THE STERILIZATION OF PARAFFIN SURGICAL DRESSINGS

BY

R. MAXWELL SAVAGE, B.A., F.I.C.

Chief Chemist, S. Maw, Son and Sons, Ltd.

Surgical dressings impregnated with mixtures having a greasy basis are now common, but so far as I am aware there is no published bacteriological information on the effectiveness of the processes proposed for their sterilization.

Methods described in an E.M.S. Circular

In February, 1941, the Ministry of Health issued a circular (E.M.S./Gen./343) for the guidance of medical officers in Emergency Medical Service hospitals and first-aid posts (see *Journal*, March 29, 1941, p. 489). This described, in two footnotes, methods for the preparation and sterilization of two of these dressings, as follows:

"Footnote 1.—To prepare sterilized vaseline dressings, half fill a biscuit tin with vaseline, stand the tin in a deep dish of water which is brought to boiling point on a stove or fire. When the vaseline is melted, drop into it pieces of gauze or lint about 6 inches square, folded in two, until the tin is full. Add more vaseline, if necessary, to cover the dressings. Leave the tin in the boiling water for half an hour. Then remove, put on the lid, and seal with a strip of strapping.

"Footnote 2.—Tulle gras, originally a French preparation, may be prepared in the following way. Curtain net, with a mesh of 2 mm., is cut into pieces 9 cm. square. These are placed in a tin box of slightly larger size. The box is then filled with the following mixture: soft paraffin 96 gm., balsam of Peru 2 gm., sufficient to impregnate and cover the material completely after sterilization by heat in an autoclave. The French preparation contained also halibut-liver oil, but the value of this when applied locally is doubtful, and it can be omitted."

These footnotes at first sight conflict with the requirements well known to be necessary for sterilization, and have not passed without comment (Forbes, 1941). A closer consideration showed that so far as Footnote 2 was concerned there were some points of peculiar technical interest, and the matter called for experimental investigation.

Experiments Dealing with Footnote 1

Throughout this paper I have assumed that soft paraffin B.P. has the same bacteriological properties as the proprietary material mentioned in the circular, and have employed it in the experiments.

It has been known from the earliest days of bacteriology that although aqueous liquids usually become sterile when heated to 115° C. for thirty minutes, oils do not, but require 150° C. for one hour, methods which are described in the appropriate books of reference—for example, the *British Pharmacopoeia*, 1932, Appendix XVII. It is obvious from Footnote 1 that extremely primitive conditions are assumed to be all that are available, presumably resulting from enemy action; but, even so, it is difficult to understand why this particular method was believed suitable. Actually, on account of the negligible vapour pressures which oils develop at 150° C. they are easier to sterilize, in the absence of proper equipment, than water, and any apparatus in which a cook could deep-fry will do the work, even under camp-fire conditions, though a thermometer would be a most desirable addition to the equipment. The E.M.S. process cannot be expected to produce a temperature above 95° C.—possibly much less—and it was in no expectation of finding sterility that the matter was put to proof.

The Testing Method

The usual method of testing sterilization is to enclose organisms of known resistance in the dressing and then to inoculate these into nutrient broth. This can hardly be done with these greasy substances, so it was decided to test the dressings themselves. There are difficulties in testing dressings (mainly connected with aerial infections), and for quantitative details of these difficulties, and of a method of circumventing them, reference must be made to a paper of mine (Savage,

1940). This method requires that the test shall be made upon ten dressings (or portions of a dressing) simultaneously and in random order with a control test upon ten dressings similar to those under examination except that they are certainly known to be sterile as the result of laboratory treatment. Two conditions are essential: (1) not more than four of these control cultures may be positive; (2) the size of the test portions must be chosen so that (if the dressing is not sterile) the average number of organisms in each portion is at least nine. In practical cases these conditions are usually satisfied, and merely indicate limits beyond which the method fails to give sufficiently certain results. When these conditions are satisfied, dressings may be taken as infected when all the test cultures but not more than four controls are positive, and as sterile when at least one test culture is negative, whatever the condition of the controls. If more than four controls are positive, infection of the dressings cannot be inferred with enough certainty, and the whole test is rejected without drawing any conclusions. These are again limiting states—normally, sterile dressings give many more than one negative culture, and four infected controls are rare. The judgment of the operator is substituted by simple enumeration having an underlying statistical basis, to which reference is not normally required but which can always be calculated if necessary. All the work in this paper, except for certain preliminary trials, was conducted according to the above scheme. It was sometimes possible to obtain additional information by examining the positive cultures: for example, non-sporing organisms such as cocci cannot be the sole survivors of mixed populations which include spores; and must therefore be contaminants arriving after sterilization, of no importance in the present work.

Soft paraffin does not melt at incubator temperature, and if a mass of it is introduced into a medium it must be a matter of chance whether or not an organism is so placed that it can grow. Moreover, the tulle gras contains an antiseptic, and there was a possibility that bacteriostatic action would interfere with a simple test. Attempts were made to remove the oil by dissolving it in light petroleum in an apparatus in which the solvent was passed through a Chamberland filter candle into the vessel with the dressing, and removed through another candle, thus filtering off the dressing with any organisms in a sterile circuit. Practical difficulties arise owing to the high viscosity of the solutions, and the method was abandoned in favour of a simple one. Workers on the sterilization of oils (Coulthard, 1935; O'Brien and Parish, 1935) found that when a layer of infected oil is floated on to a medium, growth in the medium occurs. By adding the dressing to a layer of sterile light liquid paraffin (B.P. 1932, Fourth Addendum), floating on nutrient broth, the soft paraffin dissolves on warming, and the final result is a two-layer liquid system just as in the tests upon oils. Since the test depends upon the numbers of the viable organisms in the unsterile dressing being above a certain minimum it was vital that the powers of growth of the organisms should not have been so far diminished that the basis of the method was unsound. If single organisms coated with soft paraffin give rise to growth in the medium, pieces of dressing containing, say, 500 organisms must do so with an overwhelming degree of probability. Pieces of lint thread about 0.5 cm. long contain organisms in about 50% of the samples taken, and most of these organisms will be found singly. One series of threads was taken direct into broth, and another was dipped in sterile soft paraffin and then inoculated into the liquid paraffin layer of the special medium. Of the first series 9 out of 16 were infected; of the second 4 out of 18. It is not possible from these short series to deduce accurately to what extent the oil inhibited development—actually the results are not statistically different—but at least it seemed certain that material so lightly infected that most of the inocula contained not more than one organism was capable of giving positive cultures in some cases. The original reasoning could scarcely be disturbed at all when pieces of lint containing hundreds or thousands of organisms were inoculated. The final method of testing adopted was as follows:

Six-ounce screw-capped jars were used, and about 50 mls of light liquid paraffin were placed in each. The jars and contents were then sterilized in a hot-air oven at about 150° C. for several hours. About 25 mls of nutrient Lemco broth was added, and the whole then autoclaved at 115° C. for thirty

minutes. The jars were used hot from the autoclave, and the dressings were lifted out of the melted grease by sterile forceps, drained a few seconds, then added to the medium and incubated for at least five days at 37° C.

In preliminary tests twenty-five pieces of lint, 3 inches square, were prepared by the E.M.S. method, using soft paraffin which had been exposed to the air of the laboratory for some weeks and was therefore somewhat dusty. All cultures were infected. Finally the full technique was applied. All the ten experimental dressings were infected, but none of the ten controls showed growth, thus proving that the process had failed. The general behaviour of the cultures—the rapidity and character of the growth—was entirely different from that given by partially sterilized dressings, and was strongly suggestive of gross infection.

The experiments of the next section are confirmatory, since they show that even 120° C. for 30 minutes is not effective in the absence of balsam of Peru. Measurements of temperature showed that the maximum reached by the E.M.S. process was 94° C., and if more soft paraffin was used a temperature of as low as 65° C. might have been all that was attained after the prescribed period of heating. A process for producing sterile soft paraffin dressings has been published (Smallwood, 1941), and, although no bacteriological tests have been reported, it consists in a careful application of known conditions and can scarcely be wrong. It might not be easy to carry out on a large scale (it was not meant for this), but there is nothing inherently difficult in the production of a sterile dressing by one means or another.

Experiments Dealing with Footnote 2

In the directions given in Footnote 2 an autoclave is used. Autoclaving oils is not an effective method of sterilizing them, but tulle gras has two important features which may profoundly influence sterilization. A 2% mixture of balsam of Peru and soft paraffin may be an ineffective disinfectant at room temperature, but in an autoclave it may have enhanced action. Moreover, cotton normally contains about 6% of moisture, which, when heated under conditions preventing its free escape, is amply sufficient for the sterilization of the cotton at autoclave temperatures and pressures (Savage, 1937). Autoclaving a mixture of cotton and soft paraffin is not the same as autoclaving soft paraffin alone, since it is conceivable that steam might reach spores which were not too far from the fibres. Every experiment was conducted by autoclaving at 120° C. for 30 minutes.

Balsam of Peru is not completely soluble in soft paraffin, and the mixture used was decanted from the insoluble residue. In the foregoing experiments somewhat dusty but not specially contaminated materials were used. In those which follow the lint was dusted with a specimen of earth containing spores that survived exposure to saturated steam at 116° C. for 30 minutes. It is admitted that this is unusual but not unprecedented resistance and that the tests were severe, but it will be shown that under proper and easily reached conditions even these organisms can be killed. In the first experiment one of the 10 experimental dressings grew an organism which on examination proved to be a coccus (possibly *Micrococcus luteus*) and therefore certainly a contaminant. Of the 10 in the control series 2 were infected, one with a coccus (apparently also *M. luteus*) and therefore certainly a contaminant, and the other with a sporing bacillus, which might be either a contaminant or a survivor. All the remaining 17 were sterile after six days' incubation. Bacteriostatic action was evidently not sufficient to prevent the growth of the almost certainly single viable cells or groups, and the 17 showed abundant growth when subsequently infected with earth. Sterilizing tulle gras in an autoclave at 120° C. for 30 minutes is therefore an effective process. This effective action may be due to the balsam of Peru, to the moisture, or to the two combined. These factors were investigated in turn.

Moisture.—Lint was used in soft paraffin without special treatment beyond earth contamination. None of the controls was infected, but all the experimental cultures showed growth, although one did not do so until the fourth day and another

not until the fifth. The latter proved to be a sporing rod of very slow growth, apparently in pure culture. Although formally the experiment shows lack of sterility and it is evident that the process is not efficient, the supplementary evidence suggests that a considerable degree of destruction had occurred, reducing the bacterial population to a few forms, probably in small numbers.

Balsam of Peru.—The contaminated lint was dried at about 110° C. for an hour and was then quickly immersed in warm balsam of Peru mixture. After autoclaving and testing, all the experimental cultures, but none of the controls, were infected. Evidently balsam of Peru alone is not the effective agent.

Moisture and Balsam of Peru.—Contaminated lint was taken, and in order to use it in a moist condition it was kept over saturated sodium chloride solution for 24 hours. A specimen then contained 7.04% of moisture, which is slightly above that usual in the climate of London, 6.5% being about the average. The usual treatment was applied. None of the control cultures was infected, but there were two infections in the experimental cultures, both being different species of sporing rods, which on plating seemed to be in pure culture. The formal result indicates sterility, and the supplementary observation supports the view that aerial contamination accounts for the two infections. This experiment therefore supports the first of this series and indicates that satisfactory sterilization can be carried out by the method of Footnote 2.

Experiments in which special contamination is not used may be inconclusive, since there may be no highly resistant spores present, but the conditions are closer to actual practice. An experiment was made with dry and moist (7.1%) lint, similar to the last one but with no special contamination. All the dried specimens were infected; there was one infection in the moist cultures and two in the controls. Evidently the results are similar even in this case.

Commentary

It is evident that the success of the process depends on the simultaneous presence of moisture and balsam of Peru. Moisture in cotton is not a constant quantity, but varies with climate and, although always normally present, can be removed without difficulty. In fact, Smallwood (1941) removes it to facilitate impregnation, but since he subsequently uses a sterilizing process which is independent of moisture, this does not matter to him.

When it is realized that, in addition to this variable quantity of moisture, balsam of Peru is a natural product with at least three major groups of constituents, and that the preparation of the ointment-like basis may vary, it becomes obvious that complications may arise, and the process appears to be delicately balanced. It is hoped to continue the investigation of the details, but it seems possible that, in this case, sterilization depends on the presence of sufficient hydrogen ions, which would be provided in tulle gras by the simultaneous presence of moisture and of an acid soluble both in oil and in water, but not by either ingredient separately. Some support is lent to this hypothesis by the observation that damage resembling that caused by acids occurs to a greater extent in the normal lint than in that which has been dried, in spite of the additional heating which the latter has had.

The inclusion of the details of sterilization methods in specifications involves dangers which are illustrated by the above experiments. Experience shows that, once published, these methods display an astonishing vitality. There is every reason for the publication of methods as scientific communications, or merely as guides, but sterilization specifications would, in my view, be better if the simple requirement of sterility were substituted for a detailed description of what, even if right, may not be the only method, and perhaps not the best. The responsibility for producing the sterile dressing would then devolve upon those to whom the sterilization was entrusted.

Summary

Methods for testing dressings impregnated with greasy material are described.

The water-bath method of sterilizing soft paraffin dressings is ineffective.

Tulle gras can be sterilized in an autoclave, provided that enough balsam of Peru is present and that the cotton is normally moist.

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REFERENCES

- Coulthard, C. E. (1935). *Quart. J. Pharm. and Pharmacol.*, **8**, 90.
 Forbes, A. T. (1941). *Lancet*, **1**, 553.
 O'Brien, R. H., and Parish, H. J. (1935). *Quart. J. Pharm. and Pharmacol.*, **8**, 94.
 Savage, R. M. (1937). *Ibid.*, **10**, 451.
 — (1940). *Ibid.*, **13**, 237.
 Smallwood, A. G. (1941). *Pharm. J.*, 4th ser., **146**, 102.

THE EMERGENCY SURGICAL STATION

BY

K. VERNON BAILEY, M.C., M.D., M.R.C.P., F.R.C.O.G.

The problem of the evacuation of casualties under conditions of enemy invasion of this country and their adequate accommodation and treatment after evacuation has always exercised the minds of those responsible. It is recognized that the conditions would differ greatly from those ruling in an expeditionary force operating over-seas, in so far as there would be no such thing as a "back area" and civilian casualties of both sexes would be added. Schemes have been worked out in conjunction with military and Home Guard exercises on the large scale for the evacuation of casualties from the fighting areas, and in this connexion a degree of understanding exists between these and the civil medical services. The weakness of any such scheme, however, occurs in the presumption that the established hospitals, situated in the towns and cities to which these casualties would ultimately be transferred, would so far survive the effects of enemy action as to be able to deal constantly with the influx of admissions. Should, however, the function of these hospitals fail in an appreciable degree—as well it might from single direct hits—the vital end-link in the chain of evacuation from a wide area of military action would be broken. This would apply particularly to the many small townships with only one hospital.

Relieving the Overtaxed Hospital Services

To this end, therefore, it is advisable to establish a plan whereby as much strain as possible is taken from the hospital services, and an efficient way of doing this is by segregation of a section of the surgical work normally expected to be carried out at the hospital itself. There are probably two conditions under which the hospital services might become severely overtaxed, and, therefore, under which the establishment of an emergency surgical station would be invaluable. These are (1) invasion proper, and (2) prolonged aerial attack on our large cities and built-up areas, either as a pre-invasion procedure or as a last attempt to break civilian morale. However the fortunes of war may wax or wane, it is obviously necessary to prepare the country to withstand such an assault, the chief danger of which lies in the production of casualties in excess of what can be dealt with expeditiously and concurrently.

Some disadvantages under which the established hospital functions from the point of view of its use in an invasion are: (1) Inadequate number of beds. (2) Beds occupied by cases recently operated upon but not serious; these block urgent serious admissions. (3) Time taken in continuously operating upon major and less serious cases; this imposes a perpetual strain on the staff. (4) Continual employment of material—for example, bedding, linen, etc.—for the less serious type of case. (5) Danger to serious cases by contact with infected ones of minor degree. (6) Constant risk of limitation in services by enemy action. The work of the hospital surgical department should therefore be restricted to those cases which require treatment under prolonged anaesthesia and subsequent nursing under hospital conditions—for example, abdominal, thoracic, and head injuries, severe burns, and compound fractures. These cannot be dealt with elsewhere, and the medical and nursing

staffs, theatre, and material possessions of the hospital are thus used to the fullest advantage.

In order, therefore, to relieve the strain on the resources of the surgical departments of established hospitals advantage should be taken of modern advances both in surgical technique and in the science of non-inhalation anaesthesia. By a consideration of these factors it will be seen that a large percentage of cases which are admitted to the surgical wards could in an extreme emergency be adequately dealt with at an emergency surgical station established apart from the hospital itself but having adequate communication with it for supplies.

Location and Functions of Surgical Station

This emergency surgical station should be established in towns and cities in conjunction with local hospitals and at a convenient distance therefrom. The function of this unit is based upon two main facts: (1) The necessary surgical treatment can be carried out under sedative pre-medication and anaesthesia by the intravenous or local methods only. (2) Accommodation and nursing of patients are greatly facilitated by the almost complete absence of post-operative vomiting and post-operative chest complications. Sanitary control is facilitated. These two factors would thus render it possible, without undue risk to patients: (1) to accommodate a larger number of cases in a given space; (2) to nurse them with a much smaller staff; (3) to use simpler forms of ward and theatre furniture than is the case in the organization of a general hospital.

The chief surgical conditions which can be dealt with adequately by the emergency surgical station are: (1) Minor or simple amputations under anaesthesia. (2) Reduction of dislocations and simple fractures under anaesthesia; treatment by splints. (3) Cleansing and suture of lacerated wounds with superficial drainage under anaesthesia; sulphonamide treatment. (4) Removal of superficial foreign bodies under anaesthesia. (5) Arrest of haemorrhage by ligature under anaesthesia. (6) Treatment of shock by intravenous saline. (7) Treatment of localized burns by dressing under anaesthesia. (8) Superficial primary repair under anaesthesia. This list includes many of the more common types of casualty, the outlook for which depends more upon promptitude in treatment than upon facilities that can be provided only at a general hospital. Surgical treatment, however, under sedative pre-medication followed by intravenous anaesthesia is possible in all of them. These are the cases which, under conditions of extreme stress, would unnecessarily congest the surgical wards of hospitals.

It must be remembered that the work done at the emergency surgical station is designed to relieve other main services. The immediate saving of life and prevention of permanent injury transcend, therefore, the need for that degree of surgical asepsis and amenity which is to be desired under more ideal conditions, and technique directed to the perfection of result must also be waived to the same end. It is not necessary, therefore, to equip the "wards" or "theatre" with other than the minimum necessities. I suggest that the emergency surgical station should be established in a separate building or in one or more large underground basements possessing adequate ventilation and easy means of entry and exit. Two or three wards and an operating theatre should be arranged for, and the simplest ward and theatre furniture installed—for example, the beds could be of a simple wooden type and the operating table (or tables) could also be made of wood, as only the horizontal position would be necessary.

Equipment and Staffing

It is difficult to list exact requirements for this unit. These would, of course, depend largely upon supplies available. However, as a basis the following stocks should be on hand; they could be readily renewed from hospital stocks:

1. Large drums containing sterilized dressings, gloves, etc. (no gowns required), spirit sterilizer.
2. Box containing necessary surgical instruments: scalpels, Spencer Wells, scissors, sinus forceps, dissecting forceps, tissue forceps, towel clips, retractors, aneurysm needle, needle holders, needles, tourniquet, probe, catgut, silkworm gut, rubber tubing, 20-c.cm. syringe for irrigation.
3. Box containing 10-c.cm., 5-c.cm., and 2-c.cm. syringes with stock of hexobarbitone, evipan, pentothal, and novocain.
4. Wooden splints, bandages, wool, elastoplast.
5. Intravenous saline apparatus and store of normal saline.