Lung function in children after repair of congenital diaphragmatic hernia

Diaphragmatic hernia is an uncommon cause of respiratory distress in newborn infants but it is important because it can be corrected surgically. The problems of initial management and short-term results have been well reported. The long-term effect of the anomaly on lung development has not been clearly defined. Chatrath *et al.* (1971) showed reduced forced expired volume in 1 second and forced vital capacity in 14 children they studied but no other reports are available. The present study was undertaken to confirm their findings because the lung hypoplasia associated with congenital diaphragmatic hernia may interfere with the rapid lung growth and development that occurs during infancy and early childhood.

Methods

Sixteen children who had had congenital diaphragmatic herniae repaired in early childhood were reassessed clinically, radiologically, and by a series of lung function tests.

Measurements were made of peak expiratory flow rate (PFR) using a Wright's meter, forced expired volume in 0.75 seconds ($FEV_{0.75}$) and forced vital capacity (FVC) using a reverse plethysmograph, and thoracic gas volume (TGV) and total lung capacity (TLC) using a whole body plethysmograph. The methods and normal values are described elsewhere (Cogswell *et al.*, 1975). Closing volumes and the

slope of the alveolar nitrogen plateau (phase III) after a single breath of oxygen were measured using the method of Mansell *et al.* (1972). Airway closure was measured at the absolute lung volume at which closure occurred (closing capacity) and was expressed as a percentage of TLC (CC/TLC). The nitrogen single breath test (NSB) results were expressed as the rate of rise of the nitrogen percentage during the alveolar plateau. In normal children tested in this laboratory this was less than 2.17% N_2/l of expired air.

Results

The Table gives the details of the 16 children at the time of the study. The first 11 children presented at birth and were operated on by 2 days of age, except for Cases 4 and 8 who had operations on the fourth and tenth day respectively. 5 boys (Cases 12–16) presented later at from 2 to 26 months of age. All children were of normal height and weight for age. 5 children gave a history of episodes of wheeze and in 2 (Cases 3 and 10) these were still continuing at the time of study. Chest x-rays were normal in all but Case 10, who was asthmatic, and Case 11 who had a recurrence of her hernia and showed some residual pleural thickening over the left side of the diaphragm.

In general the lung function tests were within normal limits with some minor abnormalities in 6 children: 1 of these was a mild asthmatic, 3 had histories of wheezy episodes in early childhood, and 1 other had had a recurrence of her hernia. The actual abnormalities were a reduced PFR in 3 children, reduced $FEV_{0.75}$ in 1, and abnormal NSB test in 3.

Table Lung function tests in 16 children after repair of congenital diaphragmatic hernia

Case no.	Sex	Age (yr)	(m)	Height (cm)	PFR (l/min)	$FEV_{0.75}$ (ml)	FVC (ml)	TGV (ml)	NSB (% N_2/l)	CC/TLC (%)
1	F	9	2	133	230	1260	1975	1525	2.38*	27
2	F	12	5	168	355	2850	4050	2180	1.07	25
3	M	10	4	141	255	1500	2460	1700	1.86	25
4	F	11	11	144	240	2000	2750	1480	1.49	24
5	M	14	11	166	465	3550	4520	2560	—	—
6	M	8	1	122	150	825*	1360	1255	—	—
7	M	8	10	130	200	1400	1725	1080	2.73*	46
8	F	16	3	163	470	3100	3910	3110	0.61	29
9	F	15	0	147	360	1880	2320	1880	1.74	—
10	M	10	7	143	180*	1350	2410	2065	2.36*	36
11	F	7	3	128	150*	1140	1375	1380	2.17	41
12	M	8	2	130	295	1910	2490	1475	—	—
13	M	18	8	181	610	4325	5150	3575	—	—
14	M	15	8	160	260*	2500	2900	2080	—	—
15	M	8	4	137	260	1900	2200	1500	0.74	35
16	M	8	7	131	265	1240	1500	1340	—	—

*Abnormal results for this laboratory.
See Methods for explanation of abbreviations.

Discussion

The lung function abnormalities detected in this study were minor and related to acquired lung disease rather than to the congenital diaphragmatic hernia. These results differ from those of Chatrath *et al.* (1971) who found moderate to severe abnormalities in 5 of their 14 subjects. It is difficult to see the reason for this disparity.

A decrease in the number of bronchial branchings is the main feature of the pulmonary hypoplasia associated with diaphragmatic hernia (Areechon and Reid, 1963). Although spirometric lung function tests tend not to detect minor changes in lung architecture, one would expect to find abnormalities in tests of small airways if such hypoplasia persisted into late childhood. Abnormalities of airways closure and the nitrogen single breath test reflect small airway disease before routine spirometry is affected, but no such changes were consistently detected in this group of patients.

Clinically, there is a wide variation in the severity of congenital diaphragmatic herniae, from those presenting as neonatal emergencies to those presenting asymptotically in later childhood. All degrees of severity are represented in the children from both studies so that this does not appear to be the explanation for differences between the two.

In a recent study of lung function in infants who had their herniae repaired in the first few days of life, Landau *et al.* (1977) showed normal lung volume (TGV), compliance, and airways conductance by 6 months of age and usually much earlier. In this laboratory similar changes were found in one infant studied throughout the first year of life. These findings indicate that the hypoplastic lungs in this condition are capable of rapid expansion with the development of normal lung function. The results of the present study show that this normal lung function persists at least into late childhood.

Summary

Sixteen children who had had congenital diaphragmatic herniae repaired either in the neonatal period (11), or in early childhood (5), were reviewed at between 7 and 19 years of age. Only minor abnormalities were shown in their chest x-rays and in a variety of lung function tests. This suggests that the long-term prognosis in this condition is good.

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