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The management and outcome in children admitted to hospital

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Summary

2418 children aged 0–14 years were admitted to hospital with respiratory infections; 2396 recovered and 22 (0·9%) died.

Previous respiratory illness had been experienced by 5·6%; 2·6% had congenital heart disease and 0·6% cystic fibrosis.

Antibiotics were given in every category of illness; the frequency varied from 68% in colds to 97% in pneumonia. Oxygen was given to 14% of children with croup, 29% with bronchiolitis and 13% with pneumonia. No child with upper respiratory infection or croup died. The case mortality in the 1295 children with lower respiratory infections was 1·7% : 0·6% in bronchitis, 0·7% in bronchiolitis, and 3·1% in pneumonia.

Pathogenic infective agents were isolated in half the deaths; and in 36% predisposing malformations or disease were present.

With a limited study of management and outcome deductions must be made with caution. It suggests, however, that therapy based on understanding of the infective agents and the respiratory dysfunction to which they give rise is not as yet generally applied.

Management

This survey was primarily designed to study the relationship between clinical categories and viruses in children admitted to hospital with respiratory infection. No comprehensive assessment of management was made therefore, but treatment with chemotherapy, antibiotics and oxygen were recorded. We hoped that this would throw some light on the relationship of these to our clinical categories and the infective agents associated with them.

Antibiotics

The use of antibiotics is shown in Table 1. They were given in every category of illness; the frequency varying from 68% of children with common colds to 97% of those with pneumonia.

The main antibiotics used were: benzyl-penicillin in 62% of all illnesses, tetracycline in 16%, and a combination of penicillin and tetracycline in 10%.

TABLE 1. The use of antibiotics and chemotherapy in each clinical category

	No. of children	Usage (%)
Common cold	232	68·5
Pharyngitis	244	77·0
Tonsillitis	257	89·5
Primary otitis media	142	95·1
Croup	230	85·7
Bronchitis	453	92·5
Bronchiolitis	303	86·1
Pneumonia	543	96·9
Influenza	14	28·5
All diagnoses	2418	87·6

TABLE 2. The use of oxygen in each clinical category

	No. of children	Usage (%)
Common cold	232	1·7
Pharyngitis	244	0
Tonsillitis	257	0·4
Primary otitis media	142	0
Croup	230	14·3
Bronchitis	453	6·6
Bronchiolitis	299	28·7
Pneumonia	543	13·4

The use of oxygen in each clinical category is shown in Table 2. The limited use of oxygen in bronchiolitis and pneumonia was unexpected. As cyanosis was recorded in 40% of infants under 6 months of age, in 19% of those between 6 months and 1 year, and in 23% of children from 1 to 4 years, we suspect that the frequency of oxygen administration was under-recorded.

Duration of stay in hospital

The length of stay in hospital is shown in Table 3. Nearly half the children were there for less than 5 days, and by the fifteenth day more than 90% had been discharged. The distribution was different for upper and lower respiratory illnesses; only one-third of those with upper respiratory illnesses or croup were in hospital for more than 5 days, compared with 60% of those with bronchitis and 75% of those

TABLE 3. Duration of stay in hospital for each clinical category

Days in hospital	Clinical category (% in hospital for different periods)									Total	
	Common cold	Pharyngitis	Tonsillitis	Primary O.M.	Croup	Bronchitis	Bronchiolitis	Pneumonia	Influenza	No.	%
3	31	28	30	21	25	9	2	4	36	379	16
3–5	34	43	42	42	44	31	22	20	29	773	32
6–10	19	22	20	23	23	39	52	37	36	775	32
11–15	9	5	6	6	5	13	16	20	—	286	12
16–20	3	0·4	1	1	2	4	4	9	—	97	4
21+	3	0·4	1	4	1	4	4	10	—	105	4
Not stated	—	0·4	—	1	—	—	—	—	—	3	—
Total admissions	232 (100)	244 (100)	257 (100)	142 (100)	230 (100)	453 (100)	303 (100)	543 (100)	14 (100)	2418	(100)

with bronchiolitis or pneumonia. Young infants tended to be kept in for longer than older children, irrespective of the diagnosis. Although duration of admission generally reflects the severity of an illness, other considerations, such as the child's social background and variations in ward staffing and medical management affect the length of an individual child's stay in hospital, and made comparisons between different centres unreal.

Previous health

The pattern of illness, management and outcome may be affected by predisposing disease or by previous experience of respiratory infection. We recorded this and 386 (16%) of the total group were involved. The nature of their previous or predisposing illnesses is shown in Table 4. This Table reflects two distinct processes; recurrence of respiratory illness is to be expected in early childhood and the history of previous infection in more than 5% of children supports this; in addition 2·8% had congenital heart disease and 0·6% cystic fibrosis, conditions which may lead to more severe, more prolonged, or continuing infection.

Outcome

2418 children were studied, 2396 survived, twenty-two died. Of the surviving children, 83% were well on discharge and 17% had continuing respiratory symptoms. The duration of this post-hospital ill-health and any persisting respiratory damage were not measured.

Deaths

Twenty-two of the 2418 children (0·9%) died. The details which were recorded are shown in Table 5.

TABLE 4. Children with predisposing disease or previous respiratory illness in each clinical category

Present illness		CC	Ph.	Ts.	POM.	Croup	Brs.	Bls.	Pna.	All children	
No. of children		232	244	257	142	230	453	299	543	2404	
Past or predisposing illnesses										No.	%
Croup		—	—	—	—	10	—	—	2	12	0·5
Bronchitis		3	3	3	2	4	37	10	28	90	3·7
Bronchiolitis and pneumonia		2	2	0	0	2	2	3	10	21	0·9
Other L.R.T. illnesses		0	1	1	0	1	2	1	5	11	0·5
Cystic fibrosis		4	3	0	0	0	1	0	6	14	0·6
Congenital heart disease		5	5	5	1	2	16	5	30	69	2·8
Central nervous system disease and mental deficiency		2	1	3	1	2	1	2	10	22	0·9
Miscellaneous		10	19	29	11	4	32	8	35	148	6·2
Total	No.	26	34	41	15	25	91	29	126	387	
	%	11·2	13·9	16·0	10·6	10·9	20·1	9·2	23·2	16·1	

TABLE 5. Details of the twenty-two deaths (with autopsy 1–14; without autopsy 15–22)

No.	Age	Clinical respiratory diagnosis	Autopsy diagnosis	Predisposing and other disease	Compli-cations	Antibiotic treatment*	Bacteriology			Virology	
							Cough swab	Blood	Lungs	Cough swab	Lungs
WITH AUTOPSY											
1	3 months	Pneumonia	Pneumonia	Cystic fibrosis	—	A, Bp, C, Cx, S	*Proteus* *Ps. pyocyanea*	N.D.	*Proteus spp.* *Ps. pyocyanea*	Para-influenza virus type 3	N.D.
2	5 weeks	Pneumonia,	Pneumonia, myocardial necrosis	—	Heart failure	A, Cx	*S. aureus*	N.D.	N.D.	—	N.D.
3	5 months	Pneumonia	Pneumonia; large ven. sept. def.	Cong. heart dis.; Downs syndrome	—	Nil	Neg.	N.D.	N.D.	R.S. virus	R.S. virus
4	6 months	Pneumonia	Pneumonia	Spina bif.; hydrocephalus	—	Cx	Neg.	N.D.	N.D.	—	N.D.
5	10 months	Bronchitis	Pneumonia	Cong. bil.; atresia; severe anaemia	Heart failure	Bp	*E. coli*	N.D.	N.D.	—	N.D.
6	10 months	Pneumonia	Pneumonia; fibroelastosis	Cong. heart disease	—	Bp	Neg.	N.D.	*E. coli*	—	N.D.
7	4 months	Pneumonia	Pneumonia; empyema	—	Heart failure	C	Neg.	N.D.	*S. aureus*	—	N.D.
8	6 years	Bronchitis	Purulent bronchitis; dev. pneum.; tricuspid incompetence	Cong. heart dis.; Downs syndrome	Heart failure	Bp, C, St	N.D.	N.D.	N.D.	—	N.D.

TABLE 5 Continued

9	2 months	Pneumonia	Pneumonia	Hydrocephalus	Heart failure	A, C, Cx	*E. coli* *H. influenzae*	N.D.	N.D.	R.S. virus	N.D.
10	5 months	Bronchitis	Pneumonia; fibroelastosis	Cong. heart disease	Heart failure	A, Cx	*E. coli*	N.D.	N.D.	Adenovirus type 1	—
11	3 months	Pneumonia	Pneumonia; large ven. sep. defect	Cong. heart dis.; Downs syndrome	Heart failure	Multiple	Neg.	N.D.	N.D.	—	N.D.
12	6 weeks	Pneumonia	Pneumonia; diaphragmatic hernia	Mult. cong. abnormalities	—	Cx, St	*S. aureus*	N.D.	N.D.	—	N.D.
13	4 months	Pneumonia	Pneumonia	—	Heart failure	C	N.D.	N.D.	*S. aureus*	—	N.D.
14	2 months	Pneumonia	Pneumonia (? viral)	—	Heart failure	A	*S. aureus*	N.D.	*Ps. pyocy.*	—	—
WITHOUT AUTOPSY											
15	3 years	Bronchitis	Not done	Craniofacial dysostosis	—	Bp, T	Neg.	—	Not possible	R.S. virus	Not possible
16	1 month	Bronchitis	Not done	Cong. heart dis.; vent. sep. defect	—	A, Cx	Neg.	N.D.	Not possible	—	Not possible
17	10 months	Pneumonia	Not done	Cerebral palsy	—	A, Cx	*S. aureus*	N.D.	Not possible	—	Not possible
18	17 months	Bronchiolitis	Not done	—	Convul-sions	Bp	*S. aureus*	N.D.	Not possible	—	Not possible
19	2 months	Bronchiolitis	Not done	—	—	Bp, St	N.D.	N.D.	Not possible	Para-infl. virus type 3	Not possible
0	3 years	Pneumonia	Not done	Severe brain damage	—	Bp	N.D.	N.D.	Not possible	—	Not possible
21	1 month	Pneumonia	Not done	—	Heart failure	Bp, C	Neg.	N.D.	Not possible	R.S. virus	Not possible
22	4 years	Pneumonia	Not done	Mult. cong. abnormalities	Heart failure	Bp	Neg.	N.D.	Not possible	—	Not possible

* Key: A = ampicillin; Bp = benzyl penicillin; C = chloramphenicol; Cx = cloxacillin; S = sulphonamide; St = streptomycin; T = tetracycline.

There were no deaths in children with upper respiratory infection or with croup. Among the 1295 with lower respiratory infection the case mortality was 1·7%; 0·6% in bronchitis, 0·7% in bronchiolitis and 3·1% in pneumonia.

The facts behind these figures are incomplete for two main reasons; necropsy was not permitted in eight children and no standard procedures for post-mortem bacterial or virus examination of the lungs and for histological examination were laid down in the survey protocol. However, useful information about the context and causes of death was obtained.

There were fifteen boys and seven girls, conforming to the male preponderance present in all categories of respiratory illness. The case mortality rate in children under 1 year of age was 1·6% and in children under 6 months it was 2%. The following observations on the data presented in Table 5 can be fairly made.

Infection

The distribution of bacterial and virus infections and their broad relation to predisposing disease was as follows: primary bacterial, two; presumed primary bacterial, one; primary viral, four; bacterial with predisposing disease, one; viral with predisposing disease, two; bacterial and viral with predisposing disease, one; no infective agent found, eleven.

Primary

Pathogenic infective agents were isolated in half the deaths. They were considered to be causally related to the disease, though the evidence was not equally strong in all cases.

Two cases of *primary bacterial pneumonia* (7 and 13) were due to *Staphylococcus aureus*. They occurred in previously healthy children, both aged 4 months; the organism was obtained at autopsy from multiple lung abscesses in one infant and from pneumonia with associated empyema in the second. A third child, aged 5 weeks, and previously healthy also probably died of *S. aureus* pneumonia; the radiological appearances were consistent with this diagnosis and the organism was isolated from a cough swab. She was treated with cloxacillin and ampicillin and was making a satisfactory recovery when, 8 days after admission, on the tenth day of her illness she suddenly developed left heart failure and died. At necropsy a resolving bacterial pneumonia was present together with a large area of myocardial necrosis in the left ventricle without associated vascular occlusion. Neither blood culture during life nor bacteriology of the lung at necropsy was carried out.

Of the four *primary virus infections* only one (9) came to necropsy. This was a child aged 2 months; R.S. virus was isolated from a cough swab and the histological picture was consistent with virus pneumonia. The next child (21), aged 1 month, had clinical pneumonia, and R.S. virus was isolated from the cough swab. Admitted within 24 hr of the onset of symptoms the illness was severe with recurrent periods of apnoea in which assisted respiration became necessary. Although given oxygen, chloramphenicol and benzyl penicillin he died suddenly on the seventh day of his illness from cardiac arrest. The third death was in a child aged 3 years with a clinical diagnosis of severe bronchitis without radiological evidence of pneumonia; R.S. virus, was isolated from the cough swab. In the fourth child, aged 2 months, the clinical diagnosis was pneumonia, but a review of the symptoms suggested that a diagnosis of bronchiolitis would have conformed more closely to the agreed clinical classification. Parainfluenza virus type 3, was isolated from the cough swab. The illness lasted only 48 hr and he died 24 hr after admission. Pathogenic bacteria were not isolated from the cough swabs in these children.

Three of the four children were considered normal and well before their fatal illness; the fourth had cranio-facial dysostosis but this was thought to have had no more than a marginal effect on the fatal respiratory illness.

R.S. virus and parainfluenza virus are rarely obtained from the respiratory secretions in the absence of clinical respiratory disease.

Infection with predisposing disease

There were four children in this group. The first, (6), aged 10 months, died within 48 hr of the onset of illness and 24 hr after admission to hospital; no pathogenic bacterium or virus was isolated from the cough swab. Lung puncture and necropsy bacteriology less than 24 hr after death showed a profuse growth of *E. coli*. Histology showed a bilateral haemorrhagic bronchopneumonia. The child's development was delayed, probably as a result of anoxia at birth, and she had severe heart disease due to fibroelastosis. Although blood culture was not carried out during life it was though this could have been an *E. coli* septicaemia with widespread pneumonia.

In the next two children death was associated with virus infection. The first, (3), aged 5 months, had Down's Syndrome with a large ventricular septal defect; at necropsy the greater parts of both lungs were pneumonic, and R.S. virus was isolated from the lungs. It had previously been isolated from the cough swab and blood culture was sterile. The picture in the second child, (10), a girl aged 5 months, was less clear. A diagnosis of pneumonia had been made, but without radiography. Four days after the onset

of her illness and within 24 hr of admission to hospital she died and at necropsy there was widespread bilateral bronchopneumonia together with fibroelastosis, and heart failure. Adenovirus type 1 was isolated from a cough swab. Pathogenic bacteria were not found in the upper respiratory tract. Blood culture was not carried out, and the lungs were not cultured. Adenovirus type 1 was the probable cause of the pneumonia, which, together with heart failure, led to her death.

The fourth child, (1), was aged 3 months and *Pseudomonas pyocyanea*, B *Proteus* and parainfluenza virus type 3 were obtained from the cough swab. The predisposing condition was cystic fibrosis and a widespread suppurative bronchitis was present with areas of consolidation. It seems reasonable to assume that parainfluenza virus infection was the terminal event in the child's progressive bacterial pulmonary suppuration.

Predisposing malformations or diseases

Of the twenty-two children who died, eight (36%) had malformations or diseases known to be associated with recurrent or continuing respiratory infection; the comparable figure for the whole group was 3·4%. Six children had severe congenital heart disease (three of these had large septal defects, one a tricuspid anomaly, and two had fibroelastosis; in three this was part of Down's Syndrome). One child had cystic fibrosis. One had multiple congenital abnormalities which included, in addition to a left diaphragmatic hernia with lung compression and defective lung development, micrognathos, small posterior nares and a poorly developed larynx.

Associated malformations or diseases

Other conditions which may have contributed were present in seven children: two had meningomyelocele and hydrocephalus, two severe cerebral palsy, one congenital biliary atresia, one craniofacial dysotosis, and one multiple abnormalities. Their relation to death was not easy to assess but in one child with severe brain damage it was decided that treatment would be unhelpful.

Acute processes developing during the illness and contributing to death

These occurred in sixteen of the twenty-two children. Heart failure was recorded in eleven, and considered to be the primary cause of death in six. Although diagnosis may be difficult, heart failure is associated with acute respiratory infection and its importance in severe and fatal cases was confirmed in this study. Hyperpyrexia, with temperatures of 106°F, 107°F and 108°F, was recorded in three children, and its threat to survival is well known.

Convulsions occurred in five children; this frequency (23%) is higher than in the lower respiratory infections as a whole but in only one child were they thought to have been a major factor in the death. One child was severely anaemic.

Treatment

Except for two children, one of whom died immediately after admission and the other of whom had severe incurable brain disease suggesting that intensive treatment would be unjustified, all were given oxygen and antibiotics. The antibiotics used in these twenty children were: benzyl penicillin in five, cloxacillin and ampicillin in five, chloramphenicol alone or with other antibiotics in five, benzylpenicillin with streptomycin or tetracycline in three, cloxacillin in one, and ampicillin in one.

Conclusions

Analysis of these twenty-two deaths, while not adding new knowledge, has underlined some important facts. Acute respiratory infection is still a special hazard in the first year of life. There were seven primary pneumonias: four were viral, three R.S. virus and one parainfluenza virus; three bacterial all due to *Staph. pyogenes*.

Serious malformations, or diseases known to predispose to respiratory infection, were present in eight children, more than one third of the fatal group. In three of these children the terminal illness was a viral and in one a bacterial infection. Recognition of this association has important implications for management during life and certification at death. In the events leading to death, infection, malformation and underlying disease may together produce dangerous systemic and cellular disturbance especially heart failure and hyperpyrexia.

Yet the picture is still incomplete. The degree of dehydration was not recorded, and for only two of the twenty-two children was information about the child's metabolic state, available. These are important gaps since it is increasingly recognized that hypoxia, dehydration and respiratory and metabolic acidosis are dangerous accompaniments of severe respiratory infection. A larger more detailed study of death in children with respiratory infection is urgently needed if the figure of 3000 deaths attributed to acute respiratory infection, recorded annually in England and Wales is to become more meaningful than it is at present.