TRACHEOTOMY IN ACUTE OBLITERATIVE LARYNGOTRACHEO- BRONCHITIS

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This condition was first commented on by Gover (1918) and Lynah (1919) during the influenza pandemic, and the term acute laryngotracheobronchitis was used subsequently by Baum (1924). A detailed review and bibliography of the condition is given by Neffson (1949). Unfortunately the precise significance of the term is not always clear. Brighton (1940) believed it should include only cases requiring tracheotomy or other instrumental relief. Morgan and Wishart (1947), however, considered that it should apply to all cases of "spasmodic croup." Although the condition is usually regarded as an acute non-diphtheritic respiratory infection, Gittins (1942) also included allergy and trauma as aetiological factors.

Because certain parts of the respiratory tract are more often affected than others, some workers have attempted a further subclassification to emphasize this. Neffson (1949) stressed the importance of infraglottic and supraglottic types; Gittins (1942) also subdivides his classification in relation to the main site of the lesion; and Forfar, Keay, and Thomson (1951) have reserved the term for cases of acute laryngotracheitis which have auscultatory signs of bronchitis.

FIG. 1.—Graph summarizing age incidence.

FIG. 2.—Graph showing time incidence of upper respiratory infection and stridor in relation to admission.

The term acute obliterative laryngotracheobronchitis is applied in the present series of 39 cases to an acute non-diphtheritic respiratory infection which occurred in young children and caused respiratory embarrassment due to obstruction of the respiratory passages. In 37 cases the main emphasis of the lesion was an obstruction of the small bronchi and terminal bronchioles.

A fairly characteristic clinical pattern was present in most cases. There was a history of an upper respiratory infection for three days, and usually stridor did not appear until the day of admission. The occurrence of stridor was the main reason why the parents consulted their family doctor or brought the child to hospital. On admission the child was usually restless and pale, with noticeable inspiratory and expiratory stridor. The respiratory rate was raised, intercostal recession was present, and in some cases suprasternal indrawing was also to be seen. In some of the more acutely ill children cyanosis was present, and was always a serious sign. Localizing signs in the chest were uncommon, and generalized rhonchi were the most frequent auscultatory finding. The heart rate was always rapid, often considerably so. Severe inflammation of the throat was not a frequent finding. The chest was on x-ray examination normal or showed slight emphysema. The white cell count was more often normal than raised, while throat swabs did not grow a specific organism. After admission and treatment the patients usually lost their stridor between the third and fifth day, and were fit for discharge after a further period of five days.

The physical findings were as follows. Stridor occurred in all 39 cases, rhonchi in 23, restlessness in 23, pallor in 20, and cyanosis in 12. There were two cases of pneumonia. The age incidence, and the time incidence of upper respiratory infection and stridor in relation to admission, are shown in Figs. 1 and 2 respectively.

Medical Treatment

The basis of treatment used in all cases of this series was atmospheric humidification, which was produced by steam-kettle and tent, or aerosol vaporizer. In the more severely affected patients oxygen therapy was combined with humidification. All the children were given antibiotics: terramycin was used in 15 and chloramphenicol in 10. In two of these cases terramycin was given intravenously, but otherwise the drugs were administered orally. Terramycin was given in a dose of 50–80 mg. per lb. of weight (110–175 mg./kg.), while chloramphenicol was used in doses of 100 mg. per lb. (220 mg./kg.). The remaining patients received a combination of drugs: six were given penicillin combined with chloramphenicol or terramycin, five had penicillin and streptomycin, while three received penicillin and aureomycin. In several cases the initial use of penicillin and streptomycin was because the young child was too ill to take adequate amounts of drugs by mouth.

Of these 39 cases 29 ran the characteristic course described above, and recovered with medical treatment. There was one "medical" death. Nine children, however, required tracheotomy; reports of three of these are presented to emphasize the particular indications for the operation.

Typical Cases for Tracheotomy

Case 1.—A boy aged 4½ years was admitted with a week's history of a cough and 12 hours' history of respiratory distress. On examination his temperature was 100.8° F. (38.2° C.), pulse 100, and respirations 32; there was cyanosis, and excess mucus in the mouth with diminished air entry in the chest and slight recession. Crystalline penicillin, 1 mega unit, was given immediately and pharyngo-laryngeal suction was carried out, using a direct-vision laryngoscope.

This caused deep cyanosis, and immediate tracheotomy was performed. Relief of obstruction was dramatic. Further treatment consisted of oxygen with aerosol mist, intravenous terramycin 1 g. in 24 hours, and then oral terramycin for one week. The child was well on the second day, the tracheotomy tube was removed on the fourth day, and he was discharged on the tenth day.

Case 2.—On the day of admission the child, a boy aged 18 months, developed a croupy cough and because of general deterioration was transferred to hospital. On admission he was cyanosed and dyspnoeic, and had slight costal recession. There were no localizing chest signs. Temperature 103° F. (39.4° C.), pulse 180. The child was under observation in oxygen for one hour. At the end of this period the recession and cyanosis had increased, so an elective tracheotomy was performed followed by bronchial suction. The latter produced a fair quantity of mucopus, more from the left than the right bronchus. This procedure caused immediate lessening of recession, and improvement in colour and in his general condition. One hour later the child's condition was satisfactory, and four hours later oral terramycin was begun, 250 mg. being given every six hours. Eight hours after operation bronchial suction was repeated because the respiratory signs were increasing. Casts of moderate and small size were removed from both sides, the improvement being dramatic. The child was then nursed in steam for 24 hours and afterwards in oxygen with aerosol mist. Two days after admission the child began to feed well and take an interest in his surroundings. Special nursing was discontinued on the fourth day, the tracheotomy tube was removed on the fifth day, and the child was discharged on the 13th day after admission.

Case 3.—A girl aged 1 month had a cold for five days before admission, with a cough for two days. On the day of admission she refused all feeds, and by 3 p.m. was having difficulty in breathing. Examination showed a slightly cyanosed pale baby with some chest recession. With oxygen therapy the colour improved and she was nursed overnight in an oxygen tent and received penicillin and streptomycin therapy. At 10 a.m. her condition was good, but by midday rib recession was recurring, and at 1.50 p.m. she had become pale and cyanosed, with definite basal recession. Tracheotomy and bronchial suction were performed, with marked improvement; the cervical venous distension and recession disappeared, although facial pallor persisted. Bronchial suction was done at three-hourly to four-hourly intervals, and by 10 p.m. respirations were regular, with minimal recession. Oral feeds were taken well next day, and the child was nursed in oxygen with aerosol. Convalescence was uneventful, the tracheotomy tube was removed on the sixth post-operative day, and she was discharged from hospital on the 18th day.

Comments on Cases 1-3.—In Case 1 immediate tracheotomy was life-saving, and the laryngeal region was the

main site of inflammation. Case 2 was more typical of our series, and tracheotomy was done as an elective procedure one hour after admission. Case 3 had an elective tracheotomy 24 hours after admission because of deterioration following initial improvement.

Operation

Tracheotomy was performed in all cases through a transverse skin incision and under

local analgesia. Once through the deep fascia, dissection was limited to the midline, and a low tracheotomy was performed, the largest possible tube being inserted. The only difficulty was the presence of a large thymus in two of the smaller babies, necessitating downward retraction to expose the trachea.

Method of Suction.—At first we used water-pump suction, but very soon we realized that the negative pressure achieved was inadequate to remove the thick viscid secretions. We now use an electric sucker and polythene tubing (Fig. 3). The polythene tube was the largest that would pass through the outer tracheotomy tube. Rotation of the head combined with twisting of the curved tubing allowed easy passage of the tube into either main bronchus and down distally to a distance of 4-6 in. (10-15 cm.) in a child of 3 to 6 months (Fig. 3). The histological composition of the casts removed is described by Emery (1952).

Post-operative Care

Suction was repeated in most cases every three to four hours during the first post-operative day, and in one case for as long as three days. Bronchial lavage was attempted in one case to aid removal of viscid plugs, but the results were not impressive.

No serious complication resulted from this method of suction despite the frequency with which it was used, and it was performed by both junior and senior medical residents. The nursing staff were instructed in the use of a simple suction with a soft rubber catheter to keep the tracheotomy tube clear of mucus. No crusting of secretions was encountered.

Because of one fatality early in the series (Case 6) we continually stressed that it was important to have a special nurse, that the patient should not be hidden in a canvas tent, and that adequate night lighting should be available. When any sudden deterioration occurred the nurse was instructed to remove the inner tube immediately and apply suction to the outer tubing while another nurse called medical assistance.

Complications.—Surgical emphysema was seen in the tissues of the neck of one case on a routine check radiograph but was not demonstrable clinically. One other case had a persistent croup which disappeared within four weeks.

Fatal Cases

Of the nine patients who came to tracheotomy three died; these cases are described below, as is the one "medical" death.

Case 4.—A boy aged 7 weeks was admitted as an emergency with a temperature of 107° F. (41.7° C.) and cyanosis. The history was of snuffles and a dry cough for one week. Twelve hours before admission the child appeared feverish, and from that time refused all feeds. Six hours before admission he had a convulsion. On admission he was in extremis, with cyanosis, laryngeal stridor, and severe intercostal recession. The chest signs were of generalized basal crepitations with diminished air entry, and, apart from an abnormally shaped skull, other systems appeared normal. After emergency intubation the respiratory distress decreased but not the cyanosis. The child was then put into an oxygen tent and given 200,000 units of crystalline penicillin three-hourly and streptomycin 50 mg. six-hourly. Three-quarters to one hour later respiratory distress was so severe that intubation was repeated with light suction of tracheal secretions; again there was some improvement. Twenty minutes later the child's condition had deteriorated and he appeared moribund. An indwelling endotracheal tube was passed and suction repeated. Improvement on this occasion was minimal, and tracheotomy was at once performed. This produced three to four minutes of apnoeic anoxia, and when seen half an hour later in oxygen the child was definitely easier but remained cyanosed. Bronchial suction was repeated twice in the next three hours, but the patient gradually deteriorated, and died four and half hours after tracheotomy.

FIG. 3.—Specimen of lung from a post-mortem case aged 3 months. The polythene tubes were passed and the lung dissected to show their position.

Case 5.—A boy aged 4 months was admitted with a four-days history of cough and a five-hours history of respiratory distress and stridor. On examination he was restless, with marked general pallor and cyanosis of the lips and fingers. A loud stridor was audible and there was marked recession of his chest wall. Apart from generalized moist sounds physical examination of the chest was negative. Temperature 101° F. (38.3° C.), pulse 160. Crystalline penicillin, 200,000 units, was given three-hourly and the child put into an oxygen tent. The cyanosis disappeared in oxygen and the child seemed more restful. Two hours after admission the resident medical officer found the patient in extreme respiratory distress, with pallor, cyanosis, and restlessness. Tracheotomy was performed in the ward within 10 minutes and an attempt was made to aspirate the bronchi with water suction. This failed, and as the child's condition was rapidly deteriorating it was returned to the oxygen tent and artificial respiration given. Efforts to procure effective suction were unsuccessful and, despite resuscitative measures, the baby died half an hour after the operation.

Case 6.—A boy aged 2 months was admitted with a 48-hours history of cough, running nose, and wheezing. During the last 24 hours he had had four attacks of respiratory distress, and was sent in because of the last, which was more severe. On examination he was not unduly distressed; he was a good colour, but had a definite stridor. The only abnormal physical signs were occasional generalized rhonchi and tachycardia. Oral chloramphenicol was given six-hourly. Next day the chest signs were more severe and the child was placed in a steam tent. By 4 p.m. rib recession was pronounced, with cyanosis and extreme restlessness. Tracheotomy, with bronchial suction, was performed at 4.30 p.m. Following suction, which was quite productive, cyanosis decreased. Bronchial suction was repeated twice before midnight, and the child was nursed in steam. At 2 a.m. his condition had become much worse, further suction was performed and oxygen administered. Artificial respiration was performed in the oxygen tent for a period and aerosol therapy begun. Suction was repeated on two or more occasions, and by 10 a.m. the child was sufficiently improved to take a feed. Progress throughout the day was satisfactory, but quite suddenly at 6 p.m. the child became acutely distressed and died.

Case 7.—This patient, a boy aged 7 months, was admitted with a history of an upper respiratory infection for three days and stridor on the day of admission. He was treated in a steam tent and given penicillin, 100,000 units six-hourly, and streptomycin, 20 mg. per lb. (44 mg./kg.) of body weight. Six hours after admission he was more distressed, and had considerable recession. Cyanosis appeared, and he died from apparent suffocation.

Comments on Cases 4-7.—From the onset Case 4 was most unfavourable, but there is no doubt that the repeated intubation with suction failed to produce adequate clearance of the air passages and merely added laryngeal obstruction to the child's difficulties. In Case 5, mismanagement is seen in that the initial clinical picture with cyanosis did not prompt more vigorous treatment. The tracheotomy was left until the child was in extremis, and electrical suction was not available. Case 6 died shortly after the routine changing of the inner tracheotomy tube, and when one of us (J.N.B.) reached the dead baby this tube was found to be completely blocked with inspissated mucus. Death was due to asphyxia, although clinically the child was making a satisfactory recovery before this. The deterioration in Case 7 might have been stopped had an elective tracheotomy been done. Death appeared to be due to suffocation.

Relevant Extracts from P.M. Reports

Naked-eye Appearance of Lung from Case 4.—The trachea contained brownish-grey tenacious material. Similar material extended into the orifices of the largest bronchi and a pale thread could be seen extending down almost all

of them. The lung showed some areas of collapse, with small pleural petechiae. No areas of consolidation were seen.

Lung Histology, Case 5.—Areas of collapse and abnormally distended lung were present with patches of early bronchopneumonia. There was a purulent infiltration of small bronchi and some intra-alveolar oedema. In some bronchi a cellular membrane was adherent to the mucosa.

Naked-eye Appearance of Lung from Case 6.—The bronchi contained yellowish mucus, and this appeared to become tenacious as the smaller bronchi were opened. No obvious areas of consolidation were seen, and on slicing the lung some of the small bronchioles seemed to be completely blocked with pale mucoid material. **Lung histology:** areas of alveolar oedema, dilatation and collapse were present, and some bronchi showed destruction of the epithelium and obliteration of the lumen.

In Case 7 no necropsy was performed.

Discussion

Almost all workers are agreed on the value of atmospheric humidification, which may be brought about by steam-kettle or aerosol vaporizer, and to this therapy oxygen can be added with definite advantage. The value of wetting agents is still under investigation (Gorman, 1950; Hall, 1952).

A precise statistical analysis of the value of any single antibiotic in these cases was not possible, but on the basis of clinical improvement no single antibiotic was specific. There can be no doubt, however, that antibiotics having a wide antibacterial range are of the greatest value in preventing secondary bacterial infection, which was previously such a serious complication. Preparations which can be given intramuscularly or intravenously have an added advantage, as often the child may be too ill to take medicines orally. With the use of these methods most of the patients should recover, and in our series 29 cases responded rapidly. Opinion is divided on the value of tracheotomy. Baum (1945) believed that concentrated plasma, given intravenously in doses of 25-40 ml., relieved the obstructive symptoms. While he admitted that some cases might require tracheotomy, he felt that the use of concentrated plasma and bronchoscopic suction would save many cases from operation. Forfar, Keay, and Thomson (1951) were not impressed with the value of tracheotomy in two of their 22 cases, as both of those operated upon died. McEntee (1949) stated that delay would avoid some tracheotomies and would prevent some deaths, but he offered no figures to support his view. Neffson (1949) felt that the main use of tracheotomy was in treatment of cases with supraglottic oedema. However, in a review of 549 children who had suffered from acute laryngotracheobronchitis, Morgan and Wishart (1947) stated that tracheotomy was the operation of choice, and that it should be performed early in the disease. In a study of 70 patients, 11 of whom were operated upon, von Leden (1951) also concluded that early tracheotomy is of great value. His operative mortality was nil. Braestrup (1949) is convinced that early tracheotomy in severe cases of acute obliterative laryngotracheobronchitis is one of the most important points in the management of these patients.

The condition seen by us was one of obstruction of the smaller bronchi by viscid secretions which occurred early in the disease. The degree of anoxia varied according to the extent of this obstruction. If this was severe early death was likely to be due to mechanical obstruction rather than toxæmia. Removal of this obstruction can readily be achieved by adequate and, if necessary, repeated suction.

The possible ways in which suction may be applied are through an endotracheal tube, by bronchoscopy, or by tracheotomy. Repeated suction through an endotracheal tube may do more harm than good even when performed by a skilled operator, as in one of the fatal cases of this series (Case 4). For this reason we feel that intubation

or bronchoscopy should be limited to an emergency procedure prior to tracheotomy. In these cases further emphasis must be placed on repeated suction. The performance of a tracheotomy, and then suction using polythene tubing, ensures that the smaller bronchi may be reached and cleared.

When necessary, the decision should be to do the tracheotomy as an elective procedure, and the exact time interval before the operation must vary with each individual case. This may range from immediately on admission up to 36 hours later. The use of tracheotomy as a last desperate expedient can only bring its performance in acute obliterative laryngotracheobronchitis into disrepute.

Summary and Conclusions

Thirty-nine cases of acute obliterative laryngotracheobronchitis are described. Their clinical course and medical treatment are given and their management is discussed, with especial reference to the use of tracheotomy.

The indications for elective tracheotomy are : (1) the appearance of cyanosis ; (2) extreme fatigue ; (3) increasing restlessness, pallor, and stridor, with an associated diminution of air entry.

Our cases fall into three groups. (1) *Immediate emergency tracheotomy* (see Case 1), which is necessary where there is acute glottic obstruction. (2) *Early elective tracheotomy* (see Case 2) : these are the patients who rapidly deteriorate despite adequate medical treatment. They should be under observation for a period of one hour and then have tracheotomy performed. (3) *Late elective tracheotomy* (see Case 3) : these patients at first respond to medical treatment, but later their condition deteriorates. When this occurs they should be observed for a period of one hour and then have tracheotomy performed. These cases usually do not present until 24–36 hours after admission.

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A branch of the Davidson Clinic for the out-patient treatment of psychoneurotic illness and emotional disorders was opened last month in Glasgow by the Lord Provost. The original Davidson Family Clinic (named after the Davidson Church in whose vestry the clinic was first housed) was established in Edinburgh in 1941. The Clinic is open to anyone with psychoneurotic illness, fees being charged according to the patient's means. Treatment is by psychoanalysis, with special emphasis on the correction of family disharmonies. The Edinburgh Clinic has a staff of 12 analysts, 6 of whom are medically qualified. It is the policy to use carefully selected lay therapists working under the supervision of the medical staff, so as to increase the turnover of patients. The Clinic is a registered charity and appeals to the public for funds. No grants have so far been allocated to it from National Health Service or local authority funds.

ACUTE LARYNGOTRACHEOBRONCHITIS IN CHILDREN

A STUDY OF THE INCIDENCE AND PATHOLOGY

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[WITH SPECIAL PLATE]

The impetus given to the investigation of croup by Napoleon when his nephew died of the condition stimulated many studies of membranous croup in France in the early part of the nineteenth century. Blaud (1823) was possibly the first to mention non-membranous laryngotracheitis, although the Hippocratic writer in the "Coan Prognosis" probably recognized the condition when writing, "Running of the nose and sneezing are bad signs if they precede or supervene upon an infection of the lungs" (Chadwick and Mann, 1950). It was not, however, until the influenza pandemic of 1918, and, following this, the stressing by Thomson (1922) and others of non-diphtheritic infection, that the present interest in and the importance of acute non-diphtheritic laryngotracheobronchitis arose.

The condition was at first the concern of the otolaryngologists in America, and Jackson and Jackson (1936) found a mortality rate of 70% in children under 3 years of age. It would seem that the present mortality of the type of case seen by the surgeon is often still in the region of 50%. Kayser (1941) and Neffson (1944) have well reviewed the progress of the condition as seen in America, and Neffson (1949) refers to over a hundred relevant communications. In this country the condition has received comparatively little comment, and, according to Bonham-Carter (1949), is not generally recognized because of its relative rarity. An epidemic in Dundee was reported by Forfar, Keay, and Thomson (1951), and, apart from this, only small groups have been recorded. Its present clinical state is well summarized by Moncrieff and Weller (1949) when they say, "Laryngotracheobronchitis is one of the most alarming emergencies with which the children's physician has to deal . . . other acute affections of the respiratory tract usually yield to chemotherapy . . . this one . . . is uninfluenced by such treatment."

While the clinical picture of laryngotracheobronchitis is well described and a series of clinical cases is reported by Briggs and Heseltine at page 1064 of this issue, the comparison of mortality rates and results of therapy is almost useless, owing to the different types of cases included in the milder and cured forms. The nomenclature of the condition is confusing, and is studded with dramatic adjectival prefixes such as "obliterating," "suffocating," "obstructive," "stenotic," "fulminating," etc. The pathology of the condition as seen by us does not always coincide with that described by Neffson (1949).

The present communication is an attempt to assess the incidence of mortality of the condition and to discuss the processes which lead to death and against which treatment may be directed.

Material

The material used is from a series of 650 personally conducted necropsies carried out over the last four years in children dying in Sheffield. Most of the cases were from