A New Look at Infectious Diseases

Tetanus

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Hippocrates described lucidly, perfectly and accurately the clinical details of human and equine tetanus. "Tetanos", (Greek), meaning tension, epitomizes the disease. Pharonic Egypt knew it well and I suppose the phenomenon is as old as the history of mankind: its legendary terror never fails. Today, our people know the real or imagined horrors of "lock-jaw." Yet in Britain it is a rare disease, with 200-300 cases per year contributing little to the general death rate. Poorer countries have a higher incidence resulting from contaminated wounds of bare feet and the extraordinary custom of using umbilical dressings of pure cow faeces. A colleague counted 500 babies in Baghdad in six months of 1951, all thus assaulted and all dead.

Pathogenesis

The organism, *Clostridium tetani*, is ubiquitous in the soil. It concentrates in the bowel of graminivorous animals and enters the human body through any break in the mucocutaneous integument. The *Clostridium* can produce a very powerful exotoxin which can damage nervous tissue (fig. 1) but does not

FIG. 1—Section from pons to show degenerate nerve cells, distorted, shrunken and some having lost their nuclei, lying among some of normal structure.

give rise to an inflammatory reaction. Vegetative growth and toxigenesis need very special conditions, seldom coincidental. Thus the chance of tetanic toxæmia is much rarer than the largest football pools dividend, else we would all succumb to the disease. These habits of the *Cl. tetani* are basic to an understanding of the curious nature of the disease. Like diphtheria, the clinical details are related to the dose of exotoxin and the end result by the amount fixed securely in tissue cells. Though diphtheria stimulates worthwhile immunity, tetanus does not—yet reliable, active, artificial immunity is entirely successful for at least five years.

Treatment too depends on toxin: circulating toxin is accessible to antitoxin (preferably human material, though obviously this is in short supply). The timing of toxigenesis will be unknown until symptoms herald its arrival when antitoxin treatment is inevitably too late. Antitoxin might, as it were, turn off the tap, but unfortunately often that has happened already. When fatal amounts of toxin are already fixed, invulnerable to antitoxin, the issue is merely a matter of time and that is all we may provide in treatment. Formerly, therapy depended on antitoxin, hope, sedation, and good nursing; these may have reduced the mortality to perhaps 60%. Now we can provide more time, and in well-conducted centres this has resulted in a reduction to about 20%. Although violent tetanic spasm can kill, most victims died from overwhelming aspiration pneumonia.

PERSONAL EXPERIENCE

From 1947-58 we faced some 2,000 cases of poliomyelitis which in about 20% of patients produced paralysis affecting respiration or swallowing or both in any degree. Thus we had to organize an intensive care unit before this term was ever coined. This unit has given admirable and continuing experience in the medical and nursing care of completely helpless patients and now can manage any such person requiring such care. Modern positive-pressure ventilators and the very necessary monitor equipment are basic tools. Though by 1954 we were able to follow Lassen's work in Copenhagen in the care of tetanus, few cases came our way until 1958 when the unit became known. Since then our unit has treated 153 patients with tetanus of all ages sent by doctors from all over the West Country who decided that such cases were better handled in a hospital with specialized equipment and experience.

My personal experience of tetanus is as follows:

1934-9—14 cases (10 deaths). Treated with equine antitoxin, sedatives, good nursing and, usually, general ward care.

1940-6—War service. No service case since all had received active immunization by toxoid. I saw an unknown number of mostly Arab babies; it was quite impossible to persuade the mothers not to use cow dung umbilical dressings.

1947-57—10 cases (6 deaths)—three had tracheostomies but all of these were seen before 1954.

1958-72—153 cases (31 deaths) some received antitoxin, now largely discontinued. Assessed by Cole's dicta; each treated as an individual

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problem; Lassen's respiratory care; no sedation when curarized; full intensive care in a special ward; no panic allowed.

Hippocrates regarded major spasm as inevitably indicating death within four days. Cole suggested we think in terms of a "period of onset," defined as that time between the first symptom and the first major spasm. If this is less than 48 hours then the case is very serious indeed. Longer periods of onset progressively diminish expected severity, provided one takes account of age and any other obvious factors. Any arbitrary incubation period, as from the time of wounding, is of no value in prognosis since access of the organism or toxigenesis cannot be placed in time. A good history of active immunization is useful; if doubtful, it is valueless. Passive immunity may put off the evil day when the spore may blossom and produce toxin and there is the danger of serum sickness to remember, which itself is sometimes fatal. Only prepared human gammaglobulin is safe; it is not easily obtained and operates, if at all, on a limited time scale.

When a patient has to travel, the "period of onset" might show that the services of an anaesthetist are necessary to insert a cuffed endotracheal tube under relaxant drugs. Rapid transport is very important and nothing matches the helicopter (in our hospital grounds the Royal Navy and Royal Air Force have classified a site as suitable for landing).

Clinical Features

The clinical signs and symptoms of established cases of tetanus are unmistakable. Thus the differential diagnosis list is short; tetany, hysteria, and—most commonly in our experience—drugs of the phenothiazine series, notably fentazin. A family doctor, who may well have never seen a case of tetanus in his life can readily be fooled by the sensitivity effect of even a small dose of fentazin, which he may use commonly without incident or suspicion.

Probably the commonest symptoms of the onset of tetanus are difficulties in swallowing. One of our patient's first symptoms was his inability to swallow off his usual evening pint of bitter. Muscle stiffness follows; classical risus sardonicus is often late, or absent, but diminution of bite size is usual. Easily induced tetanic spasms follow and become more violent and painful, especially in the trunk muscles (fig. 2). The picture is completed with vomiting and the usual terminal pneumonia begins. Tracheostomy does not prevent fatal respiratory spasm. Control of respiration and swallowing is now the primary consideration. Sedation merely diminishes an already impaired breathing.

FIG. 2—Tetanic spasm, major severe disease. Period of onset, 12 hours. Recovery after three weeks' curare and full care.

Prevention and Treatment

It is classical knowledge that the very young and the old fare least well with tetanus: sex has little influence but geography places the urban dweller in a better position than rural folk. The treatment of tetanus is its prevention and this is available, easy, and safe (fig. 3). Absorbed tetanus toxoid, as is contained

FIG. 3—Presumed effect of immunization.

in the "triple vaccine" against diphtheria, whooping cough, and tetanus, if properly administered, is the birth right of any child today. Immunization fails only when human apathy, intolerance, and procrastination intrudes. At the same time active immunity can be relied on only for five years and must be repeated by booster doses. One of our patients survived major tetanus, was immunized, and eight years later had a second attack at another centre. His booster dose had not been given. We invariably immunize our patients who recover before they are discharged from hospital since the disease itself confers negligible immunity. Five children presented with tetanus, aged 9 to 12, after full infant immunization: one died. None had had boosters.

Apart from prevention, therapy is a misnomer. It is scrupulous management of patients that has achieved the good presentday results, and this demands a nursing team with the proper knowledge and provided with the right conditions. Once the diagnosis has been made the prognosis should be assessed, using Cole's method: thereafter the doctor should act at once as the disease may advance dramatically.

We classified seven of our patients as mild cases, 14 as moderate, 132 as severe—and seldom changed our minds. One should never lessen scrupulous care as even a trivial error can be fatal. Doctors bear the responsibility of initiating and guiding treatment; the nursing team carry out the work twenty four hours a day. No nurse should be employed in this work who does not understand everything she does. Our nurses have been intelligent, knowledgeable, patient, long-suffering, and infinitely capable of taking pains—real nurses, caring for people. Everything must be recorded and a serious case *never* left alone. Briefly, such nurses are saints, realists, and aware of their responsibilities and they deserve to be told this.

The back-up staff must be of the same calibre, from physiotherapists to porters, and the magnitude of their tasks needs to be kept at a low key without suspicion of "blinding-with-science," medical or mechanical. For relatives the disease is enough; hope can be the watchword.

Our patients with mild tetanus received small doses of sedative, usually promazine, and continuous observation. Some 40% of all of them had no recognizable wound. Moderately ill patients, without cyanotic spasms but with any defect of swallowing or demonstrably low vital capacity, were given more sedatives, remembering that sedation depresses respiration: they were tube fed, had vigorous chest physiotherapy, frequent tipping and turning, perhaps tracheostomy and continued observation.

Severe cases had tracheostomy as soon as judged necessary, rather than when absolutely imperative. Pneumonia bulks more important than anything else and a cuffed tube in the trachea is a necessity: tracheostomy may well be preceded, temporarily, by an endotracheal cuffed tube. Since the purpose of both is to create a barrier between the oropharynx and the lungs the cuff is, within reason, always just water tight.

But this creates an entirely novel respiratory situation which must be restored mechanically. Normal function may not be possible for weeks, so accordingly the doctor should plan for suction, humidification, and physiotherapy. In our cases the vast majority of tracheostomies were performed in the intensive care unit within ten minutes of decision and using local anaesthesia with 2% lignocaine. Though tracheostomies were done by physicians there were no sequelae of the operation.

In severe cases tube feeding is necessary as well as full control of pain and respiration. Tetanic spasm needs relaxants and we came to use tubocurare, in amounts dictated by each patient's needs. The curare is given intramuscularly and dosage reviewed so as to gauge the amount which secures about two hours relaxation before return of spasm is noted by the watchful nurse.

The use of antibiotics is important to anticipate pneumonia; usually we use full doses of parenteral penicillin and streptomycin, often reviewed. We have now stopped using sedation, because dosage is impossible to estimate; to our surprise, no patient has ever complained of the lack of sedatives, and logically, these could be harmful to neurones already poisoned by the toxin. We have used steroids only in extreme shock.

In treating wounds interference is restricted to surgical toilet but no attempt is made at major surgical removal of tissue. All foreign bodies which are located should be removed. Some of the ones we encountered were strange indeed: beads, ball-bearings, paper stuffed in ears and noses, stones, wood, glass, metals—almost anything. The so-called classical tetanus wound is rare in my experience.

When patients are fully curarized, without sedation, it is impossible to know whether they are awake. They can hear well and the frequent attentions they all received were welcome and the sound of voices, relatives, nurses and doctors, very welcome. They love gossip from home. From the therapist's point of view talking to an apparent corpse is difficult but there is no doubt about the help it gives the patient.

The routine nursing and medical tasks are summarized in Appendix I. Our nurses were taught not to attempt to adjust machines, and (should failure develop), to use manual respiration, without fuss, until help came. Doctors or mechanics served and fully understood machine faults. We found that the best machine for long-term artificial respiration is the latest Engström respirator: the Cape model is also very reliable.

Warm humidification, chest physiotherapy, gentle tracheal suction, and bed movement virtually cannot be overdone. Gravity is the surest method of clearing lung secretions. We now use Gibbon catheters for females, and have not found that these give rise to urinary infections. On the other hand, conjunctivitis may develop quickly, unless the eyes are covered and treated with mild antibiotic wash. Always tell the patient whatever is happening.

Ever since patients have no longer died rapidly from pneumonia or spasm, a series of completely new features and complications have plagued them and their doctors. The first point is that today many patients are elderly. Children rarely appear (fig. 3), surely the result of being given triple vaccine. In established severe cases a critical period occurs during the second to third week of illness when "late toxæmia" develops. This is manifested by a rise or fall in the temperature, pulse rate, or blood pressure and sometimes mottled cyanosis of the extremities, despite normal respiratory control. Sweating may be excessive and the electrocardiograph may show presumptive evidence of myocardial poisoning, though the serum potassium level remains normal. Muscle paralysis, from slight to major, may occur and some patients have required artificial respiration but no curare: they lived only a few days.

Metabolism is vastly influenced in tetanus. Weight loss is massive despite good nutrition, attention to fluid balance, and curarization: the nitrogen loss may be 17-23 g/day. (Normal 11 g/day.) Creatinine clearance may be twice or thrice normal despite good urinary output and no excretion of abnormal urinary amino-acids. Two patients have benefited from peritoneal dialysis for this strange inverted "uraemia". The basal metabolic rate may be doubled and oxygen demand rises daily and must be met. A daily water intake of 6,000 ml may be needed. Compression fractures of the spine may be detected by routine radiography.

In our series patients with these complications constituted most of the deaths, though some of these were due to other causes, including coronary occlusion, torrential haemorrhage caused by cuff erosion of the innominate vein, perforated gastric ulcer in a curarized patient, and death in the ambulance of an unaccompanied patient.

The immunology of tetanus is obscure but prevention rests solidly on the proper use of toxoid. The strange fact that the disease confers so little protection against future attacks of the disease remains unexplained. But there is no doubt that—as the conclusions at the 1967 Leeds symposium on tetanus showed—severe tetanus is best treated in special centres and by nurses experienced in the wide range of modern techniques.

This work has been stimulating for me but I owe any success to many helpers, notably Dr. R. V. Walley, Dr. H. R. Cayton, Dr. A. S. Parker, and Dr. A. L. Taylor.

Appendix

Summary of routine duties: all recorded and timed. Severe tetanus

$\frac{1}{4}$ -Hourly 1st day:

Tilt bed up or down. Aspirate trachea gently

$\frac{1}{2}$ -Hourly thereafter:

Watch respirator pressure gauge

1-Hourly:

Measure temperature, pulse, blood pressure. Change position of patient from side to side. Measure tidal air. Remove water of condensation from breathing tubes. Give curare if necessary

4-Hourly:

Treat pressure areas and give nasal tube feeds

6-Hourly:

Eye toilet. Give necessary antibiotics

12-Hourly:

Check humidifier-water volume and temperature. Check manual respirator

Daily:

Enema if needed. Balance fluid chart and curare demand. Chest x-ray film. Collect 24-hour specimen of urine

3-4 days:

Change tracheostomy tube. Tracheal culture. Blood electrolytes and urea. Urine culture. Creatinine clearance

As required:

Blood gas analysis. Blood culture. Chest physiotherapy. Electrocardiograph. Weigh patient. X-ray examination of spine. Active immunization in convalescence

"Weaning":

Eventually the dose of curare lasts longer. In a day or two the need will finish. The tube is kept in situ for a further few days during which the patient's vital capacity returns. Then the cuffed tube is removed and the tracheostomy kept open for a short time by means of a loose fitting plastic tube. The tracheostomy stoma closes, usually dramatically within hours

Sedation:

Standard sedatives used have been: pentobarbitone 90-180 mg six-hourly, and promazine (Sparine) 25-100 mg six-hourly. The dosage may, of course, be altered at will or according to patient needs

Further Reading

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