COMPARISON OF MANUAL AND MECHANICAL CERVICAL ESOPHAGOGASTRIC ANASTOMOSIS AFTER ESOPHAGEAL RESECTION

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CERTIFICATE

Certified that this dissertation titled **"COMPARISON OF MANUAL AND MECHANICAL CERVICAL ESOPHAGOGASTRIC ANASTOMOSIS AFTER ESOPHAGEAL RESECTION"** is the bonafide record work done by **Dr. A. ANTOINE BERTY**, during the period 2005-08, done under my guidance and supervision and is submitted in partial fulfillment of the requirement for the M.Ch. (Branch – VI) Surgical Gastroenterology & Proctology, of The Tamil Nadu Dr. M.G.R. Medical University, August 2008 examination.

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Chapter 1

INTRODUCTION

Esophagectomy is increasingly performed for a wide spectrum of conditions but mostly for carcinoma. Improvement of perioperative management and surgical techniques has resulted in a steady decrease in postoperative mortality. Today, postoperative hospital mortality in centers with experience is well below 5%. Overall 5-year survival rates as high as 30–40% have been reported after resection with curative intent [1]. As a result, an increasing number of patients are now surviving on a long-term basis. Their quality of life may be very much influenced by the quality of their esophageal anastomosis. Furthermore, despite all efforts, in a majority of the patients surgery remains palliative mainly because of the unexpected advanced stage of the disease at the time of surgery. In such patients, quality of palliation is of paramount importance. It is widely accepted that surgery offers the best form of palliation but the quality of palliation may still be jeopardized by anastomotic complications, i.e. anastomotic leak or even worse, catastrophic complications such as the necrosis of the proximal part of the conduit used for reconstruction or in a late stage anastomotic stricture formation.

The organ most used for reconstruction after esophagectomy is the stomach. [2] Advantages include ease of construction and the prospect to achieve a substitute of sufficient length.

Following esophagectomy or esophageal bypass, restoration of continuity by gastric interposition with cervical esophagogastric anastomosis (CEGA) can be done

either by a hand-sewn or stapled anastomosis. Regardless of the surgical approach, decreasing anastomotic complications is essential for minimizing early morbidity and improving long-term functional results and quality of life. Though early complications of cervical esophagogastric anastomosis are less, the long-term sequelae such as anastomotic stricture occur in nearly half the patients with an anastomotic leak. The need for life long esophageal dilatation negates the benefit of an operation intended to relieve dysphagia. The cause of anastomotic dehiscence in cervical esophagogastric anastomosis is possibly multifactorial with both local tissue and systemic factors are being implicated. As the esophagus has no serosa, its longitudinal muscles hold sutures poorly; possibly contribute to the higher anastomotic leak rates. Surgical technique is thus likely to play an important role. The incidence of cervical esophagogastric anastomosis leakage with hand sewn has been reported from 15% to 25%. While the circular stapled anastomosis is considered to be more expedient, less traumatic to tissues, with lower leak rates and associated with less mortality and morbidity, they are criticized for increased cost and high stricture rates. Following side to side anastomosis with linear staplers the leak rates have been reported to be less than 5%, with lower incidence of anastomotic stricture after leak and improved satisfaction in swallowing compared to hand sewn technique.

This study was designed to compare two methods of esophagogastric anastomosis, one with hand-sewn anastomosis and the other with mechanical stapled anastomosis.

Chapter 2

AIM OF THE STUDY

The objectives of the study are

1. To compare the rates of anastomotic leaks after cervical esophago gastric anastomosis (CEGA) done by hand-sewn (end-to-side) technique or by linear stapled anastomosis (side-to-side) technique.

2. To compare the rates of postoperative anastomotic stricture after cervical esophago gastric anastomosis (CEGA) done by hand-sewn (end-to-side) technique or by linear stapled anastomosis (side-to-side) technique.

Chapter 3

REVIEW OF LITERATURE

Definition

The incidence of anastomotic leaks varies widely and has been reported up to 53% [3]. The main reason for this wide variation is the lack of an accurate definition of an anastomotic leak. In a recent systematic literature review of all articles dealing with anastomotic leak after esophagectomy, Bruce et al. [4] only found 13 out of 33 publications that included a definition of anastomotic leak. The clinical features used to define anastomotic leakage included evidence of hematoma or seroma at the neck wound, septicemia, peritonitis, perianastomotic collection, leak, local inflammation, evacuation of air or saliva, mediastinitis, abscess, empyema and pneumothorax. The majority of these studies reported the routine postoperative use of radiographic water-soluble contrast studies, but the timing of the contrast study ranged from 3 to 14 days after the operation. It is thus clear from this literature survey that there is a lack of consensus on the definition and seriousness of an anastomotic leak. Bruce et al. [4] in their review article proposed to use the definition as suggested by the Surgical Infection Study Group, a UK Multidisciplinary Group [5]. Obviously even in this classification the definition and thus the incidence of a leak, especially a clinically occult leak, is very much dependent on the use of routine contrast studies. In practice, many centers today rely exclusively on the clinical parameters since a radiological detection of a minute otherwise occult leak has little or no consequence on the further therapeutic strategy.

Etiology

Many factors, local and systemic, are influencing the process of wound healing and hence influencing the incidence of anastomotic complications. In addition, a number of intrinsic aspects specific for esophageal surgery may also contribute to the occurrence of complications, in particular leakage. Such intrinsic aspects are the absence of a serosa and the longitudinal orientation of the muscle fibers resulting in a more fragile environment holding sutures poorly as compared to e.g. the gastric wall. Moreover, esophagectomy followed by reconstruction requires extensive dissection as well as an extensive mobilization bringing a viscus from a distant remote position to perform an anastomosis outside of the protective peritoneal cavity [6].

Amongst systemic factors influencing the healing process, (Table-1) a number are clearly jeopardizing the chances for an uneventful healing [7]: malnutrition, hypotension, hypoxemia, neoadjuvant therapies, and other comorbidity e.g. diabetes, cardiovascular diseases, respiratory insufficiency.

Often excessive smoking and drinking habits are an underlying cause of this co morbidity but also, as such, negatively interfering with the immune system of the patient. Malnutrition, if present, can be corrected by preoperative nutritional support, e.g. parenteral nutrition. But in the literature, attitudes towards preoperative nutritional substitution are conflicting [8] because of the delay in the actual cancer treatment and the potential complications such as catheter sepsis related to total parenteral nutrition [9].

Etiologic factors for Postesophagectomy Esophagogastrostomy Anastomotic leak		
Local	**Systemic**	**Inherent**
Arterial insufficiency (gastric fundus) Venous insufficiency (gastric fundus) Tension Technical errors Gastric distention Infection Extrinsic compression	Malnutrition Hypotension Hypoxia	No serosa Extraperitoneal Longitudinal muscle (holds sutures poorly) Technically awkward

Table 1. Etiologic factors for Postesophagectomy Esophagogastrostomy Anastomotic leak

During and after surgery, hypotension should be avoided because of the potential negative impact on perfusion and tissue oxygenation. In this respect the surgeon should be familiar with the vascular anatomy of the viscus used for reconstruction. From several studies measuring gastric tissue oxygenation, it appears that tissue oxygen tension decreases after gastrolysis. After gastric pull up in the neck the tissue oxygen tension drops further down to almost half the values measured before gastrolysis. It is however not clear how far impaired tissue oxygenation in itself is responsible for anastomotic leak rather than cellular metabolic disorders or technical factors as indeed there seems to be no significant evidence of decreased tissue oxygen levels in patients with anastomotic complications [10]. In this respect a wide variety of surgery-related aspects including technical failures may interfere substantially with the occurrence of anastomotic complications.

The Conduit

Today in most centers with experience, subtotal esophagectomy with cervical anastomosis is the standard type of operation for cancer of the esophagus. Restoration of continuity is performed by using stomach, colon or jejunum. Jejunum is rarely used because the technical difficulty to prepare a loop sufficiently long to reach the neck for anastomosis. Moreover, often this will result in excessive kinking due to the particular blood supply of the jejunum. Stomach and colon on the contrary are easily transposed to the neck. The colon, especially the transverse and left colon have a rather consistent vascular anatomy based on arcades connecting left, middle and right colic artery. Provided sufficient experience, results of coloplasty are very similar to gastroplasty and reported short-term outcomes after esophagectomy for cancer are almost identical. However, the majority of surgeons do prefer to use stomach to restore continuity because of the relative simplicity of the operation and the need for only one anastomosis [11]. When using the stomach as a substitute the entire vascularization depends on the right gastroepiploic artery and vein. In this respect it is important to realize that approximately 60% of the gastric tube is supplied by this vessel, approximately another 20% more cranially by the minute connections between right and left gastroepiploic vessels. Finally, the most cranial 20% is vascularized through a dense submucosal and microvascular network [12]. Liebermann-Mefferet et al investigated the actual, as contrasted with the presumed, blood supply of the greater curvature gastric tube commonly used to reconstruct the gullet after esophagogastrectomy. Arterial and venous corrosion casts of this tube were created in 30 cadavers and demonstrated the following:

1. The right gastroepiploic artery is the exclusive conduit of blood in the pedicle.
2. The contribution of the right gastric artery is negligible.
3. Although tributaries of the left gastroepiploic artery are distributed over the central portion of the tube, the connection between the right and left gastroepiploic vessels is minute.
4. The blood supply of the cranial 20% of the greater curvature tube is through a microscopic network of capillaries and arterioles.

These findings constitute an anatomical argument for extremely gentle handling of the stomach throughout its mobilization, during construction and positioning of the tube, and during the anastomosis. As the anastomosis is mostly made at the proximal 20% of the gastric fundus, it is of paramount importance to avoid trauma of the gastric tube. Too much manipulation during gastrolysis, application of suction devices, traction sutures to facilitate the gastric pull-up maneuver are all factors favoring trauma and thus jeopardizing the esophagogastric anastomosis. For these reasons some authors advocate to resect the proximal 4–6 cm of the fundus in case of doubtful macroscopic vascularity. It is claimed that full mobilization of the stomach including Kocher's maneuver nearly always affords ample length for a tension-free anastomosis even when the proximal 4–6 cm had to be resected [12].

To improve vascularization of the gastric fundus, gastric conditioning by laparoscopic partial gastric devascularization at the time of e.g. laparoscopic cancer staging (Figure-1) has been proposed [13].

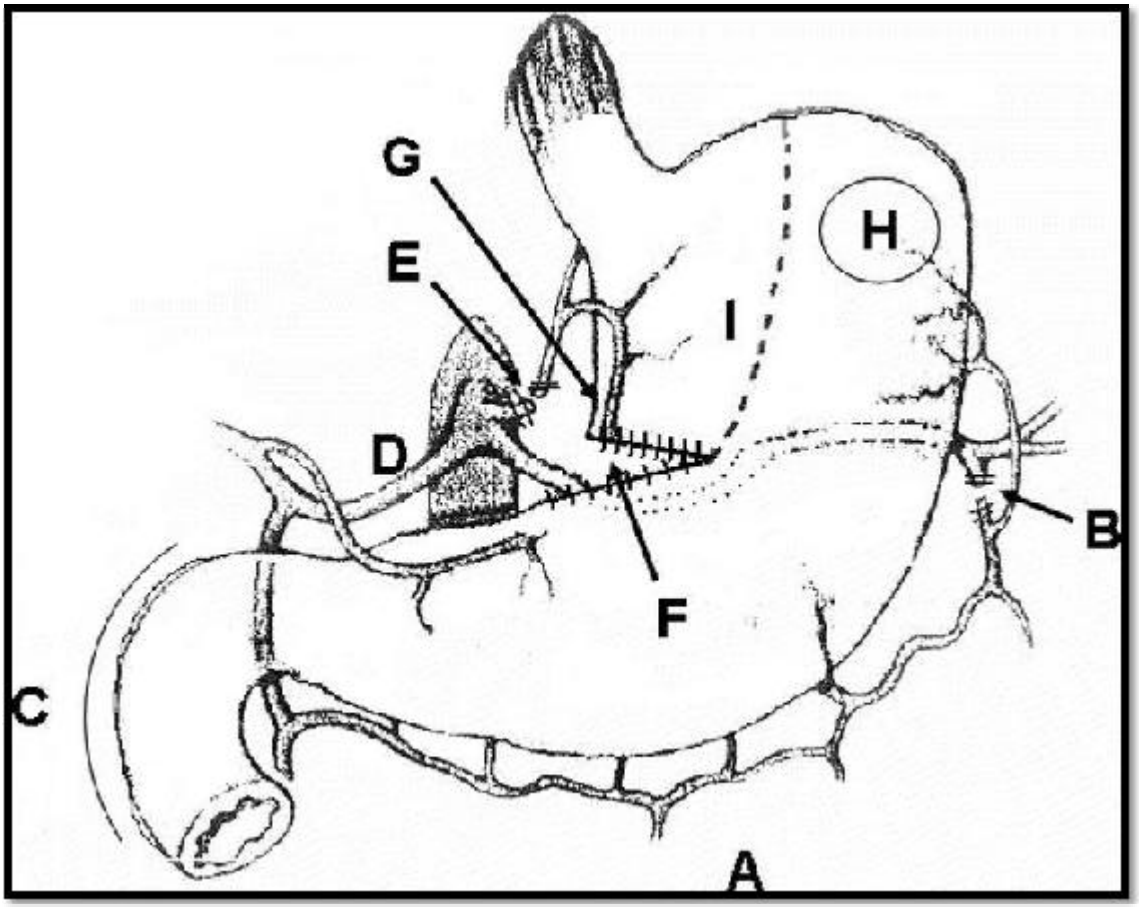


Figure 1. Final aspect of the gastric conduit after laparoscopic ischemic conditioning A, Divided gastroepiploic omentum preserving the right gastroepiploic arcade. B, Left gastroepiploic artery divided. C, Kocher maneuver performed. D, Common hepatic and splenic artery cleared. E, Left gastric artery and vein divided. F, 60-mm endostapling between the distal and middle third of the lesser curvature. G, Intended introduction site of the circular stapler in the chest. H, Intended location for esophagogastrostomy. I, Intended linear stapling for completion of the conduit in the chest.

First, all patients underwent laparoscopic mobilization of the stomach including the cardia and preparation of the gastric conduit. After a mean delay of 4.3 days (range, 3–7 days), a conventional right-sided transthoracic en bloc esophagectomy was performed. Reconstruction was done by gastric pull-up and high intrathoracic esophagogastrostomy. It is however not clear whether such methods indeed result in a decreased incidence of anastomotic complications.

Whole Stomach or Gastric Tube?

Some authors argue that a better blood supply can be obtained when using the whole stomach as compared to using a gastric tube with resection of the lesser curvature.

The arguments are firstly that the fundus is mainly supplied through intramural vascular anastomotic pathways along the lesser curvature rather than through the greater curvature segment and secondly a vasodilative effect of sympathectomy by skeletonizing the lesser curvature [14]. Major differences between gastric tube versus whole stomach are cervical anastomosis stenoses (22.3% versus 6% ; $p = 0.008$), fistulas (7.9% versus 1%; $p = 0.0209$), number of meals and snacks per day (4.6 versus 4; $p = 0.0275$), sensation of early fullness at meals (52.4% versus 17.8%; $p < 0.0001$), and calories consumed in 1 minute at a test meal (59% [$p < 0.05$] versus 77% of those consumed by control subjects). The volume of the stomach is reduced by a range of 21.4% to 47.2% after tubulization (gastric tube, Figure-2) whereas it increases by a range of 4.9% to 17.4% after denudation of the lesser curve (whole stomach, Figure-3). Another, more technical, argument used in favor of the whole stomach is the absence of a suture line in the vicinity of the anastomosis related to gastric tubulization. It is suggested that the narrow band of gastric tissue between this suture line and the margin of the anastomosis in its close vicinity may be poorly vascularized and cause necrosis and subsequent leak [15].

Figure 2. Gastric tubulization: (A) application of the distal part of the first cartridge of staples on the lesser curvature 4 to 5 cm proximal to the pylorus; (B) application of the last cartridge of staples separates the esophagus, the proximal three fourths of the lesser curvature, and the lesser omentum from the rest of the stomach

Figure 3. Gastric denudation: (A) the lesser omentum is separated progressively from the lesser curvature by ligation and division of the terminal rami of both right and left gastric vessels flush with the gastric wall from the pylorus up to the cardia. (B) The esophagus is separated from the stomach by application of a single cartridge of staples on the cardia

Others argue that there is a zone with small anastomotic sites between the various small branches of the left gastric artery and the right gastroepiploic vessels in both the anterior and posterior walls. This is a line 4–5 cm from the greater gastric curvature, a finding that supports the clinical practice to use a gastric tube rather than the whole stomach [12] since the right gastroepiploic artery is the exclusive source of blood to the gastric tube. In fact, too little is known about the real per- and postoperative situation, especially the direction of blood flow in the proximal part of the fundus to draw any conclusion in favor of either gastric tube or whole stomach

[16]. Collard et al. [14] obtained a 1% leakage rate when using the whole stomach versus 7.9% when using a gastric tube. But when performing a semi-mechanical anastomosis in 16 cases with whole stomach, he observed one, minute, leak (6.2%) [15]. Orringer et al. [17], using a whole stomach, obtained a 2.7% leakage rate when using stapled anastomosis versus 10–15% when using hand-sewn anastomosis.

As these figures are from retrospective studies they merely seem to indicate that experience most likely explains the observed decrease in leakage rate rather than anything else. Gastric distention, more often present when using the whole stomach, probably also plays a role in postesophagectomy anastomotic failure [18]. Indeed delayed gastric emptying is associated with a higher incidence of anastomotic leak [19]. Postoperative gastric decompression by performing a pyloroplasty or pyloromyotomy is therefore considered a mandatory procedure by many surgeons. However, such a procedure may induce duodenogastric reflux resulting itself in anastomotic ulceration, stenosis and eventually formation of Barrett metaplasia [20].

Which Approach? Which Route?

Controversy still exists as to optimal surgical approach, i.e. transthoracic (TTE) versus transhiatal (THE) esophagectomy for patients with carcinoma of the esophagus and gastroesophageal junction (GEJ) not only for oncologic reasons but also in relation to postoperative complications.

Transhiatal esophagectomy was first described by Levy about a hundred years ago. In 1913, Denk[21] first performed transhiatal esophagectomy experimentally. Turner[22] in 1982, performed transhiatal esophagectomy on a

patient with cancer of the esophagus and reported his first series in 1936. Le Quesne and Ranger[23] in 1966, Akiyama[24] in 1975 and 1982, and Orringer [25,26,27,28,29,30] reporting their successful results, popularized the operation.

Goldminc et al. [31] performed a randomized controlled trial comparing THE versus right-sided TTE. In terms of postoperative complications in general, there was little difference between both approaches. The incidence of anastomotic leaks was 6 and 9% respectively. In another randomized controlled trial by Chu et al. [32], again no difference was found between the two approaches with no leak in either the THE (n = 20 patients) or the TTE (n = 19 patients) group.

Morgan et al. [33] compared transthoracic (119) versus transhiatal esophagectomy [32] following neoadjuvant therapy for esophageal cancer. Despite the fact that patients receiving multimodal therapy and a TH esophagectomy were less fit, operative morbidity, mortality and recurrence were similar, and survival did not differ significantly when compared with multimodal TT esophagectomy.

In an Indian study, Narendar Mohan Gupta,[34] Transhiatal esophagectomy required markedly less operating time (137 versus 327 min) but had a higher incidence of recurrent laryngeal nerve palsy (20% versus 0%). Anastomotic leaks occurred with similar frequency in both groups (23% versus 19%) and intrathoracic disruption carried a very high mortality (80%). Transhiatal resection had lower mortality (10% versus 26%) and both groups had similar survival. These results suggest that compared to transthoracic esophagectomy, the transhiatal approach had fewer complications, a lower mortality rate, and comparable survival, and thus

remains an acceptable procedure for resection of squamous cell carcinoma of the distal esophagus

As to the route of reconstruction it is commonly believed that the posterior mediastinal route is superior to the retrosternal route because of the shorter distance and consequently a lower incidence of anastomotic leaks. Posterior mediastinal reconstruction is usually preferred when a complete (R0) resection has been accomplished.

Young et al. [35], analyzing the results after esophagectomy for benign disease, found a highly significant increase of anastomotic leaks when using the longest route but this study is a retrospective study spanning a long period of over 40 years. Blewett et al. [36] compared in a retrospective study intrathoracic and cervical anastomosis. Leaks occurred in 5% (1/19) of the cervical anastomosis and in 16% of the patients with an intrathoracic anastomosis. These figures, although indicating a trend, were not significant.

Anastomotic Technique

Numerous reports on different aspects and different variations on anastomotic techniques have been published over the last decades. Anastomosis can be handmade, stapled or semimechanical.

As to the hand-sewn anastomosis, many technical details, e.g. running versus interrupted sutures, absorbable or nonabsorbable, one- or two-layer sutures, knots within or outside the lumen, have been debated.

Simon Law [37] studied 218 consecutive patients who had an esophageal anastomosis constructed with a 1-layer, continuous technique (Figure-4). Anastomotic leaks affected 7 patients (3.2%), of whom 3 required surgical reexploration and none died. Anastomotic strictures developed in 24 patients (11.1%).

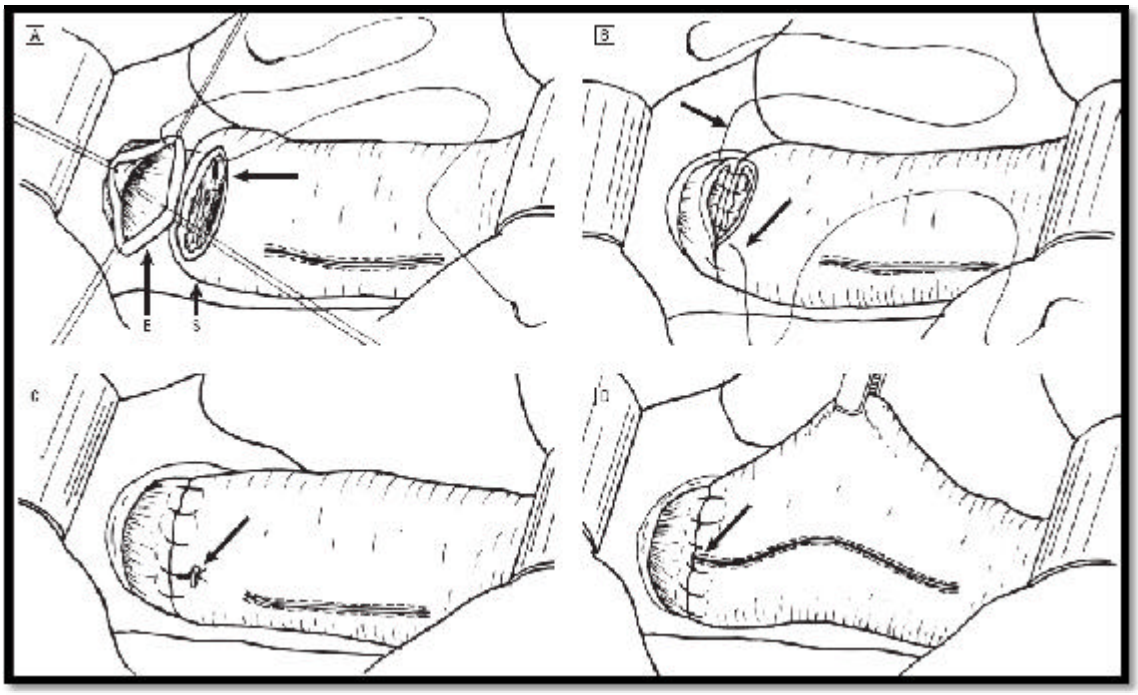


Figure 4. Technique of the single-layer, hand-sewn anastomosis. A, Technique of hand-sewn anastomosis showing the 2 single-armed sutures tied at the ends. One stitch is first passed from the stomach (S) to the esophagus (E), and the posterior wall is sutured with full-thickness bites. Horizontal arrow shows the knot anchored inside the lumen. B, The posterior wall is completed; the first stitch is now brought out from the stomach side (upper arrow). The anterior wall is begun, and the second stitch is brought out through the esophageal lumen (lower arrow). C, The anastomosis is completed with the 2 stitches tied. A clip is placed on the stitch to mark the site of anastomosis (arrow). D, The anastomosis is completed when the distal stomach is used, with the stapled line (arrow) incorporated into the anastomosis.

Bardini et al. [3] conducted a prospective randomized study comparing the efficacy of a 21 single layer of continuous absorbable monofilament (Maxon) with that of a 21 single layer of interrupted Polyglactin sutures (Vicryl) in the performance of cervical esophagogastric anastomoses. One asymptomatic anastomotic leak and two early anastomotic strictures requiring dilation occurred in patients in whom an

interrupted technique was employed. The continuous technique required significantly less operative time ($p < 0.0001$), and the cost of the suture material was reduced markedly. They concluded that either a continuous or an interrupted monolayer esophagogastric anastomosis could give satisfactory results after esophagectomy for cancer, provided that the vascular supply to the gastric fundus was maintained adequately.

Zieren et al [38] in a Prospective randomized study of one- or two-layer anastomosis (Figure-5) following oesophageal resection and cervical oesophagogastrostomy, concluded that, one-layer esophagogastric anastomosis in the neck must be considered superior to the two-layer procedure because of the lower incidence of nonmalignant stricture formation.

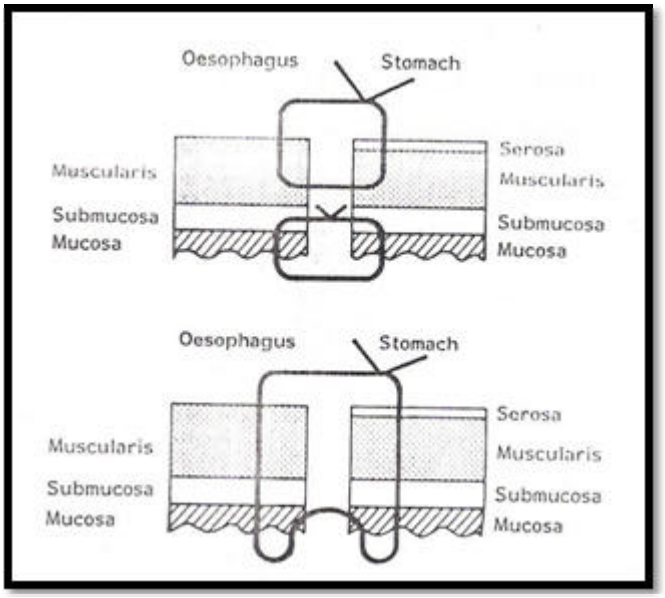


Figure 5 Technique of a two layer and one layer esophagogastric anastomosis

Han-Lei Dan et al [39] modified by a new three-layer-funnel-shaped (TLF) esophagogastric anastomotic suturing technique (Figure-6) consisting of

Cycle A: mucosa-to-mucosa suture.

Cycle B: the esophagus muscular to gastric sero-muscular suture.

Cycle C: fundoplication suture.

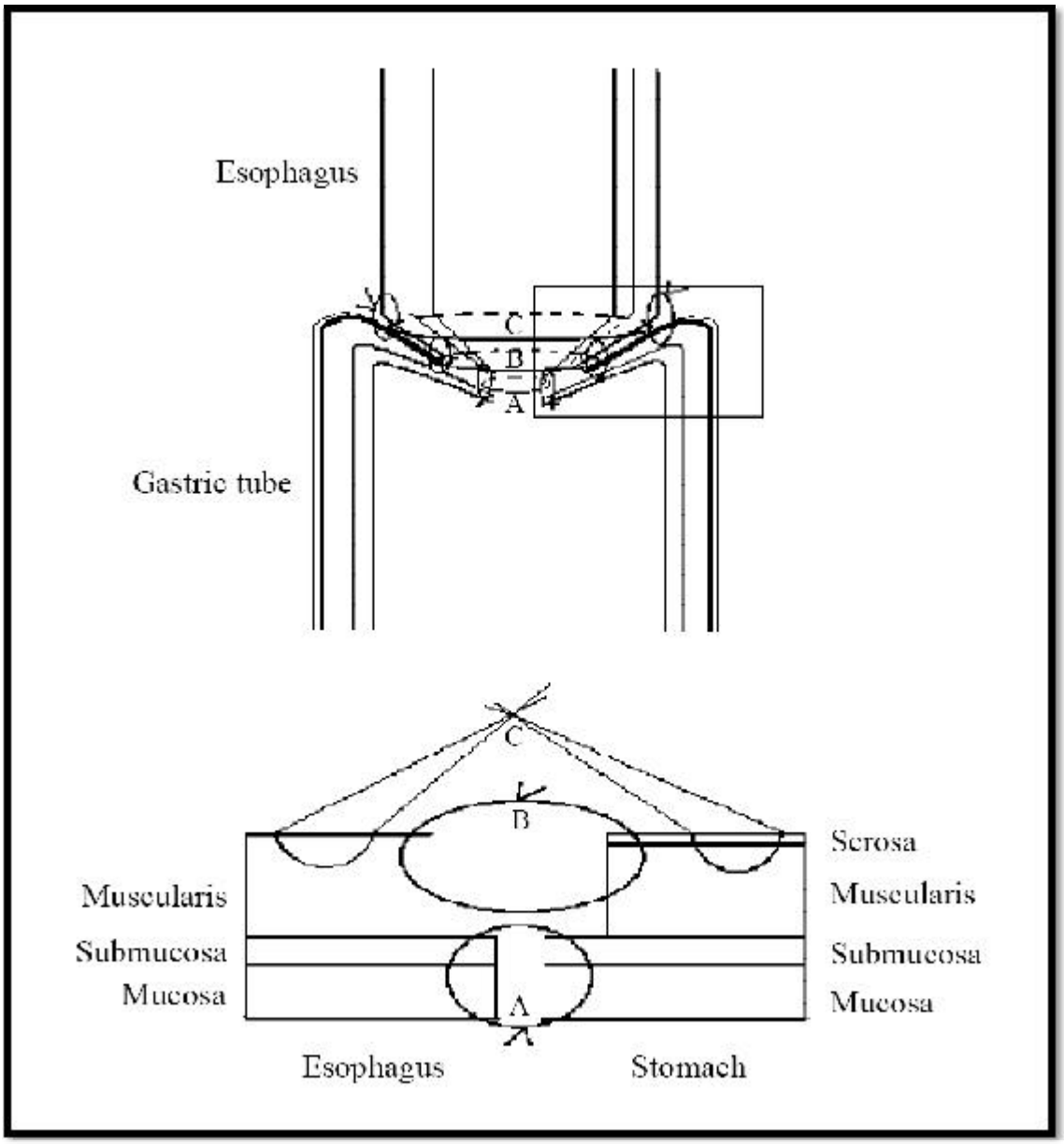


Figure 6. Technique of three-layer-funnel-shaped (TLF) esophagogastric anastomosis. A: mucosa-to-mucosa suture cycle; B: the esophagus muscular to gastric sero-muscular suture cycle; C: fundoplication suture cycle.

Zi-Jiang Zhu et al [40] introduced a layered manual esophagogastric anastomosis and compared the operative results in regard to reducing anastomotic leakage and stricture formation using a newly designed layered manual esophagogastric anastomosis versus a stapler esophagogastrostomy versus the conventional hand-sewn whole-layer anastomosis after resection for esophageal or gastric cardiac carcinoma. From January 2004 to September 2006, a total of 1024 patients with esophageal or gastric cardia carcinoma underwent a layered esophagogastric anastomosis with the assistance of a three-leaf clipper in a single university medical center. The mucosal layers of the esophagus and stomach were sutured continuously with 4/0 Vicryl plus antibacterial suture (polyglyconate). From May 2002 to December 2003, there were also 170 patients and 69 patients who underwent stapler and conventional whole-layer anastomosis, respectively; they served as control groups. The anastomotic leakage rates were 0%, 3.5%, and 5.8% for the layered group, stapler group, and whole-layer group, respectively ($p < 0.01$). Six patients in the layered group (0.6%) developed mild stricture formation compared to 16 patients in stapled group (9.9%) and 5 patients in the conventional whole-layer group (7.8%) ($p< 0.01$). The application of layered esophagogastric anastomosis could reduce the incidence of anastomotic leakage and stricture after esophagectomy compared with the stapler and whole-layer manual anastomoses.

Yoshiyuki Furukawa et al [41] introduced a new form of anastomosis, automatic triangular anastomosis using a linear staple (TA-30) (Figure-7), and compared hand sewn anastomosis method, circular stapler method and triangular anastomosis method.

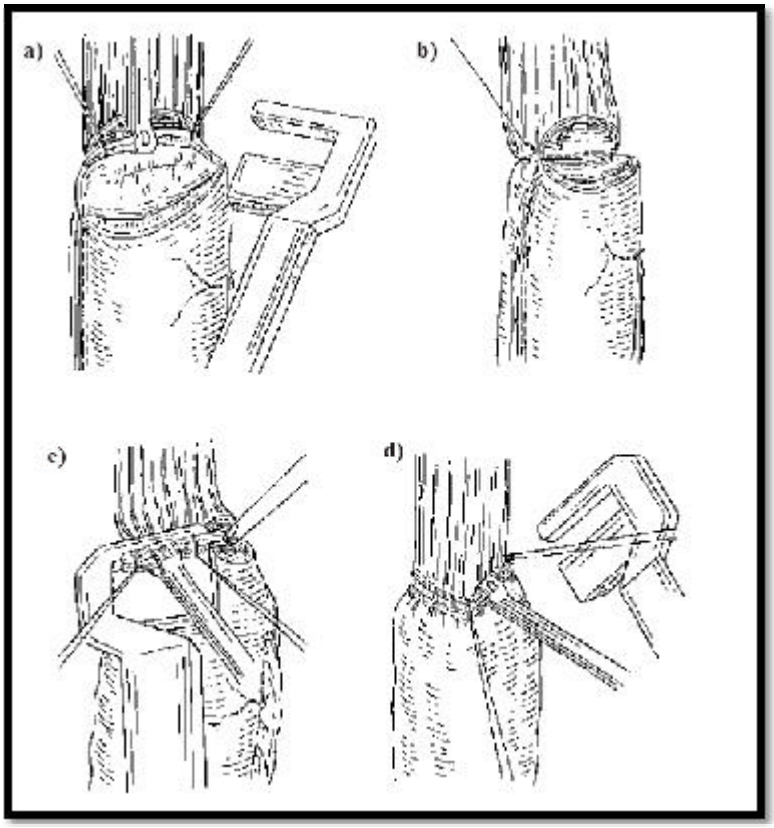


Figure 7. Cervical esophagogastric anastomosis using a linear stapler (TA-30)(a) Elevate the portion between two supporting sutures applied to the mucosa and muscularis using Allis forceps and staple it; (b) Apply supporting sutures to the right and left ends on the staple line of the sutured posterior wall, and perform anterior wall suture so that it intersects with the staple line of the posterior wall; (c) Suture everting the anterior wall to make an isosceles triangle; (d) Staple so that the both staple lines mutually intersect without fail, and finally confirm that 3 sides of the staple lines mutually intersect.

Two-three supporting sutures were taken to all the layers of the esophagus in the posterior wall and the gastric tube. Elevating these supporting sutures anastomosis of the posterior wall was done using a linear stapler (TA-30). Then by applying supporting sutures to the right and left ends of the staple line on the sutured posterior wall and to the center of the anterior wall, stapling done to make an isosceles triangle. The three staple lines should mutually intersect without fail. The anastomotic failure was 27.3%, 25.0% and 8.3% and anastomotic stenosis was found 32.4%, 45.6% and 8.3% for the hand sewn anastomosis method, circular stapler method and triangular anastomosis method respectively.

Cervical esophagogastrostomies can be performed with circular stapling devices both transorally [42] and by transitioning the stapler through the subsequent pyloroplasty site [43] and pushing the stomach up to the cervicotomy.

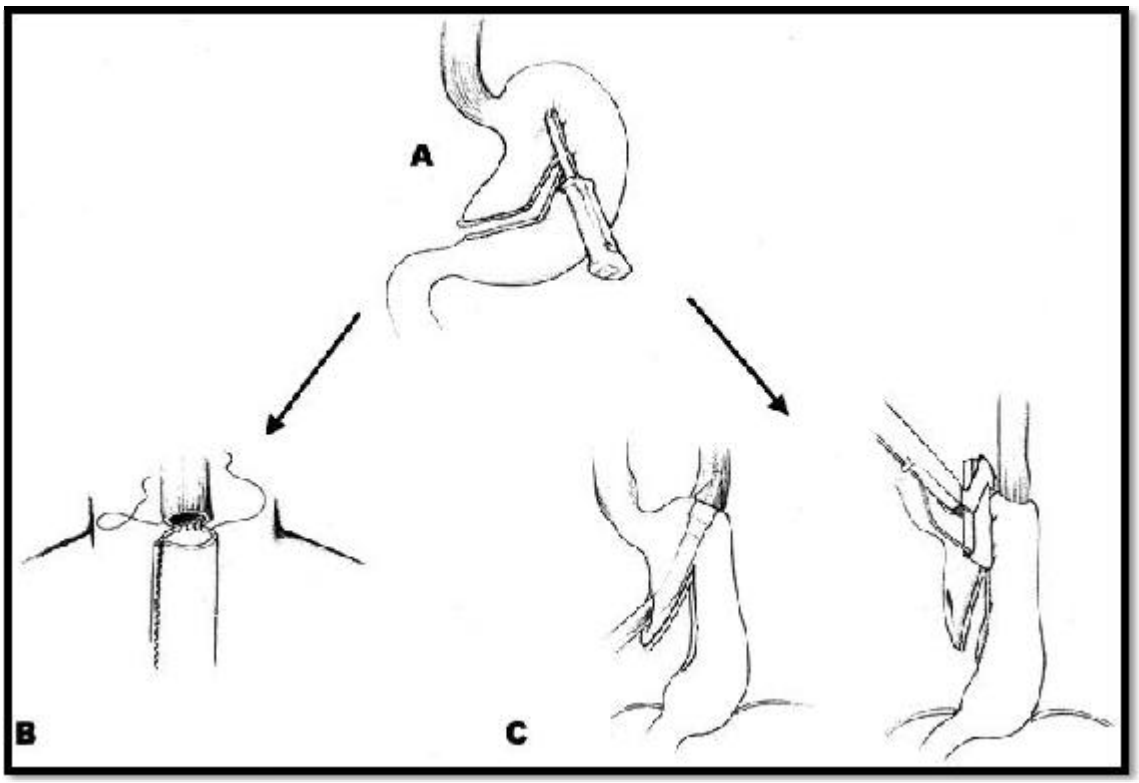


Figure 8. The gastric tube substituting the esophagus was created by serial applications of a linear cutting stapling device, TLC 55 parallel to and at a distance of 6 cm from the greater curvature, starting approximately 8 cm proximal to the pylorus at the Crow's foot (A). When the patients were randomized to receive a neck anastomosis, a running, single-layer end-to-end technique with 4–0 Polydioxanone was used through all the layers (B). When the patients were randomized to chest anastomosis (C), the esophagogastrostomy was performed, end-to-greater curvature, by insertion of a circular stapling device through the subsequently resected (TLH 90 or TL 60) lesser curvature. By this technique, everting staple lines in the proximal part of the substitute, the circulation in the most critical part could be evaluated. Care was taken to insert the subsequent stapler in the angle of the previous staple row. The crossings of the staple lines were oversewn; otherwise, no forms of reinforcing sutures were used.

Fekete et al. [44] described a technique applied to esophageal surgery, concerning 30 stapled anastomosis (Figure-9) for esophagogastric resections made for cancer of the esophagus or cardia.

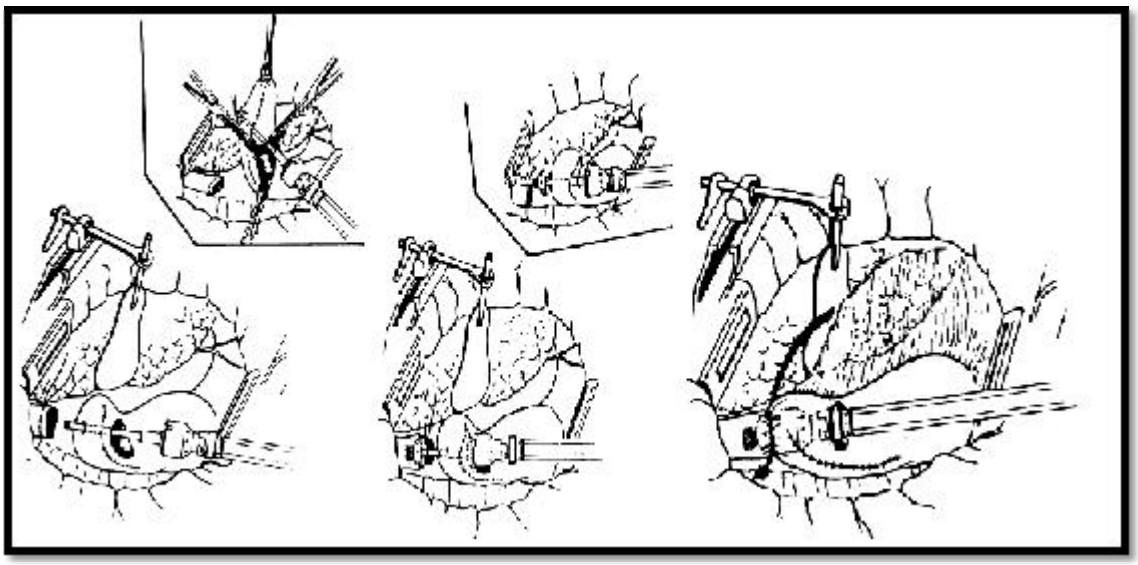


Figure 9 (a) The anvil is secured to the shaft and inserted into the esophagus. (b) Inversion of the EEA stapler through an anterior gastrotomy (right thoracotomy). (c) Anastomosis course of the great omentum meant to wrap thoroughly the anastomosis and the gastric remnant.

The gastric fundus and high lesser curvature were severed with Nakayama's stapler. The EEA stapler was inserted through a stab incision made on the anterior wall of the stomach. The esophagogastric end-to-side anastomosis was performed on the posterior wall of the stomach.

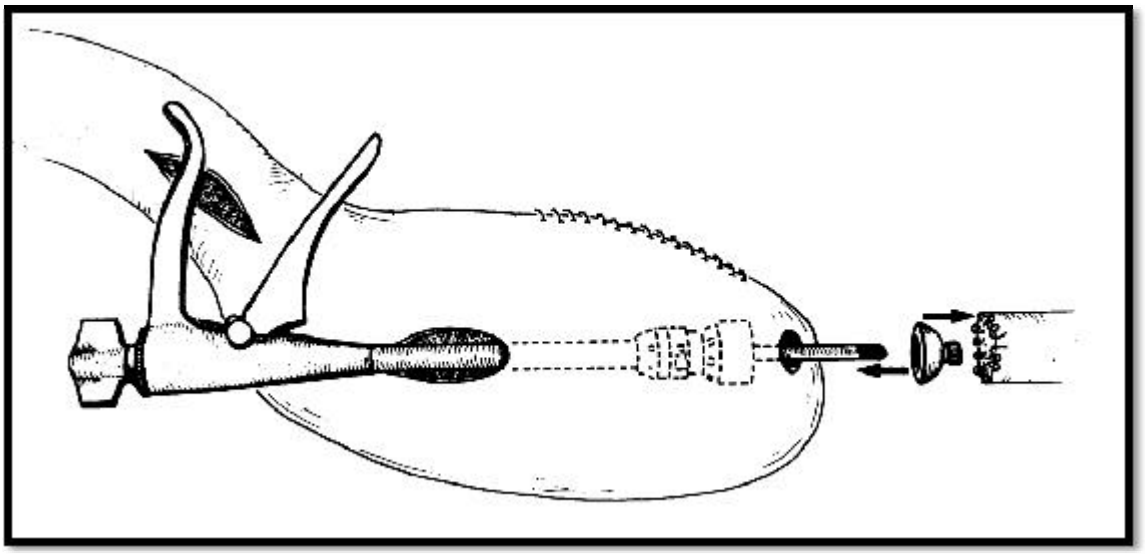


Figure 10. Esophagogastric anastomosis with the EEA stapler as viewed through a left thoracotomy. After securing the anvil to the center rod, the instrument is advanced into the esophagus, where it is secured with the purse string suture.

Fok et al. [45] compared a single-layer continuous hand-sewn anastomosis with circular stapling (Figure-10) in a prospective nonrandomized study including 611 patients. Resection was performed in 491 patients, bypass operation in 97, and 23 had exploration alone. The anastomoses of 580 patients with one-stage resection and bypass operations were evaluated. Hand-sewn anastomosis using a single layer of continuous absorbable monofilament suture was performed in 304 patients (221 resections and 83 bypasses). A stapled anastomosis was performed on 276 patients (262 resections and 14 bypasses).There were 5% anastomotic leaks in the hand-sewn group and 3.8% in the stapled anastomosis group ($p = 0.69$). The results of this non-randomized study suggested that hand-sewn anastomosis using a single layer continuous technique for the esophagus was as safe as the use of circular staplers; hand-sewn anastomosis is less likely to become stenotic. From these studies it seems that, provided there is adequate vascularization of the stomach, little difference in anastomotic leakage rate is to be expected between hand-sewn or stapled anastomosis.

Although Hsu and colleagues [46] reported that the circular stapler is a feasible option for CEGA, the application of these devices in the cervical region is technically complicated [47]. Many investigator, therefore, discourage the use of circular stapling devices [48].

More recently the semi-mechanical anastomosis has been introduced. Both Collard et al. [15] and Orringer et al. [17] have published a low incidence of leakage rate of 6.2 and 2.7% respectively.

Collard and associates [15] have reported on a side-to-side stapled CEGA (Figure-11 and Figure-12) with an Endo-GIA stapler using the tip of the mobilized stomach. This, in effect, creates a functional end-to-end esophagogastric connection. In 114 consecutive patients undergoing transhiatal esophagectomy, a functional side-to-side cervical esophagogastric anastomosis was constructed with the Auto Suture Endo-GIA II stapler (United States Surgical Corporation, Auto Suture Company Division, Norwalk, Conn) applied directly through the cervical wound. This side-to-side stapled anastomosis has 3 rows of staples. It is believed that the use of endostaplers with three rows of staplers at each side of the anastomosis decreases the incidence of leaks. But whether the reported low incidence of leaks is really the result of the particular anastomotic technique is difficult to prove.

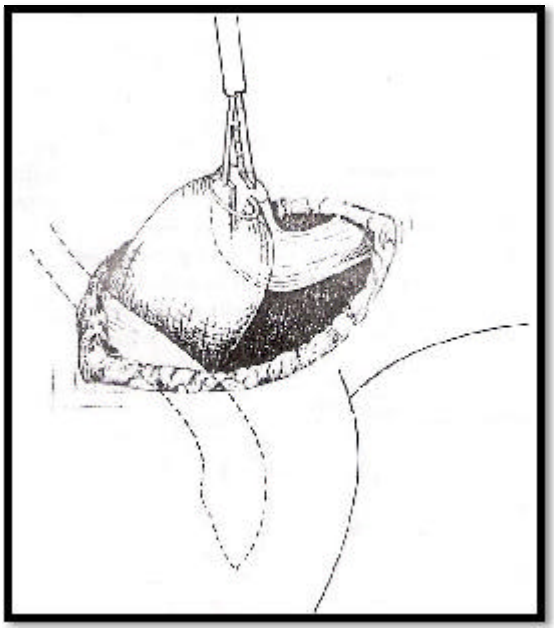


Figure 11 Terminalized semimechanical side-to-side anastomosis between the whole stomach and cervical esophageal stump with Endo-GIA 30 stapler. Note the V-shaped opening between the two lumina. The cardiac staple line is located far from the anastomotic site at the top of the fundus

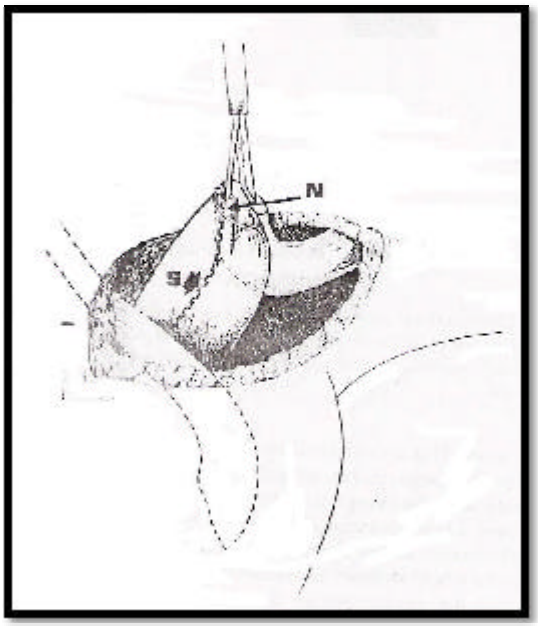


Figure 12 Terminalized semimechanical side-to-side anastomosis between the cervical esophageal stump and a greater curvature tube. The upper end of the staple line related to the gastric tubulization (S) is incorporated into the cervical anastomosis, so that a narrow band of gastric tissue between the staple line and the right margin of the V-shaped posterior opening may be poorly vascularized and may become necrotic (N)

In Collard's report indeed the semi-mechanical anastomosis was randomized against hand-sewn anastomosis with no leakage in the hand-sewn group. A terminalized semimechanical side-to-side technique of cervical esophagogastrostomy was performed in 16 patients by the application of an Endo-GIA stapler across the gastric and esophageal walls placed side by side, so as to create a V-shaped posterior opening between the two lumina. The anterior aspect of the anastomosis was hand-sewn using a classic running suture.

Kim et al. [49] and Orringer et al. [17] have reported on the usefulness of Endo-GIA 30 mm stapler in CEGA (Figure-13). They found that Endo-GIA was easy to handle in the cervical region and with a generous 3 cm anastomosis there was a reduction in anastomosis site stricture and postoperative dysphagia compared to circular staplers.

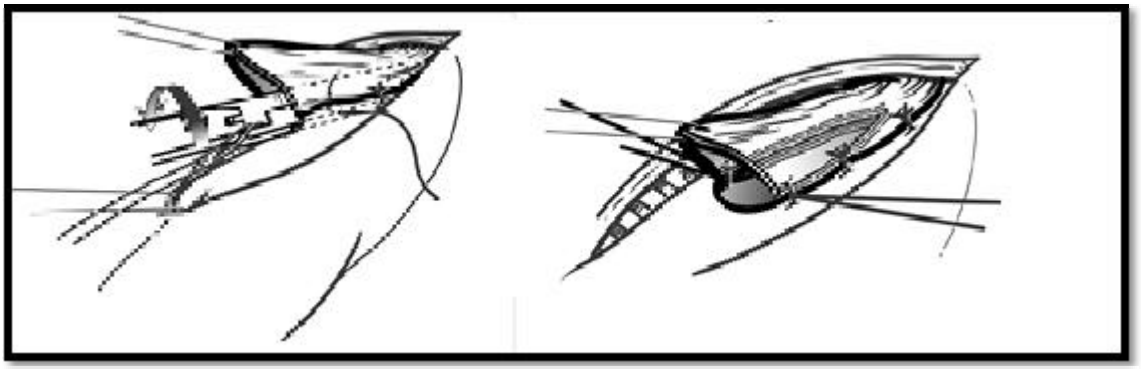


Figure 13. Semi-mechanical anastomosis

- The total mechanical anastomosis (Figure-14) is begun in similar fashion to the semi or partial mechanical technique by creating the posterolateral walls of the anastomosis with the endoscopic stapling device. The anterior aspect of the anastomosis is accomplished with

two or three additional firings of the EndoGIA stapler across the raised edges of the stomach and esophagus.

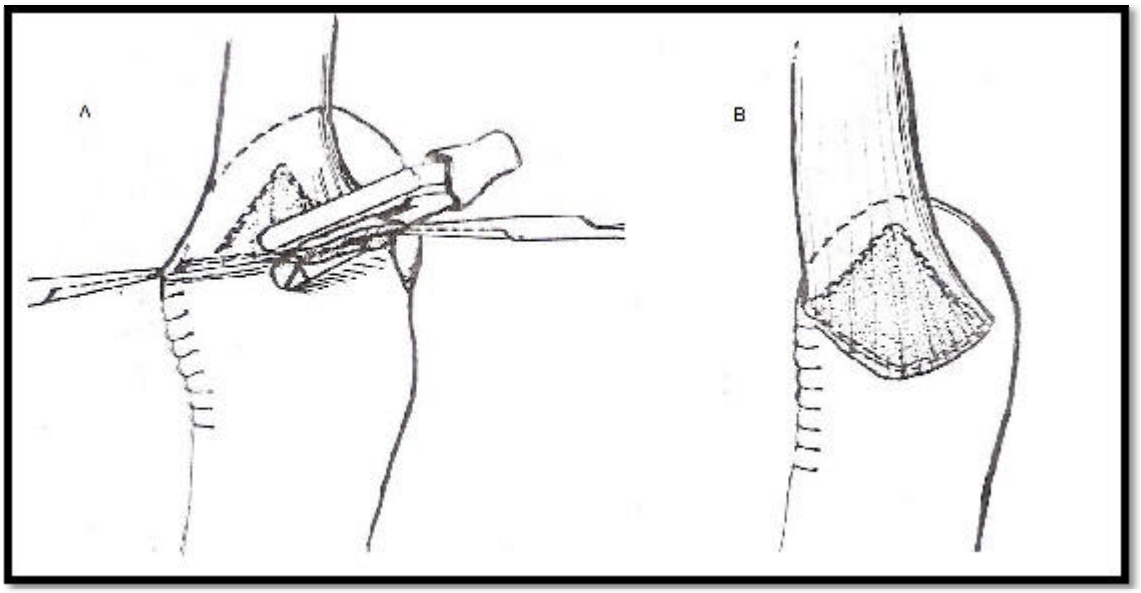


Figure 14 A-Application of endoscopic stapler device (endo-GIA) in completion of the anterior aspect of the total mechanical anastomosis; B-Completed total mechanical anastomosis.

Some authors have suggested that leakage rate is influenced by the presence or absence of a cervical drain. Choi et al. [50] performed a randomized study comparing the use of a closed suction drainage versus nondrainage in 40 patients who underwent esophagectomy for carcinoma. Anastomotic leaks did not occur in any patient. It was therefore concluded that, as in other types of visceral surgery [51], routine use of a cervical drain for esophageal anastomosis in the neck is not necessary.

Experimental study on esophageal anastomosis [52]

Hermann et al. [53] on studying the morphological evolution of anastomoses of the digestive tract, described three phases.

- Phase 1 (day 0 to day 4), or delayed phase - characterized by edema and inflammation
- Phase 2 (day 3 to day 10), or lag phase - characterized by fibroblasts regeneration. During this period edema and inflammation subside and an intense proliferation of fibroblasts is observed.
- Phase 3 (day 10 to day 180), or stable phase - characterized by reorganization and progressively there is complete recovery of the intestinal wall layers.

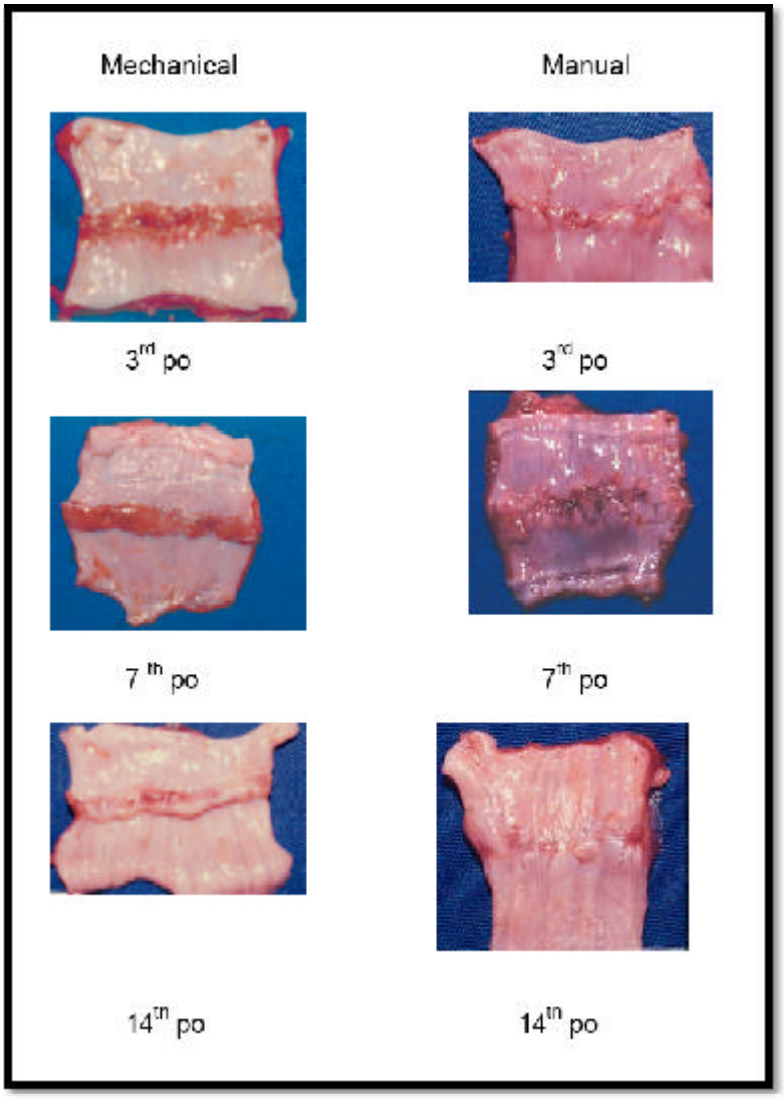


Figure 15. The macroscopic aspect.

In relation to the macroscopic study, (Figure-15) the group mechanically sutured evidenced impaired mucosal apposition at the time of the suturing, which then progressed to an important proliferation of granulating tissue around the seventh postoperative day and after that to abundant local healing by second intention. At the microscope, ischemic aspects and little inflammatory reaction in the initial phase were seen, which then rapidly regressed. In the hand sewn group, the mucosae were well apposed to construct the anastomosis, however leaks of various sizes appeared on the seventh day, which remained in great proportion until the fourteenth day postoperative, showing that the apparent mucosae union in the early stages had been illusory. Microscopically, the healing evolution is characteristic of healing by first intention, and the prolonged inflammatory reaction could be credited to the suturing material used. Therefore, both methods of anastomosis progressed with classical, although different ways of healing.

This observation has clinical correlation with those of other studies, e.g. by Fok, Wong[45], and by Bardini et al.[3], who provided evidence of healing by second intention with stapled sutures and detected higher incidence of delayed stenoses in mechanically sutured anastomosis probably as consequence of the over-abundant granulation tissue.

Comparison of the two groups showed similar bursting pressure in the 3rd postoperative day. However, the group of mechanical suturing presented a significantly greater resistance in the 7^{th} and 14^{th} postoperative day compared with the hand-sewn group.

Management of Anastomotic Leaks

In the past, anastomotic leakage was one of the leading causes of perioperative mortality after esophagectomy. Because of refinements in anastomotic technique as well as improvements in perioperative management, the consequences of an anastomotic leak today seem to be less dramatic. The clinical presentation and consequently the therapeutic attitude is largely determined by the site (thoracic versus cervical) and, the presence or absence of containment of the leak by surrounding tissues. The management of anastomotic leaks can roughly be subdivided into four categories (Table-2) based on the Surgical Infection Study Group. [5]

Leak	Definition
Radiological	No clinical signs
Clinical Minor	Local inflammation of the cervical wound. X-ray contained leak
Clinical Major	Severe disruption on endoscopy Sepsis
Conduit necrosis	Endoscopic confirmation

Table 2. Definition of leak as adapted from the Surgical Infection Study Group

In case of an asymptomatic leak only discovered at X-ray contrast study, little specific treatment is required. Usually a delay of oral intake, especially solids, for a

few days will suffice. In the presence of a minor, well-contained leak, the patient will be placed on a nil-by-mouth regimen combined with total parenteral nutrition especially in the presence of malnutrition. According to infectious parameters, broad-spectrum antibiotherapy may become necessary. Usually there is no need for a nasogastric tube in these cases. When judged necessary, e.g. in case of abscess formation in the neck, bedside opening and drainage of the cervical incision is performed. Early postoperative esophagoscopy and dilatation have been reported by Trentino et al. [54] and Orringer et al. [55]. The dilatation of a leaking anastomosis may favorably influence healing because relative narrowing by local inflammation and spasm may contribute to obstruction distal to an esophageal leak and adversely affect spontaneous closure. Once the leak has dried up or has disappeared on X-ray contrast study, oral diet can be resumed. In the presence of a documented major clinical leak a more aggressive treatment may become necessary. When the leak is located in the neck a major disruption has to be excluded by endoscopic control. The further management then very much depends on the location of the anastomosis and the perianastomotic fluid accumulation. Indeed, some patients may develop an intrathoracic fluid collection requiring CT-guided drainage. In case of intrathoracic anastomosis, the leaks have a tendency to be poorly contained by the surrounding tissues. Nevertheless, the majority of intrathoracic leaks can be managed by conservative measures as mentioned above. However, in case of rapidly developing sepsis with diffuse leakage on contrast study a reintervention becomes mandatory. In most of such cases there will be a substantial defect at the site of the anastomosis which together with the present mediastinitis will preclude a repair of the

anastomotic dehiscence. In such a situation a take down of the anastomosis with temporary esophagostomy and feeding jejunostomy may be the only valid option. Depending on the severity of mediastinitis, a T-tube drain associated with esophageal exclusion may be another option.

Finally in case of necrosis of the proximal part of the conduit, a resection of the necrotic part, debridement of the mediastinum, esophagostomy and feeding jejunostomy is the treatment of choice [56]. In the rare case of limited mediastinitis one can consider an immediate reconstruction with another type of conduit avoiding the need for a temporary esophagostomy. Overall however except for the rare cases of necrosis of the gastric conduit surgical reintervention to treat anastomotic leakage has become the exception since almost all anastomotic leaks can be cured by means of conservative treatment, including antibiotics and CT-guided drainage when necessary.

Stenosis

Despite the lowering of the incidence of anastomotic leaks, the incidence of anastomotic stenosis remains relatively high between 10 and 56% [17]. However, recent progress in the management of strictures, in particular the introduction of PPI and the development of better and safer dilatation techniques, e.g. Rigiflex balloon dilatation, resulted in a major decrease in morbidity caused by these strictures. Chronic PPI therapy combined with Savary or pneumatic dilatation are the key factors in the treatment of anastomotic stricture. From the available data it seems that anastomotic strictures occur more frequently after circular stapler anastomosis

than after hand-sewn anastomosis. In hand sewn anastomosis there is a higher tendency for stricture formation after two-layer anastomosis than after single layer anastomosis. Early postoperative endoscopy, i.e. between days 3 and 5 and dilatation when necessary, seems to result in a decreased need for multiple dilatation.

Trentino et al. [54] reported an 83% success rate after a mean of 3.6 dilatations when performing early endoscopy and dilatation. The presence of ulceration involving more than 50% of the anastomotic circumference is the most important factor in predicting development of anastomotic stricture [54].

The use of the semi-mechanical anastomosis technique seems to be promising in relation to the incidence of anastomotic stricture formation. Orringer et al. [17] reported an incidence of 48% stricture formation in hand-sewn anastomosis versus 35% in the semi-mechanical anastomosis. In this group, no patients required more than three dilatations whereas in the hand-sewn group 7.5% of the patients required five or more dilatations. It is believed that this decreased incidence of strictures and the decreased need for multiple dilatations results from a significantly wider cross-sectional area of the esophagogastrostomy after the semi-mechanical anastomosis [15]. However, such an anastomosis requires a sufficiently long remnant of proximal esophagus and is therefore contraindicated for oncologic reasons in upper half esophageal carcinomas.

Chapter 4

MATERIALS AND METHODS

The centre of study was at Department of Surgical Gastroenterology and Proctology in Madras Medical College.

- Study Type: Interventional
- Study Design: Treatment, Efficacy Study
- Number of arms in study: 2
- Period of study : September 2005 to March 2008

All the patients who attended outpatient department of GI Surgery with complaints of dysphagia were evaluated for esophageal disorder. 28 patients were included in the study. There were a total of 17 patients in the hand-sewn group and 11 patients in the semi-mechanical stapler group.

Eligibility

- Ages Eligible for Study: 18 Yrs - 80 Yrs
- Genders Eligible for Study: Both

Inclusion criteria

- Any patient with resectable carcinoma of the mid or lower thoracic esophagus and gastro-esophageal junction
- Benign esophageal lesion where esophageal resection was beneficial and feasible

Exclusion criteria

- Patients who had upper thoracic or cervical esophageal carcinoma
- Unresectable lesions (T4/M1)
- Prior gastric surgery
- Poor performance status (ECOG 3,4)

Diagnostic work up

- Barium swallow
- Upper gastrointestinal (UGI) endoscopy and biopsy (where malignancy was suspected)
- Hypopharyngoscopy (for corrosive stricture of esophagus)
- Haemogram
- Serum chemistry
- Liver function tests
- ECG
- Chest x-ray
- Pulmonary function tests
- In the malignant group, preoperative imaging included computed tomography (CT) scan from the neck to the upper abdomen including the liver and celiac axis.

Preoperative preparation

- Preoperative nutrition maintained and if required a Ryle tube insertion or feeding jejunostomy will be done.
- Incentive spirometry, steam inhalation, bronchodilators and antibiotics were used to improve the pulmonary status as required.

Surgical technique

- Either transhiatal or transthoracic esophagectomy.
- When a three-incisional esophagectomy was performed, a standard right lateral thoracotomy through the sixth intercostal space was used. This approach was primarily chosen to resect mid esophageal lesions and in conditions with dilated esophagus where injury to distal trachea azygous vein was greater when THE was used.
- Standard intrathoracic dissections of the esophagus and periesophageal lymphatics were undertaken.
- Closure of the thoracotomy was accomplished and the patient was positioned for the laparotomy and cervical aspects of the esophagectomy.
- The laparotomy aspect of the esophagectomy was standardized.
- A midline upper abdominal incision was created.
- The stomach was completely mobilized by ligation and division of the left gastric vessels at its origin from the celiac axis and ligation of all short gastric vessels distal to their communication with the right gastroepiploic arcade.

- The gastric conduit was prepared based on the right gastric and right gastroepiploic vessels and pyloromyotomy and pyloroplasty were not performed.
- Finger dilatation of pylorus was done when required.
- The conduit was prepared using 75-mm linear cutter (Figure-16).

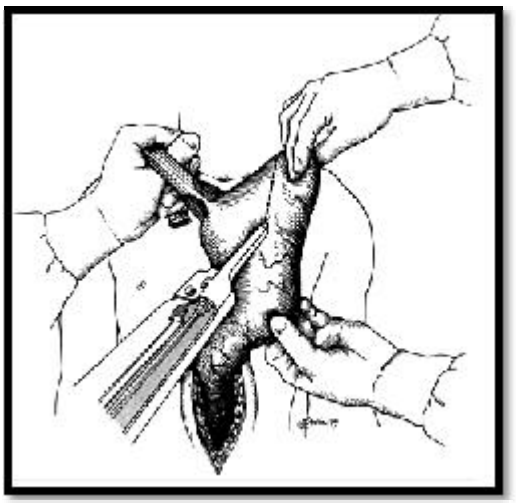


Figure 16. Gastric tubulization

- The stomach was brought up into the neck through either the retrosternal or posterior mediastinal route.
- 4 to 6 cm of the stomach was brought into the neck wound more from pushing below in the chest than from pulling from above in the neck
- The CEGA was done by a side-to-side stapled or end-to-side hand-sewn method.
- Chest tubes (32F) were inserted bilaterally to take care of any breach in the pleura.
- Feeding jejunostomy (Witzel's type) with 12F Suction catheter was done in all patients.

- The neck wound will be closed loosely with interrupted sutures over a drain.

Hand-sewn anastomosis

- A proper site on the anterior wall of stomach away from the stapled line approximately 2 cm below the highest point of the gastric conduit was anastamosed to esophagus
- The stomach was then opened transversely (2.5 to 3 cm long).
- Interrupted stitches with full thickness of the stomach and esophagus using 2-0 Polyglactin were placed to achieve mucosa to mucosa approximation.
- A 16F nasogastric tube was placed across the anastomosis into the intrathoracic stomach.
- The anterior wall of the anastomosis was completed in a manner similar to posterior wall

Stapled anastomosis

- The mobilized stomach is gently manipulated by one hand through the diaphragmatic hiatus upward beneath the aortic arch into the superior mediastinum until the tip of the gastric fundus can be grasped with a Babcock clamp inserted through the cervical incision.

The clamp is applied gently, not completely racheting the handle, and is used to deliver the gastric fundus into the neck wound until it can be grasped with the fingertips

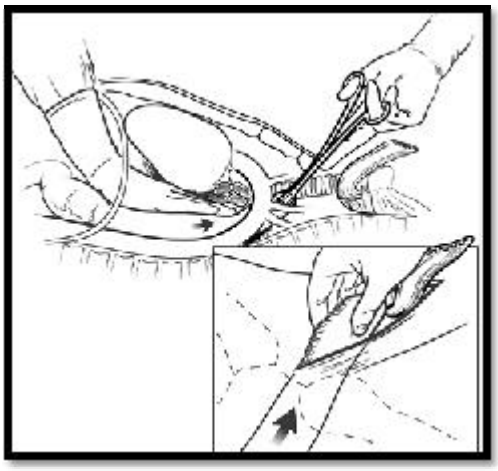


Figure 17. 4 to 6 cm of the stomach are brought into the neck wound more from pushing below in the chest than from pulling from above in the neck

- At least 5 cm of the mobilized stomach (Figure-17) was placed in the neck.
- The oversewn gastric staple line along the lesser curvature side of the stomach is toward the patient's right.

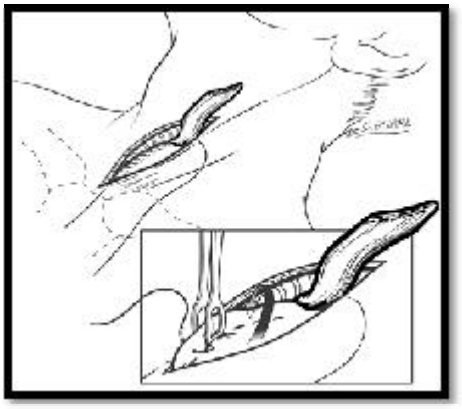


Figure 18. The stomach is elevated several more centimeters into the wound, and a seromuscular 3-0 cardiovascular silk traction suture is placed distal to the clamp

- A Babcock clamp is used to grasp the anterior wall of the stomach low in the neck wound where it emerges from the posterior mediastinum at the thoracic inlet, and the gastric staple line was rotated more medially. (Figure-18) The stomach was elevated several more centimeters into the wound, and a seromuscular 3-0 silk traction suture is placed distal to the clamp.
- A 1.5 cm gastrotomy was made. The gastrotomy must be located far enough inferior to the tip of the gastric fundus to allow subsequent full insertion of the 3-cm long staple cartridge. Placement of the gastrotomy (Figure-19) also must take into consideration the remaining length of cervical esophagus and should be performed with the realization that when the traction suture on the stomach is eventually removed, the stomach will partially retract downward into the thoracic inlet. Therefore, some redundancy in the length of the cervical esophagus should be allowed as the anastomosis is constructed.

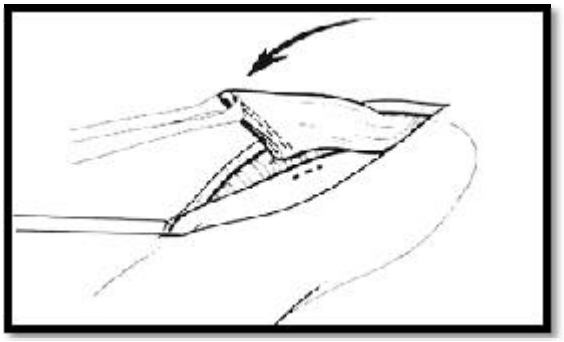


Figure 19. Placement of the gastrotomy

- An atraumatic vascular forceps serves as a guide for amputation of the cervical esophageal staple suture line, (Figure-20A) which is sent to the pathology department as the proximal esophageal margin. The cervical esophagus was divided with the stapler by placing it obliquely because the anterior tip of the esophagus should be longer than the posterior corner in construction of the anastomosis.
- Two stay sutures were taken, (Figure-20B) one at the anterior corner of the esophagus and another between the posterior corner of esophagus and the middle of the gastrotomy.

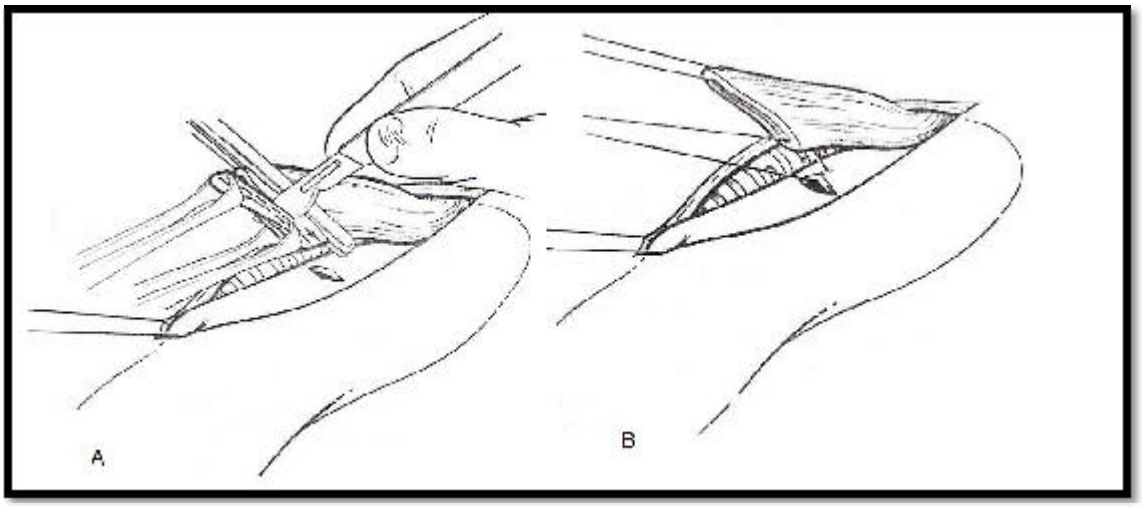


Figure 20. (A) Amputation of the cervical esophageal staple suture line. (B)Two full-thickness anastomotic stay sutures placed, one from the anterior tip of the cut cervical esophagus, and one at the midpoint of the upper edge of the transverse gastrotomy and the posterior corner of the esophagus.

- These stay sutures were retracted downwards as the stapler device (ETS-60, Endoscopic linear cutter, Ethicon Endo-surgery) was introduced, the thinner portion into the stomach and the thicker staple-bearing portion into the esophagus. (Figure-21A and 21B)

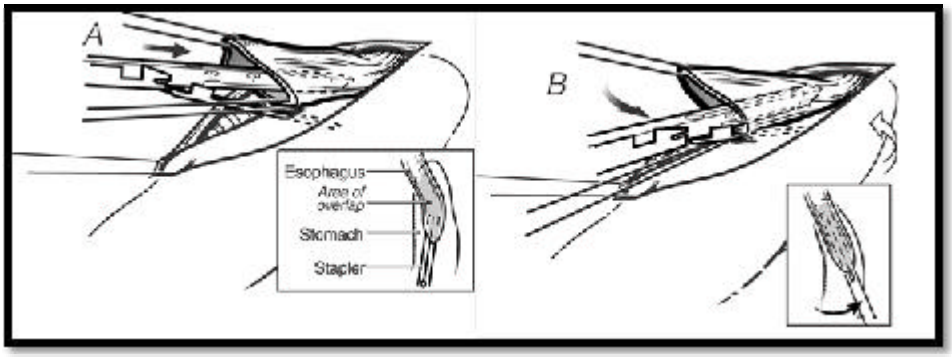


Figure 21. (A) With downward traction on the anastomotic stay sutures, the 60 mm stapler inserted, the thinner portion into the stomach, and the thicker staple-bearing portion into the esophagus. (B) The staple cartridge is advanced into the esophagus and stomach. To achieve alignment of the posterior wall of the cervical esophagus and the anterior wall of the stomach, as the stapler is inserted and advanced into the esophagus and stomach, it is rotated so that it is pointing toward the patient's right ear.

- The staple cartridge was then rotated so that the posterior wall of the esophagus and the anterior wall of the stomach were aligned in a parallel manner, keeping the site of the anastomosis well away from the gastric staple suture line.
- The stapler is closed, thereby approximating the jaws, but before firing it, two suspension sutures between the anterior stomach and the adjacent esophagus are placed on either side.

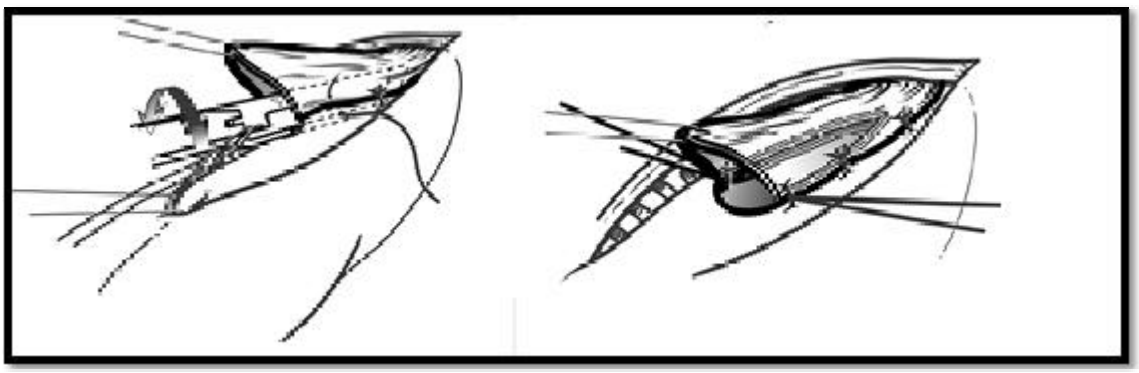


Figure 22. (A) The stapler is closed, thereby approximating the jaws. B. Side-to-side anastomosis created.

- When the knife assembly of the stapler is advanced, the common wall between the esophagus and stomach is cut, and a 5-6-cm long side-to-side anastomosis created. (Figure-22)
- Corner sutures are then placed at either side of the gastrotomy.

- A 16F nasogastric tube was placed across the anastomosis into the intrathoracic stomach
- The anterior edges of the gastrotomy and open esophagus were approximated in a single layered suture with interrupted 2-0 polyglactin. (Figure-23)

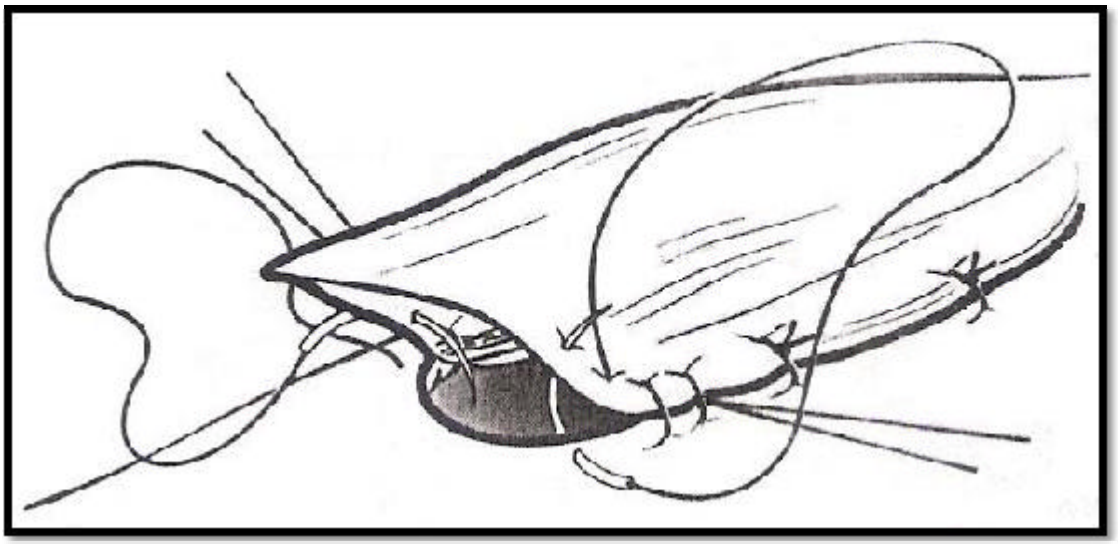


Figure 23. The gastrotomy and remaining open esophagus are approximated in an interrupted layer

Postoperative management

- Jejunostomy trial feed was started when the intestinal activity appeared.
- A contrast study using water-soluble contrast medium was done on the 7th postoperative day
- The neck drain was removed after the contrast study
- If no leakage were observed and the nasogastric tube delivered <200 ml, the patients started to drink fluids, followed by a soft diet. On the

ninth postoperative day, a regular diet was served. No form of supporting enteral nutrition was provided.

- If a leak was identified, the cervical wound was opened to establish external drainage of any cervical abscess and anastomotic fistulae.
- Regular dressing with normal saline soaked gauze was done.

Follow up

- All patients were followed one week after discharge and at monthly intervals for the first 6 months and subsequently at 3-month interval for two years
- Dysphagia if present was assessed with barium swallow and esophagoscopy.
- Anastomotic strictures were dilated with endoscopic SG dilatation.

Analysis

- Anastomotic leakage was defined as extravasation of water-soluble contrast medium and/or clinical symptoms of leakage.
- Anastomotic stricture was defined as an anastomotic narrowing that did not allow a standard fiber endoscope with a diameter of 9 mm to pass without resistance, and this was an indication for dilatation.
- Other complications, including cardiopulmonary morbidity, septic complications, duration of hospital stay after surgery and operative mortality was studied.

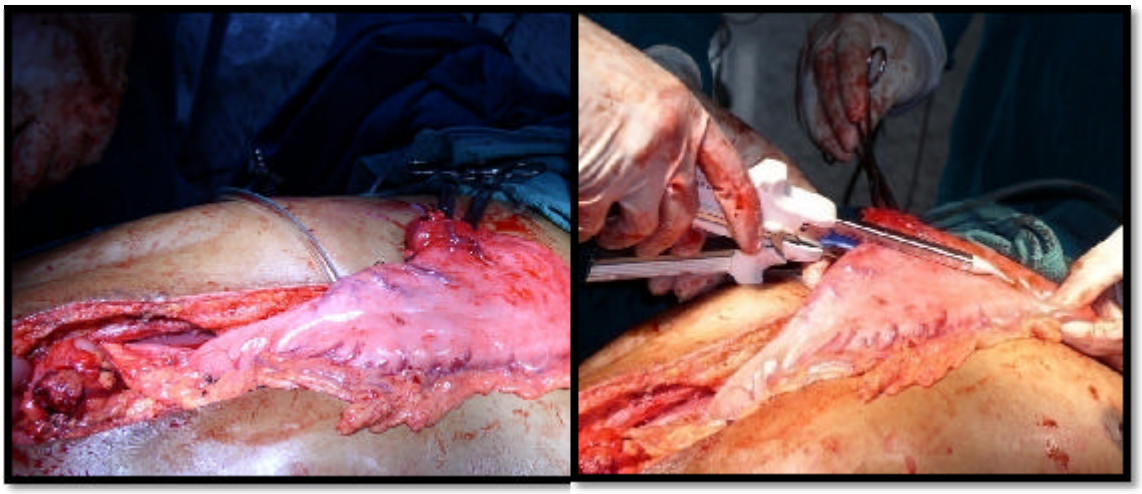
- Operative mortality included all patients who will die within 30 days of the procedure or during the same hospital admission.
- At surgery, the operative procedures, time taken for anastomosis and total operating time were recorded.
- Cost analysis of the suture materials and stapler used for hand sewn anastomosis and mechanical anastomosis were done

Statistical analysis

1. Continuous variables were reported as Mean with Standard Error of Mean (SEM)
2. Categorical variables were reported as proportions.
3. Student's t test, Chi-square tests and Fisher's exact test where appropriate were used for comparison between groups.

A p- value of 0.05 or less was regarded as significant.

Figure 24. Hand Sewn anastamosis



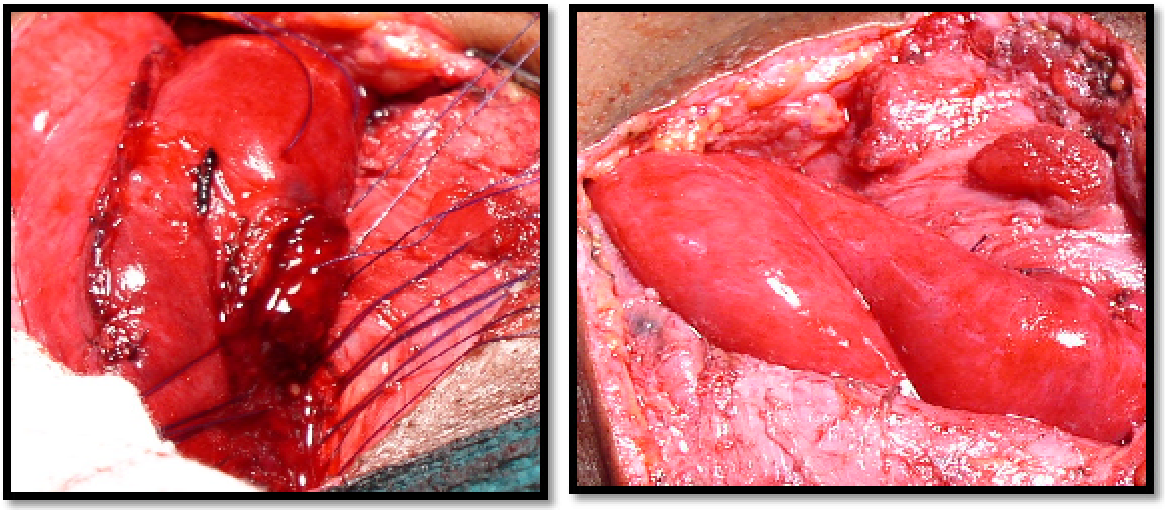


Figure 25. Semi-mechanical anastomosis-1

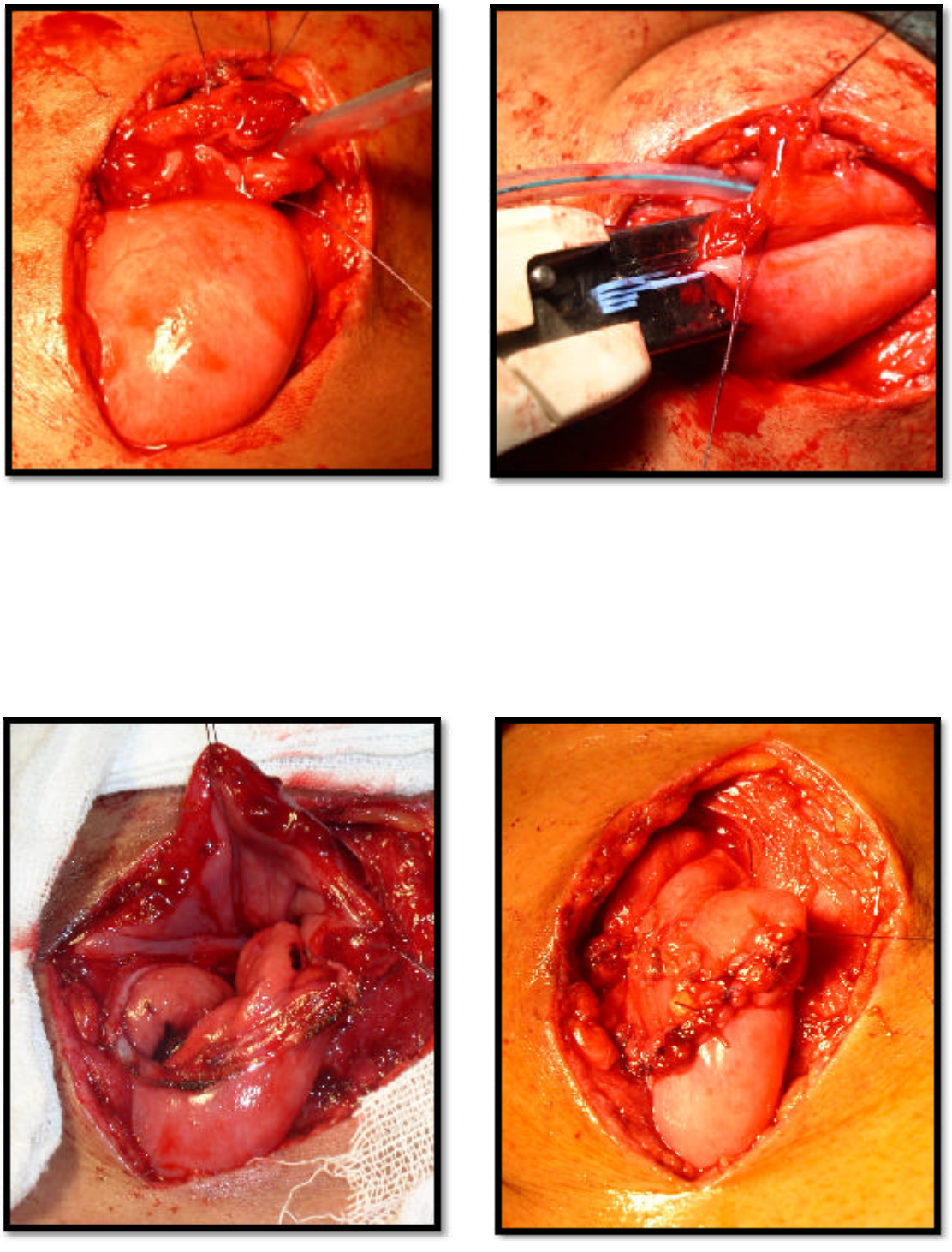


Figure 26. Semi-mechanical anastomosis-2

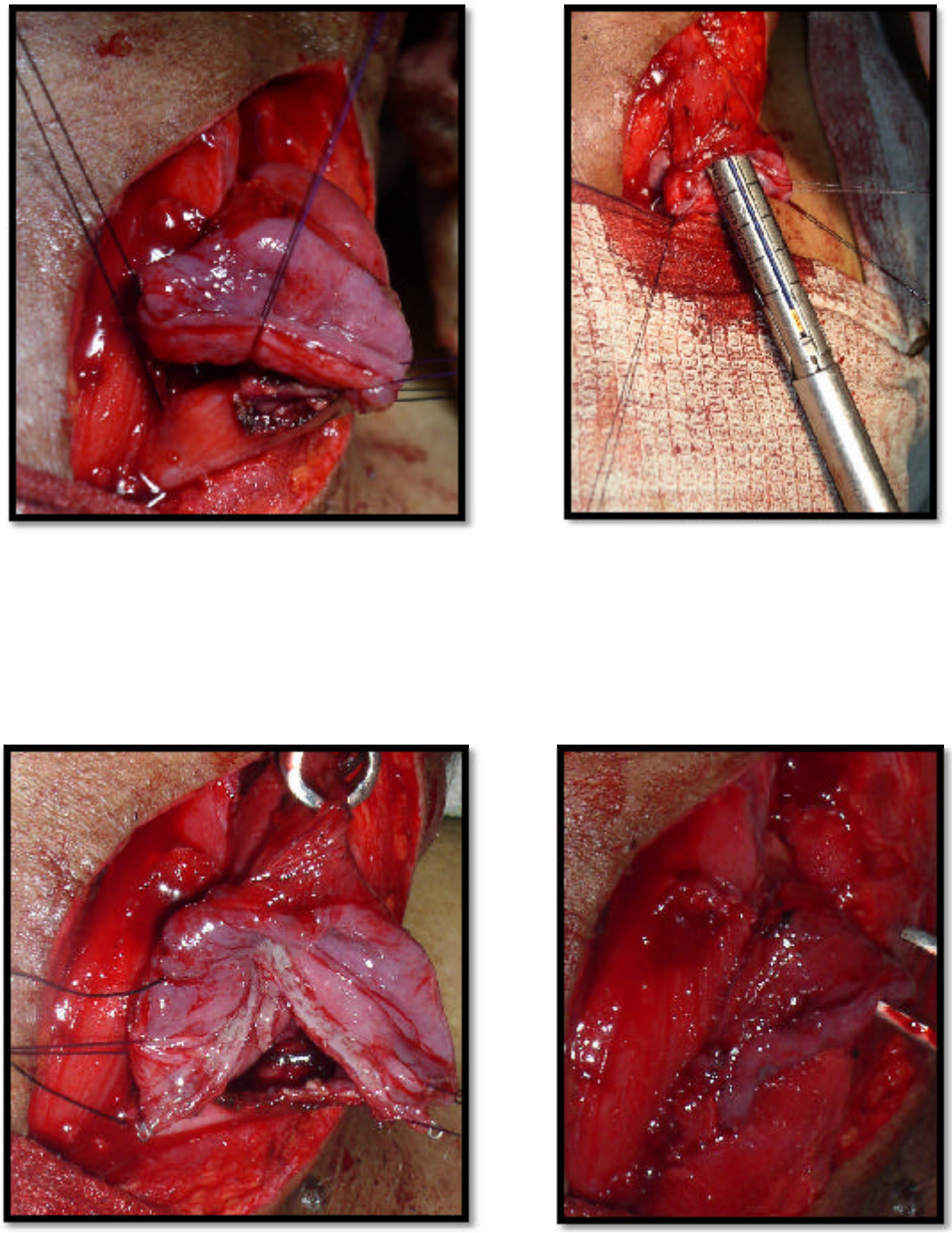
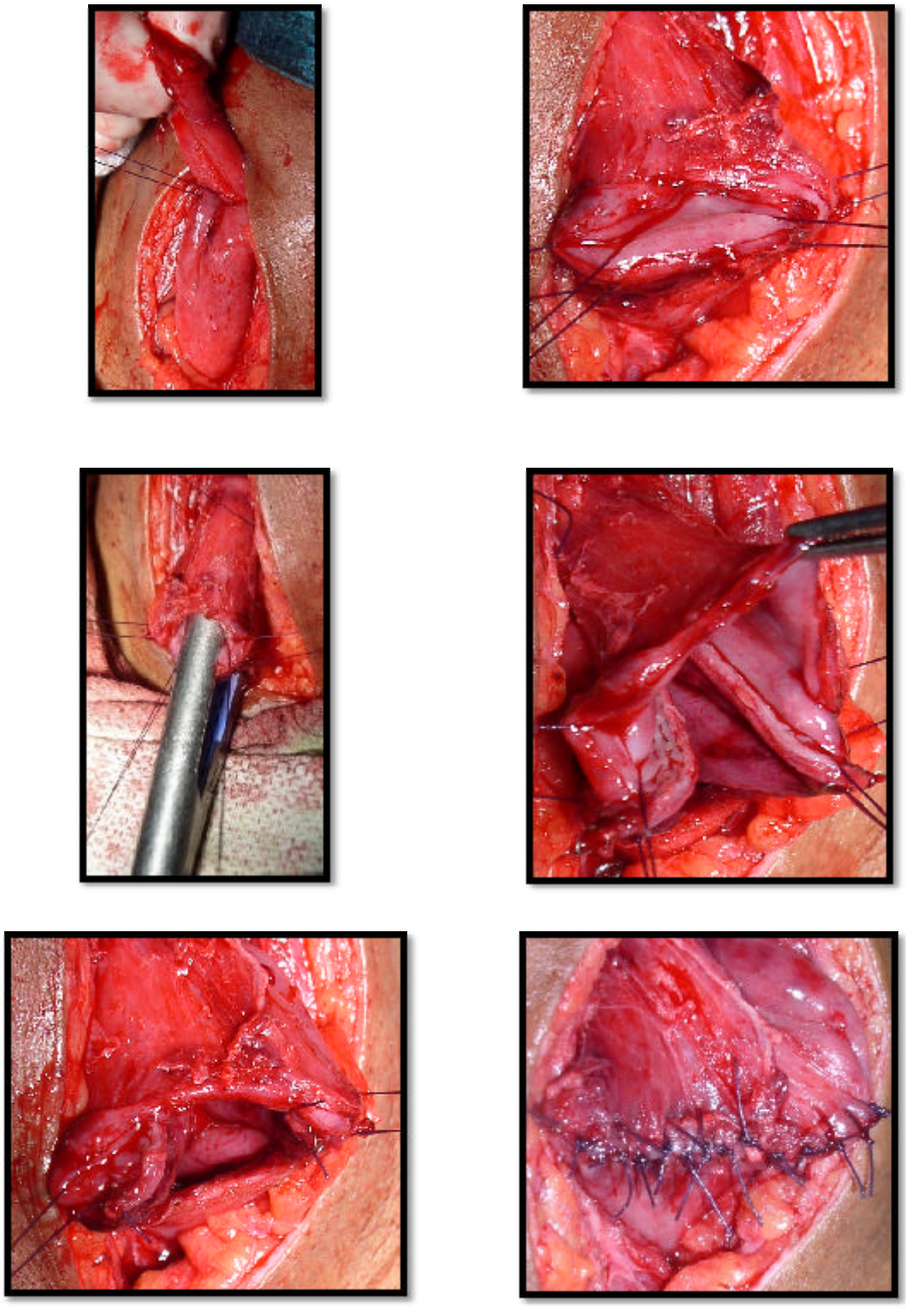


Figure 27. Semi-mechanical anastomosis-3



Chapter 5

RESULTS

The pertinent characteristics of the 28 patients are listed in Table 3. One patient (3.6%) died in hospital, and the remaining 27 patients were available for follow-up.

Characteristics and pathological condition of patients in different groups			
	Hand-Sewn N=17	Stapler N=11	p-value
Sex (male /female)	10/7	9/2	0.2311
Mean age (range) (years)	24-65 (50.5)	32-62 (50.6)	0.7985
Anemia	11.612	11.373	0.8699
Malignancy	14	8	0.6525
Benign	3	3	0.6525
Esophagectomy (THE/TTE)	13/2	8/3	0.6196

Table 3. Characteristics and pathological condition of patients in different groups

There were no differences in the age, gender distribution, distribution of disease, and the indication for operation between the two groups.

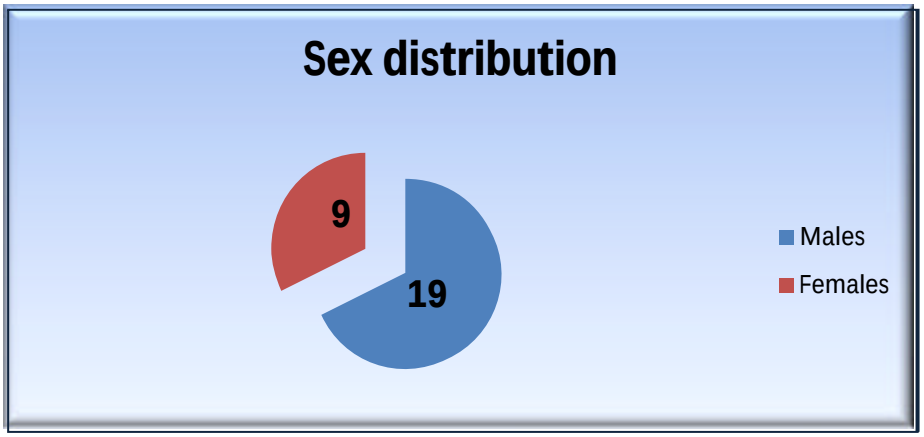


Figure 28. Sex distribution

Worldwide, males of all ages were more commonly affected than females, and the male to female ratio in this study was 2:1. Fifteen (68.2%) of the patients with carcinoma were men and 7 (31.2%) were women.

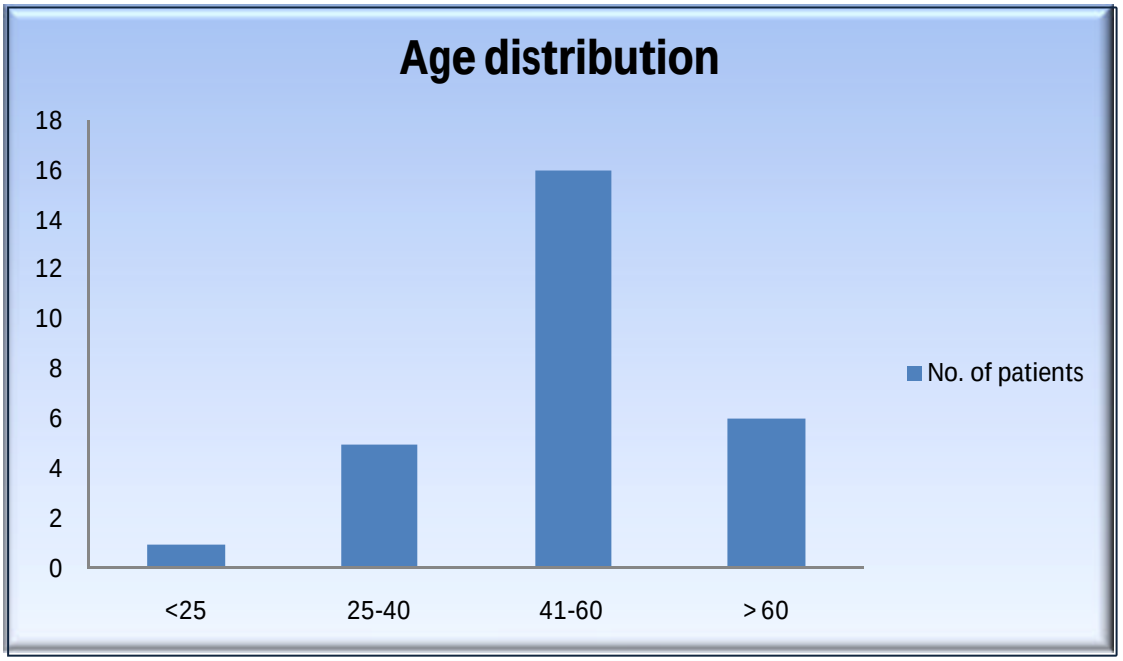


Figure 29. Age distribution

Nineteen male patients (66.7%) and 9 female patients (33.3%), ranging in age from 24 to 65 years (average 50.5 years). The study comprised mostly patients in the age group 41-60 years. In general, esophageal cancers are seen infrequently in the early adulthood. The one patient below the age of 25 had a benign pathology, corrosive esophageal stricture.

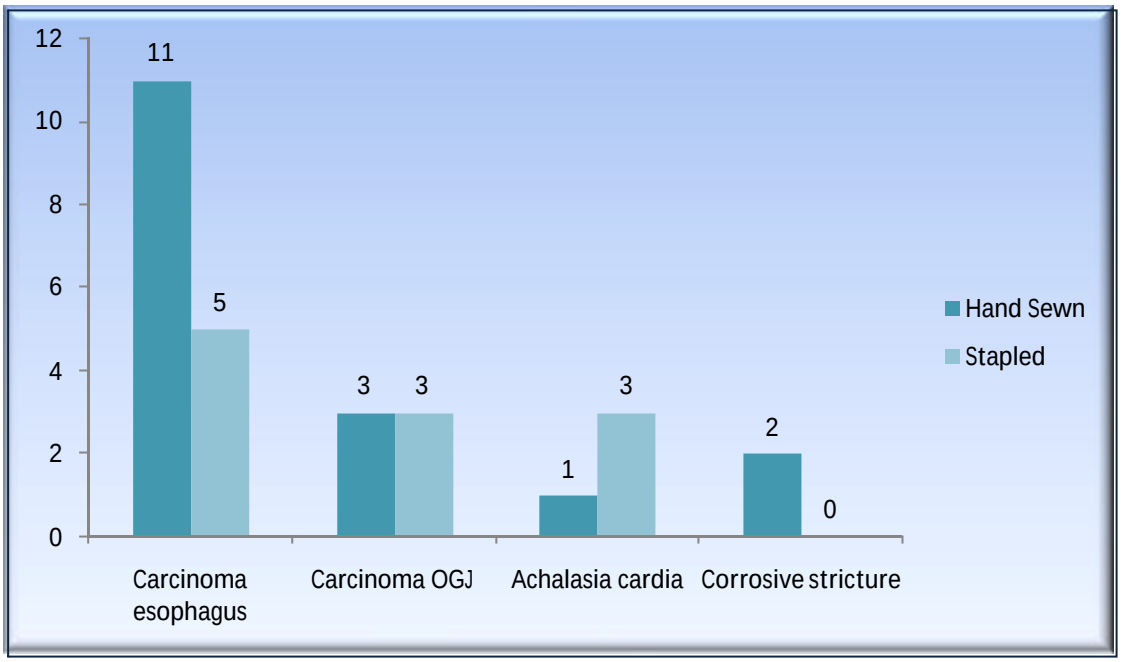


Figure 30. Disease distribution

Of these patients, 6 (22.2%) had benign disease necessitating esophageal replacement and 21 (77.8%) had carcinoma. The patients with benign disease included achalasia cardia (14.8%) and corrosive stricture (7.4%). Among the patients with carcinoma, 16 (59.3%) had esophageal malignancy and 6 (22.2%) had carcinoma of the cardia.

Surgical indicators

	Hand-Sewn N=17	Stapler N=11	p-value
Blood loss (ml) [median (range)]	313[150-600]	291[150-450]	0.5527
Transfusions (no. of units) [median(range)]	1.6[0-4]	1.5[0-2]	0.5737
Anastomotic time (min) [median(range)]	43.6[25-55]	32.3[20-45]	0.0096
Conduit necrosis	0	0	-
Vocal cord palsy (%)	2	0	0.4986
Hospital stay (days) [median (range)]	17.25	15.28	0.6730
Hospital mortality (%)	0	1	0.4074

Table 4. Operative and Perioperative data

Intraoperative blood loss averaged 305 ml and no postoperative mediastinal bleeding requiring a thoracotomy occurred in any of the patients following transhiatal esophagectomy. Much of the esophageal mobilization is performed not bluntly but under direct vision through the retracted diaphragmatic hiatus and this is reflected by the decrease in average blood loss. No differences in blood loss, transfusions, duration of chest drainage, hospital stay, morbidity, and mortality were noted between groups.

All patients received mechanical ventilation during the immediate postoperative period.

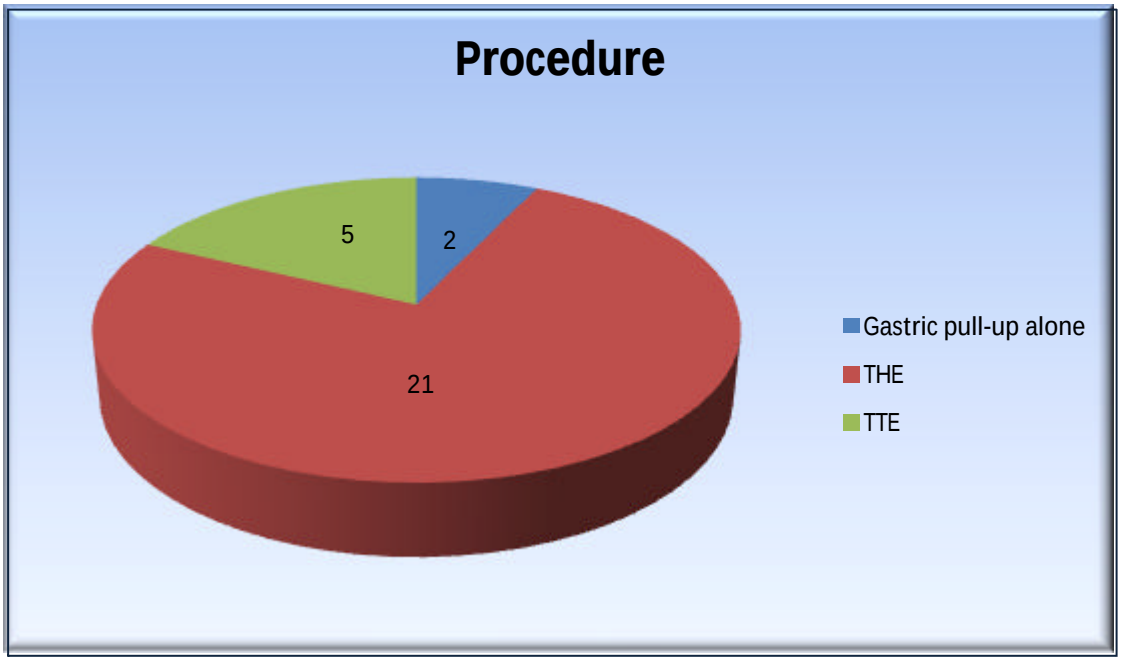


Figure 31. Operative techniques

Four patients with megaesophagus of achalasia and one patient with carcinoma esophagus in the mid-thoracic segment were planned and underwent transthoracic esophagectomy to prevent massive mediastinal bleed due to dilated and tortuous periesophageal vessels.

The time to perform the anastomoses included, in the manually sutured group, the achievement of hemostasis in the two bowel ends before suturing. In the stapled group, the anastomotic time comprised the stapled esophagogastrostomy, and the time required for any reinforcing sutures. The two-tailed P value for the anastomotic time equals 0.0096; this difference is considered to be very statistically significant.

Entry into one or both pleural cavities was identified during surgery at the time of routine inspection through the diaphragmatic hiatus after the esophagectomy and treated with a chest tube(s) in 24 (88.9%) of the patients.

Recurrent laryngeal nerve injury, as manifested by hoarseness, occurred in 2 patients (7.4%). Laryngoscopic evaluation revealed vocal cord palsies, but the hoarseness was transient in one of these patients, resolving spontaneously in 4 weeks. In the other patient there was persistent hoarseness and this may be the dilated esophagus he had because of achalasia cardia. The incidence of recurrent laryngeal nerve injury has progressively declined with greater experience with cervical esophageal mobilization and strict avoidance of placement of metal retractors against the tracheoesophageal groove.

The CEGA technique was associated with gastric conduit tip necrosis, a rare but very serious problem [17, 57]. Fortunately, we did not experience any cases of graft failure or conduit tip necrosis in our study.

Presentation of leak - clinical or radiographic

	Hand-Sewn	Stapler	p-value
Radiological	0	0	-
Clinical Minor	3(18.8%)	2 (18.2)	1.000
Clinical Major	0	0	-
Conduit necrosis	0	0	-
Total	3(18.8%)	2 (18.2)	1.000

Table 5. Incidence of anastomotic leak

Three patients with hand sewn anastomosis and 2 patients with stapler anastomosis developed leak which was minor leak based on the Surgical Infection Study Group. [5] The difference in the leak rate between the groups is not statistically significant. Cervical anastomotic leak presented with signs of localized inflammation at the cervical wound. A fluctuating gurgling mass was found elevating the incision in one patient.

Anastomotic leak based on indication			
Indication	Hand Sewn (17)	Stapler(11)	p-value
Carcinoma esophagus	2 (14)	0 (8)	0.5362
Corrosive stricture	1(2)	0	
Achalasia	0(1)	2(3)	1.0000

Table 6. Anastomotic leak based on indication

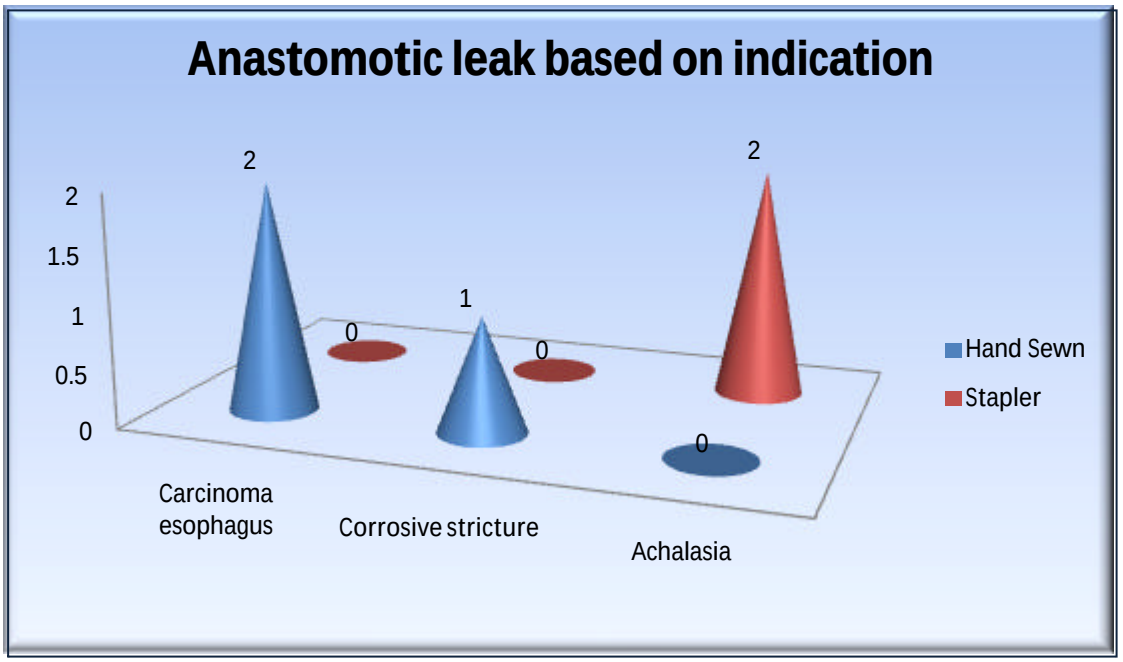


Figure 32. Anastomotic leak based on indication

Analyzing the leak rate based on the nature of the primary disease for which the surgery was indicated 2 patients in hand sewn group and none in the stapler group developed anastomotic leak when surgery was done for esophageal malignancy. Anastomotic leak with stapler anastomosis was found in two out of the three patients were operated for achalasia.

Presentation of leak - time

	Hand-Sewn	Stapler	p-value
= 7 days	2	1	1.000
> 7 days	1	1	1.000

Table 7. Presentation of leak

Two patients in the hand sewn group and one in the stapler anastomosis group developed leak before the 7th post-operative day and one in each group developed anastomotic leak after the 7th post-operative day.

Management of Leak

	Hand-Sewn	Stapler
Conservative	3	2
Surgical	0	0

Table 8

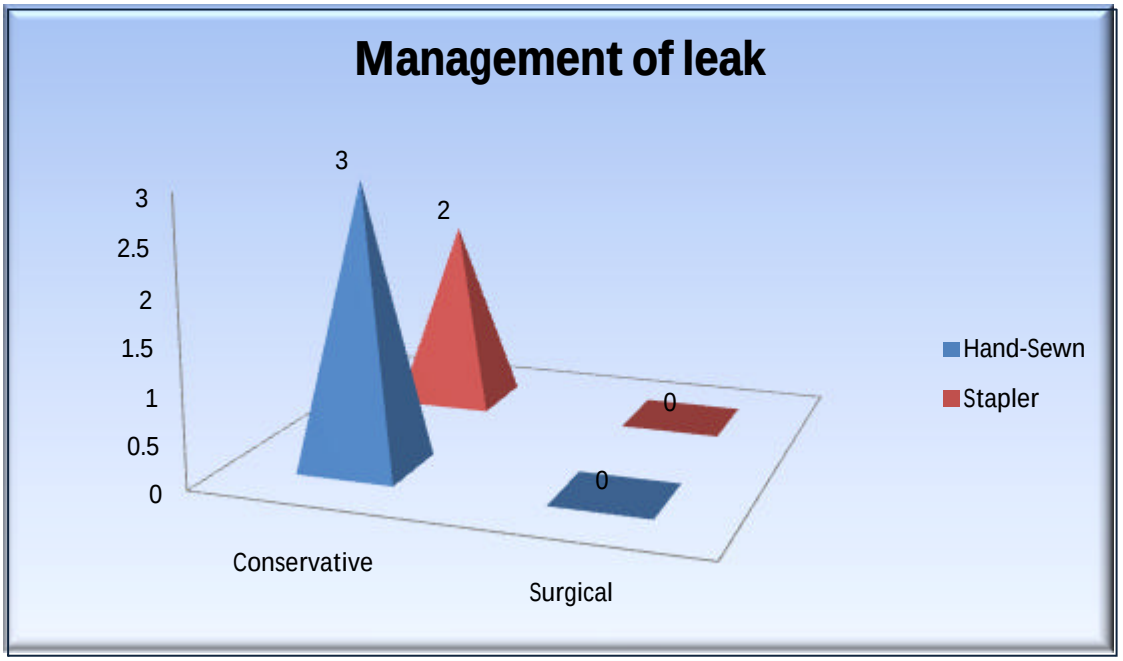


Figure 33. Management of leak

Cervical wound was opened to establish external drainage and regular dressing with normal saline soaked gauze was done. All the patients with leak healed with conservative management. A delay of oral intake, especially solids, for a few days was advised. No patient required total parenteral nutrition for the management of leak.

Incidence of anastomotic stricture

	No. of patients	Percentage	p-value
Hand-Sewn [n=17]	5	29.41	0.3497
Stapler [n=11]	1	9.09	

Table 9. Incidence of anastomotic stricture

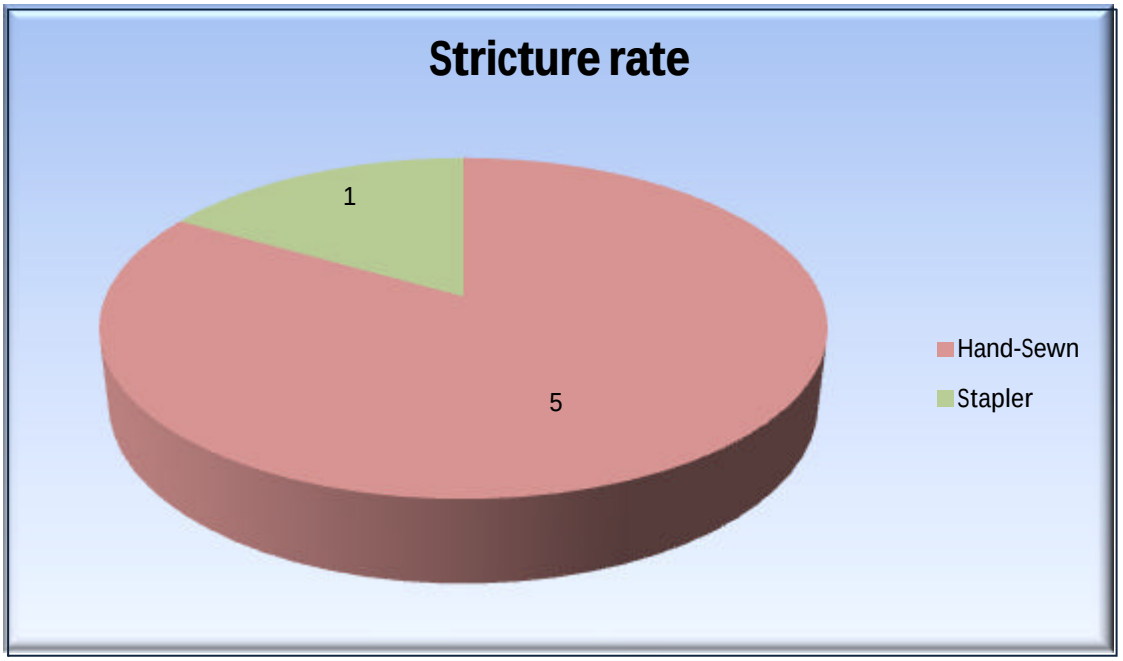


Figure 34. Incidence of anastomotic stricture

5 patients in the hand sewn group and 1 patient in the stapler group developed stricture. The patients with stricture presented as dysphagia. The difference in stricture rate between stapled and manually sutured anastomoses was not significant.

Anastomotic stricture based on indication			
Indication	Hand Sewn (17)	Stapler(11)	p-value
Carcinoma esophagus	3(14)	1 (8)	1.0000
Corrosive stricture	1(2)	0	-
Achalasia	1(1)	0(3)	-

Table 10. Anastomotic stricture based on indication

The two patients, who had anastomotic leak, following esophagectomy for achalasia after stapled anastomosis, did not develop stricture at the anastomotic site whereas one patient, operated for esophageal malignancy, developed anastomotic narrowing without anastomotic leak.

Number of dilatations

	Hand-Sewn N=5	Stapler N=1
1-3	3	1
4-5	0	0
>5	2	0

Table 11. Number of dilatations

The number of dilatations required per patient ranged from 1 to 16. All strictures were remedied within a year after two dilatations on average. A very severe stricture was seen in a patient with achalasia cardia that required monthly dilatation. No patient required reoperation for treatment of anastomotic stricture.

Types of stapler used in the stapler group

	No. of patients	Leak	Stricture
Linear cutter	5	2	1
Endostapler	6	0	0
p-value		0.1818	0.4545

Table 12. Types of stapler used in the stapler group

In the initial part of our study we used 55 mm Proximate linear cutter in 5 patients and 60 mm endostapler in the subsequent 6 patients. The proximate linear cutter had two staggered rows of stapler pins and endostapler had three staggered rows of stapler pins. There was no leak when endostapler was used. There was no correlation between stapler, need for dilatation, and the number of dilatations (P=0.4545).

No tumour recurrence at the anastomotic site was seen either of the groups.

Figure 35. Anastomotic stricture - 1

Figure 36. Anastomotic stricture - 2

Chapter 6

DISCUSSION

Anastomosis techniques, both the hand-sewn and mechanical stapling procedures, have been evaluated by many investigators. Although cervical esophagogastrostomies can be performed with circular stapling devices both transorally [49] and by transitioning the stapler through the subsequent pyloroplasty site and pushing the stomach up to the cervicotomy, [42] most surgeons prefer to suture cervical anastomoses. [7] The reported high failure rate of attempted circular stapled anastomoses in the neck and the fact that cervical anastomoses can be readily performed manually in a highly standardized manner made surgeons to choose hand-sewn technique for anastomosis in the neck. The high stricture rate for circular stapled intrathoracic esophagogastric anastomosis was reported by Law et al (40%) in a prospective randomized trial. [58] The anastomotic narrowing is presumably explained by wound contraction in the annular incision effected by the circular knife of the stapler that cuts through the anastomotic tissue. The accurate mucosa-to-mucosa apposition, considered important for good anastomotic healing was achieved only in the manually sutured neck anastomosis.

The incidence, mortality and morbidity of anastomotic complications have substantially decreased in recent years. From a number of publications it becomes clear that most centers with experience have seen a constant decrease in mortality and morbidity rates over the years. A recent study by Whooly et al. [59] analyzed the reason for reduced death and complication rates after esophageal resection. Important perioperative factors were the increased postoperative use of epidural

analgesia and bronchoscopy, a decrease in history of smoking and a decrease in surgical blood loss of less than 1,000 ml. Undoubtedly these factors and especially the decrease in respiratory failure will positively influence tissue oxygenation, hence anastomotic healing. Amongst general factors affecting anastomotic leak and stricture formation, Dewar et al. [60] found a significant correlation with low preoperative serum albumin and high intraoperative blood loss.

With the introduction of Endo-GIA 30 mm staplers, Orringer et al. [17] found that Endo-GIA was easy to handle in the cervical region and with a generous 3 cm anastomosis there was a reduction in anastomosis site stricture and postoperative dysphagia compared to circular staplers. Although Orringer's technique requires manual sewing in the final anterior closure of the CEGA, this did not increase leakage rates after esophageal resection of esophageal carcinomas. Also, anastomosis leak was uncommon. Before the side-to-side stapled anastomosis, the incidence of cervical esophagogastric anastomosis leak in over 1000 patients undergoing transhiatal esophagectomy having a manually sewn anastomosis varied from 10% to 15%. Among the 111 survivors of transhiatal esophagectomy and a side-to-side stapled anastomosis, there were 3 (2.7%) clinically significant anastomotic leaks. [17]

The risk factors predisposing to leaks from esophageal anastomoses were determined as: [61]

1. The anastomosis being performed via a retrosternal or subcutaneous route as opposed to an intrathoracic route
2. Performing a manual anastomosis as opposed to a mechanical anastomosis

3. Employing an end-to-end anastomosis, as opposed to an end-to-side anastomosis, using a mechanical method.
4. The use of colonic interposition as opposed to a gastric pedicle

Of course the refinements in technique have also contributed to the decrease of anastomotic complications and needless to stress the individual expertise of the surgeon in improving results. Atraumatic mobilization of the gastric fundus, avoiding traction sutures or suction devices, performing a watertight anastomosis without the use of excessive number of sutures, adequate mobilization of the conduit, correct orientation when transposing the conduit into the mediastinum and the neck, compression-free passage of the conduit at the narrow thoracic inlet, familiarity with the vascular anatomy of the different conduits are just a few technical points that may influence the final outcome of the anastomotic site. Obviously a majority of anastomotic complications are to be seen as the result of a technical failure related to one or more of these technical 'details'. This is endorsed by a growing body of evidence in the literature that both surgical volume and experience have a significant impact on mortality and morbidity after esophagectomy [62, 63, 64].

Singh D et al. [65] reported anastomotic leak in 10 patients (23%) with hand-sewn, 1 patient (6%) with partial mechanical, and 1 patient (3%) with total mechanical anastomoses ($p < 0.05$). Anastomotic stricture development paralleled the occurrence of anastomotic leak rate with 25 patients (58%) with hand-sewn, 3 patients (19%) with partial mechanical, and 6 patients (18%) with total mechanical anastomoses experiencing strictures requiring dilation therapy ($p < 0.05$). These results suggest that partial or mechanical cervical esophagogastric anastomoses

created with the endoscopic stapling device may be superior to hand-sewn anastomotic techniques.

Casson et al [66], critically evaluated acute and long-term complications of hand-sewn and semimechanical cervical esophagogastric anastomosis following resection of primary esophageal adenocarcinoma. All esophagogastric anastomoses were performed in the left neck using a hand-sewn technique (n=53) and, a side-to-side semimechanical technique (n=38). The semimechanical anastomotic technique was associated with a reduced leak rate compared with the hand-sewn technique (7.9%, 3/38 vs. 22.6%, 12/53; P=0.08). Anastomotic strictures developed in nine (17.0%) hand-sewn and three (7.9%) semimechanical anastomosis and concluded that a semimechanical technique for cervical esophagogastrostomy is associated with reduced anastomotic leak rates compared with hand-sewn anastomoses, resulting in a shorter postoperative stay.

Study	n		Anastomotic leaks		Anastomotic stricture	
	Hand sewn	Stapler	Hand sewn	Stapler	Hand sewn	Stapler
Singh D et al. [65]	43	16	23%	6%	58%	19%
Casson et al [66], 2002	53	38	22.6%	7.9%	17%	7.9%
Jo et al. 2006 [67]		13		0		7.7%
Orringer et al 2000 [17]	>1000	114	10-15%	2.7%	48%	35%
De Giacomo T et al 2004 [68]		26		3.9%		0
Francioni F et al 2006 [69]		34		3.3%		0
Present study	17	11	18.8%	18.2%	29.4%	9.1%
Esophagectomy for malignancy	14	8	14.3%	0	14.3%	12.5%

Table 13. Summary of outcomes in various studies

In comparison with various studies, in our study the anastomotic leak rate (18.8%) and stricture rate (29.4%) in the hand sewn group were similar. In the linear

stapled anastomosis group, when the indication for esophagectomy is malignancy, the anastomotic leak rate and stricture rate are similar to that of other studies. The studies by Casson et al [66], Jo et al [67], and Francioni et al [69] included only patients who had undergone esophagectomy for esophageal malignancy.

The key to a further decrease in death rate and postoperative morbidity is the accruing experience by a dedicated team of surgeons, anesthesiologists, intensivists, nurses, etc. in a high volume setting and working in a hospital that is fully equipped to handle such complex interventions.

Contrast studies are used by many surgeons for detection of anastomotic leaks but may be unnecessary. A prospective study by Goel AK et al.[70] was undertaken to compare gastrograffin study and test feeding using water for detection of cervical anastomotic leaks and concluded that a contrast study may be unnecessary for evaluation of a cervical esophagogastric anastomosis and can be replaced with the simpler and safer technique of 'test feeding' using water.

The postoperative hospital stay of 15 days accorded well with other reports [51] and was not related to operative time. Advanced age has not been reported to predict length of hospital stay or survival. [71]

5 patients in the hand sewn group and 1 patient in the stapled anastomosis group presented with dysphagia and all underwent endoscopy and barium swallow evaluation. Differences in dysphagia, an experience parameter, might be explained by differences in scar formation in the surrounding tissues. Fibrous stricture formation causing dysphagia after oesophagogastrectomy with a circular stapled or

sutured anastomosis remains a significant complication, occurring in up to one-third of cases. An anastomosis by linear stapler avoids this complication and patients who develop dysphagia were relieved of the symptoms with 2-3 dilations. One patient who had esophagectomy for megaesophagus with hand sewn anastomosis required more than 15 sittings to get completely relieved of his symptoms.

Although esophagomyotomy is highly effective as the initial surgical treatment of most patients with achalasia, those with either recurrent symptoms after a previous esophagomyotomy or a megaesophagus do not respond as well to esophagomyotomy. Trans thoracic esophagectomy was performed in 4 patients (two males and 2 females; average age, 49.5 years) with achalasia. One had a history of a previous esophagomyotomy, and 3 had a megaesophagus (esophageal diameter of 8 cm or larger). The stomach was used as the esophageal substitute in all patients; it was positioned in the posterior mediastinum, and a cervical anastomosis was performed. There were one postoperative death due to pulmonary atelectasis and respiratory failure. The average postoperative hospital stay was 15.5 days. Follow-up is complete and ranges from 6 to 30 months. All patients eat a regular, unrestricted diet without postprandial regurgitation. Post-operative anastomotic leak was present in 2 patients and early postoperative anastomotic dilation was required in 1 patient. In the stapled anastomosis group 2 patients developed anastomotic leak when proximate linear cutter was used whereas the patient who had stapled anastomosis with endostapler did not leak.

Young et al. [35], in a series of 255 patients who had undergone esophageal reconstruction for benign esophageal diseases preferred to visualize the esophagus

directly at the time of reconstruction usually through a right thoracotomy. The operative mortality was 5.1% and median postoperative hospitalization was 14 days. Overall 38.9% of patients underwent dilatation during follow-up.

The cost/benefit ratio of mechanical sutures is a controversial issue. To compare the cost of esophago-visceral anastomoses performed with staplers versus the cost of conventional anastomosis, not only the cost of the material, but also the economical impact of the hospital stay and operative complications needs to be evaluated. Results show a decrease in hospital stay in patients treated with mechanical sutures (15.28% vs. 17.25%, p=0.6730).

Chapter 7

SUMMARY

Anastomotic complications after esophagectomy continue to be a burden jeopardizing the quality of life and of swallowing. However, incidence, mortality and morbidity of anastomotic complications have substantially decreased in recent years. It seems that this is not so much related to the use of a particular conduit, approach or route for reconstruction, but rather related to refinement in anastomotic techniques and perhaps even more to progress in modern perioperative management. Knowledge of surgical anatomy and meticulous technique are of paramount importance and obviously related to individual expertise.

Although Orringer's technique requires manual sewing in the final anterior closure of the CEGA, this did not increase leakage rates after esophageal resection for carcinomas. The benign stricture rate, surgical outcome and long term results were satisfactory. So side-to-side stapled anastomosis according to the technique introduced by Orringer and colleagues is the preferred procedure for CEGA because it is relatively easy to perform and therefore less operator dependent, and requires less time to perform hand sewn method.

The leak incidence after both mechanical and manual anastomoses is much higher in collective reviews than in reports coming from leading centers. Performing an esophageal anastomosis is a technical matter, and suture healing is independent of the patient's biologic situation. Anastomotic fibrotic strictures are frequent after

both manual and mechanical anastomoses, and most can be avoided by meticulous suturing technique.

As to the management, most leaks can be treated by conservative measures and reintervention surgery today is rather exceptional. Early endoscopy and dilatation seem to decrease the incidence and severity of anastomotic stenosis.

Chapter 8

CONCLUSION

- Construction of the cervical esophagogastric anastomosis with a side-to-side stapled anastomosis greatly reduces the frequency of anastomotic leaks and later strictures rates.
- The side-to-side stapled anastomosis is a major technical advance in the progression of refinements of transhiatal esophagectomy and a cervical esophagogastric anastomosis.
- Transhiatal esophagectomy is feasible in most patients requiring esophageal resection for malignant disease and is a safe, well-tolerated operation if performed with care and for the proper indications.
- The semimechanical technique for cervical esophagogastrostomy is associated with a shorter postoperative stay.

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Appendix – I

Proforma

Name Folio Number IP Number Address Age Sex Date of Admission Date of Surgery Date of Discharge Diagnosis: Procedure:	
History of present illness Dysphagia Dysphagia_Duration Dysphagia_grade Odynophagia Regurgitation Vomiting Hemetemesis Weight loss Anorexia	 O - Able to take all foods I - Dysphagia to solid foods II - Dysphagia to soft foods III - Dysphagia to liquids IV - Total dysphagia
Personal History Corrosive ingestion Smoking Alcohol	
General examination Anemia Pedal edema	

Investigations Hb% Serum Proteins Albumin Ba Swallow Level of obstruction Endoscopy Site of obstruction Growth/ Achalasia/Stricture CT Chest Site of obstruction HPE Differentiation Margin	
Procedure Type of anastomosis Stapler used - Linear cutter/Endostapler Hand Sewn anastomosis - End to side/side to side Anastomosis duration **Leak** Leak_Day Leak_DT site/Wound Leak_Minor/Major Leak management_Conservative/Intervention	
Follow-up Dysphagia Endoscopy_stricture/scope passed with difficulty/Scope passed easily Endoscopic dilatation Endoscopic dilation_frequency Endoscopic dilatation_No of times Ba swallow	

Appendix – II

Master Chart

Demographic profile											
Sl. No.	Name	Folio Number	IP Number	Age	Sex	DOA	DOS	DOD	Hospitalization post surgery	Diagnosis	Procedure
1	Jeya	163/2005	726220	37	F	16/08/5	6/9/5	24/09/5	18	Ca. eso	THE
2	Subramani	220/2005	742783	51	M	30/08/5	16/09/5	30/09/5	15	Ca. eso	THE
3	Kamatchi	310/2005	749560	55	F	30/08/5	22/09/5	5/10/5	14	Ca. eso	THE
4	Pushpammal	279/2005	757997	62	F	12/9/5	4/10/5	17/10/5	14	Ca. eso	THE
5	Veerappan	371/2005	764265	55	M	9/11/5	24/11/5	12/12/5	18	Ca. eso	THE
6	Mariammal	32/2006	772170	50	F	16/12/5	19/01/6	31/01/6	13	Ca. eso	THE
7	Gowri	33/2006	775782	40	F	30/12/5	17/01/6	30/01/6	14	Ca. eso	THE
8	Mohammed Yousuf	133/2006	788828	61	M	24/2/6	23/02/6	7/4/6	13	A. cardia	TTE
9	Sornalekshmi	165/2006	798420	38	F	5/4/6	15/04/6	3/5/6	18	Ca. eso	TTE
10	Govindan	277/2006	829178	65	M	11/8/6	25/09/6	9/10/6	15	Ca. eso	THE
11	Chinnaraj	312/2006	837496	53	M	12/9/6	5/10/6	27/10/6	22	Ca OGJ	THE
12	Ganesan	375/2006	853533	32	M	20/11/6	17/12/6	12/1/7	26	Cor. Str.	Ga. up
13	Veeraiyan	18/2007	435	65	M	3/1/7	6/2/7	22/02/7	16	Ca. eso	THE
14	Lal Bag	83/2007	19685	65	M	26/03/7	12/4/7	23/04/7	21	Ca. eso	THE
15	Munusamy	81/2007	19756	57	M	26/03/7	5/4/7	18/04/7	13	Ca. eso	THE
16	Manoharan	139/2007	34169	46	M	24/05/7	5/6/7	15/06/7	10	Ca. OGJ	THE
17	Kalaiselvi	180/2007	35110	32	F	28/05/7	12/7/7	9/8/7	28	A. cardia Ca. eso	THE
18	Jeyalekshmi	215/2007	43805	24	F	2/7/7	24/07/7	10/8/7	17	Cor.str.	Ga. up
19	Ganesan	224/2007	48619	57	M	6/4/7	31/07/7	17/08/7	17	Ca. eso	THE
20	Latha	236/2007	60456	45	M	7/9/7	4/10/7	13/10/7	9	A. cardia	TTE
21	Chandrasekaran	402/2007	64608	62	M	21/9/7	9/10/7	23/10/7	14	Ca. eso	THE
22	Srinivasan	414/2007	66500	43	M	28/9/7	30/10/7	12/11/7	13	Ca. OGJ	THE
23	Kaliyan	316/2007	73901	55	M	29/10/7	10/11/7	3/12/7	23	Ca. eso	THE
24	Mohideen	324/2007	66561	50	M	28/09/7	15/11/7	30/11/7	15	Ca. OGJ	THE
25	Munusamy	321/2007	76447	58	M	9/11/7	17/11/7	26/11/7	9	Ca. eso	THE
26	Prakasam	44/2008	4809	60	M	21/01/8	7/2/8	19/02/08	12	A. cardia	TTE
27	Mehaboobnisha	50/2008	4788	45	F	21/01/8	12/2/8	25/02/08	14	Ca. OGJ	THE
28	Paranjothi	52/2008	8721	50	M	4/2/8	19/02/8	29/02/08	11	Ca. eso	THE

Sl. No.	History												General Examination	
	Dysphagia	Dysphagia_Duration	Dysphagia grade	Odynophagia	Regurgitation	Vomiting	Hemetemesis	Weight loss	Anorexia	Corrosive ingestion	Smoking	Alcohol	Anemia	Pedal edema
1	present	180 days	I	No	Yes	No	No	Yes	yes	No	No	No	No	No
2	present	90 days	II	No	Yes	No	No	Yes	yes	No	Yes	Yes	No	No
3	present	20 days	II	No	No	No	No	Yes	yes	No	No	No	Yes	No
4	present	90 days	I	No	No	No	No	Yes	yes	No	No	No	Yes	No
5	present	60 days	II	Yes	Yes	No	No	yes	yes	No	Yes	No	No	No
6	Present	120 days	III	No	Yes	No	No	yes	yes	No	No	No	No	No
7	Present	30 days	I	No	Yes	No	No	yes	yes	No	No	No	No	No
8	absent			No	No	yes	No	No	No	No	Yes	No	No	No
9	present	300 days	II	No	No	No	No	Yes	No	No	No	No	No	No
10	present	60 days	II	No	No	No	yes	Yes	yes	No	Yes	No	No	No
11	present	30 days	II	No	No	No	No	Yes	yes	No	Yes	Yes	No	No
12	Present	540 days	IV	No	No	No	No	yes	No	Yes	No	No	No	No
13	present	90 days	III	No	No	Yes	No	Yes	yes	No	Yes	No	No	No
14	Present	75 days	I	Yes	Yes	No	No	yes	yes	No	No	No	No	No
15	present	30 days	II	No	No	No	No	No	No	No	No	No	No	No
16	present	120 days	III	Yes	No	No	No	No	No	No	No	No	No	No
17	present	7 yrs	I	No	Yes	No	No	No	No	No	No	No	No	No
18	present	2 yrs	IV	No	No	No	No	Yes	No	Yes	No	No	No	No
19	present	60 days	II	No	No	No	No	No	No	No	No	Yes	No	No
20	present	10 yrs		no	yes	No	No	yes	No	No	No	No	No	No
21	present	3 months	II	no	yes	no	no	yes	no	no	yes	yes	No	No
22	present	3 months	II	No	Yes	no	No	Yes	No	No	Yes	No	No	No
23	present	6 months	III	No	Yes	No	No	Yes	yes	No	Yes	Yes	No	No
24	present	6 months	II	No	No	No	No	Yes	No	No	Yes	Yes	No	No
25	present	2 months	I	No	No	No	No	Yes	No	No	Yes	Yes	No	No
26	present	18 months	I	no	yes	no	no	No	No	No	No	No	No	No
27	present	90 days	III	Yes	Yes	No	No	Yes	yes	No	No	No	No	No
28	present	90 days	II	No	Yes	No	No	Yes	No	No	Yes	Yes	No	No

Sl. No.	Investigation								
	Hb%	Serum Proteins	Albumin	Ba Swallow_Level of obstruction	Endoscopy_site of obstruction	Endoscopy_growth/ Achalasia/Stricture	CT_site of obstruction	HPE	Margin
1	11.2	5.7	3.8	L/3	34 cm	Growth	Distal esophagus	SCC	Free
2	11.0	4.7	3.5	OGJ	36 cm	Growth	Lower esophagus	SCC	Free
3	9.9	5.9	3.0		Distal eso	Growth	Distal esophagus	SCC	Free
4	11.6	4.7	2.7		37 cm	Growth	Lower esophagus involving OGJ and extending into LC	SCC	Free
5	14.4	6.8	3.5		40 cm	Growth	Lower esophagus 3 cm proximal to cardia	SCC	Free
6	16.0	6.4	3.4	M/3	27 cm	Growth	Subcarinal to epiphrenic segment	SCC	Free
7	11.0	6.6	3.5		32-35 cm	Growth	Distal esophagus	SCC	Free
8	12.7	6.9	3.4	Achalasia	OGJ	Achalasia	OGJ	Mild dysplasia	
9	10.8	6.8	3.8	Retrocardiac segment	24-27 cm	Growth	Middle third, circumferential, 3 cm below carina, 3 cm long	SCC	Free
10	9.0	6.1	3.5		23 cm, OGJ	Growth	Growth middle third	SCC Adeno ca	Free
11	9.0	7.5	3.8		35 cm	Growth	Carcinoma OGJ	Adeno ca	Free
12	12.2	6.9	4.0	U/3	16 cm	Stricture			Free
13	13.0	6.3	3.5		31-38 cm	growth	Lower third esophagus	SCC	Free
14	10.2	6.8	3.0	L/3	30 cm	growth	L/3	SCC	Free
15	12.2	6.5	3.4	L/3	35 cm	growth	L/3 growth extending upto OGJ	SCC	Free
16	12.4	7.1	4.0	OGJ	OGJ	growth	OGJ growth	Adeno ca	Free
17	11.6	6.9	3.8	Achalasia		ulcer	Dilated esophagus	Adeno ca	
18	10.8	7	4.7	Long sement stricture		Stricture			Free
19	12.0	7.1	4.0	L/3	38 cm	growth	Distal esophagus	Adeno ca	Free
20	12.7	6.8	3.8	OGJ	OGJ	Achalasia	dilated esophagus		Free
21	9.2	7.8	3.5	L/3	35 cm	Growth	Lower third esophagus	SCC	Free
22	14.0	7.8	4.4	No filling defects noted	35 - 42 cm	growth	Growth OGJ extending to the fundus of stomach	Adeno ca	Free
23	9.0	7.1	4.2	L/3	35 cm	Growth	Lower third esophagus extending into OFJ	SCC	Free
24	12.0	7.8	4.0	Distal eso, OGJ	36 cm	growth	Lower third esophagus extending into OFJ	Adenoca	Free
25	12.0	6.7	3.4	L/3	38 cm	growth	Lower third esophagus extending into OFJ	S SCC	Free
26	10.8	6.8	3.4	OGJ	OGJ	Achalasia	Dilated esophagus		
27	11.0	6.1	3.5	OGJ	OGJ	growth	OGJ	SCC	Free
28	10.8	7.5	4.4	Retrocardiac segment	30 cm	growth	M/3, circumferential, 2cm below carina, 4 cm long	SCC	Free

Sl. No.	Management							
	Procedure	Type of anastomosis	Stapler used - Linear cutter/Endostapler	Hand Sewn anastomosis - End to side/side to side	Blood loss (mL) [median (range)]	Transfusion (no. of units) [median(range)]	Anastomosis duration (min)	Feeding Jejunostomy
1	THE	Hand-Sewn		End-to-side	300	2	46	Yes
2	THE	Hand-Sewn		End-to-side	450	2	45	Yes
3	THE	Hand-Sewn		End-to-side	200	0	25	Yes
4	THE	Hand-Sewn		End-to-side	300	2	35	Yes
5	THE	Hand-Sewn		End-to-side	300	2	48	Yes
6	THE	Hand-Sewn		End-to-side	150	0	54	yes
7	THE	Hand-Sewn		End-to-side	450	3	46	yes
8	TTE	Hand sewn		End-to-side	300	2	55	Yes
9	Mckeown	Hand-Sewn		End-to-side	500	4	40	Yes
10	THE	Hand-Sewn		End-to-side	200	0	50	yes
11	THE	Hand-Sewn		End-to-side	350	2	45	yes
12	Gastric pull-up	Hand sewn		side-to-side	200	0	45	yes
13	THE	Hand-Sewn		End-to-side	450	2	25	Yes
14	THE	Hand-Sewn		side-to-side	200	2	50	yes
15	THE	Hand-Sewn		End-to-side	600	3	40	yes
16	THE	Hand-Sewn		End-to-side	250	2	50	yes
17	TTE	Stapler	TLC-55	side-to-side	400	2	45	yes
18	Gastric pull-up	Hand-Sewn		End-to-side	150	0	45	yes
19	THE	Stapler	TLC-55	side-to-side	200	2	40	yes
20	TTE	Stapler	TLC-55	side-to-side	350	2	35	yes
21	THE	Stapler	Endo-60	side-to-side	200	0	40	yes
22	THE	Stapler	TLC-55	side-to-side	400	2	35	yes
23	THE	Stapler	Endo-60	side-to-side	250	2	35	yes
24	THE	Stapler	TLC-55	side-to-side	150	0	20	yes
25	THE	Stapler	Endo-60	side-to-side	250	2	30	yes
26	TTE	Stapler	Endo-60	side-to-side	450	2	20	yes
27	THE	Stapler	Endo-60	side-to-side	250	0	35	yes
28	THE	Stapler	Endo-60	side-to-side	300	2	20	yes

Sl. No.	Post op details						
	Leak	Leak_Day	Leak_DT site/Wound	Leak_Minor/Major	Leak_contrast study	Leak management_Conservative/Intervention	Dysphagia
1	No						No
2	No						No
3	No						No
4	No						No
5	yes	D7	Wound	Minor		Conservative	yes
6	No						No
7	No						No
8	No						No
9	No						No
10	No						No
11	yes	D4	wound	Minor		Conservative	Yes
12	No						No
13	No						No
14	No						No
15	No						No
16	No						No
17	yes	D8		Minor		Consevative	No
18	yes	D7		Minor		Consevative	Yes
19	No						No
20	yes	D10		minor		conservative	No
21	No						No
22	No						No
23	No						No
24	No						No
25	No						No
26	No						No
27	No						No
28	No						No

Sl. No.	Follow- up				
	Endoscopy_ stricture/scope passed with difficulty/Scope passed easily	Endoscopic dilatation	Endoscopic dilation_frequency	Endoscopic dilatation_No of times	Follow-up period (weeks)
1	passed easily	No			130
2	passed easily	No			129
3	passed easily	No			128
4	passed easily	No			124
5	Anastomotic stricture	yes	Random	1	119
6	passed easily	No	Random		111
7	passed easily	No			111
8	Anastomotic stricture	yes	weekly	15	106
9	passed easily	No			99
10	passed easily	No			75
11	Anastomotic stricutre	yes	weekly	6	74
12	Anastomotic stricutre	yes	Random	2	64
13	passed easily	no			56
14	passed easily	No			47
15	passed with difficulty	No	Random	1	48
16	passed easily	No			39
17	scope passed easily	No			34
18	scope passed easily	No			32
19	stricture	yes	Random	2	31
20	passed easily	no			22
21	Normal	no			21
22	passed easily	No			18
23	passed easily	No			17
24	passed easily	No			16
25	passed easily	No			16
26	passed easily	No			4
27	passed easily	No			3
28	passed easily	No			2