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Thoracotomy versus thoracoscopy in repair of esophageal atresia, prospective comparative study: As a review of literature

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Abstract
Background: Esophageal atresia (EA) is a congenital anomaly that specifically impacts newborns. Esophageal atresia is identified shortly after birth and is defined by a structural gap in the esophagus. The standard technique entails conducting an open thoracotomy to tie off the fistula, if present, and connecting the ends of the esophagus together. With the advent of minimally invasive surgery, it was expected that thoracoscopic procedures will be used to treat tracheoesophageal fistula with esophageal atresia (TEF) and pure EA.
Objective: This review aims to compare between the thoracoscopic and conventional open repair of esophageal atresia in neonates.
Methods: The data was collected through a comprehensive search that was conducted in Google Scholar, PubMed, and Science Direct, encompassing the time frame from January 2000 to July 2024. The search utilized the following keywords: thoracotomy, thoracoscopy, esophageal atresia, trachea-esophageal fistula, and congenital anomaly. The reviewers also reviewed relevant literature references. The most current or comprehensive study was taken into consideration. Unpublished papers, oral presentations, conference abstracts, and dissertations are some examples of publications that were not considered essential scientific research. Papers authored in languages other than English have been neglected due to a lack of translation resources.
Results: Esophageal atresia (EA), with or without a trachea-esophageal (TEF) fistula, is a very uncommon congenital anomaly that affects approximately one in every 3,000 infants. Traditionally, many surgical centers use open, right-sided, muscle-sparing thoracotomy as the usual method for repairing EA/TEF. However, multiple publications have demonstrated that thoracoscopic repair (TR) is both effective and safe.
Conclusion: Thoracoscopic repair of esophageal atresia/tracheoesophageal fistula (EA/TEF) is a safe and effective minimally invasive method. It has a similar operation time and complication rate compared to conventional open repair (COR).

Keywords: Thoracotomy, thoracoscopy, esophageal atresia, trachea-esophageal fistula, congenital anomaly

Introduction

The initial documentation of esophageal atresia, characterized by a closed upper pouch and a lower section connecting to the trachea, was credited to Thomas Gibson. In 1697, Gibson observed this condition during an autopsy of an infant who passed away three days after birth [1]. In 1935, a young individual with esophageal atresia became the first person who successfully survived this condition. A gastrostomy was performed until the age of sixteen, at which point a procedure known as jejunal interposition was conducted [2].

In 1941, Cameron Haight was recognized for accomplishing the initial successful primary anastomosis with long-term survival. It was done by adopting a left extrapleural method then fistula closure by a single-layered esophageal anastomosis [3]. In the early 1990s, a small number of surgeons initiated the practice of thoracoscopic mobility of the esophagus. Nevertheless, Rothenberg in 1999 officially recorded the complete successful restoration of esophageal atresia with thoracoscopy. Since then, the procedure has become commonplace in certain medical facilities and has even been utilized for the treatment of H-type tracheoesophageal fistula [4].

Embryology

The early phases of life are classed as embryonic or fetal. The embryonic period begins at conception and ends at the conclusion of the ninth week, while the fetal period starts at the end of the ninth week and continues until birth. Within the first two weeks, the human embryo goes through a process of growth and changes, resulting in the formation of a bilaminar disk made up of endoderm and ectoderm. The endoderm is responsible for development of lining of yolk sac. The endoderm provides a structural foundation for formation of the GIT system throughout development. The ectoderm is accountable for the formation of the epidermis and neural plates [5]. On 15th day, the embryo's mesoderm, or third layer, develops and acts as the basis for the gut's connective tissue, smooth muscle, angioblasts, and serosal layers. On 21st day, the mesoderm thickens to create longitudinal masses known as the paraxial mesoderm. On the 28th day, the paraxial mesoderm undergoes a process where it divides into little units of tissue called somites, which then move from the head to the tail end [6].

During the fourth week of development, the lateral folding of the embryo causes compression of the endoderm, which forms the dorsal section of the yolk sac. This compressed area is then absorbed into the embryo as a rim. As a consequence, the human embryo forms a "body cylinder," which separates the yolk sac into extraembryonic and intraembryonic components. The intraembryonic portion serves as the genesis of the digestive tract and its associated glands. By week 12, the initial digestive tract undergoes division into three parts: foregut, the gastrointestinal tract, and hindgut [6]. During the fourth week, a little protrusion develops on the lower side of the foregut, adjacent to the pharynix. The tracheobronchial diverticulum progressively lengthens then detaches from the dorsal foregut while the esophagotracheal septum is being formed, ultimately evolving into the rudimentary respiratory system [7].

During the eighth week, the lining epithelium experiences significant proliferation and effectively obstructs the foregut, resulting in the presence of only narrow residual openings. Vacuoles develop within the foregut luminal cells during the tenth week, then combine to create a single esophageal lumen. This lumen is covered in a layer of ciliated epithelial cells [9]. The ciliated epithelium is replaced by a stratified squamous epithelium in the fourth month. Esophageal glands are produced by little patches of ciliated epithelium that survive at the start and finish of the esophagus [9].

The mesenchyme of the somites that encircle the foregut gives rise to the smooth muscles of the lower esophagus and the lower esophageal sphincter (LES).Neural crest cells go to the foregut and then the hindgut in the seventh week of development. Eventually, these cells differentiate into the myenteric plexus. During the sixth week, neural crest cells move through the circular muscle layer, leading to the development of the submucosal plexus. By the 14th week, the interstitial cells of Cajal (ICCs) form a network that encircles the myenteric plexus. The ICCs, also known as interstitial cells of Cajal, play a vital role in initiating slow-wave contractions and facilitating neuronal transmission inside the gastrointestinal tract [10].

Anatomy of the Esophagus

The stomach cardia, also known as the cardiac orifice, is reached by the esophagus from the inferior border of the cricoid cartilage at the level of the C6 vertebra. However, the length of the esophagus at birth in neonates is 8-10 cm and measures about 19 cm at the age of 15 years [11].

Course and Relations

Cervical part: The esophagus originates at the midline and gradually deviates to the left near to the entrance of the thorax [12].

Thoracic part: eosphagus traverses the superior and then the posterior mediastinum. Anteriorly, it is crossed by the trachea, the left bronchus (Which constricts it), the pericardium (separating it from the left atrium), and the diaphragm. Posteriorly lies the thoracic vertebrae, the thoracic duct, the azygos vein and its tributaries and, near the diaphragm, the descending aorta. On the left side, it is related to the left subclavian artery, the terminal part of the aortic arch, the left recurrent laryngeal nerve, the thoracic duct, and the left pleura. On the right side, there is the pleura and the azygos vein [12].

Abdominal part: esophagus moves forward through the gap in the right crus of the diaphragm and is located in the esophageal groove on the rear surface of the left lobe of the liver. The front and left sides are covered in peritoneum. The left crus of the diaphragm is located behind it [12].

The blood supply of the esophagus is divided according to its anatomical position. The inferior thyroid artery branches provide blood supply to the cervical region, the thoracic segment by bronchial arteries and direct aortic branches, and the abdominal region by the left gastric and inferior phrenic arteries. Venous drainage to the esophagus is provided by the submucosal venous plexus, which runs parallel to the artery supply in the cervical and abdominal areas. However, in the thoracic area, the esophagus secretes its contents into the azygous and hemizygous systems [13].

The lymphatic drainage of the esophagus: The cervical part of the component guides its drainage into the deep cervical lymph nodes, while the thoracic segment directs its drainage towards the superior and posterior mediastinal lymph nodes. Similarly, the abdominal part directs its drainage towards the stomach and celiac lymph nodes [13].

Epidemiology & Etiology

Esophageal atresia is a common congenital defect, occurring in around 1 in 3,500 live babies. Most instances of esophageal atresia are sporadic or non-syndromic, although a small number of cases in this non-familial group are associated with chromosomal abnormalities [13]. The cause of tracheoesophageal anomalies is mostly unknown and involves multiple aspects, including both hereditary and environmental influences. In certain instances, genetic factors may be the primary influence, whereas environmental influences have either a negligible or minimal effect. Alternatively, one or more particular environmental variables may be involved, especially if a fetus already has a genetic predisposition, making it more sensitive to detrimental consequences resulting in birth abnormalities [14].

Associated Anomalies

Regardless of the specific origin, the first disruption in organogenesis leads to EA abnormalities, which in turn impacts other organ systems. Approximately half of all malformations linked EA-TEF may be characterized as a specific malformation syndrome, including Opitz G, Goldenhar, Fanconi anemia, CHARGE, VACTERL, or chromosomal. The remaining 50% of patients with comparable symptoms are classed as "nonsyndromic" and have a variety of congenital illnesses. A

recent research done in France indicated that the abnormalities observed included cardiovascular problems in 24% of patients, urogenital anomalies in 21% of cases, digestive anomalies in 21% of cases, musculoskeletal anomalies in 14% of cases, and central nervous system anomalies in 7% of cases [15].

Classification

In 1929, E.C. Vogt developed the first categorization system for EA. Gross converted the numerical terminology to an alphabetic one with minimal changes. This categorization approach divides anomalies into six main categories: Esophageal atresia (EA) is classified into the following types: EA without tracheoesophageal fistula (Type A), EA with proximal TEF (Type B), EA with distal TEF (Type C), EA with TEF between both esophageal segments and trachea (Type D), TEF without EA or H-type fistula (Type E), and esophageal stenosis (Type F) (Figure 1) [16].

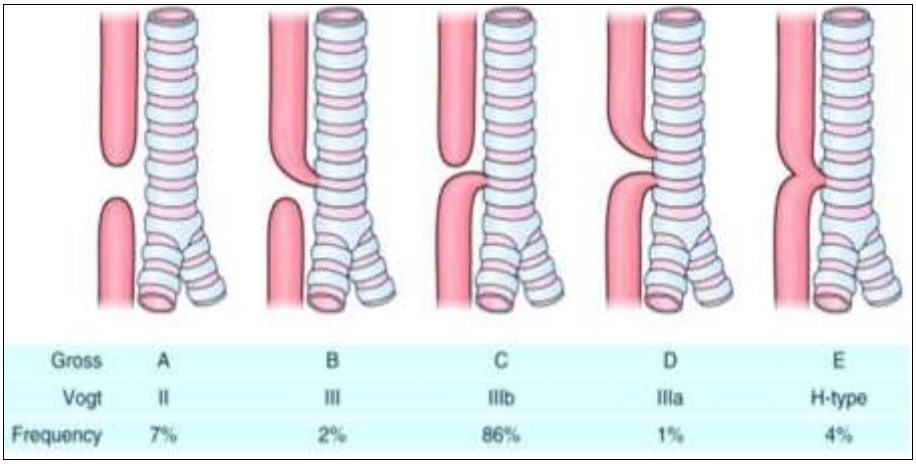

Fig 1: Gross, Vogt classification of congenital anomalies of the esophagus [16]

Waterston's 1962 classification (Prognostic classification): The classification was determined by evaluating the factors that contribute to the likelihood of risk factors. It had an impact on the provision of surgical treatment for these individuals. Infants categorized as "good" risk (A) typically underwent prompt surgical intervention., whereas infants classified as "moderate" risk (B) were managed with delayed repair. Infants classified as "high" risk (C) were treated with staged repair, as shown in Table 1. Despite the ongoing use of the Waterston classification for comparing results across different locations, numerous researchers have raised doubts about its continuing relevance in providing care for these infants. Thanks to advancements in neonatal critical careLow-birth-weight babies are now more likely to survive. Additionally, there are now more treatment choices for infants who have several congenital defects. Consequently, the hunt for contemporary standards for survival has led to the development of multiple novel classification systems [17].

Table 1: Waterston classification of esophageal atresia [17]

Group	Birth weight	General health	Survival
A	>2500 g	Otherwise healthy	100%
B	2000–2500 g	Moderate associated anomalies (Noncardiac, PDA, VSD, ASD)	85%
C	<2000 g	Severe associated cardiac anomalies	65%

In a study conducted by Spitz *et al*., 357 children diagnosed with esophageal atresia (EA) between 1980 and 1992 received care at the Hospital for Sick children on Great Ormond Street in London. They found that two important indicators of survival were birth weight and the existence of serious heart illness. Currently, the most used method is the Spitz classification (Table 2) [18].

Table 2: Spitz classification of esophageal atresia.

Group	Features	Survival
I	>1500 g, no major cardiac anomalies	98.5%
II	<1500 g, or major cardiac anomalies	82%
III	<1500 g, and major cardiac anomalies	50%

Okamoto *et al*. proposed a modification to the Spitz classification (Table 3). They stated that when the general care of infants with either low- or very-low-birth weights gets better, the presence of heart abnormalities becomes more important in determining the outlook for infants with EA [19].

Table 3: Okamoto modification of the Spitz classification [46]

Class	Description	Risk	Survival
Class I	No major cardiac anomaly, BW ≥ 2000 g	Low	100%
Class II	No major cardiac anomaly, BW < 2000 g	Moderate	81%
Class III	Major cardiac anomaly, BW ≥ 2000 g	Relatively high	72%
Class IV	Major cardiac anomaly, BW < 2000 g	High	27%

Diagnosis

Prenatal diagnosis: Polyhydramnios, a prominent esophageal pouch, and the absence or small size of the stomach "bubble" coupled with fluid-filled intestinal loops on ultrasound examination, often appearing in 3rd trimester of pregnancy, might suggest existence of this disorder [20].

Postnatal diagnosis: Typical signs of EA/TEF that may appear soon after birth include: increased production of saliva, bringing up food, coughing, and choking during initial feeding attempts, difficulty breathing, bluish discoloration of the skin, and the nasogastric tube may coil in the upper pouch (Unable to put a

catheter into the stomach), suggesting the risk of atresia [20].

Nasogastric Intubation Test of Neonates: It is recommended to use an 8 French (F) catheter in premature infants and a 10-12 F catheter in term infants. This procedure is carried out when there is a suspicion of esophageal atresia, either by prenatal sonography or based on the clinical presentation of the newborn. Typically, the distance between the gums and the stomach cardia of an infant is 17 cm. However, when an EA tube is used, it usually reaches a length of 10-12 cm. This procedure is inconclusive, as the external compression of the esophagus can result in a false positive test [21].

Other findings suggestive of EA: An expanded, air-filled belly shows esophageal atresia (EA) with a Type C distal tracheoesophageal fistula (TEF), which happens when the trachea allows air to enter the digestive system. An air-filled blind pouch due to esophageal atresia (EA), air in the gastrointestinal tract in cases of distal tracheoesophageal fistula (TEF), and pneumonia from gastric reflux into the lung from a distant TEF are all visible on the radiographs of the chest and abdomen. (Figure 2) [22]. If there is an air-filled pouch nearby and there is no gas in the belly, the individual most likely has EA without TEF (Type A). During a radiographic examination, nonionic water-soluble contrast or diluted barium is usually used to detect an H-type fistula (type E). Bronchoscopy can help diagnose tracheoesophageal fistulas (TEF) and develop surgical procedures (Figure 3). There have been descriptions of CT, virtual bronchoscopy, and MRI; nevertheless, their use for diagnosis is debatable [23].

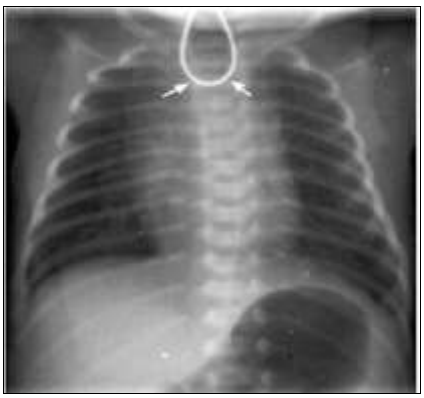

Fig 2: Chest radiograph suggesting EA with a nasogastric tube curled in the proximal atretic pouch [23]

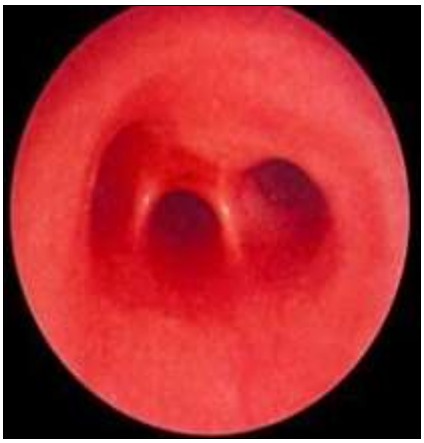

Fig 3: Bronchoscopy demonstrating a distal trachea-esophageal fistula arising from the region of the carina in a patient who has EA with distal TEF (type C) [23]

If there are components of the VACTERL relationship, it is more likely that there is esophageal atresia (EA). Roughly half of the patients diagnosed with EA or TEF exhibit accompanying congenital abnormalities. An exhaustive assessment should encompass the following: Chest, abdominal, pelvis, and spine radiographs; spine and kidney ultrasound tests; Cardiac ultrasound imaging of the heart and aorta [23].

Differential diagnosis of EA: Esophageal diverticula, Gastroesophageal reflux disease, esophageal stricture Esophageal rupture, Esophagitis, Pneumonia, aspiration**,** Respiratory failure, Zenker diverticulum, Tracheomalacia [24]

Management of Esophageal Atresia

Preoperative preparation's main objective is to safeguard the airway and avoid lung damage from saliva or stomach contents being inhaled. Prior to surgery, it is important to conduct preoperative diagnostic examinations. One effective method is to evaluate the heart and aorta using echocardiography, which helps determine the best surgical strategy. When a typical left-sided aortic arch is shown, it is preferable to use the right chest [25].

A. Preoperative Management

After confirming the diagnosis of esophageal atresia, the infant must be transferred to a neonatal intensive care facility. To limit the risk of pulmonary aspiration, the patient is positioned with his head lifted at a 30-degree tilt. After being placed into the upper esophagus, a 10F Replogle tube is attached to a continuous suction system. In order to prevent ulcers and pressure sores, the double-lumen Replogle tube minimizes suction on the mucosa while facilitating secretion extraction [26]. Bass devised a suction catheter administration technique that works better. The vent of the Replogle tube is attached to a three-way stopcock. Ten milliliters of saline solution are injected intravenously every hour, and the three-way valve is opened to allow air to enter [23].

Newborns with esophageal atresia, particularly those of low birth weight, require cooling treatments when being transferred from the delivery room to the critical care unit and during diagnostic testing. To avoid heat loss, place the newborn in an incubator or on a warmed surgical bed and provide them with protective gear [23].

B. Operative Management

Open (lateral thoracotomy): Begin by doing a tracheobronchoscopy using a rigid 3.5 mm endoscope. The trachea and major bronchi are swiftly examined, and the connection between the esophagus and typically, the trachea is situated 5–7 mm above the carina. It's interesting to note that it may be seen at the carina or within the right major bronchus, indicating that the lower segment is shorter and that the esophageal gap is probably larger. Checking for a superior fistula is the next course of action. A membranous structure makes up the section of the tracheal wall that reaches the cricoid cartilage. Small upper fistulas are easily ignored. Using the tip of a 3F ureteric catheter inserted via the bronchoscope, any anomalies on the upper layer of the bronchial wall are carefully examined in order to resolve this potential problem. The ureteric catheter may readily pass through a fistula if one exists [27].

The specific classification of EA/TEF, in addition to the size of the defect, influences the timing and method used for the surgical repair. The most prevalent manifestation, esophageal atresia with distal tracheoesophageal fistula (type C), advocates

for adopting the right-sided posterolateral extrapleural technique at the fourth intercostal gap to achieve initial repair [27].

The proximal pouch is elevated to match the distal segment of the esophagus. To prevent tracheal injury, the fistula is dissected gently and completely. When the vagus nerve reaches the trachea, it may serve as a landmark to help locate the distal pouch. When doing a dissection, use care and take efforts to prevent causing harm to the esophageal branches. The fistula is surgically separated and completely sliced, leaving a border of esophageal tissue on the trachea, around the area close to the trachea. Nonabsorbable sutures that are interrupted are utilized to seal the fistula and strengthen the trachea's subsequent weakening [27].

To prevent harm to the limited blood supply of the distal esophagus, the dissection should be restricted. The connection between the upper part of the esophagus and the lower part is typically made by joining the two segments together using two opposing traction sutures. Next, starting at the posterior wall and working their way down the whole length of the esophagus, continuous fine absorbable sutures are placed to fix the knots within the lumen. The tip of a 6 French catheter is placed past the anastomosis and into the esophagus, often in the stomach. The front wall is then sutured interrupted, with knots placed outside the tube (Figure 4) [27].

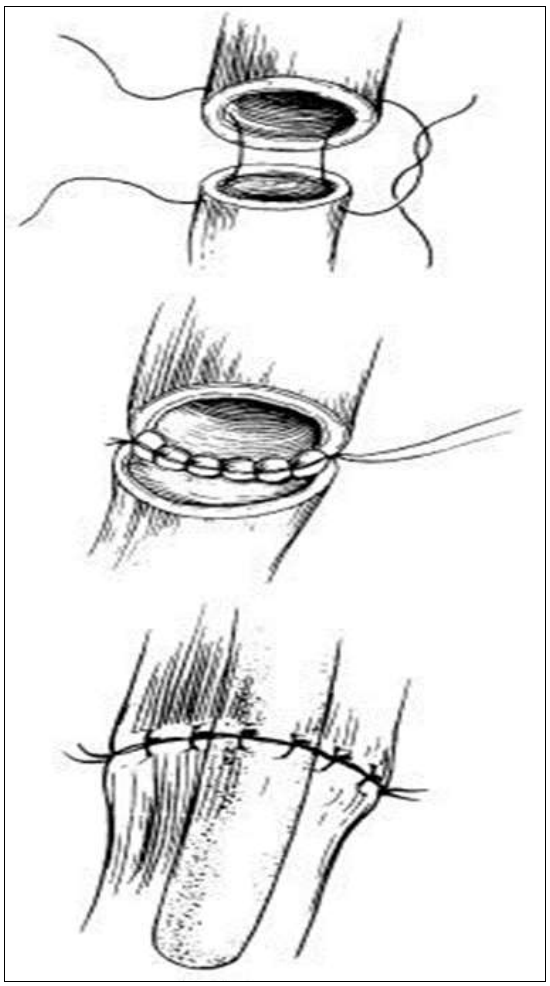

Fig 4: Single-layer esophageal anastomosis [27].

a. Corner stitches are placed, and the knots are tied to the outside.

b. The posterior row is placed with the knots tied on the inside.

c. The anterior row completes the anastomosis over a tube with the knots tied on the outside

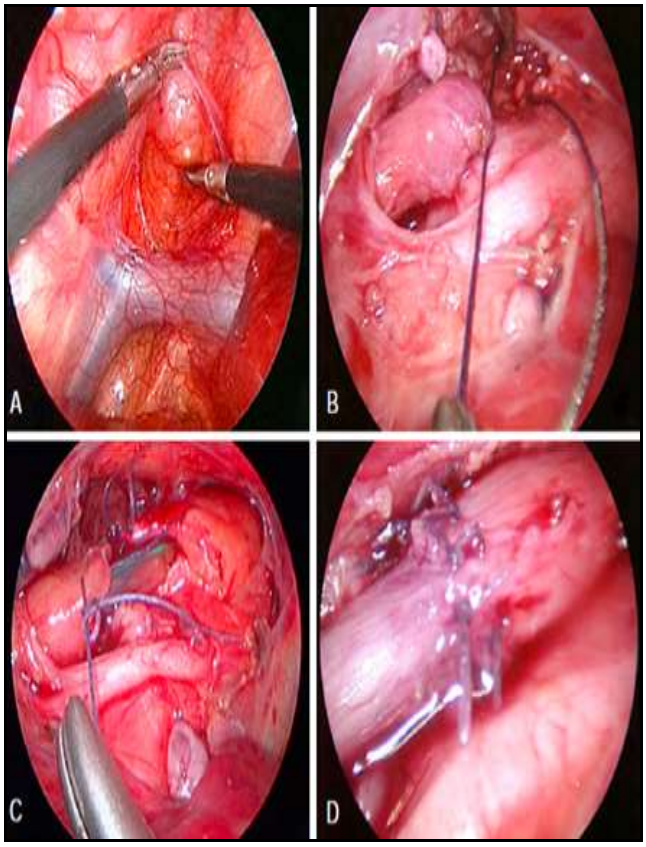

Fig 5: Thoracoscopic approach [29], a) Proximal pouch dissection is seen. B) The distal fistula is isolated close to the trachea and is being suture ligated. C) The back wall of the esophageal anastomosis is finished with interrupted sutures knotted on the inside. The front part of the anastomosis is performed using a tumbled square knot. A nasogastric tube can be seen in this photograph. D) Completed anastomosis

II. Thoracoscopic Repair

Thoracoscopy is being used to treat EA as a result of advancements in pediatric minimally invasive surgery. Lobe *et al*. provided the first record of thoracoscopic repair in 1999 [28]. The advantages and disadvantages were summarized in table (4)

Table 4: Advantages and disadvantages of the thoracoscopic approach to esophageal atresia [24]

Potential advantages of thoracoscopic approach	Potential disadvantages of thoracoscopic approach
Cosmetic appearance (Minimal scarring)	Transpleural, if an anostomotic leak occur
Magnification provides excellent visualization	Small operative space
Uniform collapse of lung eliminates retraction trauma	High experience
Less postoperative pain	Thoracoscopic approach requires good lung compliance

Position and Port Placement

The ideal method for thoracoscopic repair is to administer general anesthesia with endotracheal intubation, with a focus on the left mainstem bronchus. The case is positioned either lying face down in the prone position of Darius or lying on their side in the semi-lateral posture of Rothenberg, with the right side raised at a 45° angle. Optimal positioning of the ports is crucial for achieving clear visibility of the thoracic cavity and facilitating the required manipulation of instruments. At the fifth intercostal gap, a cannula with a diameter of 3 to 5 millimeters is

placed into the posterior axillary line. After that, a 30-degree angle camera is placed into the thoracic cavity and carbon dioxide is administered to it. Two intercostal gaps are positioned one above the telescopic port and one below it for a 5-mm port and a 3-mm port, respectively, that are implanted in the midaxillary line. The purpose of both ports is to hold instruments, which must be positioned at a roughly 90° angle. In some cases, it may be necessary to use a fourth port to achieve the best possible lung retraction, however this is usually not needed [29], as shown in figure [5].

Closure of the Tracheoesophageal Fistula

The chest has expanded, causing the lungs to collapse. The lower esophageal segment is monitored proximally until it reaches the posterior wall of the trachea. The fistula was ligated surgically, and then separated using scissors [29].

Mobilization of the Upper Pouch

On find the upper pouch, the anesthetist applies downward pressure on the orogastric tube. Using both blunt and sharp dissection techniques, the pouch is pushed in the direction of the neck [29].

Esophageal Anastomosis

The anastomosis is achieved using an absorbable suture of the size 4/0 or 5/0. To accurately line the mucosal surfaces, interrupted sutures must be precisely placed across all layers [29].

Esophageal replacement

Esophageal replacement is necessary for individuals who are unable to undergo repair of the original esophagus. Various techniques for substitution were described as affecting the stomach, small and large intestine. Gastric transposition is a highly efficient technique that reestablishes the link of the upper gastrointestinal system, as demonstrated in a significant number of patients. Schärli proposed a technique that utilizes the lower curvature of the stomach to form a tube of 3 to 4 centimeters in length, which serves as a replacement for the required esophageal length. Comparable methods can be employed to produce a gastric tube that is inverted or isoperistaltic Using the larger curvature of the stomach. Jejunal, ileal, and colonic segments have also been used for esophageal replacement. Possible risks of these treatments include impaired movement of the digestive tract (Dysmotility), difficulty swallowing (Dysphagia), problems with feeding, the backflow of stomach acid into the esophagus (Gastroesophageal reflux), and the development of narrow passages (Strictures) [30].

Complications

Complications can be categorized into two main groups: early complications and late complications. Early complications encompass anastomotic leak, wound infection, pneumonia, pneumothorax. Late complications include gastroesophageal reflux (GER), anastomotic stricture, recurrent tracheoesophageal fistula, esophagitis, esophageal stenosis, esophageal dysmotility, epithelial metaplasia and cancer, tracheomalacia, and chest wall deformities [31].

Anastomotic leak

Anastomotic leakage at the site of esophageal anastomosis is observed in around 15% to 20% of individuals with EA. Historically, leakage from the connection between the esophagus has been a significant cause of health complications following surgery [32]. When evaluating anastomotic leakage, it is important to consider both the extent of the leaking and its subsequent consequences (Table 5) [33].

Table 5: Management of anastomotic leakage after the repair of esophageal atresia [30]

A postoperative contrast examination revealed an incidental discovery, with no clinical signs.	Observe, no particular therapy. Continue oral feedings.
There was a minor leakage of saliva in the chest drain, but the infant is OK.	Stop taking oral meals and antibiotics. It will close spontaneously.
A significant leak might be caused by mediastinitis, an abscess, a pneumothorax, or an empyema.	If anastomosis is severely disrupted on imaging, discontinue oral feeding and antibiotics. It may need further surgery or drainage. Begin TPN.

Esophageal Stricture

Esophageal stricture frequently occurs as a consequence of esophageal anastomosis in individuals with esophageal atresia (EA). According to recent extensive studies, around 80% of individuals experience a condition called stricture that need dilatation. Spitz and Hitchcock suggested that stricture might be characterized by the presence of symptoms such as dysphagia and recurring respiratory issues caused by aspiration or obstruction by a foreign object. Additionally, narrowing observed during endoscopy or contrast esophagography could be indicative of stricture [34].

The factors involved in the development of esophageal stricture include suboptimal surgical technique (Excessive tension, two-layered anastomosis, and the use of silk sutures) as well as ischemia at the esophageal ends and leakage at the surgical connection site. Additionally, gastroesophageal reflux (GER) is a strong factor in the development of stricture formation. The coexistence of gastroesophageal reflux (GER) with delayed esophageal clearance, due to esophageal dysmotility, results in prolonged exposure of the sensitive area of the anastomosis to acid. This raises the risk of developing an anastomotic stricture. A substantial restriction in the area of the esophageal anastomosis is frequently addressed by conducting dilatation using antegrade or retrograde bougienage [35].

Recurrent Tracheoesophageal Fistula

Recurrent tracheoesophageal fistula (TEF) is observed in 3% to 15% of patients following the initial surgical separation or closure, and it typically develops in the vicinity of the original fistula. Recurrent tracheoesophageal fistula (TEF) is caused by an anastomotic leak, which leads to local inflammation and erosion at the place where TEF was previously repaired. The identification of an air-filled esophagus on plain radiographs of the chest may suggest the diagnosis. To decrease the chances of a fistula forming again after the first recurrence of tracheoesophageal fistula (TEF), it is advised to insert intercostal muscle, pleura, or pericardium between the esophagus and trachea [36].

Gastroesophageal Reflux Disease

The extent of the problem is evident from the research indicating that GERD is present in 27% to 75% of individuals following EA surgery. The reason for gastroesophageal reflux (GER) in these newborns is likely due to the shortening of the intra-

abdominal section of the esophagus. This shortening might be caused by anastomotic tension or malfunction in the esophageal muscles, which can be acquired after surgery or inherent to the congenital defect itself [37]. Pathologic GERD is diagnosed when patients present with symptoms such as vomiting, difficulty swallowing, and recurring narrowing of the surgical connection, which can sometimes be caused by the blockage of a foreign object or a mass of food. There is disagreement on the antireflux surgery to choose. The Nissen fundoplication has traditionally been regarded as the optimal choice. Nevertheless, the 360-degree wrap procedure has often resulted in severe dysphagia and notable problems, such as wrap disruption and recurring GERD, affecting one-third of patients [37].

Esophagitis

The average occurrence rate of esophagitis in numerous studies was 53%, with the majority of patients falling between the age range of 20 to 40 years [38].

Esophageal dysmotility

Esophageal manometric investigations revealed a near-total lack of coordination in esophageal peristaltic action. The amplitude of contractions in the entire esophagus was significantly reduced compared to healthy individuals, and the amplitude of contractions in the distal esophagus stayed consistently below 30 mm Hg in 58% to 100% of patients. The primary long-term abnormalities in esophageal motility after repairing esophageal atresia are the lack of coordination in esophageal contractions and the weak strength of contractions in the lower part of the esophagus. The motility problems are most likely caused by developing neurological disorders that impact the proximal pouch and distal fistula [39].

This ailment, known as post-esophageal atresia repair syndrome, is characterized by persistent symptoms following surgical repair of esophageal atresia. These symptoms include difficulty swallowing (Dysphagia), blockage of the esophagus by foreign objects, gastroesophageal reflux disease (GERD), and recurring respiratory issues [40].

Growth

Preliminary research indicated that survivors of esophageal atresia may experience stunted growth. Additional research has verified that certain children display early physical developmental delays, but, their height and weight eventually reach typical levels. After the surgical correction of esophageal atresia, the distribution of height and weight percentiles in adulthood conforms to a normal distribution [41].

Epithelial metaplasia and cancer

Columnar metaplasia in the esophagus is a precancerous condition that occurs due to gastroesophageal reflux. Adenocarcinoma of the esophagus arises in the esophagus that is lined by columnar cells [40].

Tracheomalacia

Respiratory problems that emerge following the repair of EA-TEF can be caused by tracheomalacia, a condition that affects a significant portion (up to 75%) of pathological specimens from patients with EA-TEF. Tracheomalacia refers to a condition where the trachea, or windpipe, becomes weak either in a specific area or across its whole length. This weakness causes the front and back walls of the trachea to collapse or narrow when a person exhales or coughs. Tracheal collapse typically occurs in the area around or slightly above the initial location of the tracheoesophageal fistula (TEF) in the lower part of the trachea, usually at the level of the aortic arch [40].

Chest wall deformities

A notable proportion of scapular winging anterior chest wall abnormalities and scoliosis cases involve chest wall malformations. These conditions can arise due to postoperative complications, scoliosis, and congenital abnormalities of the spine. The prevalence of scapular winging has been documented to be approximately 20%. Scapular winging could be reduced by ensuring the meticulous protection of the long thoracic nerve, a practice that is currently not implemented during thoracotomy procedures [42].

Post-Operative Scar Formation

The advent of the Patient and Observer Scar Assessment Scale (POSAS) marks a significant advancement in scar assessment, particularly in the open group compared to the thoracoscopic group. This scale is the first to take into account both the patient's and evaluator's perspectives. POSAS evaluates the physical characteristics of scars, such as vascularity, pigmentation, thickness, relief, and pliability. Additionally, it enables patients to rate scar-related discomfort and itching using a 10-point rating system. While subjective symptoms such as pain and itching are taken into account, the assessment does not include functional impairments or any psychological impacts [43].

Conflict of Interest

Not available

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Not available

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