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Title: Oesophageal Atresia: are "long gap" patients at greater anaesthetic risk?

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Abstract:

Background:

Long gap oesophageal atresia occurs in approximately 10% of all oesophageal atresia infants and surgical repair is often difficult with significant post-operative complications. Our aim was to describe the perioperative course, morbidity and early results following repair of long gap oesophageal atresia and to identify factors which may be associated with complications.

Method:

This is a single centre retrospective cohort study of consecutive patients with oesophageal atresia undergoing surgical repair at The Royal Children's Hospital Melbourne from January 2006 to June 2017.

Results:

Two hundred and thirty-nine consecutive oesophageal atresia infants included 44 long gap oesophageal atresia infants and 195 non-long gap infants. A high rate of prematurity (24.7%), major cardiac (17%), and other surgically-relevant malformations (12.6%) was found in both groups. The median age at oesophageal anastomosis surgery was 65.5 days for the long gap group vs. 1 day for the oesophageal atresia group (mean difference 56.8days, 95%CI 48.1-65.5 days, $p < 0.01$). Surgery for long gap oesophageal atresia included immediate primary anastomosis (n=10), delayed primary anastomosis (n=11), oesophageal lengthening techniques (n=12) and primary oesophageal

replacement (n=6). Long gap oesophageal atresia was not associated with an increased incidence of difficult intubation (OR 2.8, 95%CI 0.6-22.1 p=0.17), intraoperative hypoxaemia (OR 1.6, 95%CI 0.6-4.5p=0.32) or hypotension (OR 0.9, 95%CI 0.5-1.8 p=0.81). The surgical duration [177.7 vs. 202.1 min, mean difference (95% CI), 28 (5.5-50.4 min), p = 0.04] and mean duration of postoperative mechanical ventilation (107 vs. 199.8 hrs, mean difference (95% CI), 91.8 (34.5-149.1 hrs), p<0.01] were shorter for the non-long gap group. Overall in hospital mortality was 7.5% (15.9% long gap vs. 5.6% non-long gap oesophageal atresia OR 1.1, 95%CI 0.4-3.4, p=0.85).

Conclusion:

Long gap oesophageal atresia infants have a similar incidence of perioperative complications to other infants with oesophageal atresia. Current surgical approaches to long gap repair, however, are associated with longer anaesthetic exposures and require multiple procedures in infancy to achieve oesophageal continuity.

Key words: Oesophageal atresia; Thoracotomy; Thoracoscopy; Anaesthesia, endotracheal; Infant, newborn.

Clinical implications:

What is already known about the topic?

Induction of anaesthesia in infants with oesophageal atresia in the presence of a distal tracheo-oesophageal fistula risks preferential ventilation of the stomach, especially with large peri-carinal fistulas and co-existing high lung impedance. Infants with long gap oesophageal atresia represent a difficult surgical group and multiple surgical approaches have been described to achieve oesophageal continuity.

What new information this study adds:

Long gap oesophageal atresia infants were significantly more likely to be of lower gestational age, have lower birthweight and have higher perioperative mortality.

Long gap oesophageal atresia is not associated with a higher incidence of difficult intraoperative ventilation despite the fact oesophageal repair is achieved at an older age.

Introduction

Oesophageal atresia (OA) with or without tracheoesophageal fistula (TOF) occurs in 1:2500 to 4500 live births (1, 2). In a proportion of infants with OA, the gap between the two ends of the oesophagus is too great to allow initial primary repair, termed "long gap" OA. Long gap OA is variously defined as a gasless abdomen on initial x-ray (Gross type A or B) and/or a measured gap between the two ends of 3-3.5cm (or 3 vertebral bodies) or more(1, 3). Using these definitions long gap OA occurs in 8-10% of all cases of OA, or 1:40,000 live births (4). The surgical approach includes delayed primary anastomosis (at 3 months of age) with or without lengthening procedures such as the Foker procedure (traction suture oesophageal lengthening) or oesophageal replacement with gastric tube, gastric transposition, small bowel or colonic transposition (5-9). Long gap OA has been identified as having distinct constellations of co-morbidities and greater potential for long term hospitalisation (4, 10-12). Anaesthetic management of OA is challenging especially in infants with a distal tracheoesophageal fistula where preferential ventilation of the fistula may cause profound hypoxia and potentially gastric perforation (13, 14). In contrast, it is not known whether long gap OA represents a greater anaesthetic risk.

The primary aim of this study was to describe the management of long gap OA and to describe the complications that occur during operative repair. A secondary aim was to determine which factors are associated with perioperative complications.

Method:

This is a single centre retrospective cohort study of all patients with OA undergoing surgical repair at Melbourne Royal Children's Hospital (RCH) from January 2006 to June 2017. Patients were identified from the *Nate Myers Oesophageal Atresia database*, an existing log of patients with OA.

Data:

Information collected from patient medical records included patient demographics, perinatal factors, type of OA, other congenital anomalies, associated syndromes, the presence of major cardiac anomalies, age at surgery and type of repair. Anaesthetic charts were reviewed for general anaesthetic complications, difficulty with ventilation and intubation, the presence of intraoperative hypotension and surgical duration. We were also interested in the presence of post-operative hypotension, complications of central venous access devices inserted within 48 hours of surgery and the duration of postoperative ventilation which included ventilation in the neonatal intensive care unit (NICU)

Relevant definitions:

Anatomically OA cases were described by the Gross classifications which comprise isolated OA without TOF (7% Gross type A); OA with proximal TOF (1%, Gross type B); OA with distal TOF (85%, Gross type C); OA with proximal and distal TOF (3%, Gross D) and H-type TOF without OA (4%, Gross type E) (15-17). "Long gap" OA cases were defined as those with a gap between oesophageal segments of over 3cm (or 2 vertebral bodies), or a gap which precluded primary oesophageal anastomosis, or pure OA with no fistula (18).

The definition of a "major cardiac anomaly" followed that of the Spitz criteria, and included all congenital cyanotic heart disease, and non-cyanotic congenital heart disease requiring medical or surgical treatment(19). Intraoperative hypotension was defined as a 20% decrease in SBP or MAP from baseline, or where inotropes were required to maintain normotension.

Patients were also classified according to the risk groups defined by Spitz et al. namely group 1: birth weight > 1500 g, without major cardiac disease; group 2: birth weight < 1500 g or with a major cardiac disease; group 3: birth weight < 1500 g and with a major cardiac disease(19).

The presence of VACTERL association was diagnosed if at least 2 of the following were found in addition to the tracheoesophageal malformation: vertebral anomaly (V); anorectal malformation (A); and cardiovascular (C), renal (R) or limb (L) malformations, defects or anomalies(20).

Statistics:

Continuous variables were analysed using student's t-test or Wilcoxon's rank sum test in cases of heteroscedasticity or non-normality. Categorical variables were analysed using Fisher's exact test. A univariate regression analysis was used to determine the effect of patient variables potentially associated with anaesthetic complications. The type 1 error was set at 5% (2 sided) for all statistical tests. Stata 15 (College Station Texas USA) was used for data analyses.

Results:

We evaluated 239 consecutive infants with oesophageal atresia treated between January 2006 and June 2017. Patient demographics are summarised in table 1. The presence of additional congenital anomalies was common with similar incidences seen in both groups (86% of patients with long gap OA and 92% of non-long gap OA). Major congenital heart disease occurred in 32 infants (13.4%) and minor congenital heart disease in a further 41 infants (17.2%). Other common anomalies were VACTERL association [53 infants (22.2%)], and chromosomal anomalies [15 patients (6.3%)]. Surgically-relevant non-cardiac malformations were present in 33 infants (13.8%) and included 16 infants with anorectal malformations (6.7%) and 14 with duodenal atresia (5.9%). Thirteen ribs were identified in 14 infants.

Long gap OA infants were significantly more likely to be of lower gestational age (mean difference 2.3wks, 95%CI 1.2-3.3, P<0.001) have lower birthweight (mean difference 626 gms,95%CI 370-883, P<0.001) and have higher perioperative mortality (OR 3.2,95%CI 1.2-8.7, P=0.02).

Volatile anaesthetics were used for induction of anaesthesia in 38% of cases overall and 64% of cases when tracheo-bronchoscopy was performed by the surgeon prior to attempted anastomotic repair. There was no significant difference in the number of gas inductions between groups (long gap OA 31.8%, non-long gap OA 39.5%, OR 0.66 95%CI 0.33-1.3, p=0.34). Mean (SD) operative duration was significantly longer in the long gap OA group (mean difference 27.9 min,95%CI 5.5-50.5, p=0.03].

In the non-long gap OA group, 188 infants underwent primary anastomosis (96.4%), 2 underwent delayed primary repair (1.1%), 4 had a gastrostomy and/or fistula ligation and 2 infants had no surgery (1.1%) (Fig 1). In the long gap OA group, numerous surgical approaches were described (table 2). An extrapleural approach was used for all primary anastomoses and a trans pleural approach for anastomosis following Foker oesophageal lengthening if adhesions were present. Gastrostomy with or without fistula ligation was performed at a median of 1 (IQR 1-2) days and primary oesophageal anastomosis at 75.5 (IQR 3-100) days. Of the 12 infants who underwent the placement of traction lengthening sutures (Foker procedure or other traction-suture techniques), the average age at which this was performed was 24.5 (SD 16.6) days and oesophageal anastomosis was attempted on average 66.6 (SD 35.0) days later.

Perioperative complications are described in table 3. Central venous access devices (CVAD) were placed in 158 infants including 57 umbilical vein catheters, 124 peripherally inserted central catheters (PICC), 25 non-tunnelled central venous catheters and one broviac catheter. CVADs were removed early due to occlusion or malposition in 36 (22.1%). Most complications occurred in infants with 2F PICC lines (32 infants 25.8%). Univariate regression analysis was conducted to determine the effects of long gap OA, prematurity and low birth weight on perioperative anaesthetic complications (Table 4). Long gap OA was not associated with intubation difficulty (OR 1.2, 95%CI 0.5-5.1, P=0.36), intraoperative ventilation difficulty (OR 1.3, 95%CI 0.4-3.3, P=0.65) or intraoperative hypotension (OR 1, 95%CI 0.5-2.1, P=0.98). Mortality was strongly associated with low birth weight and prematurity.

Difficult airway management occurred in 7.1% and difficult intubation in 3.3%. Difficult intubation was not associated with long gap OA, low birth weight or prematurity. Intraoperative ventilation difficulties occurred in 28 infants (11.8%). All infants were paralysed prior to intubation attempts. The preferred intubation technique (nasal endotracheal tube) was not possible in 6 choanal atresia infants. Difficult ventilation was not associated with long gap OA, low birth weight or prematurity. Hypotension requiring colloid bolus or vasopressor occurred in 72 infants (30.2%) and was associated with prematurity (OR 2,1, 95%CI 1.0-4.2, p=0.04) but not long gap OA, low birth weight or major cardiac anomalies.

The postoperative in-hospital mortality rate was 7.5% overall, with a significantly higher mortality rate seen in the long OA group (15.9% vs 5.6%, OR 3.2, 95%CI 1.2-8.7, p=0.02). In hospital mortality occurred in 7 long gap OA patients. Of these, unmanageable respiratory failure and pulmonary hypertension occurred in 3 infants and 4 infants had treatment withdrawn after gastrostomy and fistula ligation had already been performed. The causes of death included severe intracerebral abnormalities (n=2), multi-organ failure (n=1) and sepsis (n=1). In the non-long gap OA group, there were 11 in-hospital deaths as a result of severe idiopathic pulmonary hypertension (n=5) and severe intracranial abnormality (n=4). A further two deaths occurred intraoperatively due to massive haemorrhage. Both occurred in infants of 25 weeks gestation and less than 1000g birth weight.

Discussion:

In this series, there was a high incidence of perioperative complications including difficult intubation, difficult ventilation and intraoperative hypotension but there were no significant differences between long gap OA and non-long gap OA infants. The high incidence of difficult intubation was predictable given the incidence of prematurity, CHARGE syndrome and Pierre Robin sequence in both groups. The incidence of difficult intraoperative ventilation was multifactorial. In the long gap OA infants with a distal TOF, hypoxaemia occurred until the fistula was ligated. In infants without a distal TOF, hypoxaemia occurred frequently during surgical dissection, even in those infants where primary repair was delayed until 3 months of age.

The surgical approach to oesophageal anastomosis contributed to the incidence of anaesthetic complications. Numerous oesophageal lengthening procedures have been reported, all of which aim to decrease the interval between diagnosis and oesophageal anastomosis (8, 21). Some series suggest anastomosis may be obtained as early as 14 days after thoracoscopic oesophageal lengthening procedures (22). In this series however, oesophageal lengthening procedures failed to decrease the gap between oesophageal ends and repair was delayed until 65 days of age. Even after this length of time, significant lung retraction was required to adequately dissect and mobilise the segments. The retraction required also impacted on intraoperative haemodynamics with a high incidence of hypotension in the long gap OA group. The long gap OA group were also likely to require multiple procedures in the neonatal period to achieve oesophageal anastomosis, and as a result, multiple anaesthetic exposures. There are concerns about the potential adverse effects of multiple anaesthetic exposures, and the associated hypotension and hypercarbia on neurodevelopment(23). Episodes of hypercarbia, hypotension and hypoxaemia during thoracoscopic oesophageal atresia repair are common but there is some evidence that cerebral oxygenation may be preserved. In two small observational series involving repair of type C OA, cerebral oxygenation measured by NIRS was maintained (24, 25).

All infants with OA are at risk of anaesthetic complications especially those of low gestation and low birth weight. Several surgical papers have suggested long gap OA represents a group at high risk of post-operative surgical complications including oesophageal leak and stricturing, but few report anaesthetic events (11, 26). The first oesophageal lengthening case series reported 70 infants with OA treated by primary repair. Ten of the patients had long gap OA of which 4 were treated with the Foker approach but no anaesthetic events were reported(27). It has been recognised that OA infants have significant co-morbidities and congenital anomalies which may impact anaesthetic management (28). In a 30 year review of the RCH cohort, approximately one third of all OA patients had recognised syndromes or associations, including 20% with VACTERL association and 11% with diagnoses such as CHARGE, Trisomy 21, Trisomy 18 and Trisomy 13(29). Anatomical variants of OA have a significant impact on anaesthetic complications especially long gap OA. It is recognised that the presence of a distal TOF risks preferential ventilation of the stomach, especially with large peri-carinal fistulas and co-existing high lung impedance. In the current series there were 3 cases of gastric or duodenal perforation which preceded surgical intervention, all in extremely low birth weight infants with pulmonary hypertension. This is consistent with another Australasian series of traditional open thoracotomy repair where seven cases of ventilatory difficulty included 3 cases where emergency gastric decompression was required (13).

Overall, in hospital mortality occurred in 7.5% of patients and was significantly associated with low birth weight, low gestational age at birth, pulmonary hypertension and weakly associated with the presence of a major cardiac anomaly. Other series report mortality rates of 14.2% despite having a cohort with no long gap OA patients(13). The mortality rate of the long OA group in the current series was significantly higher than the non-long gap OA group, largely due to a higher incidence of prematurity and post-operative ventilation failure. The long gap OA group also included 3 infants where treatment was withdrawn in light of coexistent neurological or major congenital anomalies.

This is consistent with data within the prognostic systems that seek to stratify operative risk. The Waterston classification stratifies infants into three risk groups based on birth weight (<2500g), pneumonia and congenital anomaly(30). The Spitz classification emphasizes the impact of low birth weight and the presence of major congenital anomalies, with survival ranging from 97% (birth weight >1500g) to 22% (Birth weight <1500g and major cardiac anomaly)(19). Current scoring systems suggest the presence of associated major cardiac malformations defines the risk of mortality with low birth weight of OA neonates being less important (31, 32). The Montreal classification of patients with oesophageal atresia suggests birth weight does not independently influence mortality, but severe pulmonary dysfunction with preoperative ventilator dependence and severe associated anomalies have a prognostic influence. Mortality of high-risk class II infants (life-threatening anomalies or both major anomalies and ventilator dependence) was 69% vs 7.3% for low-risk class I infants.

Limitations:

This study was limited by the retrospective nature of the data analysed. Due to the low incidence of long gap OA, patients were not evenly allocated between groups leading to potential bias. The imprecise definition of long gap OA and multiple surgical approaches made this a heterogeneous group and as result firm conclusions are difficult to make. A number of outcomes analysed, especially mortality, were not affected by anaesthetic management but are influenced by the presence of major co-morbidities and decisions to withdraw care. Factors associated with mortality all demonstrated large effect size and wide confidence intervals largely due to a sparse data effect where the number of events is low in combinations with independent and dependent variables.

Conclusions: Long gap OA infants have a similar incidence of perioperative complications to other infants with OA. Intraoperative vigilance is recommended especially in the low birth weight and low gestational age groups. Current surgical approaches to long gap OA repair have not been able to deliver better operating conditions at subsequent anastomosis and are associated with both longer anaesthetic exposures and multiple procedures in infancy to achieve oesophageal continuity.

Ethics statement:

This study was approved by the Human Research Ethics Committee of the Royal Childrens Hospital (HREC 36365A).

Disclosures:

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Any conflict of interest: all authors confirm no conflict of interest for this study.

Author contributions:

The corresponding author helped conceive, design and conduct the study, coordinate the data, contribute to the statistical analysis plan, interpret the data, and write and revise the manuscript. All authors (LP, JF, WT, JC, and GF) were involved either in the perioperative management of cases, collection of data, analysis of results and critically reviewing the manuscript. All authors read and approved the final manuscript.

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Fig 1. Surgical approach to oesophageal atresia (OA). Traction techniques group includes Foker and similar technique patients. One patient failed Foker oesophageal lengthening and underwent oesophageal replacement. Long gap oesophageal atresia (OA), RCH Royal Childrens Hospital.

			Non-long gap OA N=195	Long Gap OA N=44	Mean difference (95%CI)	Odds ratio (95% CI)
Gender	Male (%)		119 (61%)	32 (72.7%)		1.7 (0.8-3.5)
Gestation	Weeks mean (SD)		37.3 (3.0)	35.0 (3.6)	2.3 (1.2-3.3)	
Birth weight	Grams mean(SD)		2764.6 (807)	2138.2 (646)	626 (370-883)	
Antenatal diagnosis	Yes (%)		15 (7.7%)	20 (45.5%)		10 (4.5-22)
Anatomical types	Type A	Isolated OA	0	17		
	Type B	OA proximal fistula	0	6		
	Type C	OA distal fistula	182	21		
	Type D	OA dual fistula	5	0		
	Type E	H type	8	0		
Co-morbidities	Major Cardiac		26 (13.3%)	6 (13.6%)		
	Minor cardiac		35 (18%)	6 (13.6%)		1.1(0.5-2.6)
	VACTERL		40 (20.5%)	13 (29.6%)		1.6(0.8-3.4)
	CHARGE		4 (2%)	0 (0%)		
	13 Thoracic ribs		9 (4.6%)	5 (11.4%)		2.6(0.8-8.3)
	Chromosomal	Downs	2 (1%)	3(6.8%)		
		Other	7(3.6%)	3 (6.8%)		
	Pierre Robin Sequence		2 (1%)	0 (0%)		

Table 1. Demographics of infants with Oesophageal Atresia (OA) with or without Tracheo-oesophageal atresia (TOF). Anatomical classification uses Gross system. Major cardiac anomalies include cyanotic congenital heart disease and anomalies requiring surgical or medical intervention (VSD, PDA, and PFO). Dichotomous variables described with odds ratio continuous variables with mean difference.

Technique		Primary anastomosis (n=10)	Traction techniques (n=12)	Delayed primary anastomosis (n=11)	Gastrostomy +/-Fistula Ligation (n=4)	Oesophageal replacement # (n=6)
Anatomy	Type A	1	9	1	1	4
	Type B	0	3	1	0	2
	Type C	9	0	9	3	0
Antenatal diagnosis		3 (30%)	8 (66.7%)	3(27.3%)	1 (25%)	4(66.7%)
Intraoperative complications	Intubation/ Ventilation	2 (20%)	2 (16.7%)	1 (9.1%)	1 (25%)	1(16.7%)
	Hypotension	5 (50%)	1 (11%)	4 (25%)	1 (25%)	1(16.7%)
Operative duration (min)	Gastrostomy +/- Fistula ligation	0	125.2 (34.4)	193.6 (53.1)	146.2 (107.6)	130.8 (48.1)
	Foker sutures	0	207.9 (87.1)	0	0	115
	Primary anastomosis	233 (44)	203.5 (48.3)	205.9 (62.0)	0	260.8 (140.7)
Procedures	Median (IQR)	1	3 (2.5-3.5)	2	1	3 (2-4)
Postoperative	Ventilation hours mean (SD)	166.4 (114.9)	173.6 (277.9)	230.1 (302.5)	230.1 (335.0)	321.7 (487.4)

	CVAD complications	0 (0%)	3 (25%)	2 (18.2%)	0	1 (16.7%)
Mortality *		0 (0%)	2 (16.7%)	0 (0%)	4 (100%)	0 (0%)

Table 2. Surgical approach to long gap oesophageal atresia (OA). All values are mean (SD), median (interquartile range) or absolute value (%). Central venous access device (CVAD) complications included occlusion, infection or local thrombosis. # Traction techniques group includes Foker and similar technique patients. One patient failed Foker approach and underwent oesophageal replacement. * One patient died prior to any surgical intervention.

		Non-long gap OA (n=195)	Long gap OA (n=44)	Odds ratio # 95%CI	P value
Difficult airway	All	13 (6.6%)	5 (11.3%)	1.79(0.6-5.2)	0.28
	Choanal atresia	9 (4.6%)	2 (4.6%)	1.0 (0.2-4.7)	0.98
	Difficult Intubation	5(2.6%)	3 (6.8%)	2.8 (0.6-22.1)	0.17
	Fistula intubated	2 (1%)	0		
Ventilation complications	Gastric or Duodenal perforation	0 (0%)	3 (6.8%)		
	Fistula ventilated	5 (2.6%)	3 (6.8%)	2.8 (0.6-12.1)	0.16
	Hypoxaemia	17 (8.7%)	6 (13.6%)	1.6 (0.6-4.5)	0.32
	Extubation	3 (1.5%)	1 (2.3%)	1.5 (0.1-14)	0.73
	Pneumothorax	6 (3.1%)	1 (2.3%)	0.9 (0.1-7.7)	0.77
Hypotension	All	81 (41.5%)	17 (38.6%)	0.90(0.5-1.8)	0.81
	Inotrope/Colloid required	58 (29.7%)	14 (31.8%)	1.1(0.53-2.2)	0.78
Operative time	Minutes mean (SD)	178.7 (4.9)	202.1 (12.1)	27.9 (5.5-50.5) #	0.03
NICU ventilation	Hours median (IQR)	72.0 (50-114)	105.5 (65.5-176.5)	124.8(102-147) #	<0.01
CVAD complications	All	30 (15.4%)	6 (13.6%)	0.9 (0.28-2.4)	0.49
	Occlusion	29 (14.9%)	4 (9.1%)	1.2 (0.3-4.6)	0.32
	Thromboembolism	1 (0.5%)	2(4.6%)	0.6 (0.2-1.9)	0.03
Post-Operative complications	Mortality	11 (5.6%)	7 (15.9%)	3.2 (1.2-8.7)	0.02
	Pneumothorax	15 (7.7%)	8 (18.2%)	2.7 (1.1-6.7)	0.04

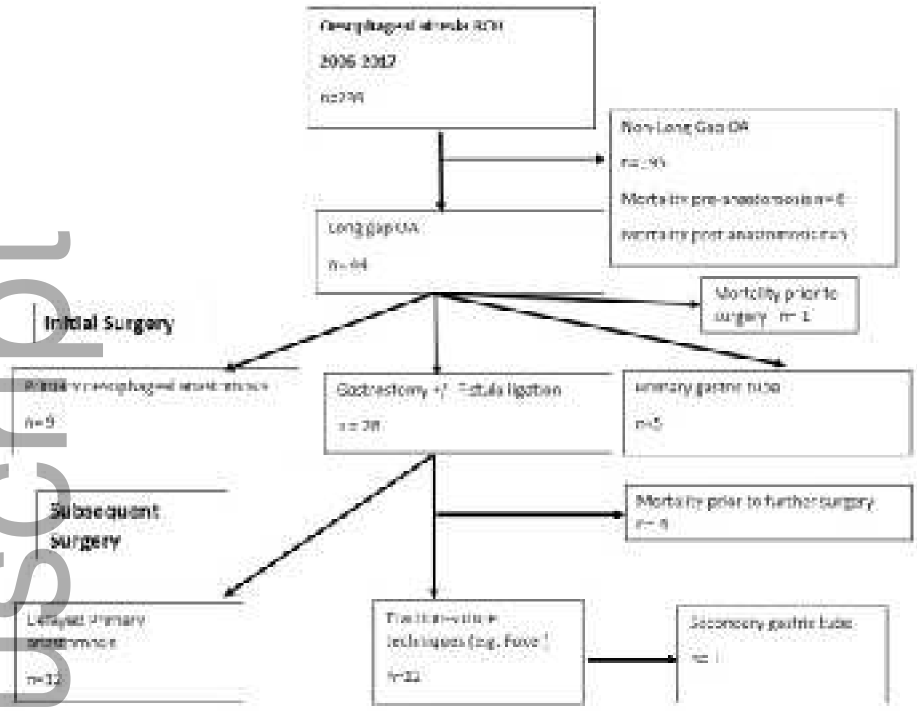
Tracheomalacia	20 (10.2%)	7 (15.9%)	1.4(0.6-3.5)	0.28
Vocal cord palsy	14 (7.2%)	3 (6.8%)	0.95(0.26-3.4)	0.93

Table 3. Perioperative complications in infants with Oesophageal Atresia (OA). Long gap OA is defined as either OA with no fistula, a gap between oesophageal segments of >3cm or more than 2 vertebral bodies or where primary anastomosis was not possible at first operation. Hypotension was defined as a 20% decrease in SBP or MAP from baseline, or where inotropes were required to maintain normotension. # Operative time included anaesthetic and surgical times and are presented as mean difference (95%CI). CVAD central venous access device, NICU neonatal intensive care unit.

	Variable	Odds Ratio	Std.Error.	P value	95% CI
Intubation	Gender (Male)	1.41	0.80	0.55	0.46-4.26
	Prematurity	2.18	1.48	0.27	0.54-8.76
	Low birth weight	1.42	1.12	0.45	0.30-15.7
	Long gap OA	1.16	0.20	0.36	0.54-5.14
Ventilation	Prematurity	0.70	0.55	0.65	0.15-3.20
	Low birth weight	3.08	2.24	0.12	0.74-12.8
	Long gap OA	1.27	0.52	0.65	0.43-3.25
	Chromosomal	2.10	0.93	0.08	0.90-5.0
Intraoperative Hypotension	Prematurity	2.10	0.76	0.04	1.02-4.20
	Low birth weight	1.1	0.61	0.83	0.38-3.25
	Cardiac Disease	0.95	0.36	0.89	0.45- 2.0
	Long gap OA	0.99	0.37	0.98	0.47-2.1
Mortality	Prematurity	4.34	2.5	0.01	1.36-13.8
	Low birth weight	5.67	3.56	<0.01	1.62-19.5

Long gap OA	1.11	0.63	0.85	0.36-3.41
Spitz Score [+]	4.96	1.74	<0.01	2.50-9.87
Cardiac Disease	3.10	2.05	0.09	0.84- 11.3
Ventilation failure [#]	52.08	60.06	<0.01	5.4- 499.3
Surgery	1.66	0.44	0.06	1- 2.78

Table 4. Univariate regression analysis of factors associated with adverse anaesthetic outcomes and mortality. For factors with a binary outcome the Odds ratio represents the presence or absence of the factor. Low birth weight defined as less than 1500grams, prematurity defined as less than 35 weeks gestation. Oesophageal atresia (OA). [+]Spitz score of 2 or 3 compared to score of 1. [#] Ventilation failure defined as inability to adequately ventilate despite complex ventilation modalities.



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