lack of resistance. With an increasing array of new agents becoming available, paediatricians will have to continually re-evaluate antibiotic policies as patterns of microbial resistance change and new drugs enter clinical use. It is unlikely however that new antibiotics alone will significantly alter the mortality and morbidity associated with bacterial meningitis. The advent of effective vaccines and new therapeutic interventions to modulate the damaging host inflammatory response to invading micro-organisms should ultimately improve the outcome of bacterial meningitis in the future.

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- 1 Steele RW. Cephalosporins for bacterial meningitis: which one is best? *J Pediatr* 1989;114:991-2.
- 2 Levin M, Heyderman RS. Bacterial meningitis. *Recent Advances in Paediatrics* 1990;9:1-19.
- 3 Public Health Laboratory Service. *Haemophilus influenzae regional survey* London: PHLS, 1991. (Communicable Disease Report 1991;2(26).)
- 4 Howard AJ, Dunkin KT, Musser JM, Palmer SR. Epidemiology of *Haemophilus influenzae* type b invasive disease in Wales. *BMJ* 1991;303:441-5.
- 5 Kaplan SL. Recent advances in bacterial meningitis. *Adv Pediatr Infect Dis* 1989;4:83-110.
- 6 Kaplan SL, Fishman MA. Update on bacterial meningitis. *J Child Neurol* 1988;3:83-93.
- 7 Givner LB, Abramson JS, Wasilaukas B. Meningitis due to *Haemophilus influenzae* type b resistant to ampicillin and chloramphenicol. *Rev Infect Dis* 1989;11:329-34.
- 8 Campos J, Garcia-Tornel S, Gairi JM. Multiply resistant *haemophilus influenzae* type b causing meningitis: comparative clinical and laboratory study. *J Pediatr* 1986;108:897-902.
- 9 Klugman KP, Koornhof HJ. Bacterial pneumonia caused by penicillin resistant pneumococci. *N Engl J Med* 1988;318:123-4.
- 10 Anonymous. Penicillin resistant pneumococci [Editorial]. *Lancet* 1988;i:1142-3.
- 11 Saez Nieto JA, Vazquez JA, Marcos C. Meningococci moderately resistant to penicillin. *Lancet* 1990;336:54.
- 12 Botha P. Penicillin-resistant *Neisseria meningitidis* in southern Africa. *Lancet* 1988;i:54.
- 13 Ezzo DV, Fontanals D, Uriz S, et al. *Neisseria meningitidis* strains with decreased susceptibility to penicillin. *Pediatr Infect Dis J* 1987;6:438-9.
- 14 Mulhall A, Berry DJ, de Louvois J. Chloramphenicol in paediatrics: current prescribing practice and the need to monitor. *Eur J Pediatr* 1988;147:574-8.
- 15 Swedish Study Group. Cefuroxime versus ampicillin and chloramphenicol for the treatment of bacterial meningitis. *Lancet* 1982;i:295-8.
- 16 Marks WA, Stutman HR, Marks MI. Cefuroxime versus ampicillin plus chloramphenicol in childhood bacterial meningitis. A multicentre randomised control trial. *J Pediatr* 1986;109:123-30.
- 17 Lebel MH, Hoyt JM, McCracken JH. Comparative efficacy of ceftriaxone and cefuroxime for treatment of bacterial meningitis. *J Pediatr* 1989;114:1049-54.
- 18 Schaad UB, Suter S, Gianella-Borradori A, et al. A comparison of ceftriaxone and cefuroxime for the treatment of bacterial meningitis in children. *N Engl J Med* 1990;322:141-7.
- 19 Rodriguez WJ, Puig JR, Khan WN. Cefazidime versus standard therapy for pediatric meningitis: therapeutic, pharmacologic and epidemiologic observations. *Pediatr Infect Dis J* 1986;5:408-15.
- 20 Jacobs RF, Wells TG, Steele RW, et al. A prospective randomised comparison of cefotaxime versus ampicillin and chloramphenicol for bacterial meningitis in children. *J Pediatr* 1985;107:129-33.
- 21 Congeni BL, Bradley J, Hammerschlag MR. Safety and efficacy of once daily ceftriaxone for the treatment of bacterial meningitis. *Pediatr Infect Dis J* 1986;5:293-7.
- 22 Peltola H, Anttila M, Renkonen PV. Randomised comparison of chloramphenicol, ampicillin, cefotaxime and ceftriaxone for childhood bacterial meningitis. *Lancet* 1989;i:1281-7.
- 23 Martin E, Hohl P, Guggi FH, Kayser M, and Members of the Swiss Multicentre Meningitis Study Group. Short course single daily ceftriaxone monotherapy for acute bacterial meningitis in children: results of a Swiss multicentre study. Part 1: clinical results. *Infection* 1990;18:70-7.
- 24 Hohl P, Martin E, Kayser M, and Members of the Swiss Multicentre Meningitis Study Group. Short course single daily ceftriaxone monotherapy for acute bacterial meningitis in children: results of a Swiss multicentre study. Part 2: bacteriological results. *Infection* 1990;18:78-82.
- 24 Radetsky M. Duration of treatment in bacterial meningitis: a historical inquiry. *Pediatr Infect Dis J* 1990;9:2-9.

Fibreoptic bronchoscopy in infants

In the past decade endoscopic airway examination has become an important diagnostic tool.¹ In neonates and infants the aims of fibreoptic bronchoscopy are nearly the same as in older children: assessment of proximal airway patency and sampling of lavage fluids for microbiological, cytological, or chemical studies. There are a number of special problems in infants: frequency of malformations and malacias, and mechanical complications of assisted ventilation. As the fibreoptic bronchoscopes are obstructive, the smallest infants and those with precarious respiratory status demand well trained operators and well adapted techniques and instruments. These precautions should allow exploration of infants' airways safely and lead to subsequent investigations and the diagnosis.

Techniques

Despite some uncertainty as to the indications for rigid bronchoscopes and fibreoptic bronchoscopes, paediatricians generally prefer fibreoptic bronchoscopes for most procedures.² The standard paediatric fibreoptic bronchoscopes have an external diameter of 3.5 mm and an operating channel of 1.2 mm (Olympus BF 3C20, FB 10-H Pentax). Most examinations can be performed with sedation and local anaesthesia.^{3,4} The flexibility of the bronchoscope increases the patient's comfort. The controlled angulation of the distal tip allows more selective manoeuvres and improves the visualisation of the upper lobe bronchi. Fewer medical and nursing personnel are required with fibreoptic bronchoscopy. It can be performed on an outpatient basis and even at the bedside of the infants in intensive care units.

Rigid bronchoscopes are more suitable for the removal of foreign bodies, excision of granulation tissue, and examination of tracheo-oesophageal fistulas.^{3,5} Their internal diameter allows the insertion of forceps for bronchial biopsies. Clearly rigid and flexible bronchoscopes neither duplicate nor replace each other, rather they are complementary and should be used when appropriate for the particular problem.

When fibreoptic bronchoscopy is indicated, it must be carried out in a properly equipped and staffed room with facilities for resuscitation. In our practice sedation is achieved with subcutaneous atropine 0.01 mg/kg and rectal midazolam 0.25 mg/kg between 6 months and 1 year and 0.5 mg/kg between 1 and 2 years. Infants younger than 6 months are given atropine and rectal diazepam 0.5 mg/kg.

As the fibreoptic bronchoscope is passed through the nose, careful topical anaesthesia of upper airways and larynx is an important step. For a skilled operator, the duration of fibreoptic bronchoscopy does not exceed 2-3 minutes. Oximetry and electrocardiographic monitoring are mandatory in infants with low weights or borderline respiratory status. Supplemental oxygen through the free nostril is indicated in infants less than 5 kg, in children with diffuse lung disease, and in children with borderline or poor blood gases. The fibreoptic bronchoscope is reinserted several times if necessary.

Anatomical indications

Bronchoscopy is required to diagnose anatomical abnormalities responsible for persistent or recurrent pneumonia,

atelectasis, or hyperinflation. Specific laryngeal problems have been reviewed elsewhere by ear, nose, and throat specialists.⁶

Fibreoptic bronchoscopy is particularly indicated in an infant with persistent wheezing or inspiratory and expiratory stridor, chronic tracheobronchial hypersecretion that is unresponsive to bronchodilator treatment, physiotherapy and antibiotics, and particularly if chest radiography is abnormal. Fibreoptic bronchoscopy frequently yields significant abnormalities of the lower respiratory tract such as unsuspected foreign bodies, tracheal stenosis, endobronchial masses, bronchial stenosis (especially in infants having previously received prolonged mechanical ventilation), airway compression by aberrant vessels or extrinsic masses, tracheomalacia, and bronchomalacia.⁴⁻⁷ Only local anaesthesia with spontaneous ventilation permits the study of the dynamic aspects of the airways and the evidence of excessive and premature expiratory collapse of the trachea and the main stem bronchi. Bronchial brushing can be performed with the paediatric fibreoptic bronchoscopy and may confirm the diagnosis of primary ciliary dyskinesia.⁸

In infants with abnormal chest radiography due to pulmonary tuberculosis, fibreoptic bronchoscopy verifies the underlying cause of atelectasis or hyperaeration (compression, granuloma, obstructive cellular debris), indicates resection of granulation tissue by rigid bronchoscopy, or indicates the need for corticosteroids.⁹

Only suspected foreign body aspirations are considered for fibreoptic bronchoscopy. Rigid bronchoscopy with general anaesthesia is required when a foreign body is disclosed by fibreoptic bronchoscopy or when clinical history and radiological findings are highly suggestive of aspiration.

Bronchoalveolar lavage

The aim of fibreoptic bronchoscopy is not limited to anatomical examination of the airways. Obtaining samples for further examination is often required. In an immunocompetent infant, bronchoalveolar lavage (BAL) is used in the investigation of a non-infectious interstitial pneumonitis (pulmonary alveolar proteinosis, haemosiderosis, histiocytosis X). In the immunocompromised infant with interstitial pneumonitis and acute severe pneumonia, BAL is valuable in the diagnosis of an opportunistic infection. The increasing number of patients undergoing immunosuppressive agents for malignancy or for transplantation, and of HIV infected patients, explain the expansion of BAL. In our series of 73 patients where BAL was used for pulmonary infiltrates, 54% of children were less than 2 years of age. BAL disclosed an infectious agent in 50% of cases.¹⁰ The best microbiological yield (75%) was observed in HIV infected children with acute interstitial pneumonitis, mainly *Pneumocystis carinii*. Examination of sputum obtained by non-invasive methods has been advocated in HIV infected children with acute *P. carinii* pneumonia.¹¹⁻¹² The reliability of these methods has been questioned.¹² In chronic interstitial pneumonitis, with clinical and radiological features suggesting pulmonary lymphoid hyperplasia-lymphoid interstitial pneumonitis, BAL showed a characteristic profile associating an isolated lymphocytosis, without neutrophilia or *P. carinii*.¹³

Therapeutic bronchoscopy

Atelectasis is frequently observed in infants after extubation or after thoracic surgery. Only the few cases of atelectasis which persist a few days despite chest physiotherapy require fibreoptic bronchoscopy, which can be performed at the bedside. Removal of mucous plugs, or sometimes instillation and reaspiration of normal saline in

the atelectatic airway, allows reaeration and improvement of respiratory status.

Fibreoptic bronchoscopy in the neonatal intensive care unit

In infants less than 3000 g, the 3.5 mm fibreoptic bronchoscope will nearly totally obstruct the airway. Preoxygenation with 100% oxygen is mandatory, it provides adequate oxygenation but not ventilation.¹⁴ Despite the possibility of alternatively ventilating or aspirating the airways, the bronchoscope must not remain below the glottis more than 30–40 seconds.¹⁵ The ultrathin fibreoptic bronchoscope now available (outer diameter 2.2 mm) can be passed through a connector located between the endotracheal tube and the ventilator. This connector allows uninterrupted mechanical ventilation and oxygen delivery during the examination.¹⁶⁻¹⁷ This ultrathin bronchoscope has a directional tip, but lacks a suction channel, therefore careful airway suctioning before the procedure is mandatory.

Airway obstruction is a concern particularly, but not exclusively, in newborns and infants receiving mechanical ventilation. Inflammatory stenosis, granuloma, severe extrinsic compression and tracheomalacia or bronchomalacia are frequently observed in infants with persistent radiological abnormalities.¹⁶⁻²⁰ These abnormalities can coexist and their correct diagnosis influences management. Airway compression in congenital cardiopathies may hasten the need for surgery. Inflammatory stenosis and granuloma necessitate extreme care in suctioning to avoid aspirating beyond the endotracheal tube. These conditions might lead to steroid treatment. Positive end expiratory pressure may be required for severe tracheomalacia responsible for sudden 'unexplained' deterioration of respiratory status.²¹⁻²²

Complications of fibreoptic bronchoscopy

Patients with pulmonary hypertension are at high risk and bronchoscopy should be delayed unless the obtained information is considered essential for proper management. At high risk are also infants with severe coagulopathy, although thrombopenia can be corrected for the duration of the procedure. In infants with severe airway obstruction or severe hypoxaemia, fibreoptic bronchoscopy may induce respiratory failure due to the procedure, the BAL, or the sedation. If information gained by fibreoptic bronchoscopy is considered essential, then it should be performed by a highly experienced bronchoscopist in the intensive care unit. Midazolam produces more respiratory depression in the younger infants. This explains why infants between 6 months and 1 year of age are given a half dose and why midazolam is avoided below 6 months. Another reason for withdrawing midazolam is the observation of few cases of brief convulsions in the youngest subgroup (unpublished data). However the role of midazolam alone, compared with midazolam with topical lignocaine, remains undetermined. A transient fever occurs four to six hours after the BAL in 40% of infants and subsides spontaneously.

Conclusions

Bronchoscopy is an essential step in the investigation of numerous neonates and infants with severe or persistent pulmonary disease. The good tolerance and the high diagnostic yield of fibreoptic bronchoscopy have transformed the diagnostic strategy. In the near future the use of this technique in infants will probably expand further. The reduced external diameter of ultrathin bronchoscopes will allow a more comfortable procedure in non-ventilated small infants requiring anatomical evaluation of their airways.

And finally, a better examination of lavage fluid and cells will provide important information about the pathophysiology of lung diseases.²³

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- 1 Wood RE. Spelunking in the pediatric airways: explorations with the flexible fibreoptic bronchoscope. *Pediatr Clin North Am* 1984;31:785-99.
- 2 Godfrey S, Springer C, Maayan Ch, Avital A, Vatahky E, Belin B. Is there a place for rigid bronchoscopy in the management of pediatric lung disease? *Pediatr Pulmonol* 1987;3:179-84.
- 3 Raine J, Warner JO. Fibreoptic bronchoscopy without general anaesthesia. *Arch Dis Child* 1991;66:481-4.
- 4 Wood RE, Postma D. Endoscopy of the airway in infants and children. *J Pediatr* 1988;112:1-6.
- 5 Kosloske AM, Jewell PF, Cartwright KC. Crucial bronchoscopic findings in esophageal atresia and tracheoesophageal fistula. *J Pediatr Surg* 1988;23:466-70.
- 6 Arnold JE. Advances in pediatric flexible bronchoscopy. *Otolaryngol Clin North Am* 1989;22:545-51.
- 7 Benjamin B. Endoscopy in congenital tracheal anomalies. *J Pediatr Surg* 1980;15:164-71.
- 8 Barlocco EG, Valetta EA, Canciani M, et al. Ultrastructural ciliary defects in children with recurrent infections of the lower respiratory tract. *Pediatr Pulmonol* 1991;10:11-7.
- 9 de Blic J, Azevedo I, Burren CP, Le Bourgeois M, Lallemand D, Scheinmann P. The value of flexible bronchoscopy in childhood pulmonary tuberculosis. *Chest* 1991;100:688-92.
- 10 de Blic J, Mc Kelvie P, Le Bourgeois M, Blanche S, Benoist MR, Scheinmann P. Value of bronchoalveolar lavage in the management of severe acute pneumonia and interstitial pneumonitis in the immunocompromised child. *Thorax* 1987;42:759-65.
- 11 Hague RA, Burns SE, Mok JYQ, Lap PL. Diagnosis of *Pneumocystis carinii* pneumonia from non-invasive sampling of respiratory secretions. *Arch Dis Child* 1990;65:1364-5.
- 12 Wood RE, Leigh MW, Retsch-Bogart G. Diagnosis of pneumonia in immunocompromised patients. *J Pediatr* 1990;116:836-7.
- 13 de Blic J, Blanche S, Danel C, Le Bourgeois M, Caniglia M, Scheinmann P. Bronchoalveolar lavage in HIV infected patients with interstitial pneumonitis. *Arch Dis Child* 1989;64:1246-50.
- 14 Wood RE. Clinical applications of ultrathin flexible bronchoscopes. *Pediatr Pulmonol* 1985;1:244-8.
- 15 de Blic J, Scheinmann P, Paupe J. Successful treatment of persistent neonatal emphysema by flexible bronchoscope. *Lancet* 1984;iii:1389-90.
- 16 de Blic J, Delacourt C, Scheinmann P. Ultrathin flexible bronchoscope in neonatal intensive care unit. *Arch Dis Child* 1991;66:1383-5.
- 17 Schellhase DE, Graham LM, Fix EJ, Sparks LM, Fan LL. Diagnosis of tracheal injury in mechanically ventilated premature infants by flexible bronchoscopy. A pilot study. *Chest* 1990;98:1219-25.
- 18 Shinwell ES, Higgins RD, Auten RL, Shapiro DL. Fiberoptic bronchoscopy in the treatment of intubated neonates. *Am J Dis Child* 1989;143:1064-5.
- 19 Finer NN, Etches PC. Fiberoptic bronchoscopy in the neonate. *Pediatr Pulmonol* 1989;7:116-20.
- 20 Fan LL, Sparks LM, Dulinsky JP. Applications of an ultrathin flexible bronchoscope for neonatal and pediatric airway problems. *Chest* 1986;89:673-6.
- 21 Cohn RC, Kerckmar C, Dearborn D. Safety and efficacy of flexible bronchoscopy in children with bronchopulmonary dysplasia. *Am J Dis Child* 1988;142:1225-8.
- 22 Sotomayor JL, Godínez RI, Borden S, Wilmott R. Large-airway collapse due to acquired tracheobronchomalacia in infancy. *Am J Dis Child* 1986;140:367-71.
- 23 Cherniack RM, Banks DE, Bell DY, Davis GS, Hughes JM, King Jr TE. Bronchoalveolar lavage constituents in healthy individuals, idiopathic pulmonary fibrosis and selected comparison groups. *Am Rev Respir Dis* 1991;141:S169-202.