

# Adult outcome of congenital lower respiratory tract malformations

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## Summary

In this article, the most important lower respiratory tract malformations are briefly reviewed, with special focus on those factors that may have some impact on the long-term respiratory outcome of specific lesions, like the amount of lung tissue resected, compensatory lung growth, lung hypoplasia, intensive care and mechanical ventilation.

*Key words: bronchogenic cyst; cystic adenomatoid malformation; congenital diaphragmatic hernia; congenital lobar emphysema; lung cyst; pulmonary sequestration; sequelae; tracheo-oesophageal fistula*

## Introduction

Congenital malformations of the lower respiratory tract, infrequent but fascinating disorders of lung development, today are usually diagnosed and managed antenatally, in the newborn period, in infancy, or in childhood. In a small number of patients, such malformations may go unrecognised in infancy and childhood [1–4]. In the latter cases, late complications such as recurrent localised pneumonitis, abscess formation, and haemoptysis, or the coincidental discovery on a chest radiograph may lead to a diagnosis in adolescence or adulthood.

A discussion of very rare malformations of the lower respiratory tract is beyond the scope of this review. The manuscript is based on a lecture given at the 2005 Annual Conference of the Swiss Society of Pneumology, the Swiss Society of Thoracic Surgery, and the Swiss Society of Sleep Research, Sleep Medicine and Chronobiology, and in part on a review article published in *Thorax* 2001;56: 65–72.

## Tracheo-oesophageal fistula (TOF)

In most cases TOF occurs in association with oesophageal atresia, resulting in a fatal outcome without surgical repair of the anomaly. In contrast, the rare “H-type” TOF without oesophageal atresia is compatible with survival beyond the neonatal period and may go undiagnosed for months, years, or even decades [3]. About half of all infants with TOF show associated anomalies, which most often involve the urinary, gastrointestinal, or cardiovascular system, eg the VATER or VACTERL association (vertebral defects, anal atresia, cardiac anomalies, tracheo-oesophageal fistula, renal anomalies, limb anomalies) [5]. In the last decades, the surgical and perioperative management of TOF patients has improved progressively; the chances of survival are now nearly 100% for those infants without other severe anomalies [5, 6].

### Outcome of TOF

Patients tend to show continued respiratory morbidity after TOF repair. Structural anomalies of the tracheal wall, ie disrupted cartilage rings and a concomitant increase in the membranous portion, result in tracheomalacia of varying severity that in most patients persists beyond surgical repair [7]. Oesophageal function tends to be disturbed after surgery as well, with absence of the

### Abbreviations

CAM:	Cystic adenomatoid malformation
CDH:	Congenital diaphragmatic hernia
CLE:	Congenital lobar emphysema
RV:	Residual volume
TOF:	Tracheo-oesophageal fistula
TLC:	Total lung capacity

normal peristaltic wave, atonia, and pooling of oesophageal contents [6]. These persisting defects in tracheal and oesophageal structure and function are the basis of a chronic morbidity in infancy and childhood, which may occasionally extend into adolescence and adulthood. Chronic respiratory symptoms are common in the first years after TOF repair. The most typical of these symptoms is a brassy, seal-like cough (“TOF-cough”) that is attributed to residual tracheomalacia. In rare cases, severe tracheal instability may cause life-threatening apneic spells [7]. In many patients, recurrent bronchitis and pneumonitis are also observed [7]. With growth, however, tracheal stability tends to increase in most patients and respiratory symptoms decrease concomitantly in both frequency and severity. When reaching adulthood, most patients have little or no respiratory symptoms [8, 9]. Even those with major problems in infancy tend to grow into a normal or near-normal life with few respiratory restrictions in sports or social activities [10]. In contrast, dysphagia, gastro-oesophageal reflux and oesophagitis tend to persist into adolescence and adulthood in many former TOF patients

[5, 7–9]. Lung function testing in TOF survivors usually shows a restrictive respiratory impairment, thus indicating lower respiratory tract pathology [8–10]. Reduced lung growth after surgery has been suggested as an explanation of the lung function findings [10]. Another explanation is suggested by the observation that the frequency of bronchitis and pneumonitis episodes and the severity of dysphagia appear to correlate in former TOF patients [8], indicating that some patients tend to aspirate recurrently after TOF repair. The occasional observation of scoliosis in former TOF patients is thought to be a non-specific long-term consequence of thoracotomy [11]. However, associated vertebral defects in up to 50% of TOF patients [12] might have a predisposing role in the development of scoliosis.

Patients with an “H-type” TOF tend to suffer from bouts of coughing after drinking, retrosternal pain, recurrent pneumonitis, and haemoptysis [3]. Even in an adult, TOF should be included into the list of diagnostic possibilities when such symptoms occur.

### Cystic malformations

This subsection comprises a spectrum of different congenital malformations of the lower respiratory tract (table 1). The common denominator of these lesions is that cysts may (but not necessarily have to) constitute a prominent part of the anomaly. The nomenclature of these disorders was never very clear. Recently, a reappraisal of the nomenclature of congenital lung disease was suggested [13].

#### Lung cyst

This is also referred to as “congenital parenchymal cyst” and represents a localised malformation of the terminal bronchopulmonary airway. Depending on its origin, a lung cyst may be of a bullous alveolar type, or its wall may contain bronchial elements such as cartilage, smooth muscle, and glands [14]. Lung cysts may occur as a single or multicystic lesion. Moreover, they may or may not communicate with the bronchial tree, and thus can contain fluid, air, or both (figure 1).

The most frequent complication is infection (protracted pneumonitis including formation of abscesses). Enlarging cysts may cause compression of the surrounding lung tissue, resulting in atelectasis. Occasionally, a lung cyst may rupture into the pleural space and lead to pneumothorax [12].

Depending on the development of complications the clinical manifestation of lung cysts may vary. While large lesions tend to cause symptoms in the newborn period or in infancy, other lung cysts may remain asymptomatic for many years. Some are only diagnosed coincidentally when a chest radiograph is done for other reasons.

The routine treatment of lung cysts is surgical resection, especially if the malformation has already caused complications. However, if the lesion is small, has not yet caused complications, or has been diagnosed by chance, many paediatric pulmonologists will tend towards an expectant non-surgical management [12].

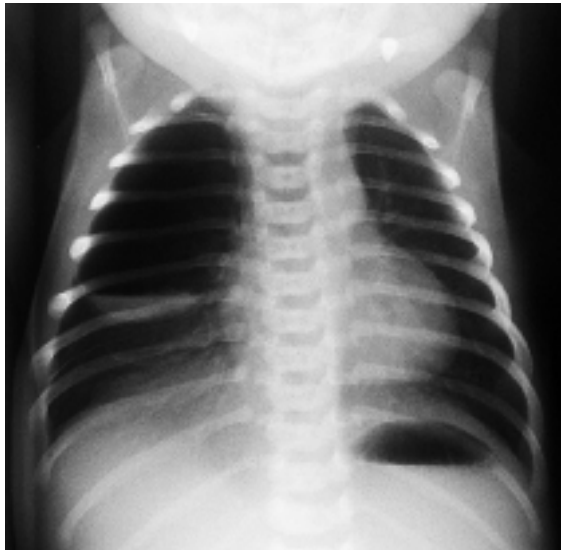
#### Cystic adenomatoid malformation (CAM)

This is a rare malformation of the terminal respiratory structures that contain no cartilage, consisting of cysts and solid airless tissue [12]. In the rare “macrocytic type” one or more large cysts predominate; this type may be hard to distinguish from lung cysts. The more frequently occurring “microcytic type” consists of numerous small cysts. The “solid type” is characterised by a mass of airless tissue. The lesion may affect only part of a lobe, an entire lobe, two lobes, or even an entire lung [15].

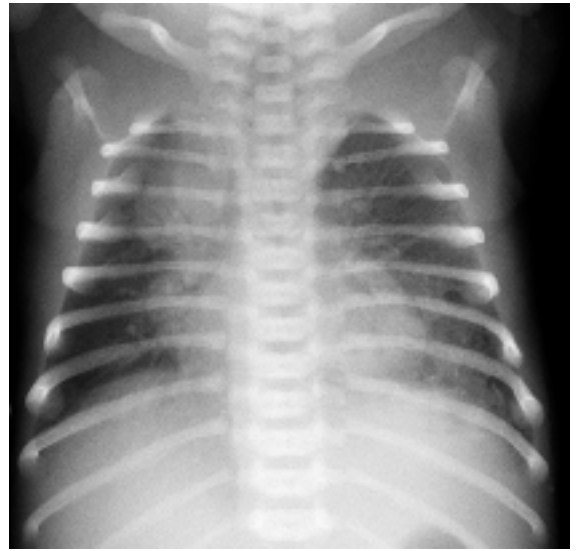
CAM often presents as an emergency with severe respiratory symptoms at birth, as large malformations may result in a shift of the mediastinum and compression of surrounding lung tissue and the contralateral lung (figure 2). Sometimes CAM can be hard to distinguish from congenital diaphragmatic hernia in a newborn with respiratory

**Table 1**  
Cystic malformations.

Lung cyst
Cystic adenomatoid malformation
Congenital lobar emphysema
Bronchogenic and other foregut cysts
Pulmonary sequestration

**Figure 1**

Congenital lung cyst. Chest radiograph of a 4-day-old boy with a single large cyst in the right upper lobe, containing air and fluid. The cyst caused some compression of the surrounding lung tissue, and the baby presented with moderate tachypnoea.

**Figure 2**

Cystic adenomatoid malformation (CAM). Chest radiograph of a female newborn with a CAM in the left lower lobe. The malformation caused a shift of the mediastinum, and the baby presented with tachypnoea and shortness of breath.

**Figure 3**

Congenital lobar emphysema (CLE). Chest radiograph of a 4-month-old boy with a CLE in the left upper lobe. The significantly hyperinflated lobe caused compression of the surrounding lung tissue and displacement of the mediastinum. In addition, the patient showed cor triatriatum as an isolated cardiac anomaly.

**Figure 4**

Bronchogenic cyst. Chest radiograph of a 2-year-old girl with a bronchogenic cyst projecting from the mediastinum. The typically rounded paratracheal mass with uniform density was found incidentally, and the girl was asymptomatic.

distress. In contrast, the diagnosis of smaller lesions may be delayed until infancy, school age, or even adolescence. The latter anomalies typically present with unresolving pulmonary infiltration, failure to thrive, or pneumothorax [12]. In addition, CAM has repeatedly been described to be a predisposing condition for the development of lung neoplasms. Rhabdomyosarcoma arising within a CAM has predominantly been reported for the paediatric age group [16]. Bronchoalveolar carcinoma may also develop on the basis of a pre-existing CAM, and the mean age for this latter complication appears to be young adulthood [17].

Today, congenital lower respiratory tract malformations, particularly CAM and pulmonary se-

questration, are frequently diagnosed antenatally [18]. The natural history is variable, and all infants with a prenatal diagnosis require postnatal evaluation. The management of completely asymptomatic patients with suggested decrease in the size of the lesion is a controversial issue, but most authors advocate surgical resection as the treatment of choice for all cases of CAM because of the risk of pulmonary compression, infection, or malignant transformation [18]. Recommendations for the timing of surgery range from early elective resection within the newborn period [19] to elective excision after three months [20]. The latter authors' suggestion is supported by low morbidity and less need for postoperative ventilation.



**Figure 5**

Bronchogenic cyst. Chest radiograph of an 8-month-old girl with an intrapulmonary bronchogenic cyst in the left lung. The rounded lesion was found incidentally, and the girl was asymptomatic.



**Figure 6**

Pulmonary sequestration. Chest radiograph of an 8-month-old boy with intrapulmonary sequestration in the posterior basal segment of the left lower lobe. The triangular lesion was found incidentally, and the boy was asymptomatic.

### Congenital lobar emphysema (CLE)

CLE is characterised by significant postnatal hyperinflation of one or more lung lobes [12]. About half of all lesions are located in the left upper lobe. The right upper lobe and the middle lobe are less frequently affected. CLE is often found in association with congenital heart disease. While it appears that the development of CLE is heterogeneous, the term “emphysema” implies lung destruction and thus is a source of confusion. In fact, in at least some variants (polyalveolar lobe) there may be a striking increase in the number of alveoli [21]. Thus, it was suggested that the term “congenital large hyperlucent lobe” should be used instead of CLE [13].

Complications caused by CLE are mostly mechanical. The hyperinflated lobe will tend to compress the surrounding lung tissue and to displace the mediastinum (figure 3). In severe cases, the lesion may cause severe respiratory distress of the newborn. In contrast to this early manifestation, a coincidental detection of the malformation may occur at any age.

Not so long ago, surgical removal of the affected part of the lung was the standard treatment [12]. However, after several reports advocated expectant management on the basis of a gradual resolution of symptoms in a number of cases [22], many paediatric pulmonologists will now tend towards a trial of supportive treatment and observation instead of resorting to surgery immediately after diagnosis [23].

### Bronchogenic and other foregut cysts

Bronchogenic cysts are usually single, sometimes very large malformations. In the majority of cases they are located in the right paratracheal or carinal region, but intrapulmonary forms may also be seen (figures 4 and 5). Depending on its location, the lesion may cause airway compression resulting in cough, wheeze, dyspnoea, or even respi-

ratory distress. With secondary infection of the cyst acute distention may develop, consequently leading to an exacerbation of symptoms. In addition, peptic ulceration may develop in cysts containing gastric mucosa [24]. As a serious complication, malignant transformation of epithelial cells of bronchogenic cysts has been reported repeatedly [25]. Many cysts, however, are asymptomatic and may be found incidentally on a chest radiograph. Radiographic findings range from a rounded mass, with uniform density similar to that of the cardiac shadow and projecting from the mediastinum, to hyperinflation or atelectasis of a lobe or an entire lung. When a bronchogenic cyst communicates with the tracheobronchial tree, varying air-fluid levels may be seen. The treatment of choice is surgical resection. Both the risk of developing typical cyst-related complications and the small risk of malignant transformation justify complete removal of the lesion even in asymptomatic patients. Surgery can usually be performed without loss of functional lung tissue [26].

Other mediastinal cystic lesions include enteric duplication cysts, pericardial cysts, and intrathoracic meningoceles. A discussion of these malformations is beyond the scope of this article.

### Pulmonary sequestration

This malformation comprises a bronchopulmonary tissue mass with abnormal communication with the tracheobronchial tree, and a normal or anomalous arterial supply and/or venous drainage. There are two types of sequestration: the more frequent “intrapulmonary” sequestration lies within the pleural boundary which surrounds the adjacent normal lung tissue, while the rare “extrapulmonary” type has its own pleural covering and typically remains outside the pleura that surrounds the rest of the lung. Usually the lesion, that may contain cysts or not, occupies a lung segment or less. Approximately two-thirds of all sequestra-



tions are located in the posterior basal segment of the left lower lobe (figure 6). A communication with the bronchial tree is either lacking or abnormal, and the frequently found anomalous arterial supply arises from the lower thoracic or upper abdominal aorta or one of its major branches. A sequestration usually drains its venous blood into the left atrium. Occasionally, the venous drainage may also be abnormal to the right atrium, inferior caval vein, or the azygos system [12].

Usually the malformation remains asymptomatic until infection develops. Recurrent localised pneumonitis, with fever and occasionally purulent sputum or haemoptysis, may develop at any age from infancy to adulthood [27]. The lesion may also be found incidentally on routine chest radiography [12].

Surgical removal is indicated in all patients with symptomatic pulmonary sequestration [26, 27]. Interestingly, embolisation of the anomalous arterial supply was also reported to result in a complete resolution of symptoms and chest x-ray changes in some cases [12]. This approach allows the option to manage a patient expectantly for a prolonged period subsequent to embolisation. If surgical resection of the lesion is considered necessary later, the preceding embolisation may reduce the risk of vascular complications at surgery [28].

### Outcome of cystic malformations

#### *Surgical resection*

Many cystic malformations, especially those that have started to cause complications, are treated by surgical resection in infancy or childhood. In most cases surgical treatment will involve a lobectomy (or at least the resection of a segment), but sometimes even a pneumonectomy has to be performed. Clearly, the long-term respiratory outcome will depend on the amount of lung tissue resected. However, some interesting questions remain: (1) does the long-term outcome also depend on the age at which the resection is performed?, (2) to what extent does postoperative compensatory lung growth change structure and function of the remaining lung?, and (3) is the dimension and the reparative potential of this postoperative compensatory lung growth dependent on age, ie is it more extensive in younger patients, when the normally occurring growth of respiratory structures and increasing sophistication of function might support and enhance such compensatory mechanisms? These important questions are discussed in detail in a recently published review [29]. In a few words, definitive answers to these questions are still lacking.

Studies on human subjects after lung tissue resection early in life have mainly employed pulmonary function measurements with somewhat controversial results. One study reported reduced lung volumes and diffusing capacity, approximately to the extent that could be predicted from the size of lung resected [30]. Other authors found

evidence for some compensatory growth, but no normalisation of physiological measurements [31], and another group reported complete normalisation of lung volumes after lobectomy for CLE in infancy [32]. Larger lung volumes than expected from the amount of remaining lung tissue, however, do not necessarily reflect the presence of adequate remodelling in the remaining lung; the frequently found increased RV/TLC ratios rather indicate a predominating distension of the remaining lung parenchyma [33]. In summary, existing studies of human subjects do not provide clear answers to the questions mentioned above on post-pneumonectomy lung growth.

Animal studies showed that compensatory lung growth after pneumonectomy occurs to a certain extent, involves an increase in tissue mass and some remodelling, and predominantly affects the parenchyma and not so much the conducting airways [34, 35]. A number of additional experiments failed to produce conclusive evidence for a better net result of compensatory growth, both in terms of alveolar number and structure, after lung tissue resection in younger animals as compared to older ones [36, 37]. This preliminary conclusion suggests that there is no significant pressure for a surgical approach to a congenital malformation at the youngest age possible. Thus, some lesions might be managed expectantly without significant threat of progressively losing the chances for compensatory growth.

#### *Expectant management*

Traditionally, immediate surgical resection was considered as the standard treatment for cystic malformations, and such an approach was still advocated more recently by some authors [18, 26, 27]. Others, however, by reporting cases of successful long-term expectant management challenged such recommendations [22, 23]. Today, an increasing proportion of patients with cystic malformations is managed expectantly by paediatric pulmonologists. This strategy is mainly applied to oligo- or asymptomatic cases of CLE, but other cystic lesions might also qualify for such an approach. Of course, cystic lesions big enough to cause severe neonatal respiratory distress will require emergency surgery, and the risk of a malignancy originating from a CAM or a bronchogenic cyst also calls for a surgical management of these specific cystic malformations.

Some time ago, a normal growth rate of functional lung tissue could be demonstrated for both children after surgical resection of CLE and children in whom this malformation had been managed expectantly [38]. Thus, it appears that the growth of the remaining lung is not hampered by a nonresected cystic lesion, or space-occupying hyperinflated lobe. It seems that the functional end result in an adolescent or adult might turn out to be approximately the same irrespective of absence or presence of the lesion.

## Congenital diaphragmatic hernia (CDH)

The most frequently occurring type of CDH, Bochdalek hernia, is located in the posterolateral part of the diaphragm and predominantly found on the left side (figure 7). The malformation results from a faulty development of the septum transversum, which should separate the body cavities between the third and the ninth week of gestation [39]. As a consequence, abdominal viscera are found in the thorax and the ipsilateral lung is hypoplastic, with bronchi of reduced size and branching, a thick-walled arterial tree with a decreased number of divisions, and a severely reduced alveolar surface area [40]. To a lesser extent, the contralateral lung is also hypoplastic. The dimension of lung hypoplasia is the most critical factor for prognosis in CDH; survival becomes increasingly unlikely when the lung volume deficit approaches or even exceeds 50%. On the other hand, a normal or near-normal lung volume before repair significantly increases the chances for survival, provided pulmonary arterial hypertension is managed successfully [41]. The prognosis of children with CDH is also determined by associated congenital anomalies that occur in roughly one-third of all cases and most often involve the cardiovascular, genitourinary, central nervous, or skeletal system [39].

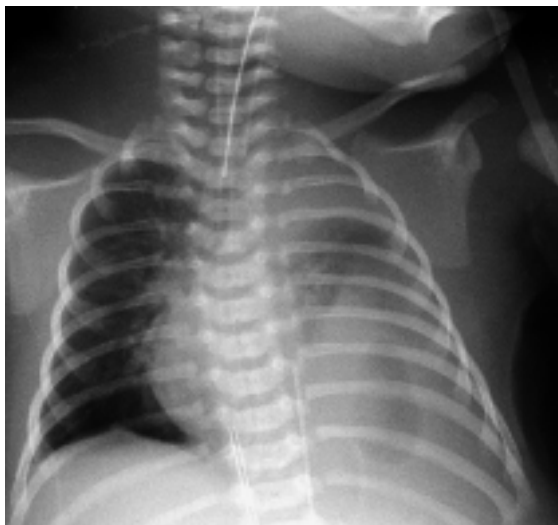
CDH of Bochdalek usually presents with severe symptoms on the first day of life. Ideally, the malformation nowadays will already have been diagnosed prenatally, and the child is delivered into a medical setting that is prepared for the emergency management of the newborn. Modern management is complex and sophisticated; amongst others, ventilatory adjuncts such as high frequency oscillatory ventilation, inhaled nitric oxide, and extracorporeal membrane oxygenation were intro-

duced as potential advances into this management. However, these interventions did not significantly improve outcome in CDH patients, and recent survival rates still lie around 60% of all cases of CDH [39, 42, 43].

Congenital anterior diaphragmatic hernia (Morgagni) represents a very rare type of CDH; it mainly occurs on the right side, and most commonly contains omentum followed by colon and stomach (figure 8). The diaphragmatic defect is usually small. Thus, Morgagni hernias are asymptomatic in many children, and are often found incidentally on chest radiographs or, alternatively, may be late-presenting. Once diagnosed, these hernias should be surgically repaired even in asymptomatic patients because of the risk of small bowel strangulation [44].

### Outcome of CDH

With a high incidence of long-term morbidity, particularly focused on the respiratory and gastrointestinal systems, long-term follow up is warranted for all patients with CDH. Residual respiratory morbidity in CDH survivors is the consequence of remaining respiratory malformations plus the various sequelae of surgery, intensive care and mechanical ventilation. A number of studies describe the clinical outcome, as well as the radiological and functional results after successful neonatal repair. These publications, however, have to be interpreted with caution, as they might not accurately describe the morbidity and prognosis of current CDH survivors. Today, patients with much more severe congenital defects, and thus more severe lung hypoplasia, have a chance of survival, though at the price of more residual damage and long-term morbidity [29].



**Figure 7**  
Congenital diaphragmatic hernia (CDH). Chest radiograph of a female newborn with the characteristic picture of left-sided posterolateral diaphragmatic hernia (Bochdalek) that had been diagnosed prenatally.



**Figure 8**  
Congenital diaphragmatic hernia (CDH). Chest radiograph of a 14-year-old girl showing a moderately dense tumour at the right cardiophrenic angle that turned out to be right-sided Morgagni hernia. The girl presented with slowly resolving pneumonia in the right lower lobe.

Due to their reduced pulmonary reserve, CDH survivors tend to suffer more severely from viral respiratory infections in their first years of life. After this period most patients are able to lead a normal or near-normal life without significant respiratory morbidity, including participation in regular physical activity [45, 46]. Some children suffer from recurrent bronchitis and fail to thrive [47]. Only a minority remains severely handicapped, requiring long-term tracheostomy and mechanical ventilation [48]. Chest radiographs after surgical repair range from no pathological findings to a radiolucent lung field on the side of the former defect [45]. As evident from lung perfusion scans, the most consistently found functional defect in CDH survivors is underperfusion on the side of the former defect [39, 45]. Pulmonary function studies generally revealed mild to moderate airway obstruction with a tendency towards hyperinflation. However, patients with normal lung function and a restrictive pattern of changes have also been described [45, 46, 49]. Lung volumes were mostly found to be normal or near-normal, and diffusion capacity was shown to be within normal limits [45, 49]. Lung morphology studies after CDH repair describe a striking increase in alveolar size, especially on the side of the former defect [50]. This indicates predominating distension of parenchyma and suggests that compensatory alveolar multiplication, if occurring at all, fails to normalise alveolar numbers. There is a high prevalence of airway hyperresponsiveness in CDH survivors [45, 49]. In contrast to patients with bronchial asthma, CDH survivors tend to respond positively to pharmacological challenges like methacholine but not to metabisulfite, suggesting that their bronchial hyperresponsiveness might arise from an altered airway geometry [49].

As most neonates with CDH require complex pre- and postoperative intensive care, often including prolonged artificial ventilation, some of the observed residual defects might rather stem from this mechanical ventilation and oxygen toxicity than the malformation itself. A recent study compared the long-term outcome of CDH survivors with that of patients without CDH, who had undergone comparable intensive care and mechanical ventilation as newborns [49]. Mild airway obstruction was found in both groups with more peripheral airway obstruction in CDH patients than in controls. In the CDH group a negative correlation between the duration of mechanical ventilation and lung function measurements was observed. Furthermore, patients who had been ventilated for up to seven days had significantly better lung function than those who had been ventilated for seven days or more. Thus, the authors suggested that both residual lung hypoplasia and neonatal intensive care are important determinants of persistent lung function abnormalities in CDH survivors.

A high prevalence of gastro-oesophageal reflux additionally contributes to chronic pulmonary

morbidity [47, 51]. Further occasionally observed gastrointestinal complications after CDH repair are susceptibility to intestinal obstruction, hiatus hernia, and recurrence of diaphragmatic hernia [39, 47, 51].

The neurodevelopmental outcome of CDH survivors does not differ from that of other neonates who require prolonged intensive care, mechanical ventilation, and extracorporeal membrane oxygenation [39]. Neurological problems and developmental delays are thus relatively common in these patients. Associated congenital anomalies may cause considerable chronic morbidity in some patients.

A rare subset of CDH does not present in the first 24 hours of life but later in childhood, adolescence, or even adulthood [52]. In these patients, presenting symptoms may be respiratory or gastrointestinal, but presentation with gastrointestinal problems appears to be more common in left-sided hernias, whereas respiratory symptoms predominate in right-sided lesions [39, 52]. Some authors speculated that such late-presenting defects might rather be acquired than congenital [53].

## Conclusions

Many congenital lower respiratory tract malformations require surgery in the newborn period. Other malformations are diagnosed and operated upon in infancy, childhood, adolescence or even adulthood when causing symptoms and complications. Long-term morbidity will depend on a variety of factors like the nature and size of the lesion, the timing and extent of the surgical intervention, the presence and dimension of postpneumectomy compensatory lung growth, residual malformations, and sequelae of intensive care. With more sophisticated surgical techniques and constantly improving perioperative intensive care, patients with more severe defects will increasingly tend to survive in the future, though at the price of more severe long-term morbidity. Many patients enter adulthood in good general health but with a somewhat underdimensioned or damaged lower respiratory tract that is characterised by reduced structural and functional reserves. It may be speculated that residual defects will interact with various environmental factors (eg smoking), ageing, or other concomitant respiratory diseases, resulting in more rapidly lost respiratory reserves.

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## References

- 1 Davenport M, Warne SA, Cacciaguerra S, Patel S, Greenough A, Nicolaidis K. Current outcome of antenally diagnosed cystic lung disease. *J Pediatr Surg* 2004;39:549–56.
- 2 Nitecki S, Bar-Maor JA. Late presentation of Bochdalek hernia: our experience and review of the literature. *Isr J Med Sci* 1992; 28:711–4.
- 3 Azoulay D, Regnard JF, Magdeleinat P, Diamond T, Rojas-Miranda A, Levasseur P. Congenital respiratory-oesophageal fistula in the adult. *J Thorac Cardiovasc Surg* 1992;104:381–4.
- 4 Van Raemdonck D, De Boeck K, Devlieger H, Demedts M, Moerman P, Coosemans W, et al. Pulmonary sequestration: a comparison between pediatric and adult patients. *Eur J Cardiothorac Surg* 2001;19:388–95.
- 5 Spitz L. Esophageal atresia and tracheoesophageal fistula in children. *Curr Opin Pediatr* 1993;5:347–52.
- 6 Orford J, Cass DT, Glasson MJ. Advances in the treatment of oesophageal atresia over three decades: the 1970s and the 1990s. *Pediatr Surg Int* 2004;20:402–7.
- 7 Filler RM, Messineo A, Vinograd I. Severe tracheomalacia associated with esophageal atresia: results of surgical treatment. *J Pediatr Surg* 1992;27:1136–41.
- 8 Couriel JM, Hibbert M, Olinsky A, Phelan PD. Long term pulmonary consequences of oesophageal atresia with tracheoesophageal fistula. *Acta Paediatr Scand* 1982;71:973–8.
- 9 Biller JA, Allen JL, Schuster SR, Treves ST, Winter HS. Long-term evaluation of oesophageal and pulmonary function in patients with repaired esophageal atresia and tracheoesophageal fistula. *Dig Dis Sci* 1987;32:985–90.
- 10 Agrawal L, Beardsmore C, McFadyen UM. Respiratory function in childhood following repair of oesophageal atresia and tracheoesophageal fistula. *Arch Dis Child* 1999;81:404–8.
- 11 Durning RP, Scoles PV, Fox OD. Scoliosis after thoracotomy in tracheoesophageal fistula patients. *J Bone Joint Surg* 1980;62: 1156–9.
- 12 Clements BS. Congenital malformations of the lungs and airways. In Taussig LM, Landau LI, eds: *Pediatric respiratory medicine*, St. Louis, Mosby, 1999, 1106–36.
- 13 Bush A. Congenital lung disease: a plea for clear thinking and clear nomenclature. *Pediatr Pulmonol* 2001;32:328–37.
- 14 Cooke FN, Blades B. Cystic disease of the lungs. *J Thorac Surg* 1952;28:546–73.
- 15 Madewell JE, Stocker JT, Korsower JM. Cystic adenomatoid malformation of the lung: morphologic analysis. *Am J Radiol* 1975;124:436–43.
- 16 Murphy JJ. Rhabdomyosarcoma arising within congenital pulmonary cysts: Report of three cases. *J Pediatr Surg* 1992;27: 1364–7.
- 17 Granata C, Gambini C, Balducci T, Toma P, Michelazzi A, Conte M, et al. Bronchoalveolar carcinoma arising in congenital cystic adenomatoid malformation in a child: A case report and review of malignancies originating in congenital cystic adenomatoid malformation. *Pediatr Pulmonol* 1998;25:62–6.
- 18 Shanmugam G, MacArthur K, Pollock JC. Congenital lung malformations – antenatal and postnatal evaluation and management. *Eur J Cardiothorac Surg* 2005;27:45–52.
- 19 Kim YT, Kim JS, Park JD, Kang CH, Sung SW, Kim JH. Treatment of congenital cystic adenomatoid malformation – does resection in the early postnatal period increase surgical risk? *Eur J Cardiothorac Surg* 2005;27:658–61.
- 20 Khosa JK, Leong SL, Borzi PA. Congenital cystic adenomatoid malformation of the lung: indications and timing of surgery. *Pediatr Surg Int* 2004;20:505–8.
- 21 Hislop A, Reid L. New pathological findings in emphysema of childhood: 1. Polyalveolar lobe with emphysema. *Thorax* 1970; 25:682–90.
- 22 Shannon DC, Tödres ID, Moylan FMB. Infantile lobar hyperinflation: expectant treatment. *Pediatrics* 1977;59:1012–8.
- 23 Özçelik U, Göçmen A, Kiper N, Doğru D, Dilber E, Yalçın EG. Congenital lobar emphysema: evaluation and long-term follow-up of thirty cases at a single center. *Pediatr Pulmonol* 2003;35: 384–91.
- 24 Kirwan WO, Walbaum PR, McCormack MM. Cystic intrathoracic derivatives of the foregut and their complications. *Thorax* 1973;28:424–8.
- 25 Endo C, Imai T, Nakagawa H, Ebina A, Kaimori M. Bronchioloalveolar carcinoma arising in a bronchogenic cyst. *Ann Thorac Surg* 2000;69:933–5.
- 26 Coran AG, Drongowski R. Congenital cystic disease of the tracheobronchial tree in infants and children. Experience with 44 consecutive cases. *Arch Surg* 1994;129:521–7.
- 27 Van Raemdonck D, De Boeck K, Devlieger H, Demedts M, Moerman P, Coosemans W, et al. Pulmonary sequestration: a comparison between pediatric and adult patients. *Eur J Cardiothorac Surg* 2001;19:388–95.
- 28 Clements BS, Warner JO, Shinebourne EA. Congenital bronchopulmonary vascular malformations: clinical application of a simple anatomical approach in 25 cases. *Thorax* 1987;42:409–16.
- 29 Zach MS, Eber E. Adult outcome of congenital lower respiratory tract malformations. *Thorax* 2001;56:65–72.
- 30 Cook CD, Bucci G. Studies of respiratory physiology in children IV. The late effects of lobectomy on pulmonary function. *Pediatrics* 1961;27:234–42.
- 31 Frenckner B, Freyschuss U. Pulmonary function after lobectomy for congenital lobar emphysema and congenital cystic adenomatoid malformation. *Scand J Thorac Cardiovasc Surg* 1982;16: 293–8.
- 32 McBride JT, Wohl MEB, Strieder DJ. Lung growth and airway function after lobectomy in infancy for congenital lobar emphysema. *J Clin Invest* 1980;66:962–70.
- 33 Cagle PT, Thurlbeck WM. Postpneumonectomy compensatory lung growth. *Am Rev Respir Dis* 1988;138:1314–26.
- 34 Burri PH, Sehovic S. The adaptive response of the rat lung after bilobectomy. *Am Rev Respir Dis* 1979;119:769–77.
- 35 McBride JT. Postpneumonectomy airway growth in the ferret. *J Appl Physiol* 1985;58:1010–14.
- 36 Holmes C, Thurlbeck WM. Normal lung growth and response after pneumonectomy in rats at various ages. *Am Rev Respir Dis* 1979;120:1125–36.
- 37 Davies P, McBride J, Murray GF, Wilcox BR, Shallal JA, Reid L. Structural changes in the canine lung and pulmonary arteries after pneumonectomy. *J Appl Physiol* 1982;53:859–64.
- 38 Eigen H, Lemen RJ, Waring WW. Congenital lobar emphysema: long-term evaluation of surgically and conservatively treated children. *Am Rev Respir Dis* 1976;113:823–31.
- 39 Thibeault DW, Sigalet DL. Congenital diaphragmatic hernia from the womb to childhood. *Curr Probl Pediatr* 1998;28:5–25.
- 40 Shochat SJ. Pulmonary vascular pathology in congenital diaphragmatic hernia. *Pediatr Surg Int* 1987;2:331–4.
- 41 Antunes MJ, Greenspan JS, Cullen JA, Holt WJ, Baumgart S, Spitzer AR. Prognosis with preoperative pulmonary function and lung volume assessment in infants with congenital diaphragmatic hernia. *Pediatrics* 1995;96:1117–22.
- 42 Stege G, Fenton A, Jaffray B. Nihilism in the 1990s: the true mortality of congenital diaphragmatic hernia. *Pediatrics* 2003;112: 532–5.
- 43 Smith NP, Jesudason EC, Featherstone NC, Corbett HJ, Losty PD. Recent advances in congenital diaphragmatic hernia. *Arch Dis Child* 2005;90:426–8.
- 44 Minneci PC, Deans KJ, Kim P, Mathisen DJ. Foramen of Morgagni hernia: changes in diagnosis and treatment. *Ann Thorac Surg* 2004;77:1956–9.
- 45 Vanamo K, Rintala R, Sovijärvi A, Jääskeläinen J, Turpeinen M, Lindahl H, et al. Long-term pulmonary sequelae in survivors of congenital diaphragmatic defects. *J Pediatr Surg* 1996;31:1096–100.
- 46 Trachsel D, Selvadurai H, Bohn D, Langer JC, Coates AL. Long-term pulmonary morbidity in survivors of congenital diaphragmatic hernia. *Pediatr Pulmonol* 2005;39:433–9.
- 47 Naik S, Greenough A, Zhang Y, Davenport M. Prediction of morbidity during infancy after repair of congenital diaphragmatic hernia. *J Pediatr Surg* 1996;31:1651–4.
- 48 Greenholz SK. Congenital diaphragmatic hernia: an overview. *Semin Pediatr Surg* 1996;5:216–23.
- 49 Ijsselstijn H, Tibboel D, Hop WJC, Molenaar JC, deJongste JC. Long-term pulmonary sequelae in children with congenital diaphragmatic hernia. *Am J Respir Crit Care Med* 1997;155: 174–80.
- 50 Thurlbeck WM, Kida K, Langston C, Cowan MJ, Kitterman JA, Tooley W, et al. Postnatal lung growth after repair of diaphragmatic hernia. *Thorax* 1979;34:338–43.
- 51 Vanamo K, Rintala RJ, Lindahl H, Louhimo I. Long-term gastrointestinal morbidity in patients with congenital diaphragmatic defects. *J Pediatr Surg* 1996;31:551–4.
- 52 Congenital diaphragmatic hernia study group. Late-presenting congenital diaphragmatic hernia. *J Pediatr Surg* 2005;40:1839–43.
- 53 Wiseman NE, McPherson RI. “Acquired” congenital diaphragmatic hernia. *J Pediatr Surg* 1977;12:657–65.



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