THE ANAESTHETIC MANAGEMENT OF TRACHEO-OESOPHAGEAL FISTULA: A REVIEW OF FIVE YEARS' EXPERIENCE

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THE CONGENITAL ANOMALY of tracheo-oesophageal fistula and oesophageal atresia was uniformly fatal until 1939, when Leven and Ladd, working independantly, successfully repaired the defect. Primary anastomosis of the oesophagus with closure of the fistula was reported by Haight in 1941. This surgical procedure,[1, 2] now standard, was first carried out at the Hospital For Sick Children in Toronto, late in the year 1944.[3]

The problems of anaesthetic management of such patients have been previously reported in several centres.[4-9]

It is the purpose of this paper to review our experience with the 104 cases of tracheo-oesophageal fistula which were treated surgically at the Hospital For Sick Children during the period 1959 to 1963 (Table I).

TABLE I

TRACHEO-OESOPHAGEAL FISTULA WITH OR WITHOUT OESOPHAGEAL ATRESIA

Year	No. of cases
1959	19
1960	17
1961	25
1962	25
1963	18
Total for 5-year period	104

TYPES OF ANOMALY

Tracheo-oesophageal fistula and oesophageal atresia are interrelated anomalies which occurred in 112 cases during the five-year period. The anatomical classification shown (Fig. 1) is based on the frequency of occurrence.

The most common anomaly in this series was that in which there was an oesophageal atresia and a fistula between the trachea and the distal segment of the oesophagus (type I or Gross' type C). This accounted for 100 of the 112 cases reviewed (86.2%).

There were 12 cases (10.3%) of type II, with complete oesophageal atresia without a tracheo-oesophageal fistula. These cases were not included in the present review.

Type III consists of those cases with a tracheo-oesophageal fistula without atresia of the oesophagus—the so-called H-type fistula. There were 3 cases of this type (2.5%). Types IV and V are quite rare. There was only one case in this

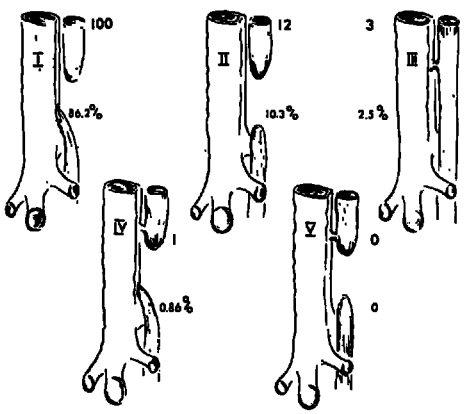

FIGURE 1

series in which there was oesophageal atresia and associated fistulae connecting the proximal and distal segments to the trachea. There were no cases in which there was only a fistula between the proximal oesophageal segment and the trachea.

DIAGNOSIS

Early diagnosis is important so that this correctable anomaly can be presented for surgery while the patient is in the best possible condition, particularly with respect to pulmonary complications.

The classical signs in the newborn are excessive salivation and choking with the first feeding. The presence of oesophageal atresia may be confirmed by the attempt to pass a #10 to #12 Fr. catheter. X-ray studies with contrast media will further support the diagnosis and give additional information as to the type of lesion present.

The typical diagnostic X-ray picture is seen in Figure 2. The proximal oesophageal segment is outlined, and the presence of air in the stomach indicates the probability of a type I lesion with a distal tracheo-oesophageal segment.

PREOPERATIVE FACTORS INFLUENCING SURVIVAL

The three main preoperative factors influencing survival are (1) associated congenital anomalies, (2) prematurity, and (3) the degree of pulmonary involvement.

1. Significant associated congenital anomalies occurred in 28 cases (Table II). The most common system involved was the gastrointestinal tract. The most common anomaly in this group is an imperforate anus. Omphalocele, duodenal atresia, and Meckel's diverticulum also occurred. The necessity for a second surgical procedure increased the risk in these patients. The most common anomalies in the cardiovascular system were ventricular septal defect, coarctation of the aorta, and patent ductus arteriosis. Genitourinary anomalies included were absent or non-functioning kidneys. A further miscellaneous group included

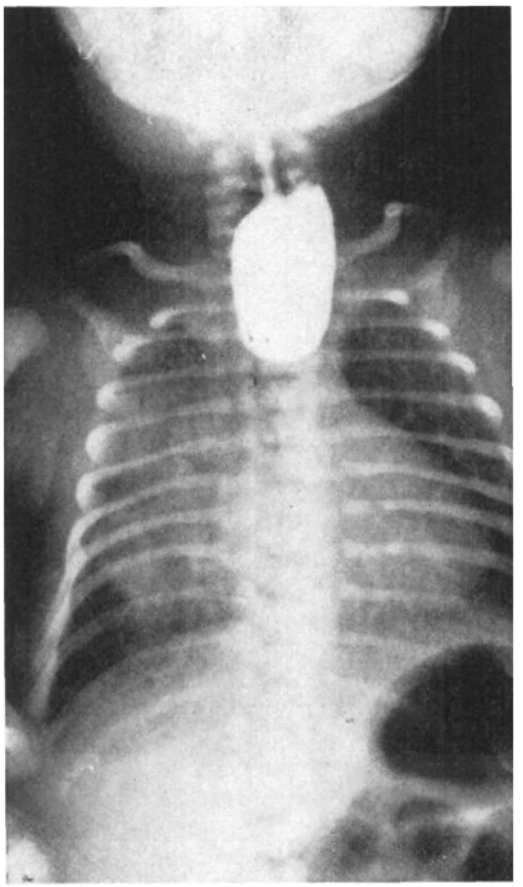

FIGURE 2

TABLE II

ASSOCIATED CONGENITAL ANOMALIES, 1959–1963

Condition	No. of cases
Cardiovascular (V.S.D., coarctation, P.D.A.)	5
Multiple gastrointestinal	5
Genito-urinary (absent or non-functioning kidney)	6
Imperforate anus	10
Cleft palate and lip	6
Erythroblastosis requiring exchange	1
Subdural Haemorrhage	1
Mongoloid	1

six with severe cleft palate and lip, one subdural haemorrhage, one mongoloid, and one case of erythroblastosis foetalis requiring exchange transfusion.

2. A birth weight of less than 2500 gm. was taken as being indicative of prematurity. It is recognized, however, that the degree of prematurity is not always reflected accurately in the birth weight. Of the 104 cases, 40 were in the group weighing less than 2500 gm., and 64 were 2500 gm. or over (Fig. 3).

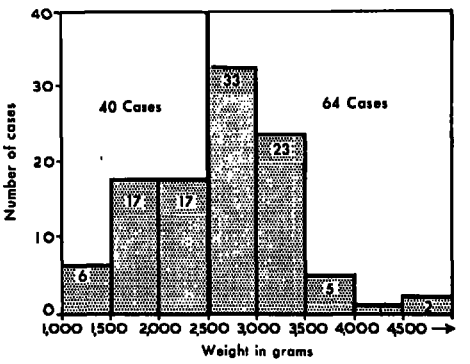

FIGURE 3

3. In one-third of the cases, pulmonary involvement was detected and confirmed by X-ray. Aspiration of secretions or feeding from the proximal oesophageal segment commonly occurs in such cases. This may result in atelectasis or lobar pneumonia, particularly of the right upper lobe. Regurgitation of gastric juice through the fistula is more serious. This may result in widespread pneumonitis which is often resistant to treatment.

RESULTS

The over-all survival rate in this series (Table III) was 63.5 per cent, with a 36.5 per cent mortality. If the mature group or those over 2500 gm. are considered separately, the survival rate here was 76.6 per cent with a 26.4 per cent mortality. On the other hand, in the premature group, or those under 2500 gm., the survival rate was only 42.5 per cent or approximately half that of the mature group.

TABLE III

TOTAL MORTALITY, 1959–1963

	No. of patients	Survivors		Deaths	
		no.	%	no.	%
Total	104	66	63.5	38	36.5
<2500 gm.	40	17	42.5	23	57.5
>2500 gm.	64	49	76.6	15	23.4

Results in the premature group are shown in Table IV. In the group of 16 patients in which there were no associated anomalies or pulmonary complications, the survival rate was 68 per cent, the mortality being slightly under half that of the whole premature group, or 31.2 per cent. However, one notes that the presence of pulmonary complications doubles this mortality, and the presence of associated anomalies either alone or with pulmonary complications almost triples it.

TABLE IV

MORTALITY IN PATIENTS LESS THAN 2500 GM.

	No. of patients	Survivors		Deaths	
		no.	%	no.	%
Total	40	17	42.5	23	57.5
Anomalies plus pulmonary complications	5	1	20	4	80
Significant anomalies	11	3	18	9	82
Pulmonary complications	8	3	37.5	5	62.5
No anomalies or pulmonary complications	16	11	68.8	5	31.2

A similar relationship is seen in the mature group (Table V). In the group without anomalies or pulmonary complications the survival rate was 87.5 per cent, with a mortality half that in the total mature group, or 12.5 per cent. Here again, the presence of pulmonary complications almost doubled the figure, and the presence of other significant anomalies more than tripled the mortality figures.

TABLE V

MORTALITY IN PATIENTS MORE THAN 2500 GM.

	No. of patients	Survivors		Deaths	
		no.	%	no.	%
Total	64	49	76.6	15	23.4
Anomalies plus pulmonary complications	3	2	66.7	1	33.3
Significant anomalies	9	4	44.5	5	55.5
Pulmonary complications	20	15	75	5	25
No anomalies or pulmonary complications	32	28	87.5	4	12.5

These figures would bear out the opinion that the fate of many such infants is probably determined before operation is undertaken.[8] The prognosis is good unless there are associated anomalies, a significant degree of prematurity, or undue delay in diagnosis, with widespread pulmonary involvement.

PREOPERATIVE PREPARATION

Following diagnosis, oral feeding was discontinued, and the infants were nursed in a semi-upright position, in which position it is felt that regurgitation of gastric juice is less likely. Secretions in the upper pouch were controlled by frequent careful suctioning. Fluid balance is not usually a major problem because the normal neonatal fluid requirements are low and electrolyte depletion is not a problem as with lower gastrointestinal obstruction in which vomiting is a feature.

These cases were presented for surgery as soon as possible following diagnosis. The majority (Fig. 4) were under 48 hours of age. It was felt that prolonged attempts to treat pulmonary complications were unlikely to be successful until the fistula was closed and oesophageal continuity restored.

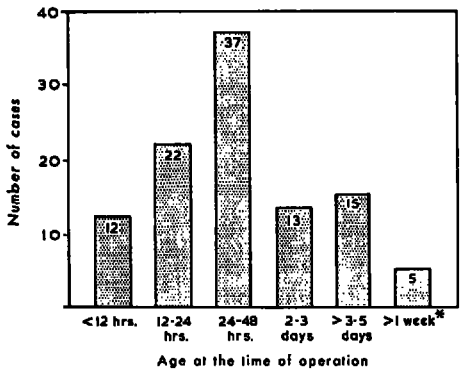

FIGURE 4

The most common surgical procedure was a transthoracic, transpleural ligation of the fistula, and oesophageal anastomosis (85 cases). In two cases an extrapleural approach was used and in three cases an H-type fistula was ligated by a cervical approach.

In the very premature group and in those with marked bilateral pneumonia, pneumonitis, or respiratory distress syndrome, a delay in the definitive procedure may be advisable. An initial gastrostomy or an extrapleural ligation of the fistula and gastrostomy may be preferred. Oesophageal anastomosis is undertaken when the condition has improved sufficiently.

Staged procedures were carried out in 14 of these cases and in only two was an initial gastrostomy done without ligation of the fistula. The results in these cases would seem to indicate that the procedure adopted is not the whole answer, and final judgment on the advisability of a staged procedure is still reserved.[10]

ANAESTHETIC MANAGEMENT

Atropine was administered preoperatively (0.02 mg./kg.) and a venous cut-down was prepared. If there was evidence preoperatively of gross endobronchial exudate or pulmonary atelectasis, bronchoscopy could be performed prior to induction.[11] The average anaesthetic time was 2 hours, 18 minutes, with a range of 1¼ to 4 hours.

The induction techniques used during the period under review were of three types. Inhalation induction prior to intubation was used in 40 per cent of cases. A muscle relaxant was used prior to intubation in 33 per cent of cases, and in 25 per cent awake intubation was carried out. In only two cases was an intravenous induction agent used.

At the present time our procedure of choice is an intubation awake followed by careful tracheobronchial suction before proceeding with an inhalational induction. Care is exercised that the gastrointestinal tract is not inflated through the fistula. To facilitate suctioning, the endotracheal tube should be the largest size which can be inserted easily. Under no circumstances must any force be applied to facilitate introduction of the tube. It should be remembered that the narrowest portion of the infant airway is at the cricoid ring and not at the glottis. There has been some suggestion that cricoid narrowing may be an anomaly associated with tracheo-oesophageal fistula.

In the majority of cases, a 3.5 mm. portex endotracheal tube was used, a 3.0 mm. being the next most frequently used. The range was 2.5 to 4.0 mm. When the Cole-type tube was used, 14 Fr. was the most common, with a range of 10 to 16 Fr.

Postoperative subglottic oedema was not reported in this series.

The anaesthetic agent used depends on the preference and experience of the anaesthetist and on the condition of the patient. Halothane was used as the sole agent in 70 per cent of cases, and in combination with ether in 20 per cent. Ether was used in 8 per cent and methoxyflurane in 2 per cent of the cases. At the present time, non-explosive agents are used exclusively. Ventilation is controlled using a modified T-piece arrangement with an open-ended bag. In the poor-risk patient, N_2O and O_2 with intermittent muscle relaxant may be used. In a critical situation the infant may be hyperventilated with 100 per cent oxygen.

Supplementary muscle relaxant was used in just over 50 per cent of cases. A dilute solution of succinylcholine (2 mg./c.c.) was administered as required, and the average amount used was 16 mg.

Blood pressure and cardiac rate and rhythm are carefully monitored in this procedure. It is also important to monitor the air entry in the left chest, and this may be done satisfactorily by positioning a small stethoscope in the left axilla. Temperature control is given careful attention.[12] Warm solutions for surgical preparation and a warming blanket are used in an attempt to maintain normothermia. The importance of temperature control of the patient and his environment has been underlined by recent evidence that the neonate may respond to the cooling effect of his environment with an actual increase of oxygen consumption. This may occur even when normothermia is maintained.[13]

Blood loss is determined by measurement of suction loss and the weighing of sponges. In the cases which we studied, blood replacement ranged from 15 to 200 c.c. with an average of 68 c.c. This represents 25 c.c./kg. or about 30 per cent of the blood volume.

Bronchoscopy is performed immediately post-operatively when endobronchial secretion has been a problem during the procedure, or when it is impossible to achieve full inflation of the lungs at the end of the procedure.

Complications during Operation (Table VI)

Difficulty with intubation was reported in two cases. Repeated intubation of the fistula occurred once, and in another case subglottic narrowing was reported.

TABLE VI

COMPLICATIONS DURING OPERATION

Complication	No. of cases
Difficult intubation	2
Inflation of the stomach	0
Accidental extubation	1
Atelectesis (unable to inflate)	1
Administration of aminophylline(?)	1
Cyanosis and bradycardia during intubation (P.M. showed V.S.D. and P.D.A.)	1
Prolonged period of hypotension (P.M. showed bilateral adrenal haemorrhage)	1
Cardiac arrest	6

Accidental extubation occurred on one occasion. Marked distension of the stomach from artificial ventilation, in association with a fistula, is an occasional complication. Bradycardia and cyanosis was noted during induction of one case with a large ventricular septal defect and a patent ductus arteriosis. Bilateral adrenal haemorrhage was detected at post-mortem examination in one case that had a prolonged period of hypotension during the procedure. The one patient in which there was a persistant lobar atelectasis illustrates the necessity for frequent full inflation of the lungs during the procedure to reduce the possibility of postoperative atelectasis.

Aminophylline was given during operation in one case. Since bronchospasm is a rare complication in paediatric anaesthesia, problems with ventilation are usually the result of airway obstruction. The tube or bronchus may be partially obstructed with blood or secretions, perhaps requiring replacement of the obstructed tube. Another possible cause is kinking of the left main bronchus due to enthusiastic retraction of the right lung.

A total of six cardiac arrests were reported, with one operating room death occurring in a two-pound premature infant with sclerema. In two of these cases, it is interesting to note, there were repeat arrests during a second surgical procedure on the following day, and in neither case was resuscitation successful.

POSTOPERATIVE CARE

In the postoperative period, care must be directed to the prevention and management of pulmonary complications. Skilled nursing care is extremely important. A careful programme of chest physiotherapy was instituted, which involved turning, percussion, and suction. The pharynx was suctioned with a catheter marked in length so as not to damage the site of the anastomosis. Awake intubation may be performed by the anaesthetist for tracheobronchial suction when required. As an aid in the assessment of the adequacy of ventilation, pH and P_{CO_2} determination were obtained using the Astrup micro technique. If there were any problems in the immediate post-operative period the endotracheal tube was left in place to facilitate suction and ventilatory assistance. When

assisted or controlled ventilation was required, a nasotracheal tube was used. It is now known that an endotracheal tube may be left in place in this age group for much longer periods than had been formerly appreciated.[14-16] Tracheotomy is now infrequently performed.

In this present series, 12 infants were managed with a respirator for varying periods of time. In an additional 5, the endotracheal tube was left in place for a short period of time. Tracheotomy was performed in only 5 cases.

A gastrostomy was usually performed 24 to 28 hours following the repair, and gastrostomy feedings were started the next day.

Mortality

Of the 38 deaths, 21, or 55 per cent, occurred in the first 48 hours. Thirty-one, or 80 per cent, occurred within the first postoperative week (Table VII). The causes are shown in Table VIII. Pulmonary complications form the largest group (Table IX). In the congenital anomaly group there were three patients with large ventricular septal defects and one genito-urinary abnormality incompatible with life.

TABLE VII

Time of Death, 38 Cases (36.5%)

Time	No. of cases
During surgery	1
Within 24 hours	12
Between 24 and 48 hours	8
Between 48 hours and one week	10
After one week	7

TABLE VIII

Causes of Death, 38 Cases

	No. of cases
Pulmonary complications (atelectesis, pneumonia, pneumothorax)	27
Congenital anomalies (G.U., C.V.S.)	4
Infection (liver abscess at 3 months)	1
Subdural haemorrhage with postoperative aspiration	1
Cardiac arrest	5

TABLE IX

Deaths Due to Pulmonary Complications, 27 Cases

Complication	No. of cases
Pneumonia	11
Atelectesis	4
Gross aspiration of feeding	3
Tension pneumothorax	3
Severe preoperative chest condition	3
Premature with R.D.S.	1

There were five deaths following cardiac arrest. A two-pound infant with sclerema died in the operating room. Two died early in the postoperative period following resuscitation in the operating room. Two deaths followed repeated arrests during colostomy for imperforate anus the following day.

It is of particular interest to note the group of patients weighing 2500 gm. and over with neither associated anomalies or pulmonary involvement preoperatively. Although one would hope for a 100 per cent survival rate, in this series it was 87.5 per cent. There were four deaths. Two occurred in the 24- to 48-hour postoperative period. In one of these cases, a persistant lobar collapse required bronchoscopy at the end of the procedure. This infant expired following repeated respiratory problems. In the other case aspiration occurred, followed by massive atelectasis and death. A third patient died on the third day as a result of a breakdown of the anastomosis and lobar pneumonia. The fourth died two weeks following the operation, with a leak at the site of the anastomosis. Pneumonia and tension pneumothorax occurred.

Summary

The features relative to the anaesthetic management of 104 cases of tracheo-oesophageal fistula have been reviewed. The over-all survival rate in this series was 63.5 per cent. The three main preoperative factors influencing survival are: (1) associated congenital anomalies, (2) prematurity, and (3) the degree of pulmonary involvement. In the mature group without associated anomalies or a significant degree of pulmonary involvement, the survival rate is 87.5 per cent.

Résumé

Cet article analyse l'expérience dans la conduite de l'anesthésie chez 104 malades porteurs de fistule trachéo-œsophagienne opérés à l'hôpital des enfants malades, à Toronto, de 1959 à 1963.

Dans le cas de fistule trachéo-œsophagienne, il est bien important de faire le diagnostic précocement pour que le malade qu'on présente à la chirurgie soit dans le meilleur état possible, surtout en ce qui concerne les complications pulmonaires. Trois facteurs préopératoires principaux peuvent influencer la survie. Ce sont: (1) les anomalies congénitales associées; (2) la prématurité; (3) le degré de l'atteinte pulmonaire.

Dans cette étude, 40 malades sur 104 pesaient moins de 2500 grammes; ils étaient considérés comme prématurés. Le tiers de ces cas présentaient une pathologie pulmonaire confirmée par la radiologie. L'atteinte pulmonaire est habituellement due à l'aspiration de sécrétions ou de débris alimentaires venant du segment proximal de l'œsophage ou à l'aspiration du contenu gastrique régurgité par la fistule.

Le taux général de survivance dans cette série a été de 63.5 pour cent. Dans le groupe de bébés à terme, 76.6 pour cent ont survécu, tandis que, chez les prématurées, le taux de survivance n'a été que de 42.5 pour cent. Ces résultats sont influencés par la présence d'anomalies associées ou par des complications pulmonaires, comme le montrent les Tableaux IV et V.

Lorsque le diagnostic est fait, l'alimentation orale est discontinuée et les bébés sont gardés en position semi-assise où, vraisemblablement, la régurgitation du contenu gastrique n'a pas lieu. On les opère le plus tôt possible une fois le diagnostic fait et la plupart n'ont pas encore atteint 48 heures.

Avant l'opération, nous donnons de l'atropine à raison de 0.02 mg./Kg. et nous faisons une dissection veineuse.

Nous avons fait une induction par inhalation avant l'intubation chez 40 pour cent des cas concernés dans cet article, nous avons employé un myorésolutif avant l'intubation chez 33 pour cent des malades et avons intubé 25 pour cent des malades sans anesthésie. Actuellement, la méthode de choix consiste à intuber le malades sans anesthésie, à faire une toilette soignée de l'arbre respiratoire et, ensuite, à faire l'induction par inhalation. Il faut faire attention de ne pas insuffler le système gastro-intestinal à travers le fistule. Le tube endotrachéal doit être le plus gros que la trachée puisse tolérer facilement. L'échelle de diamètre des tubes allait de 2.5 millimètres à 4 millimètres; un tube de 3.5 millimètres a été celui que nous avons employé le plus souvent. Nous avons employé l'halothane seul chez 70 pour cent des malades et en association avec l'éther chez 20 pour cent des cas. Nous avons employé l'éther chez 8 pour cent des malades et le méthoxyflurane chez 2 pour cent. Nous avons contrôlé la ventilation en employant un tube en T modifié, assemblé avec un ballon au bout ouvert. Chez les mauvais risques, il est possible d'employer seulement du protoxyde d'azote et de l'oxygène et, de façon intermittente, des myorésolutifs. Nous avons enregistré la tension artérielle, la vitesse et le rythme cardiaques; il est également important de vérifier l'entrée de l'air dans le poumon gauche.

Nous conseillons de porter une attention toute particulière à la température. Dans cette série, l'échelle du remplacement de sang est allée de 15 ml. à 200 ml., avec une moyenne de 68 ml. Cela représente environ 30 pour cent du volume sanguin. Nous faisons une bronchoscopie immédiatement après l'opération lorsque des sécrétions endobronchiques nous ont posé des problèmes durant l'opération, ou encore lorsqu'il est impossible de réussir à gonfler totalement les poumons à la fin de l'opération. Au cours des suites opératoires, il faut concentrer son attention sur la prévention et le traitement des complications pulmonaires.

Sur les 38 morts, 55 pour cent sont survenues au cours des 48 premières heures et 80 pour cent au cours de la première semaine postopératoire. Les complications pulmonaires ont été la cause la plus fréquente de décès.

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