“ANTISEPTIC” PREPARATIONS OF CATGUT AND SILK;

THEIR RELATION TO WOUND INFECTION.¹

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(PRESENTED BY MR. BOWLBY.)

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IN the Bradshaw Lecture, delivered by Sir Spencer Wells in December, 1890, allusion² was made to certain experiments, which were then being conducted by me at the Research Laboratories of the conjoint Colleges of Physicians and Surgeons. These experiments are now sufficiently completed to enable me to bring forward certain definite facts, which may throw some light upon the occurrence of suppurations in wounds treated apparently in strict accordance with antiseptic principles, and upon the aseptic course of others treated apparently without these precautions.

It is unnecessary here to do more than allude to the

¹ This paper is a short account of experiments conducted at the research laboratories of the conjoint colleges during the winter of 1890-91.

² ‘British Medical Journal,’ Dec. 20th, 1890, p. 1418.

fact that suppurations, often of a severe character, arising from the presence of ligatures and buried sutures have been frequently noted. It is only, however, within recent years that special attention has been directed to the actual presence of septic organisms in the material so employed. Zweifel¹ was amongst the first to draw attention to this point, and Sir Joseph Lister² has himself referred to an interesting instance occurring in his own practice in connection with the use of the old hempen ligature. It is Kocher, however, who has specially emphasised the importance of employing absolutely aseptic ligature and suture material, and of clinically observing the behaviour of material preserved in apparently trustworthy antiseptic solutions. The history of his practice, so far as it bears upon this, is most instructive. Shortly after Zweifel drew attention to the point, he traced septic complication in one of his cases to the carbolised catgut employed in the operation, and on opening several new bottles of carbolised gut he found that they had a putrid smell, similar to the smell of the pus in the case referred to. This may have been caused by originally contaminated gut, but, as Kocher remarks, the fact remains that its preservation in 20 per cent. solution of carbolic acid in oil, and before use in 5 per cent. aqueous solution was insufficient to render it aseptic.³ He consequently discarded catgut and used silk sterilised according to Czerny's method.⁴ In 1881, in consequence of his well-known experiments with juniper oil,⁵ he commenced using catgut and silk treated with juniper oil and preserved in alcohol. In 1888,⁶ however, he tells us that he has again discarded catgut, and finally adopted silk for all operations, preserving it in 1 in 1000 solution of mercuric

¹ 'Centralb. f. Gynäk.,' 1879, iii, p. 295, "Catgut als Träger der Infection."

² "Inaugural Address," 'Trans. Clin. Soc.,' vol. xiv.

³ 'Centralb. f. Chir.,' 1881, p. 353.

⁴ 'Beiträge zur Operativ. Chir. Enke,' 1878, p. 11.

⁵ "Zubereitung von antiseptischen Katgut," loc. cit.

⁶ "Eine einfache Methode zur Erzielung sicherer Asepsis," 'Correspondenzb. f. Schweizer Aerzte,' 1888, No. 1, p. 3.

chloride. This change of practice was due to the fact that out of a series of 31 major operations, performed during a period of seven weeks, he had 22 cases of suppurative wound infection distinctly traceable to the catgut employed, whereas in a series of 62 subsequent operations, in which silk alone was used, there was not a single bad result.

Reference must also be made to an exhaustive and elaborate article on “Catgut Infection,” by Dr. Conrad Brunner, of Zurich, published last year;¹ an article which is the most important that has yet appeared on the subject, but which I was unfortunately unable to obtain for perusal until after completing my experiments. It is noteworthy, however, that the results of similar experiments, conducted by him, are to a great extent confirmed by mine; a fact to which reference will be made later on.

My experiments were commenced in October, 1890, with a view to testing by bacteriological methods the so-called antiseptic preparations of manufacturers, and for the purpose of discovering, if possible, a simple and efficient method of ensuring absolute purity of ligature and suture materials at the time of their use. This latter point is of vast importance to surgeons who may have to undertake operations without the means of sufficiently steralising their material at the time, and has a special bearing on the surgical equipment of armies in the field; while the results of my experiments on manufacturers’ preparations may be of interest and value to those who use such preparations under the impression that they are actually what they are said to be, and, therefore, in no need of further sterilisation.

The experiments were conducted in three series:—(1) Experiments testing the purity of dry material supplied by surgical instrument makers; (2) experiments testing the purity of material preserved in “antiseptic” solutions; (3) experiments with specially contaminated silk,

¹ ‘Beiträge zur klin. Chir. von Brunsek.,’ 1890.

to test the antiseptic value of the solutions in which the material is usually preserved.

Control experiments were made; and, with a view to eliminating sources of error, the breath and hands of the operator, as well as the air and dust of the room, were examined as to the presence of micro-organisms at various periods. An inoculating box was used, whenever this was possible, and the instruments employed (scissors and forceps) were sterilised by heat in the usual manner. The material used was tested by placing pieces about half an inch in length in sterilised meat infusion, and incubating for at least three weeks, often much longer, at a temperature of 37°C . In all doubtful cases, and in many others, stroke and puncture cultivations were made from the meat infusion on nutrient gelatine, and any resulting growths examined under the microscope. As regards comparative results, these latter observations have no bearing on the purity or otherwise of the material, and, therefore, for the sake of brevity, no detailed statement of them will be made here. Cultivations could only be obtained with difficulty from minute particles of dust in the room, and negative results were obtained after coughing and breathing into the tubes of nutrient material. Exposure of the tubes to the air, with the cotton-wool plugs removed, for one or two minutes also gave negative results; so that it may be assumed that the condition of the room was highly satisfactory for the carrying out of these tests, and that wherever the nutrient material showed putrefactive changes, these changes were due to putrefactive organisms originally adherent to, and introduced by, the silk or catgut.

FIRST SERIES.—*Dry Preparations.*

The materials tested under this head were sulphurochromic gut, surgeon's silk, untreated by any antiseptic method, and "carbolised silk" stated to have been prepared under the instructions of Sir Joseph Lister. Two

experiments were also made with plated wire ; and a comparative test was made with "button-hole" silk, similar to surgeon's silk, but taken from the table of a constantly occupied sitting-room. The results of these experiments are shown in the following table.

TABLE I.—*Experiments with Dry Material.*

No. of experiment.	Nature of material.	Where obtained.	Date of experiment.	Result.
1	Sulphuro-chromic gut	Army Med. Stores, Woolwich (from bearer's dressing case of field surgical haversac)	1890 Oct. 24	Haziness of broth ; no definite putrefaction. Puncture cultivation Nov. 24, 1890, showed no growth on April 4, 1891. Stroke cultivation Nov. 24, 1890, showed single colony on Feb. 6, 1891.
2	"	"	Nov. 5	Haziness ; no definite putrefaction. Stroke and puncture cultivations on Nov. 24, 1890, showed no growth on April 4, 1891.
3	"	Field Med. Companion (new) at Auxiliary Hosp., Woolwich	Nov. 28	Wrinkled pedicle formed in 2 days. Fluid remained clear.
4	"	"	"	Permanently clear. ¹
5	"	"	Dec. 1	Permanently clear.
6	"	"	"	Slight haziness. No definite putrefaction.
7	Surgeon's silk (twist), untreated	"	Oct. 24	Permanently clear.
8	"	"	May 11	Permanently clear.
9	"	Surgeon's pocket case, in daily use	Oct. 24	Hazy Oct. 27 ; turbid Oct. 31. Rapid liquefying growths in gelatine cultivations.
10	Surgeon's silk (plaited), untreated	Reel, in case of instruments at Med. Dept., Royal Arsenal	Nov. 28	Permanently clear.
11	"	"	Nov. 28	Permanently clear.
12	"Carbolised silk" (medium size)	Surgical instrument maker	Oct. 24	Turbid Oct. 27 ; pedicle Oct. 29. Rapid liquefying growths in gelatine cultivations.

¹ Tubes noted as remaining "permanently clear" were under observation for periods varying from one to three months.

TABLE I (continued).

No. of experiment.	Nature of material.	Where obtained.	Date of experiment.	Result.
13	"Carbolised silk" (medium size)	Surgical instrument maker	Oct. 29	Turbid Oct. 31, 1890. Rapid liquefying growths in gelatine cultivations.
14	"	"	"	Turbid Oct. 31, 1890. Rapid liquefying growths in gelatine cultivations.
15	"	Manufacturer of antiseptic dressings	1891 Jan. 30	Turbid Feb. 4, 1891.
16	"	"	"	Turbid Feb. 4, 1891.
17	Same material, but finest size	"	"	Permanently clear.
18	"	"	"	Permanently clear.
19	"Button-hole" silk, similar to surgeon's twist silk (untreated)	Skein of silk in occupied sitting-room	1890 Nov. 28	Wrinkled pedicle Nov. 29, 1890. Fluid remained clear.
20	"	"	"	Clear till Dec. 12, 1890; then slight turbidity.
21	"	"	Dec. 1	Wrinkled pedicle Dec. 3, 1890. Turbid Dec. 8, 1890.
22	"	"	"	Turbid Dec. 3, 1890.
23	Plated wire	Case of instruments in Medical Dept. of Royal Arsenal	Oct. 24	Permanently clear.
24	"	"	Nov. 5	Permanently clear.

Remarks.—The sulphuro-chromic gut and the surgeon's silk of experiments 7 to 11, as well as the plated wire, had been kept in instrument cases on reels or cards, and had been placed and kept in ordinary paper envelopes after removal from the cases. The "carbolised silk" was rolled on a glass rod attached to a cork stopper and kept in glass bottles. Of all the material shown in the table, the "button-hole" silk had been the most exposed

to contamination by dirt or dust, and the "carbolic silk" the least.

It is a remarkable fact that of the material shown in Table I, the only material subjected to any "antiseptic" method of preparation by manufacturers was undoubtedly the most septic, if we except, that is to say, the "button-hole" silk, which had not been intended for surgical use.

The silk in the surgeon's pocket case was expected to prove septic, because it had been exposed to contamination in many places at home and abroad almost daily during a period of eight years, and consequently the only other experiments made with it were with a view of sterilising it. This was readily effected by boiling for one hour, and also by placing it for one hour in 1 in 4000 solution of mercuric chloride. I may mention here that the same processes were applied to portions of other material, which proved septic in these experiments, and in all the cases the material was rendered aseptic by them.

The results of the experiments with "carbolic silk" (which is, I believe, silk coated with a mixture of bees-wax and carbolic acid, prepared, as stated on the bottle, according to the instructions of Sir Joseph Lister) show that this method of treatment offers not only no guarantee that the silk is aseptic, but points rather to the probability that septic organisms become permanently adherent to the silk during the process. Experiments are detailed below (*vide* Tables IIIA and IIIB), which show how liable manufacturers are to miss the point in preparing aseptic material. At the same time, the coating of ligatures with viscid substances, however "antiseptic" they may seem to be, is objectionable, for the manifest reason that micro-organisms are more liable to adhere to such substances than to untreated material. The proposal by Dr. J. Craig¹ to coat silk with shoemaker's wax because it is "highly antiseptic" is a case in point.

The results of experiments 7, 8, and 10, 11, revealed

¹ 'New York Med. Journ.,' vol. xlii, 1885, p. 611.

what was to me a new fact, namely, that surgeon's silk, untreated in any way, is apparently an aseptic material. The fact, however, is amply explained when one inquires into the processes to which it is subjected in the silk manufactories. As these processes¹ are of great interest, and have not, so far as I know, been previously noted in this connection, they may with advantage be detailed here.

The silk threads are "thrown" in China and Italy (chiefly in Milan), and come into this country coated with the dried viscid material of the cocoon, or, as it is technically called, *in the gum*. The processes to which these threads are subjected in English manufactories, have in view the removal of the *gum*, which is a valuable mordant, and the production of a thread as pure and white as possible. The *gum* is removed by boiling, and the threads are afterwards washed with the best curd soap. The soap is then removed by the process of "stoving," *i. e.* placing the threads for six to twelve hours in sulphur kilns. Finally, the threads are bleached by one or other of the patent bleaching powders. "Surgical" silk, which is the whitest silk obtainable, and more resistant than inferior qualities to the action of heat, is subjected twice to the process of "stoving." *Boiling, stoving, and bleaching* are, of course, powerful germicide processes, and, when it is remembered that after the silk has gone through three stages of preparation, the greatest care is taken to keep it free from dirt or dust by having manufactories in country districts,² by employing young girls, who are obliged to keep themselves neat and clean, and by immediate packing in clean cardboard boxes, we have ample explanation of the results of experiments 7, 8, and 10, 11, and, if I may venture to say so, of "*the use without evil consequences of silk ligatures*

¹ I am indebted to Mr. Gilles, of Messrs. Bayliss, Gilles, and Co., silk manufacturers, for a statement of these processes.

² Manufactories were first started in the country because it was difficult to obtain the silk perfectly white and pure in town atmospheres.

which have not been subjected to any antiseptic preparation." I quote from Sir Joseph Lister's recent admirable address on the subject of antiseptic surgery,¹ in which, however, he states that until Metschnikoff's phagocyte theory cleared up the mystery, the fact, just noted, would have otherwise seemed to him incomprehensible.

With regard to sulphuro-chromic gut it is difficult to draw any definite conclusions from the results of experiments 1 to 6. Only one definite growth, however, was obtained in the nutrient broth, and that probably from a particle lightly adherent to the catgut, which, as has been noted, was not specially protected from dirt or dust. The haziness of the nutrient material, subsequent to the introduction of the gut, may possibly have been caused by the chemicals employed in the manufacture of sulphuro-chromic gut.

Plated wire was apparently aseptic. It is worthy of remark that in the pre-Listerian period wire had frequently been urged as the most satisfactory material for use, not only as sutures, but also as ligatures.¹

SECOND SERIES.—*Preparations in "Antiseptic" Solutions.*

Under this head manufacturers' preparations of catgut and silk in aqueous and oily solutions of carbolic acid and mercuric chloride, and one preparation of silk in juniper oil, were tested. All the bottles in which the material was preserved had, with the exception of two, rubber or "gelatole" stoppers, through which the ends of the catgut or silk were threaded, so that the pieces could be drawn out and cut off without opening the

¹ "The present position of Antiseptic Surgery," 'Trans. Tenth Inter. Med. Cong.,' vol. i, p. 30. Also referred to by Prof. White in an article in the 'Annals of Surgery,' Jan., 1891, p. 3.

² Cf. Nunneley, "On the Substitution of Iron Wire for Thread and Silk as Ligatures for Arteries," 'Lancet,' 1862, i, p. 486.

bottles. The two exceptions were the glass-stoppered and cork-stoppered bottles noted in the table below (Table II). The glass-stoppered bottle had in addition a parchment covering, and it was opened for the first time, since it had been obtained from the manufacturer, inside the inoculating box. The cork-stoppered bottle had been previously opened, pieces of the gut having been used for a major operation performed at the Royal Arsenal on the previous day. All the remaining bottles, except these two (which were obtained from army medical stores), were obtained direct from surgical instrument makers or manufacturers. The "gelatole"-stoppered bottles and the rubber-stoppered bottle of experiments 1 to 5 were prepared by foreign, the remainder by English firms. The silk in experiments 27, 28, as well as the bottle, grid and spools, had been boiled for one hour before the bottle was filled with the antiseptic solution. The catgut used in experiments 11 to 13 was the apparent cause of suppuration which took place in the case referred to above. Suppuration in the track of the stitches was almost invariably noted in many subsequent minor operations, in which this gut had to be used. I mention this here, because the occurrence of slight exudation of pus from the track of a suture, and from no other point, is in my experience quite common when carbolised catgut is used; and although it seems to indicate the impurity of the material, the attention of surgeons has not been sufficiently directed to its importance.

TABLE II.—*Experiments with Material kept in "Antiseptic" Solutions.*

No. of experiment.	Nature of material and solution.	Where obtained.	Strength of solution.	Kind of stopper.	Date of experiment.	Result.
1	Catgut in "carbolic oil"	Surgical instrument maker	5%	Rubber	1890 Oct. 20	Permanently clear.
2	"	"	"	"	"	Haziness Oct. 24, 1890. Slight humidity Oct. 26, 1890. Slowly growing, non-liquefying growth on gelatine cultivations.
3	"	"	"	"	"	Haziness Oct. 24, 1890. Slight humidity Oct. 26, 1890. No growth on gelatine cultivations.
4	"	"	"	"	Oct. 29	Turbid Oct. 31, 1890. Rapid liquefying growths on gelatine cultivations.
5	"	"	"	"	"	Turbid Oct. 31, 1890. Rapid liquefying growths on gelatine cultivations.
6	"	Bottle in field medical pannier, Army Med. Stores, Woolwich	?	Glass	Oct. 24	Turbid and pedicle Oct. 29, 1890. <i>Staphylococcus cereus albus</i> cultivated on gelatine.
7	"	"	?	"	Oct. 29	Permanently clear.
8	"	"	?	"	"	Permanently clear.
9	"	"	?	"	"	Permanently clear.
10	"	"	?	"	"	Wrinkled pedicle Oct. 31, 1890. Very slow growth on gelatine cultivations, liquefying Feb. 13, 1891.
11	"	Bottle in use in Med. Dept., Royal Arsenal, obtained from surgical instrument maker	?	Cork	Nov. 12	Shreddy growth from thread Nov. 17, 1890. No turbidity.
12	"	"	?	"	"	Shreddy growth from thread Dec. 15, 1890. No turbidity.
13	"	"	?	"	"	Permanently clear.

TABLE II (continued).

No. of experiment.	Nature of material and solution.	Where obtained.	Strength of solution.	Kind of stopper.	Date of experiment.	Result.
					1890	
14	Silk in "carbolic oil"	Manufacturer of antiseptic dressings	5%	"Gelatole"	Nov. 5	Turbid Nov. 8, 1890. Pedicle Nov. 10, 1890. Cultivation of <i>Staphylococci</i> and <i>Bacillus subtilis</i> on gelatine.
15	Catgut in oily solution of mercuric chloride	"	1 in 2000	"	Nov. 24	Permanently clear.
16	"	"	"	"	"	Permanently clear.
17	Silk in oily solution of mercuric chloride	"	"	"	Nov. 3	Growth from thread, turbidity and pedicle Nov. 10, 1890. Rapid liquefying growths on gelatine.
18	"	"	"	"	"	Turbidity and pedicle Nov. 5, 1890. Rapid liquefying growths on gelatine.
19	"	"	"	"	Nov. 5	Growth from thread and turbidity Nov. 8, 1890. Rapid liquefying growths on gelatine.
20	"Chromicised" catgut in oil (juniper oil?)	"	—	"	Nov. 24	Clear Nov. 29, 1890. Tube accidentally broken.
21	"	"	—	"	"	Permanently clear.
22	Silk in "juniper oil"	"	—	"	"	Turbid Nov. 28, 1890.
23	"	"	—	"	"	Turbid and thick growth from thread after Dec. 8, 1890.
24	Silk in aqueous solution of carbolic acid	Surgical instrument maker	6%	Rubber	Oct. 24	Permanently clear.
25	"	"	"	"	Nov. 3	Permanently clear.
26	"	"	"	"	Nov. 5	Permanently clear.
27	Silk in aqueous solution of mercuric chloride	"	1 in 10,000	"	Nov. 28	Permanently clear.
28	"	"	"	"	"	Permanently clear.

These experiments show generally, I think, the untrustworthiness of manufacturer's preparations so far as *asepsis* is concerned. I cannot, of course, say under what conditions these preparations were made, and in the case of the "gelatole"-stoppered bottles it is possible that micro-organisms may have been obtained from the stopper itself. Most of the solutions, indeed I may say all the solutions, in which the material is stated to have been kept, are, by laboratory experiments, more or less antiseptic. So, at any rate, the next series of experiments would seem to prove. But it is a remarkable fact that Reverdin,¹ Thomson,² and Brunner,³ in testing similar manufacturer's preparations, obtained similar evidence of septic impurities. Brunner, for example, tested 52 bottles obtained from 6 different manufactures. His results were briefly as follows:—*sublimated gut*, 25 bottles examined, no septic growths from any; *carbolicised gut*, 12 bottles examined, no septic growths in 5, septic growths in 7; *chromicised gut*, 7 bottles examined, no septic growths in 3, septic growths in 4; *Ol. Juniperis gut*, 8 bottles examined, no septic growths in 5, septic growths in 3. Brunner states, therefore, with regard to Lister's process of preparing catgut with chromic acid, and Kocher's of preparing it with oil of juniper, that, "so far as these processes are carried out in manufactories, they afford no guarantee of the asepsis of the catgut." It must be noted that these observers tested catgut preparations only, and seemed inclined to blame the material, and not the solutions, for the septic results. It would appear, however, from the experiments in Table II that "antiseptic" preparations of silk are equally untrustworthy, and certainly afford no guarantee of the asepsis of the silk.

I do not for a moment wish to imply that manufacturers are not acting in strict good faith while pre-

¹ "Recherches sur la sterilisation du catgut et d'autres substances employées en chirurgie," 'Rev. Méd. de la Suisse romande,' 1888.

² "Experimentelle Untersuchungen über die gebräuchlichen Nahtmaterialien," &c., 'Centralb. f. Gynäk.,' 1889, No. 24.

³ Loc. cit.

paring the material and the solutions, but I would direct attention to the fact that they may miss some essential point to which we have no clue, but which may make all the difference between an aseptic and a septic material, or between an antiseptic and an inert solution. An instance, occurring to myself, is instructive with reference to this very point. I asked a well-known surgical-instrument maker to prepare for me a rubber-stoppered bottle of silk, giving him written instructions regarding the method of preparing it aseptically. The silk was first directed to be rolled on glass spools, which were to be placed inside the bottle on a metal grid, and the free ends of the silk were to be threaded on needles. The bottle and its contents were then to be steamed for one hour in a steamer, and immediately afterwards the free ends of the silk were to be drawn through the rubber stopper and the bottle at once permanently closed. I gave these instructions in October, 1890, and obtained the bottle about a month afterwards. I then tested the silk in the laboratory, in the same way as I had tested the other preparations, with the following results :

TABLE IIIA.—*Experiments with Silk prepared "Aseptically" by Surgical-instrument Maker.*

No. of experiment.	Date of experiment.	Result.
1	Nov. 28, 1890	Permanently clear.
2	"	Pedicle on surface of fluid Dec. 1, 1890.
3	Dec. 1, 1890	Turbid on Dec. 3, 1890.
4	"	" "
5	"	Permanently clear.
6	"	" "

These results were, as may be imagined, somewhat disconcerting, three out of the six pieces of silk tested showing evidence of the presence of micro-organisms. I, consequently, applied to the manufacturer for a statement in writing, detailing the process to which the silk had actually been subjected. The following is the statement

which I obtained :—"The bottles, grid, spools, needles, and silk were boiled for one hour at a temperature of 212° F. The silk was dried in a steam bath *after* the boiling process and *before* being put on the spools in the bottle." There was thus ample opportunity for the contamination of the silk, both by the hands of the workman and by the dust of the workshop, during the time intervening between the boiling process and the permanent closure of the bottle. Accordingly, I removed the rubber stopper in the laboratory, threaded the ends of the silk on needles, and placed the bottle and its contents in a steam steriliser for thirty-five minutes, the rubber stopper being in the interval placed in mercuric chloride solution (1 in 1000). Immediately on the removal of the bottle from the steriliser, the ends of the threads were drawn through the rubber stopper and the bottle permanently closed. I then tested the silk at different periods with the following results :

TABLE III.B.—*Experiments with Silk prepared Aseptically in the Laboratory.*

No. of experiment.	Date of experiment.	Result.
1	Dec. 8, 1890	Permanently clear.
2	"	" "
3	"	" "
4	"	" "
5	Jan. 5, 1891	" "
6	"	" "
7	"	" "
8	"	" "
9	Jan. 13, 1891	" "
10	"	" "
11	"	" "
12	"	" "
13	"	" "
14	"	" "
15	"	" "
16	"	" "
17	"	" "
18	"	" "
19	"	" "
20	"	" "

All the pieces of silk in the first thirteen of the experiments in Table III_B were drawn out, cut off, and placed in the tubes by means of sterilised instruments, such as were employed in the previous experiments. In the remaining seven experiments the finger and thumb of the hand, previously washed with soap and water, dried, and then momentarily dipped in 1 in 1000 sublimate lotion, were employed instead of the forceps.

The contrast between the results of the two tables (Tables III_A and III_B) is sufficiently striking, and needs no further comment. The method of rendering and keeping silk aseptic, detailed in connection with the experiments of the latter table, seems a reliable and trustworthy method, if it is carried out strictly in accordance with the requirements of a bacteriological experiment. The process should not, therefore, be entrusted to manufacturers of antiseptic dressings or to surgical-instrument makers.

THIRD SERIES.—*The Antiseptic Value of the various Solutions in which Catgut and Silk are usually preserved.*

In these experiments surgeon's twisted silk was contaminated by being steeped for three hours in the meat infusion, rendered putrid by Experiment 14 of Table II, and containing growths of several micro-organisms, of which spore-bearing *Bacillus subtilis* and a form of *staphylococcus* (*Staphylococcus albus*) were differentiated. The silk, after being thus contaminated, was cut into pieces about half an inch long, dried under a bell-jar on clean blotting-paper for two days, and afterwards placed in the various solutions noted in Table IV. From time to time pieces were placed from the solutions in tubes of sterilised meat infusion, and incubated at 37° C., with the following results :

TABLE IV.—*Showing results of placing Contaminated Silk in “Antiseptic” Solutions.*

Nature of the solution.	Length of time the threads remained in the solutions before being placed in the nutrient material, with the results.							
	30 seconds.	30 minutes.	1 hour.	24 hours.	3 days.	7 days.	39 days.	67 days.
1 in 2000 solution of mercuric chloride in distilled water	+	<u>+</u>	<u>+</u>	○	○	○	○	○
1 in 2000 solution of mercuric chloride in juniper oil	+	+	<u>+</u>	○	○	○	○	○
1 in 2000 solution of mercuric chloride in olive oil	+	+	+	+	<u>+</u>	<u>+</u>	○	○
1 in 20 solution of crystalline carbolic acid in distilled water	+	+	+	+	⊕	⊕	⊕	○
1 in 10 solution of crystalline carbolic acid in olive oil	+	+	+	+	+	+	+	○
Juniper oil (undiluted)	+	<u>+</u>	<u>+</u>	○	○	○	○	○
Inert control solution, containing .6 % chloride of sodium in distilled water	+	+	+	+	+	+	+	+
Boiling water	?	○	?	?	?	?	?	?

EXPLANATIONS.

A cross (+) indicates that the nutrient meat infusion became turbid after 48 hours.

One line under the cross (+) indicates that the turbidity was delayed for 4 days, and two lines that it was delayed for 6 days.

A cross within a circle (⊕) indicates that all micro-organisms except one (*Bacillus subtilis*) ceased to grow.

A circle (○) indicates that no micro-organisms developed, and that the infusion remained permanently clear.

? indicates that no experiment was made under this particular head.

It would appear from these results that all the solutions, with the exception of the inert control solution, have a germicide action varying considerably in degree. Employing gut prepared from rabbits which had died after inoculation with anthrax bacilli, Brunner¹ made similar experiments with the following results:—The gut was aseptic after remaining for 1½, 3, and 6 hours in 1 in 1000 aqueous solution of mercuric chloride, after 3 days in a 30 per cent., and after 12 days in a 20 per cent. solution of carbolic acid in oil, and after 36 hours in juniper oil. After 24 hours in juniper oil only some of the pieces tested were aseptic. The gut was also aseptic after exposure to dry heat for one hour according to Reverdin's method. I do not think that these results are quite satisfactory as a comparative test of the value of the solutions, because it is not certain that each piece of gut contained a similar number of or even any anthrax bacilli. However, if we take into consideration the fact that Brunner's solutions were double the strength of similar solutions of Table IV, the results of his experiments and mine bear a close resemblance to one another. With juniper oil there is a considerable discrepancy. The possibility of different qualities of juniper oil having been used may account for this.

How can we reconcile the difference between the results of Table II and the results of Table IV? a difference which I have already referred to, and which, as I have noted, Brunner and others have also observed; the difference, that is to say, between manufacturers' and laboratory preparations? There is no question of the material not having remained a sufficient time in the solutions. Attention has been already directed to the possibility of error on the part of the manufacturer. One other point, however, suggests itself. Is it not possible that the quantity of material is too great in proportion to the quantity of the solution in which it is kept? that, in other words, there is not sufficient antiseptic agent

¹ Loc. cit.

present in the bottles to render the material aseptic throughout. Most of the bottles which I tested were of two ounce capacity, and the difference of weight, for example, between the bottle of silk in carbolised oil, of Experiment 14 of Table II, and the bottle of silk used in the experiments of Tables IIIA and IIIB, was one ounce, so that, roughly speaking, the bottle of Table II contained equal proportions of material and solution. Though no experimental tests were made to decide this question, it is possible that such a proportion is insufficient to destroy all the germs that may be present, not only, be it remembered, in the silk or catgut themselves, but also in the bottle, spools, and solvent medium, none of which probably undergo previous sterilisation. There seems, at any rate, a necessity for further investigation in this direction.

I am fully sensible of the fact that these experiments are incomplete from many points of view ; but they are sufficient to teach one or two practical lessons.

1. All so-called “antiseptic” preparations must be received with considerable caution ; so much so that those, who are not prepared to accept entirely Kocher’s aphorism, “*Away with catgut,*” may with good reason consider the advisability of rejecting its so-called antiseptic preparations.

2. Asepsis can with certainty be obtained by the simplest, cheapest, and most efficient process of all, namely, by boiling or steaming.

3. Material thus rendered aseptic may be readily kept aseptic (by the method detailed in connection with the experiments of Table IIIB) in bottles containing no solutions of any kind. Such bottles have the further advantage of being at least half the weight of bottles containing a solution, an advantage of some importance, for example, in connection with the transport of field surgical equipment.

4. The preparations of such bottles cannot be entrusted to manufacturers.

5. The methods of keeping ligature material aseptic by means of solutions, suggested from time to time by many eminent surgeons,¹ are unnecessary; but, should one of these methods be preferred, the most reliable solution to use is a solution of mercuric chloride in water (1 in 1000 or 1 in 2000).

6. The most aseptic material sold by surgical instrument makers is probably the pure undyed silk twist, untreated by any "antiseptic" method.

In concluding, I have gratefully to acknowledge my indebtedness to my friend, Dr. G. Sims Woodhead, the Director of the Laboratories, for his valuable supervision, and for the kind interest he took in the experiments, and to the Laboratories' Committee of the Conjoint Board in England for the liberal use I was permitted to make of the Laboratories.

¹ Brunner (loc. cit.) records the methods recommended from time to time by Lister, Macewen, Mickulicz, Kocher, Roux, Kümmel, Schede, Esmarch, Zweifel, Reverdin, and Beuchisser.

(For report of the discussion on this paper, see 'Proceedings of the Royal Medical and Chirurgical Society,' Third Series, vol. iv, p. 74.)