this subject, viz.: that the method has been objected to on various grounds, but chiefly because those who have failed in their attempts have looked on the spray as the essential element, and on aseptic surgery as the performance of operations or dressings in a spray of carbolic acid. There cannot be a more fatal error than this, for the spray is in the great majority of cases merely a convenience, and not a necessity, and those who look on it as a necessity are apt to forget the really essential details, and to trust too much to the spray. I say it is not essential, for if the wound be easily accessible, and be thoroughly washed out during and after the operation, the great probability is that an aseptic result will be obtained. Only it must be remembered that if the spray is not used, this washing out must not be neglected. But to deluge the wound with carbolic lotion is an undesirable thing; and it is for this reason, and also because the feeling of certainty as to the result must be greater when the spray is used than when it is not, that I would advocate its continuance.

Other surgeons look on the gauze as an essential element, and that this is equally an error is evident from a consideration of Mr. Lister's earlier methods, and also from the results at present obtained by the use of other materials. One surgeon has indeed gone so far as to use the term 'spray and gauze method' as synonymous with Listerian or aseptic surgery; in other words, to define aseptic surgery by two of its least or even non-essential elements. Aseptic surgery is not treatment by spray, nor by gauze, nor by spray and gauze, nor by carbolic acid, but is any method of treatment which aims at and succeeds in *excluding* the causes of fermentations from wounds.

CHAPTER XVII.

RESULTS OF ANTISEPTIC SURGERY.

Chief points for consideration. How far do the various methods prevent fermentations in wounds? How to ascertain the true value of any individual method. The value of the various methods in guarding against infective disease: meaning of the term 'infective disease.' Relations of aseptic surgery to infective disease. *Mr. Lister's results in Glasgow. The recent Glasgow statistics. Mr. Lister's results in Edinburgh; results in septic and aseptic cases—Mr. Spence's practice—Mr. Syme's results—Mr. Lister's results at King's College Hospital:—Volkmann—Nussbaum—Socin—Saxtorph—Esmarch—Hueter—Czerny—Lucas-Championnière—Gross—Létiévant—Panas—Schede—Reyher—Spencer Wells—Keith—Thornton. Thiersch's results with salicylic acid. Thymol.* The relations of other forms of Antiseptic Surgery to these diseases—*Treatment by Antiseptics—Reyher—Lister—Nélaton—Hutchinson. Occlusion—Jules Guérin—Alphonse Guérin. Treatment by irrigation and water bath—Langenbeck—Valette. Open Method—Bartscher and Vezin—Burow—Krönlein.* Results where no antiseptic measures were adopted—*Billroth—Malgaigne—Paul—Holmes—Erichsen.* Results of cleanliness—*Savory—McVail—Bardenheuer.*

In looking at the results of the various methods of treatment, the following are the chief points which present themselves for consideration.

1. Results of the various methods as to saving life
   (*a*) by preventing infective disease.
   (*b*) by preventing profuse suppurations and consequent exhaustion.
   (*c*) in other ways, such as by rendering operations on weak or diseased individuals possible, or by enabling the surgeon to undertake with safety by one method operations which by other methods would be unjustifiable.
2. Results according as one or other method enables the surgeon to render the patient a more useful member of society.

Here I shall have chiefly to consider the bearing of the various methods on conservative surgery.

3. Method of healing in various cases, and also the behaviour of sloughs, ligatures, blood clots, &c.

4. The bearing of the various methods on constitutional disturbance after operations or wounds.

5. Discussion of the objections against the various methods, and other points.

Before entering on these questions, I must say a few words as to how far these methods answer the purpose of preventing fermentations in wounds.

The aseptic method, when properly carried out, does this completely. There is no putrefaction, and no other kind of fermentation; and, as I have shown, organisms can be entirely excluded if it be wished. No doubt in ordinary practice one form of organism does sometimes get in, but this is only generally towards the end of the case, and it does not cause putrefaction, while the products of its growth seem to be but little irritating.

Treatment by antiseptics does not prevent fermentations or the entrance of organisms, unless, indeed, it is so thorough as to render the wound aseptic. The specimens of bacteria which are figured on Plate I. were taken from wounds treated with antiseptics. Although, however, fermentations are not altogether prevented, yet from the frequent removal of the organisms and their destruction by the antiseptics employed, fermentation does not, as a rule, occur to any great extent.

The open method hinders the putrefactive fermentation, more especially because the discharge flows rapidly away and also because it becomes too concentrated and too freely admixed with oxygen. Nevertheless, whenever the discharges are retained, they undergo fermentation, showing that the causes of fermentation are constantly present.

Treatment by irrigation or by water bath is more effectual than the open method, because the discharge is removed still more rapidly and thoroughly; but, nevertheless, unless a sufficiently strong antiseptic solution be employed, the causes of fermentation are always present in the wound, and may act if they have opportunity.

The various methods of occlusion are the most imperfect of all, and I have already referred to the stench and the state of the pus in wounds treated by Alphonse Guérin's cotton-wool method.

In determining whether any instrument or any method is safe and suitable for use in the ordinary circumstances in which it will be employed, one does not simply content oneself with using it under such circumstances, but various tests are applied to it, *i.e.* it is subjected to trials greater than those which it will have to undergo in every-day work. A gunmaker is not satisfied with a gun if it does not burst with an ordinary charge; he overcharges it, and if it withstands this test, he very properly concludes that it will be efficient and safe as ordinarily used. A boilermaker does not send out a boiler as trustworthy till he has subjected it to pressure such as it may never have to bear afterwards, but which it might, under rare circumstances, have to endure.

In considering the value of the various methods of wound treatment as protectors against death, we must in like manner consider how they behave in the very worst circumstances, in circumstances in which they may never or only very rarely have to be employed; for a method which is effectual under unfavourable circumstances ought to be employed in all, unless there is some special and valid objection to its use. The tests, therefore, which I shall apply to these methods (so far as I can find the requisite material) with the view of determining how far one or other may be *depended on* as a guard against the more serious dangers of operations, are their behaviour in unfavourable hygienic conditions, or indeed, in infected atmospheres, and to what extent they protect patients after operations which are peculiarly liable to be followed by serious consequences.

Firstly, then, with regard to *Infective Disease*. Under this heading I include Pyæmia, Septicæmia, Erysipelas and Hospital Gangrene. Closely allied to these is Septic Intoxication, which I would call, after Matthews Duncan, Sapræmia. For though this is merely the result of a chemical poison, it is a disease which is dependent for its occurrence on fermentation in

wounds, and it must, therefore, be included in this group. I do not add Tetanus, because I do not think that there is sufficient evidence as yet to justify us in classing it among septic diseases, though several eminent surgeons, more especially in Germany, hold that view.

I shall first consider

THE RELATIONS OF ASEPTIC SURGERY TO THESE DISEASES.

The first record which I can find—and it is a very striking one—is a paper published by Mr. Lister himself, in which he gives his results in Glasgow up to the time when he went to Edinburgh. This will be found in the 'Lancet' for 1870. In this paper he describes the progress of his cases and the state of his wards in the Glasgow Infirmary before and after the introduction of aseptic surgery. He tells us that on account of the constant presence of infective diseases in that hospital when he went to Glasgow, he had to diminish the number of beds in each ward, and he states that infective disease was so common, that whenever a case of compound fracture was admitted into his wards, he at once ordered the internal administration of sulphites, which were at that time much used as prophylactics against these diseases. In some of the other wards these diseases became at times so prevalent that the wards had to be closed.

Mr. Lister gives the following statistical table of his results in amputation cases before and after the introduction of aseptic surgery. The statistics *before* the introduction of that method include the results of two years' practice (1864 and 1866, the report for 1865 being imperfect). During that time the following amputations were performed, with the following results:—

	Cases	Deaths
Through the shoulder-joint	3	2
„ upper arm	3	2
„ elbow-joint	1	1
„ forearm	5	1
„ hip	5	4
„ thigh	10	3
„ knee-joint	3	1
„ ankle	5	2
Total	35	16

A mortality of 45·7 p. c.

The causes of death are not definitely stated, but almost all were due to infective disease. Thus of the six deaths following amputations of the upper extremity, four were due to pyæmia and one to hospital gangrene.

In contrast to this, Mr. Lister mentions the results obtained during the aseptic period (1867, 1868, 1869). The following were the amputations performed:—

	Cases	Deaths
Shoulder-joint	3	—
Upper-arm	3	—
Forearm	6	1
Hip-joint	2	1
Thigh	4	—
Knee	13	4
Ankle	9	—
Total	40	6

A mortality of 15 p. c.

The causes of death in all the cases is not given. In two—an amputation at the hip-joint and a double amputation at the knee—death occurred from shock and loss of blood. Mr. Lister also states that two of the deaths resulted from pyæmia, but in one of these the pyæmia existed before the operation (amputation of the forearm), and in only one case (an amputation at the knee) did pyæmia arise after the operation. But further, these were the only cases of pyæmia which occurred in Mr. Lister's hospital practice during these three years, and that in spite of the former frequency of the disease. And among the other cases treated during this time were twenty-two compound fractures, and several compound dislocations.

During the same period only one case of erysipelas occurred, but it did not prove fatal.

Hospital gangrene attacked one or two wounds, but it was of a very mild type; and Mr. Lister states that during the last year of this period he had no cases of that disease.

Two other points must also be taken into consideration. Firstly, the annual cleaning of the wards, which had previously been necessary, was not carried out during those three years. Secondly, when Mr. Lister remarked the great improvement in the healthiness of his wards, he increased the number of beds in each.

Here we have a very valuable piece of statistics; and it is so much the more striking as the results were obtained in the early days of aseptic surgery before any of the recent improvements had been introduced. During a period of three years, there occurred only two cases of pyæmia, one case of erysipelas and one or two cases of mild hospital gangrene, and this result was obtained in unhealthy wards in which these diseases were previously common, and in wards which, towards the end of the aseptic period, were in much more unfavourable hygienic conditions than before the commencement of that period. Looking at only one class of operations, the mortality after amputations was reduced from 45·7 p.c. to 15 p.c., and that reduction was in the main or altogether owing to the abolition of infective disease. I say that these statistics are of the greatest value, and it is strange that they have been allowed to pass unnoticed by those who have cried so loudly for statistics; for they answer almost all the requirements. They are results obtained by the *same* surgeon in the *same* wards in successive years. And the result cannot be ascribed to better hygienic conditions; for, as I have just pointed out, there was no improvement in the hygienic arrangements during the aseptic period, in fact, rather the contrary, for the annual ward cleaning was done away with, while an increased number of beds was introduced. Nor can the results be ascribed, as is so much the fashion in some quarters, to cleanliness alone, to the cleansing of the instruments after each dressing, &c.; for long before Mr. Lister had thought of the aseptic method, he had striven to prevent all such contamination, being fully impressed with the evils of putrefaction, and with the necessity of avoiding it, as far as possible. Nevertheless, though cleanliness had been tried, it had failed.

While speaking of Glasgow, I may mention here the recent statistics given by Mr. MacEwen in 1879.[1] They are merely numerical, but nevertheless, they are striking, and when considered along with the other results which will be referred to presently, they will be seen to be of great value. Mr. MacEwen, thinking that pure air was of more value than aseptic treatment, asked the medical Superintendent of the Glasgow Infirmary to compile comparative statistics of cases treated aseptically and of those treated in other ways. To his surprise, the facts showed the opposite of what he had expected. Thus, during the years 1875, 1876, 1877 and 1878, 1706 cases were treated strictly aseptically under the care of Dr. Cameron, and of these 50 or 2·93 p.c. died. During the same period, in the same number of wards, under Dr. Morton's care, 1884 cases were treated not aseptically, and of these 110 or 5·84 p.c. died, the cases in each instance being practically of the same character. And not only was the mortality in the latter case more (it was double) than in the former for the whole period taken together, but a similar difference was found when the results of each year were looked at separately. Thus the percentage mortality during

1875	was, among	aseptic cases	3·29 p. c.
„	„	non-aseptic cases	7·63 „
1876	„	aseptic cases	3·28 „
„	„	non-aseptic cases	6·91 „
1877	„	aseptic cases	3·68 „
„	„	non-aseptic cases	5·13 „
1878	„	aseptic cases	2·93 „
„	„	non-aseptic cases	3·96 „

As is remarked in a leader in the 'British Medical Journal' on this subject: 'The result, therefore, proves that, under antiseptic treatment, the mortality was, under apparently strictly comparable circumstances, much smaller than under the ordinary mode. . . . This is a case very much to the point, and will meet some of the conditions of comparative statistics rightly insisted on by Mr. Holmes.' Some correspondence followed between Dr. Cameron, Dr. Morton, and Mr. MacEwen, after the publication of these results, but the further information elicited did not in any way alter the significance of the facts.

I will now pass on to Mr. Lister's results in the Edinburgh Infirmary. These have been already published in his speech at the meeting of the metropolitan branch of the British Medical Association at St. Thomas's Hospital in December, 1879;[1] and some further facts were given by Mr. Lister in his reply, in February 1880, to Mr. Spence's attack.[2] I shall not, therefore, enter at great length into these general statistics, more espe-

[1] *British Medical Journal*, 1879.

[1] See MacCormac's *Antiseptic Surgery*.
[2] *British Medical Journal*, 1880.

cially as I intend presently to allude to some of the facts in detail.

From the end of 1871 to the middle of 1877—a period of about five and a half years—Mr. Lister treated 553 cases aseptically. Of these 2, or ·36 per cent., died of blood poisoning. During the same period, Mr. Lister treated 292 cases in other ways, some with antiseptics, some without, and of these 4, or 1·36 p. c., died of blood poisoning. Now this alone is a very striking statistical fact, as it shows that the same surgeon, in the same wards, during the same time, lost four times as many patients from blood poisoning in cases not treated aseptically as in those which were treated on strict aseptic principles. And when we look at the nature of the cases in each instance, this difference will become much more apparent.

Of the 553 cases treated aseptically, 29 died.

Among these were 80 major amputations, of which 9 died—6 from shock within a few hours, 1 from diphtheria in the throat nine weeks after operation, when the wound was almost entirely healed; 1 from cerebral hæmorrhage three months after the operation; and 1 from hæmorrhage into the thigh from a malignant tumour of the femur three days after amputation at the shoulder-joint—the amputation wound was doing well.

The following is a complete table of Mr. Lister's amputations:—

	Primary		For disease and secondary to injury		Total	
	Cases	Deaths	Cases	Deaths	Cases	Deaths
Hip	1	1*	2	2*	3	3
Thigh	3	2*	26	1†	29	3
Leg	3	0	5	0	8	0
Ankle	2	0	16	1‡	18	1
Shoulder	4	1*	1	1§	5	2
Upper-arm	3	0	6	0	9	0
Forearm	—	—	8	0	8	0
Total	16	4	64	5	80	9

* Died in a few hours from shock; † died from diphtheria; ‡ from cerebral hæmorrhage; § from hæmorrhage into the thigh.

There were also 21 excisions of the larger joints performed aseptically without a death (7 of knee, 2 of shoulder, 10 of elbow, 2 of wrist).

Thirty-seven excisions of the mamma were performed aseptically with two deaths, both from infective disease. One of the deaths was from septicæmia occurring after the removal of a very large portion of skin and of the whole contents of the axilla. Everything went on perfectly till the tenth day, when a mistake was committed in the dressing; putrefaction occurred, and septicæmia commenced. On post-mortem examination no abscesses or infarcts or other marked appearances were found. The other patient died of erysipelas. Among these 37 cases there were 24 in which not only the mamma, but also the fat and glands from the axilla were removed.

There were 27 operations for un-united, or badly united, fractures without a death. These consisted of 8 operations on the femur, 9 on the bones of the leg, 4 on the humerus, 5 on the bones of the fore-arm, and 1 on the clavicle (removal of a projecting splinter of bone in a case of simple fracture, thus converting the case into one of compound fracture).

There were 14 operations on healthy joints, in which the joints were opened and kept open for some days by means of a drainage tube. No death.

In 11 cases incisions were made into diseased joints in which suppuration had not yet occurred. No death. These were cases of gelatinous disease.

There were 39 cases in which abscesses of joints were opened and a drainage tube inserted, none of the diseased parts (bone, synovial membrane, &c.), being removed. Of these, 2 died, both from tubercular meningitis confirmed on post-mortem examination.

An incision was made and a drainage tube inserted in 2 cases of synovitis of the knee-joint. No death.

There were 4 cases in which operations were performed to relieve old standing dislocations. In some of these the bones were simply replaced. In one case it was necessary to remove portions of the bone before the surfaces of the joint could be brought into apposition. No death.

In 3 cases the femur was divided for knock-knee. No death.

In 7 cases of ostitis a groove was dug in the bone by a gouge and hammer. No death.

There were 7 cases of ligature of the large arteries in their continuity, with 1 death. The fatal case is not entered in the note-books, but I remember its occurrence. During attempts to reduce a dislocation of the shoulder-joint of seven weeks' standing, the axillary artery

was torn and hæmorrhage occurred into the axilla. Mr. Lister at once cut down and ligatured the artery, but the patient died the same night from exhaustion, owing to the loss of a large quantity of blood.

There were 2 cases of excision of the thyroid gland. No death.

There were 4 cases of excision of the testicle. No death.

There were 9 cases of strangulated hernia, with 3 deaths. The gut was gangrenous in all the fatal cases.

There were 30 cases of abscess (psoas or lumbar) connected with disease of the spine. Of these 4 died—2 from phthisis, 1 from exhaustion, and in one case the lumbar abscess was almost absolutely healed when a little glandular abscess formed in the neck. This was opened without aseptic precautions, and the wound was attacked with erysipelas, of which the patient died. Though this was an aseptic case, yet the erysipelas did not attack a wound treated aseptically, and therefore the death from infective disease is included among the cases not treated aseptically, and not among the aseptic ones.

There were 91 cases of acute or chronic abscesses. These included a great variety of abscesses, but they were all more or less extensive. There were 2 deaths; one death occurred in a case of peri-renal abscess. The patient was in a very low state when operated on, had diarrhœa, &c., and he sank in ten days. On post-mortem examination the typical scrofulous kidney was found. The other death occurred in a case of abscess in the right lumbar region, but in which there was no disease of the spine. The abscess was opened on May 20, 1873, and went on very well till July. There was then only a small sinus, and the patient was permitted to get up. During autumn the discharge was allowed to putrefy, and it afterwards increased rapidly in amount and became purulent. For some days before her death, on November 15th, the patient had very severe pain in the right iliac region and the right limb, and following this the leg and foot became gangrenous (phlebitis?).

There were five cases of empyema. No death.

There were eight cases of chronic bursitis, in which incisions were made and drainage tubes inserted. No bad result.

There were twelve cases of removal of exostoses without a death.

There were forty cases of removal of large tumours from various regions. No death. (There were also a number of cases in which smallish tumours, fatty or otherwise, were removed. These are not included among the forty.)

There were three cases of suprapubic lithotomy, with two deaths. In one fatal case, an adult male, the peritoneum was intentionally opened below the umbilicus, the bladder incised through its peritoneal coat,

and the stone extracted. The wound in the bladder was then stitched up, as was also the wound in the abdominal wall. The patient was doing well till the second morning (about forty hours) after the operation, when he got out of bed, or was made to get up. As a result of this exertion the intestines protruded between the stitches. They were returned as soon as the accident was discovered, but the patient died of shock on the same day. In the other fatal case, a little boy, the peritoneum was also opened, but the stone was not removed. The child cried incessantly after the operation, and in spite of the close stitching of the wound in the abdominal wall, the intestines escaped between the stitches. The patient died on the following day from shock.

There were three cases of spina bifida, into which minute drains, in two cases horse-hair (two or three threads), and in one a drainage tube, were introduced. The patients apparently died as the result of the constant draining away of the cerebro-spinal fluid, although as soon as bad symptoms were evident, the drains were withdrawn. In two cases no macroscopical appearances were found to account for death. (I do not know what the microscopical appearances of the cord may have been.) In one case the sac was congested, and contained a little turbid fluid, but there was no violent inflammation, and the little which was present did not apparently spread up the canal. In fact, the appearances found could not explain the fatal result in any of the cases, and therefore it is possible that the disturbance due to the constant draining away of the cerebro-spinal fluid had something to do with death. The first two cases died in two and nine days respectively. The last died in five days.

One case of chronic hydrocephalus was treated in this way (by drainage) and died in six days. There was no trace whatever of inflammation. The ventricles were extremely distended, containing forty-two ounces of clear cerebro-spinal fluid. Apparently the fatal result was due to the same cause as in the former instances, viz., the disturbance consequent on the constant draining away of the cerebro-spinal fluid.

These are the most important of the 553 cases. (Although there were only two deaths from infective disease after aseptic operations, and although that fact was all that was necessary for our present purpose, I have thought it well to mention all the causes of death, and to indicate the sort of cases treated.)

The 292 cases not treated aseptically contained a very much larger proportion of trivial operations, such as removal of