

# Is Minimal Access Surgery of Esophageal Atresia with Distal Esophageal Atresia by Thoracoscopy is better than Conventional Thoracotomy? A Multi-institutional Review of Literature to get the Answer

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## ABSTRACT

**Topic:** Is minimal access surgery of esophageal atresia with tracheoesophageal fistula by thoracotomy better than conventional thoracotomy? A multi-institutional review of literature.

**Objective:** Minimal access surgical technique has been one of the most important surgical advances in the last few decades; we have reached now in such era that complex neonate surgical issue can be addressed safely by minimal access surgery without significant morbidity. Esophageal atresia (EA) with distal tracheoesophageal fistula (TEF) has been successfully treated by traditional thoracotomy, but now the trend has been shifted toward minimal access surgery via thoracoscopic repair of EA with distal EA. The quest of this multi-institutional review is to get the answer that is minimal access surgery is better than the traditional open approach.

**Materials and methods:** A literature view was performed from 2005 to 2012 using the PubMed, science direct, OVID search EBSCOhost and search engines Google and Yahoo. The following search terms were used, thoracoscopic repair or thoracoscopic surgery, thoracotomy and EA.

Inclusion criterion is EA with distal esophageal fistula with comparative study by open thoracotomy or by historical data. Exclusion criteria were other esophageal anomalies.

**Results:** In 182 patients operated by minimal access surgery by thoracoscopy, the mean gestational age, weight, associated congenital anomalies, mechanical ventilation, perioperative pCO<sub>2</sub>, postoperative early and late complication are comparable with historical open thoracotomy. However MAS has a superadded advantage in markedly reduction in scar tissue, postoperative pain and no chest wall deformity.

**Conclusion:** This multi-institutional review provides a recent comparison of the approached to EA with TEF without any worse effect of thoracoscopy and competes well with traditional open thoracotomy approach. There is dramatic advancement of pediatric MAS over the last decade and the result are comparable with open thoracotomy in perioperative, postoperative and long-term outcome with potential advantages of less scar tissue, less postoperative pain, less disruption of anatomy and function and better cosmesis with markedly reduced musculoskeletal complication. Thoracoscopic repair is a promising adjunct, but there are difficulties for setting it as the open thoracotomy and it still needs more subjective studies with the consideration of learning curve and long surgical time. However, thoracoscopic repair of EA with TEF is a favorable and effective procedure with good prognosis.

**Keywords:** Thoracoscopy, Minimal access surgery, Esophageal atresia, Tracheoesophageal fistula.

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**Source of support:** Most of the center have changed the surgical approach for esophageal atresia with distal esophageal atresia from open traditional thoracotomy to minimal access surgery by thoracoscopic repair (references: 2, 12, 13, 14, 16).

**Conflict of interest:** There is also debate that traditional approach of tracheoesophageal atresia with distal esophageal fistula by thoracotomy as described by Burford M concluded as complication rates similar to thoracoscopic repair but increased rate of anastomotic leaks and greater need of anti reflux surgery. However no musculoskeletal sequelae were directly attribute to thoracotomy.

## INTRODUCTION

Esophageal atresia (EA), with or without tracheoesophageal fistula (TEF), occurs in three out of 1,000 live births.<sup>1</sup> The most common anatomic variant of EA is the presence of a tracheal fistula to the distant remnant of the esophagus. This type of TEF occurs in 85% of all infants born with EA. The common anomaly has been traditionally operated by classical right poster lateral thoracotomy. The first entirely thoracoscopic repair was reported by Lobe et al<sup>2</sup> in 1999 and described repair of EA in an 8-month-old patient. Rothenberg<sup>3</sup> has subsequently reported on a series of eight neonates with EA and distal fistula operated thoracoscopically. With the advancement of minimal access surgery in technology, engineering, fine instrument, optical magnification and surgical skill it provokes the pediatric surgeons to use the minimal access surgery in pediatric patient. To date, there have been few literature published of thoracoscopic repair of EA with TEF. Still it is unclear how much beneficial is thoracoscopic approach. This study describes the comparative results of 260 (Fig. 1) newborn babies from eight different institutes who underwent thoracoscopic repair of EA with TEF (Table 1) and compared it with the open classical method of thoracotomy from recent and historical group (Table 2).<sup>4-8</sup>

## RESULTS

The literature review from 2005 to 2012 were collected and 61 articles were selected but only eight papers were selected

due to number of patients and have control study either with open thoracotomy or historical review. There were some individual papers which mentioned only the outcome of minimal access surgery by thoracoscopy without control study.<sup>9,10</sup> Similarly, some studies have small number of patient also which were not included.<sup>11</sup> These data were collected from the literature and compared with the open thoracotomy approach based on text book and some recent literature (Table 1).

The review of literature showed no difference of minimal access (MAS) surgery between thoracoscopy (TR group) and open thoracotomy (OR group) in EA with TEF in regard of gestational age of patient, with average age of 2.7 to 3.5 days. Similarly, associated anomalies were almost same in both groups. Both groups operated premature babies successfully.

Ma Li<sup>12</sup> and Szavay<sup>13</sup> revealed a significant difference in operation time between TR and OR groups (185 vs 148 and open 106 vs 141 minutes), but Tariq<sup>14</sup> et al and Brian Lugo<sup>15</sup> did not find significant difference in operation time

between thoracoscopic and open thoracotomy group (179 and 123 minutes and 149 and 156 minutes respectively). Patkowski<sup>16</sup> reported higher time initially but significant improvement after gaining experience (mean 171 minutes for first 10 cases reduce to mean 98 minutes for last 13 cases).

Neonatal tolerance to pneumothorax with CO<sub>2</sub> showed hypercarbia 1 hour after the surgery in both groups, although ET CO<sub>2</sub> was higher in TR group but not reached to significant difference (Table 3).<sup>12</sup>

In other study the impact of CO<sub>2</sub> also showed almost same result by Mark Bishay<sup>17</sup> however in their study although the pH became normal at the end of surgery but the cerebral oxygen saturation decreased.

Szavay<sup>13</sup> in their studies found a significant difference of pCO<sub>2</sub> max in both groups with higher level in TR group (62 vs 48 respectively; p = 0.014) (Table 3).

Perioperative surgical complications were also mentioned in the literature including two tracheal injuries in TR group. No other perioperative complication is mentioned in the literature other than that in both groups.<sup>16</sup>

Postoperative ventilation and pain has been studied also but most of literature did not reach to significant difference. However Brian Lugo<sup>15</sup> found significant difference in TR and OR group in regard of postoperative ventilation (4.6 vs 19 days) and need of narcotics analgesia (5 vs 23.1 days).

Tariq et al<sup>14</sup> reported early postoperative complication which significantly happened in OR group with lung collapse, pneumonia, chylothorax, recurrent laryngeal nerve injury and wound infection.

Holcomb et al<sup>18</sup> and Burfurd et al<sup>4</sup> found longer hospital stay in OR group as compared to TR group (29 vs 18.1 days and 66 vs 21 days respectively). Tariq et al<sup>14</sup> found no difference in hospital stay.

The rate of anastomotic leak in either group in all literature did not reach to significant level and none of leak needed redo surgery and managed conservatively.

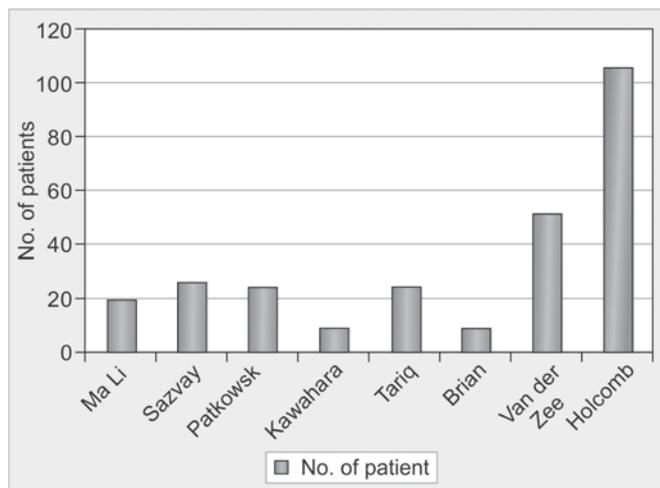


Fig. 1: The number of patient including in this series from different authors. The largest series is by Holcomb

	Ma Li	Szavay	Patkowski	Kawahara	Tariq	Brian	Van der Zee	Holcomb
Year	2012	2011	2009	2009	2008	2008	2007	2005
No. of patients	20	25	23	7	23	8	50	104
Mean gestational age (week)	39.0	35	NR	NR	36.3	39.9	37.2	2.6
Mean weight (kg)	2.6	2.09	2.298	2.814	2.735	2.7	2.620	1.2
Mean operative time	185	141	131	NR	149.4	157	178	129.9
Conversion	NR	NR	NR	NR	NR	1 (12.5%)	2 (4%)	0
Anastomosis leak	NA	—	3 (13%)	3 (30%)	4 (17%)	(1)(12.5)	9 (18%)	8 (7.6%)
Recurrent fistula	NA	—	0	0	2 (8.6%)	—	2 (4%)	2 (1.9%)
Stenosis	NA	—	4 (17%)	—	—	(1) 14%	2 (4%)	4 (3.8%)
Dilatation required	NA	—	4 (17%)	—	—	—	22 (45%)	12 (31.7%)
Antireflux surgery	NA	—	—	2 (28.5%)	—	—	11	26 (24%)
Death	NA	—	3 not related	—	1	—	1 (sepsis)	2 (0.9%)

**Table 2:** Comparison with open thoracotomy with recent studies done by Burford and historical study as control

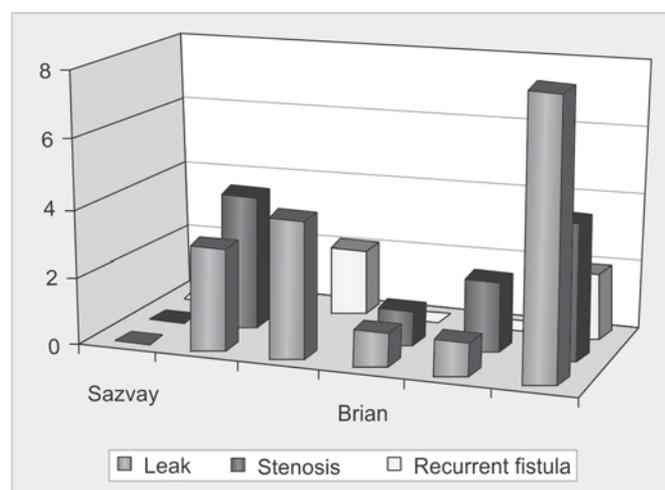
	Burford serried <sup>4</sup>	Historic contro <sup>5-8</sup>
No. of patient	72	340
Anastomotic leak	2.7%	17.9%
Stricture	5.50%	16.7%
Recurrent fistula	2.70%	7.9%
Fundoplication	12.50%	21%

Postoperative stricture formation is another squella of ES/TEF surgery. Holocomb et al<sup>4</sup> found a significant difference with lower rate in TR vs OR group (7.6% vs 17.9% respectively) (Fig. 2).

Gastroesophageal reflux is common after EA with TEF repair and needs to address. Nowadays all cases are treated medically however, a number of patients need antireflux surgery.<sup>19,20</sup> Holocomb et al<sup>4</sup> showed that 24% of thoracoscopy patient need fundoplication. The historical data showed fundoplication rate from 15 to 45%.<sup>5-8</sup> Burford et al<sup>4</sup> in his study of open thoracotomy mentioned 12.5% patient need fundoplication.

There is no difference in the incidence of recurrent fistula in either group and incidence is between 0 and 5%.

Few literature mentioned death but it is difficult to ascertain that whether it is pure surgical related or medical

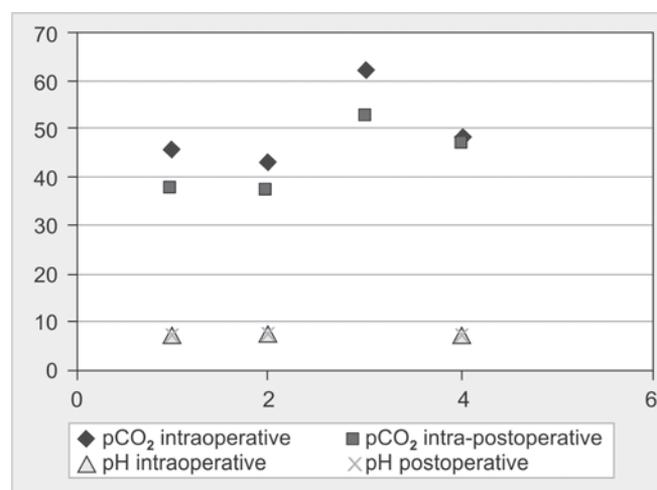
**Fig. 2:** Number of anastomotic leakage, postoperative anastomotic stricture and recurrent fistula in different studies in current study

related. The mortality by Tariq et al<sup>14</sup> was 3, Pakowaski et al<sup>16</sup> was 3, Van der Zee et al<sup>21</sup> was 2 but none of them is found due to surgical related.

Holocomb et al<sup>18</sup> and Burford et al<sup>4</sup> mentioned scoliosis and higher right shoulder deformity in OR group. None of the literature mentioned such complication in TR group.

## DISCUSSION

Advancement in the minimal access surgery have been used in adult for long time but later on it has been used increasingly in pediatric surgery.<sup>22</sup> This evolution lead the surgeon to address the most of the congenital anomalies by minimal access surgery and several report have revealed the safety in pediatric patients.<sup>23</sup> Initially it was hypothesized that neonate may not be able to tolerate the burden of CO<sub>2</sub> but comparative studies done by Ma Li et al<sup>12</sup> showed same ET CO<sub>2</sub> in TR and OR groups without any significant difference (Fig. 3). Although pCO<sub>2</sub> increased intraoperatively but reduced at the end of surgery. Similar studies were done by Matsunari<sup>24</sup> with the finding that thoracoscopy group had a higher incidence of intraoperative hypercapnia and acidosis and required higher inspired oxygen fraction but on admission to ICU Pa(CO<sub>2</sub>) was in the normal range

**Fig. 3:** Study done by Ma Li and Sazvay on intraoperative and postoperative pCO<sub>2</sub> and pH of thoracoscopic repair of EA with TEF showing that intraoperative and postoperative pH and pCO<sub>2</sub> had no significant differences**Table 3:** Comparison of pCO<sub>2</sub> and pH monitoring during open and thoracoscopic repair of EA with TEA. Clearly there is no significant difference between two groups

	Ma Li		Sazvay	
	*TR	**OR	*TR	**OR
pCO <sub>2</sub> (mm Hg) intraoperative	46 ± 8	43 ± 10	62	48
pCO <sub>2</sub> (mm Hg) at end of procedure	38 ± 5	37 ± 6	53	47
pH intraoperative	7.28 ± 0.06	7.30 ± 0.05	—	7.16
pH postoperative	7.32 ± 0.06	7.34 ± 0.07	—	7.20

\*TR: Thoracoscopic group; \*\*OR: Thoracotomy group

in both groups and there was no difference in the duration of mechanical ventilation and ICU stay. Preliminary studies by Mark Bishay et al<sup>17</sup> showed no difference in pCO<sub>2</sub> but mentioned that thoracoscopy may be associated with acidosis and decreased cerebral hemoglobin oxygenation saturation measured by near infra-red spectroscopy but still it is not clear and need more data.

The operative time is always long in MAS due to two factors, firstly the MAS is by default a slow surgery and secondly due to the learning curve. A detailed study done by David et al<sup>25</sup> of thoracoscopic repair of EA with TEF over 10 years, in which they have divided the thoracoscopy repair of EA with TEF in two periods of 5-year each. In all 10 years the duration of operative time remained unchanged. Initially due to learning curve and in second half the other members and fellows principally performed surgery under the supervision of the senior surgeon which again leads to same operative time.

Almost all literature mentioned postoperative anastomotic leak, which related to many factors from preoperative to postoperative patient course, but majority of these patient need conservative management. The anastomotic leak was almost same in both groups with average of 10 to 27%.<sup>4-8,13-16</sup> All the leak was mentioned minor leak and healed by conservative management.

Another strong association EA with TEF is with gastroesophageal reflux and is common problem after repair. This incidence of reflux is related to esophagus dysmotility, delayed gastric emptying,<sup>26</sup> there was controversy about the optimal treatment between nonoperative management to surgical intervention with fundoplication. Noteworthy now there is drop in fundoplication rate<sup>26</sup> which can be attributed to the increased use of H<sub>2</sub>-blockers and proton pump inhibitors. It was postulated that thoracoscopic repair of ET/TEF may lead to improved esophageal motility but Hisyoshi et al<sup>27</sup> did study between TR and OR group of EA with TEF showed that there were no significant differences in esophageal acid exposure [5.5% (0.7-24.6%) vs 3.7% (0.3-56.8%); p = 0.71] or mean esophageal acid reflux time [0.5 minutes (0.1-1.4 minutes) vs 0.5 minutes (0.1-1.3 minutes); p = 0.87] between the two groups. Fundoplication was conducted in two patients in each group (p = 0.60). There are unlikely to be benefits from thoracoscopic repair of EA in terms of postoperative esophageal motor function. A big advantage of MAS repair of EA with TEF is reduced musculoskeletal complication as compared to open thoracotomy<sup>28-31</sup> as 23% of patient developed winged scapula and 20% asymmetry of thoracic wall and 16% scoliosis was mentioned (but a recent study done by Burford et al<sup>4</sup> mentioned that in OR, two patient developed scoliosis

and two patient developed high right shoulder deformity; however no literature showed any of this complication in thoracoscopic patients operated for EA with TEF.

There are two main factors of survival/prognosis for neonates with EA with TEF, birth weight and presence of major cardiac anomalies. Infants with birth weight less than 1,500 gm had 20% less chance of survival compared with those weighting more than 1,500 gm at birth. Similarly, infants with a major cardiac anomaly had 20% higher mortality this is independent to surgical approach.<sup>32</sup>

## CONCLUSION

This multi-institutional review provide a recent comparison of approach to EA with TEF without any worse effect of thoracoscopy and compete well with traditional open thoracotomy approach. There is dramatic advancement of pediatric MAS over the last decade and the results are comparable with open thoracotomy in perioperative, postoperative and long-term outcome with potential advantages of less scar tissue, less postoperative pain, less disruption of anatomy and function and better cosmesis with markedly reduced musculoskeletal complication. Thoracoscopic repair is a promising adjunct, but the difficulties for setting it as the open thoracotomy still need more subjective studies with the consideration of learning curve and long surgical time. However, thoracoscopic repair of EA with TEF is a favorable and effective procedure with good prognosis.

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