



# The Importance of Upper Pouch Contrast X-ray Radiography in Esophageal Atresia: A Retrospective Analysis

## Özofagus Atrezisinde Üst Kese Kontrastlı X-ışını Radyografisinin Önemi: Retrospektif Analiz

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### ABSTRACT

**Objective:** To investigate the effectiveness of preoperative upper pouch radiography in determining the treatment method in neonates with esophageal atresia (EA) and also to analyze the contribution of radiographic assessment of upper esophageal level to the prediction of anastomotic tension.

**Method:** Neonates who underwent primary esophagus repair due to EA with distal fistula between 2014 and 2020 were analyzed retrospectively. Upper esophageal levels assessed on preoperative upper pouch radiographs and during surgery were compared.

**Results:** A total of 36 cases were included in the study. Contrast-enhanced upper pouch radiograms were obtained using a thin catheter in 18 (50%) patients and using a thick catheter in 18 (50%) patients. The upper esophageal levels of preoperative pouch radiographs and surgery were consistent in 80.5% (n=29) and not consistent in 19.5%. The rate of compliance between radiographic and intraoperative levels was found to be significantly higher in the use of thick catheters compared to thin catheters (p=0.03). Six patients (16.6%) whose upper pouch level was in the 1<sup>st</sup> or 2<sup>nd</sup> thoracic vertebra had tense anastomosis.

**Conclusion:** Withdrawing the upper pouch radiography by advancing a thick catheter is effective for determining the actual level of the upper esophagus. If the upper esophageal pouch is at the 1<sup>st</sup> or 2<sup>nd</sup> thoracic level on the radiographs obtained with a thick catheter, it can be predicted that the anastomosis will be tense.

**Keywords:** Esophageal atresia, diagnosis, newborn, surgery, upper pouch graphy

### ÖZ

**Amaç:** Özofagus atrezili (ÖA) yenidoğanlarda preoperatif üst poş radyografisinin tedavi yönteminin belirlenmesindeki etkinliğini araştırmak ve ayrıca üst özofagus seviyesinin radyografik değerlendirmesinin anastomoz gerilimi tahminine katkısını analiz etmektir.

**Yöntem:** 2014-2020 yılları arasında distal fistüllü ÖA nedeniyle primer özofagus onarımı yapılan yenidoğanlar retrospektif olarak incelendi. Preoperatif üst poş grafilerinde ve ameliyat sırasında değerlendirilen üst özofagus seviyeleri karşılaştırıldı.

**Bulgular:** Çalışmaya toplam 36 olgu dahil edildi. On sekiz (%50) hastada ince kateter, 18 (%50) hastada kalın kateter kullanılarak kontrastlı üst poş grafileri çekildi. Preoperatif poş radyografileri ve intraoperatif üst özofagus seviyeleri %80,5'te (n=29) tutarlıydı; %19,5'te tutarlı değildi. Kalın kateter kullanımında radyografik ve intraoperatif düzeyler arasındaki uyum oranı ince katetere göre anlamlı olarak yüksek bulundu (p=0,03). Üst poş seviyesi 1. veya 2. torasik vertebrada olan altı hastada (%16,6) anastomoz gergin olarak yapılabildi.

**Sonuç:** Kalın kateter ilerletilerek üst poş radyografisinin çekilmesi, üst özofagusun gerçek seviyesinin belirlenmesinde etkilidir. Kalın kateter ile çekilen grafilerde üst özofagus poşu 1. veya 2. torasik seviyede ise anastomozun gergin olacağı tahmin edilebilir.

**Anahtar kelimeler:** Özofagus atrezisi, tanı, yenidoğan, cerrahi, üst poş grafisi

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## INTRODUCTION

Tracheoesophageal fistula (TEF) and esophageal atresia (EA) are congenital anomalies characterized by an abnormal communication between the trachea and the proximal and/or distal esophagus segments. The incidence of EA is 2.99 cases per 10,000 births<sup>(1)</sup>.

EA with TEF is a congenital malformation requiring surgery soon after birth<sup>(2)</sup>. Accurate preoperative determination of the distance between esophageal pouches is mandatory in order to establish an ideal surgical plan<sup>(2)</sup>. Anteroposterior chest radiography can provide a rough idea of the distance between pouches, whereas it mostly cannot assess this distance precisely. Contrast radiography is widely used for imaging the dilated upper pouch and also for assessing fistulas and interpouch distance<sup>(2,3)</sup>. Some studies suggested that contrast radiography may be misleading for estimating exact location of pouch levels in the preoperative period when an appropriate-sized catheter and technique are not employed<sup>(4,5)</sup>. Nevertheless, studies conducted on this subject are very limited and most of them include a limited number of cases<sup>(5)</sup>.

The aim of this study was to investigate the effectiveness of upper pouch radiography in the assessment of upper pouch level in cases with EA and to analyze the contribution of radiographic assessment of upper esophageal level to the precise prediction of anastomotic tension.

## MATERIALS and METHODS

The study included 36 neonates with EA and TEF (Type C) who were operated on in our clinic between January 2014 and April 2020. The diagnosis of EA was confirmed radiologically by thoracoabdominal radiographs with the use of a rubber catheter/an infant feeding tube in situ and upper pouch radiograms were obtained in all cases. Intraoperatively upper esophageal pouch level, fistula level, anastomotic tension findings, catheter size, demographic findings (gender, birth weight) and gestational age were recorded. Patients whose radiographs could be retrieved from the hospital database were included in the study. The first pouch radiograms of some patients who were referred to our department from external centers for surgery were not available in the hospital database and these patients were excluded from the study. The study was approved by the local ethics committee (decision number: 142, date: 08.07.2020).

## Statistical Analysis

Data were analyzed using SPSS for Windows version 18.0 (Chicago, IL, USA). Descriptive statistics were expressed as frequencies (n) and percentages (%) for categorical variables and as mean  $\pm$  standard deviation and median (minimum-maximum) values for continuous variables. Categorical variables were compared using chi-square test or Fisher's Exact tests. A p value of <0.05 was considered to be statistically significant.

## RESULTS

The study population consisted of 36 neonates including 20 (55.5%) girls and 16 (44.5%) boys. Median gestational age was 34 weeks (range; 28-41 weeks). Median birth weight was 2137 g (range; 1100-3480 g). Associated congenital heart disease was present in 28 (77.7%), anorectal malformation in two (5.5%), and duodenal atresia in one (2.7%) patient.

Thoracoabdominal radiography confirmed the presence of EA in all patients. Contrast-enhanced [iohexol (Omnipol; Polifarma, İstanbul, Turkey)] upper pouch radiograms were obtained using a thin catheter [ $<10$  F (Bıçakçılar, İstanbul, Turkey)] in 18 (50%) and a large-caliber catheter [10-12 Fr rigid rubber (Bıçakçılar, İstanbul, Turkey)] in 18 (50%) patients. Primary repair was performed via thoracotomy through the 3<sup>rd</sup> or 4<sup>th</sup> intercostal space. During the surgery, assessment of the upper pouch was performed with the help of a catheter which was inserted with sufficient pressure to allow the catheter to curl up at the lowest point of the upper pouch. Radiographically detected levels of upper esophageal pouch complied with intraoperative findings in 29 (80.5%), but they were more proximal in six (16.7%), and more distal in one (2.8%) patient. Radiographs obtained with insertion of a thin catheter demonstrated that the upper pouch level were consistent with the intraoperative pouch level in 12 (66.7%), and more proximally located in six (33.3%) out of 18 patients. Radiographs of the remaining 18 patients were obtained using a larger-caliber catheter and the level of the pouch detected on the radiographs was consistent with the intraoperative pouch level in 17 (94.4%) patients. In one patient where a large-caliber catheter was used, the pouch level was more distal on radiographs compared to its intraoperative level.

Figure 1 shows a radiograph obtained using a thin catheter (radiographically and intraoperatively detected levels were incompatible, and the upper esophageal pouch was revealed at the 3<sup>rd</sup> thoracic vertebral level during surgery).

Figure 2 shows a radiograph obtained with a larger caliber catheter (radiographic and intraoperative levels were compatible).

The rate of compatibility between radiographically and intraoperatively detected levels was found to be significantly higher in the group catheterized with a larger-caliber catheter compared to the group in whom a thin catheter was used ( $p=0.03$ ). Table 1 presents the effectiveness of catheter size on compatibility between radiographically and intraoperatively detected levels of upper esophageal pouches.

Primary repair was performed via thoracotomy through the 3<sup>rd</sup> intercostal space in patients in whom the

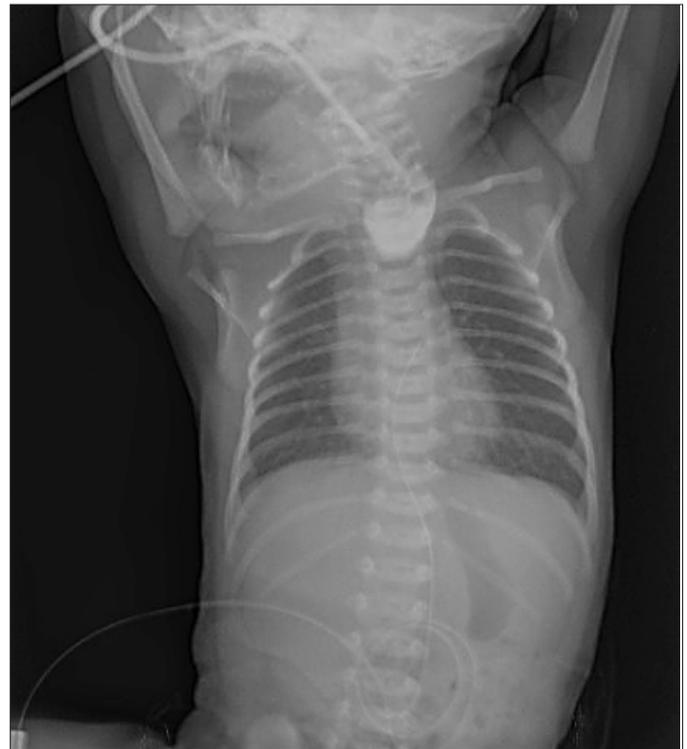
upper pouch was detected at the level of the 1<sup>st</sup> and 2<sup>nd</sup> thoracic vertebra on radiography and it was performed through thoracotomy incision into the 4<sup>th</sup> intercostal space for the other patients. Primary anastomosis was performed successfully in all cases without further need for elongation techniques.

TEF communicated with the trachea at the carina in 32 (88.9%), and at the level of the 3<sup>rd</sup> thoracic vertebra in the remaining four (11.1%) patients. Six patients (16.6%) whose upper pouch level was at the level of the 1<sup>st</sup> or 2<sup>nd</sup> thoracic vertebra had tense anastomosis. In these patients, pouch radiographs were obtained using a large-caliber catheter in four and a thin catheter in two patients. In the same patients, radiographically



**Figure 1.** Radiograph obtained with a thin catheter in a patient (radiographic and intraoperative levels were not compatible and the upper esophageal pouch was detected at the 3<sup>rd</sup> thoracic vertebral level during surgery)

	Catheter size	
	Thin	Thick
<b>Consistent</b>	12 <sup>a</sup> (66.7%)	17 <sup>b</sup> (94.4%)
<b>Inconsistent</b>	6 (33.3%)	1 (5.6%)
p <sup>a-b</sup> =0.03		



**Figure 2.** Radiograph obtained with a thick catheter in a patient (radiographic and intraoperative levels were compatible) (2<sup>nd</sup> thoracic vertebra level)

and intraoperatively detected levels were compliant in five patients, whereas in the remaining one patient, a larger caliber catheter was used and the pouch was detected more distally on radiograms compared to its intraoperatively detected level of the pouch. There were two vertebral gaps between the proximal and distal esophagus in all cases with tense anastomosis. In

these patients, the anastomosis was tense despite the use of extra muscle relaxants. Moreover, the knots of some sutures could not fit properly or the sutures were cutting through the tissue. Minor anastomotic leakage was observed in two patients with tense anastomosis. No serious postoperative complications occurred in other cases. Table 2 presents data on gender distribution,

**Table 2. Gender distribution, radiographic and intraoperative upper pouch levels, tendency for anastomosis, and catheter sizes**

Sex	Level of upper pouch on X-ray (thoracic vertebra)	Level of upper pouch intraoperation (thoracic vertebra)	Level of fistula (thoracic vertebra)	Anastomosis tendency	Catheter size
<b>M</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>Tense</b>	<b>Thin</b>
<b>F</b>	<b>2</b>	<b>2</b>	<b>3</b>	<b>Tense</b>	<b>Thin</b>
<b>M</b>	<b>3</b>	<b>1</b>	<b>4</b>	<b>Tense</b>	<b>Thick</b>
F	2	3	3	Comfortable	Thin
F	3	3	4	Comfortable	Thin
F	3	3	4	Comfortable	Thin
F	3	4	4	Comfortable	Thin
F	3	3	4	Comfortable	Thin
F	3	3	4	Comfortable	Thin
F	3	3	4	Comfortable	Thin
F	4	4	4	Comfortable	Thin
F	4	4	4	Comfortable	Thin
M	3	3	4	Comfortable	Thin
F	3	3	4	Comfortable	Thin
M	5	5	5	Comfortable	Thin
<b>F</b>	<b>1</b>	<b>1</b>	<b>4</b>	<b>Tense</b>	<b>Thick</b>
<b>M</b>	<b>2</b>	<b>2</b>	<b>4</b>	<b>Tense</b>	<b>Thick</b>
<b>F</b>	<b>1</b>	<b>1</b>	<b>4</b>	<b>Tense</b>	<b>Thick</b>
F	4	4	4	Comfortable	Thick
M	3	3	4	Comfortable	Thick
F	4	4	4	Comfortable	Thick
M	2	3	4	Comfortable	Thin
M	2	2	3	Comfortable	Thick
M	2	2	4	Comfortable	Thick
M	3	3	4	Comfortable	Thick
M	1	3	4	Comfortable	Thin
F	3	3	4	Comfortable	Thick
F	4	4	4	Comfortable	Thick
F	4	4	4	Comfortable	Thick
F	5	5	5	Comfortable	Thick
M	2	4	4	Comfortable	Thin
M	3	3	4	Comfortable	Thick
F	3	3	4	Comfortable	Thick
M	4	4	4	Comfortable	Thick
M	4	4	4	Comfortable	Thick
M	2	3	4	Comfortable	Thin

M: Male, F: Female

radiographically and intraoperatively detected upper pouch levels, tendency for anastomosis, and catheter sizes.

## DISCUSSION

EA and/or TEF is one of the most challenging congenital anomalies for pediatric surgeons. It is very important to determine the exact location of the upper pouch and fistula as well as inter-pouch gap for surgery plan<sup>(2-5)</sup>. Magnetic resonance imaging (MRI) and computed tomography (CT) have been used preoperatively to define, and evaluate the tracheoesophageal anatomy. Although MRI seems advantageous for imaging the pouch and fistula line and for prenatal detection of accompanying anomalies, debates continue about its sensitivity, cost and effective use<sup>(1-3)</sup>. Preoperative CT scan of chest has many advantages, but it involves significant exposure to ionizing radiation<sup>(5)</sup>. Nevertheless, experience with these imaging methods in newborns in the preoperative period is quite limited. Transport to the radiology center, radiation risk, sedation or general anesthesia seem to be its major disadvantages<sup>(2)</sup>. Recent studies concluded that there is no role for CT scan or MRI in the routine preoperative assessment of EA<sup>(2,5)</sup>. The authors reported that performing CT or MRI in preoperative period provide limited information that may contribute to modifying the surgical plan<sup>(2,3,5)</sup>.

Contrast esophagram is still used in many clinics for the preoperative evaluation of the esophagus since it can detect the location of the dilated upper esophageal pouch in relation to the thoracic inlet and also reveal a proximal TEF<sup>(2,6)</sup>. However, the downsides of this technique include aspiration risk and though rarely, inability to show fistula due to mucus plug and radiation<sup>(2,7)</sup>. Nonetheless, the risk of aspiration is minimal when the technique is performed meticulously, and the technique can provide highly useful information regarding the preoperative period when used with an appropriate-sized catheter and a proper extraction technique<sup>(4,8,9)</sup>.

The caliber and rigidity of the catheter used in radiographic examination is of paramount importance, and studies emphasize the importance of using a rigid rubber catheter instead of a soft feeding tube for the diagnosis of EA<sup>(6,9)</sup>. Many authors recommend a rigid 10-F nasogastric tube for radiography<sup>(10)</sup>. Using a thinner tube may cause the catheter curl up in the posterior pharynx or upper pouch<sup>(10-12)</sup>. In our series, the radiographically and intraoperatively detected upper

pouch levels showed a high rate of compliance (80.5%). Moreover, this rate was lower in the patients where a thin catheter was used compared to those in whom a larger-caliber catheter was employed (66.7% vs. 94.4%). These findings implicate that the thin catheter is less effective in determining the lowest level of the upper pouch, mainly because it is curled up inside the pouch due to its more flexible nature.

Preoperative assessment of the level of the upper pouch and interpouch distance is important for determining the location of the incision<sup>(2)</sup>. In our study, we planned the thoracotomy site based on the location of the upper pouch and interpouch distance, whereby the 3<sup>rd</sup> intercostal space was selected in cases with upper pouches and the 4<sup>th</sup> intercostal space in the presence of lower pouches. In doing so, better surgical field dominance was achieved and primary repair was easily performed in all patients. In some cases, however, radiographs were misleading and thus led to difficulties during surgery. Although we believe that a large-caliber catheter should be used when performing pouch radiography, pushing a thin catheter with excessive force during the radiographic examination may produce misleading results about the pouch level in the preoperative period, as was seen in one of our patients.

Literature indicates that an appropriate technique is also important besides the caliber and type of the catheter for determining the level of the upper pouch on radiography<sup>(4,13)</sup>. Lyall et al.<sup>(13)</sup> found that the level of the upper pouch detected on radiography was seriously affected by the position of the head in porcine animal model. The authors also noted that a full flexion of the neck was associated with a 9% reduction in the length of the esophagus<sup>(13)</sup>. In addition, the size and position of the upper pouch are influenced by swallowing and breathing as well<sup>(4)</sup>. Accordingly, we consider that in our study these factors may also be effective in the errors experienced in the assessment of the level of the upper pouch on radiography.

In our study, in six patients, the upper pouch was determined at the 1<sup>st</sup> and 2<sup>nd</sup> vertebral level in contrast-enhanced radiography. Thus, we preoperatively predicted that the anastomosis could be tense. Indeed, intraoperatively, tense anastomoses were detected in these six patients. Although the number of our cases in our study was limited, our findings indicate that contrast-enhanced radiography can help predict possible anastomotic tension. There is no detailed study about effectiveness of preoperatively obtained upper

pouch radiography in neonates with EA in the literature. Further studies are required to compare our findings.

In recent years, preoperatively, endoscopy and bronchoscopy have been used for determining the location of TEF and the interpouch distance and also for evaluating vocal cords and anomalies such as tracheomalacia and tracheal cleft<sup>(2)</sup>. In our clinic, bronchoscopy and esophagoscopy are not routinely performed for every patient, and are only performed in patients with suspected proximal fistula. In patients with suspected proximal fistula, bronchoscopy and esophagoscopy are performed in consideration of the patient's weight. However, they cannot be performed in our study anyway, because the caliber of our endoscope is not suitable for infants weighing less than 2000 grams.

### Study Limitations

The limitation of the study was that it was a retrospective study and the data were obtained from medical records of hospital. Non-standardized evaluation is also a serious limitation of such retrospective studies.

### CONCLUSION

As a summary, the assessment of the upper pouch level is highly important for determining the surgical technique and incision site and also for predicting anastomotic tension in cases with EA. Performing the upper pouch radiography by inserting a large-caliber catheter is effective for determining the actual level of the upper esophagus. If the upper esophageal pouch is at the 1<sup>st</sup> or 2<sup>nd</sup> thoracic level on the radiographs obtained with a large-caliber catheter, the anastomosis is likely to be tense.

### Ethics

**Ethics Committee Approval:** The study was approved by the Zeynep Kamil Woman and Children Diseases Training and Research Hospital Ethics Committee (decision number: 142, date: 08.07.2020).

**Informed Consent:** Retrospective study.

**Peer-review:** Externally and internally peer-reviewed.

### Author Contributions

Surgical and Medical Practices: T.M.O., C.G., A.C., Concept: S.S., A.C., Design: S.S., A.C., Data Collection and/or Processing: T.M.O., C.G., A.C., Analysis and/or Interpretation: S.S., A.C., Literature Search: S.S., Writing: S.S., T.M.O., C.G., A.C.

**Conflict of Interest:** The authors have no conflict of interest to declare.

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