

Paediatric obstructive sleep apnoea

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Habitual snoring occurs in 12% of children in the United Kingdom.¹ Two large cross sectional studies from the UK and Italy found that the prevalence of obstructive sleep apnoea in children was 0.7% to 1.8%.^{1,2} A recent, well designed cross sectional study of 700 children in the United States found that the prevalence of primary snoring was 15.5% and of sleep apnoea 1.2%.³ Delayed diagnosis of obstructive sleep apnoea can lead to neurobehavioural consequences and even serious cardiorespiratory morbidity.⁴ History and examination alone are insufficient to distinguish reliably those with sleep apnoea from those who simply snore.⁵ Paediatric obstructive sleep apnoea has completely different clinical features and requires different management strategies from adult obstructive sleep apnoea. In this review we provide an overview of the diagnosis and management of children with obstructive sleep apnoea, from primary to specialist care. The review is based on the best available evidence, which for much of obstructive sleep apnoea comprises longitudinal or cohort studies.

How do snoring and obstructive sleep apnoea differ?

Sleep disordered breathing refers to the whole spectrum of breathing disturbance during sleep, from primary snoring through to obstructive apnoea. Obstructive sleep apnoea is defined as a disorder of breathing during sleep that is characterised by prolonged partial upper airway obstruction and/or intermittent complete obstruction that adversely affects ventilation during sleep and disrupts normal sleep patterns.⁶ Snoring is noisy breathing caused by turbulent airflow through the upper airway without the sequelae of obstructive apnoea, frequent arousals from sleep, or disordered gas exchange.⁶

The normal sleep pattern has several phases. Muscle relaxation usually occurs during rapid eye movement sleep,

SOURCES AND SELECTION CRITERIA

We conducted a Medline search using the key words “sleep apnoea”, “sleep disordered breathing”, “upper airways resistance”, and “snoring”. We limited our search to the English language and to children (age 0-18). We searched the Cochrane database. We hand searched reference lists to check that we had considered all relevant articles. We selected articles for this review if they were the best evidence available on a particular point or the best summary of the evidence. We included some articles to place the review in historical context.

possibly as a protective mechanism to prevent sleep movements during dreaming. A child's soft pharyngeal upper airway is held open only by active pharyngeal muscle tone. Relaxation of the pharyngeal constrictor muscles narrows the airway at the pharynx. Obstructive sleep apnoea may be caused by anatomical obstruction in the pharyngeal airway or a reduction of pharyngeal muscle tone, or a combination of both.⁷ Negative pharyngeal pressure is generated by the diaphragm to compensate for the upper airway resistance, which contributes to airway obstruction.

Are diagnoses of obstructive sleep apnoea in children increasing?

Obstructive sleep apnoea in children has existed for a long time without being widely recognised as a clinical syndrome. In 1889 Hill published an article in the *BMJ* on “some causes of backwardness and stupidity in children.”⁸ Several startling revelations appear in this work—for example, Hill identified the symptoms of obstructive sleep apnoea: “... children, the victims of nasal and pharyngeal obstructions, often suffer from headaches especially when engaged in study, and frequently evince marked inability to fix their attention on their lessons or work for any length of time . . .”⁸

In the 1960s and '70s tonsillectomy was almost routine in children for a range of perceived clinical reasons, including blocked noses and frequent upper respiratory infections. Many children may have had unrecognised sleep disordered breathing. The first case series describing obstructive sleep apnoea in children was not published until 1976.⁹ The increasing interest in the condition has led to more diagnoses, and a position paper published by ENT-UK (the British Association of Otorhinolaryngology—Head and Neck Surgery) has estimated that about a quarter of the 27 400 paediatric tonsillectomies in 2008-9 in the UK were carried out for obstructive conditions.¹⁰ In many countries the adenotonsillectomy rate has fallen, and the Australasian College of Physicians and the

SUMMARY POINTS

Obstructive sleep apnoea has a prevalence of 0.7% to 1.8% in the paediatric population
The condition can be difficult to diagnose clinically
Even mild to moderate obstructive sleep apnoea can result in adverse neurobehavioural consequences and negatively affect quality of life
Adenotonsillectomy is an effective treatment in most uncomplicated cases
More complex cases need management by paediatric and ear, nose, and throat teams in hospitals with appropriate support facilities

Australian Society of Otolaryngology Head and Neck surgery conclude in their position paper that too few adenotonsillectomies are performed in Australia and New Zealand for obstructive sleep apnoea.¹¹

Who gets obstructive sleep apnoea?

Children with no underlying medical diagnosis can get physical obstruction of the nasal airway by enlarged adenoids and of the oropharyngeal airway by enlarged tonsils, resulting in increased airway resistance. The peak incidence of obstructive sleep apnoea in this group occurs in those aged 3 to 6 years, coinciding with the time when the adenoids and tonsils undergo hypertrophy.⁷ The situation is more complex than simple obstruction by adenoid and tonsil hypertrophy as not all children with large lymphoid tissue have obstructive sleep apnoea; this reflects variation between individuals in pharyngeal muscle tone and anatomical differences.⁷

The increasing prevalence of obesity in children has led to the emergence of a second group in whom obstructive sleep apnoea can occur.¹² The pathogenesis is multifactorial, with pharyngeal adipose tissue and decreased respiratory capacity contributing, but the exact mechanism is unclear.¹²

In a third group of children (those with congenital abnormalities such as achondroplasia or craniofacial abnormalities) the cause of obstructive sleep apnoea is complex. Children with such congenital abnormalities have narrow pharyngeal airways, which will predispose them to obstruction. Children with Down's syndrome have both an abnormally narrow upper airway and reduced pharyngeal muscle tone. Two thirds of children with Down's syndrome have some form of sleep disordered breathing, and regular screening for obstructive sleep apnoea is advised.¹³ Box 1 lists conditions associated with an increased risk of obstructive sleep apnoea.

What symptoms and signs might the child have?

Children with obstructive sleep apnoea are different from adults with the syndrome. In adults, daytime sleepiness and snoring are the predominant features of obstructive sleep apnoea.¹⁴ In children, tiredness is not a prominent symptom. The symptoms may be divided into daytime and night time symptoms.

During the night the universal symptoms of obstructive sleep apnoea are habitual snoring, restless sleep, and possibly witnessed apnoeas. The symptoms may be exacerbated when the child has an upper respiratory tract infection. The parents may report the child sleeping in a position with the head extended in an effort to open his or her airway. Reports of apnoea differ, but a well designed prospective cohort study showed that even a history of apnoea episodes could not predict obstructive sleep apnoea reliably.⁵ Parents may often be anxious about their child's breathing during sleep. Parents may report secondary enuresis, which is thought to result from decreased appropriate arousals during sleep.¹⁵ Evidence also exists of an association of primary enuresis with habitual snoring from a population based study.¹⁶

A systematic review of observational studies has concluded that a suggestive history is an unreliable predictor of a diagnosis of obstructive sleep apnoea.¹⁷ This review was somewhat limited as nearly a half of the studies were retrospective, although others were well designed cohort

studies. A meta-analysis of the raw data showed history and examination to have poor positive predictive value for obstructive sleep apnoea.

During the daytime, neurobehavioural symptoms such as irritability, behavioural problems, and poor concentration predominate. These result not only from hypoxia but also from sleep fragmentation.¹⁸ In experimental models hypoxia has resulted in neuronal cell loss, which has detrimental effects on memory and cognition.¹⁵ A review identified 22 studies that compared children with obstructive sleep apnoea with controls using tools such as the child behaviour checklist, Conners' rating scale, and the child health questionnaire.¹⁹ Although the studies provided a low standard of evidence, they showed almost universally poorer concentration, attention, behaviour, and quality of life in the group with obstructive sleep apnoea.

In the most severe cases the child may fail to thrive.²⁰ Pulmonary complications arise from complex mechanisms that increase pulmonary vessel resistance. When this becomes persistent pulmonary hypertension and cor pulmonale can occur.¹⁵ Serious complications leading to death are rare.⁶

What is the differential diagnosis?

A child who snores may simply have primary snoring or may have obstructive sleep apnoea. Apnoeas without respiratory effort can occur with central apnoea as a result of a lack of neural drive. Describing other sleep problems is

Box 1 | Conditions that carry an increased risk of obstructive sleep apnoea¹³

Down's syndrome
Neuromuscular disease
Craniofacial abnormalities
Achondroplasia
Mucopolysaccharidoses
Prader-Willi syndrome

Box 2 | Taking a sleep history

Ask about night time symptoms

Do they snore?
Do they get a good night's sleep or are they restless?
Do they wake through the night?
Do they struggle with their breathing or stop breathing?
Do they sleep in an unusual position (such as with extended head)?
Do they sweat excessively?
Do they wet the bed?

Ask about daytime symptoms

Do they have any behavioural or concentration problems?
Do they breathe through their mouth?
Are they growing normally?

Box 3 | Grading of tonsil size by how much of the oropharyngeal airway is occupied²²

Grade 0: Within tonsillar fossa
Grade 1: 0-25% of oropharyngeal airway
Grade 2: 26-50%
Grade 3: 51-75%
Grade 4: >75%

Box 4 | Indications for paediatric respiratory investigations²⁵

- Unclear or inconsistent diagnosis of obstructive sleep apnoea
- Age <2 years
- Weight <15 kg
- Down's syndrome
- Cerebral palsy
- Hypotonia or neuromuscular disorders
- Craniofacial anomalies
- Mucopolysaccharidoses
- Obesity (body mass index >95th centile for age and sex)
- Important comorbidity such as congenital heart disease, chronic lung disease
- Residual symptoms after adenotonsillectomy



Fig 1 | Enlarged tonsils in patient with obstructive sleep apnoea under general anaesthetic for adenotonsillectomy (endotracheal tube and tonsillar gag are visible)

beyond the scope of this article, but these are discussed in a recent excellent review.²¹

What history can be taken in primary care?

We recommend taking a sleep history for all children presenting with symptoms of blocked nose, recurrent nasal or throat infections, and recurrent ear infections, and for children whose parents are concerned about snoring. Snoring sounds (stertor) are different from the higher pitched sounds (stridor) that arise from a narrowed larynx or trachea. In our experience children with sleep apnoea may have several seemingly unrelated symptoms, such as failure to thrive and poor concentration, and nocturnal symptoms are not volunteered unless a sleep history is routinely taken. Box 2 lists questions that might be used to elicit daytime and night time symptoms associated with disordered breathing.

What examinations can be performed in primary care?

An assessment of nasal airflow can be performed by holding a cold spatula or tongue depressor under the nose. Misting of the cold metal indicates airflow. A lack of airflow may indicate nasopharyngeal obstruction resulting from enlarged adenoids or nasal obstruction, usually caused by rhinitis. The nasal cavity may be examined using a headlight or an otoscope for the presence of rhinitis or obstructive polyps.

Assessing the mouth and pharynx elicits information on tonsillar size and any abnormality of the palate. Tonsils can be graded by size (box 3). Examine the neck for any lymphadenopathy and the ears for glue ear, which may coexist with adenoid hypertrophy.

Who should be referred and where should they be sent?

Children with clinical evidence of adenotonsillar hypertrophy (fig 1) and symptoms of persistent snoring plus any of the daytime or night time features of obstructive sleep apnoea require referral, in the first instance to an ear, nose, and throat surgeon with an interest in paediatrics.

Children with underlying diagnoses, such as those listed in box 1, and any of the clinical features of obstructive sleep apnoea need to be investigated. If the child is already in the care of a paediatric team, then liaising with that team, which can refer the child to the paediatric respiratory/sleep team, is the most appropriate route.

Children with obesity and features suggestive of obstructive sleep apnoea can be referred, usually to a paediatrician in the first instance.

How are children with sleep disordered breathing investigated and managed in secondary care?

An ear, nose, and throat surgeon will take a sleep history with reference to presenting symptoms and may ask about symptoms of hearing loss. A full ear, nose, and throat examination will be done, with a hearing assessment if indicated. The clinician will then decide if investigations are indicated. There are two common investigations for this condition: overnight pulse oximetry and polysomnography.

Overnight pulse oximetry provides information, on heart rate and oxygen saturation, which may be valuable if more detailed tests of sleep disordered breathing are not available. This does not always require an overnight hospital admission as the family can go home with portable pulse oximetry equipment. Periods of apnoea are indicated by occasions when the oxygen saturation drops; these episodes are usually accompanied by a rise in heart rate (fig 2). A group of Canadian researchers devised an oximetry scoring system, which they tested in a prospective cohort

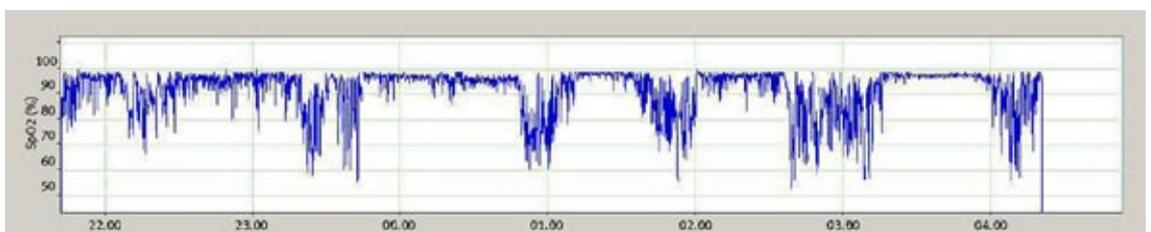


Fig 2 | An overnight oximetry trace, with oxygen saturation on the y axis and time (24 hour clock) on the x axis, showing recurrent desaturations in a patient with obstructive sleep apnoea

study, and found that higher scores were associated with increasing severity of obstructive sleep apnoea.²³ Oximetry has a high positive predictive value (97%) for diagnosis of obstructive sleep apnoea, but because not all apnoeas result in a drop in saturations the negative predictive value is low (53%).²⁴

Polysomnography (a sleep study) is currently the optimal investigation. The minimum elements of investigation should comprise measurements of oxygen saturation, airflow, and respiratory effort; electrocardiography; and videotaping with sound.¹³ Polysomnography can measure apnoeas (cessation in airflow) or hypopnoeas (reduction in airflow). These two measures are often combined as the apnoea-hypopnoea index, which is the total number of apnoeas and hypopnoeas per hour of sleep. Other additional measurements can be included in a sleep study, such as results from electroencephalography, electro-oculography, or electromyography.

In the United States the American Academy of Pediatrics' management guideline recommends polysomnography as the optimal investigation and oximetry or abbreviated studies if this is not available.⁶

The UK Royal College of Paediatrics and Child Health's working group concluded in its management guideline that oximetry is a useful screening tool but that to discriminate reliably primary snoring from obstructive sleep apnoea polysomnography would be required.¹³

A UK working party consensus statement endorsed by the British Association of Paediatric Otolaryngology, ENT-UK, the Association of Paediatric Anaesthetists, the Royal College of Anaesthetists, and the Royal College of Paediatrics and Child Health was published in 2009.²⁵ The statement recognised that in the UK the decision to operate on children with sleep disordered breathing is a clinical one, based on symptom severity.

If the symptoms are inconsistent and the child is very young or at the extremes of the weight centiles then investigations are indicated. In patients with a suspected underlying syndrome or serious illness then investigations are essential before further management. Box 4 lists indications

Box 5 | Children who should be referred for treatment in a specialist centre (not a district general hospital)²⁵

Age <2 years
 Weight <15 kg
 Failure to thrive (weight <5th centile for age)
 Obesity (body mass index >95th centile for age and sex)
 Severe cerebral palsy
 Hypotonia or neuromuscular disorders (moderately severely or severely affected)
 Serious craniofacial anomalies
 Mucopolysaccharidoses and syndromes associated with difficult airway
 Serious comorbidity (such as congenital heart disease; chronic lung disease; ASA 3 or above—that is, grade 3 in the American Society of Anesthesiologists' physical status classification system)
 Electrocardiographic or echocardiographic abnormalities
 Severe obstructive sleep apnoea (described by polysomnographic indices including an obstructive index >10, a respiratory disturbance index >40, and an oxygen saturation nadir <80%)

A PARENT'S PERSPECTIVE

A parent of a child with obstructive sleep apnoea treated by adenotonsillectomy: "Before the operation, my son had noisy breathing, and even with the television on you could hear his breathing when he slept. He had loud snoring, and I could tell something was not right. During the day he seemed to have a cold all the time. He had an operation to remove his tonsils and adenoids. He came through this well and didn't have too many problems with pain. He ate and drank well. The results from this were fantastic. His symptoms vanished after the operation. He now makes no noise when he sleeps and seems to have a better night's sleep. His speech is clearer—before, he always seemed to talk with a blocked nose. During the day he seems happier and more settled than he was before the operation."

for considering investigation before treatment in a child suspected of having obstructive sleep apnoea.

As a history and examination alone cannot reliably differentiate between obstructive sleep apnoea and primary snoring, if a strategy of surgery without respiratory investigations is adopted, some children with primary snoring may have adenotonsillectomy.¹⁷ However, it is not logistically possible for all snoring children to have polysomnography. A pragmatic approach is taken, and the decision to treat is based on the severity of the daytime and nocturnal symptoms reported and on the occurrence of early complications associated with obstructive sleep apnoea. These children are diagnosed with sleep disordered breathing with a suspicion of obstructive sleep apnoea.

What are the possible treatments?

For the child with no underlying medical condition and with clinical evidence of adenotonsillar hypertrophy an adenotonsillectomy would be the most appropriate treatment. As discussed above, adenotonsillectomy is appropriate in some children without further investigations if they have clinical features suggestive of obstructive sleep apnoea.²⁵ The symptoms and signs need to be considered along with other indications for tonsillectomy and adenoidectomy, such as recurrent tonsillitis or glue ear. Children with fewer symptoms of sleep disorder may still require adenoidectomy or tonsillectomy for other indications. A Cochrane review of treatment of obstructive apnoea by adenotonsillectomy found only one paper meeting the Cochrane criteria,²⁶ and this was primarily concerned with surgical technique.²⁷ The patients were randomised either to radiofrequency tonsil reduction and adenoidectomy or to conventional adenotonsillectomy. The outcome measures did not differ.

The main physiological outcome is the apnoea-hypopnoea index, calculated from polysomnography results as described above. Several studies show a reduction in the apnoea-hypopnoea index after adenotonsillectomy, and these have been summarised in a recent meta-analysis.²⁸ The inclusion criteria for the meta-analysis included paediatric patients with no underlying syndrome or diagnosis who had adenotonsillectomy with preoperative and postoperative polysomnography. The meta-analysis pooled data on 355 children from 14 series. The data are limited by the fact that they come from case series and no control groups were included. An improvement in the polysomnography results to normal occurred in 83%, and a reduction in the

apnoea-hypopnoea index of 14 events an hour was found.

Measuring outcomes other than the physiological sleep outcomes—such as neurocognitive outcomes and quality of life by proxy—is of increasing interest. The only UK study to have measured quality of life improvement was by Georgalas and colleagues.²⁹ In a cohort of patients, adenotonsillectomy improved all domains of the child health questionnaire. In North America disease-specific quality of life measures such as the OSA-18 are widely used.³⁰ A review article found 11 publications measuring changes in behaviour, neurocognition, and quality of life after adenotonsillectomy.¹⁹ The authors of the review over-rate the quality of evidence as these studies are generally prospective, single sample, observational studies, although five of the 11 do include a control group. Universal improvement in quality of life is reported in these studies. Behaviour and neurocognitive measures also show improvement. Longer term studies show that the quality of life improvement can be sustained

over a couple of years but may be less pronounced than initially.³¹

Adenotonsillectomy can still be done if an underlying condition or syndrome is present, but the surgery needs to be evaluated carefully as the obstructive sleep apnoea in this group is likely to be multifactorial. Continuous positive airway pressure may need to be considered if adenotonsillectomy is contraindicated or unlikely to help. A randomised control trial of continuous versus bilevel positive airway pressure in children with obstructive sleep apnoea who were unsuitable for adenotonsillectomy found no difference between the methods.³²

Nasal steroids can be used to treat rhinitis if nasal obstruction is thought to be making a substantial contribution. A well produced, double blind, randomised control trial of nasal steroids (six weeks of fluticasone) showed a reduction in the apnoea-hypopnoea index.³³ The only long term data relate to a non-randomised longitudinal study, which found that symptom scores in mild obstructive sleep apnoea decreased after four weeks of a nasal steroid and remained at this level nine months later.³⁴

In specific circumstances such as craniofacial abnormality, specific surgery or dental appliances such as advancement splints may be required.

Can complications of treatment occur?

The main risk of adenotonsillectomy is of postoperative haemorrhage, which has a rate of 3.5%.³⁵ Clinicians are concerned that children who have obstructive sleep apnoea may be at increased risk of perioperative respiratory complications. They may be more sensitive to opiates and inhalational anaesthetic agents. Postoperative desaturations can occur in up to 10% of children.⁴ Rarely, children can develop pulmonary oedema. This happens as a result of the loss of the positive end expiratory pressure they experienced secondary to the airway obstruction. With relief of the obstruction a transudate and pulmonary oedema can develop.⁴ In children who have been identified as high risk (box 5), surgery should be performed in a hospital with paediatric intensive care facilities. Careful preoperative investigation is essential.²⁵

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Patient consent obtained.

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UNANSWERED QUESTIONS

- Can a clinical assessment be designed to detect sleep apnoea accurately?
- What should be the consensus definition for paediatric obstructive sleep apnoea based on polysomnographic criteria?
- What is the natural course of mild obstructive sleep apnoea?
- At what level of mild obstructive sleep apnoea should surgical intervention take place, and who could be treated conservatively?
- How does paediatric obstructive sleep apnoea affect the long term risk of developing adult obstructive sleep apnoea?
- What is the significance of the metabolic changes that occur in obstructive sleep apnoea?³⁶

TIPS FOR NON-SPECIALISTS

- Take a full sleep history in children presenting with symptoms of upper respiratory infection and ear infection
- Consider referral of patients with habitual snoring and other daytime or nocturnal symptoms of obstructive sleep apnoea
- Uncomplicated cases with symptoms suggestive of obstructive sleep apnoea and evidence of adenotonsillar hypertrophy can be referred to an ear, nose, and throat specialist
- Patients with congenital abnormalities, syndromes, comorbidity, or obesity can be referred to the paediatric team in the first instance

ADDITIONAL EDUCATIONAL RESOURCES

For professionals

- Royal College of Paediatric and Child Health Working Party on Sleep Physiology and Respiratory Control Disorders in Childhood. *Standards for services for children with disorders of sleep physiology*. 2009. www.rcpch.ac.uk/Research/ce/Guidelines-frontpage/Guideline-Appraisals-by-Organisation/RCPC-Working-Party. (This is a comprehensive review of children's sleep disorders, including obstructive sleep apnoea)
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For parents

- ENT-UK (www.entuk.org/patient_info/throat/tonsil_html)—A guide to tonsil surgery
- ENT-UK (www.entuk.org/patient_info/throat/adenoid)—A guide to adenoid surgery
- American Academy of Otolaryngology-Head and Neck Surgery (www.entnet.org/HealthInformation/Child-Child-Have-Sleep-Apnea.cfm)— Fact sheet: *Could My Child Have Sleep Apnea?*

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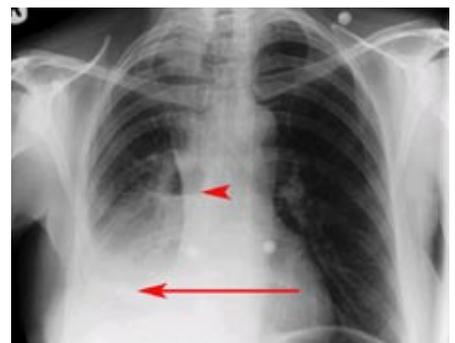
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ANSWERS TO ENDGAMES, p 1039. For long answers go to the Education channel on bmj.com

PICTURE QUIZ An ominous cough

- 1 The chest radiograph shows an air fluid level at the right intermediate bronchus close to the site of the bronchial stump. In addition, opacification of the right lower zone of the hemithorax is obscuring the right hemidiaphragm and right heart border, probably because of a right pleural effusion (figure). This radiograph combined with the clinical history suggests the presence of a postoperative bronchopleural fistula.
- 2 Factors associated with an increased risk of postoperative bronchopleural fistula include right pneumonectomy, immunocompromise, preoperative pleuropulmonary infection or radiotherapy, mechanical ventilation, and residual carcinoma at the bronchial margin.
- 3 Immediate management includes insertion of an intercostal chest drain to drain the infected pleural space and administration of broad spectrum antibiotics once microbiological cultures have been taken (blood, sputum, and pleural fluid cultures, plus a wound swab if the site seems to be infected). Computed tomography of the chest and bronchoscopy should be performed to identify the site and size of the fistula. Definitive management of the fistula depends on its size, and options include surgical or endoscopic repair in appropriate patients.



Chest radiograph showing an air fluid level close to the bronchial tree at the level of the bronchial stump (arrowhead) and opacification of the right hemithorax with loss of clarity of the right hemidiaphragm and right heart border (arrow)

CASE REPORT Multiple emboli after gastrectomy

- 1 Heparin induced thrombocytopenia is the most likely diagnosis. Important differentials are disseminated intravascular coagulation and thrombotic thrombocytopenic purpura.
- 2 Clinical assessment based on platelet count, timing of exposure to heparin, and thrombotic complications, in combination with testing for antibodies to heparin-platelet factor 4 complexes.
- 3 All heparin should be stopped, and anticoagulation started with lepirudin or danaparoid.
- 4 Platelet transfusion. Warfarin should not be started until the platelet count has recovered.

STATISTICAL QUESTION Errors when statistical hypothesis testing

Scenario 1: answer a (correct conclusion);
 scenario 2: answer b (type I error);
 scenario 3: answer c (type II error).