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THE RÔLE OF SURGICAL MAGGOTS IN THE DISINFECTION OF OSTEOMYELITIS AND OTHER INFECTED WOUNDS *

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One of the characteristics of the Baer maggot treatment is a marked reduction in the infection of the wound. Baer^{1,2} noted an unusual decline in the number of bacteria present in the wound when maggots were used, and he described maggots as a "viable antiseptic". Confirmation of his results has appeared in the extensive literature on the subject of the maggot treatment.

An investigation has been made of the manner in which disinfection is brought about. A discussion of results follows, with details of the experiments omitted in this article.

DESTRUCTION OF BACTERIA BY DIGESTION

When maggots are implanted in an infected wound they feed upon the necrotic and purulent materials present and, at the same time, take up large numbers of bacteria. The digestion of such bacteria is one means by which maggots could reduce wound infection. To determine the fate of ingested bacteria, observations were made of their progress through the alimentary tract. Maggots which had fed within osteomyelitis wounds for one to two days were dissected aseptically. Portions of the intestine and the tubular "stomach" were removed and cultured bacteriologically.

In all of the specimens dissected abundant bacterial growth was obtained in cultures from the "fore-stomach". On the other hand, no growth whatever was observed in any of the cultures from the intestine. An intermediate area called the "hind-stomach" showed slight growth in one-third of the cases.

A progressive destruction of the ingested bacteria was, therefore, found to take place in the alimentary canal. The sterility of the intestine is evidence that the bacteria are destroyed in the stomach.

In a study of the nutrition of blow-fly larvae, Hobson³ found proteolytic enzymes in the fore and hind portions of the stomach, activity being especially marked in the hind section. The digestive effect of these enzymes may explain the destruction of bacteria in the stomach. It is significant that the hind stomach, where the decrease in numbers of bacteria is most evident, is the section with greatest enzymic activity.

Some tests were therefore made of the ability of these enzymes to destroy such bacteria as streptococcus hemolyticus and staphylococcus

* Contribution from the Division of Insects Affecting Man and Animals, Bureau of Entomology, United States Department of Agriculture, Washington, D. C., and the Pathological Laboratory of the Church Home and Infirmary, Baltimore, Md.

aureus, commonly found in the osteomyelitis wound. The digestive enzymes of the maggots were obtained by macerating sterile maggot tissue, consisting principally of alimentary tract. This was then inoculated under various conditions with the bacteria mentioned. All subcultures showed abundant growth; and no evidence was obtained, even with the lightest inoculations and the longest periods of contact, of any destructive effect. In view of the fact that such bacteria are destroyed within the maggot, the negative results obtained may be due to the death of the enzyme-secreting cells during maceration.

These results differ from those reported by Livingston⁴, who stated that "paste made from the dead bodies (of maggots) is also effective as a curative agent"; and from the results reported by Livingston and Prince⁵ as follows: "filtered, uncontaminated products derived from the bodies of larvae in culture, when brought into contact with pyogenic organisms in petri dishes, destroyed the cultures". Also, in his report⁴ of one hundred cases of infected wounds in which he used the maggot treatment, Livingston observes that, "If the wound was clean and the discharge moderate or slight after the third application (of maggots), the use of live maggots was discontinued, and gauze packs saturated with active principle were introduced daily until healing was accomplished, or until the discharge again increased in amount. If the discharge again became profuse, maggots were reintroduced from one to three times." Under this method of treatment any healing effect of an "active principle" or maggot extract is not readily evident.

REMOVAL OF NECROTIC TISSUE AN AID TO WOUND DISINFECTION

It is recognized that necrotic tissue remaining in the wound favors increased infection as well as absorption of toxic substances. Myers and Czaja⁶ have shown the difficulty or impossibility of complete elimination of all such tissue surgically. Furthermore, additional necrosis frequently occurs.

Maggots feed voraciously upon the devitalized and purulent materials which accumulate within the wound, and are usually found in such areas. The amount of necrotic material which each implantation of maggots is capable of removing is surprisingly large. An average implantation will consume as much as ten to fifteen grams. This is augmented by further implantations every four or five days. Maggots, therefore, aid in cleaning up the wound by penetrating necrotic areas, suitably opened up, and feeding therein, thus making the condition of the wound less suitable for bacterial growth.

SECRETIONS A FACTOR IN DISINFECTION OF THE WOUND

During maggot treatment the wound is stimulated to secrete a thin, serous discharge in comparatively large quantities. This is heavily contaminated and carries off numbers of the pathogenic organisms of the

wound. Such drainage, which continues as long as maggots are present, becomes a significant factor in hastening disinfection of the wound.

LIVING MAGGOTS APPEAR NECESSARY IN TREATMENT

The effects obtained in this investigation have all been the result of the direct activities of living maggots. Mixtures of macerated maggot tissue gave negative results in cultures. The removal of necrotic tissue, which is important in treatment, also requires living maggots. The presence of active maggots in the wound, therefore, appears to be a prime requisite in treatment.

This differs from the view-point expressed by Livingston and Prince⁵ who reported that a maggot extract was "in itself a curative agent". The use of such an extract in wounds, whereby maggots could be eliminated, would be very desirable. However, data sufficient to prove the effectiveness of these mixtures have not yet been given.

DEVELOPMENT OF GRANULATION TISSUE

The abundant growth of granulation within the wound is one of the outstanding characteristics of the maggot treatment. This growth is sometimes regarded as the result of a stimulation by maggots. In view of the present investigation, it seems possible that the increased growth may not be altogether due to actual stimulation. Where maggots are not used in treatment of chronic osteomyelitis, there is likely to be a greater amount of necrotic tissue present and a higher infection. Such conditions may produce sufficient toxins to prevent the natural growth of granulation. Under the maggot treatment, with its more rapid cleaning up of the wound, the tissue may be free to grow spontaneously at its normal rate; and, in contrast with the usual rate, may appear to be a stimulation.

SUMMARY

When used in infected wounds, the surgical maggots are able to hasten disinfection. A study has been made of the means by which the destruction of bacteria has been brought about. Maggots ingest bacteria in large numbers in feeding upon the necrotic tissues of the wound. Cultures of aseptic dissections of the alimentary tract of maggots showed an abundance of bacteria in the fore-stomach, decreasing numbers in the hind-stomach, and apparently a total disappearance of the bacteria in the intestine. This indicates that ingested bacteria are destroyed in passing through the alimentary tract.

To determine whether or not destruction is caused by digestion, tests were made of the action of digestive enzymes of maggots upon streptococcus hemolyticus and staphylococcus aureus. The enzymes were obtained by maceration of sterile maggot tissue. Results were negative in all cases. This is probably due to death of enzyme-secreting cells during maceration. Livingston and Prince report positive results and

state that applications of maggot extract were effective as a curative agent. The data, however, do not make clear how the healing effect obtained was due to maggot extract. Repetition of our tests confirm our negative results.

Maggots feed upon the necrotic and purulent materials within the wound. They thus aid in cleaning up the wound and making its condition less suitable for bacterial growth.

Drainage from the wound is stimulated under maggot treatment. The excessive discharge, which is heavily contaminated with bacteria, assists in wound disinfection.

This investigation indicates that the effects obtained in the maggot treatment of infected wounds are due to the action of living maggots in the wound, and that living maggots can not be eliminated in treatment.

The increased growth of granulation tissue within the wound and its relation to maggot activities is discussed.

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