease in the intraluminal pressure, (b) changes in time of contraction and relaxation and (c) the ability of the sphincter to retain its capacity to contract and to prevent reflux oesophagitis. Ellis *et al.* (1967) and Guilford and Strombeck (1996) preferred short Heller myotomy, as it lead to permanent reduction in gastroesophageal sphincter tone and maintained its capacity to prevent oesophageal reflux. In the present study no sign of oesophagitis indicating gastroesophageal reflux was observed in any of the animals.

Complications of myotomy reported were reflux oesophagitis (Clifford *et al.*, 1967), oesophagitis and reapproximation of myotomy edges (Ellis *et al.*, 1967), oesophagitis and subsequent stricture formation (Gourley and Leighton, 1971), inadequate re-establishment of antireflux barrier, gastric dilatation and gastroesophageal intussusception (Burrows and Merrit, 1992).

The complications of myotomy encountered in the present study was narrowing of the caudal end of oesophagus in one animal and dilatation of the stomach in three animals.

Closure of the gastroesophageal myotomy wound

Closure of the gastroesophageal myotomy wound was done in two stages. viz.,

1. Closure of the wound at the hiatus oesophageus
2. Closure of the gastroesophaeal myotomy wound.

Closure of the wound at the hiatus oesophageus

In the present study the suturing of the wound at the hiatus oesophageus was done in such a manner to increase the width of the oesophagus at the hiatus. The most cranial edge of myotomy incision and the border of diaphragm at the centre of the hiatal incision were apposed first. The sutures were continued on either side between the myotomy edge and the border of diaphragm to completely close the oesophageal hiatal incision. The suturing converted the longitudinal incision into a transverse one and the exposed oesophageal mucosa became intraabdominal in position thus enhancing the width at the gastroesophageal region.

Boothe (1978) sutured the border of diaphragm with the ventral aspect of the oesophageal musculature to close the

hiatal incision. Suturing the oesophageal hiatal incision as in the present study, through thoracic approach was done by Leighton (1982 and 1983) and reported that the technique of suturing prevented the chance of oesophagitis and gastric reflux by acting as a valve at the gastroesophageal region.

Closure of the gastroesophaeal myotomy wound.

The myotomy wound became intraabdominal in position after closure of wound at the hiatus oesophageus in all the animals. The myotomy wound was left as such in animals of Groups I and II.

In the experiments in Groups III, IV and V, in order to study the suitability and the healing effect of grafting with diaphragm and omentum, the gastroesophageal incision was sutured to

1. intact diaphragm
2. to a pedicle graft of diaphragm and
3. to a pedicle graft of omentum.

Since the myotomy site remained intraabdominal in position after suturing of the wound at the oesophageal hiatus, abdominal approach was found more suitable for these techniques.

Petrovsky (1961) used diaphragm graft in man, to close the oesophageal defect in cardiospasm after resection of scarred muscular wall and obtained good results. Lammerding *et al.* (1976) used diaphragm graft to substitute a portion of oesophageal wall in experimental dogs and obtained good healing without any narrowing or leakage. Orton and McCracken (1996) reported the grafting of thoracic oesophageal wall with diaphragm pedicle flap as an onlay or inlay graft.

In the present study in Group III, the edges of myotomy wound were sutured with the overlying part of the diaphragm so that the exposed mucosa at the myotomy site was completely under the cover of diaphragm. The technique was found suitable for protecting the myotomy site and to retain the width. Good healing was observed in all the animals.

In Group IV, the diaphragm pedicle graft prepared from the dome of the diaphragm without directly opening into the thorax was sutured to the edges of myotomy wound so that the mucosa at the myotomy site was completely covered by the graft. Since the pedicle graft was prepared without opening into the pleural cavity suturing of the diaphragmatic rent was easier. Though the technique was time consuming, suturing of the pedicle graft with myotomy wound was easier than suturing to intact diaphragm. Good healing was observed with grafting as was reported by Petrovsky (1961) in man.

In Group V, the gastroesophageal myotomy wound was sutured to an omental pedicle graft. Short pedicle graft prepared from the anterior aspect of the greater omentum without disruption of vascular supply and attachment to the stomach was used as the graft. The omental pedicle thus prepared was sufficient in length to draw over the myotomy site, for grafting. The grafting of the omentum was easier than suturing with the diaphragm and there was no tension on the suture line. In all the animals in the present study, the graft has healed completely with the myotomy wound and was indistinguishable. Mukerjee *et al.* (1973) found good healing in dogs at the oesophageal anastomotic site when omentum was used to reinforce the suture line, there was minimum leakage, the bursting pressure at the site was high and the omentum was indistinguishable from the site.

Post operative observations

Physiological parameters

Significant decrease in rectal temperature was observed at 30 min and 90 min after surgery and became normal by 24 h and remained in the normal range through out the period of observation. The decrease in the rectal temperature observed initially could be due to depression of the basal metabolism brought about by the anaesthetic effect.

Reduction in the rectal temperature in xylazine anaesthesia was reported by Peshin *et al.* (1980). Sharma *et al.* (1983a) observed reduction in rectal temperature in thiopental sodium anaesthesia, maintained with chlorpromazine.

Significant increase in pulse rate observed from 30th min to 24h in animals of Groups, I, III, IV and V retured to normal range and remained in the normal range throughout the period of observation. The increase in pulse rate observed initially may be due to the effect of anaesthesia and surgical stress.

Significant increase in respiration rate was observed upto 24 h after surgery in animals of Groups I, II, IV and V and was normal on 7th day and remained in the normal range throughout the period of observation. There was no change in the character of respiration during the post operative period. The increase in rate observed initially may be due to the compensatory mechanism to counteract the influence of surgical stress and anaesthesia. The observations were similar to the findings of Sharma *et al.* (1983a) with thiopental sodium anaesthesia in dogs.

The observations on physiological parameters during the post operative period revealed that the surgical technique employed did not cause any untoward systemic effect.

Clinical signs

General condition

The animals in all the groups except three were alert and active by 24 h. One animal was dull for the first three days and two animals were dull and weak for 48 h but all the three animals recovered without any complication. The changes noticed might have been due to the prolonged anaesthesia and stress caused by the surgical procedures.

Appetite

All the animals showed normal appetite throughout the period of observation except two where poor appetite was observed for the first three days. Swallowing was normal in all the animals of all the groups.

Vomition was observed only once in one animal (D4), on the second day, in which penetration of oesophageal mucosa happened during myotomy. In experimental gastroesophageal myotomy Ellis *et al.* (1967) observed frequent regurgitation and oesophagitis with classic Heller myotomy and it was absent in animals operated with short Heller myotomy.

Healing of the surgical wound was uneventful in all the animals except in five where swelling of the suture line was

observed but responded to drainage and dressing. Suppuration was not observed in any of the animals.

Observations on clinical signs revealed that the surgical technique employed has not affected the general health, habits, and function of upper gastrointestinal tract in the experimental animals.

Haemogram

The haemoglobin concentration and packed cell volume showed only marginal variations within the normal range in all the animals.

Erythrocyte sedimentation rate (ESR) was within normal range in the animals of all the groups. Diphasic ESR was observed in four animals throughout the period of observation with a minimum reading at 21 day and is considered to be an indication of erythropoisis, seen in anaemia due to various causes (Jain , 1986). Since it was noticed from the preoperative period, it cannot be considered as an after effect of surgery.

In all the animals erythrocyte count was within normal range except in Group I where a transient reduction was observed on the 14th day but did not affect the post operative recovery of the animals.

The total leucocyte count was within normal range in all the animals of Groups II, III and IV. Increase in leucocyte count was observed at 30 min. in Group I and on 7th and 14th day in Group V.

Neutrophil count showed a gradual increase within normal range in Group III and a significant increase in Group V, with its maximum on the 7th day. A corresponding decrease in lymphocyte count was also observed during the period in these groups. Monocyte count was within normal range in all the animals of all the groups. Eosinophil count showed a decrease upto 21st day in Group I but the variation were within normal range.

The changes observed in haemogram may be due to the transient period of cellular reaction to trauma, elicited towards the healing process (Gourley and Vasseur, 1985), especially when there was no sign of sepsis at surgical site

The observations on haemogram revealed that the surgical technique employed in all the five groups of animals had not caused severe systemic reaction as noticed by the absence of functional or structural changes in the experimental animals.

Electrocardiogram (ECG)

Consistent changes in ECG was not observed in any of the animals. Changes observed like increased heart rate, depression of R wave, elevation of ST segment and T wave resolved spontaneously without adverse effects. These changes could be attributed to surgical stress, intrathoracic manipulations and anaesthesia using xylazine and thiopentone sodium (Bolton, 1975; Peshin *et al.*, 1980) and hence of no serious consequence.

Radiographic evaluation

Barium meal contrast radiography during the period of observation revealed normal size and shape of oesophagus in all the animals except in one, in which slight decrease in width of oesophagus was observed close to the hiatus. Oesophagal emptying was normal. Sign of oesophagitis, hiatal hernia and leakage of contents were not observed in any of the animals. An increase in the width of cardia was observed in all the animals indicating that the technique of myotomy performed in the animals were satisfactory for dilating the lower end of the oesophagaus. The abdominal portion of oesophagus was found slightly elevated to join the stomach more vertically in two animals where diaphragm pedicle graft was employed and there was gastric dialatation in three. But such variation did not cause any clinical change in animals.

In the present study barium meal in liquid form was administered through a stomach tube into the caudal oesophagus, so that the full size of the oesophageal lumen could be visualised.

The radiographic observations in the present study suggest that the surgical techniques employed in the experiments effected an increase in the width of the gastroesophageal region without any adverse change in emptying of oesophagus and sphincter function.

Terminal findings

The experimental animals were sacrificed at the end of the period of observation and autopsy findings were recorded. Histomorphological studies of the gastroesophageal region was carried out in two animals, from each group.

Gross morphological observations

The caudal thoracic oesophagus was normal in size and shape in all the animals except in one. In two animals in Group I fibrous tissue was observed over the surface at the caudal end of thoracic oesophagus for a length of four centimetre. Adhesion of oesophagus with caudal lung lobe was observed in two animals. These changes may probably due to mild mediastinal pleuritis or due to trauma over the

oesophageal surface caused by handling of the organ during surgery.

Diaphragm was normal and intact in all the animals of Groups I, II, III and V. In Group III the sutured portion of diaphragm with the myotomy site formed an outer layer of tissue over the mucosa, was firmly adherent with it and caused an increase in thickness over the myotomy site.

In Group IV, the suture line on the diaphragm has healed completely and the sutured portion was adherent with thoracic wall in four of the six animals. The diaphragm pedicle graft sutured to the myotomy wound was firmly adherent and formed an outer layer of tissue over the oesophagus. The upper surface of the diaphragmatic pedicle graft was adherent with the dome of diaphragm in two animals.

In Group V, where omental pedicle graft was used for closure of oesophagomyotomy wound the mucosa was covered with the graft and the omental graft was indistinguishable from the adjoining gastroesophageal region except in one animal where a little omental fat was observed at the region.

Mediastial pleuritis was observed only in one animal. Congestion and collapse of lung lobes, adhesion of lung with oesophagus, diaphragmatic pleura and thoracic wall were observed in a few animals of Group I, but were absent in

animals of other groups. However signs of infection was not observed in any of the animals. Knight (1963) in a survey report stated that in transthoracic oesophagotomy complications encountered were pleurisy, wound infection, pneumothorax, pneumonia, cardiospasm, and cardiac arrest. Ellis *et al.* (1967) observed adhesion of lung to diaphragm, pleuritis and pneumonia in dogs, after thoracotomy and myotomy. Lammerding *et al.* (1976) observed adhesion of lung with oesophagus and mediastinal pleuritis, in thoracotomy and oesophagoplasty using diaphragm grafts in dogs.

Hiatus oesophageus was intact in all the animals of all the five groups. Hofmeyr (1966) observed herniation of the stomach into thorax, due to disruption of hiatal sutures after cardioplasty, where the stomach was sutured to the diaphragm to reduce tension.

Increased width of gastroesophageal region and cardia was observed in all the animals of all the groups. Myotomy site was thin in all the animals of Groups I, II and V. In Groups III and IV, good healing with the diaphragm sutured to the myotomy site was observed as reported by Petrov sky (1961) in man. The myotomy site showed firm adhesion with diaphragm and thus it increased the thickness of the site. In two animals, the adhesion of diaphragm pedicle with the dome of the diaphragm was noticed and was probably responsible for the

elevated appearance of the caudal end of oesophagus in radiography of these animals.

The stomach was normal in size in all the animals except in three and it showed an outpouching of the greater curvature. In three animals slight dilatation and flaccidity of the stomach was noticed. The changes in the stomach could be due to injury to the branches of vagus nerve supplying the stomach but had not produced any functional disturbance in any of the animals. Gastric dilatation was reported as a complication of myotomy (Burrows and Merrit, 1992). In the animal in which the spirocerca nodules were observed on the oesophagus, it might have caused added injury to the nerve endings, leading to dilatation.

Contrast radiography of the autopsy specimens of oesophagus and stomach from two animals (A3 and B2) showed increased width of the gastroesophageal region with out any change in size of oesophagus and stomach.

There was an outpouching at the greater curvature of the stomach with normal mucosal folds. The outpouching could probably be due to the severing of the muscle fibres, especially the longitudinal fibres of the stomach at the cardia (Evans and Christenson, 1979). The injury might have caused loss of holding power of the muscles, leading to

distention of the part. Such a phenomenon was not seen reported earlier.

Adhesion of a portion of omentum with abdominal wall and diaphragm observed in a few animals was not accompanied by any functional disturbance.

Mucosal surface of the oesophagus was normal in all the animals except in one. The stomach revealed normal mucosal folds, except in five animals where mucosal folds were less and was more flattened. In animals where mucosa was injured during surgery, the mucosa in the vicinity was without folds, was smooth and elevated. No evidence of inflammation was noticed in the mucosal surface in the oesophagus and stomach in other animals.

From the autopsy findings it was observed that complications like collapse of lungs, adhesion of oesophagus or lungs and pleuritis were present only in a few animals operated through thoracotomy (Group I). In animals operated through laparotomy adhesion of a part of omentum with abdominal wall and diaphragm, part of myotomy site with diaphragm were observed in a few animals indicating that surgery for myotomy of gastroesophageal region performed through laparotomy was accompanied by least complications.

Histomorphological observations

Histomorphological examination of the gastroesophageal region wherein the myotomy wound was not sutured, revealed filling of the myotomy site with fibrovascular connective tissue. The region was devoid of oesophageal musculature and the mucosa was intact. In Groups III and IV, where myotomy wound was sutured with diaphragm, the mucosa was intact and a layer of fibrovascular tissue was seen superficial to the mucosa. The muscle fibrils of diaphragm was seen as an outer layer. There was no sign of inflammation in any of the animals in Groups I, II, III and IV.

In Group V, where omental graft was sutured to myotomy wound, the mucosa was intact and normal. Cellular infiltration of mononuclear cells, consisting of neutrophils, plasma cells, lymphocytes and macrophages indicative of inflammatory reaction were observed in the submucosa, over which a thin layer of fibrovascular reaction was seen. Peripheral to fibrovascular layer, fibrous tissue was seen without muscle fibres.

Signs of inflammation involving mucosa and submucosa as reported by Guilford and Strombeck (1996) was not observed in any of the animals, indicating that the grafts of diaphragmatic tissue and omentum healed well with oesophageal

tissue and the grafts at the gastroesophageal region was well tolerated.

In the experimental study to effect widening of gastroesophageal region, four surgical techniques were evaluated. viz., gastroesophageal myotomy without closure, myotomy with suturing the edges directly to the overlying diaphragm, myotomy with diaphragm pedicle grafting and myotomy with omental pedicle grafting. In clinical and radiographic evaluation, it was observed that all the four techniques produced satisfactory widening of gastroesophageal junction without any adverse effect. Gross morphological and histologic studies revealed that suturing to diaphragm and diaphragm pedicle graft produced less local reaction and provided a stable covering to gastroesophageal mucosa. The pedicle grafting of diaphragm and omentum were well tolerated. But the fibrous reaction with omental grafting and the fibrovascular reaction in myotomy without grafting could be detrimental as there is possibility of subsequent fibrotic contraction and stricture. Suturing the myotomy edges directly to diaphragm was more satisfactory than pedicle grafting since it avoided creating a defect in the diaphragm.

Summary

SUMMARY

The study was conducted with the objectives of designing a surgical approach to the gastroesophageal region in dogs and to evaluate the efficacy of diaphragmatic and omental grafting at the gastroesophageal myotomy site.

The study was conducted in 30 adult nondescript dogs of either sex, divided into five groups of six animals each.

The animals were premedicated with atropine sulphate (0.04 mg/kg body weight) and xylazine (0.5 mg/kg body weight) IM. Anaesthesia was induced and maintained with intravenous administration of five per cent solution of thiopentone sodium to effect. Induction of anaesthesia and recovery were smooth and uneventful. Duration and depth of anaesthesia were satisfactory.

During surgery respiration was maintained with respiration pump or Boyles' Tec anaesthetic apparatus. Respiratory arrest was observed during surgery in seven animals and the animals except one could be revived with administration of oxygen.

Gastroesophageal myotomy was performed through left side thoracotomy with resection of eighth rib in Group I and laparotomy through the 12th intercostal space with resection

of 12th rib in Group II to study the suitability of surgical approaches. Based on the results the abdominal approach was found suitable and was adopted for experiments in Groups III, IV and V.

In animals of Groups III, IV and V gastroesophageal myotomy was performed through abdominal approach and the myotomy wound edges were sutured to the overlying portion of diaphragm in Group III, to a deflected portion of diaphragmatic pedicle graft in Group IV and to an omental pedicle graft in Group V.

The animals were kept under observation for 21 days and physiological changes and clinical signs were recorded. Haematologic, radiographic and electrocardiogram changes were recorded at weekly intervals. The animals were sacrificed and autopsy was conducted.

Thoracic approach needed assisted ventilation and handling of thoracic viscera. It was accompanied by complications like adhesion of lungs, congestion and consolidation of lungs, collapse of the lungs, mediastinal pleuritis and formation of fibrous tissue over the oesophagus.

The abdominal approach gave better exposure of the gastroesophageal region and required less mechanical assistance. Omental adhesion with abdominal incision or

diaphragm and myotomy site with diaphragm in a few animals were the only complications.

Significant reduction in the rectal temperature was seen upto 90 min in all the animals. Significant increase in pulse rate (Groups I, III, IV and V) and respiration rate (Groups I, II, IV and V) was observed upto 24 h.

All the animals were alert and active by 48 h. Food intake and swallowing was normal in all the animals though reluctance to take feed was observed upto three days in a few animals. Vomition was noticed only once in one animal.

Haemoglobin concentration, erythrocyte sedimentation rate and packed cell volume were within normal range in all the animals during the period of observation.

Erythrocyte count was within normal range in all the animals but for a transient reduction observed on 14th day in Group I.

An increase in the total leucocyte count was observed at 30 min in Group I and on 7th and 14th day in Group V.

In the animals of Groups III and V neutrophil count showed an increase on 7th and 14th day but became normal by 21st day. Lymphocyte count showed a decrease on the 7th and 14th day, but became normal by 21st day. Eosinophil count

showed a decrease in animals of Group I, and was within normal range in the animals of other groups.

The electrocardiogram changes observed during surgery and in post operative period were depression of R wave and elevation of ST segment and T wave in a few animals. These changes got spontaneously corrected.

Contrast radiography during the period of observation revealed normal oesophageal emptying and there was no leakage, stricture or oesophagitis in any animal. Narrowing of caudal thoracic oesophagus with dilatation of stomach was observed in one animal and dilatation of stomach alone in two animals. Contrast radiography of autopsy specimen of oesophagus and stomach showed an increased width of the gastroesophageal region and cardia, normal size of oesophagus and stomach and an outpouching of the stomach with normal mucosal folds in Groups I and II.

Autopsy revealed an increase in the width of gastroesophageal region, with intact hiatus in all the animals. An outpouching of the stomach at the greater curvature was observed in all the animals. The stomach was flaccid in three animals.

The myotomy site was thin in Groups I, II and V. In Group III the myotomy site sutured to the overlying portion of

diaphragm and in Group IV the diaphragm pedicle graft sutured to the myotomy wound were firmly adherent. In Group V, the omental pedicle graft sutured to the myotomy site has healed completely and was indistinguishable.

The oesophageal mucosa was normal in all the animals except one. Mucosal folds at the cardia was more flattened in a few animals.

Histomorphological study revealed the filling of the myotomy site with fibrovascular tissue in all the groups. In Groups III and IV in addition to the thin fibrovascular layer the muscle fibrils of diaphragm was observed at the periphery. Myotomy site with thin fibrovascular layer in Group V was infiltrated with plasma cells, lymphocytes and macrophages and a few neutrophils. Over the thin fibrovascular layer, a layer of fibrous tissue was observed at the periphery. Inflammatory changes were not observed in the gastroesophageal mucosa or submucosa in any of the animals.

Based on the results of the study, the following conclusions could be drawn.

1. Premedication with atropine and xylazine and induction and maintenance of anaesthesia with thiopentone sodium was satisfactory for gastroesophageal myotomy in dogs.

2. Abdominal approach through the 12th intercostal space with resection of 12th rib provided better exposure for surgery of gastroesophageal region in dogs.

3. Suturing the oesophageal myotomy wound to the hiatal incision in a horizontal direction increased the width at the gastroesophageal region.

4. The diaphragm or the diaphragmatic pedicle graft sutured to the gastroesophageal myotomy incision was well tolerated, increased the thickness at the myotomy site and did not bring about any adverse change in the structure or function of oesophagus.

5. Omental pedicle graft sutured to the gastroesophageal myotomy incision was tolerated, did not create any untoward structural or functional change in the oesophagus but was accompanied by local inflammatory reaction.

6. Suturing myotomy incision to intact diaphragm was more advantageous than suturing to pedicle graft of diaphragm.

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EVALUATION OF THE EFFICACY OF DIAPHRAGMATIC AND OMENTAL TRANSPLANTS AT THE GASTROESOPHAGEAL JUNCTION IN DOGS

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ABSTRACT OF A THESIS

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ABSTRACT

The study was undertaken with the objectives of designing a surgical approach to the gastroesophageal region in dogs and to evaluate the efficacy of diaphragmatic and omental grafting at the gastroesophageal myotomy site.

The study was conducted in 30 adult dogs of either sex divided into five groups of six animals each.

The animals were premedicated with atropine sulphate (0.04 mg/kg body weight) and xylazine (0.5 mg/kg body weight) IM. Anaesthesia was induced and maintained with five per cent solution of thiopentone sodium to effect. Induction of anaesthesia and recovery was smooth and uneventful and the duration was satisfactory. Respiratory arrest observed in a few animals could be corrected except in one and respiration was maintained with respiration pump or Boyles' Tec anaesthetic apparatus.

Gastroesophageal myotomy was performed through left side thoracotomy with resection of eighth rib in animals of Group I and by laparotomy, through the 12th intercostal space with resection of 12th rib in animals of Group II, to study the suitability of surgical approaches.

Abdominal approach adopted in Group II was found suitable for experimental approach and was adopted in animals of Groups III, IV and V. In the animals of Groups III, IV and V gastroesophageal myotomy was performed and the myotomy edges were sutured to the overlying portion of diaphragm in Group III, to a deflected portion of diaphragmatic pedicle graft in Group IV and to a deflected portion of omental pedicle graft in Group V.

The animals were kept under observation for 21 days post operatively and observed for physiological changes, clinical signs, haematologic, radiographic and electrocardiogram changes. Physiological parameters showed a significant decrease in rectal temperature upto 90th min after surgery and significant increase in pulse and respiration rate upto 24 h. All the animals were alert and active throughout the period of observation. Feed intake and swallowing was normal. Skin wound had healed without complications in all the animals.

Haemogram showed normal haemoglobin concentration, erythrocyte sedimentation rate and packed cell volume throughout the period of observation in all the animals. Erythrocyte count was within normal range in all the animals except for a transient decrease in Group I and leucocyte count showed an increase in Group V. An increase in neutrophil count was observed on the 7th and 14th day in Groups III and V with a corresponding decrease in lymphocyte count. Monocyte

count was normal in all the animals and oesinophil count showed a decrease in Group I. The values returned to normal range by 21st day in all the animals.

The electrocardiogram changes observed during surgery and in post operative period were spontaneously corrected.

Contrast radiography of the oesophagus and stomach revealed normal emptying and absence of leakage. Narrowing of the caudal end of thoracic oesophagus along with dilatation of the stomach was observed in one animal and dilatation of stomach alone was observed in two animals. Contrast radiography of the autopsy specimen of oesophagus and stomach of one animal each from Group I and II revealed increased width of gastroesophageal region and an outpouching of the stomach at the greater curvature.

Gross morphological examination on autopsy in Group I revealed adhesion of lung with thoracic wall, diaphragm and oesophagus, congestion and consolidation of lung, collapse of the lung lobes and mediastinial pleuritis in a few animals. Fibrous tissue covering over the caudal end of thoracic oesophagus was also seen in two animals.

Adhesion of omentum with abdominal wall and diaphragm was the autopsy changes noticed in Group II.

Oesophagus was normal in size in all the animals except in one animal where slight narrowing at the caudal end was observed. Increased width at the gastroesophageal region was evident in all the animals. An outpouching at the greater curvature of the stomach was seen in all animals except three where slight dilation and flaccidity of the stomach was noticed. The myotomy site was thin in Groups I, II and V. In Groups III, the portion of diaphragm sutured to the myotomy wound was firmly adherent with it and in Group IV, the diaphragm pedicle graft sutured to the myotomy wound has healed and was firmly adherent to the myotomy site. In Group V, the omental pedicle graft sutured to the myotomy site has healed completely and was indistinguishable.

On histological examination no sign of inflammation was noticed in the mucosa and submucosa. At the myotomy site fibrovascular connective tissue proliferation was observed in all the groups. In Groups III and IV peripheral to the fibrovascular connective tissue, the fascicles of diaphragmatic muscle fibrils were observed.

In Group V beneath the thin fibrovascular layer infiltration of plasma cells, lymphocytes, macrophages and a few neutrophils were observed extending into the stroma and lamina propria. A layer of fibrous connective tissue was observed as the outermost layer over the thin fibrovascular layer and contained a few fat cells in one animal.