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Potentially of early chest roentgen examination in ventilator treated newborn infants to predict future lung function and disease

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Abstract. The potentially of early chest X-ray to predict the risk of lung function abnormalities was studied prospectively in 40 preterm ventilator treated infants in a 8-10-year follow-up investigation. According to the findings at chest X-ray 3 to 10 days after completed ventilator treatment the infants were divided into 3 groups considered to represent increasing risk and severity of lung damage: 1) normal findings, 2) interstitial parenchymal abnormalities exclusively or 3) in combination with local or general hyperinflation. Lung function tests and chest x-ray were performed at the age of 8 to 10 years. A correlation was found between the findings at the early chest roentgen examination and the risk of abnormal lung function at the follow-up. Occurrence of focal or general hyperinflation or both were associated with a greater risk of airway obstruction. Infants with only interstitial abnormalities were, however, at a higher risk than those with normal chest examination to develop general hyperinflation and increased air way obstruction.

Bronchopulmonary dysplasia (BPD) is a chronic obstructive pulmonary disease induced by ventilator treatment in the newborn period irrespective of the underlying lung disease if any [1]. The severity of the lesions is related to the peak ventilator pressure and the oxygen concentration in the inspired air as well as to the duration of the ventilator assistance [2]. The risk of developing BPD increases substantially in cases with altered integrity of the pulmonary epithelium as in respiratory distress syndrome, of lung immaturity and in the presence of a patent ductus arterious (literature survey [3]).

Chest roentgen examination is the basis for the diagnosis and staging of BPD. The histological correlates of the radiographic findings have been described in a comprehensive investigation by

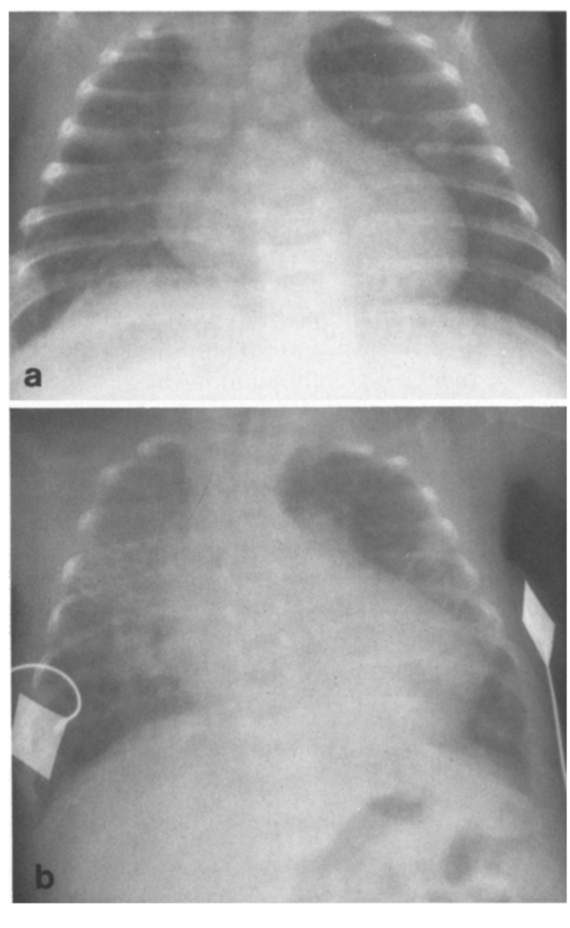


Fig. 1. Chest roentgen examination soon after completed ventilator treatment exemplifying a Group 2- (**a**) and a Group 3-case (**b**)

Table 1. Means of gestational age (weeks) and birth weight (g) of the patients and of the duration of ventilator treatment (days)

	N	Gest. age Mean	Birth weight Mean	Duration of IPPV Mean
Group 1	20	29.7	1516	14
Group 2	8	28.9	1290	22
Group 3	10	27.7	1078	33
1 v. 3	*P*<	0.02	0.005	0.02

Differences between Groups 1 and 2 and Groups 2 and 3 N.S. (Student's two-tailed t-test)

Table 2. Cause of ventilator treatment

	Group 1	Group 2	Group 3
IRDS	9	7	9
Repeated apnoea	6	1	2
Others[a]	6	-	-

[a]Surgery 5 cases, sepsis 1

Table 3. Pulmonary abnormalities on chest roentgen examination at the age of 8 to 10 years

Initial examination	Examination at 8-10 years of age				
	N	Normal	Interstit. abnormal.	Hyperinflation	
				local	general
Group 1	20	17	0	0	3
Group 2	8	2	1	0	5
Group 3	10	2	5	4	8

Northway et al. [4]. However, there is still some discussion on the definition of BPD and about the nature and the significance of minor abnormalities seen on the roentgen examination in the early stage [5, 6]. The present prospective investigation is a contribution to this discussion. It describes the radiographic pulmonary abnormalities soon after completed ventilator treatment and their subsequent fate and relation to lung function during the following 8 to 10 years.

Material and methods

The material comprised a consecutive series of 48 preterm infants born 1976-1978, who survived ventilator treatment in the neonatal period. One infant later succumbed to sudden infant death syndrome, four have moved from the region, four refrained from the follow-up investigation and one child could not do the tests because of tetraplegia.

The remaining 38 infants were divided into 3 groups according to the findings at chest radiography performed 3 to 10 days after the patients were weaned from ventilator; this examination will be referred to as the initial investigation.

Group 1. Normal findings.

Group 2. Various degrees of interstitial abnormalities, mainly perihilar (Fig. 1a).

Group 3. Interstitial parenchymal abnormalities plus general hyperinflation or areas of local hyperinflation or both (Fig. 1b).

This classification was considered to reflect increasing severity of lung damage. The diagnosis of general hyperinflation was based on presence of flattening of the diaphragm, increased anteroposterior thoracic diameter with bulging of the anterior chest wall with or without airfilled lung anterior to the mediastinum.

The clinical material is presented in Tables 1 and 2.

The follow-up investigation was performed when the children were 8 to 10 years of age and included roentgen examination of the chest and assessment of the vital capacity (VC), forced expiratory volume in one second (FEV_1) and functional residual capacity (FRC) as described elsewhere [7].

The radiograms were interpreted without knowledge of clinical data or findings of other investigations.

Differences between groups were considered to be statistically significant if the probability that they would occur in a random fashion was 0.05 or less.

The study was approved by the local ethical committee and informed parental consent was obtained.

Results

Roentgen examination. Interstitial parenchymal abnormalities regressed particularly in the first year of life. Additional resolution occurred during the following years. Slight remnants persisted in some cases at the follow-up investigation, mainly in Group 3-children (Table 3).

Local areas of hyperinflation remained consistent throughout the observation period. With one exception they were located in the lower part of the right lung. Also general hyperinflation persisted with the exception of two cases (Fig. 2). In addition, hyperinflation appeared in the follow-up period in several other cases (Table 3), more frequently in Group 2) than in Group 1 ($p < 0.01$).

Lung function test. At the age of 8 to 10 years, the mean values of FEV_1 and FRC deviated significantly in all groups from the expected values whereas VC was abnormal only in Group 3 (Fig. 3). The Group 3-children differed from Groups 1 and 2 concerning FEV_1 ($p < 0.005$ and 0.05 respectively) an concerning FRC also from Group 1 ($p < 0.025$).

Irrespective of which group they initially were assigned to, in total sixteen children presented with general hyperinflation at the age of 8-10 years. These had reduced VC and FEV_1 compared to 22 without hyperinflation ($p < 0.05$) (Fig. 4). FRC was also more abnormal in these children but the difference to the non-hyperinflated group was not statistically significant.

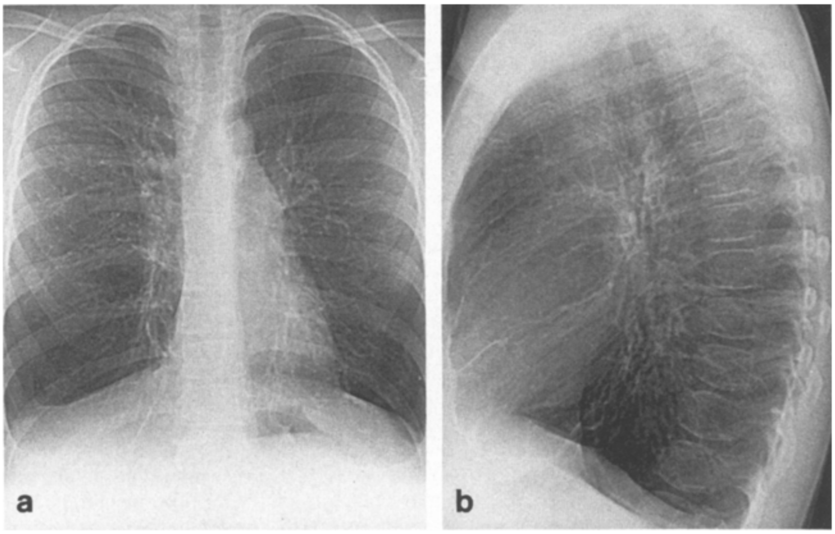
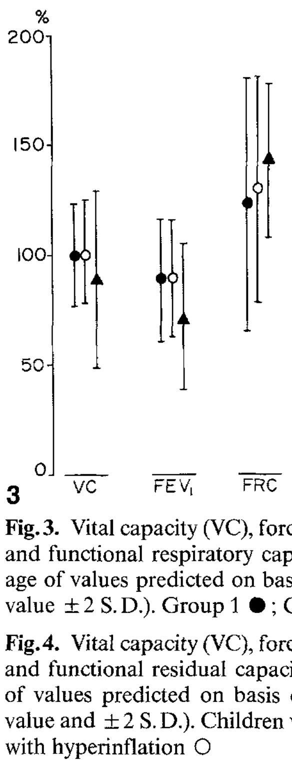


Fig. 2. Chest roentgen examination of a Group 3-girl at the age of 8 years with marked general hyperinflation accentuated in the lower right lung



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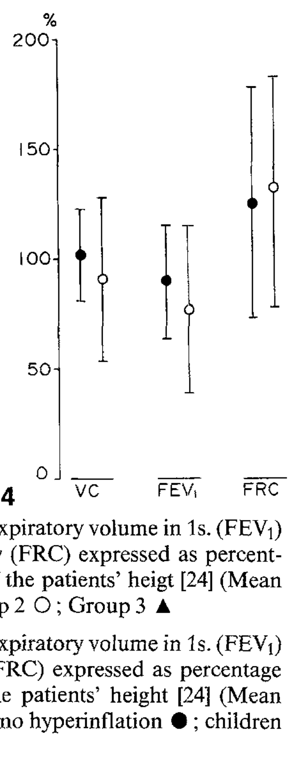

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Fig. 3. Vital capacity (VC), forced expiratory volume in 1s. (FEV_1) and functional respiratory capacity (FRC) expressed as percentage of values predicted on basis of the patients' heigt [24] (Mean value ±2 S.D.). Group 1 ●; Group 2 ○; Group 3 ▲

Fig. 4. Vital capacity (VC), forced expiratory volume in 1s. (FEV_1) and functional residual capacity (FRC) expressed as percentage of values predicted on basis of the patients' height [24] (Mean value and ±2 S.D.). Children with no hyperinflation ●; children with hyperinflation ○

Discussion

Improved medical management of preterm infants with respiratory difficulties has reduced mortality rate in the acute stage of their illness [8]. In addition, less severe forms of BPD are now seen. The morbidity rate of BPD is, however, less readily to assess, partly because it must be based on long term follow-up investigations and partly because subsequent changes of the radiological definition has passed towards designating only severe lesions as BPD [6, 9]. Reported differences in the incidences of BPD may therefore largely be due to various definitions of BPD. This may also be responsible for the reported divergences between the clinical diagnosis and the results of functional tests.

Histologically the repair phase of hyaline membrane disease merges with the early stage of BPD. The former commences within 2 days [10] and only minor histological remnants are left after 7 days of age [11, 12]. We assumed that pulmonary abnormalities in the shape of interstitial parenchymal abnormalities and focal or general hyperinflation on chest roentgen examinations one week after completed ventilator treatment represented BPD. The question to be answered was if chest radiography at that time might be useful to predict the subsequent development of the parenchymal abnormalities and deterioration of the lung function.

The rapid disappearance or decrease of the interstitial abnormalities suggested they consisted mainly of inflammatory oedema. General or areas of hyperinflation were obviously due to permanent lesions. However, new areas of local hyperinflation did not appear.

The parenchymal abnormalities have usually been reported to subside successively [13–15]. In our cases this was true almost exclusively for the interstitial abnormalities. General hyperinflation has, however, been reported to persist – albeit decreasing in number with age [13, 15, 16]. In our study, general hyperinflation present shortly after completed ventilator treatment persisted in almost all cases. In addition, hyperinflation appeared or progressed in severity in several cases during the first 10 years.

The classification of our patients according to the radiological findings in the early post-ventilator period enabled us to allocate them to one of three groups with different development of the parenchymal abnormalities and compromised lung function at the age of 8-10 years. The presence of local or general hyperinflation or both at the examination soon after completed ventilator treatment (Group 3) substantially increased the risk of unfavourable development compared to the other two groups. Absence of parenchymal abnormalities did not exclude subsequent abnormal lung function tests; the "ventilator lung disease" is of a complex nature and includes a spectrum of abnormalities and is not restricted to the morphological injuries detectable on the early chest X-ray. The underrating of minor BPD on roentgen examination compared with histological examination has also been stressed by Rosan [17] and histological evidence on BPD has ben proven in ventilator treated infants with no clinical evidence of disease [18]. However, infants with normal chest X-ray at the first investigation had only a slightly increased risk of developing general hyperinflation or airway obstruction with time. The Group 2-infants had an intermediate position of risk but behaved more like the children in Group 1 than in Group 3. They differed, however, from Group 1 in one important aspect, namely the risk of developing general hyperinflation and airway obstruction. The genesis of the hyperinflation is not clear. Poor multiplication of the alveoli in the neonatal period [19] and emphysema due to alveolar wall destruction [20] certainly are contributing factors. The decrease in the airway flow resistance following inhalation of bronchodilator suggests that a bronchiolar hyperactive reaction pattern play a significant role, as has been reported previously [21, 22].

In conclusion, the present classification reflected the severity of pulmonary lesions in the early post-ventilator period and might be useful in predicting future development. Previous investigations have shown that it also reflected the risk of subsequent risk of lower respiratory tract infection including wheezing bronchitis [23]. If cases with minor pulmonary abnormalities are excluded and distinction not made between interstitial abnormalities and hyperinflation, the information available in the radiograms are not fully used.

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