كليـــــــة الطب
والصيدلة - مراكش
FACULTÉ DE MÉDECINE
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MARRAKECH
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Anastomotic Stricture after Esophageal Atresia Surgical Repair

THESIS

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BY

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TO OBTAIN THE DEGREE OF DOCTOR OF MEDICINE

KEYWORDS

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بسم الله الرّحمن الرّحيم

"Glory be to You (Allah). We have no knowledge except
what You have taught us. You are truly
the All-Knowing, All-Wise"
(2-32)

Oath of Hippocrates

At the time of being admitted as a member of the medical profession:

I solemnly pledge to dedicate my life to the service of humanity
The health and well-being of my patient will be my first consideration
I will respect the autonomy and dignity of my patient
I will maintain the utmost respect for human life
I will not permit considerations of age, disease or disability, creed, ethnic origin, gender, nationality, political affiliation, race, sexual orientation, social standing or any other factor to intervene between my duty and my patient
I will respect the secrets that are confided in me, even after the patient has died
I will practise my profession with conscience and dignity and in accordance with good medical practice
I will foster the honour and noble traditions of the medical profession
I will give to my teachers, colleagues, and students the respect and gratitude that is their due
I will share my medical knowledge for the benefit of the patient and the advancement of healthcare
I will attend to my own health, well-being, and abilities in order to provide care of the highest standard
I will not use my medical knowledge to violate human rights and civil liberties even under threat
I make these promises solemnly, freely, and upon my honour.

Geneva Declaration, 1948

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321	SAADI Khadija	Pr Ass	Pédiatrie
322	DAFIR Kenza	Pr Ass	Génétique
323	CHERKAOUI RHAZOUANI Oussama	Pr Ass	Neurologie
324	ABAINOU Lahoussaine	Pr Ass	Endocrinologie et maladies métaboliques
325	BENCHANNA Rachid	Pr Ass	Pneumo-phtisiologie
326	TITOU Hicham	Pr Ass	Dermatologie
327	EL GHOUL Naoufal	Pr Ass	Traumato-orthopédie
328	BAHI Mohammed	Pr Ass	Anesthésie-réanimation
329	RAITEB Mohammed	Pr Ass	Maladies infectieuses
330	DREF Maria	Pr Ass	Anatomie pathologique
331	ENNACIRI Zainab	Pr Ass	Psychiatrie
332	BOUSSAIDANE Mohammed	Pr Ass	Traumato-orthopédie
333	JENDOUZI Omar	Pr Ass	Urologie
334	MANSOURI Maria	Pr Ass	Génétique
335	ERRIFAIY Hayate	Pr Ass	Anesthésie-réanimation

336	BOUKOUB Naila	Pr Ass	Anesthésie-réanimation
337	OUACHAOU Jamal	Pr Ass	Anesthésie-réanimation
338	EL FARGANI Rania	Pr Ass	Maladies infectieuses
339	IJIM Mohamed	Pr Ass	Pneumo-phtisiologie
340	AKANOUR Adil	Pr Ass	Psychiatrie
341	ELHANAFI Fatima Ezzohra	Pr Ass	Pédiatrie
342	MERBOUH Manal	Pr Ass	Anesthésie-réanimation
343	BOUROUMANE Mohamed Rida	Pr Ass	Anatomie
344	IJDDA Sara	Pr Ass	Endocrinologie et maladies métaboliques

LISTE ARRETEE LE 09/01/2024

DEDICATIONS

With profound gratitude and deepest appreciation,
I dedicate this thesis to..

Say, 'surely my prayer, my worship, my life, and my death are all for Allah, Lord of all worlds'." (6–162)

To My Creator, the sovereign of the heavens and earth and all that lies between them, to Allah, The Merciful Provider, The Mighty and Majestic, The Bestower of Life and The Bringer of Death.

فلا الحمدُ في ذا ولا ذاکَ لي   ولکنْ لکَ الحمدُ فِي ذا وذاک

To my dearest Mother Fatiha SEBBAA

Beloved Mother, forgive my brevity as words falter before the depth of my feelings. Your presence is a melody of warmth and comfort, resonating my existence, Your quiet countless sacrifices, form the very fabric of my existence. Through every stumble and uncertainty, you have been there, holding my hand with a love that transcends the bounds of understanding. Thank you for being the quintessence of love and blessings in my life.

For all you are and all you've given, I cannot be but eternally grateful.

To my cherished Father Abdellatif EL HARCHI

Constant source of unconditional love, inspiration, and guiding light. Your words and sacrifices have carved the very essence of who I am today.

With heartfelt appreciation, I dedicate this humble work to you, acknowledging the profound impact you've had on guiding my journey through life,

I hold you in the deepest affection, beyond what words can express.

To my beloved grandmother Fatima EL HARCHI, to my dearest aunt Fouzia SEBBAA, To The purest souls of my grandfather M'hammed SEBBAA and grandmama Aicha EL BAKRI

My dearest primary caregivers, the cherished souls who raised me from the very start, I cannot help but express profound gratitude for the unwavering love, boundless affection, and tireless care you provided with open arms and warm hearts. This humble dedication stands as a testament to the profound affection and love I hold for you.

To my forever little Asmaa EL HARCHI

Beloved Sima, partner-in-crime and support system, words fall short in expressing the immense joy your presence brings into my life, you were always a source of courage and determination, through tick and thin you've stood by my side, cheering me on every step of the way. Witnessing the incredible person you're becoming fills me with immense pride, this humble work is a tribute to you, my eternal source of joy and little ray of happiness.

To my best ever Abdelmoughit EL HARCHI

Dear brother and fellow adventurer, Your presence has been a strength, a source of confidence in moments of uncertainty, and an endless wellspring of laughter. With a blend of appreciation and joy, this dedication is a shout-out to you, my reliable co-conspirator, cherished confidant and forever best friend, love you more than words could ever convey.

To my dearest Uncles and their families

In loving memory of my dear Uncle Simohammed, with heartfelt regards to my uncles Abdelilah, Khalid, Mustapha, Abdellatif and their families, your appreciated support and encouragement have been a constant motivation throughout my journey.
This thesis is a tribute to the deep respect and affection I hold for each of you.

To my precious friends and nightshift partners Aicha El Hadri, Wiam El Horre and Bahia El Hadek

Dear ones, our journey together was full of joy, companionship, and cherished memories.
To the laughter we shared, the shoulders we leaned on, and the bond that transcended friendship,
This thesis is devoted to each and every one of you.

To my dear confidant Fatima Zahra EL Idrissi and her little Adam

Together, we have shared more than friendship, forging bonds that endure the test of time, from the moment we embarked on this path, you were a steady rock, facing every challenge with grace and determination,
To Little Adam, with his laughter and radiant presence.
Thank you for being the wonderful friend that you are.

To my beloved buddies yousra Belboukhari, imane EL Harradi, meryem EL Gazzar, oumaima Oulougoum, hajar EL Hilali, oumaima Zarhouni, and fatiha Rahali and to the ones i unintentionally overlooked

Through the long hours and countless cups of coffee, our journey has been nothing short of an adventure. Each memory, from the late nightshifts to our unexpected escapades, holds a special place in my heart.
Here's to the ones who make even the toughest times feel like a breeze, and transform moments into cherished memories.

To my dearest Imane, Nissrine and Samia Qanoune, Najia Amine, Bouchra Bouyeknifen, Imane Khassil, Assia Tiji, Salma EL Warraki, Hajar EL Maski, Asmaa Fathi, Douaa Irrou, Hajar Ennaimi, Hajar Anouar and others i unintentionally didn't mention

To my kindred spirits, whose companionship is a treasure beyond measure, a guiding light that illuminates the path. May our connection continue to thrive, sharing moments of joy and growth together. Blessed beyond measure to have you.

To my dearest Doctor Aicha EL MESSOUSSI

Under the gentle care of your skilled hands and warmhearted smile, Your sweet and nurturing guidance has not only brightened my smile but also warmed my heart, your kindness and support that have touched me in the most delightful ways.

With genuine appreciation and affection, this dedication stands as a heartfelt testimony to my enduring admiration for you.

To the Lady of the lands, The Mother of all Beginnings and Mother of all Endings, To Palestine,

May this Dedication serve as an Appology, and a humble tribute to your people, in the hope for a future where liberation and peace prevail.

Last but not least,

To my esteemed Teachers, Mentors, and All those who have carved the very essence of who I am today on my journey of learning and growth, please find this as a testimony of my high esteem and deep appreciation.

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Head of Pediatric Intesive Care Unit
Professor of Anesthesiology–Resuscitation
and Chairman of my thesis

We extend our deep honor and gratitude for your willingness to chair this thesis defense. Your expertise, extensive knowledge, and compassionate demeanor have made a lasting impact on everyone, from students to patients. Through this work, we express our heartfelt gratitude and deepest respect to you.

To Professor OULAD SAIAD Mohamed
Head of Pediatric General Surgery Department
Professor of Pediatric Surgery
and Supervisor of my thesis

I express my sincere gratitude to you esteemed supervisor, whose guidance and wisdom have been instrumental throughout the journey of this work. your expertise and dedication have shaped not only the content of this thesis but also my path in medicine,
I extend the assurance of my highest esteem and deepest respect to you, admired Professor, through this work.

To Professor BOURRAHOUAT Aicha
Professor of Pediatrics in the Pediatric "B" Department
and Judge of my thesis

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To Professor ABALLA Najoua
Professor of Pediatric Surgery in the Pediatric General Surgery Department
and mentor of my thesis

I would like to express my deepest gratitude to you, dear Professor, for your invaluable guidance and support throughout the creation of this thesis, from the earliest stages of conceptualization to the final moments of refinement, your presence was a constant source of inspiration and reassurance.
Despite your demanding schedule, you always made time to provide insightful feedback and thoughtful suggestions. Your humility and inexhaustible knowledge make you the ideal mentor that every student and doctor aspires to have.

Please accept this as a testimony of my high esteem and deep appreciation.

Last but not least, I express my gratitude to all those who contributed to this thesis, particularly all the Esophageal Atresia patients and their parents. Their active participation and generous dedication of time greatly enriched our research endeavors.

LIST OF ABREVIATIONS

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AS : Anastomotic Stricture

CRP : C-Reactive Protein

EA : Esophageal Atresia

EET : Endoscopic Electrocautery Therapy

GA : Gestational Age

GERD : Gastroesophageal Reflux disease

L-EASI : Lower-Esophageal Atresia Stricture Index

N/R : Not reported

PPIs : Proton Pump Inhibitors

SG Dilator : Savary-Gilliard Dilator

SI : Stricture index

TEF : Tracheoesophageal fistula

U-EASI : Upper-Esophageal Atresia Stricture Index

VACTERL : Association of Vertebral anomalies, Anorectal anomalies, Cardiac anomalies, Tracheoesophageal fistula with/atresia, Renal anomalies, and Limb anomalies.

VB : Vertebral bodies

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SUMMARY

INTRODUCTION

Esophageal atresia is a serious congenital malformation of the digestive system characterized by an interruption in the esophageal lumen, either with or without tracheoesophageal fistula formation. This condition requires surgical repair to establish a connection between the two segments of the esophagus. However, even after successful surgical intervention, a constriction of the repaired area may give rise to anastomotic stricture, a common morbidity that can occur.

The absence of a consistent definition for anastomotic stricture following esophageal atresia repair poses a challenge when attempting to compare findings across various studies. Most studies define esophageal stricture as a narrowing of the esophageal lumen requiring at least one dilation. Some require approval of the presence of anastomotic stricture, at least three dilations regardless of the presence of symptoms. In current literature, definitions vary based on the frequency of dilations, luminal diameter, or symptomatology[1].

Anastomotic stricture has an incidence between 32 and 80% and has been reported to be the most common complication of esophageal atresia repair[2], while up to 60% of children with esophageal atresia develop an anastomotic stricture after surgical correction mostly in the first year of life[3]. As a consequence, this issue creates a challenging and time-intensive responsibility for both healthcare providers and families alike.

While the exact cause of anastomotic stricture is not fully understood, it is believed that several underlying factors can contribute to the development of this complication, some risk factors are well-established, while others remain controversial such as sex ratio, race, Waterston class, and surgical approach[4]. The role of these factors in the development of anastomotic strictures is still a topic of debate among medical professionals and researchers, and further studies are needed to better understand their potential contribution to this condition.

From a clinical perspective, a variety of symptoms thought to be due to anastomotic stricture have been described in the literature, gastrointestinal symptoms include feeding and swallowing difficulties, respiratory symptoms notably cough and recurrent respiratory infections are the main symptoms alongside additional symptoms to be detailed subsequently.

While paraclinically, diagnostic techniques including esophageal contrast studies and upper endoscopy enable the identification and possibly the treatment of esophageal stricture with different advantages of the two techniques.

The management of anastomotic strictures requires a comprehensive and collaborative approach, involving multiple steps and disciplines. Endoscopic dilations using balloon/bougie catheter are typically the first-line treatment for anastomotic strictures.

This conservative approach may be combined with other therapies in cases of refractory or recurrent strictures, and only in extremely selected cases, surgical intervention may be necessary as a last alternative after careful evaluation of the patient's overall condition and needs[4].

PATIENTS AND METHODS

I. Type of study:

Through a retrospective cohort study, we investigated a group of 80 patients who underwent surgical treatment for esophageal atresia at the General Pediatric Surgery Department of the University Hospital Center Mohammed VI of Marrakesh during an Eight-year timeframe between 2015 and 2023.

II. Purpose of the study:

We aim first, to determine the incidence of anastomotic stricture among esophageal atresia operated patients. Secondly, we intend to evaluate the degree of correlation between a group of factors and the development of strictures. The third aim of this study is to explore anastomotic stricture management techniques and evaluate patient outcomes after undergoing dilatation sessions.

III. Patients:

1. Inclusion criteria:

The current study involved living patients, diagnosed with esophageal atresia based on both symptoms and paraclinical investigations, and to whom an End-to-End anastomosis was performed.

2. Exclusion criteria:

Patients with Type 1 esophageal atresia, those who died prior to surgery, those with insufficient data, and Type 3 esophageal atresia patients who did not undergo primary anastomosis were excluded from this study.

IV. Methods:

1. Data collection:

The methodology of this study comprised the following steps:

- *Step 1:*

A medical operative sheet (Appendix) was created to encompass a range of parameters, including:

- **Esophageal atresia anamnesis:**

- Epidemiological data (age, gender, birth weight...), clinical findings and paraclinical examination
- Management of esophageal atresia: age at surgery, surgical approach, type of esophageal atresia, gap length, type of material suture, complications.
- VACTERL association was defined in the presence of at least three of the following features: vertebral defects, anal atresia, cardiac defects, tracheoesophageal fistula, renal anomalies, and limb abnormalities[5].
- Long-gap esophageal atresia was defined as a gap between the two pouches of > 4 vertebral bodies[6].
- Waterston prognostic scoring system used to predict mortality in infants with esophageal atresia included birth weight, the presence of pneumonia at the time of presentation, and the presence of associated anomalies essentially major cardiac anomalies (Table I).

TABLE I: WATERSTON SCORE DEFINITION

Waterston score	Definition
Group A	Birth weight over 2500g and well
Group B	Birth weight 1800g to 2500g and well or over 2500g with moderate pneumonia and congenital anomaly
Group C	Birth weight under 1800g and well or 1800g to 2500g with severe pneumonia and severe congenital anomaly

- **Anastomotic stricture:**

In this study, the definition adopted for stenosis specifically referred to cases necessitating at least one dilation procedure.

Clinical findings, paraclinical examination, management and follow up.

- *Step 2:*

The essential data from medical records of each patient fitting the criteria mentioned above was searched and collected using Pediatric Intensive Care Unit, Pediatrics, and Pediatric Surgery archives.

We subsequently conducted a prospective follow-up to evaluate the actual condition of the patients, parents of the patients were contacted via telephone, and joined the hospital to undergo clinical and paraclinical examination in order to evaluate the outcomes of dilation sessions.

2. Statistical analysis:

The collected data was recorded using Microsoft Excel 2021 version.

The statistical analysis was conducted using SPSS Statistics (Statistical Package for the Social Sciences) version 27.0. Quantitative variables were presented as mean ± standard deviation and range, and analyzed using the Wilcoxon-Mann-Whitney test. Categorical variables were presented as absolute values and percentages, and analyzed using Pearson's Chi-square and

Fisher's exact test depending on the characteristics, statistical significance was determined at a p level <.05.

V. Ethical aspect:

The data collection was carried out with due consideration for overarching ethical principles concerning confidentiality and the safeguarding of patient data.

RESULTS

A total of eighty patients underwent surgery for esophageal atresia in our department over the course of eight years. This translates to an average incidence of 10 patients per year. A significant majority, seventy-one cases (89%), continued to maintain good health and have not experienced any long-term complications from the procedure.

Between 2015 and 2023, nine out of eighty patients who underwent surgery for esophageal atresia developed anastomotic stricture (11.25%).

Two cases were excluded from the anastomotic stricture group because they did not require dilations. The remaining 71 patients (89%) did not present anastomotic stricture.

The results from the analysis of medical records compared patients who developed anastomotic stricture (AS group/group1) with those who did not (non-AS group/group2) after esophageal atresia surgical repair.

The analysis focused on identifying potential risk factors, including preoperative, intraoperative, and postoperative variables, as well as the management and follow-up of anastomotic strictures.

I. Epidemiological Data:

1. Gender:

Male patients constituted 56% (n=5) of the population who developed anastomotic stricture, resulting in a sex ratio of 1.25.

Fifty-one percent of non-anastomotic stricture group were male, with a sex ratio of 1,02 (Figure 1).

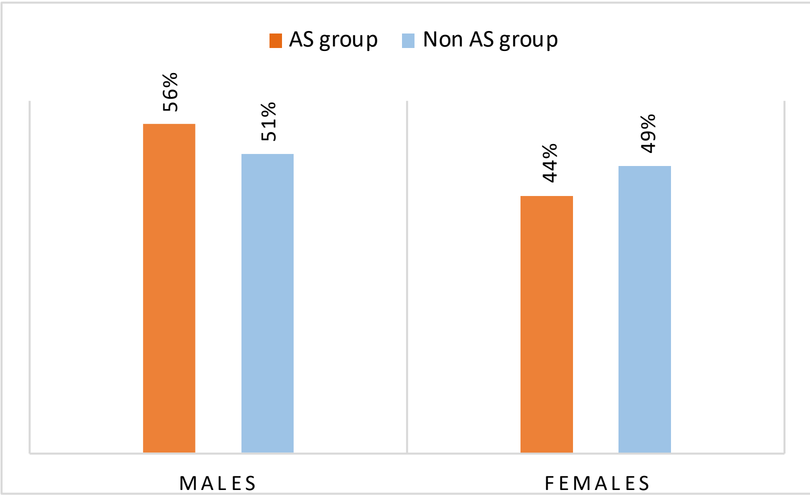


FIGURE 1: GENDER DISTRIBUTION BETWEEN GROUP 1 AND GROUP 2

2. Prenatal diagnosis:

Among all the cases operated for esophageal atresia with prenatal ultrasound assessments, none exhibited prenatal anomalies, except for one case with hydramnios. The follow-up after surgery was uneventful, and the patient with hydramnios did not develop any anastomotic stricture (p value:1)

3. Gestational age:

All the patients who presented anastomotic stricture after surgical repair were born at term.

In the group of non-anastomotic stricture, 4 newborns were premature (6%) (Figure 2).

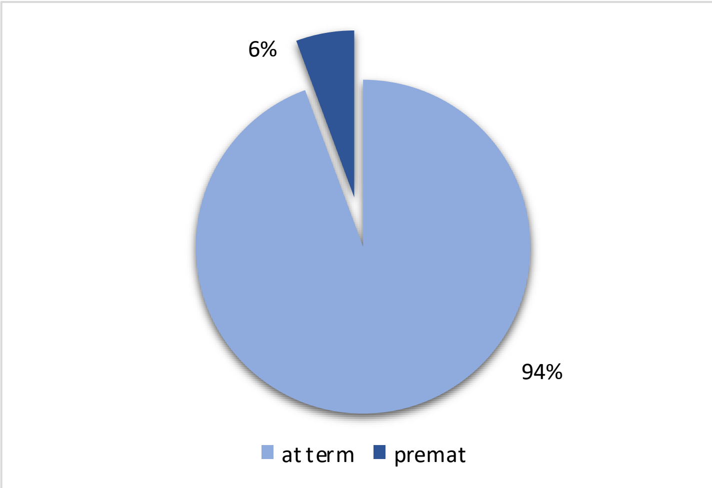


FIGURE 2: NON ANASTOMOTIC CASES DISTRIBUTION BY GESTATIONAL AGE

4. Birth weight:

The average birth weight in both groups was 2800g. In AS group, no patient had a birth weight under 2000g. Six patients had a birth weight exceeding 2500g (67%) (mean: 2857.14 +- (395.2)) (Figure 3).

In non-AS patients, 3% of the patients had a birth weight below 2000g and 39 had a birth weight exceeding 2500g (78%). (Mean: 2842.63 +- (478.8)) (p value: .939) (Figure 4).

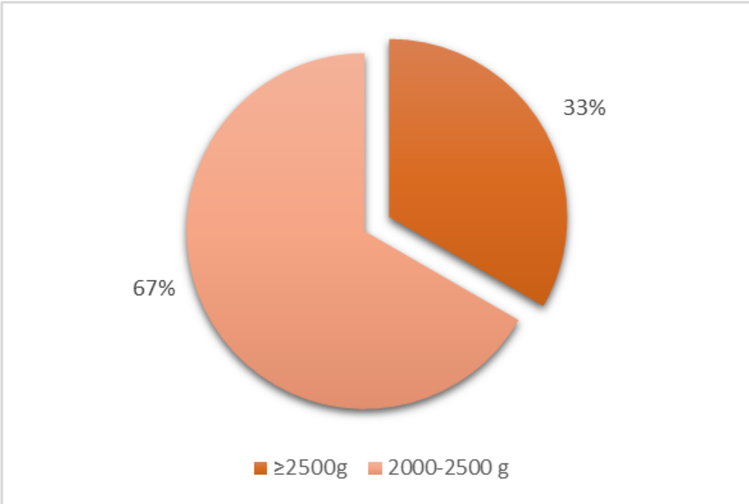


FIGURE 3: AS GROUP DISTRIBUTION BY BIRTH WEIGHT

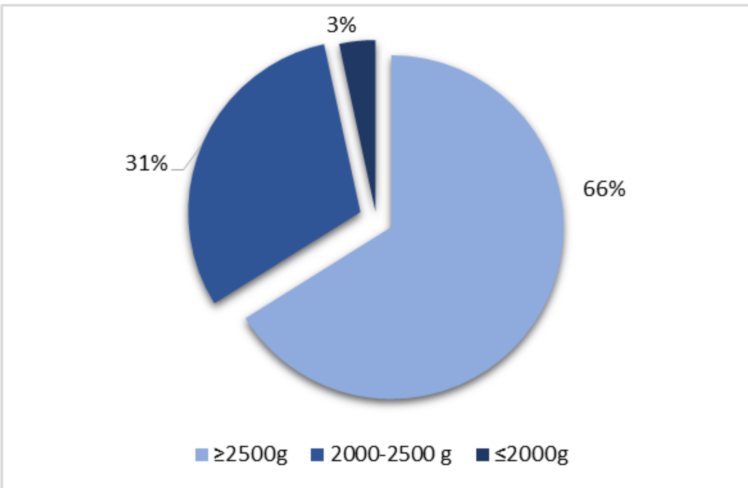


FIGURE 4: NON-AS GROUP DISTRIBUTION BY BIRTH WEIGHT

5. Nasogastric tube insertion test:

Nasogastric tube insertion test was conducted on 4 patients (44%) from AS group and on 35 patients on non-AS group, equivalent to 49% of patients.

Four patients from the whole population had normal results, indicating false negatives. (p value: 1) (Figure 5).

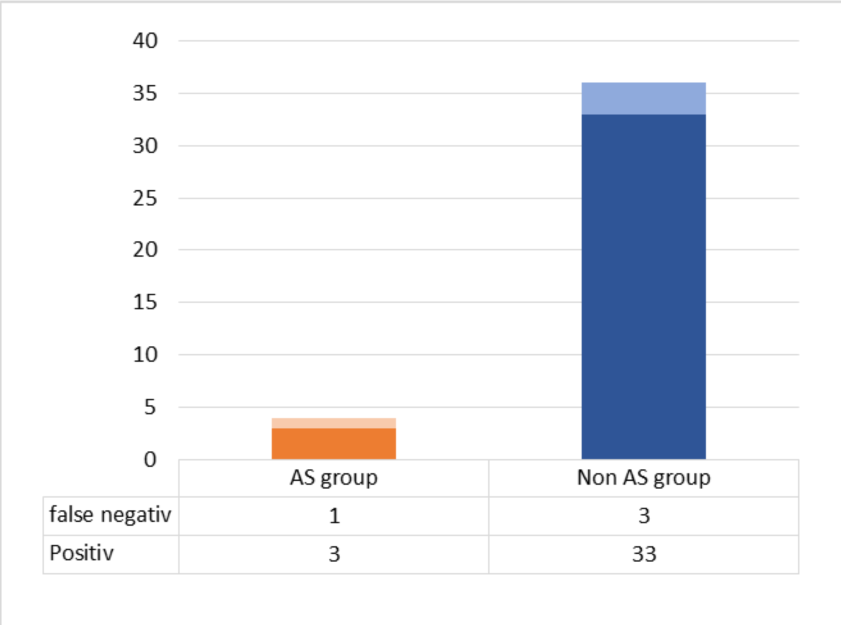


FIGURE 5: NASOGASTRIC TUBE INSERTION TEST COMPARISON

6. Breastfeeding attempt:

Breastfeeding initiation was attempted for all patients with anastomotic stricture, and for 55 patients among non-AS group (77%) (p value: .192) (Figure 6).

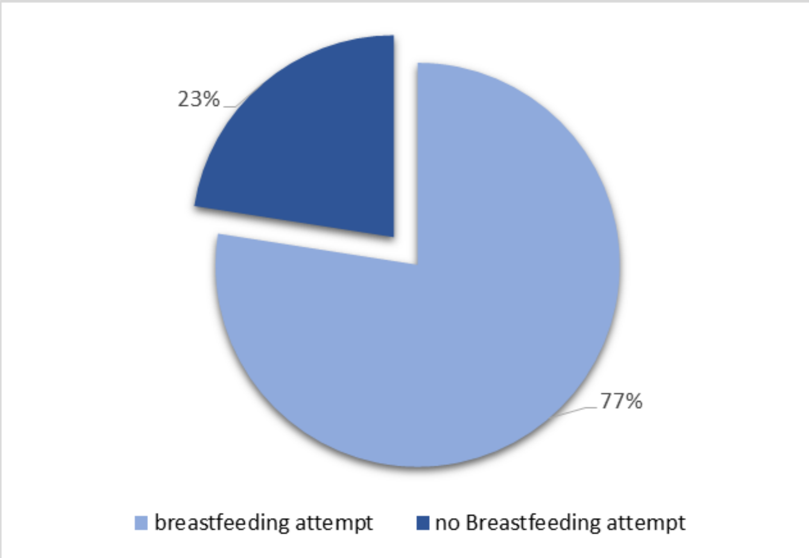


FIGURE 6: NON-AS GROUP PATIENTS DISTRIBUTION BY BREASTFEEDING ATTEMPT

7. Malformations assessment:

Following clinical examinations aimed at identifying any potential malformations, a comprehensive assessment was conducted for each patient and identified:

- In anastomotic stricture patients, the only associated malformation identified was musculoskeletal: bilateral pinna malformation + neck chondroma in 1 patient.
- In non-Anastomotic stricture group, 12 patients had associated congenital malformations (29%) (Figure 7) divided into:

7.1. Genitourinary malformations:

The most common malformation in our series was genital-urinary detected in 7 cases (10%):

- Hypospadias in two cases.
- Right cryptorchidism in 2 cases.
- One case diagnosed with bilateral hydrocele.
- Bilateral hydronephrosis in one case.
- Two patients diagnosed with renal hypoplasia

7.2. Musculoskeletal malformations:

Musculoskeletal malformations were identified in 5 cases (7%):

- Left arm hypoplasia in 1 patient.
- Bilateral radial agenesis in one patient.
- Bilateral Pinna malformation in 1 patient.
- Right choanal atresia in 1 patient.
- Congenital talipes equinovarus in one patient.

7.3. Cardiovascular malformations:

Based on ultrasound cardiography, Atrial Septal Defect was diagnosed in two patients, accounting for 3% of the cases.

7.4. Anorectal malformations:

One patient had an imperforated anus with peri anal fistula (1%).

7.5. VACTERL association:

Out of the 12 patients with associated malformations, VACTERL syndrome was diagnosed in two patients, accounting for 3% of the non-AS cases.

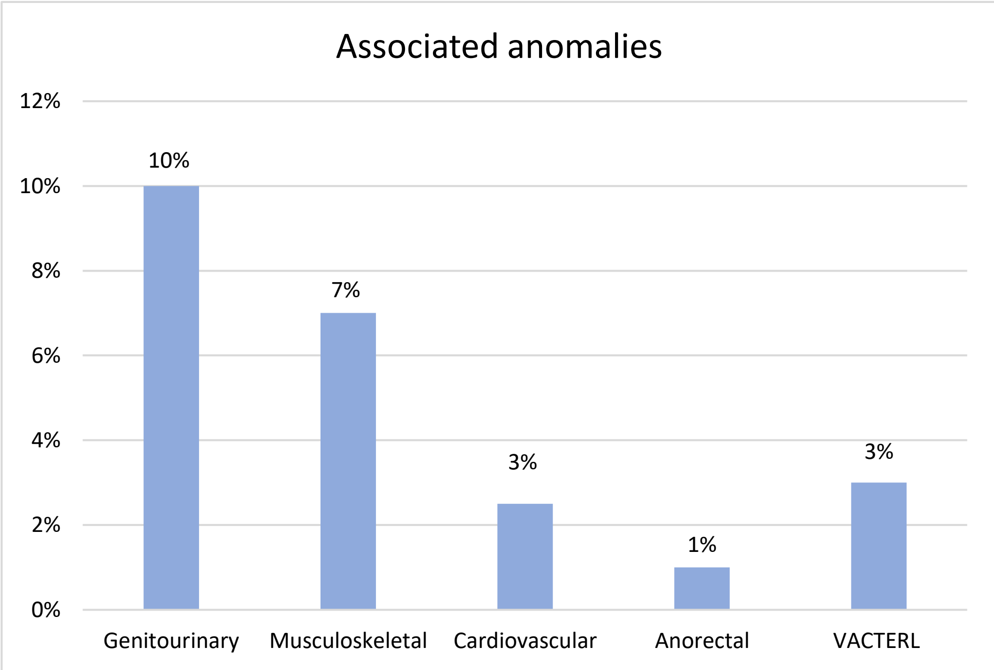


FIGURE 7: DIFFERENT MALFORMATIONS AMONG NON-AS GROUP

II. Preoperative variables:

1. Preoperative lung condition:

Within the anastomotic stricture group, six out of 9 patients (66%) suffered from pneumonia detected before proceeding with the anastomosis.

Twenty-nine patients among the non-AS group consisting of 71 patients (41%) had a similar condition prior to surgery (p value: .169) (Figure 8).

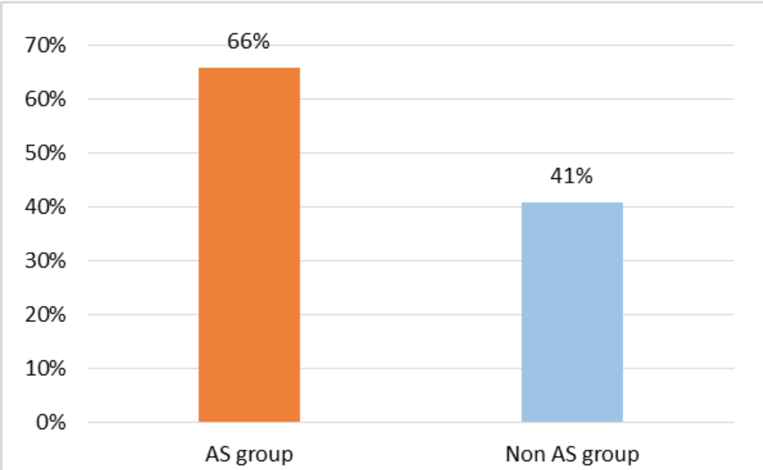


FIGURE 8: DISTRIBUTION OF CASES BASED ON THE OCCURRENCE OF PREOPERATIVE PNEUMONIA

2. Waterston score:

According to the Waterston score definition (Table I), thirty-nine patients (61%) within the non-AS group, were classified as category B. In contrast, category C was the least represented comprising only one patient.

Among AS group, category B predominates with 6 patients (67%), (p value: 1) (Figure 9).

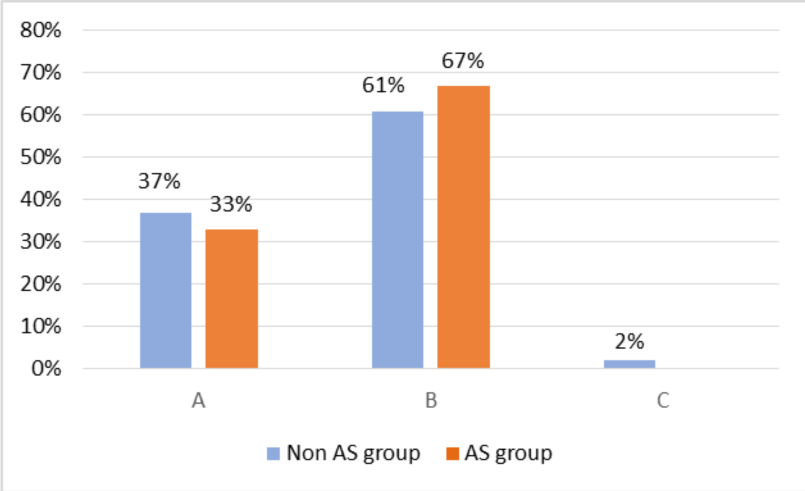


FIGURE 9: PATIENTS DISTRIBUTION BASED ON WATERSTON SCORE

3. Preoperative CRP levels tests:

The following outcomes were obtained upon performing a preoperative CRP levels blood test on our patients: The CRP levels above 10 mg/L were observed in six out of eight patients among AS group (75%) with an average mean of 16 mg/L and in 40 from 66 patients within non-AS group (60%) (p value: .680) (Figure 10).

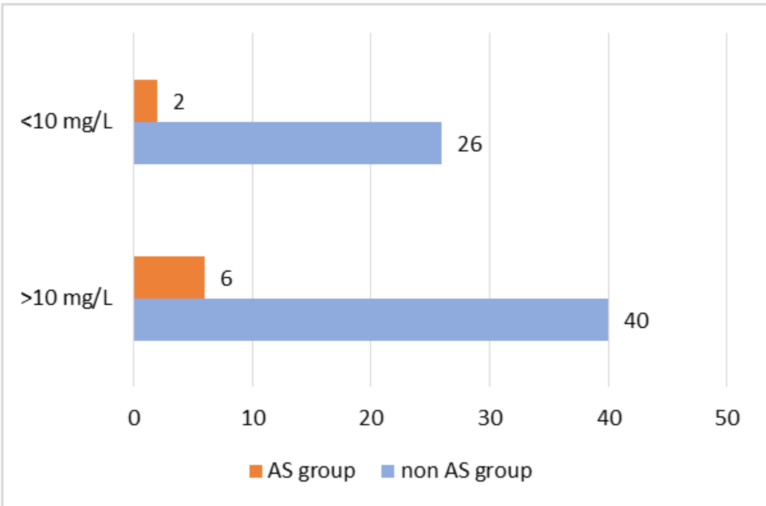


FIGURE 10: CASES DISTRIBUTION BY CRP LEVELS

4. Age at surgery:

The average age at surgery in both groups was 5 days, it varied in the AS group from 2 to 11 days and ranged from 1 to 40 days in the non-AS group (Figure 11)

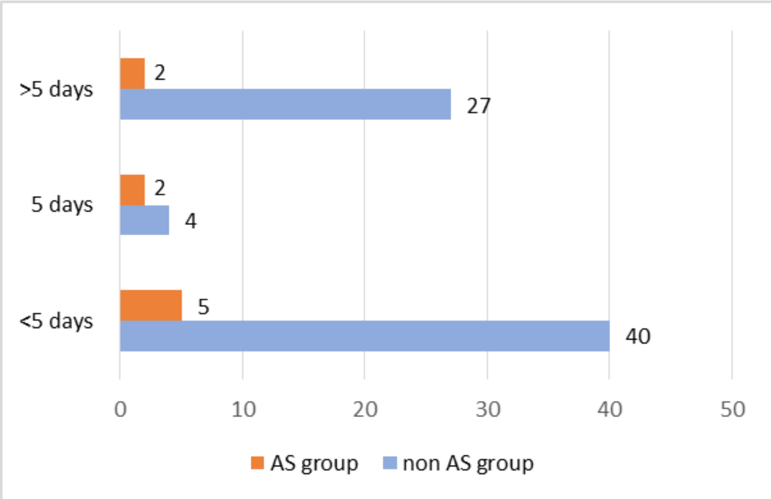


FIGURE 11: PATIENTS DISTRIBUTION BY AGE AT SURGERY

III. Intraoperative variables:

1. Surgical approach:

Among the AS group, 89% of the patients underwent posterolateral thoracotomy. 27% within non-AS patients had a modified posterior approach (p value: .437) (Figure 12).

A conversion from thoracoscopy to modified posterior thoracotomy occurred in a single case belonging to the non-AS group.

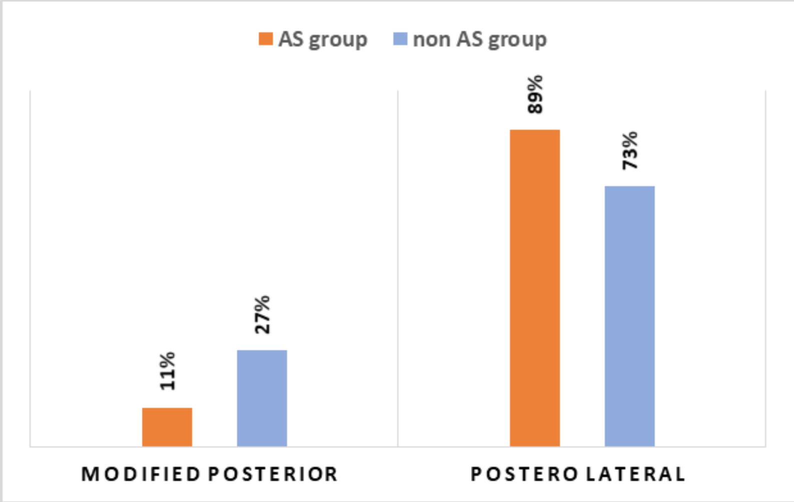


FIGURE 12: PATIENTS DISTRIBUTION BASED ON SURGICAL APPROACH

2. Esophageal atresia anatomical type:

Type 3 encompassed the entirety of patients with anastomotic strictures (100%) and the majority of the non-AS group accounted for 98% of the cases, only one patient had a type 4 esophageal atresia (p value: 1) (Figure 13).

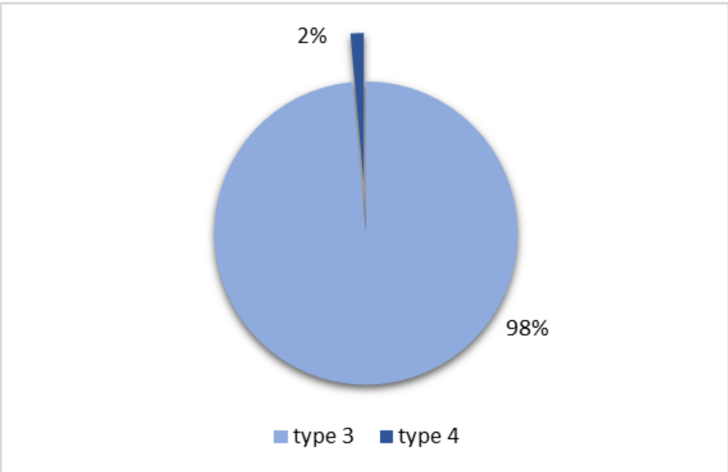


FIGURE 13: DISTRIBUTION OF ESOPHAGEAL ATRESIA TYPES WITHIN THE NON-AS GROUP

3. Esophageal gap:

The gap length can be conveniently measured in centimeters during surgical procedures or, as an alternative method, expressed in terms of vertebral body equivalents. In the AS group, approximately 67% of cases had a gap ranging between 2 and 6 vertebral bodies.

The non-AS group predominantly presented with a gap of less than two vertebral bodies, accounting for 57% of cases (p value: .705) (Figure 14).

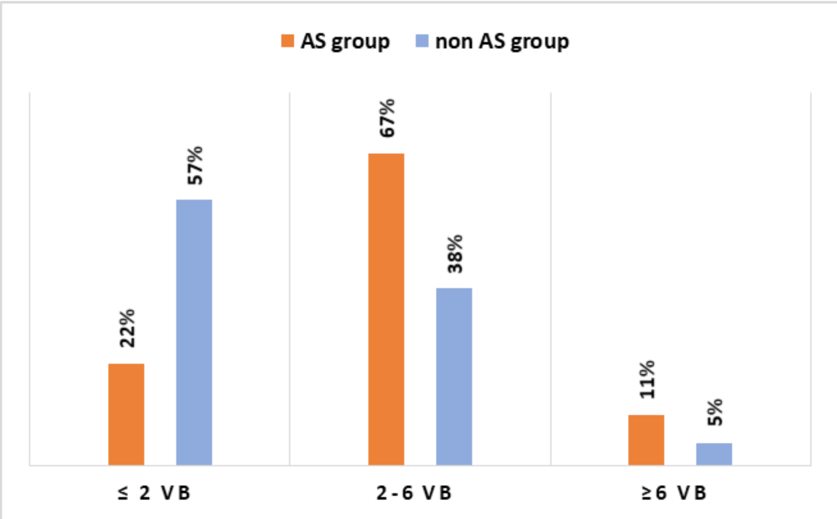


FIGURE 14: CASES DISTRIBUTION BASED ON THE LENGTH OF THE ESOPHAGEAL GAP

4. Type of EA surgical repair:

Only one patient among AS group underwent wave like anastomosis.

Within non-AS group, 24 patients had wave like anastomosis as a surgical procedure (34%) (p value: .260) (Figure 15).

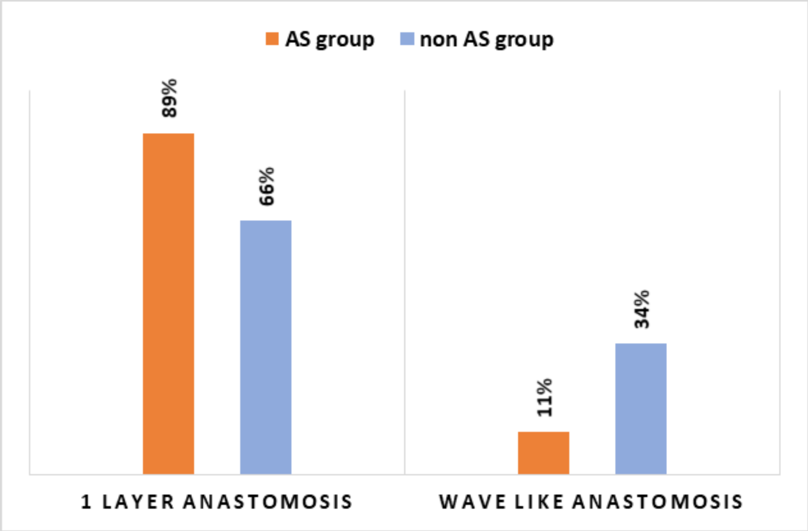


FIGURE 15: PATIENTS DISTRIBUTION BASED ON THE TYPE OF SURGICAL REPAIR

5. Type of suture material:

Polydioxanone monofilament suture was used in the majority of anastomosis procedures with a percentage of 97% within the non-AS group.

Polyglactin 910 suture filament was utilized in only 3% of the procedures among AS group (p value: .045) (Figure 16).

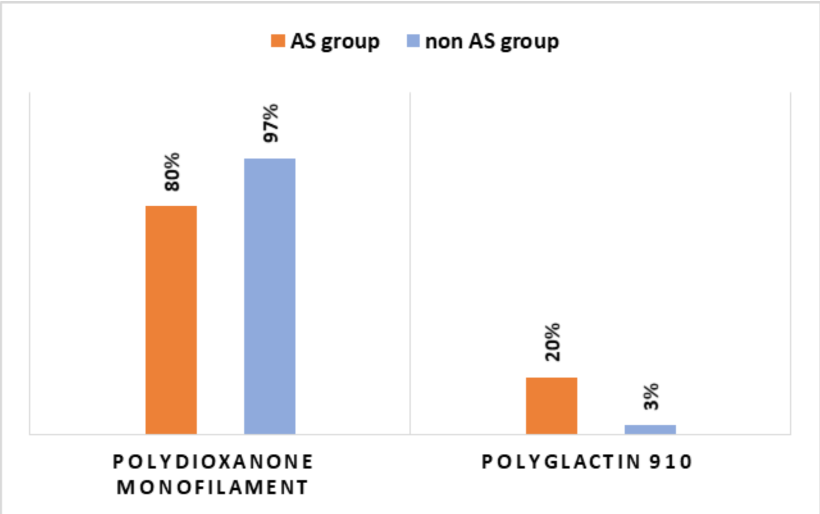


FIGURE 16: CASES DISTRIBUTION BY THE TYPE OF SUTURE MATERIEL USED IN SURGICAL PROCEDURES

6. Tension:

During the assessment of anastomosis, surgeons evaluated the tension. In 41 procedures among the non-AS group, no tension was observed.

Seven procedures, 78% of the AS group, involved application of significant tension (p value: .030) (Figure 17).

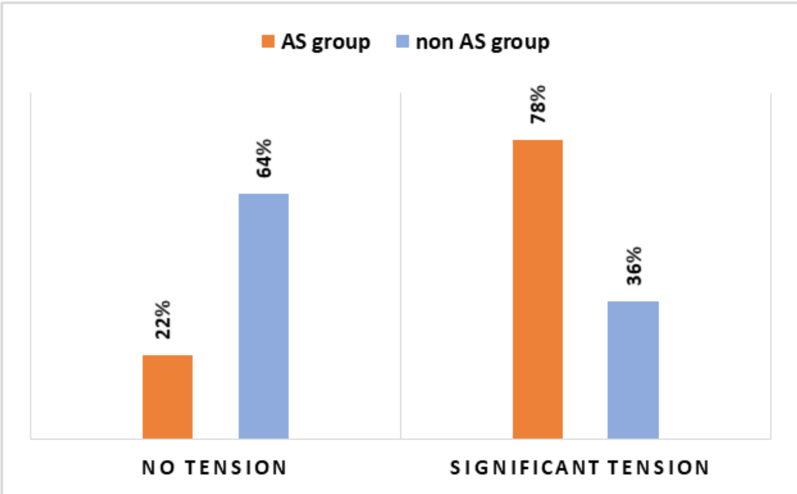


FIGURE 17: CASES DISTRIBUTION BY DEGREE OF TENSION DURING ANASTOMOSIS

7. Trans anastomotic tube insertion:

In the AS group, all patients underwent placement of a trans anastomotic tube during surgery, with CH08 tube being the most frequently used in 8 patients (89%).

In the non-AS group, 60 patients underwent 08 French trans-anastomotic tube placement, while only eight patients didn't undergo trans anastomotic tube placement (p value: .587) (Figure 18).

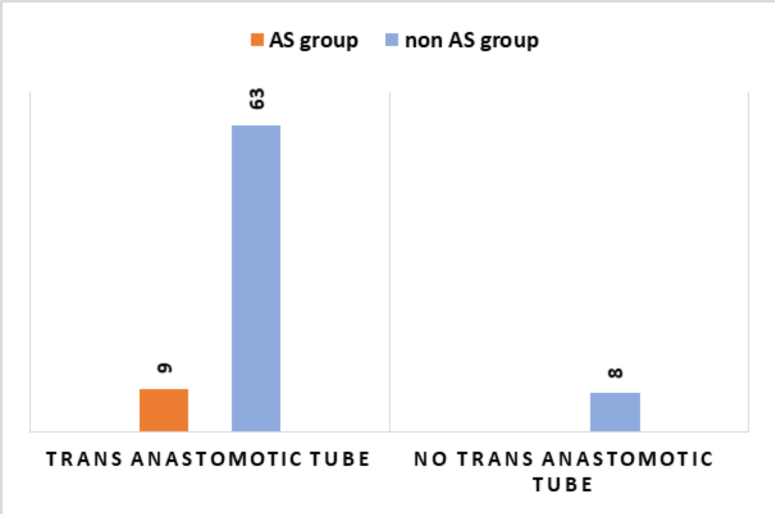


FIGURE 18: DISTRIBUTION OF PATIENTS BY TRANS ANASTOMOTIC TUBE UTILIZATION

IV. Postoperative variables:

1. Duration of trans anastomotic tube placement:

All the group 1 had a duration of trans-anastomotic tube of 6 days at least and 8 days at last with a mean time of 6,8 days.

Within the group 2, 4 patients experienced a fall of the trans-anastomotic tube at day 4. the mean time duration was 7 days with an average between 4 and 10 days.

2. Intubation duration:

Among AS group, only one was intubated for less than one day, while the remaining patients underwent intubation for more than 24 hours. (Mean in days: 2.43 +-(0.97)).

Within non-AS group, approximately forty-seven percent of the patients underwent intubation with a duration of less than 24 hours (Mean in days: 2.33+-(2.01)) (p value: .902) (Figure 19).

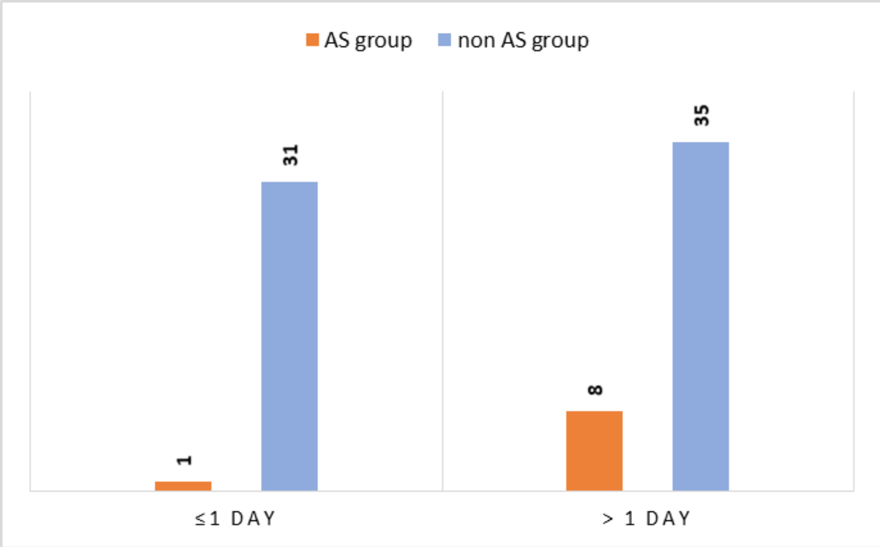


FIGURE 19: PATIENTS DISTRIBUTION BY INTUBATION DURATION

3. Postoperative complications:

Anastomotic stricture was the most common early complication occurring after esophageal atresia repair, followed by pneumonia, which affected 10% of cases. Pleural effusion was the least common complication observed.

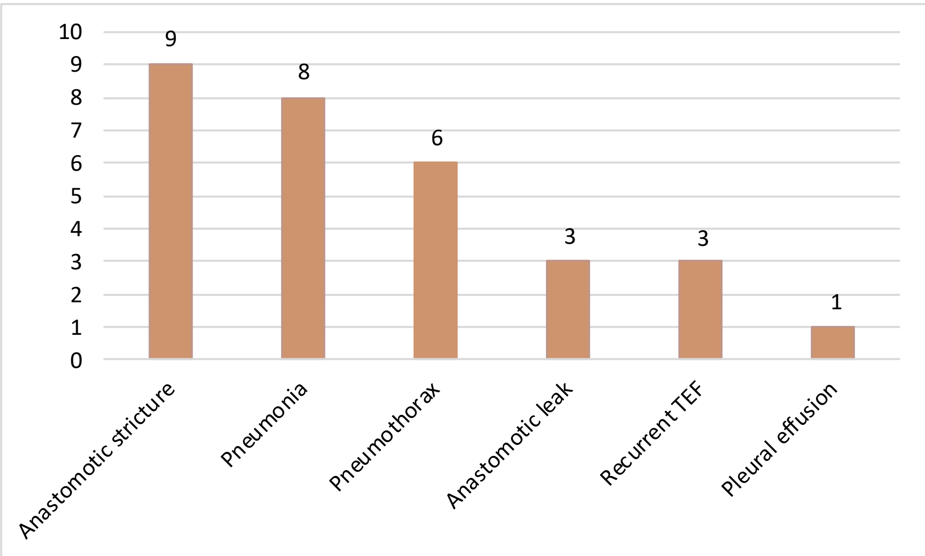


FIGURE 20: COMPLICATIONS OF THE SURGERY WITHIN OUR CASES SERIES

This table represents a statistical summary of variables, including their respective p-values and percentages, as outlined above (table

TABLE II: VARIABLES SUMMARY: P–VALUES AND PERCENTAGES

	Non stricture cases (71)	Stricture cases (9)	P value
Gender, n			
male	36 (87.8%)	5 (12.2%)	1
female	35 (89.7%)	4 (10.3%)	
Prenatal diagnosis, n	1 (100%)	0 (0%)	1
Prematurity, n	4 (100%)	0 (0%)	1
Birth weight, mean (+- SD), g	2842.63 +- (478.8)	2857.14 +- (395.2)	.939
NG insertion test, n	35 (89.7%)	4 (10.3%)	1
Breastfeeding attempt, n	55 (85.9%)	9 (14.1%)	.192
Associated anomalies, n			
Cardiovascular	2 (100%)	0 (0%)	1
Genitourinary	7 (100%)	0 (0%)	1
Anorectal	1 (100%)	0 (0%)	1
Musculoskeletal	5 (83.3%)	1 (16.7%)	.523
VACTERL	2 (100%)	0 (0%)	1
Pre operative lung condition, n	29 (82.9%)	6 (17.1%)	.169
Waterston score, n			
A	24 (32.9%)	3 (4.1%)	1
B	39 (53.4%)	6 (8.2%)	
C	1 (1.4%)	0 (0%)	
Pre operative CRP blood levels			
CRP: above 10 mg/l	23.05 +-(40,65)	17.032 +-(12.26)	.680
Age at surgery, mean (+- SD), days	5.75 +-(5.78)	4.89 +-(3.14)	.665
Surgical approach, n			
Modified posterior	19 (95%)	1 (5%)	.437
Posterolateral	52 (86.7%)	8 (13.3%)	
EA type, n			
Type 3	70 (88.6%)	9 (11.4%)	1
Type 4	1 (100%)	0 (0%)	
Esophageal gap, n			
≤ 2 VB	21 (91.3%)	2 (8.7%)	.705
2-6 VB	14 (70%)	6 (30%)	
≥6 VB	2 (66.7%)	1 (33.3%)	

Type of EA surgical repair, n End-to-End anastomosis Wave like anastomosis	 47 (85.5%) 24 (96%)	 8 (14.5%) 1 (4%)	.260
Type of suture material, n Polydioxanone Polyglactin	 57 (89.1%) 1 (33.3%)	 7 (10.9%) 2 (66.7%)	.045
Tension, n	24 (77.4%)	7 (22.6%)	.030
Trans anastomotic tube, n	63 (87.5%)	9 (12.5%)	.587
Intubation duration, days	2.33+-(2.01)	2.43 +-(0.97)	.902

V. Anastomotic stricture:

1. Onset period:

The time span between esophageal atresia surgical repair and the onset of anastomotic stricture symptoms varied among patients, with 66% experiencing symptoms beyond the 6-month mark, representing the most common timeframe (Figure 21).

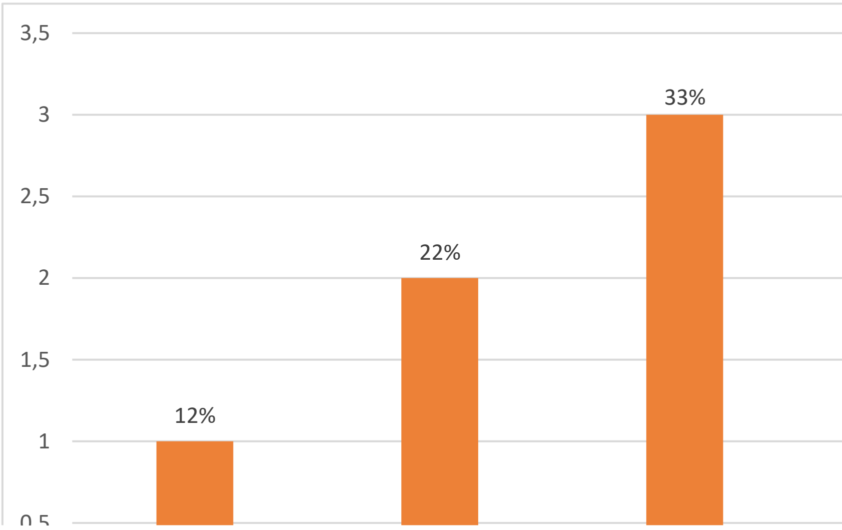


FIGURE 21: DISTRIBUTION OF PATIENTS BY TIME INTERVAL

2. Clinical signs:

Anastomotic stricture was revealed essentially by dysphagia (50%) followed by regurgitation, and vomiting, two patients were found to have a stricture incidentally (Figure 22).

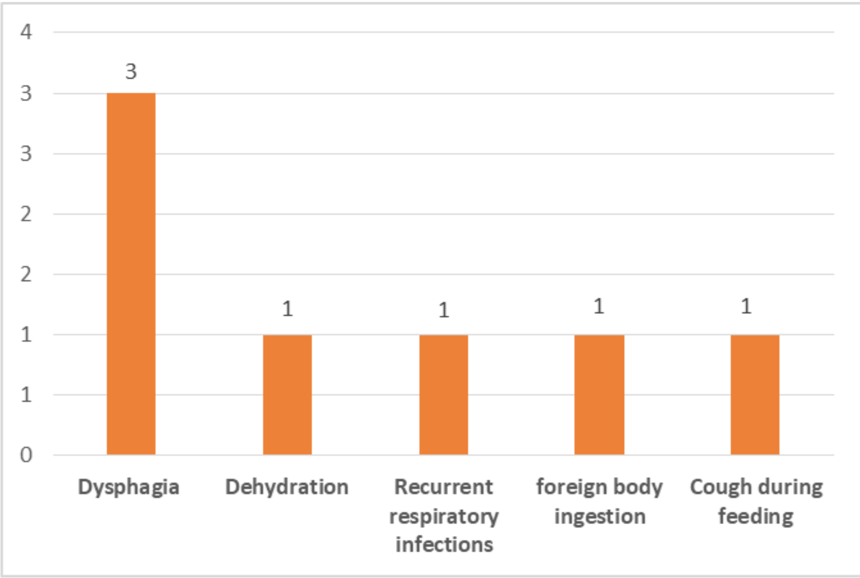


FIGURE 22: ANASTOMOTIC STRICTURE SYMPTOMS DISTRIBUTION

3. Paraclinical examination:

All anastomotic strictures were detected using upper gastrointestinal series and confirmed through the use of Upper Endoscopy.

4. Management:

Multiple dilations appear to be imperative when dealing with anastomotic strictures, 27 dilation sessions were performed in total, with the most commonly observed number of sessions per patient being three and performed on four patients in our study (Figure 23).

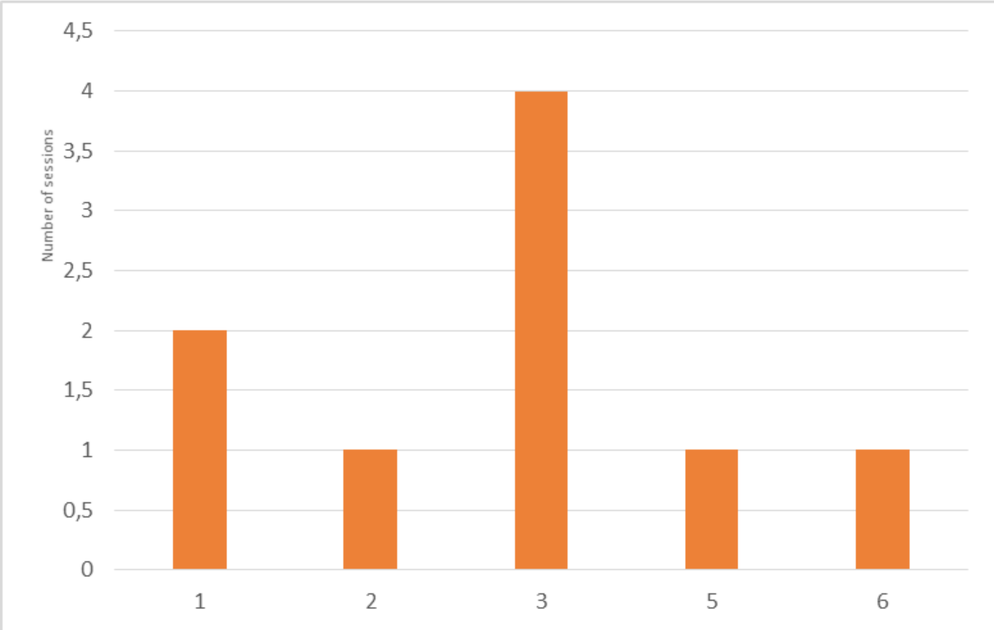


FIGURE 23: CASES DISTRIBUTION BASED ON THE NUMBER OF DILATION SESSIONS

4.1. Dilation tools:

The predominant approach for managing anastomotic stricture involved the utilization of a balloon dilator exclusively in 67% of the cases.

One patient underwent dilation via a Savary-Gilliard dilator initially, which was subsequently changed to a balloon dilator, another patient changed to balloon dilator during the last dilation session after five sessions using Savary-Gilliard dilator (Figure 24).

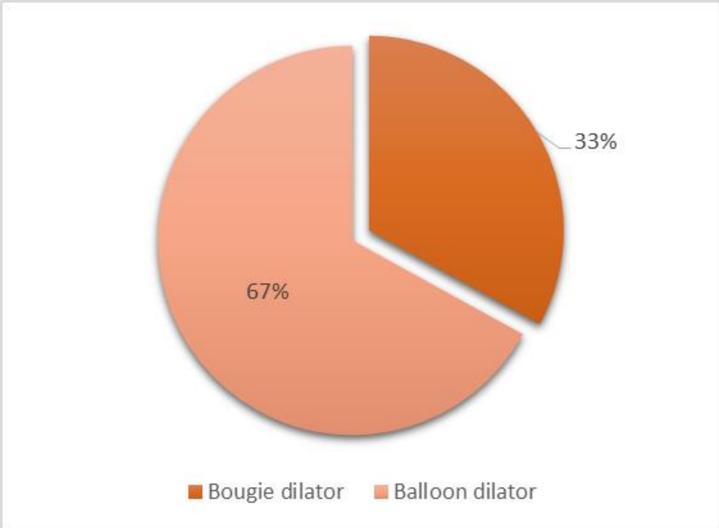


FIGURE 24: CASES DISTRIBUTION BASED ON ANASTOMOTIC STRICTURE MANAGEMENT TOOLS.

4.2. Dilation Sessions Outcomes:

Among anastomotic stricture cases, two to 24 months was the age of patients at the first dilation, a consistent stenotic segment was identified, situated at a mean distance of 18.5 cm from the dental arch and only one case exhibited fibrosed margins.

The inflation time using balloon dilators ranged from 30 seconds to 120 seconds. It is worth emphasizing that one dilation session sufficed for the resolution of the stricture in only one case. Further information regarding the dilation sessions for each patient are detailed in the table presented below (Table II).

TABLE III: DETAILS ABOUT DILATION SESSIONS FOR PATIENTS WITH ANASTOMOTIC

Dilation sessions	Location from dental arch (cm)	Characteristics of the stenosis	Dilation tool	Control after dilation
Patient 1				
1st dilation session	15	highly narrowed, punctiform, with intact margins	Balloon dilator (8mm)	Dilated but impassable stenosis.
2nd dilation session	15	highly narrowed, punctiform, with intact margins	Balloon dilator (8mm)	Dilated but impassable stenosis.
Patient 2				
1st dilation session	22	Narrowed stenosis with a dilated upstream esophagus.	Balloon dilator (8mm)	Impassable stenosis
2nd dilation session	22	Narrowed stenosis with a dilated upstream esophagus.	Balloon dilator (8mm)	Impassable stenosis
3rd dilation session	22	Narrowed stenosis with a dilated upstream esophagus.	Balloon dila-tor (8mm)	Dilated stenosis but remains impassable
Patient 3				
1st dilation session	17	Very narrowed stenosis, punctiform, with intact margins.	Balloon dilator (8mm) Balloon dilator (10mm)	Lightly dilated but remains impassable
2nd dilation session	17	Very narrowed stenosis, punctiform, with intact margins.	Balloon dilator (10mm)	Lightly dilated but remains impassable.
3rd dilation session	17	Very narrowed stenosis, punctiform, with intact margins.	Balloon dilator (10mm)	Lightly dilated but remains impassable.
4th dilation session	17	Very narrowed stenosis, punctiform, with intact margins and very dilated upstream esophagus	Balloon dilator (10mm)	Lightly dilated but remains impassable.
5th dilation session	17	Very narrowed stenosis, punctiform, with intact margins and very dilated upstream esophagus	Balloon dilator (10mm)	Dilated stenosis but remains impassable.

Patient 4				
1st dilation session	15	Impassable stenosis with fibrosed margins.	Balloon dilator (8mm) Balloon dilator (10mm)	Lightly dilated but remains impassable.
2nd dilation session	15	Impassable stenosis with fibrosed margins.	Balloon dilator (10mm)	Lightly dilated but remains impassable.
3rd dilation session	15	Impassable stenosis with fibrosed margins.	Balloon dilator (12mm)	Dilated passable stenosis
Patient 5				
1st dilation session	17	Punctiform stenosis with intact margins.	SG dilator (5mm)	Dilated stenosis but remains impassable
2nd dilation session	17	Punctiform stenosis with intact margins.	SG dilator (5mm) SG dilator (7mm)	Dilated stenosis but remains impassable
3rd dilation session	16	Punctiform stenosis with intact margins.	SG dilator (5mm) SG dilator (7mm) SG dilator (9mm)	Dilated passable stenosis.
Patient 6				
1st dilation session	17	impassable stenosis with intact margins.	SG dilator (7mm) SG dilator (9mm)	Dilated stenosis but remains impassable, presence of a lateral image, suspecting a fistula
2nd dilation session	15	Tight impassable stenosis with intact margins	Balloon dilator (10mm)	Dilated passable stenosis.
3rd dilation session	15	Tight stenosis with intact margins	Balloon dilator (10mm)	Dilated stenosis, presence of an image suspecting a fistula.
Patient 7				
1st dilation session	15	Tight stenosis with intact margins	SG dilator (5mm)	Lightly dilated stenosis,
Patient 8				
1st dilation session	22	Punctiform stenosis, with intact margins.	SG dilator (5mm) SG dilator (7mm)	Lightly dilated stenosis.
2nd dilation	22	Punctiform stenosis, with	SG dilator	Lightly dilated

session		intact margins.	(5mm)	stenosis.
			SG dilator (7mm)	
			SG dilator (9mm)	
3rd dilation session	22	tight stenosis with intact margins	SG dilator (5mm)	Lightly dilated stenosis.
			SG dilator (7mm)	
			SG dilator (9mm)	
4th dilation session	22	punctiform stenosis with intact margins	SG dilator (5mm)	Lightly dilated but still impassable stenosis.
			SG dilator (7mm)	
			SG dilator (9mm)	
5th dilation session	22	Impassable stenosis	SG dilator (7mm)	Dilated stenosis
			SG dilator (9mm)	
			SG dilator (11mm)	
6th dilation session	22	Foreign body extraction	Balloon dilator	Dilated passable stenosis.
Patient 9				
1st dilation session	17	Impassable stenosis with intact margins	Balloon dilator	Lightly dilated stenosis.

5. Outcomes of follow-up examinations:

Out of the nine cases diagnosed with anastomotic stricture, five patients (55%) were available for check-up assessments in order to evaluate their general health and well-being. The average interval between the initial symptoms of anastomotic stricture and their recurrence was 11.5 months.

Detailed information about each patient is presented below:

5.1. Patient 1:

Male patient born at term with a birth weight of 2800g and Waterston score B, admitted after breastfeeding attempts for cyanosis, hyper sialorrhea, respiratory distress and diagnosed with esophageal atresia type 3 with a gap of 2 to 6 vertebral bodies and a pre operative C-reactive protein level at 0,3 mg/L, the patient underwent surgery at the age of four days: posterolateral thoracotomy with tracheoesophageal fistula ligation and one layer anastomosis using Polydioxanone monofilament without any tension.

The patient was admitted 5 months after surgery for cyanosis, vomiting, dehydration and presented a stenosis located at 15cm from the dental arch, confirmed by upper endoscopy and managed by two dilatations one month apart using a balloon dilator.

Two months after the last dilatation, the check-up revealed dysphagia for solids, post prandial vomiting and recurrent respiratory infections, the upper gastrointestinal series showed persistence of the esophageal stenosis (Figure 25).

5.2. Patient 2:

Female patient, born at term with a Waterston score of A, admitted due to respiratory distress following attempts at breastfeeding, subsequently diagnosed with a less than two vertebral bodies gap type 3 esophageal atresia, and pre-operative C-reactive protein level of 7.04 mg/L. At the age of nine days, the patient underwent a posterolateral thoracotomy, tracheoesophageal fistula ligation and one layer tense anastomosis performed using Polydioxanone monofilament.

The patient was readmitted 18 months after surgery for dysphagia with foreign body ingestion. An examination confirmed a stenosis located at 22 cm from the dental arch, which was managed through three dilatations, one month apart, using a balloon dilator.

Two years after the last dilatation, the clinical follow up revealed dysphagia for solids and post prandial vomiting, the upper gastrointestinal series showed persistence of the stenosis (Figure 26).

5.3. Patient 4:

Female patient born at term with a birth weight of 2400g and Waterston score B, admitted after breastfeeding attempts for hyper sialorrhea, respiratory distress and diagnosed with esophageal atresia type 3 with a gap of 2 to 6 vertebral bodies and a preoperative C-reactive protein level at 42,23 mg/L, the patient underwent surgery at the age of two days: posterolateral thoracotomy with tracheoesophageal fistula ligation and one layer anastomosis using Polydioxanone monofilament with significant tension.

The patient was admitted 10 months after surgery for dysphagia and presented with a stenosis located at 15 cm from the dental arch, confirmed by upper endoscopy and managed by two dilations one month apart using a balloon dilator.

After the last dilatation, one month later, the clinical check-up demonstrated normal results and the upper gastrointestinal series showed a mild non-stenosing esophageal stenosis (Figure 27).

5.4. Patient 5:

Female patient with bilateral ear pavilions malformation + neck chondroma, born at term with a 3600g birth weight and a Waterston score of A, admitted due to cyanosis, hypersialorrhea following attempts at breastfeeding, subsequently diagnosed with type 3 esophageal atresia with a gap of 2 to 6 vertebral bodies, and pre-operative C-reactive protein level of 15mg/L. At the age of five days, the patient underwent a posterolateral thoracotomy, trachea esophageal fistula ligation and one layer tense anastomosis performed using Polydioxanone monofilament.

The patient was readmitted 3 months after surgery for cyanosis and cough during feeding. An examination confirmed a stenosis located at 17 cm from the dental arch, managed through three dilatations, one month apart, using a Savary-Gilliard dilator.

Six years after the last dilatation, the clinical examination yielded no abnormalities and the upper gastrointestinal series showed a mild non-stenosing stenosis (Figure 28).

5.5. Patient 9:

Male patient born at term with a B Waterston score, admitted after breastfeeding attempts for hyper sialorrhea, respiratory distress and diagnosed with esophageal atresia type 3 with a gap over 6 vertebral bodies and a pre-operative C-reactive protein level at 22,35 mg/L, the patient underwent surgery at the age of three days: posterolateral thoracotomy with tracheoesophageal fistula ligation and one layer anastomosis using Polydioxanone monofilament without significant tension.

Six days post-surgery, the patient was admitted for an anastomotic leak with no indication for surgical repair. However, he presented with a stenosis two years later located at 17cm from the dental arch, confirmed by upper endoscopy and managed successfully performing two dilatations one month apart using a balloon dilator.

Three years after the last dilatation, the clinical assessment as well as the upper gastrointestinal series returned normal results (Figure 29).

FIGURE 25: UPPER GASTROINTESTINAL SERIES OF PATIENT 1 SHOWING PERSISTENCE OF A NON-STENOSING ESOPHAGEAL CONSTRICTION CENTERED ON THE UPPER THIRD OF THE THORACIC ESOPHAGUS AT THE LEVEL OF D3-D4, WITH UPSTREAM DILATION ASSOCIATED WITH MILD DILATION OF THE DOWNSTREAM SEGMENTS.

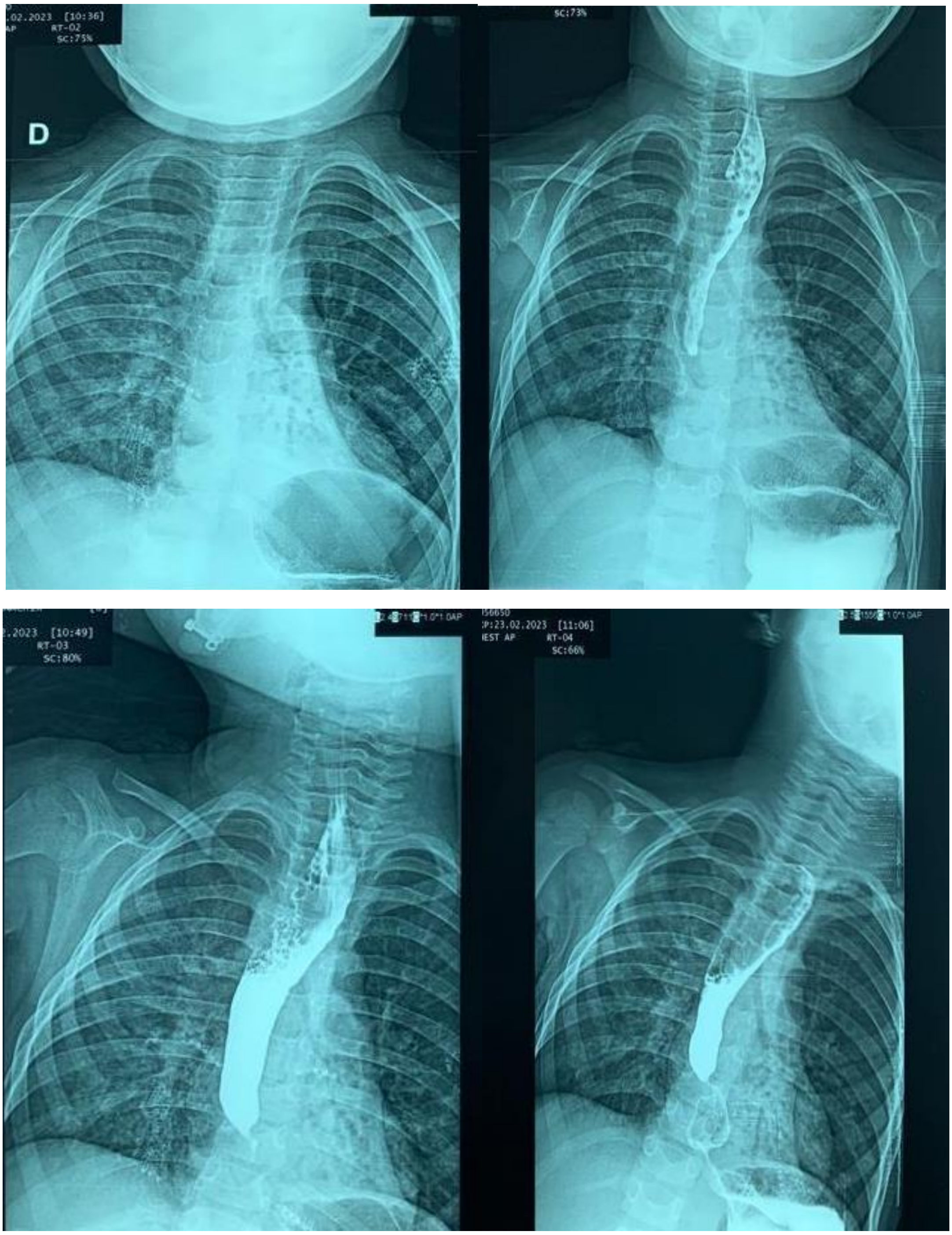


FIGURE 26: UPPER GASTROINTESTINAL SERIES OF PATIENT 2 SHOWING MILD NARROWING OF THE CERVICAL ESOPHAGUS AT THE LEVEL OF C4-C7 RESULTING IN SLIGHT UPSTREAM DILATION.

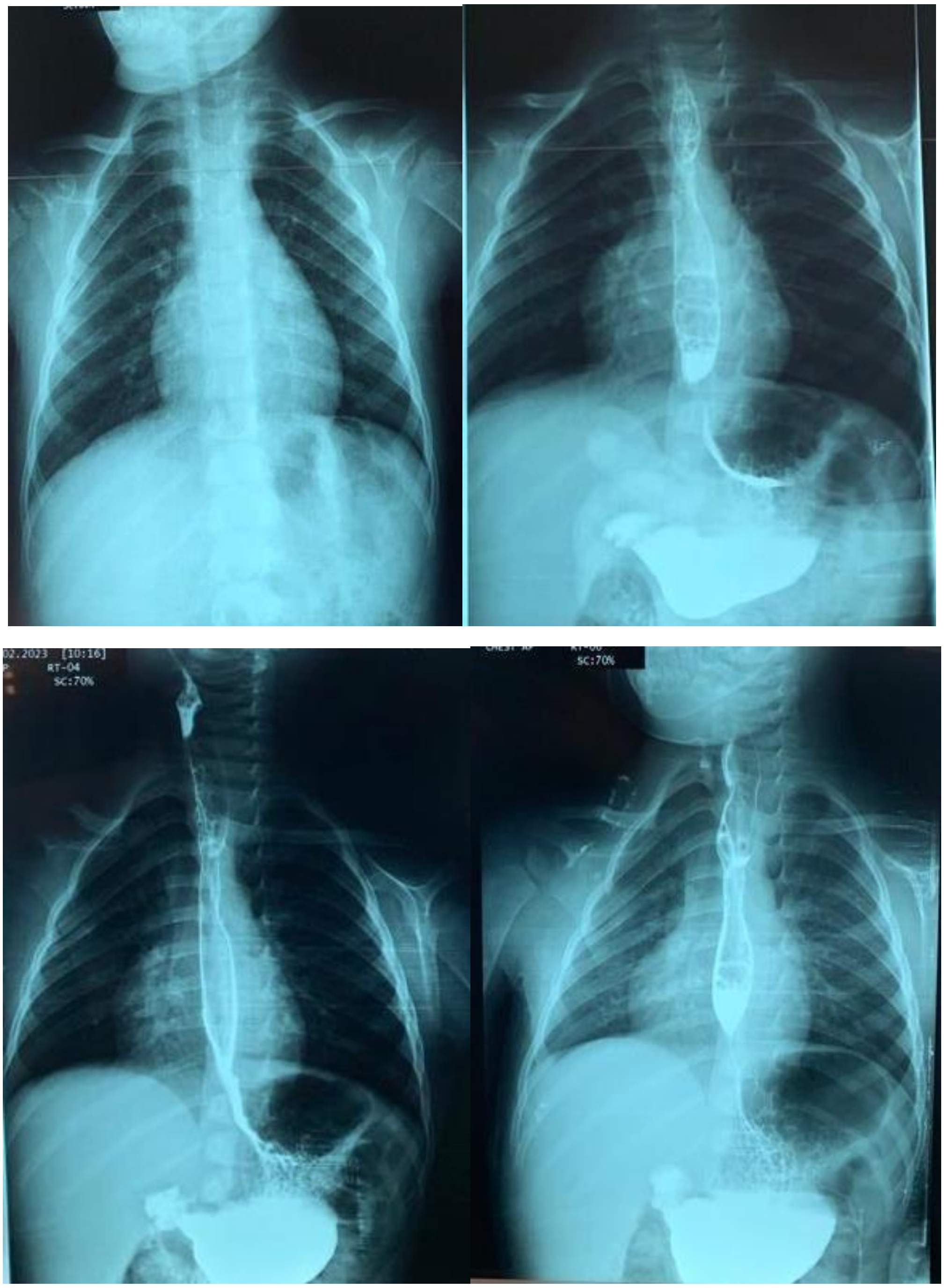
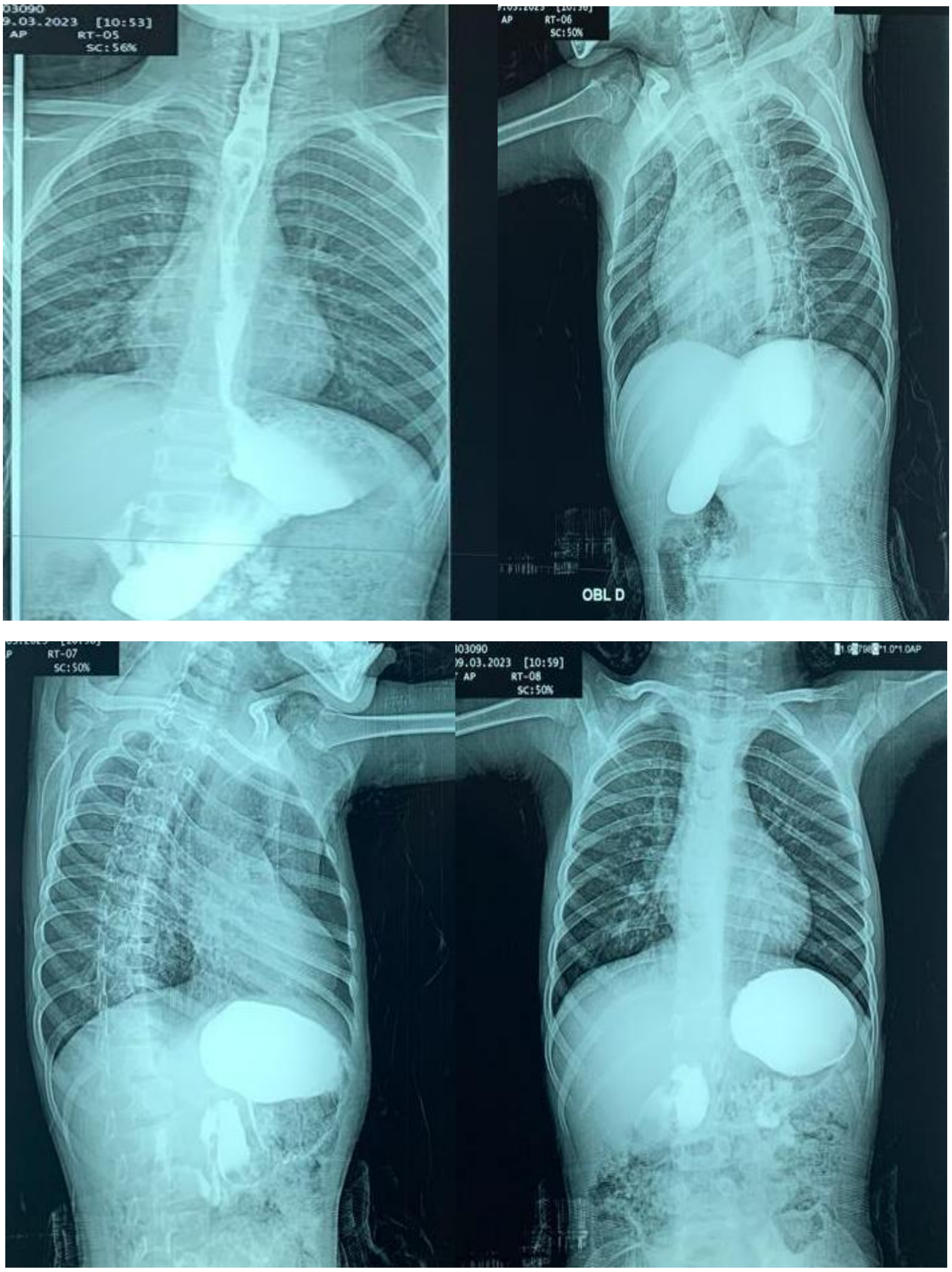


FIGURE 27: UPPER GASTROINTESTINAL SERIES OF PATIENT 4 SHOWING A MILD NON-STENOSING ESOPHAGEAL CONSTRICTION.

FIGURE 28: UPPER GASTROINTESTINAL SERIES OF PATIENT 5 SHOWING A MILD NON-STENOSING ESOPHAGEAL CONSTRICTION.



<u>FIGURE 29: UPPER GASTROINTESTINAL SERIES OF PATIENT 9 SHOWING A MILD NON-STENOSING ESOPHAGEAL CONSTRICTION.</u>

DISCUSSION

I. Definition:

According to Krishnan et al.[7], anastomotic stricture is defined as a narrowing at the site of anastomosis noticeable on endoscopy and/or contrast study and accompanied by clinical symptoms demanding at least one dilation. An anastomotic stricture should be considered clinically relevant only in symptomatic patients considering that the severity of esophageal narrowing does not correlate with symptoms.

The lack of a concrete definition of anastomotic stricture in the literature despite the well-established dilation techniques has led to the occurrence of the stricture index as a diagnostic as well as a prognostic tool for pediatric surgeons to better manage anastomotic stricture, therefore various studies have been conducted to find a suitable definition of anastomotic stricture index based on contrast study or upper endoscopies[8]:

Said et al.[9] proposed in a publication assessing the utility of balloon dilation under fluoroscopy a stricture index obtained on postoperative esophagrams and defined as follows:

$$\mathrm{SI} = \frac{A-a}{A}$$

Where: *A*: the diameter of the lower pouch and *a*: the stricture diameter.

Parolini et al.[10] quoted the same equation but measured it using the endoscopy assessment performed one month after surgery, and was divided into 3 categories: no evidence for stricture (SI $\leq$ 0.1), mild stricture (0.1 $<$ SI $<$ 0.3) and high-grade stricture (SI $\geq$ 0.3). It is worth noting that this study was considered the first attempt at anastomotic stricture index classification based on endoscopy in the literature[8].

A retrospective study conducted by Macchini [11] where the stricture index was measured both radiologically and endoscopically revealed that the stricture index measured from the first endoscopy after surgery was better allowing diagnosis as well as evaluation of the severity of the stricture categorized as follows: no stenosis ($SI < 0.33$), mild stenosis ($0.33 \leq SI < 0.44$) and severe stenosis ($SI \geq 0.44$), and also predicting the need for dilatation.

Parente et al.[8] conducted a similar study and propose that an anastomotic stricture can be defined by a $SI \geq 0.6$ and the higher the number of dilations needed in the follow-up as the index increases.

Another anastomotic stricture index was suggested by Sun [12] based on the first esophagram performed after surgery, measured using either the upper pouch (U-EASI) or the lower pouch (L-EASI) however, the study suggests using the lower pouch in measurement since the upper pouch is consistently dilated:

$$\text{U-EASI} = \frac{lateral\ \frac{d}{D} + Anteroposterior\ \frac{d}{D}}{2} \qquad \text{L-EASI} = \frac{lateral\ \frac{d}{D} + Anteroposterior\ \frac{d}{D}}{2}$$

Where: d : the stricture diameter and D : the pouch diameter

The study considers the esophageal atresia stricture index as a practical tool to predict the development and severity of anastomotic stricture, in a way that a course of dilatation may be required when the EASI is ≤0.3[12].

Landisch et al.[13] determined the stricture index using the equation by Sun [12] measuring exclusively the upper pouch on delayed esophagrams due to the possible resolution of edema and concluded that an upper pouch esophageal atresia stricture index (U-EASI) of ≤0.39 can predict the need for multiple anastomotic dilations.

II. Discussion of the results:

A. Epidemiological Data:

1. Incidence:

Anastomotic stricture remains the most common complication after esophageal atresia surgical repair[14], the most common cause of esophageal stenosis in children and infants[15], and the most common cause of recurrent surgery in children with esophageal atresia and tracheoesophageal fistula[16] with an incidence ranging from 32% to 80% reported in the recent literature[2], children with esophageal atresia develop anastomotic stricture after surgical correction mostly in the first year of life according to Vergouwe et al[1].

In our series, anastomotic stricture affected a total of nine out of the 80 cases that underwent surgical repair of esophageal atresia, accounting for 11%, which is lower than what has been reported in the majority of studies conducted worldwide and detailed in (Table IV).

The reported prevalence of anastomotic stricture after EA/TEF repair is highly variable[17], this can be attributed, as stated by Mousa et al.[14], to variations in the definition of anastomotic stricture and differences among centers regarding patient populations' risk factors for the development of this complication.

The uncertainty surrounding the incidence of anastomotic stricture in Morocco is primarily due to the limited body of research dedicated to this condition within the country. As of now, no studies in Morocco have specifically addressed this issue to provide a basis for comparison.

TABLE IV: INCIDENCE OF ANASTOMOTIC STRICTURE IN SOME SERIES AROUND THE WORLD

Series	Year of publication	Country	AS cases / population (%)	Study duration (years)	incidence (cases/ year)
Serhal et al.[18]	2010	France	23/62 (37%)	5 (2000-2005)	4.6
Koivusalo [19]	2012	Finland	102/130 (78%)	21 (1991-2011)	4.8
Nice et al.[20]	2016	USA	26/121 (21%)	14.5 (1999-2014)	1.8
Macchini [11]	2018	Italy	24/40 (60%)	11 (2004-2014)	2.1
Vergouwe et al.[1]	2019	Nether-lands	251/436 (58%)	14 (1999-2013)	18
Chiang et al.[21]	2021	Taiwan	16/40 (40%)	11 (2008-2018)	1.4
Besendörfer et al.[22]	2021	Germany	21/43 (49%)	8 (2010-2018)	2.6
Huang et al.[23]	2021	China	56/107 (52%)	5 (2013-2018)	11.2
Newland et al.[2]	2023	Czech Republic	55/169 (33%)	10 (2011-2020)	5.5
Our series	**2024**	**Morocco**	**9/80 (11%)**	**8 (2015-2023)**	**1.1**

2. Gender:

Gender and birth weight as risk factors for anastomotic stricture after esophageal atresia repair have been investigated in a systematic review and meta-analysis[24] including six articles that matched gender impact analysis criteria. A collective rate of 40% was found among females, while males exhibited a slightly lower rate of 39% on combined data. The study then suggests no significant difference between males and females with regard to the risk of developing anastomotic stricture.

The study of Ekselius [25], where the esophageal atresia population consisted of an equal representation of males and females (50%), found no significant association between gender and stricture formation. Our study primarily included 51% of males with esophageal atresia, aligning closely with the study as well as the findings.

In contrast, Chiang et al.[21] suggests a potential influence of male gender in stricture formation (p value .03). This result could be attributed to the composition of the esophageal atresia populations regarding gender distribution, Chiang et al.'s study was predominantly composed of males with esophageal atresia (75%), which might have influenced the findings.

Having a gender-balanced cohort, strengthens the credibility of the findings and add further weight to the notion that gender might not independently exert significant influence as a risk factor for stricture development[25].

TABLE V: COMPARISON OF THE INFLUENCE OF GENDER IN AS FORMATION IN OUR SERIES WITH OTHER SERIES

Series	AS Sex ratio	P value
Nice et al.[20]	1.16	.573
Besendörfer et al.[22]	2	.477
Huang et al.[23]	2.3	.538
Ekselius [25]	1	.074
Our series	**1.25**	**1**

3. Prenatal diagnosis:

Only one patient has benefited from prenatal diagnosis, and didn't develop anastomotic stricture, due to the lack of a significant value of this variable as well as findings assessing this factor, we cannot conclude to a correlation between prenatal diagnosis and stricture development.

4. Gestational Age:

The role of prematurity in anastomotic stricture formation has generated controversy in the literature. Studies conducted by Nice et al.[20], Besendörfer et al.[22] and Newland et al.[2] have suggested that prematurity may not have a significant influence on anastomotic stricture development, our series of results align with their findings with a p value of 1.

In contrast, studies by Huang et al.[23], Chiang et al.[21], and Tambucci et al.[4], have reported evidence suggesting a potential influence of prematurity on anastomotic stricture development, a retrospective cohort conducted by Dingemann et al.[26] studied two groups: one with severe preterm (≤34 weeks of GA) and the other with (>34 weeks of GA), anastomotic stricture was significantly lower in patients with extreme prematurity.

5. Birth weight:

The meta-analysis conducted by Teimourian et al.[24] including four articles have found no association between birth weight and stricture development. In contrast, Donoso [27] identified high birth weight as an independent factor for stricture development.

Our findings are consistent with the majority of studies conducted worldwide suggesting no association between birth weight and stricture formation as indicated in the table below (Table VI)

TABLE VI: COMPARISON OF BIRTH WEIGHT AND ITS IMPACT ON AS FORMATION AMONG DIFFERENT STUDIES

Series	Year of publication	Birth weight mean +- (SD)	P value
Michaud et al.[28]	2000	2 800 ± 460	Non sign
Nice et al.[20]	2016	N/R	.451
Besendörfer et al.[22]	2021	2359 ± 779	.775
Huang et al.[23]	2021	2770 ± (520)	.173
Newland et al.[2]	2023	1830 ± (770.94)	.320
Our series	2024	2857.14 +- (395.2)	.779

6. Nasogastric tube insertion test:

According to Spitz [6], nasogastric tube insertion test is used to precociously diagnose esophageal atresia, and should be done in all newborns with polyhydramnios history or excessive frothy oral secretions shortly after birth.

Nevertheless, misdiagnosis can still occur due to initial passage of oral tube into stomach via distal tracheoesophageal fistula as indicated in two case reports[29],[30] (Figure 30).

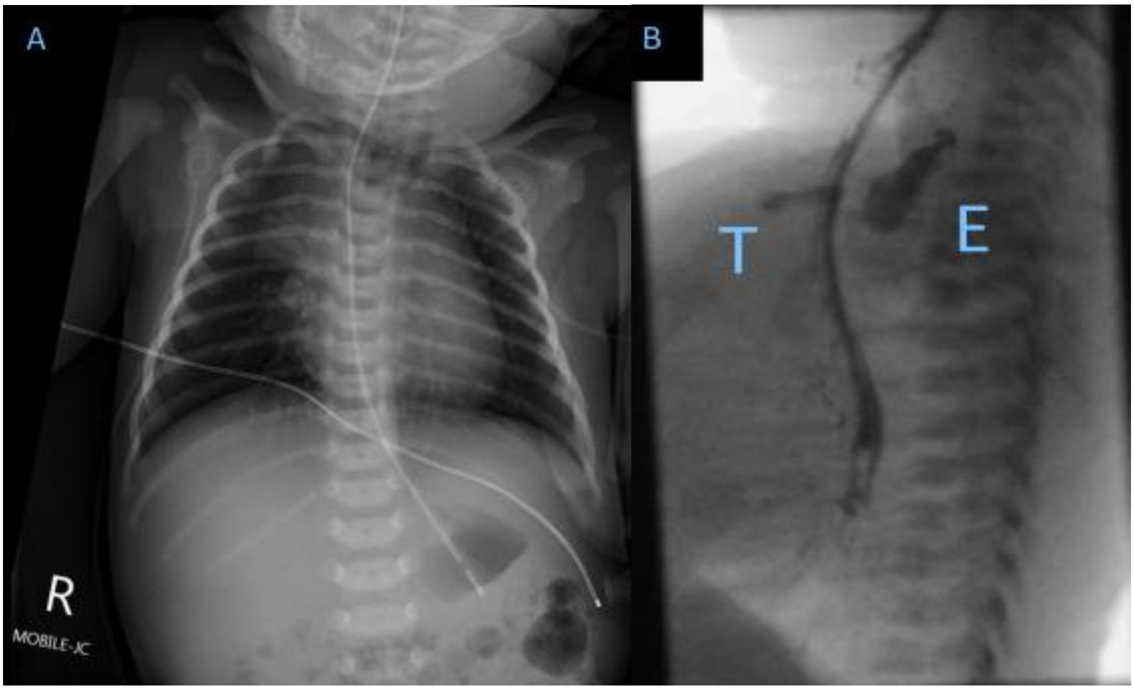


FIGURE 30: FALSE NEGATIVE ESOPHAGEAL ATRESIA CASE[30]:

A: Nasogastric tube tip position confirmed in the stomach on chest radiograph.

B: Distal tracheoesophageal fistula confirmed by a contrast study: T: Trachea, *E*: Esophagus.

In our context, this test is performed systematically to every newborn to early detect esophageal atresia, unless the delivery was done at home or in other constraints. 5% of the whole population in our study had false negative test, and 10 % of the patients who had a nasogastric tube insertion test at birth developed stricture after esophageal atresia surgical repair, as statistical conclusion, we found no significant correlation between the early discovery of esophageal atresia and prevention of anastomotic stricture development.

7. Breastfeeding attempt:

Our study found that all the patients who presented an anastomotic stricture after esophageal atresia surgical repair, were subjected to an attempt at breastfeeding, yet no relation was statistically ascertained between early breastfeeding attempts and anastomotic stricture development.

8. Malformations assessment:

This association is defined as a condition with multiple congenital malformations: vertebral anomalies, anal atresia, cardiac malformation, tracheoesophageal fistula with or without esophageal atresia, renal dysplasia and limb abnormalities[31].

The presence of two to 3 malformations is required to confirm the diagnosis of VACTERL, this association can complicate the treatment and outcomes for neonates with esophageal atresia.

Therefore, it is essential to assess neonates with esophageal atresia for VACTERL association alongside genetic and chromosomal anomalies[5].

Our research findings indicated no statistically significant correlation between VACTERL association and the formation of anastomotic strictures, considering that only two patients had VACTERL and did not develop stenosis. Which aligns with the conclusions of Besendörfer et al.[22], Huang et al.[23], and other studies.

However, Serhal et al.[18] reported contradictory findings suggesting no correlation between VACTERL association and stricture formation (Table VII).

TABLE VII: CORRELATION BETWEEN VACTERL AND AS FORMATION ACCORDING TO DIFFERENT STUDIES

Series	Year of publication	VACTERL association	P value
Besendörfer et al.[22]	2021	23%	.7023
Huang et al.[23]	2021	21.5%	.585
Chiang et al.[21]	2021	32.5%	.89
Our series	2024	2.5%	1

B. Preoperative variables:

1. Preoperative lung condition:

Our findings statistically identified no contribution of a poor pre-operative pulmonary condition in the development of anastomotic stricture after esophageal atresia surgical repair. (p value: .169)

Stated differently, 66% of the patients who developed anastomotic stricture suffered from decreased lung condition essentially prior to surgery.

We encountered limitations in making comparisons due to the absence of series investigating this factor as a potential risk factor for stricture development.

2. Waterston Score:

The first prognostic classification based on birth weight, related abnormalities, and pneumonia was proposed by Waterston et al.[32] in 1962, to assess the severity and prognosis of esophageal atresia, as well as guide treatment decisions and anticipate outcomes for newborns with this condition[33].

Waterston prognosis score was found to have no significant influence on anastomotic stricture formation in our series same as Nice et al.[20] retrospective cohort.

3. Preoperative CRP levels tests:

Within the patients with anastomotic stricture, 75% had an elevated CRP level, however we couldn't prove the presence of a relation between high CRP levels and anastomotic stricture development.

Due to the lack of series examining this factor as a potential risk for stricture development, we faced limitations in making comparisons, highlighting the need for further exploration in subsequent series.

4. Age at surgery:

Among patients who developed anastomotic strictures, 78% underwent surgery within the first five days of life. However, our study findings did not reveal a statistically significant correlation between the timing of surgery and the incidence of strictures (p-value.665).

It is important to note that we encountered challenges in conducting comparisons, emphasizing the imperative for additional exploration in subsequent series.

C. Intraoperative results:

1. Surgical approach:

1.1. Open thoracotomy:

a) Posterolateral thoracotomy:

Open surgical repair of esophageal atresia with tracheoesophageal fistula is usually managed through a right posterolateral thoracotomy in patients with a left-sided aortic arch[34], considered as the most common approach to manage esophageal atresia[35] (Figure 31).

In our study, 13% of the patients who underwent esophageal atresia surgery via posterolateral approach, developed anastomotic stricture.

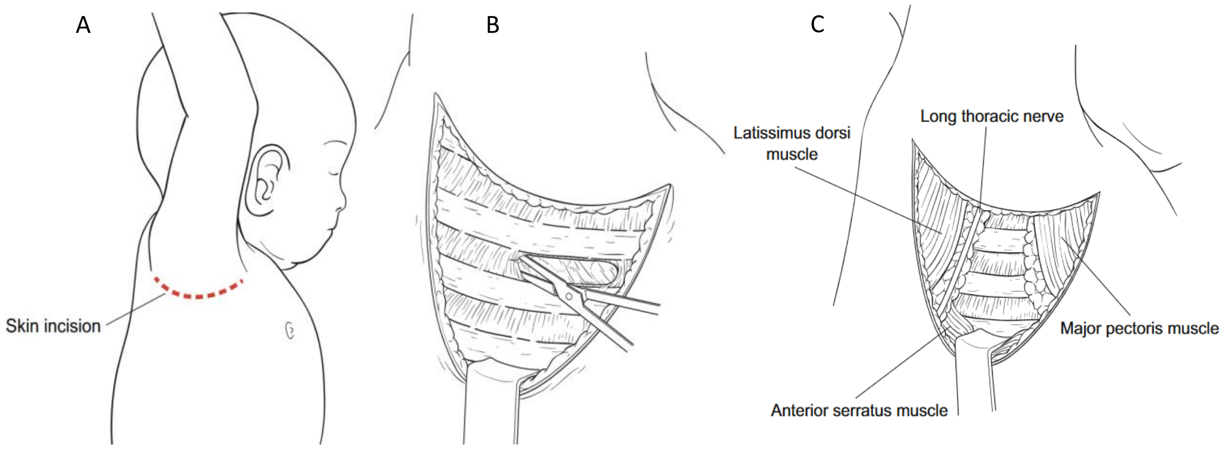


FIGURE 31: RIGHT POSTEROLATERAL THORACOTOMY[35]:

A: Right axillary skin crease incision

B: Incision of the 4th intercostal muscle

C: Anatomy of muscles and costa after dissecting between the chest wall and the pleura.

According to earlier researches, 5% of newborns with esophageal atresia associated to tracheoesophageal fistula were born with a right-sided aortic arch, such rare congenital vascular abnormalities have been shown to impact the prognosis of children with esophageal atresia[36], then a considerable controversy over the most appropriate side for thoracotomy emerged when it comes to right-sided aortic arch cases, considering thoracotomy from either chest is proven feasible, however right-sided approach may be associated with a higher risk of anastomotic stricture development[37].

b) Modified posterior thoracotomy:

A new recent technique is introduced by Saiad[38] and performed on 25% of our study cases, the modified posterior surgical approach allows compared to the commonly used methods a quicker and safer operative access preserving muscle structures and nerves usually split or retracted during classical posterolateral surgeries (Figure 32).

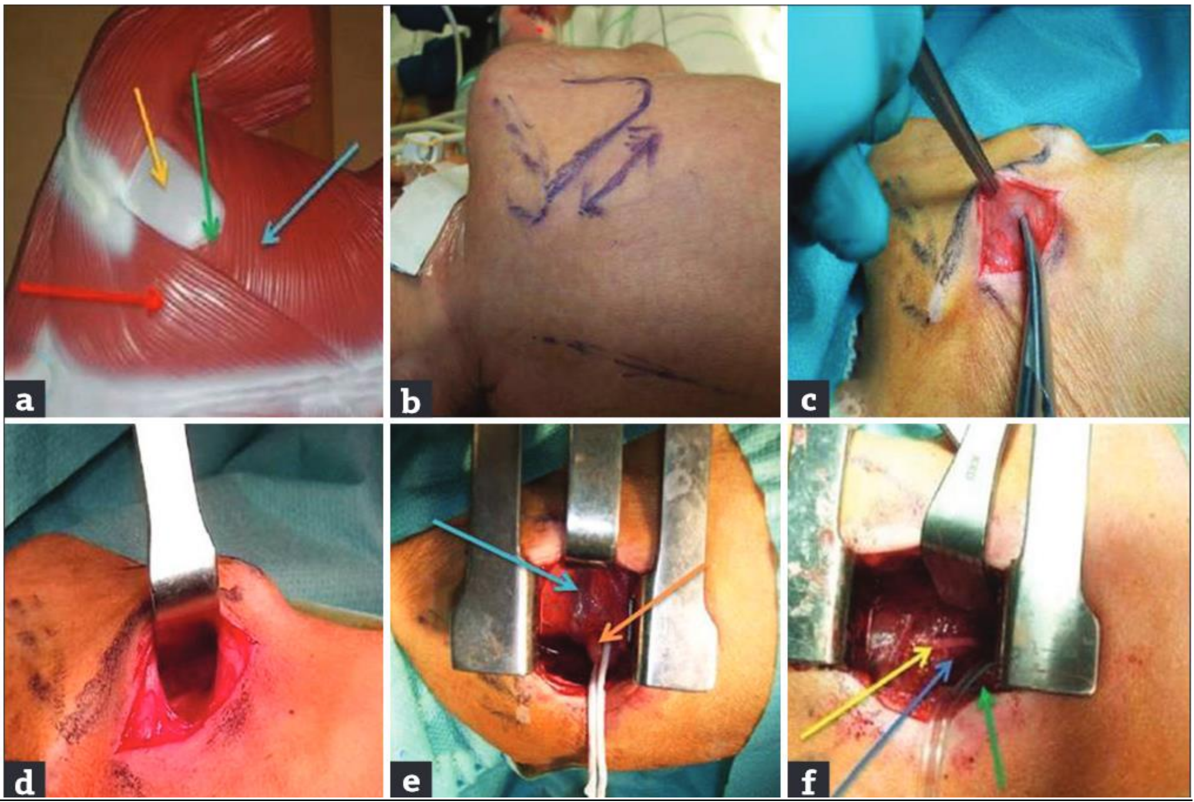


FIGURE 32: MODIFIED POSTERIOR THORACOTOMY[38]:

a: Interscapular region: red arrow: Trapezius. Yellow arrow: Scapula.

Green arrow: Rhomboid major. Blue arrow: Latissimus dorsi.

b: Newborn positioned.

c: Medial border of the scapula elevated; passage created by splitting the avascular fascia.

d: Elevation of the scapula to identify the fourth intercostals space.

e: Exposure of the posterior mediastinum.

Blue arrow: Azygos vein. Orange arrow: Distal esophagus with a tape.

f: Posterior mediastinum. Yellow arrow: Vagus nerve.

Blue arrow: trachea. Green arrow: Distal esophagus with a tape.

When considering the outcomes of the study of Saiad[38], only one out of 56 patients who underwent surgery via modified thoracotomy developed anastomotic stricture and was successfully treated by dilatation[38].

Similarly, only one out of 20 patients in our study developed an anastomotic stricture after modified thoracotomy method, yet our results suggested no association between surgical approach and anastomotic stricture development whether it is a posterolateral or a modified posterior thoracotomy, it is possible that the size of our sample was insufficient to prove a remarkable impact of the modified posterior approach on anastomotic stricture development.

1.2. Thoracoscopy:

Thoracoscopy was first introduced by Lobe et al.[39] as a novel technique providing better visualization, and leading to significantly reduced dissection compared to thoracotomy. It was considered as the procedure of choice in managing esophageal atresia with good prognosis if properly performed[40] (Figure 33).

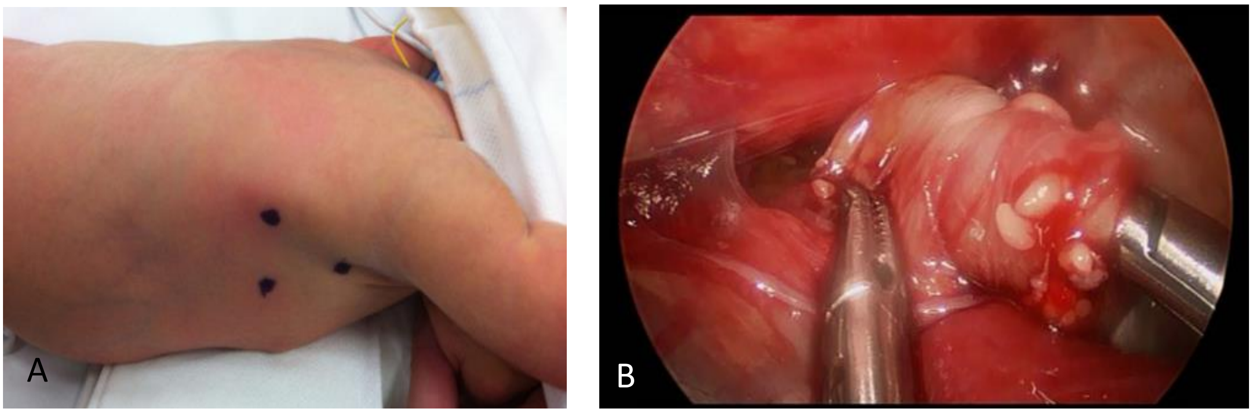


FIGURE 33: THORACOSCOPY TECHNIQUE[41]:

A: Marking Placement for Three Trocars: under the axilla, at the tip of the scapula for optics, and on the antero-axillary line

B: Thoracoscopic View of Dissection of the Upper Pouch

However, recent studies report similar rate of anastomotic stricture to open thoracotomy what didn't prove a remarkable difference between the two methods, this hypothesis was strengthened by a review of the literature and meta-analysis conducted by Borruto et al.[42].

Lin [43] found no significant difference in the anastomotic stricture rate, however, they observed that thoracoscopy is correlated with prolonged operation durations and increased risk of complications in comparison to open repair.

While Nice et al.[20] and Huang et al.[23] found that thoracoscopy is related to a higher rate of anastomotic stricture.

We were unable to offer further information in terms of comparison between thoracotomy and thoracoscopy and the potential risk in anastomotic stricture formation since all the patients in our study underwent open thoracotomy with the exception of one case where thoracoscopy was converted to posterolateral thoracotomy. Although it is worth noting that 11% of the patients developed anastomotic stricture, a slightly low percentage that falls within the range reported by recent studies addressing the incidence of anastomotic stricture following open thoracotomy surgery: from 5% to 58%[20].

2. Esophageal atresia anatomical type:

Various anatomical classifications of esophageal atresia have been developed, taking into account the presence or absence of a tracheoesophageal fistula and its location.

The initial anatomical classification was proposed by Vogt[44] , Ladd[45] introduced his own classification in 1945, which was later revised by Gross[46] in 1953.

In 1976, Kluth[47] established a comprehensive classification "Atlas of Esophageal Atresia" that encompasses all known anatomical variants of esophageal atresia and tracheoesophageal fistula including 10 major types, each with numerous subtypes, based on the original Vogt classification[6] (Figure 34):

2.1. Esophageal atresia with distal tracheoesophageal fistula (86% Vogt IIIb. Gross C. Ladd III/IV.)

The most common variety in which the proximal dilated esophagus, ends blindly in the superior mediastinum at about the level of the third or fourth thoracic vertebra. The distal esophagus, which is thinner and narrower, enters the posterior wall of the trachea at the carina or more commonly one to two centimeters more proximally in the trachea, the distance from the blind proximal esophagus to the distal tracheoesophageal fistula ranges from overlapping segments to a wide gap.

2.2. Isolated esophageal atresia without fistula (7%, Vogt II. Gross A.)

The two ends of the esophagus terminate blindly, with no connection to the trachea, the distance between the two ends varies and determines whether a primary repair is feasible or if a delayed primary anastomosis or an esophageal replacement should be performed which is often the case.

It is important to exclude a proximal tracheoesophageal fistula in these cases.

2.3. Tracheoesophageal fistula without atresia (4%, Gross E)

A variable-sized fistula connects the intact esophagus with the trachea, and it can be either single or multiple, as described in some studies[6,48].

2.4. Esophageal atresia with proximal tracheoesophageal fistula (2%, Vogt III and Gross B)

This rare anomaly needs to be distinguished from the isolated variety, the fistula is sited 1-2 cm above the end of the esophagus[6].

2.5. Esophageal atresia with proximal and distal tracheoesophageal fistula (<1%, Vogt IIIa, Gross D)

A rare entity, previously mistaken for a recurrent fistula, the early recognition of the "double" fistula is made with the increasing use of preoperative endoscopy and total repair is performed at the initial procedure.

If the proximal fistula is not identified preoperatively, the diagnosis should be suspected by a large gas leak emanating from the upper pouch during the fashioning of the anastomosis.

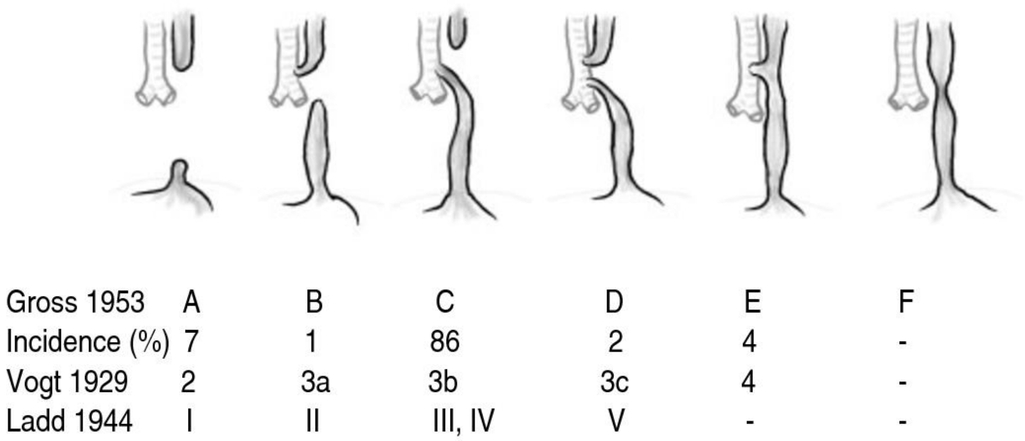


FIGURE 34: ANATOMICAL TYPES OF ESOPHAGEAL ATRESIA WITH OR WITHOUT TRACHEOESOPHAGEAL FISTULA[49].

TABLE VIII: ESOPHAGEAL ATRESIA ANATOMICAL TYPE ACCORDING TO GROSS CLASSIFICATION IN DIFFERENT STUDIES

Series	A	B	C	D	E	P value
Nice et al.[20]	1(14.3%)	2(100%)	22(21.6%)	1 (33.3%)	0	.046
Besendörfer et al.[22]	1 (33%)	0	18 (54%)	2 (67%)	0	.691
Our series	**0**	**0**	**9 (12%)**	**0**	**0**	**1**

The findings from Parolini et al.[10] and Krishnan et al.[7], indicate that types A and B present an increased risk of undergoing esophageal dilations compared to esophageal atresia type C, what suggests that the anatomical classification of esophageal atresia can indeed have significant clinical implications[10],[7].

On the other side, Nice et al.[20] found that the repair of type A had a lower stricture rate which is surprising and noteworthy, type A is typically associated with a larger gap between the proximal pouch and distal esophagus, which can increase tension during the surgical repair or even require a staged procedure, both of which have been shown to increase the risk of stricture formation, however, the study found that type A surgical repair had a lower stricture rate than type C.

Our study aligns with the research conducted by Besendörfer et al.[22], indicating that esophageal atresia type does not have a significant impact on the formation of anastomotic stricture (Table VIII).

3. Esophageal gap:

The absence of consensus on the definition of the esophageal gap and the methods for measuring the length between the two ends complicates the ability to make objective comparisons between publications.

The measurement for what constitutes a “long gap” can vary, being expressed in centimeters or vertebral bodies. Some researchers set cutoff points at 2, 3, or 3.5 centimeters, others categorize the gap as short (1 cm), intermediate (2.5-3 cm), and long (>3 cm equal to more than 2 vertebral bodies)[4,50]. Additionally, some suggest considering esophageal replacement if the gap exceeds the length of six vertebral bodies[51].

However, long-gap esophageal atresia is considered a significant predictor for the occurrence of strictures after surgery, both early and late as stated by the majority of studies[52]. In contrast, our study unexpectedly revealed no association between the length of the gap and the formation of stricture aligning with the findings of Huang et al.[23] and Besendörfer et al.[22] (Table IX).

TABLE IX: CORRELATION BETWEEN ESOPHAGEAL GAP AND ANASTOMOTIC STRICTURE FORMATION

Series	Year of publication	Long gap EA within AS group	P value
Besendörfer et al.[22]	2021	11 (52%)	.231
Huang et al.[23]	2021	N/R	.462
Newland et al.[2]	2023	17 (31%)	.007
Our case series	**2024**	**7 (78%)**	**.705**

4. Type of esophageal atresia surgical repair:

The first successful repair of esophageal atresia with tracheoesophageal fistula was carried out in 1941 by Cameron Haigh summarized in two key steps[53]:

1. Ligation of the tracheoesophageal fistula: Prior to the repair, in order to improve the patient's respiratory status.
2. End-to-end esophageal anastomosis: through a primary single-stage left-side extra pleural approach.

4.1 End to End anastomosis:

The single-layer, end-to-end anastomosis with absorbable monofilament sutures is commonly used to achieve esophageal continuity. This technique involves connecting the two ends of the esophagus using a single layer of sutures[16].

And it has shown a decrease in stricture formation following one-layer repair of the esophagus in newborns with esophageal atresia[4] (Figure 35).

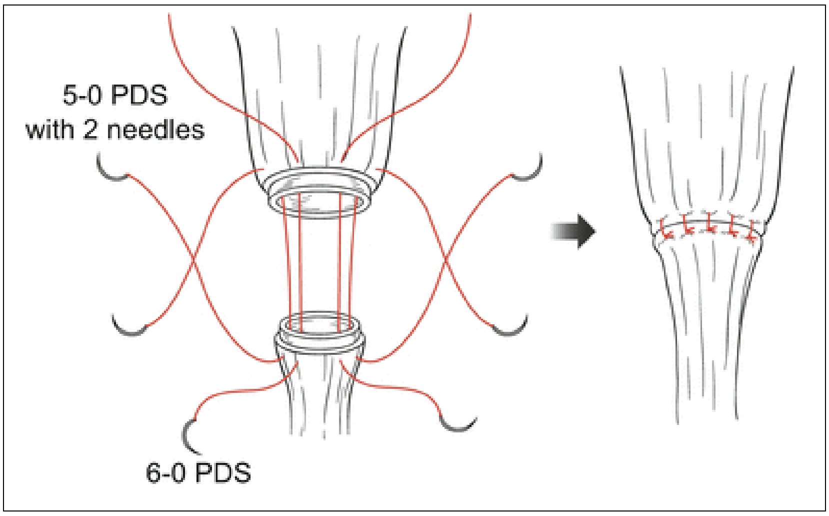


FIGURE 35: ONE LAYER ANASTOMOSIS TECHNIQUE[35]

4.2 Two-layer anastomosis:

Later, Haight revised his technique to a two-layer anastomosis and a right-side extra pleural approach, this method involves the use of absorbable sutures for both layers, with an outer seromuscular stitch of silk. The inner layer is a transmural layer, while the outer layer is a seromuscular layer. However, this technique was found to be associated with an increased incidence of stricture[4,54] (Figure 36).

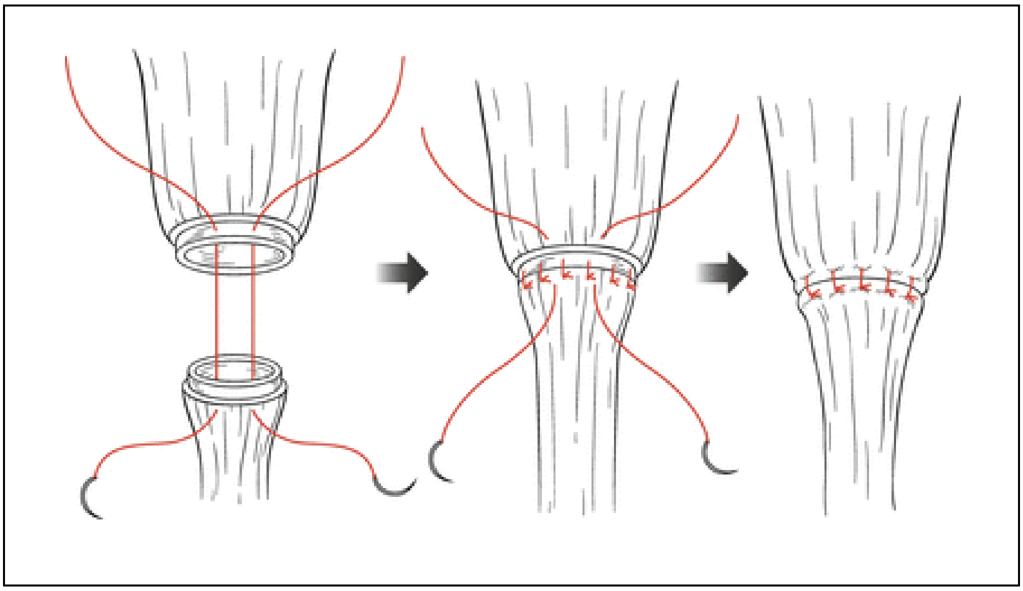


FIGURE 36: TELESCOPE TYPE TWO-LAYER ANASTOMOSIS (HAIGHT)[35]

4.3 Wave-like anastomosis:

The wave-like anastomosis technique as a new surgical method was introduced by Saiad[55] and used to prevent stricture formation after esophageal atresia repair.

This technique involves creating a multiple plains wide anastomosis with a large low traction zone. The flap from the upper pouch is laid into the open V of the lower pouch, creating a wide anastomosis, and the suture line is not restricted to one plain (Figure 37Figure 38Figure 39).

The findings were very promising, with wave-like anastomosis resulting in one stricture occurrence, whereas end-to-end anastomosis led to eight stricture cases. This indicates a potential advantage of wave-like anastomosis in lowering the risk of stricture formation compared to end-to-end anastomosis[55].

Our findings revealed only one instance of stricture among 25 patients who underwent wave-like anastomosis. However, we did not observe any correlation between end-to-end anastomosis and the development of strictures.

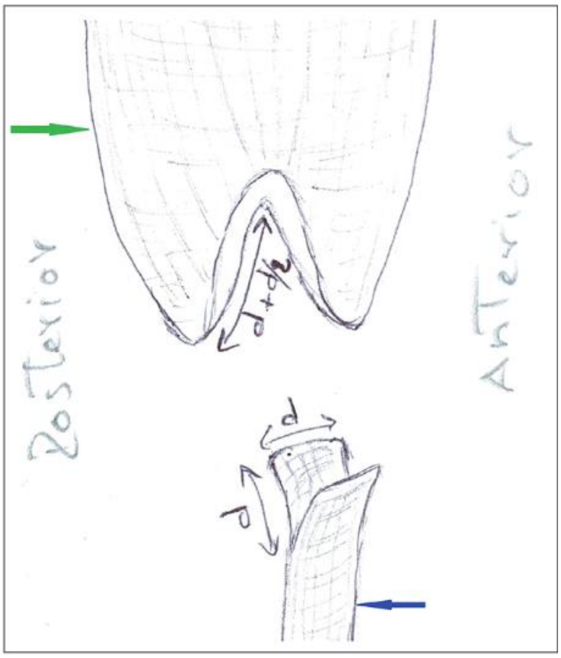


FIGURE 37: THE "WAVE LIKE TECHNIQUE" EXPLAINED BY SAIAD [55]:

- **d**: diameter of the lower end after dividing the TEF.
-Sagittal incision of the lower end esophagus equal to 'd'
-Transversal incision on the upper pouch equal to 'd + d/2'

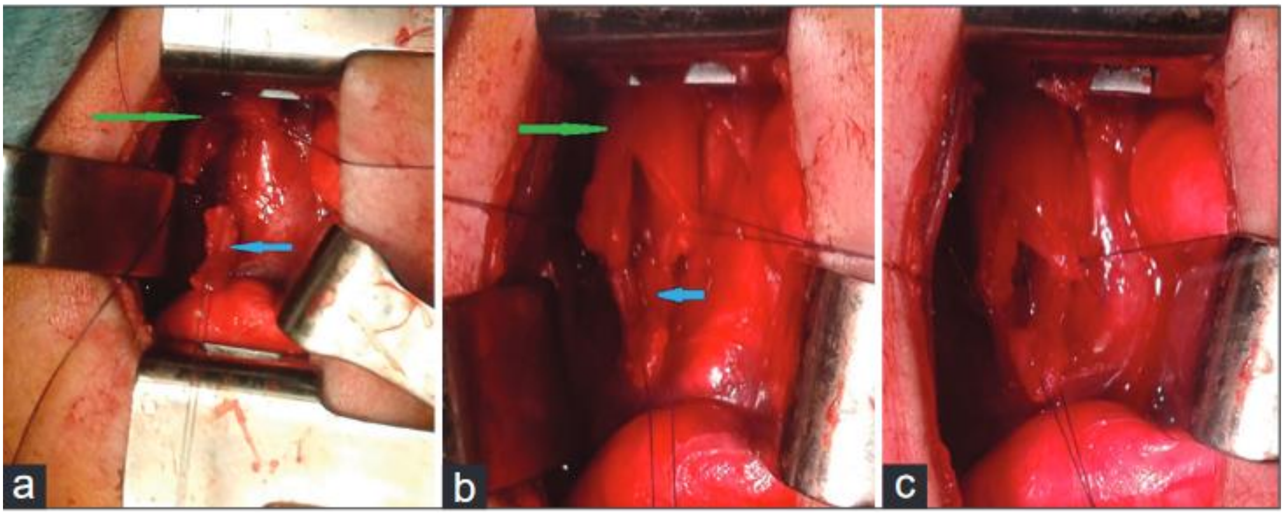


FIGURE 38: THE "WAVE LIKE TECHNIQUE" SURGICAL STEPS FOR ESOPHAGEAL ATRESIA REPAIR PERFORMED BY SAIAD[55]:

a: Intra-operative view of the incisions, the plain of the incision on the upper pouch (green arrow) is perpendicular to the plain of the incision on the lower end of the esophagus (blue arrow).

b: First step of anastomosis: Left flap from the lower end is laid into the left open V.

c: Second step of anastomosis: Suture of the left lower flap to the left sides of the anterior and posterior upper flaps

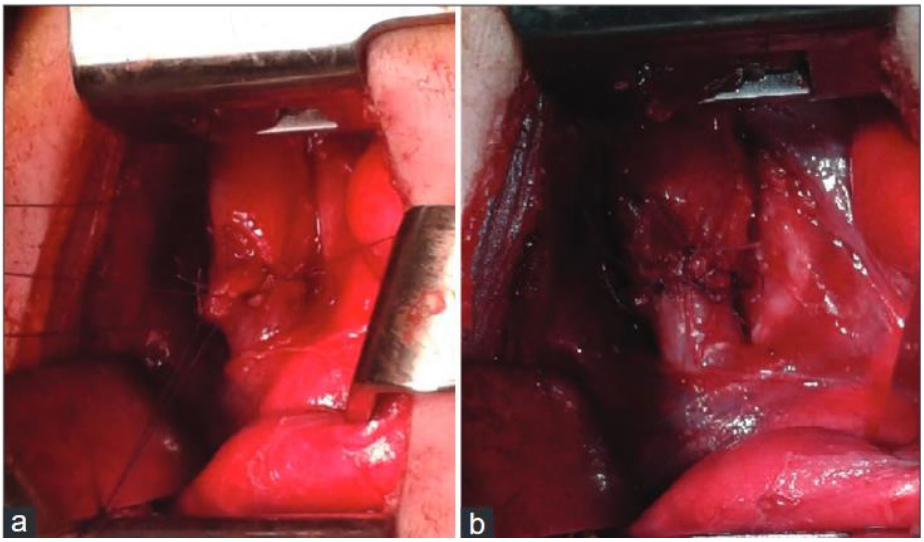


FIGURE 39: THE "WAVE LIKE TECHNIQUE" SURGICAL STEPS FOR ESOPHAGEAL ATRESIA REPAIR PERFORMED BY SAIAD[55]:

c: Third step of anastomosis: After passing the nasogastric tube the right lower flap is laid into the right open V.

b: Last step of anastomosis: End of the wave-like anastomosis by suturing the right lower flap to the right side of the anterior and posterior upper flaps

Several studies have demonstrated the association between surgical techniques and stricture formation in the context of esophageal atresia repair [4,56].

However, our study found no significant association between the surgical methods and stricture formation. (p value: .260) This finding suggests that the choice of current surgical techniques may not have a substantial impact on the development of strictures in patients undergoing surgery.

5. Type of suture Material:

The choice of suture material is considered by many as an important factor in preventing the development of strictures, however opinions on this matter are divided, lacking robust findings to validate them[57].

The studies that have compared between silk filament and absorbable filament, have found a statistically significant increase in the rate of anastomotic stricture using braided silk suture material[58,59], and less frequent anastomotic strictures with absorbable suture material[4,54].

In parallel, more recent studies demonstrated no difference in stricture development between absorbable and non-absorbable sutures whether they are monofilament or braided sutures[57],[60].

The suture material used in the surgical repair of all our cases was absorbable, and we have statistically noticed that the PDS (*polydioxanone, Ethicon, Inc., Somerville, NJ*) suture material was associated with higher rate of anastomotic stricture compared to Vicryl (*polyglactin, Ethicon, Inc., Somerville, NJ*) with a p value of .045.

Conversely, in a study conducted by Santos [61], polydioxanone resulted in less fibrosis than polyglactin in rat intestinal anastomosis yet no significant differences were observed between the two materials regarding complications including stricture. Similar findings were confirmed in a study by Andersen [62] in colonic anastomosis in rats.

Given the established correlation between fibrosis and stricture formation[63], the discrepancy between our findings and those of Santos [61] and Andersen [62] suggests that additional factors may influence stricture development. Notably, these observations were made across three different anatomical sites, this underscores the need for further research and clinical evidence to make definitive conclusions in the context of esophageal atresia anastomosis.

6. Tension during surgery:

Tension during anastomosis in esophageal atresia surgery is a critical consideration in surgical procedures. However, determining the degree of tension remains operator-dependent and difficult to objectively measure and assess.

The traditional evaluation of anastomotic tension is based on the gap length before surgery. However, this method lacks uniformity and accurate measurement since there is no definitive guideline to estimate gap length[64].

The relationship between the tension applied when linking both ends of the esophagus during anastomosis and stricture formation is well-documented in the literature and several studies have highlighted the influence of significant tension during surgery on the development of strictures [2,4,10,18,27,28,54,58,65].

For instance, a prospective multicentric study identified anastomosis under tension as an independent risk factor for anastomotic strictures in infants with esophageal atresia [66], our study aligns with the majority of these findings, as statistically indicated by a significant p-value of .030. This underscores the consensus among studies regarding the association between tension during surgery and the development of anastomotic strictures.

The most likely cause behind this relationship is that the lower esophagus receives its blood supply from segmental branches of the aorta or intercostal blood vessels, making it more susceptible to compromised blood flow when excessively mobilized. This poses a greater risk of devascularization, ischemia at the esophageal ends, and subsequent stricture formation as noted by Kovesi [54].

In contrast, the upper esophagus benefits from a robust blood supply originating from the inferior thyroid artery, enabling extensive mobilization without vascular compromise (Figure 40).

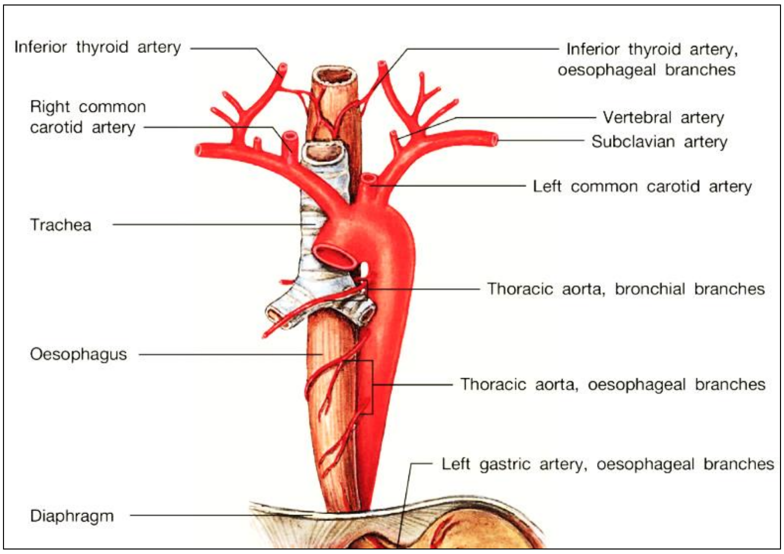


FIGURE 40: ESOPHAGEAL ARTERIAL SUPPLY (FRONT VIEW)[67]

It is rather important for actual and practical evaluation of anastomotic tension to know how far the delicate distal esophageal stump is stretched by anastomosis, Nagaya [64] provided valuable insights into the development of a new method for assessing anastomotic tension in patients with esophageal atresia and distal tracheoesophageal fistula. In this study, the novel method involved measuring the stretching ratio of the distal esophagus during surgery.

This ratio was calculated on the subsequent esophagram by dividing the stretched length (distance from a tiny metallic clip inserted in the tracheal side after cutting off the tracheoesophageal fistula to the anastomotic site) by the original distal esophageal length (distance from the clip to the esophago-cardiac junction) (Figure 41).

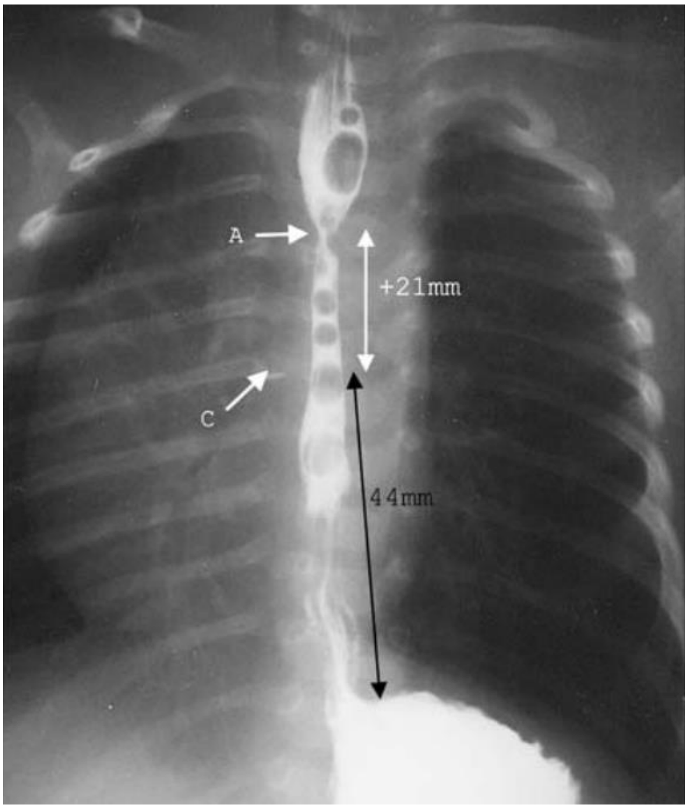


FIGURE 41: REPRESENTATIVE CASE EXPLAINING THE STRETCHING RATIO[64]

A: The site of anastomosis, **C**: The clip site

The stretched length*: distance between **C** and **A** = 21mm

The original distal esophageal length**: distance between **C** and the esophago-cardiac junction = 44 mm

The stretching ratio = */** = 47.7%

The stretching ratio was found to be significantly correlated with the stretched length on the esophagram and its number expressed as a percentage corresponds to about double the number of the stretched length in millimeters. For instance, if the stretched length is 5 mm, it corresponds to about 10% of the distal esophageal length.

Anastomotic tension may be neglected if the stretched length remains within 5 mm. On the other hand, if it exceeds 10 mm, strict care should be taken regarding potential stricture and/or GER[64]. This proposed method has the potential to enhance the precision and safety of anastomosis in this patient population, ultimately contributing to improved clinical care and outcomes.

The paramount challenge during anastomotic surgical procedures lies in the imperative endeavor to minimize high tension, primarily achieved through meticulous tissue handling and the deliberate avoidance of excessive mobilization, particularly concerning the lower esophagus[16,68].

7. The use of trans anastomotic tube:

In 1996, Moriarty et al.[69] were pioneers in introducing trans anastomotic feeding tubes in esophageal atresia surgical management, and their findings revealed no significant impact of this procedure on anastomotic stricture formation.

The use of trans anastomotic tubes in esophageal atresia repair procedures remains prevalent, as highlighted by an international survey of pediatric surgeons, with 83% reporting their incorporation in these surgeries[70] and left in situ by the vast majority of surgeons (90%)[71].

This strategy has shown promising outcomes in Europe primarily aimed at enabling early enteral feeding and reducing the necessity for prolonged total parenteral nutrition. Moreover, it has demonstrated no significant increase in complications such as anastomotic leak or stricture and no difference either in the need for postoperative esophageal dilatations[72]. Our study aligns with the previous findings supporting the lack of discernible correlation.

On the other side, several findings suggest that the use of trans anastomotic tube may increase stricture rate. A study of Lal et al.[73] retrospectively analyzed a 6-year cohort of esophageal atresia patients to investigate the effect of trans anastomotic tube use on stricture formation, in the univariate analysis, strictures were notably linked only to the use of a trans anastomotic tube (p value: .013). After accounting for pre and perioperative variables (including congenital heart disease, anastomotic leak, long gap length and acid suppression) in the multivariate analysis, the association with trans anastomotic tube use remained statistically significant (p value: .04). Moreover, there was a noticeable rise in the stricture rate corresponding to an increase in the frequency of trans anastomotic tube usage.

Further studies presented in (Table X) provide additional support for the previous findings:

TABLE X: ASSOCIATION BETWEEN THE USAGE OF TRANS ANASTOMOTIC TUBE AND AS FORMATION

Case series	Year of publication	P value
Alabbad et al.[72]	2009	.64
Wang [74]	2018	. 0005
Fusco [75]	2018	<.0005
Larusso et al.[76]	2022	.004
Our case series	**2024**	**.587**

D. Postoperative results:

1. Duration of trans anastomotic tube placement:

The average duration of trans anastomotic tube placement in the patients who developed anastomotic stricture within our case series was approximatively 7 days, and there was no correlation between the interval the tube was in place and the development of anastomotic stricture, aligning with the findings of Michaud et al.[28] (8.6 days) and Serhal et al.[18].

It is noteworthy that we were unable to conduct more extensive comparison between our series and others due to the limited number of studies that addressed the duration of trans-anastomotic tube placement as a risk factor for stricture formation.

2. Duration of intubation:

On average, the duration of intubation exceeded one day in 89% of patients who experienced anastomotic stricture development in our case series.

However, our findings revealed no significant correlation between the duration of intubation and the development of anastomotic strictures matching the findings of Michaud et al.[28] whose patients experiencing anastomotic strictures underwent intubation for an average period of seven days as well as the findings of Serhal et al.[18].

In contrast, Castilloux [77] observed a high incidence of anastomotic stricture in cases with prolonged intubation duration.

3. Postoperative GERD:

The prevalence of GERD among esophageal atresia patients is variable ranging from 20% to 63%, this underscores the differences in patient selection and diagnostic methodologies across published literature[14].

Complications that can result from this disease, particularly dysphagia and stricture formation, are the result of a complex mechanism. An inflammatory process sustained by gastroesophageal reflux following wound healing, due to the exposure of the anastomotic area to acid secretions, leads to the deposition of connective tissue and ultimately fibrosis, resulting in anastomotic stricture as well as recurrence or resistance to treatment[4,27].

Gastroesophageal reflux has been identified as a significant factor in both the development and recurrence of postoperative stricture, as evidenced by studies conducted by Gottrand [78]. and others[4,58,79,80]. However, a multivariate analysis conducted by Serhal et al[18]. revealed no association between GER and subsequent stricture formation, a finding consistent with the study conducted by Michaud et al. [28].

We were unable to address GERD due to the lack of objective investigations including pH monitoring and impedance study within the patient data. Additionally, the available data was insufficient to provide a basis for statistical analysis.

4. Esophageal atresia post operative follow-up:

Esophageal atresia, once confined to the neonatal phase as a surgical issue, has evolved into a lifelong challenge for patients, respiratory, nutritional, and gastroenterological problems seem to be the most common consequences, persisting not only in the first years of life but also in adolescence and adulthood[81]. Therefore, post-operative outpatient follow-up for esophageal atresia with tracheoesophageal fistula children has been shown to be crucial for complications monitoring[82].

4.1. Postoperative prophylactic acid suppression:

The consensus guidelines recommend treating all esophageal atresia infants with prophylactic doses of proton pump inhibitors (PPIs) after surgery during the first year of life, and continuing treatment based on reflux symptoms thereafter. However, only few studies have proved the effect of prophylactic PPIs on stricture prevention[14,83].

A study comparing esophageal atresia patients receiving no therapy versus those on 3 months of postoperative PPI prophylaxis did not find evidence supporting PPI prophylaxis in preventing anastomotic stricture formation[84], a finding supported by another study conducted by Alin et al.[79]. Similarly, a retrospective observational study comparing infants with EA and symptomatic gastroesophageal reflux disease (GERD) on PPI to asymptomatic infants on prophylactic PPI during the first year of life revealed no significant differences in the incidence of anastomotic strictures, median age of first anastomotic stenosis, or number of dilations[27].

Another study comparing outcomes in EA patients receiving 3-month and 12-month PPI prophylaxis post-surgery found no reduction in the development of anastomotic strictures within the first year after EA reconstruction with prolonged PPI prophylaxis[85].

Moreover, the common use of acid suppression treatment in infants poses risks, including higher chances of necrotizing enterocolitis, lower respiratory infections, sepsis, and Clostridium difficile infection[86,87].

On the other side, prophylactic doses of histamine-2 receptor antagonist (H2RA) treatment have shown promising results in improving stricture during the late postoperative phase, as indicated by Murase [88].

In our context, a 6-month prophylactic PPI treatment is systematically administered to all children who have undergone esophageal atresia surgery. Therefore, we were unable to determine the effectiveness of PPIs in reducing stricture rates due to the absence of a control group, this underscores the necessity for further research to gain a better understanding of the impact of prophylactic anti reflux treatment in this context.

4.2. Routine dilations:

It is noteworthy that we don't perform nor systematic screening for anastomotic stricture detection neither routine preventive dilations, instead we tend to opt for the "wait and see" approach suggested by Koivusalo [89], this method was compared to systematic screening and routine dilations even in the absence of symptoms in order to prevent the development of symptoms secondary to anastomotic stricture, nevertheless they found no differences in the outcomes of the two methods, moreover, the "wait and see" approach is less invasive for the patient and may be superior to prophylactic dilations[7].

The European Society for Pediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) and the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition (NASPGHAN)[7] guidelines for the evaluation and treatment of gastrointestinal and nutritional complications in children with esophageal atresia with tracheoesophageal fistula suggest close follow-up of all patients in the first two years of life with special attention to symptoms suggestive of anastomotic stricture. Infants exclusively on liquid diets must be followed during the transition to solid foods as well as patients with long-gap esophageal atresia and postoperative anastomotic leak need close follow-up to prevent severe, and occasionally complete, anastomotic stenosis, which poses a significant risk for aspiration and complicates the efficacy of endoscopic dilations.

In our series, nine months was the average period between the surgery and the onset of symptoms ranging from two months to two years, 67% of our stricture cases were diagnosed within one year significantly more than what Comella et al.[82] reported from a conducted study (36% within one year).

Chittmittrapap's series showed that 70% of the patients were diagnosed within a

6-month interval, suggesting that the earlier the onset of symptoms, the more dilatations were required [58].

III. Anastomotic stricture:

1. Clinical signs:

A variety of symptoms associated with anastomotic stricture have been documented in the literature[4,90]. These symptoms vary depending on the child's age and the consistency of ingested food (liquid versus solid). Common symptoms include difficulties with feeding and swallowing, regurgitation and vomiting, retention of mucus or food in the proximal pouch, coughing, drooling, recurrent respiratory infections, foreign body impaction, and poor weight gain[7].

The presence of any of these symptoms should raise suspicion for anastomotic stricture. However, no studies have determined whether these symptoms alone are sensitive or specific enough to diagnose strictures[7,14].

Several studies have declared swallowing difficulties as the most common symptom suggesting the presence of anastomotic stricture[15,28,58,91].

Our series found dysphagia to be the most prevalent symptom among diagnosed patients, which aligns with the findings of the majority of studies followed by dehydration, cough during feeding, and foreign body ingestion.

2. Paraclinical examination:

It is crucial to conduct paraclinical examinations when symptoms suggesting anastomotic stricture are present, either contrast study or endoscopy can reveal stenosis, contrast radiographs evaluate the esophageal morphology while endoscopic assessment allows diagnosis and treatment with dilations combined[7,92] (Figure 42Figure 43).

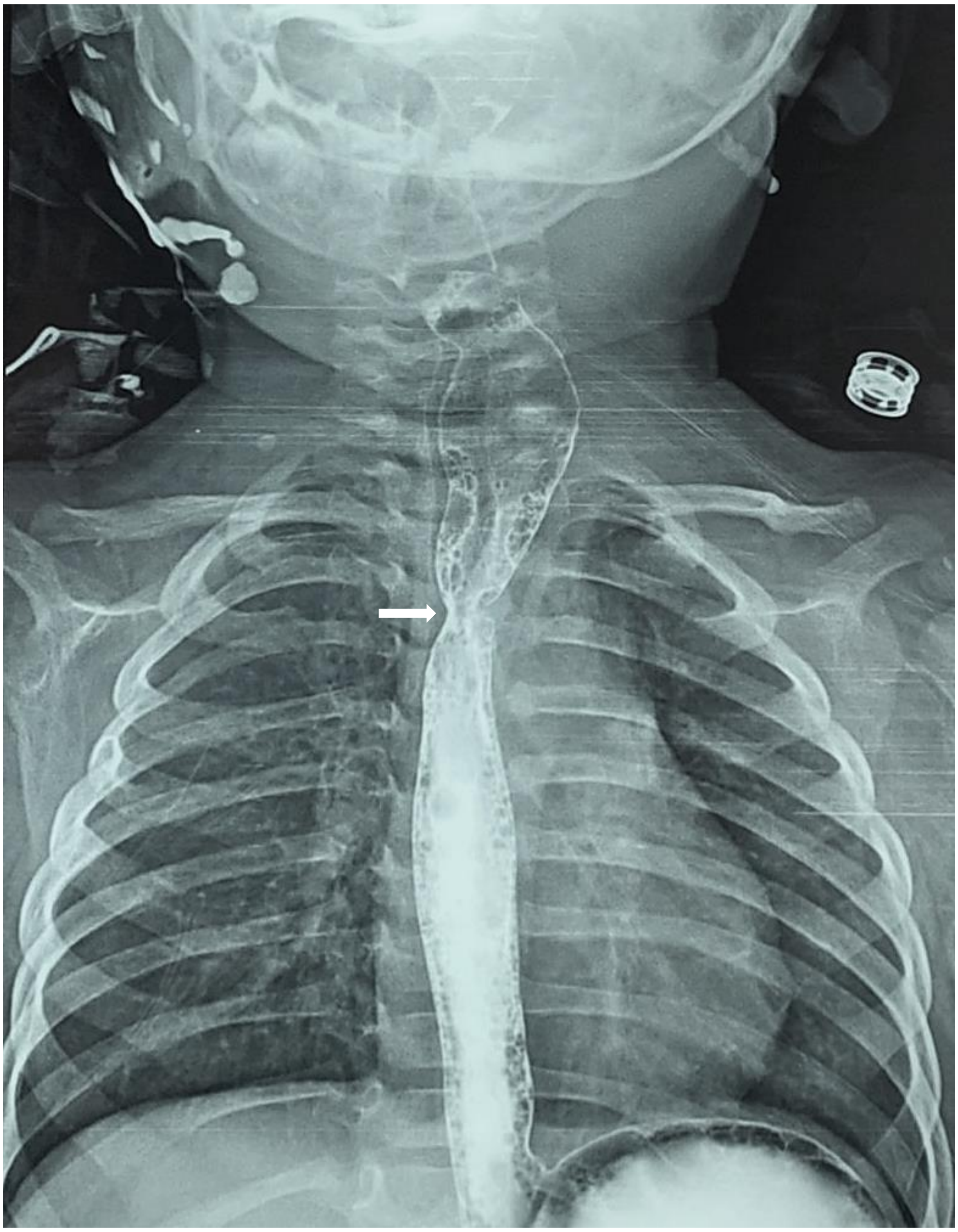


FIGURE 42: UPPER GI CONTRAST STUDY OF A STENOSIS AT THE SITE OF ANASTOMOSIS (WHITE ARROWS) IN A 1-YEAR-OLD MALE PATIENT FROM OUR SERIES.

FIGURE 43: ENDOSCOPIC IMAGE OF AN ESOPHAGEAL STENOSIS IN A MALE PATIENT FROM OUR SERIES.

In our study, all anastomotic stricture cases were detected through the use of upper endoscopy following the onset of symptoms and simultaneously underwent dilations.

While Parolini et al.[10] and Ko et al.[93] relied on contrast radiographs to confirm the stenosis, 81% of the stricture cases in Chiang et al.[21] series were diagnosed based on contrast radiographs and 19% via upper endoscopy.

3. Management:

The management of anastomotic strictures after esophageal atresia surgical repair consists essentially of dilations as the recommended first line treatment with a 58-96% success rate[94], aiming to achieve symptom relief, maintain an age-appropriate oral nutrition, and reduce the risk of pulmonary aspiration[4].

The dilation through upper endoscopy can be performed using two main types of tools: Fixed diameter push-type dilators (**Bougie dilators**) and radial expanding balloon dilators (**Balloon dilators**), the choice of dilators type depends on operator preference and the characteristics of the stricture[95]:

3.1. Bougie dilators:

The Bougie dilators are mainly utilized to manage esophageal strictures by exerting radial as well as longitudinal forces as they are advanced through a stenosis, they are available in various designs, sizes, and lengths, in contrast to balloon dilators, most of them are marketed to be reused[95]:

- **Maloney and Hurst dilators** (*Medovations, Milwaukee, Wisc, and Teleflex Medical, Research Triangle Park, NC*):
  Non-wire-guided flexible push-type dilators, The Hurst dilators have a rounded blunt tip, whereas Maloney dilators have an elongated tapered tip, because of concerns over exposure, the newer bougies are internally weighted with tungsten instead of mercury.

- **Savary-Gilliard dilators** (*Cook Medical, Winston-Salem, NC*):
  Flexible wire-guided polyvinyl bougie dilators, made with latex-free cylindrical solid tubes with a central channel to accommodate the guidewire, the Savary-Gilliard dilators have a long-tapered tip with a radiopaque marking at the base of the taper designating the point of maximal dilating caliber allowing fluoroscopic guidance.

- **American Dilation System dilators** (*ConMed, Utica, NY*):

  They resemble Savary-Gilliard dilators in most aspects, but with the specific distinction of having a shorter tip and a total radiopacity throughout their length indicating the distance from the tip.

3.2. Balloon dilators:

The radial expanding balloon dilators (**Balloon dilators**) are marketed as single-use items and made of low-compliance inflatable thermoplastic polymers that expands by pressure injection of liquid using a handheld accessory device, fluoroscopic observation is enhanced when the inflation is performed through radiopaque contrast injection.

The hydraulic pressure of the balloon is monitored manometrically exerting only radial forces to allow uniform and reproducible expansion at maximum inflation within the stenosis[95].

In our series, 67% of the patients with anastomotic stricture underwent dilations via balloon dilators (Figure 44), the initial approach involved a Savary-Gilliard dilator for two patients before transitioning to balloon dilators, three dilations was the average number of sessions performed, while 33% of the patients underwent dilations exclusively via Savary-Gilliard dilator and one case presented a cervical swelling without crepitus suggestive of emphysema following the dilation session.

Successful dilation was achieved in four patients. However, two patients (22%) experienced refractory strictures necessitating five or more dilations. Additionally, three patients were unavailable for follow-up examinations to assess treatment progress (Table XI).

FIGURE 44: ENDOSCOPIC VIEW OF A DILATION SESSION VIA BALLOON DILATOR

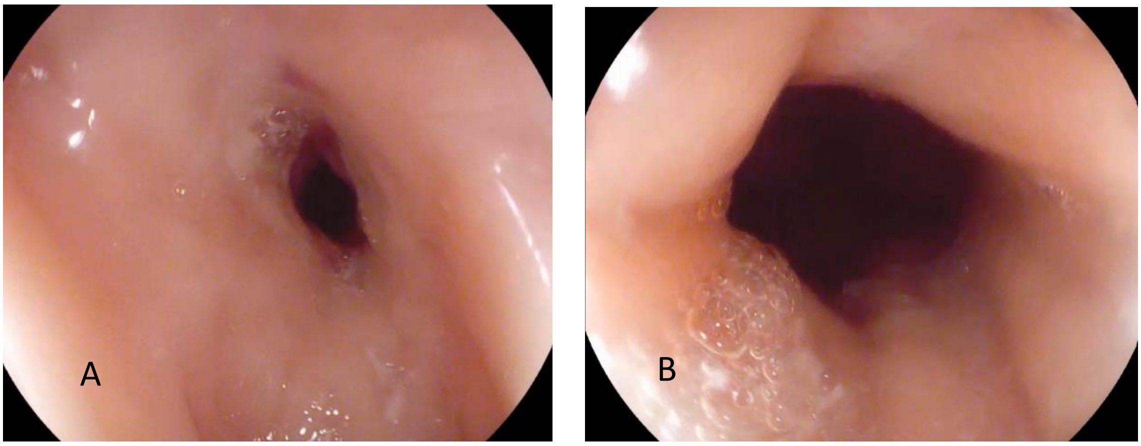


FIGURE 45: ENDOSCOPIC VIEW OF A STENOSIS BEFORE (A) AND AFTER A BALLOON DILATION SESSION (B)

TABLE XI: DETAILS ABOUT DILATION SESSIONS IN OUR STUDY PATIENTS

Patients	Dilator	Sessions(n)	Last dilation results	Follow up
1	Balloon dilator	2	Dilated stenosis but still impassable	Persistence of symptoms
2	Balloon dilator	3	Lightly dilated still im-passable	Persistence of symptoms
3	Balloon dilator	5	Lightly dilated still im-passable	Unavailable data
4	Balloon dilator	3	Dilated passable ste-nosis	No symptoms
5	SG dilator	3	Dilated passable ste-nosis	No symptoms
6	SG dilator Balloon dilator	1 2	Dilated passable ste-nosis	Unavailable data
7	SG dilator	1	Lightly dilated stenosis	Unavailable data
8	SG dilator Balloon dilator	5 1	Dilated passable ste-nosis	No symptoms
9	Balloon dilator	1	Dilated passable ste-nosis	No symptoms

Lang et al.[96] reported fewer dilations with balloon catheters than bougie dilators, similar to the results of Chiang et al.[21], however our study reported the same number of dilations per patient between the two tools.

Antoniou [15] reported a strong correlation between the grade of dysphagia at presentation and the number of sessions required for effective treatment so the more severe the dysphagia is, the greater the number of dilation sessions is required, nevertheless we were unable to evaluate the degree of dysphagia before dilations in our series.

TABLE XII: COMPARISON OF DILATIONS ACROSS MULTIPLE STUDIES

Series (year)	Type of dilator	Patients	Dilations range (mean)	Efficacy
Said et al.[9] (2003)	Balloon dilator	25	1-14 (4)	100%
Lang et al.[96] (2006)	Balloon dilator	22	1-7 (2)	100%
Ko et al.[93] (2006)	Balloon dilator	29	1-5 (1.6)	93%
Antoniou [15] (2010)	Balloon dilator	59	1-9 (2.79)	79.7%
Serhal et al.[18] (2010)	Bougie dilator	23	1-7 (3.2)	87%
Huang et al. [97] (2012)	Balloon dilator	7	2-6	100%
Chiang et al.[21] (2021)	Balloon dilator Bougie dilator Conversion	6 8 2	1-11 (2.5) 3-17 (10)	No major complications
Our series (2024)	**Balloon dilator** **Bougie dilator** **Conversion**	**5** **2** **2**	**1-5 (3.2)** **1-5 (2)**	**No major complications**

IV. Recurrent and refractory anastomotic stricture:

1. Definition

Most authors consider esophageal dilatation to be successful when dysphagia declines and symptoms disappear, although recurrence is a common deficiency of this treatment modality[15].

A comprehensive Japanese analysis spanning 35 years of handling esophageal atresia cases, indicated that approximately 50% of anastomotic strictures tend to ameliorate within a 6-month timeframe. However, about 30% will show persistent stricture requiring repeated dilatations[98].

Kochman [99] established a definition of refractory/recurrent anastomotic strictures for adult population, while Baird [100] proposed a pediatric definition (Table XIII).

TABLE XIII: ADAPTATION OF THE DEFINITION OF REFRACTORY/ RECURRENT AS IN PEDIATRIC POPULATION

	Refractory anastomotic stricture	Recurrent anastomotic stricture
Kochman [99] definition for adults	Inability to dilate to 14 mm diameter over five sessions at 2-week interval	Inability to maintain a satisfactory diameter > 4 weeks once 14 mm reached
Adapted definition for children according to Baird [100]	SI remains > 10% after five sessions	Recurrence of symptoms or SI > 50% after > 4 weeks after SI < 10% achieved
	SI: stricture index by Said et al.[9] (Definition)	
Adapted definition according to the ESPGHAN-ESGE guidelines[101]	Inability to successfully remediate the anatomic problem to obtain age-appropriate feeding possibilities after a maximum of 5 dilation sessions with maximal 4-week intervals	inability to maintain a satisfactory luminal diameter for 4 weeks once the age-appropriate feeding diameter has been achieved" for recurrent stricture

2. Incidence:

In this study, two patients developed a refractory stricture necessitating ≥5 dilations after an end-to-end anastomosis, Vergouwe et al.[1] reported a percentage of 7.3%, while Huang et al.[23] recorded an incidence of 13.1% of refractory stenosis. We suggest that the smaller size of the sample population in our study might have contributed to this high number of refractory strictures.

3. Risk factors:

Multiple factors have been identified as contributors to refractory and/or recurrent strictures; isolated esophageal atresia, anastomotic leakage, early strictures (≤28 days after anastomosis)[1], low birth weight, poor preoperative nutritional status, long gap esophageal atresia[23], repeated acid exposition at the site of the anastomosis due to persistent gastroesophageal reflux could be as well considered as potential risk factor[102].

Tambucci et al.[4] indicated that the dilation procedure itself could contribute partially to the resistance of stricture due to the intense fibrogenesis that occurs during the healing process afterward.

We faced limitations in our study regarding the determination of precise risk factors contributing to refractory strictures due to the small sample size. Consequently, the need for further studies to better understand and confirm these risk factors is highly suggested.

4. Management:

Esophageal strictures refractory to conservative treatment are indeed difficult to manage, when dilation sessions become repetitive, it may result in psychological implications alongside other potential complications especially perforation (5%-8%) as well as increasing the risk of carcinoma[102].

Therefore, once a stricture becomes unresponsive to esophageal dilation, a conservative approach is preferable before considering surgery for the patient, for this, numerous adjuvant/alternative treatments can be used for refractory and recurrent strictures[4]:

4.1. Intralesional Steroid Injection:

Have been recently introduced in refractory benign esophageal stricture management, the most used steroid is Triamcinolone diacetate or Acetonide, by reducing collagen synthesis, fibrosis, and chronic scarring processes as a theorized explanation of the mechanism, however the effectiveness of this adjuvant treatment is still questionable due to the small, heterogeneous studies that have addressed this hypothesis[4].

Holder et al.[103] attempted intralesional injection of Triamcinolone diacetate in a group of children with anastomotic strictures and reported positive outcomes but only in cases of short strictures.

Gandhi et al.[104] stated that endoscopically guided steroid injection when coupled to string-guided esophageal dilations, is a safe and reliable method for treatment of severe esophageal strictures.

In contrast, the guidelines established by ESGE-ESPGHAN for pediatric gastrointestinal endoscopy[101] do not advocate the regular application of intralesional steroids for refractory esophageal stenosis in children.

4.2. Systemic steroid injection:

High dose intravenous methylprednisolone in addition to intralesional injection of dexamethasone following balloon dilation is an effective therapeutic strategy for persistent esophageal strictures as reported by Morikawa et al.[105].

However, there is a dearth of research regarding this adjuvant treatment[7].

4.3. Mitomycin C:

Is an antineoplastic antibiotic with anti-fibrotic activities[7]. Local application of mitomycin C is a therapeutic option for treatment of refractory esophageal strictures in children[101].

The short-term results reported in the literature of this adjuvant treatment are very encouraging as systematically reviewed by Berger et al.[106], a partial to complete relief of symptoms was reported for 87.1% of the cases after a mean follow-up time of 22 months.

While Chapuy et al.[107] stated that there is no benefit when adding mitomycin-C treatment to dilations compared with only repeated esophageal dilations in the resolution of the stricture.

4.4. Endoscopic Electrocautery Therapy (EET):

Utilized as alternative therapy for refractory strictures, aiming to reduce the necessity for repetitive dilations, the most common being the use of needle knife, by performing a radial incision and cutting off of the stenotic rim, and can be associated with adjunctive therapies, to prevent re-stenosis, such as balloon dilations, systemic or intralesional steroids or argon plasma coagulation[108].

This kind of alternative procedure has demonstrated favorable outcomes, particularly for relatively short stenosis (< 1 cm) with good safety profile and acceptable long-term patency[108].

EET has also been shown to be equivalent to Savary-Gilliard bougienage as a primary therapy, and can be used as an alternative or additional therapy to Savary bougienage but only in the adult population as stated by Hordijk et al.[109], further studies are necessary to precisely explore these findings in pediatric populations.

4.5. Stents:

Esophageal stenting shows promise as a valuable tool in treating recurrent and refractory strictures. Its advantages encompass prolonged maintenance of luminal patency and improved oral feeding[4], particularly with the "dynamic stents"; a plastic or silicon customized tube affixed to a nasogastric tube[110].

However, suboptimal patient tolerance, potential migration, and other complications may arise. The long-term efficacy and safety warrant confirmation through prospective trials[4].

4.6. Surgical approach:

Refractory anastomotic strictures are commonly managed with resection of the stenosis and esophageal re-anastomosis when it comes to surgery[4].

Nevertheless, operations for refractory strictures when associated with recurrent trache-oesophageal fistula are more likely to develop complications, moreover the new anastomosis may require several dilatations before constant functional luminal diameter is reached and even the occasional need for dilatation may persist for years as stated by Koivusalo [111].

4.7. Esophageal reconstruction[112]:

Through graft placement including gastric transposition, colon interposition, jejunal interposition, and gastric tube.

Colon interposition is the most common time-tested procedure used in children with minimal and less serious complications.

Gastric transposition is simpler with lower risk of ischemia, can be performed in emergency and in newborns, while gastric tube remains technically riskier, and might be associated with early serious complications.

Jejunal interposition is alternative in various situations when a second intervention may be necessitated with good long-term results.

The decision when it comes to the choice of graft is established by both individual and institutional expertise.

Regarding our findings, studying the effectiveness of different adjuvant and alternative treatments was beyond the scope of our study's objectives.

RECOMMENDATIONS

Through this study, we were able to gather a comprehensive understanding of the situation in our context regarding anastomotic stricture as a complication following esophageal atresia surgery, highlighting its incidence, potential risk factors, and methods of management.

With the objective of minimizing the occurrence of this issue, and based on literature findings, we propose the following:

- Scheduling regular consultations with the pediatrician and pediatric surgeon to monitor the child's growth and overall condition is crucial, and requesting further diagnostic tests if symptoms appear concerning.
- Educating parents about the symptoms and signs to observe, particularly when gradually introducing solid foods, is absolutely imperative.
- It seems that managing esophageal atresia with a single-layered end-to-end repair, applying minimal tension and meticulous tissue handling associated with a deliberate avoidance of excessive mobilization appears to be protective from stricture formation.
- The "wait and see" approach is recommended over systematic screening and routine dilations, as it showed no differences in outcomes while being less invasive for patients, aiming to prevent the development of symptoms secondary to anastomotic stricture.

CONCLUSION

Despite advancements in surgical techniques for managing esophageal atresia, the incidence of postoperative complications, particularly anastomotic stricture, remains a concern. This challenging issue carries significant implications.

In the short term, Anastomotic stricture can result in immediate clinical issues such as feeding difficulties, regurgitation, and recurrent respiratory infections, thereby impacting the patient's physical well-being. Moreover, frequent medical interventions can exacerbate the psychological burden on both the patient and caregivers.

In the long term, managing recurrent AS entails significant financial implications, including costs associated with repeated endoscopic procedures, medical consultations, and potential surgical interventions. Furthermore, the chronic nature of AS and its management can profoundly affect the patient's quality of life, psychological well-being, and nutritional status over time.

Throughout this study, we have extensively addressed the topic of anastomotic stricture, encompassing its definition, incidence, potential risk factors, diagnosis, and diverse management modalities. Additionally, we have explored recurrent and refractory strictures as significant components of our investigation.

Our findings highlighted the type of suture material as a potential contributor to the elevated risk of developing anastomotic stricture. Specifically, the usage of Polydioxanone in esophageal anastomosis was found to be associated with a higher rate of anastomotic stricture in our series.

Our study emphasized a well-established risk factor for anastomotic stricture, namely, the application of high-tension during anastomosis. We observed a significant correlation between high tension and an increased incidence of anastomotic stricture.

Conversely, other factors were deemed insignificant in this context.

Indeed, our study was subject to the inherent weaknesses commonly found in most retrospective studies, including reliance on data obtained from medical records and the limited size of sample, making it difficult to conduct a robust statistical analysis, but this challenge was also compounded by the scarcity of studies locally as well as worldwide that have specifically focused on anastomotic stricture.

The need for vigilant monitoring and potentially tailored interventions to mitigate the risk of anastomotic stricture formation, improve patient outcomes and enhance the quality of life remains crucial while further research and refined clinical approaches are warranted to better understand the predisposing factors and optimize management strategies for this complication.

ABSTRACT

Abstract:

Introduction: Anastomotic stricture is a complication that arises after esophageal atresia surgery. It is commonly defined as a narrowing at the site of anastomosis, observable through medical imaging techniques, and often accompanied by clinical symptoms requiring at least one dilation procedure.

Patients and methods: Our study involved a retrospective cohort study of 80 cases of esophageal atresia in patients treated at the Pediatric Surgical Department "B" of the Mohammed VI Marrakech Hospital over an 8-year period spanning from 2015 to 2023.

The primary aim of our investigation was to assess the incidence of anastomotic stricture and identify potential risk factors associated with its development.

Additionally, we sought to explore various techniques utilized in the management of anastomotic strictures and evaluate patient outcomes following dilation procedures.

Finally, our study also addressed the challenges posed by recurrent and refractory strictures, discussing strategies for their management.

Results: Among the 80 patients diagnosed with esophageal atresia, 9 cases (11.25%) were identified to have developed anastomotic stricture during the study period.

Dysphagia emerged as the primary symptom, typically manifesting beyond 6 months post-repair. The diagnosis was confirmed via upper endoscopy for all the cases.

Comparison between the stricture and non-stricture groups revealed several notable findings:

The usage of Polydioxanone suture material during surgery was significantly more prevalent among patients who developed anastomotic stricture.

Statistical analysis demonstrated a significant association between high tension on anastomosis and the development of anastomotic stricture.

No significant associations were observed for gender, term, age at surgery, surgical approach, esophageal gap, type of surgical repair, duration of intubation and other factors.

These findings suggest that the use of Polydioxanone in surgery as well as high tension on anastomosis may predispose patients with esophageal atresia to develop anastomotic stricture.

The management of anastomotic stricture primarily entailed the use of balloon dilators for dilation procedures. A total of 27 dilation sessions were conducted, averaging three dilations per patient.

Successful dilation was achieved in four patients. However, two patients experienced refractory strictures necessitating five or more dilations. Additionally, three patients were unavailable for follow-up examinations to assess treatment progress.

Conclusion: Anastomotic stricture remains a significant concern in the management of esophageal atresia despite advancements in surgical techniques. This complication presents immediate clinical challenges impacting patients' well-being and imposes a substantial psychological burden. Managing recurrent anastomotic strictures entails significant financial implications and profoundly affects patients' quality of life.

Vigilant monitoring and tailored interventions are crucial to mitigate anastomotic strictures risk and improve patient outcomes.

Additional research is warranted to refine management strategies for this complication, given that our study represents the inaugural investigation in Morocco focusing specifically on anastomotic stricture.

Résumé :

Introduction : La sténose anastomotique est une complication qui survient après une chirurgie de l'atrésie de l'œsophage. Elle est généralement définie comme un rétrécissement au niveau du site de l'anastomose, observable à l'aide de techniques d'imagerie médicale, et est souvent accompagnée de symptômes cliniques nécessitant au moins une procédure de dilatation.

Patients et méthodes : Notre étude a porté sur une analyse de cohorte rétrospective comprenant 80 cas d'atrésie de l'œsophage chez des enfants traités au Département de Chirurgie Pédiatrique "B" de l'Hôpital Mohammed VI de Marrakech sur une période de 8 ans, de 2015 à 2023.

L'objectif principal de notre investigation était d'évaluer l'incidence de la sténose anastomotique et d'identifier les facteurs de risque potentiels associés à son développement.

De plus, nous avons exploré différentes techniques utilisées dans la prise en charge des sténoses anastomotiques et évalué les résultats des patients après les procédures de dilatation.

Enfin, notre étude a abordé les défis posés par les sténoses récurrentes et réfractaires, en discutant des stratégies pour leur gestion.

Résultats : Parmi les 80 patients diagnostiqués avec une atrésie de l'œsophage, 9 cas (11,25 %) ont été identifiés comme ayant développé une sténose anastomotique pendant la période d'étude.

La dysphagie est apparue comme le symptôme principal, se manifestant généralement au-delà de 6 mois après la réparation. Le diagnostic a été confirmé par endoscopie haute pour tous les patients.

La comparaison entre les groupes avec sténose et sans sténose a révélé plusieurs résultats notables :

L'utilisation du matériau de suture en Polydioxanone pendant la chirurgie était significativement plus fréquente chez les patients ayant développé une sténose anastomotique. L'analyse statistique a démontré une association significative entre une tension élevée sur l'anastomose et le développement de la sténose anastomotique.

Aucune association significative n'a été observée pour le sexe, le terme, l'âge lors de la chirurgie, l'approche chirurgicale, l'écart œsophagien, le type de réparation chirurgicale, la durée de l'intubation et d'autres facteurs.

Ces résultats suggèrent que l'utilisation de Polydioxanone pendant la chirurgie ainsi qu'une tension élevée sur l'anastomose peuvent prédisposer les patients atteints d'atrésie de l'œsophage au développement d'une sténose anastomotique.

La prise en charge de la sténose anastomotique impliquait principalement l'utilisation de dilatateurs à ballonnet pour les procédures de dilatation. Un total de 27 séances de dilatation a été réalisées, avec en moyenne trois dilatations par patient.

Une dilatation réussie a été obtenue chez quatre patients. Cependant, deux patients ont présenté des sténoses réfractaires nécessitant cinq dilatations ou plus. De plus, trois patients n'étaient pas disponibles pour des examens de suivi afin d'évaluer la progression du traitement.

Conclusion : La sténose anastomotique demeure une préoccupation majeure dans la prise en charge de l'atrésie de l'œsophage malgré les avancées des techniques chirurgicales. Cette complication pose des défis cliniques immédiats qui impactent le bien-être des patients et engendrent un fardeau psychologique considérable.

La gestion des sténoses anastomotiques récurrentes entraîne des implications financières significatives et affecte profondément la qualité de vie des patients. Un suivi attentif et des interventions personnalisées sont cruciaux pour atténuer les risques de sténoses anastomotiques et améliorer les résultats cliniques des patients.

Des recherches supplémentaires sont nécessaires pour affiner les stratégies de gestion de cette complication, étant donné que notre étude représente la première investigation au Maroc se concentrant spécifiquement sur la sténose anastomotique.

ملخص :

مقدمة :يعتبر التضيق التوصيلي مشكلة تنشأ بعد جراحة رتق المريء .يُعرَّف عادةً على أنه تضيق في موقع التوصيل، قابل للتشخيص من خلال تقنيات التصوير الطبية، وغالبًا ما يترافق مع أعراض سريرية تتطلب عملية توسيع على الأقل

المرضى والطرق :شملت دراستنا دراسة تحليلية لسجلات الحالات السابقة ل 80 حالة من رتق المريء لدى المرضى الذين تلقوا العلاج في قسم الجراحة الأطفال" ب "في مستشفى محمد السادس بمراكش على مدى فترة زمنية تمتد لثمانية أعوام من 2015 إلى2023

كان الهدف الرئيسي للدراسة تقييم معدل حدوث التضيق التوصيلي وتحديد العوامل المحتملة المرتبطة بتطوره بالإضافة إلى ذلك، سعينا لاستكشاف مختلف التقنيات المستخدمة في معالجة التضيقات التوصيلية وتقييم نتائج المرضى بعد الإجراءات التوسيعية .وفي الختام، تناولت دراستنا أيضًا التحديات التي تطرحها التضيقات التوصيلية المتكررة والعنيدة، وناقشت الاستراتيجيات المتبعة لإدارتها

النتائج :بين المرضى البالغ عددهم 80 والذين تم تشخيصهم برتق المريء، تم تحديد 9 حالات التي ظهر عليها التضيق التوصيلي خلال فترة الدراسة

ظهرت صعوبة في البلع كأعراض رئيسية، وكانت تظهر عادة بعد مرور 6 أشهر على العملية الجراحية لإصلاح الرتق تم تأكيد التشخيص من خلال التنظير العلوي للمريء لجميع الحالات أظهرت المقارنة بين مجموعتي التضيق وغير التضيق عدة نتائج ملحوظة

كان استخدام البوليديوكسانون في عملية الجراحة أكثر انتشارًا بشكل ملحوظ بين المرضى الذين ظهرت عليهم تضيقات توصيلية .أظهر التحليل الإحصائي ارتباطًا ملحوظًا بين التوتر العالي على التوصيل وتطور التضيق التوصيلي .لم يتم ملاحظة ارتباطات ملحوظة للجنس، والمدة، والعمر عند الجراحة، والنهج الجراحي، وفجوة المريء، ونوع الإصلاح الجراحي، ومدة الإنعاش وعوامل أخرى

تشيرهذه النتائج إلى أن استخدام البوليديوكسانون في الجراحة بالإضافة إلى التوتر العالي على التوصيل قد يسبب لدى المرضى الذين يعانون من تضيق المريء احتمالية تطور التضيق التوصيلي

تضمنت إدارة التضيق التوصيلي في الغالب استخدام موسعات البالون لإجراءات التوسيع

تم إجراء مجموع 27 جلسة توسيع مع متوسط ثلاث جلسات توسيع لكل مريض .تم تحقيق التوسيع الناجح لذى أربعة مرضى .ومع ذلك، عانى مريضان من تضيقات عنيدة تستدعي خمسة أو أكثر من جلسات التوسيع بالإضافة إلى ذلك، لم يتمكن ثلاثة مرضى من إجراء الفحوصات المتابعة لتقييم تقدم العلاج

خاتمة :يظل تضيق التوصيل مصدر قلق كبير في إدارة رتق المريء على الرغم من التطورات في تقنيات الجراحة . يُثير هذا التعقيد تحديات سريرية فورية تؤثر على رفاهية المرضى وتفرض عبء نفسي كبير

إدارة تضيقات التوصيل المتكررة تنطوي على تبعات مالية كبيرة وتؤثر بشكل عميق على جودة حياة المرضى

المراقبة اليقظة والتدخلات المخصصة ضرورية للتخفيف من مخاطر تضيقات التوصيل وتحسين نتائج المرضى

يتطلب الأمر إجراء بحوث إضافية لتحسين استراتيجيات الإدارة لهذا التعقيد، نظرًا لأن دراستنا هي الأولى من نوعها في المغرب التي تركز بشكل خاص على تضيق التوصيل بعد جراحة رتق المريء

APPENDIX

Operating sheet:

I. Patient identity:

Name:

File number:

Gender: ☐ M ☐ F

Entry age:

Admission date:

Discharge date:

II. Esophageal Atresia:

1. Anamnesis:

Term:

Birth weight:

Prenatal diagnosis: ☐ Yes ☐ No

NG tube insertion test: ☐ Yes ☐ No

Breastfeeding attempts: ☐ Yes ☐ No

Clinical signs of EA:

- Cyanosis ☐ Yes ☐ No
- Hyper sialorrhea ☐ Yes ☐ No
- Vomiting ☐ Yes ☐ No
- Cough ☐ Yes ☐ No
- Dehydration ☐ Yes ☐ No
- Fever ☐ Yes ☐ No

Others: …………………………………………………………………………………….

2. Paraclinical examination:

EA Type: ☐ I ☐ II ☐ III ☐ IV ☐ V

Pneumonia:

Associated malformations:

- Vertebral:
- Anorectal:
- Cardiovascular:
- Tracheal:
- Renal:

Limbs:

Others: ……………………………………………………………………

Waterston score: ☐ A ☐ B ☐ C

CRP Blood Levels : ………………………………………………………………………

3. EA Management:

Age at surgery: ……………………………………………………………………….

Surgical approach:

Thoracoscopy: ☐ Yes ☐ No

Thoracotomy: ☐ Right thoracotomy ☐ Modified posterior ☐ Left thoracotomy

Primary repair:

TEF ligation: ☐ Yes ☐ No

End to end anastomosis: ☐ 1-layer anastomosis ☐ 2-layer anastomosis ☐ Wave-like

Type of suture material: ☐ PDS ☐ Vicryl

Tension: ☐ No ☐ Moderate ☐ Great

Trans anastomotic tube insertion: ☐ Yes ☐ No

Duration of trans anastomotic tube placement: ……………………………………

Duration of intubation: ……………………………………………………………………

4. EA complications:

Short term complications:

Anastomotic leak ☐ Yes ☐ No

Anastomotic stricture ☐ Yes ☐ No

Mediastinitis ☐ Yes ☐ No

Recurrent TEF ☐ Yes ☐ No

Pneumonia ☐ Yes ☐ No

Pleural effusion ☐ Yes ☐ No

Others: ………………………………………………………………………………

Long term complications:

GERD ☐ Yes ☐ No

Tracheomalacia ☐ Yes ☐ No

Dysmotility ☐ Yes ☐ No

Poor weight gain ☐ Yes ☐ No

Others: ………………………………………………………………………………

III. Anastomotic stricture:

1. Clinical signs:

- GI problems:

Dysphagia: ☐ Yes ☐ No

Vomiting: ☐ Yes ☐ No

Slow feeding: ☐ Yes ☐ No

Hyper sialorrhea: ☐ Yes ☐ No

Others: ……………………………………………………………………………………

- Respiratory problems:

Recurrent respiratory infections: ☐ Yes ☐ No

Aspiration pneumonia: ☐ Yes ☐ No

Cough during feeding: ☐ Yes ☐ No

Others: ……………………………………………………………………………………

2. Paraclinical examination:

Interval: ……………………………………………………………………………………………

Diagnosis: ☐ Contrast study ☐ Upper endoscopy

3. AS management:

Dilation tool: ☐ Balloon dilator ☐ Bougie Dilator

Duration of dilator insertion: ………………………………………………………

Number of dilations: ……………………………………………………………………

4. AS complications:

Perforation: ☐ Yes ☐ No

Hemorrhage: ☐ Yes ☐ No

Pleural effusion: ☐ Yes ☐ No

Mediastinitis: ☐ Yes ☐ No

Local infection: ☐ Yes ☐ No

Recurrence: ☐ Yes ☐ No

Others: ……………………………………………………………………………………

IV. Recurrent/Refractory strictures:

1. Management:

Conservative approach:

Steroid injection: ☐ Yes ☐ No

Topical application of Mitomycin C: ☐ Yes ☐ No

Esophageal stenting: ☐ Yes ☐ No

EIT: ☐ Yes ☐ No

Surgical approach:

Resection with re anastomosis: ☐ Yes ☐ No

Esophageal replacement: ☐ Yes ☐ No

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قسم الطبيب

أقْسِم بِالله العَظِيم

أن أراقبَ الله في مِهْنَتِي.

وأن أصُونَ حياة الإنسان في كآفّة أطوَارهَا في كل الظروف والأحَوال باذلة وسْعِي في إنقاذها مِن الهَلاك ِوالمرَضِ و الألَم والقَلَق.

وأن أحفَظَ لِلنَاسِ كرَامَتهُم، وأسْتر عَوْرَتهُم، و أكتمَ سِرَّهُمْ.

وأن أكونَ عَلى الدوَام من وسائِل رحمة الله، باذلة رعايتي الطبية للقريب والبعيد، للصالح والطالح، والصديق والعدو.

وأن أثابر على طلب العلم، وأسَخِّرَه لِنَفْعِ الإنْسَان لا لأذَاه.

وأن أُوَقّرَ مَن عَلَّمَني، وأُعَلّمَ مَن يصغرني، وأكون أختا لِكُلِّ زَميلٍ في المِهنَةِ الطِّبّيَة مُتعَاونِينَ عَلى البرِّ و التقوى.

وأن تكون حياتي مِصْدَاق إيماني في سِرّي وَعَلانيَتي ،نَقِيَّة مِمّا يشينها تجَاهَ الله وَرَسُولِهِ وَالمؤمِنين.

والله على ما أقول شهيد

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أطروحة رقم 102 **سنة 2024**

التضيق التوصيلي بعد جراحة رتق المريء

الأطروحة

قدمت ونوقشت علانية يوم 2024/03/07

من طرف

الانسة **خولة الحرشي**

المزدادة في 23 أبريل 1999 بالشماعية

لنيل شهادة الدكتوراه في الطب

الكلمات المفتاحية:

جراحة - مريء – توصيل – تضيق – رتق

اللجنة:

السيد	**س. يونس** أستاذ في التخدير و الإنعاش	**الرئيس**
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