Treatment. — Atropine sulphate (1-1000 solution) and rice flour mixture were started. Two drops of the solution was the amount required and the food was taken eagerly.

Occasional vomiting spells occurred, but the gain in weight was excellent. By 4 months of age all symptoms of the condition had disappeared and the atropine was stopped. At 7 months the weight was 16 lbs. 14 oz. and the child appeared normal in every respect. The twin sister never vomited and at 7 months weighed 18 lbs. 7 oz.

CASE 4

W. M., a boy, first seen at 2 months of age. Weight 6½ lbs. *Birth.*—Weight 7 lbs.

Feeding history.—Breast-fed for 2 weeks; since then he had been on a cow's milk mixture.

Vomiting had been noticed ever since birth and for the four weeks before examination it had been projectile in character. There had been no improvement and the child had lost weight.

Examination. — Revealed a poorly developed and markedly undernourished baby, fretful, and apparently hungry. Very large gastric peristaltic waves were seen and a definite hard pyloric tumour was palpated.

Treatment. — Atropine sulphate (1-1000 solution) was started in the usual way, and 4 drops was the dose required. A thick feeding, in this instance, cow's milk, farina and sugar was given and well taken.

Progress.—Vomiting ceased in two days and a slow but steady gain in weight was made. During the next seven weeks the child gained 34 oz.

REMARKS

There seems no question that if these cases can be carried successfully through the first four months of life recovery without operation is certain. Definite symptoms of the condition usually disappear at this age; they have been reported as lasting till 6 months. Growth is probably the biggest factor in enlarging the lumen of the pylorus, but by this time the spasm of the muscle must have entirely subsided. Certainly, the hypertrophied muscle causes no after-affects and these cases have been reported 15 years later in satisfactory condition.

Sauer[6] states, and I agree, that weight, severity of vomiting, paucity of fæcal material, complications and the general condition of the patient are the factors that determine how long this type of treatment may be tried. If after a trial of one or two weeks, the vomiting is still frequent and there is no definite gain in weight, operation should be resorted to.

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THE MAGGOT TREATMENT OF OSTEOMYELITIS*

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THE post-operative treatment of suppurative wounds by the use of maggots is a rather recent innovation in surgery, but as has been shown by Baer[1] and Goldstein[2] in their historical reviews very little of our knowledge of the subject is new. The fact that neglected wounds especially in times of war may become infested with maggots was known to Renaissance writers such as Ambroise Paré and Benvenuto Cellini. Paré of course was aware of it and in speaking of head injuries he wrote, ". . . after some months space a great number of worms came forth by the rotten bone, which moved me to hasten the separation and falling away of the putrid bones . . . the patient recovered beyond all men's expectation." Zachman in 1704 was the first to attempt to explain the origin of maggots in wounds. Baron Larrey, in his description of the Egyptian campaign, explained how the wounds became infested and then stated that "these insects, so far from being injurious to their wounds, promoted rather their cicatrization by cutting short the process of nature and by causing the separation of the cellular eschars which they devoured. These larvæ are indeed greedy only after putrefying substances and never touch the parts endowed with life." Similar views have been held by many military surgeons since then. Crile, for example, in speaking of neglected war wounds in 1917 said, "those that have done best are those that contain maggots; the maggots live on devitalized tissue and if they destroy that tissue, they do in time what the surgical operation does."

Maggots were first used clinically by a Confederate Army surgeon, J. F. Zacharias. In

* From the Clinic of Dr. W. G. Turner, Shriners' Hospitals for Crippled Children, Montreal Unit, and the Shriners' Hospital Laboratories.

writing of his Civil War experiences he says, "I first used maggots to remove the decayed tissue in hospital gangrene, with eminent satisfaction. I used them afterwards in various places and I am sure I saved many lives by their use." He seems to have had no imitators however, and nothing more was heard of this form of treatment until it was re-introduced by the late Dr. Wm. S. Baer, of Baltimore. His first cases were treated in 1928, and in July, 1931, he published[1] the details of his method and a summary of 89 cases treated by it. Since then various modifications of the original laboratory procedures have been advocated, and a few shorter series of cases have been published. The treatment was first used in Montreal by Dr. Dudley Ross, in 1930. In 1931 the work was taken up at the Shriners' Hospital for Crippled Children, Montreal Unit, under the Henry J. Elliott Research Grant, using the original Baer technique.

Baer's early cases were treated with maggots obtained by leaving meat out of doors, but he found with this method he was unable to obtain a steady supply of larvæ, and, what was more serious, some of his patients developed tetanus. The necessity for breeding the flies in the laboratory and for devising some method of producing sterile maggots was obvious. The former was accomplished with relative ease; the latter problem is not solved satisfactorily as yet. The maggots of various blow flies and bottle flies have been used in treatment with apparently similar results. We use a type known as *Lucillia Cæsar,* which is a green bottle fly with a distinct bronze sheen. In size it is a little larger than a house fly. In common with all other flies its life cycle is made up of stages—egg, larva or maggot, pupa and fly.

TECHNIQUE

The eggs are deposited in clusters on meat, the individual eggs being about 1 mm. long and white in colour. They hatch in 8 to 12 hours into transparent larvæ, which, if meat be provided for food, grow rapidly. When fully grown, that is in about five days, they are 1.5 cm. long. They then leave the food and crawl about for two or three days, gradually becoming more opaque and less active in their movements. Eventually all movements cease and they assume an ovoid shape. Within a day or so these ovoid bodies become dark red in colour. This resting, or pupa, stage is reached in about ten days after hatching and lasts for about five days. The fully developed flies then emerge. They are sexually mature in three to five days and live about three weeks. To breed the flies it is only necessary to provide proper conditions for this cycle. Maggots are allowed to develop on fly-blown beef, and fresh meat is supplied when necessary. The Petri dish containing the meat is placed in a large enamelled tray partly filled with clean dry sawdust. Pupation takes place in the sawdust and the pupæ are collected in Petri dishes which are placed in fly cages. When the flies emerge, food is supplied.

The fly cages are wooden frames covered with cheese cloth, ten inches in diameter and sixteen inches high. It takes one to two cages, each containing about 100 flies, to supply maggots for one patient. The cages are kept in a box or incubator, four feet long, two feet wide and three feet high, which is capable of holding 16 cages in two tiers. It is largely of glass construction. The incubator is ventilated by a small blower at one end which exhausts air from the interior and discharges into a fume cupboard, and thence outdoors. The incoming air, which is room air, before entering at the opposite end of the incubator is warmed and moistened by passing through a monel-metal heater, eight feet square and two feet long. This contains about one and one-half inches of water, the depth being maintained by the position of the overflow pipe. The water is in constant circulation and the temperature is regulated largely by the rate of flow through the heater. The water is heated by electric immersion heaters. To increase the moisture content of the air, gas stove wicks are suspended transversely from the top of the heater into the water. An opening at one end admits the incoming air and the other end communicates by piping with the incubator. Flies require a moderate and a fairly constant temperature and we have found that they do well at temperatures between 70 and 80 degrees Fahrenheit. Moist air is necessary to prevent drying of the eggs and to prevent too rapid evaporation of the fly food.

The fly food consists of honey, 25 c.c., one egg, and distilled water 1,000 c.c. A piece of absorbent cotton in a Petri dish is soaked with this mixture each morning and placed in the fly

cage, where it is allowed to remain for 24 hours. Each morning a strip of beef, one-half inch square and eight inches long, is coiled up, placed on a Petri dish and put into each fly cage containing sexually mature flies. It is removed in the late afternoon and the deposited eggs are transferred by a scalpel to a flat bottomed tube, one inch by three inches, partly filled with distilled water. The clumps are broken up thoroughly with a wooden applicator and the individual eggs settle to the bottom. The supernatant fluid is discarded and the watery suspension of eggs is poured into a sterile test tube. The eggs are allowed to settle again and as much as possible of the water is removed by decanting. The sterilizing solution is then added and is allowed to act for one-half hour exactly, and the contents of the tube are stirred frequently with a sterile applicator throughout this period. Thorough breaking up of the clumps of eggs and frequent stirring are necessary to obtain good results. The sterilizing solution consists of:—

	Parts
1/1000 Hg. bichloride	50
50 per cent alcohol	50
HCl. (C.P.)	½

The subsequent procedures are carried out with the usual bacteriological technique. When sterilized, the eggs are separated from the solution by filtering through a Gootch crucible containing a piece of cheese cloth. After washing thoroughly with distilled water the cheese cloth containing the eggs is transferred to a bottle of maggot food and the eggs are shaken free.

The maggot food is prepared as follows.—Wide-mouthed bottles, about six inches high, are cleaned, stoppered with non-absorbent, wrapped in cheese-cloth, and dry-sterilized. A pig's liver is freed from connective tissue, cut into half inch cubes and broiled over an open flame for one-half hour. A cube of meat is placed in each sterile bottle and bacto-dextrose agar, prepared according to the manufacturer's directions, is added until the bottom half of the liver is immersed. The bottle is then autoclaved. The bottle of maggot food containing the sterile eggs is placed in the fly incubator overnight. By morning the eggs will have hatched. Ærobic and anærobic cultures are then taken and incubated for 24 hours. If at the end of that time the cultures show no growth, the maggots are prepared for use by washing them out of the bottle with distilled water, straining, and transferring to small test tubes.

This method of preparation of sterile maggots is rather unsatisfactory. The yield of maggots from eggs is very low. The sterilizing solution, although strong enough to destroy most of the eggs, is too weak to destroy bacterial spores if any be present. The larvæ are used usually within 24 hours of taking cultures, which is too short a time for spores to develop into recognizable colonies. Furthermore, the maggots are exposed to contamination after the cultures have been taken. There is always the danger therefore, of using infected maggots. We have used maggots contaminated with staphylococci with no ill-effects, but Baer's experiences show the danger of using larvæ contaminated with anærobes.

Various methods have been advocated to overcome these objections; that used by Child and Roberts[3] seems the most promising. They first wash the eggs with sodium hypochlorite to remove the albuminous coating and sterilize by continual washing with 4 per cent neutral formaldehyde for three minutes. According to Zinsser,[5] however, it takes a 5 per cent formalin solution 6 hours to kill the spores of *B. tetani,* so the method is open to the same criticism as that of Baer, which has the advantage of being simpler and better suited to a small production.

A step in the Child and Roberts' procedure which is applicable to any method has certain advantages. After the cultures are taken they are incubated for two or three days, the maggots in the meantime being stored in the ice chest to arrest development. If the cultures show no growth at the end of this time, the sterilization was probably complete. It has been our experience, however, that such stored maggots are less active in cleaning the wounds and are more liable to produce systemic reactions.

CLINICAL USE

The maggot treatment has been used principally as a post-operative treatment in osteomyelitis. Maggots are placed in the wounds four to five days after the operation, and fresh batches are added at intervals of about five days

until the wounds heal, or there is definite evidence that further operative treatment is necessary. The duration of treatment varies from six weeks to six months. Many of the larvæ fail to survive in the wounds and disappear. The remainder develop rapidly, utilizing the exposed tissues for food. When full grown, that is in three to five days, they become sluggish and inactive, and a fresh supply should be used to replace them. If left, they soon leave the wound to pupate. Pupation does not seem to occur in the wounds. Feeding is accomplished by biting, but mainly by the ingestion of tissues altered by ferments contained in the saliva which is excreted. An extract containing these ferments is said to have been prepared by Livingstone, but no report has been published as yet. Necrotic and devitalized material is removed rapidly. Healthy tissue, although more resistant, is not immune and may be channelled or pitted, especially if a large number of maggots are used. More commonly, however, after healthy tissue is exposed by removal of the debris, firm healthy granulations form and the wound slowly heals. It is unlikely that the larvæ destroy bone.

The wound secretion is copious and thin. When vascular areas either in the form of exuberant granulations or of healthy tissues, are being removed, the secretion is blood tinged. The reaction is frequently acid to litmus before treatment is commenced, but when granulations are well formed it is commonly alkaline. The bacterial count, as estimated by direct smears, falls rapidly under treatment and at times cultures show no growth. These changes are probably mainly the result of the removal of necrotic material and continual exposing of healthy tissues.

Pain is a very common complaint and is the result of the action of the larvæ on unprotected healthy tissue. At times it is so severe that the patient is unable to rest. Fever occurs in practically all children especially in the early weeks of treatment, although in some patients a temperature of 102 to 104 degrees occurs after each change of dressing. Destruction of healthy tissue usually results in moderate fever as well as pain. Fever in adults seldom occurs. Complications have been rare. In one patient healthy tendons were exposed and destroyed; in another hæmorrhage occurred, but this was possibly due to trauma.

A sufficient number of cases have not been healed as yet to warrant comparisons with other methods. Baer has reported 85 cases, Child and Edwards 10, and Hegner 1. Since September, 1931, 9 cases have been treated in Montreal, 2 under Dr. Turner, 2 under Dr. Ross, and 4 under Dr. Pretty. Of these, 2 died, but neither death was due to the local condition, nor could the maggot treatment have been any factor in causing death. Two cases received inadequate treatment. Of the remaining 5 cases, 3 are under treatment, and 2 are cured.

The following case reports illustrate the results so far obtained.

CASE 1

The first is that of a girl, 8 years of age, who had had chronic osteomyelitis of the lower third of the left femur for two years prior to admission to the Shriners' Hospital, Montreal Unit, under Dr. W. G. Turner. At that time there was a backward subluxation at the left knee joint, with only a slight range of movement at the joint. Numerous sinuses were present. The x-ray showed destruction of the lower third of the femur posteriorly, destruction of the outer portion of the lower femoral epiphysis, which throughout was irregular in outline and rarefied. On July 8, 1931, the lower portion of the femur was exposed by median and lateral incisions, and sequestra were removed from the posterior surface of the shaft. From July to October 21, 1931, the patient did not receive maggot treatment, as at that time no larvæ were available. In that interval the soft tissues had to be reopened on August 15th, and again on October 15th. On October 21st the first batch of maggots was placed in the wounds and fresh batches have been added at four to seven day intervals since that date.

In changing the dressings the routine procedure was to remove the old larvæ by irrigating and with forceps; to scrape the larvæ into the wound from the test tube with a hoe-shaped glass rod, and then to apply the cage which consisted of a piece of wire netting, on the edges of which was sewn a strip of soft rubber about ½ inch square. Strips of adhesive were used to keep the cage in position. A cradle containing an electric light was placed over the affected limb. X-rays taken at intervals show that there has been a slow improvement, in that new bone has been laid down. The outline of the shaft and epiphysis is smoother. No sequestra have formed. The wounds are slowly closing in, but lately very few of the larvæ survive after being placed in the wound. The general condition has improved a great deal. There have been no complications other than pain and fever.

CASE 2

The other case is that of a man, 45 years of age, who was admitted to the service of Dr. Gurth Pretty at the Montreal General Hospital on November 19, 1931, with a history of pain, redness and swelling of the middle third of the left arm for three weeks. In August, 1930, the arm was affected in the same way and the condition persisted for two months. At the age of 15, he had had osteomyelitis which did not finally heal until he was 18. An x-ray on admission showed mottling of the shaft in the middle third and some thickening of the cortex. Operation was performed on November 20, 1931, and pus was found under the periosteum. The bone was guttered, and communication established between the cloacæ. The wound was then dressed and

packed with acriflavine gauze. No larvæ were used until December 7th, but from then on until January 20, 1932, this treatment was used. The wound healed rapidly, and at time of discharge on January 20th, was completely closed, and the scar was depressed slightly in an area less than one-half inch in length.

The patient suffered considerably, and he was usually given a day's rest on the removal of a batch of maggots, and before a fresh batch was applied. There was no fever or other complications. The dressings were carried out as in the previous case. The patient has been seen at intervals since discharge from the hospital, and there have been no signs of disease.

The ultimate value of the maggot treatment is still uncertain. Its disadvantages are obvious. The patient must be hospitalized throughout; the larvæ are expensive and can only be used in the neighbourhood of the producing laboratory. There is also some prejudice among surgeons regarding this form of treatment. However, these disadvantages would be of minor importance if an appreciable increase in the percentage of cures, or a decrease in the duration of the disease, be obtained. The series so far published indicates that the results more than offset the disadvantages, and we believe that this method of treatment has a definite value in the treatment of acute and chronic osteomyelitis.

I desire to acknowledge my indebtedness to Dr. Gurth Pretty, for permission to publish the second case.

COMMENT BY DR. W. G. TURNER

Since Dr. McLellan wrote this paper, I would like to cite one of his cases. Some months previously I had removed a sequestrum practically the length of the shaft of the tibia, which still left an excavation in the head of the tibia that had invaded the knee joint some time previously. On March 16, 1932, I operated on this case and exposed the upper portion of the tibia where there were several sinuses. There was extensive destruction of the bone, which penetrated the knee joint. The anterior portion of the head of the tibia was removed, so as to make a wound about 4 inches long. The patellar tendon was preserved and this cavity extended under the same, allowing three fingers to be easily passed under the patellar tendon from side to side. This left a wide crater-like cavity. As soon as the oozing had been partially controlled, Dr. McLellan started his maggot treatment, which he followed faithfully.

July 1, 1932. This extensive bone cavity is now completely healed. It has been remarkable to note the progress of this case. During this latter period of treatment it was very important that the maggots should not get drowned by the excess secretion, and this was wonderfully controlled by Dr. McLellan. This last case illustrates the very great value of having the resources of the maggot treatment available.

I would like to say how much I appreciate Dr. McLellan's work in the laboratory. He was successful throughout the winter in keeping a very healthy strain of maggots, and this, single-handed. In this way we have been able to supply healthy maggots for selected cases to four of the hospitals.

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THE USE OF LOCAL ANÆSTHESIA IN THE TREATMENT OF FRACTURES

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NO one who has attended Böhler's fracture clinic in Vienna can fail to be impressed with the many advantages obtainable by the routine use of local, or regional, anæsthesia in the treatment of fractures. The idea is not new. Conway injected cocaine between the fragments to produce anæsthesia forty-seven years ago. Lerda and Quenu[2] reported satisfactory results following the use of local anæsthesia for fractures, in 1907 and 1908 respectively. The method, however, has never become widely used, largely because few surgeons have actual experience with the technical procedure and hesitate to use a new method with which they are unfamiliar. Also, because the routine use of ether anæsthesia for these cases has become a habit in many clinics. A theoretical objection to the use of local anæsthesia that is often mentioned is the danger of introducing infection with the novocaine. If the usual aseptic precautions be taken, this complication rarely if ever occurs. Many objections can be brought against the routine use of general anæsthesia for the setting of fractures. First, the services of a trained anæsthetist are required and these are not only expensive but, at times, not immediately available, thus causing delay. The next consideration is the danger of post-operative lung complications following general narcosis. While few men to-day would be rash enough to state that lung complications practically never follow local anæsthesia, they do appear to occur in a smaller percentage of cases. Ether irritates the bronchial passages to a greater extent, causes more secretion, and, for some hours after its inhalation, depresses respir-