

necrosed bone, fistula in ano, hæmorrhoids, &c. There were ten deaths, of which two were from pyæmia, one from septicæmia, one from erysipelas, and six from exhaustion (?).

The cases of pyæmia occurred, one after a plastic operation on the nose, and one after amputation of the penis. The case of septicæmia occurred after excision of the tongue. The case of erysipelas occurred after the opening of a small abscess in the neck without aseptic precautions; this case is mentioned among the psoas abscesses (p. 373). One case of excision of the hip-joint (æt. seventeen) died twenty-nine days after the operation, apparently of exhaustion from the profuse discharge. One case of excision of the mamma (æt. sixty-three), where putrid sinuses were present before the operation, died in three days of exhaustion. (May not the fatal result in this case have been due to sapræmia?) One case of excision of the upper jaw (æt. sixty-three), died twenty-three days later, apparently of exhaustion; there were no marked symptoms during life, and no post-mortem appearances; there were hæmorrhages on various occasions after the operation. One case of excision of the tongue (æt. seventy-five) died in ten days without any special symptoms, apparently of exhaustion; no morbid appearances were found on post-mortem examination. One case in which the floor of the mouth was removed for malignant disease (an old woman) died apparently of exhaustion. One case of old standing, necrosis of the ilium (æt. twenty), died twenty-three days after an attempt to remove the dead bone. He is also said to have died of exhaustion, but there is no record of the post-mortem examination, and he had coffee-ground vomiting during the forty-eight hours preceding death. (Several of these cases of exhaustion were probably cases of sapræmia or septicæmia.)

If we compare the causes of death in the two instances and the nature of the operations, the case in favour of the aseptic method becomes much stronger than if we simply compare the deaths from infective disease. In the septic cases the patients either died of septic disease or of exhaustion, the result of profuse suppuration, again the result of putrefaction. If we consider the aseptic cases, on the other hand, we get a very different result. Thus, among the deaths after amputation there was not a single case where any method of treatment applied to the wound could possibly have saved the patient. The two deaths from tubercular meningitis, the three cases of hernia in which the gut was gangrenous, and the two cases of phthisis were all independent of the treatment of the wound.

The case of peri-renal abscess was also hopeless, and so also, possibly, the case of abscess in the loin where gangrene of the foot occurred. In the case of exhaustion after psoas abscess the disease was extremely extensive. But suppose we include this case, the two cases of infective disease, the three cases of spina bifida, the case of hydrocephalus, and the two cases of suprapubic lithotomy, we have only nine instances of what we may term preventible deaths. In the last six cases, however, it was rather to the direct surgical interference than to anything in the after-progress of the wound, looked at from our present point of view, that the deaths must be attributed; and here, of course, we are not considering the former point. Leaving then out of view the question of the surgical interference, there are only three cases among these, which can be considered in connection with the method of wound treatment alone. Indeed, I doubt very much if it is fair to include the case of exhaustion after psoas abscess, for the disease was of such a nature, so very extensive, as to render it doubtful whether recovery was possible under any circumstances.¹

On the other hand, among the fatal septic cases, there were none independent of the after-progress of the operation wound, unless indeed we exclude the case of necrosis of the ilium in which probably waxy degeneration of the internal organs had occurred extensively before the operation. This leaves 9 out of 292 septic cases, of which a large proportion were trivial operations in which death occurred on account of the course which the wound followed, while in the former instance, in the 553 aseptic cases, a very small proportion of which were trivial operations, there were only, at the most, three such instances.

During this same period there were treated aseptically in hospital seventy-two cases of injury (wounds, compound fractures, and wounds of joints), of which four died.

Three of these deaths occurred in cases of compound fracture treated conservatively, and in all death took place within 48 hours. The other death occurred in a case in which the attempt to eradicate putrefaction was unsuccessful, and where the patient is said to have died of bronchitis and cardiac disease.

¹ See the list of psoas abscesses, No. 21, Chapter XX.

Here again, there is only one case of possibly preventible death, and that in a septic case. Among those which were rendered aseptic no death occurred which was preventible by any known method of wound treatment.

We have fortunately the opportunity of comparing these results with those obtained by another surgeon—Mr. Spence—in the same hospital during the same time, by the use of methods of treatment which were not aseptic but which consisted sometimes in the application of water dressing, sometimes of boracic lint, and in some cases no dressing was used. I cannot give a name to the method of treatment. It was a mixture of principles, in fact a sort of mongrel method. There were certain differences in the hygienic conditions which will be presently alluded to, but these were all more favourable to Mr. Spence.

Mr. Spence's report extends from October 1872 to April 1878 with the exception of the winter session 1874-75.¹ I regret that I cannot find any report for this session, as during it there was a virulent epidemic of erysipelas in Edinburgh, and it would have been interesting to know how Mr. Spence's cases progressed during that time. Taking, however, the period so far as it is given, but always remembering that a very testing winter included in Mr. Lister's results is not present here, we find that during this time 328 more or less severe operations were performed with fifty-eight deaths, and that three cases of compound fracture were treated conservatively with one death. What proportion of these deaths were due to infective disease, we shall, I suppose, never know. In sixteen out of the fifty-eight cases the cause of death is not stated at all; five died within thirty hours, and may therefore be left out of consideration; while in eight the fatal result is directly assigned to septic poisoning. In twenty-nine of the cases no distinct causes of death are given, though such statements as the existence of irritative fever, unhealthy action in the wound, uncontrollable oozing of blood, &c., lead us to suspect that infective disease was also at work in these instances.

These results form a marked contrast to Mr. Lister's.

¹ See *Medical Times and Gazette*, March 13, 1875; the same journal for October 28, 1876; and the November and December numbers of the *Edinburgh Medical Journal* for 1879.

Here we have a percentage mortality of nearly eighteen p.c. as compared with Mr. Lister's percentage mortality in aseptic cases of nearly five p.c., i.e. a mortality in septic cases 3·7 times greater than in aseptic ones. And further the cases of death which are distinctly stated by Mr. Spence as having been due to septic diseases were eight in number or 2·4 p.c., that is to say, eight times more than the mortality from similar causes in Mr. Lister's aseptic practice. And, as I have just indicated, the mortality from these causes in Mr. Spence's practice was probably very much greater; and this difference is not due to greater severity of the operations in Mr. Spence's practice, as we shall see from the following statement of the nature of his cases.

During this period Mr. Spence performed 97 amputations, of which 25, or 25·7 per cent., died. (Compare this with Mr. Lister's mortality of 11·25 per cent. after amputations performed on aseptic principles.)

The following table gives Mr. Spence's results in major amputations:—

	Primary		Secondary to injury and for disease		Total	
	Cases	Deaths	Cases	Deaths	Cases	Deaths
Hip	0	0	3	1	3	1
Thigh	5	3	26	6	31	9
Knee-joint	1	0	0	0	1	0
Leg	4	0	9	2	13	2
Ankle	1	0	24	2	25	2
Shoulder	1	1	3	1	4	2
Arm	2	1	7	2	9	3
Fore-arm	2	2	2	2	4	4
Total	16	7	74	16	90	23

From this table I have excluded 6 partial amputations of the foot, with 2 deaths, and 1 partial amputation of the hand. These are included by Mr. Spence among his major amputations, but I have already excluded such operations from Mr. Lister's list.

As to the causes of death in these cases, one patient on whom amputation at the hip-joint was performed rallied after the operation, but sank suddenly next day. One case of primary amputation of the thigh died from shock, and 1 from pyæmia: 1 amputation of the

thigh for disease died of tubercular meningitis; 1 died 5 days after the operation, and it is stated that he had diarrhœa; in 1 case oozing of blood came on 2 or 3 days after the operation. One secondary amputation at the ankle-joint died from septic poisoning, and 1 had diarrhœa and tabes mesenterica. One fatal case of amputation at the shoulder-joint had repeated hæmorrhages from the wound. One case of amputation through the upper arm died 2 days after the operation, having had continuous oozing of blood; in 1 case general oozing began on the 6th day but was arrested by styptics, and the patient died on the 7th day. One primary amputation of the fore-arm died from pneumonia, and 1 had fever, traumatic delirium, diarrhœa and vomiting, and died on the 10th day; 1 died from erysipelas and 1 from pleurisy and pneumonia. The causes of death in the other fatal cases (8 in number) are not referred to.

Among the other cases treated were 57 excisions of various joints, of which 7 died; 34 excisions of the mamma with 2 deaths; 10 cases of lithotomy with 1 death; 44 cases of removal of tumours with 8 deaths; 9 complete or partial excisions of the tongue, 4 deaths; 4 cases of tracheotomy, no death; 31 operations for necrosis, no death; 1 operation for badly-united fracture of the femur, no death; several miscellaneous severe operations, 6 deaths; 3 excisions of the lower jaw, no death; 3 castrations, no death; 2 cases of trephining.

On comparing these cases with Mr. Lister's we find that the operations were not more severe, and yet the mortality was nearly four times as great.

Mr. Spence had thirty-one amputations of the thigh against Mr. Lister's twenty-nine, but nine deaths against three.

The total number of cases in which bones were operated on, such as for ununited fractures, excisions, &c. was greater in Mr. Lister's practice, and yet he had no death as compared with Mr. Spence's seven fatal cases. This difference is the more remarkable when it is remembered that many of Mr. Lister's operations were performed on healthy bones, while the greater number of Mr. Spence's were performed on diseased bones. It is less dangerous to operate on the extremity of a bone than on the dense shaft, especially where the medullary cavity is opened. And the dangers of the operation are diminished if the bone be previously the seat of chronic inflammation, for a chronically inflamed bone is well advanced on the road to

granulation, and granulation is, therefore, much sooner complete after the operation than in the case of healthy bone. In other words, the time during which there is risk of absorption from the wound is shorter in the case of chronically inflamed bone than in the case of healthy bone, while the risk is from the first less, because in the diseased bone a partial barrier is present from the beginning.

Then, among Mr. Spence's cases there is not a single instance of simple incision and insertion of a drainage tube into a healthy joint, a diseased joint or a suppurating joint, while Mr. Lister had seventy-six of these cases.

Then, also, Mr. Spence does not seem to have treated a single case of psoas or lumbar abscess.

Thus, however we look at the matter, the contrast between septic and aseptic surgery is very markedly in favour of the latter. This is well seen in Mr. Lister's own hands, in which the results of cases treated aseptically were much better than of those treated in other ways, these results being obtained by the same surgeon, in the same wards, and during the same time. The same contrast in favour of aseptic surgery is shown by the results obtained by another surgeon, in the same hospital, during the same time, and under circumstances in every way more favourable, both as regards the severity of the cases and the hygienic conditions under which the patients were placed. With regard to the latter point, it must be noted that Mr. Spence's wards were well ventilated and at the top of the building; Mr. Lister's wards were at the lower part of the building, some on the basement floor. Mr. Spence did not overcrowd his wards; Mr. Lister had as a rule nearly seventy patients in wards containing fifty beds, and these beds were more closely packed than Mr. Spence's. (The way in which this was managed was, that those adult patients who were well enough to be up during the day, slept on mattresses placed in various parts of the ward at night, while children were placed two, three and sometimes even four in a bed.) Then, lastly, Mr. Spence's wards were thoroughly cleaned out once a year; Mr. Lister's wards, on the other hand, did not, at his own request, undergo this annual process.

That the wards in which Mr. Lister worked were unhealthy

wards, is shown by the results obtained by Mr. Syme during his last four years. Of amputation cases (120 in number) he lost twenty-five from infective diseases alone, while Reyher,¹ who published these comparative statistics, states that Mr. Lister, up till the end of 1873, in 123 amputations, had not lost one from infective disease, unless indeed we include a case of tetanus as such.

These statistical facts fulfil the conditions required by Mr. Holmes in his recent utterances, and they are therefore deserving of careful consideration.

I shall now pass on to consider Mr. Lister's results in King's College Hospital, from November 1877 till November 1880. During this period there were 207 operations performed aseptically, of which fourteen died. All of the operations were more or less serious, and the following is a sample of them, with the causes of death in the fourteen cases.

There were 3 amputations at the hip-joint for disease, with 1 death. This case died from shock half an-hour after the operation.

There were 4 amputations of the thigh for disease, of which 3 died:—1 got suppression of urine on the second day and died; his kidneys were extremely fatty, and the fact that he had marked albuminuria had been overlooked before the operation. One case died of pneumonia; he had a slight cold before the operation, caught from draughts in the ward; afterwards he got pneumonia, which was apparently distinctly traceable to exposure during the energetic ventilation of the wards in the intense cold of winter. (Such ventilation is, I need hardly say, unnecessary in wards where aseptic treatment is carried out; the comfort of the patients is the point to be attended to rather than the constant flow of a current of air through the wards.) A post-mortem examination was not allowed in this case. The third case was one of spontaneous gangrene of the foot and leg, where amputation of the thigh was performed. Gangrene recurred, and the patient died on the 4th day after the operation.

There were 2 amputations of the fore-arm. No death.

There were 16 excisions of the mamma and axillary glands, with 2 deaths. Both operations were very extensive, and both patients died from shock within 36 hours.

There were 13 incisions into healthy joints, no death; 5 incisions into joints affected with synovial degeneration, but without suppuration, no death; 3 incisions into joints affected with synovitis,

¹ *Archiv für Klin. Chirurgie*, Bd. xvii. p. 499.

no death; 9 incisions into suppurating joints, 2 deaths, one of which was due to tubercular meningitis, confirmed on post-mortem examination, and 1 occurred in a child admitted with acute abscesses in various joints, in fact with pyæmia after scarlet fever; he died 2 days after admission.

There were 31 operations on healthy bones for deformities, ununited fracture, &c. No death.

There were 8 abscesses (lumbar or psoas) connected with disease of the spine. One death. This case putrefied, and the patient was sent home, but died at home from exhaustion a few weeks later. Though not a death in hospital, it is a death in a case treated at the first aseptically, and I have therefore included it. Putrefaction occurred owing to the circumstance that the patient suffered from carbolic acid poisoning, and hence the dressings were left on longer than usual, and thymol dressings were ultimately substituted for the carbolic gauze, with the result that the discharge putrefied.

There were 4 cases of strangulated hernia with 3 deaths. In one fatal case the bowel was gangrenous; the gangrenous portion was cut away and the divided ends of the gut united by suture; the patient, who was collapsed at the time of the operation, died in 2 or 3 hours. In one case the patient, an old woman, was in a state of collapse at the time of the operation and never recovered, dying within 24 hours. In one case the gut, which was in a suspicious state at the time of the operation, gave way 60 hours later, and its contents escaped into the peritoneal cavity. The patient died in a few hours.

There were 3 operations for radical cure of hernia, in which the greater part of the sac was cut away and the margins stitched with cat-gut. No death.

There were 3 cases of acute necrosis where incisions were made down to the bone and drainage tubes inserted; the bones were not resected, as Mr. Spence recommends, such a procedure being unnecessary with aseptic management. One of these cases, a child, which was apparently in a septicæmic state before the operation, died 5 days afterwards.

There were 23 large abscesses, among which were 6 iliac abscesses, 3 gluteal, 1 pelvic, 2 mammary, 2 in calf, 2 in thigh, 1 case in which there were 7 chronic abscesses, 2 cases of suppuration of bruises; all of them extensive. No death. Two cases of empyema. No death.

There were 2 cysts of the thyroid gland, which were opened and drained; no death. Three excisions of the thyroid gland; one death. In the fatal case the tumour was adherent to the trachea,

which had become thinned by the pressure, and in removing the tumour the thin membrane gave way. Thus the case was no longer an aseptic one. The putrid matters passed down the trachea, and gave rise to inflammation of the bronchi. The difficulty in breathing was not relieved by the operation. The patient died 16 days after the operation. At the post-mortem examination an opening was found in the trachea large enough to admit the tip of the little finger, and communicating with the wound. The lungs were cedematous, and a small quantity of pus could be squeezed from various parts, but there were no abscesses or infarcts. A large tumour was found in the thorax surrounding the trachea, and partly also the arch of the aorta. There were no other post-mortem appearances. This is, of course, a septic case, and ought not to be included in this list, but I insert it, as the operation was undertaken with the intention of performing it aseptically, and as it is such a marked contrast to the others.

Then there were a number of single operations, which it would be too tedious to enumerate, such as 2 cases of nerve stretching, 2 castrations, 1 operation for aneurismal varix, 5 varicoceles (veins tied), removal of tumours of various kinds, &c.

If now we look at the causes of death we find that several were unconnected with the treatment of the wound. Thus the case of shock after amputation at the hip-joint and the two fatal cases after excision of the mamma are quite irrelevant. So also are the three deaths after strangulated hernia, the death from tubercular meningitis, and the death of the little boy admitted with pyæmia.

How are we to look at the cases of death from suppression of urine, after acute necrosis, and after recurrence of gangrene? Could these have been prevented by any method of treatment? The thyroid case was a septic one.

This leaves us with two cases to consider: the case of pneumonia, which I myself saw, and which I, as well as others who know the facts, firmly believe to have been caused by imprudent ventilation; and the fatal case of psoas abscess, which undoubtedly ought to have been avoided, and would in all probability have been so, had not the patient been so sensitive to the effects of carbolic acid.

During these eight years, three wounds of healthy joints and fourteen compound fractures were treated, with one death.

This death occurred in a case of compound fracture of the skull, the patient being comatose when admitted; trephining was performed, but he died within twenty-four hours. There were also a number of more or less severe wounds under treatment at the same time.

Looking then at the whole results attained by Mr. Lister, we must, I think, come to the conclusion that he is correct in stating, from his own experience, that infective disease is abolished by aseptic treatment, so that, if an operation can be performed aseptically the risk of infective disease may practically be left out of consideration in deciding on the advisability of the operation. This view has been amply borne out, as I have shown, by thirteen years' constant work in three different hospitals—none of them particularly noted for healthiness.

One of the first surgeons to take up the aseptic method thoroughly, was Professor Volkmann of Halle; and he has contributed some remarkable testimony to the efficacy of the system. For many years he had used the open method, and during the war in 1866 all amputation wounds were treated in this way. He also employed immersion in water containing carbolic acid: recent wounds of the hands and feet were placed in vessels containing this solution. In his earlier cases the wounds were stitched, drainage being provided for, but for the four years preceding the adoption of the aseptic method—*i.e.* up till 1872—he left the wounds quite open. During the first years in which these methods of treatment were carried out, the results were very favourable, and Volkmann was thoroughly convinced of their superiority over the older modes. As time went on, however, and as overcrowding of the wards became necessary, infective diseases also progressively increased, and at last, in the summer and autumn of 1871, the deaths from pyæmia and septicæmia were so numerous that he made up his mind to shut up the hospital altogether for a time. Before doing so, however, he thought that he would try the Listerian method for a few weeks, and it is to the result of this trial that I now wish to refer.

I need not go into the details which he gives as to the hygienic conditions of the hospital. They seem to have been very wretched. There were no proper arrangements for ventilation; waterclosets opened into the wards; there was no place for keeping the dead bodies, which were therefore laid in a cellar situated beneath the surgical wards, and the wards were full of beds. It was under these conditions and in this infected atmosphere that the aseptic method was first employed.

Volkmann's first report extends from December 1872 to February 1874.¹ This was the period in which he was learning the method, and I shall not, therefore, refer at length to his results during this time. Among the cases in which the aseptic method was tried there was one death from pyæmia and one from erysipelas. Erysipelas attacked eight wounds treated on aseptic principles. There were other cases of infective diseases in the hospital during this time, but these were either admitted while suffering from them, or they arose in cases not treated aseptically.

This remarkable result was obtained in a hospital which, at the commencement of this period, was going to be closed on account of the enormous mortality from these diseases. Surely here there was some benefit derived from the introduction of the aseptic method! And it must be noted that these two deaths from infective disease occurred in the early period of aseptic practice and, with regard to them and the erysipelas cases, Volkmann states that he could generally point out an error in the manipulations, as a rule, in the mode in which the dressing was applied. In a note written in 1875 Volkmann states, that during the last eighteen months,² *i.e.* from the middle of December 1873, there had been no case of pyæmia, and erysipelas had almost or altogether disappeared. With regard to these results Volkmann expressly shows that they were not due to the mere use of carbolic acid as a disinfectant, for carbolic acid had been, as I have just stated, extensively em-

¹ *Beiträge zur Chirurgie*, 1875: 'Ueber den Antiseptischen Oclusiv Verband und seinen Einfluss auf den Heilungsprocess der Wunden;' Volkmann's *Sammlung*, No. 96, 1875.

² In the Appendix Volkmann states that this holds true for metastatic pyæmia, but that only fifteen months had elapsed since he had a case of 'Pyæmia simplex.'

ployed during the preceding period to irrigate wounds, but latterly without any apparent benefit.

In 1877 Volkmann published the continuation of this report,¹ and I will refer to it in some detail. The report extends from March 1874 to March 1877, a period of three years. He does not give all the cases treated, but, omitting the septic cases, there is a record of 465 operations performed with aseptic precautions. Of these cases 29 died.

Among these 465 operations were 157 amputations, of which 15 died. On analysing these cases of amputation we find that 139 of them were uncomplicated with other injury or mutilation, and of these only 4 died. Three of these deaths occurred within the first 24 hours from shock, and 1 from 'habitual erysipelas.' Omitting from this list 7 partial amputations of the foot, there were 132 major amputations, with 4 deaths, or, leaving out the cases of shock, which were of course independent of the method of treatment, there were 129 major amputations, with 1 death.

The following is the list arranged in a tabular form:—

Amputation	Cases	Deaths
Amputation at the shoulder-joint	4	1*
„ through humerus	14	—
„ „ forearm	23	—
„ at wrist-joint	3	—
„ „ hip-joint	2	1*
„ through thigh	42	1*
„ „ leg	25	1†
„ at ankle (Syme and Pirogoff)	19	—
„ partial of foot	7	—
Total	139	4

* Died from shock; † from 'habitual erysipelas.'

There were 9 cases of double amputations, with 2 deaths; 1 died within a few hours, and 1 died on the third day (amputation through both thighs) with symptoms of collapse.

There were also 6 amputations in cases where other severe injuries had been received. Of these 4 died within 24 hours. These were all very severe cases, as for example, amputation at the shoulder-

¹ *Vorläufiger Bericht über die innerhalb der letzten drei Jahre in der chirurgischen Klinik zu Halle stationär oder poliklinisch mit Hilfe der Antiseptischen Methode behandelten schweren Operationen und schweren Verletzungen.* By Volkmann and Kraské, Halle, 1877.