Treatment of Tetanus Neonatorum with Muscle Relaxants and Intermittent Positive-pressure Ventilation

P. M. Smythe, M. D. Bowie, T. J. V. Voss

Summary

Intermittent positive-pressure ventilation and muscle relaxants were first used in Cape Town in 1958 in an attempt to reduce the mortality from tetanus neonatorum, which was then over 90%. Problems of effective ventilation, of tracheostomy, and of infection in the neonate were gradually overcome so that between 1967 and 1972 the mortality in 186 cases was 21%. In a consecutive series of 97 cases the mortality was 10%.

Introduction

Until preventive measures are widely established neonatal tetanus will remain a problem in many parts of the world, with a mortality in the region of 90% on conservative treatment. A regimen of treatment with intermittent positive-pressure ventilation (I.P.P.V.) and muscle relaxants, which has been evolved after much trial and error, is described because it has stood the test of time and of changes of staff, has greatly reduced the mortality and, it is hoped, will prove helpful in areas where tetanus neonatorum is still a problem.

Patients and Methods

On admission to hospital all cases received 1-2 ml paraldehyde intramuscularly or 1-2 mg diazepam (Valium) to help control the spasms and were given oxygen as required. Antibiotic serum 10-20,000 U intravenously and 20,000 U intramuscularly in divided doses was given at four different sites on the outer aspect of the thigh. Intramuscular gammaglobulin 2 ml helped to control infection, and 1-2 mg vitamin K1 was given intramuscularly to minimize bleeding at tracheostomy. Intramuscular procaine penicillin 100,000 U and kanamycin 15 mg/kg/day in two doses were given for 10 days to control the unbilical infection and supply antibiotic cover.

A small percentage of neonates with tetanus survived on a conservative regimen of tube feeding and sedation. These infants had mild spasms which did not materially interfere with breathing or swallowing saliva. Severe spasms, a severe cyanotic episode, or an apnoeic episode were absolute indications for tracheostomy and assisted respiration.

Tracheostomy

Tracheostomy is best carried out under general anaesthesia with the use of an endotracheal tube. Local anaesthesia alone increases the risk of the procedure. A high tracheostomy with a longitudinal incision through the second, third, and fourth tracheal rings using a short incision of exposure has virtually abolished the complication of pneumothorax. Excision of any cartilage or a transverse incision of the trachea was found to be undesirable.

A Pilling-Holinger tracheostomy tube 5 mm in diameter (size 1) and 33 mm long had a T-piece welded on to the inlet to provide a side attachment to the respirator and an end opening for suctioning (fig. 1). Care was taken to see that the spigot blocking the opening at the end was firmly fixed and could not blow out. Without any cuff the tube fitted snugly into the lumen of the trachea preventing any appreciable leak

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FIG. 1—Pilling-Holinger tracheostomy tube showing T-piece welded on for attachment to ventilator.
of air when positive pressure was applied. Pressure erosions of the infant's trachea developed very easily, and to lessen the chances of this occurring the tapes holding the tracheostomy tube were not tied too tightly and the tube was kept loose enough to be pulled in and out for 0.5 cm each day so that it did not apply constant pressure on one site. The attachment to the respirator was light and flexible (biliary T-tubing) and the tube was not so long as to impinge on the carina. The angle of the head, neck, and body were such as to ensure that the tracheostomy tube and the tracheal lumen were in alignment.

VENTILATION

The best ventilator was found to be the one with which the nursing and medical staff were most familiar, and the simpler the better. The East Radcliff ventilator working through a warm water humidifier proved excellent. The humidifier was set so that the gases entering the patient were between 33-35°C. This meant that the humidifier was set at ± 60°C. Good thermostatic control of the humidifier was essential, as failure of the thermostat might have meant death of the child. Tubing was angled to allow all water condensation to drain back into the humidifier. More modern systems are available but satisfactory results were obtained with the simple system shown in fig. 2.

FIG. 2—A simple system used for ventilating most infants.

At the time of tracheostomy all equipment was ready, with the humidifier warmed, for attachment of the infant to the ventilator with a minimum of delay to prevent drying and inspissation of tracheal secretions. A medical officer always accompanied the infant from the theatre back to the ward.

The ventilator was run at 37 cycles a minute at an initial pressure of 15 cm water. Subsequent adjustments were made to the inspiratory pressure to keep the PCO₂ at about 32 mm Hg. If an Astrup apparatus is not available the mixed venous PCO₂ can be measured by a rebreathing method (Sykes, 1960) by which equilibrium is obtained between the mixed venous PCO₂, the lung gas, and a bag or rubber balloon containing oxygen. The percentage of CO₂ was then estimated in a Haldane CO₂ gas analysing apparatus. At first measurements were made every two hours but as the respiratory function stabilized they were made less often. Once efficient care of the infant on the ventilator was established checks of PCO₂ were rarely required and many infants were successfully treated without any check at all. Accurate recordings, by showing a rise in pulse rate, gave warnings of impairment of respiratory function. Most infants were successfully ventilated using air only, which had the advantage of cyanosis appearing early as a manifestation of inadequate ventilation. Recently more sophisticated studies have shown presence of subclinical hypoxia, and 30-40% oxygen in air is preferable to air. Higher inspiratory percentages of oxygen lead to respirator lung syndrome and diffuse atelectasis. Therefore inspired oxygen should not exceed 30-40% unless specific indications exist. An Ambu bag, or some other means of hand ventilation, must always be available in case of ventilator failure.

MUSCULAR RELAXATION

Muscular relaxation was maintained with 10 mg of tubocurarine chloride given intramuscularly. Injections were repeated whenever muscular twitchings occurred. Some recovery of muscular action was allowed between each injection of tubocurarine otherwise ileus might have developed. Infants were nursed on their backs for the duration of I.P.P.V. to avoid displacement of the tracheostomy tube. Nursing the infant with his head inclined upwards by about 15° helped to drain the upper lobe bronchi, the upper lobes being most liable to collapse. Severe flattening of the occiput and pressure sores could have developed if the head had not been turned every half-hour. This was best achieved by fitting a tray under the mattress on which the whole child and the ventilator attachment was tipped to one side or the other without disturbing the attachment of tracheostomy tube to respirator. Some support under the neck took weight off the head but was only enough to keep the tracheostomy tube in correct alignment with the trachea. A foam rubber mattress shaped to the contour of the infant's neck and back distributed pressure evenly.

HAZARDS

Maintenance of a clear airway was the most important factor in obtaining good results. Any deterioration in the child's condition focused attention on airway obstruction. Obstructions sometimes occurred in the tubing leading to the child; the insertion of a manometer attached to the T-piece biliary tubing both helped in localization of an obstruction and provided the nurses with an easily visible indicator of the functioning of the ventilator. Another danger was inspissation of mucus which could obstruct the tracheostomy tube, particularly if humidification was inadequate. Also incorrect alignment of the tracheostomy tube could tilt the tube so that the end impinged on the tracheal wall—an indication of this having occurred was difficulty in passing the suctioning catheter. Most often obstruction followed accumulation of secretions in the trachea and bronchi, especially in the smaller bronchi. Aspiration was carried out hourly and later every two hours. Using a sterile No. 3 English gauge or No. 8 French gauge rubber catheter with a whistle tip (end and side openings) reduced the risk of adherence to the tracheal mucous membrane. If a whistle tip catheter is not available then a catheter with its tip cut off obliquely should be used. Strict sterile precautions were taken during suctioning and catheters were rinsed through with sterile water which was discarded after use. Saliva accumulated in quantity in the mouth of the curarized child. It was sucked out often, especially before suctioning the trachea and bronchi as it might have leaked past the tracheostomy tube down into the air passages.

Physiotherapy was carried out every four hours to bring up secretions obstructing the smaller bronchi. Only practice made this efficient; hyperinflation of the lung with positive pressure was followed by compression of the chest wall with both hands.
to simulate a cough. Pressure on the diaphragm was applied by the thumbs pressing upwards under the costal margin. Too vigorous compression can result in fractured ribs. So long as rhonchi could be felt or auscultated, or there was diminished air-entry or movement of any area of the chest, physiotherapy and suctioning was continued. X-ray pictures were sometimes needed to show the collapse or the re-expansion of a collapsed lobe immediately after efficient physiotherapy.

Infection was the other great hazard to these infants. If there was infection in the stoma around the tracheostomy tube, the tube was changed daily (but not during the first four days), otherwise weekly. The importance of preventing pressure by the tracheostomy tube on the tracheal wall must again be stressed, as an ulcer at the site may act as a nidus of infection, and the need to prevent stagnation of secretions in the bronchi and collapse of segments of lung is also important. Systemic antibiotics may help, but a dramatic reduction of infection resulted from the instillation of 0.25 ml of sterile solution of penicillin 500 U, and colistin 500 U (Smythe, 1967), freshly made up each day, down the tracheostomy tube every four hours for the first two days. Afterwards this treatment was continued only if the secretions became purulent. Bacteriological identification and drug sensitivity of the infecting organism may indicate a change of antibiotics.

FEEDING

Feeding was by gastric tube. Half-strength Darrow's solution was given for the first 48 hours. The stomach was aspirated before each feed; any residue indicated some ileus. Milk feeds were not started until there was no residue. Ileus could have occurred at any time and the abdomen was palpated daily for faeces in the left iliac fossa. If these were felt clear feeds were given only until the bowels acted. Occasionally a quarter of a bisacodyl (Dulcolax) suppository was required.

WEANING FROM VENTILATION

After a period of between two and four weeks tetanic muscular twitching lessened and the period between injections of tubocurarine lengthened. Spontaneous respiratory movements occurred at this time and a trial was made of stopping curare. Phenobarbitone 7-5 mg was given three times a day by stomach tube to maintain relaxation. The ventilator had to be continued for four to five days after stopping curare, however, gradually reducing the inspiratory pressure, as sudden fatal apnoea can occur for no apparent reason during the period of re-establishment of normal breathing; as if the respiratory centre becomes unresponsive after prolonged artificial take over.

After respiration had been re-established, the hypertonicity of the jaw muscles relaxed sufficiently for sucking movements to be made and feeding by mouth was attempted with a Bellcroy feeder. Only when this was carried out without any difficulty was an attempt made to detubate.

A size 00 Pilling-Holinger tracheostomy tube of 3 mm diameter was inserted and the stoma of the tube blocked with the bung from a stomach tube. The diameter of the trachea was so much larger that breathing around the tube through the nose or mouth usually resulted. When the tube could be occluded continuously for 24 hours and all feeds were taken without difficulty the tube could be removed without likelihood of its having to be reinserted.

If the infant would not tolerate blocking of the tube this indicated that one of three types of obstruction was present (Smythe, 1964); granulations which had formed above the level of the tracheostomy tube; compression of the tracheal rings above the level of the stoma; or angling or kinking of the trachea with inspiration because it was attached by fibrous tissue forming around the stoma to the skin. The methods that were used to effect detubation in these children are described elsewhere (Smythe, 1967). Severe ulceration of the tracheal wall could result in a stricture developing.

Immunization with tetanus toxoid was started before the infant was discharged as the amount of toxin which causes the disease is inadequate to produce a state of immunity.

Tetanus is a preventable disease and neonatal tetanus should never occur with good obstetrical practice. Nevertheless, where this is not available and the risk is high the disease can still be prevented by immunization of the pregnant mother with tetanus toxoid.

All the tubing was thoroughly washed out before sterilization. Boiling water or steam was used for the humidifier and only sterile water was added when in use. Ventilators were best sterilized using ethylene oxide but if this is not available it does not mean that this method of therapy should be abandoned. The risk of infection is low if the ventilator is used only for this type of patient. On one occasion three infants developed tuberculosis which was later traced to a ventilator having been used on a child with miliary tuberculosis.

RESULTS AND DISCUSSION

Altogether 415 children have been treated for tetanus neonatorum, of whom 267 survived. The mortality of over 90% in 1956-7 fell to 21% in 186 cases admitted between 1967 and 1972 (fig. 3). L.P.P.V. was first tried in 1959 (Smythe and Bull, 1959) with some improvement, but it was the introduction of the Sykes rebreathing method (Sykes, 1960) to control the inspiratory pressure which caused a sharp reduction in mortality after 1961 (Smythe, 1963). The deterioration in 1964 was largely a result of problems with tracheostomy; when these were clarified (Smythe, 1964) improvement followed. In 1967 a further sharp fall in mortality followed the introduction of the instillation of antibiotics down the tracheostomy tube to control infection (Smythe, 1967). Since then the only significant rise in mortality was in 1970 when for three weeks 100% oxygen was used in error (fig. 3). But for this the mortality would have been 16%, in 155 cases. In a consecutive series of 97 admissions there were 10 deaths. In the last 30 admissions there have been no deaths.

It is not our purpose to compare and contrast different methods and results. But it should be stressed that other methods have been tried, and deviations from the recommended procedures should be approached with caution.

This unit has been under the care of doctors who have other responsibilities as well as the tetanus unit. About 30 infants are
Can I Have an Ambulance, Doctor?

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In view of this and because of the increasing emphasis on rehabilitation services we have studied the transport arrangements for patients attending the Harrow Physical Treatment Centre, which is in effect the outpatient physiotherapy department of Northwick Park Hospital.

Summary

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