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MANUAL

OF

ASEPTIC SURGERY

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PREFACE.

This small work is the outcome of conviction that the practicability and essential details of asepsis are not as generally understood as they might be. It is hoped that it may supply a want, by embodying in compact form information which is only to be found scattered throughout larger manuals.

Though it cannot pretend to be anything like a complete exposition of the subject, it has been the author's endeavour to give simple and practical directions, with sufficient latitude in details to meet varying requirements.

A strong case has been made out for the more extended use of rubber gloves by many surgeons, and the time may come when their routine use will be proved indispensable, even at aseptic operations. There is still apparently a wide field of bacteriological work before the best "workaday" practice can be decided. In the meantime until the "pathogenic virulence" of bacteria ordinarily present in or on the skin, as opposed to their "mere power of growth" in culture media has been settled, no final verdict can be passed on the comparative utility of chemical antiseptics; further experiments may not unlikely show that the value of their "inhibitory powers" has been greatly under-rated by the advocates of physical antisepsis pure and simple.

With this very general conclusion, what is written must stand.

I must express my indebtedness to Major Moir and Major L. Rogers, of the Indian Medical Service, and to Senior Assistant Surgeon Probodhe Chandra Bose for much assistance with references, to Messrs. Down Bros., London, for permission to copy illustrations of instruments, and to Messrs. Thacker, Spink and Co., Calcutta, for the pains they have taken in publication.

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INTRODUCTORY.

ERRATA.

Page 22, line 2. After word "virulent" insert the words "and the greatest care must be exercised."

Page 106 (Appendix to Chapter VI), line 17, As 454 : 332 : : 3·75, etc., 3·75 should be 8·75.

Page 212, line 4 for the word "hetol" substitute the word helmitol."

ASEPTIC SURGERY.

CHAPTER I.

Historical.

THE successful treatment of wounds before the last thirty years of the last century was unknown. History indeed shows that Hugh of Lucca, his son Theodoric Bishop of Cervia, and his pupil Henry of Mondeville, three surgeons who practised in Europe in the 13th and earlier part of the 14th centuries, recognized the true principles, but their light was quickly extinguished, and Henry incurred much abuse for his teachings.

Theodoric wrote: "It is not necessary for pus to be generated in wounds. No error can be greater than this."

Henry wrote "Every simple wound will heal without any notable quantity of pus, if treated on Theodoric's principles and mine. Avoid every cause of the formation of pus. More surgeons know how to cause the formation of pus than to heal a wound."

But after their day darkness again closed in on surgical practice as regards the treatment of wounds, until more than 500 years afterwards, the genius of Lister placed the question on such a sure basis of fact, that it gradually became the common property and practice of all educated surgeons and revolutionized surgery.

Before Hugh's time the old doctrine of "coction" was universally held, *viz.*, that to eradicate the poison from a wound, it was necessary to set up suppuration by which it was eliminated. After Henry's time this doctrine was again revived, and the most fantastic notions and practices were based on it. Gunshot wounds were considered to be poisoned wounds, and to counteract this boiling oil was poured into them!

Paré during a campaign in Switzerland was forced on one occasion when his supply of oil ran short, to abandon this drastic treatment, and found to his surprise that the wounds untreated with it were in better case than those into which boiling oil had been poured. This seems to have been its death knell. Paracelsus revived the baneful practice of inducing suppuration in gunshot wounds, but Paré and Wurtz both condemned the use of greasy and moist dressings in the treatment of wounds. After this there seems to have been but little progress made, though the application of aromatic herbs may, from their mild antiseptic properties, have been of some service in checking suppuration.

It is true that many surgeons before Lister's time were working to improve the treatment of wounds, and notably Thomas, of Liverpool in England, towards the end of the last century, laid down rules for the hygiene of surgical wards and the conduct of hospitals, which have hardly been surpassed since, but the actual practice of dressing wounds was tentative and uncertain. Semelweiss, a great Hungarian obstetrician, was also a noteable pioneer, but he died a disappointed and mentally broken man, from the obloquy and derision with which his teachings were received. The open air method and the water dressing disputed the field ; the former, though not actively mischievous, could not even by the widest stretch of the imagination, be called actively beneficial, nor was it generally practicable. Operations were regarded as a necessary evil, and were rarely performed except to save life or for intractable disease, as even the infliction of the smallest wound might result in cellulitis or worse evils. Surgical fevers were common, often in widespread epidemic form, as were severe local infections, including hospital gangrene, now hardly ever seen ; while suppuration was regarded as the normal process in the healing of wounds, and "*union by first intention*" was thought to be a fortunate accident for which there was no explanation.

Secondary hæmorrhage after amputation, the result of septic processes, was an ever present danger until the ligatures left hanging from the wound had separated, and operations on the peritoneum were never performed except in cases of extreme urgency. It was a cardinal rule of surgery never to open the sac of hernia if this could be avoided. These facts are still fresh in the memories of the older generation of surgeons now passing away.

At the present day the reverse of this is true. In a well regulated hospital, extensive suppuration after set operations is rarely seen, while such an untoward occurrence as septicæmia is regarded with consternation. Joints are opened and operations on the abdomen, involving wide interference with the peritoneal sac, are performed in the absolute confidence that no untoward results will follow if proper precautions are taken. Another important result of the improved methods of the present day, is the wide extension of conservative surgery ; many a limb is now saved after extensive injury to the soft parts, which of necessity had to be amputated in the old days on account of the inevitable onset of septic disease, and a fatal result if left alone. Perhaps the most striking results are shown by the great fall in the death-rate after operation. Some 30 years ago this was 30 per cent. after major operations in the great London hospitals, at the present time it is about 3 per cent., while the mortality after minor operations is practically *nil*.

In the year A.D. 1867 Lord Lister, then an assistant surgeon at the Glasgow Infirmary, who had been working for some years at the subject, placed the results of his labours before the profession. His methods were known as "Listerism" or "Antiseptic Surgery."

Attracted by the researches of Pasteur on fermentation, Lister came to the conclusion that septic processes in wounds were caused in the same way, *i.e.*, that they were the direct result of something in the air (in those days called a "ferment") which, getting access to wounds, set up septic changes. Carbolic acid he found interfered with or prevented the action of this ferment, by checking or retarding decomposition in broth exposed to the air, and applying these results to surgical practice, he argued that by the use of carbolic acid in various ways, the ferment could be destroyed in the air round a wound, or even in the wound itself.

In practice he invented and adopted (1) the steam spray, which played constantly on the wound and the surrounding air during an operation; (2) he used strong solutions of carbolic acid or even the pure acid to wash wounds with; and (3) he prepared dressings impregnated with carbolic acid, which he placed thickly on wounds, with the object of excluding the air from them.

Lister did not discover carbolic acid, which had been in use for the preservation of pathological specimens, but the application of it to surgical purposes was his work entirely.

Experience fully justified the adoption of these measures, many wounds healed by first intention, and suppuration when it did occur, was much less profuse and of shorter duration. Severe local infective processes, such as hospital gangrene, no longer occurred, and the mortality after operations was much reduced.

To fairly estimate the wonderful insight which Lister displayed, it must be remembered that the actual causes of suppuration and blood poisoning, *i.e.*, bacteria of various kinds, had not then been discovered. The truth of his conclusions and the soundness of his methods, though modified and perfected in many details, will remain true for all time.

The air was the medium at first chiefly blamed for the infection of wounds, it was not then understood that the so-called ferment, not only might be, but, indeed, was more likely to be introduced on anything which came in contact with a wound. Later this was recognized, and instruments were disinfected by placing them in a strong solution (1—20) of carbolic acid. Greater attention was also paid to the thorough cleansing of the surgeon's hands with soap and water and finally steeping them in a lotion of carbolic acid.

At first Lister's teachings were largely disregarded; later, when his results could no longer be overlooked or explained away, they were bitterly opposed and criticized, but in course of time the fame of his successful methods spread, and his practice began to be more widely adopted; it was not until 10 or 12 years, however, after his results were first published, that the practice became general in England, though continental surgeons had adopted his methods with enthusiasm, for some time.

Carbolic acid was found to have its disadvantages used in the way above described. In a pure state it was corrosive to the tissues, even in solution it was very irritating to wounds, and caused much serous exudation, which prevented the complete approximation of their edges and thus interfered with rapid union. It was also irritating to the patient's skin and the surgeon's hands, a drawback to its routine use, and toxic poisoning occasionally took place from excessive absorption. Carbolized dressings, too, had to be frequently changed, partly on account of the excessive serous discharge, and partly because carbolic acid, by reason of its volatility, was found to disappear from the dressings in two or three days' time. This was met by fixing it with paraffin, but it rendered the dressing less absorbent and stiff, which were serious objections in practice. For some years the carbolic steam spray held the field, it was however cumbersome in practice ; as the lessened importance of the air as a medium for the infection of wounds and the fact that such a momentary application of carbolic could not possibly disinfect it, gradually became recognized, the use of the spray was eventually given up, and Lister himself finally discarded it in the year 1887. Though it failed in its special purpose it served its turn and probably saved life in days when asepsis was not well understood and aërial infection was more frequent, by keeping everything bathed in carbolic lotion.

In place of dressings impregnated with carbolic acid, Lister next introduced dressings prepared with a solution of corrosive sublimate or perchloride of mercury, which not being volatile remained in the dressings longer. This too had its drawbacks in practice, it was found to be irritating, though less so than carbolic acid, and, moreover, it was unstable and was quickly altered and rendered inert by albuminous fluids. Lister tried to overcome this by dissolving it in blood serum, but the dressing was costly and difficult to prepare. A solution of sublimate with ammonium chloride (sal alemproth) was next tried as being more stable, but in practice it was found to be too soluble and consequently irritating to the skin, and was further liable to be washed out of the dressings if there was much discharge. Though Lister experimented with this he never formally placed it before the profession, it was widely adopted none the less. Finally he invented a dressing prepared with the double cyanide of zinc and mercury, a salt which, while only feebly germicidal in its action, proved to be powerfully inhibitory, and was at the same time insoluble and quite unirritating. This dressing has not been improved on, and is still the best and most efficient of antiseptic dressings. He also brought boric acid into general use as a weak and unirritating antiseptic when stronger ones were inadmissible, and expended much time and trouble in perfecting the preparation of catgut ligatures, while he was largely responsible for the introduction of iodoform into general use.

In this way, extending over a period of nearly thirty years, Lister gradually improved and perfected his methods.

As time passed the study of bacteriology revealed the existence and identity of various micro-organisms, causing general and local surgical infections. This *germ theory* of disease, in which Koch was one of the great pioneers, also met with an extraordinary amount of opposition, but the truth of the discovery was triumphantly established and the various bacteria were classified and described, and definite rules were laid down for testing their specific character. Next the germicidal properties and mode of action of various chemical antiseptics were ascertained and compared, and the practice of antiseptic surgery or "Listerism," at first tentative and uncertain, was finally placed on a basis of scientifically ascertained fact.

A single instance of this will suffice. Cotton threads infected with the anthrax bacillus were placed in a solution of corrosive sublimate, next they were thoroughly washed with water, and, lastly, placed in sterile broth. No growth of the bacillus resulted. The apparently obvious conclusion was that the sublimate solution had killed the bacilli and their spores also. The experiment was then varied, and instead of washing the infected threads with water, they were washed with a solution of ammonium sulphide, which neutralized all traces of the mercuric chloride by converting it into the inert sulphate of mercury. The threads thus treated, when placed in sterile broth, showed the characteristic growth of the anthrax bacillus.

The conclusion drawn from these experiments was that the spores were not actually killed by immersion in the mercuric solution, but that after merely washing the threads with water some traces of perchloride of mercury remained, which prevented their development when placed in sterile broth. When all traces of the antiseptic were removed by neutralization with ammonium sulphide, the still living spores developed when placed under suitable conditions. Perchloride of mercury, therefore, it was clear, was not so actively *germicidal* as had been supposed, it's efficiency depended to some extent on its *inhibitory* action.

Stronger proof of the value of chemical antiseptics, in dressings at all events, could hardly be adduced; but, oddly enough, certain authorities have placed an exactly opposite conclusion on these facts, and have argued that, mercuric salts being largely inhibitory in their action, are not to be depended on; at any rate, in such weak solutions as can be used with safety in practice. Whether they act by active germicidal or merely inhibitory qualities, seems a minor consideration, so long as they do actually prevent septic processes. This instance was however only given to show that the value of antiseptics was scientifically tested and proved, quite apart from practical clinical experience of their utility. At the present time the germicidal powers of various chemical antiseptics have been very carefully and accurately compared, and their mode of action ascertained.

Some 26 years or more ago, another school of thought arose, which condemned the use of chemical antiseptics for the destruction of the micro-organisms in the treatment of wounds and trusted largely to dry or moist heat in the shape of hot air, boiling water or steam for this purpose. This practice was called "Aseptic Surgery" as opposed to "Antiseptic Surgery" founded by Lister. It will be fully considered later, and the two systems compared.

CHAPTER II.

Surgical Bacteriology.

Two kinds of micro-organisms generally known as *Bacteria* are of importance in surgery. The first kind cannot grow in living tissues and are called "saprophytes," nor can they cause disease, and are therefore also known as "non-pathogenic" bacteria. They set up decomposition accompanied by an abominable odour, in the discharges of dirty and neglected wounds. Though they are of minor importance, they are capable of causing a considerable constitutional disturbance from the absorption of substances produced in their growth and are frequently present with the most virulent minds of pathogenic bacteria. Their presence may therefore indicate serious danger, and they may play no unimportant part in aiding severe local and general infections. The commonest is the Bacillus protens vulgaris though there are many others.

The second kind are of far greater importance, and from their power of causing disease, are known as "pathogenic bacteria." They can live and maintain their vitality, outside the living body, this is called the "saprophytic" stage of their existence, as opposed to the "parasitic" stage, when they are living and multiplying inside the body.

There are many different varieties of these pathogenic bacteria, recognizable by their shape, and the characteristic appearances of their growth on gelatine or other culture media. The rod-shaped ones are called "Bacilli," the round or spherical shaped ones, "Cocci." Bacilli multiply by "fission" or by "spore-formation." Cocci only by fission. Spores are recognizable under high powers of the microscope as round highly refractile dots in the length of the bacillus, while in stained specimens they take the stain more deeply. These spores under suitable conditions develop into fully formed bacilli, as spores they are not apparently active, but by reason of a thick containing envelope, they are far more resistant to the action of germicidal agents, and can maintain their vitality in a dry state for almost indefinite periods. Cocci or non-sporing bacteria apparently enjoy these properties in common with spores to some extent and in consequence are more resistant to the action of germicidal agents; they cannot, however, maintain their vitality for long in the dry state, but are devitalised. Bacteria which are ordinarily saprophytic may under certain circumstances apparently acquire the power of growing in living tissues, they are then known as "facultative parasites."

The "pyogenic" or pus-forming bacteria are mostly cocci. They include the following "Staphylococcus pyogenes albus, aureus, and citreus," and the "Streptococcus pyogenes." Some of these are always found in collections of pus, and, if injected, into the tissues, or rubbed into the skin, causes abscesses or boils. The staphylococcus is a minute round body, many of which are collected together in clumps or bunches, hence their name from their similarity to a bunch of grapes. S. aureus grows on culture media in clumps of a golden yellow colour ; it is the micro-organism mostly found in abscesses and local collections of pus. It is very resistant, and is found in dust and dust-laden air, particularly in hospitals ; in short it is one of the most ubiquitous of bacteria, and may be present on the skin, on worn clothing, dressings, vaseline-smeared instruments, and in other undesirable situations. S. albus is distinguished by its growth in whitish clumps in nutrient media. It is frequently found in stitch abscesses and a special variety called S. albus epidermidis is constantly found in the skin ; it is doubtful if this is a distinct variety however, and its pathogenic properties are questionable. S. citreus is less common than the others ; it is said to be more virulent than S. albus, which is the least virulent of the three. Streptococcus pyogenes is a minute round body, arranged as its name implies in strings ; it grows in culture media in characteristic whitish filaments. It is found in acute abscesses and severe forms of diffuse suppuration or cellulitis. It is the bacterium chiefly concerned in the production of septicœmia, spreading chiefly by the lymphatics, though probably virulent forms of staphylococcus can also produce the disease.

Besides these there are many variously named cocci, and bacilli said to be the specific organisms of different forms of inflammation, *e.g.*, erysipelas, acute spreading gangrene, etc.; the bacillus coli communis is constantly found in pus in connection with the alimentary canal the pneumococcus in certain cases of empyema, while the bacillus septicus though not apparently pyogenic, is the cause of the most virulent and dangerous forms of septicœmia. It is possible that many of these cocci are really the same micro-organism, endowed with extra virulence. *When pus is formed in the living body, it may be taken as a fact that, it is due to the presence of one or other of these pyogenic bacteria.* This is disputed by some authorities, who hold that suppuration may be induced by chemical irritation ; this is certainly the case, *e.g.*, the injection of cadaverine (the toxin of certain saprophytic bacteria), into the tissues induces suppuration. Clinically speaking, however, this statement may be taken as true.

How then is pus formed? When the pyogenic bacteria gain access to the living body, under suitable conditions, they begin to multiply and by means of the toxins they produce in the growth act as an irritant to the tissues in which they have lodged. This irritation sets up the usual signs of inflammation, the blood supply to the part is increased by the dilatation of the capillary vessels, serous exudation follows and the leucocytes in large numbers pour out to repel the invaders. These leucocytes actually envelop and destroy the bacteria. If they are successful in killing them off at once, the symptoms of inflammation subside without the formation of pus. But in other instances, the leucocytes themselves succumb and die in the struggle, from the action of the bacterial poison, or *toxins*, which peptonize or digest them, and the surrounding tissues. The dead leucocyte is a pus cell, and many such cells suspended in the fluids of the body together with the destroyed and macerated tissues cells form pus, with its characteristic opaque yellow appearance. These leucocytes are called "*phagocytes*" or eating cells, and the whole process by which they collect and envelop bacteria is called "*phagocytosis*."

The formation of pus is therefore due in part to the unavailing efforts of the phagocytes to destroy invading bacteria, but though many of them die in the process, and pus is formed, their self-sacrifice is not wasted, as others form an enveloping wall or barrier, the so-called pyogenic membrane of the abscess cavity, and thus prevent the bacteria from getting access to the blood stream, and so setting up a general infection or septicœmia. In this way then the bacillary invasion may be limited to the formation of a local abscess only.

In addition to this process of phagocytosis, there is another natural safeguard against bacillary invasion. The fluids of the body have themselves the power of neutralizing toxins, and killing bacteria by the production of certain substances called *bacterio-lysins;* this action is known as bacteriolysis, literally bacteria-slaying ; it is, according to certain observers, the preliminary step to phagocytosis, bacteria being first killed or weakened and next eaten up.

It by no means follows then, that because bacteria gain access to wounds they will necessarily cause general infection, or even local suppuration. This depends on three factors, *viz* :—

(1) the degree of *resistance* the body cells and fluids by virtue of their bacteriolytic and phagocytic powers offer to bacterial growth ;

(2) the activity of the bacteria or what is known as their degree of *virulence* ; and

(3) the number of bacteria entering, or the *dosage.*

In man the tissues and body fluids are highly resistant to the specific micro-organisms of certain cattle diseases for instance ; when this resistance is so great that the bacteria of a certain disease, although they get access, never cause the disease, it is called *natural immunity*, and man is thus immune to many diseases very fatal in animals.

Wright has devised a method of ascertaining and calculating the degree of resistance, or bacteriolytic power of the blood in vitro, on certain pathogenic bacteria including the pyogenic cocci, this he terms the "opsonic index." The method is too complicated for clinical application at present, but is a great step in advance.

But though the degree of resistance to various micro-organisms unquestionably varies greatly in different individuals, in some instances the surgeon can say with absolute certainty that it is low, *e. g.*, in diabetics, in the subjects of chronic renal disease, or in those addicted to alcoholic excess.

These are practical points in surgery.

Further, starvation or its opposite, high living, also reduce resistance, and such temporary causes as exposure to cold, shock, physical exhaustion and particularly nervous exhaustion after mental exertion. The degree of resistance can be artificially raised by the subcutaneous injection in suitable doses of

(1) an attenuated but living virus ;

(2) bacterial toxins, produced by cultivation ;

(3) bacterial toxins, in the bodies of the killed bacteria given in the form of an emulsion, or after extraction (these are called *vaccines*), and

(4) the serum of animals immunized by one of the above methods, known as *antitoxic sera.*

In man the first method is used in Pasteur's anti-rabic treatment ; the second not at all ; the third in anti-plague inoculation ; and in the treatment of chronic pustular affections ; the fourth in tetanus, and increasingly so in acute septicœmic infections. These anti-sera contain anti-toxins, and probably also anti-bacterial bodies.

Their mode of action need not be considered, the subject is a very complex one. The point to bear in mind is that they *have* reached the stage of practical utility and are harmless, even if they do no good. Their disadvantages are their costliness, impairment by keeping especially in hot climates, and their uncertain action. This is probably due to the fact that they are "specific" in action, and often fail because septicœmia is not a specific disease. If a generally active or "polyvalent" antistreptococcic serum could be produced, there is no doubt that it would have a wide field of usefulness, in the treatment of septic infections. This, however, is a digression.

In practice the importance of the normal power of resistance of the body can hardly be overrated. Few wounds are absolutely sterile, or in other words contain no bacteria. The best aseptic precautions therefore would probably fail without the aid of this natural resistance, but such precautions both tend to diminish the number of bacilli which get into a wound, and also to lessen the virulence of those that do. In extensive burns the danger of septic infection is the greater, because tissue vitality in the immediate proximity is so much lowered by the heat.

The second factor in the supervention of local or general infection, *viz*., the degree of *virulence* of the pathogenic micro-organism, is in practice a still vaguer matter than the resistance offered by the body. It is undoubtedly raised by the passage though or growth in the living body, and though it is at times possible to say that the discharges from any given case, are highly virulent in cleansing the hands, before dressing other wounds, yet when a patient is exposed to the invasion of bacteria, through, say the use of infected ligatures, it is clearly impossible to say whether it is a virulent infection or not.

The third or numerical factor, or *dosage*, has been experimentally proved by Cheyne and others. On the face of it, it is not unreasonable to suppose that the larger the numbers of bacteria that find access the greater the probability of their growing. It is comforting to know that experiment has not only shown this to be the case, but has also proved that a few bacteria will not grow on serum or bloodclot outside the body. Their chances of multiplying therefore are still less in living tissues, where cell activity has also to be reckoned with, in addition to the bacteriolytic power of the body fluids.

The moral to be drawn from these three factors is obvious. No precautions should ever be neglected first to prevent the lowering of the natural resistance of the body or the tissues, and secondly, to prevent the access of micro-organisms to wounds; or, as this is almost an impossibility in practice, to lessen the number, weaken the virulence, and inhibit the activity of those that do so. The natural resistance of the body may then be confidently counted on to do the rest. Though the natural resistance is a factor of supreme importance it is practically speaking beyond the reach of the surgeon. *Asepsis is, however, directly under his control, and he is only to blame if wounds in healthy or aseptic tissues become septic.*

So far local pus formation has been chiefly considered, but there may be general constitutional disturbance, or general infection associated with this local condition, due to the growth of pyogenic bacteria locally, or their invasion of the body generally. There are two distinct and well defined general conditions, which may accompany or follow local pus formation. The first is septic intoxication or *saprœmia*, the second is septic infection or *septicœmia*. In saprœmia certain poisons or *toxins* produced by the growth of saprophytic bacteria in the discharges of a dirty and neglected sore, or of staphylococci causing a local abscess, are absorbed by the system, and give rise to fever, headache, and other discomforts. On the suitable treatment of the sore or the free incision and drainage of the abscess, the absorption of these toxins immediately ceases, those already absorbed are rapidly destroyed, and the headache, fever, and constitutional disturbance quickly subside. In septicœmia, on the other hand, the bacteria having gained access to the general circulation, spread and breed all over the body. This is a far more serious condition than saprœmia. Their toxins are absorbed and give rise to rigors, pyrexia, headache, and other symptoms, but whereas in sapræmia the absorption was local only, in septicœmia it is going on throughout the system, and cannot be checked by local means.

As stated above, though the streptococcus pyogenes is the commonest cause of septicœmia, virulent forms of staphylococcus as well as certain bacilli may also cause it too. It further seems probable, that several varieties of streptococcus may exist, and may thus account for the different manifestations of the disease, and its non-amenability to different strains of anti-sera, though this may also be explained by the varying degree of virulence of the infective micro-organism.

There is another disease consequent upon the invasion of the system by pyogenic bacteria, *viz.*, *Pyœmia*, or pus in the blood. Both the staphylococcus or the streptococcus pyogenes, may be the exciting cause. It is both a local and a general disease. When suppuration is going on in the body, minute masses of diseased tissue or even pure cultures of the pyogenic cocci may be detached and carried off to other parts, where local suppurative processes are again set up. The joints are commonly the affected seats of secondary pyœmic infection, though pyœmic abscesses may form in almost any part of the body. Septic phlebitis is particularly dangerous, on account of the ease with which infective material may be detached and carried by the blood to other parts.

This is a brief account of the bacteriological aspects and theories, of the commoner surgical disorders. There are, of course, other surgical infective complaints, caused by other specific bacteria; they need not be alluded to here, it is only necessary to remark that, whatever has been said about the commoner kinds, applies with equal—if not with greater force—to the rarer or more virulent forms.

One indeed deserves special mention, *viz.*, the bacillus of *Tetanus*. It is a straight bacillus with a round knob or head, not unlike a drumstick. It breeds particularly in garden soil, horsedung, on rusty iron and in the dust of dark and ill-ventilated rooms. Punctured wounds with rusty nails or the rusty steel needles of hypodermic syringes, or wounds contaminated with soil or gross dirt, are on this account peculiarly dangerous. It causes little or no local reaction (negative chemiotaxis), but may be present with other pyogenic bacteria as a mixed infection. The toxins produced by its growth have a powerful effect on the central nervous system, with the cells of which they appear to unite in close chemical combination, and thus produce the characteristic symptoms of tetanus or lockjaw.

Tetanus anti-serum is an agent of proved value, as a prophylactic and also as a curative agent. Its action is not so certain in the latter case, on account of the close combination of the toxins with the central nervous system, above mentioned. In the treatment of tetanus it must be given subcutaneously as early as possible in full doses, and its administration must be persisted with, though no immediately good results may be produced. Like other anti-sera it is harmless, even if no benefit is derived from its use in a given case.

With a view to producing its immediate effect, it has been injected into the spinal canal by lumbar puncture with a long needle, after drawing off a small quantity of the cerebro-spinal fluid, which is highly infective. This plan, which necessitates the administration of a general anæsthetic, seems to be based on good grounds, and is best calculated to give full access of the anti-toxin to the affected central nervous system, and to produce the fullest benefit obtainable from its use. Though even this method of injecting the anti-toxin may fail, especially if the treatment is deferred till too late, and the dose of tetanic toxin already absorbed is too large, yet it is well worth trying, particularly when the patient does not come under treatment until the disease is established.

CHAPTER III.

Repair of Wounds.

A brief account of the ways in which wounds heal, and the conditions favourable and inimical to their union may be given.

The infliction of a wound is followed by greater or less hæmorrhage; when this ceases and the clot is wiped away, the raw surface becomes glazed over with lymph, *i.e.*, coagulated fibrin containing leucocytes. This is the first step in all healing processes.

"*Union by first intention*" takes place when the sides and edges of the wound are closely approximated and nothing interferes with the progress of the healing process. The exuded lymph glues the sides together, leucocytes of various kinds infiltrate it, develop into spindle-shaped cells and form young fibrous tissue, permeated by numerous fine blood vessels. Gradually the fibrous tissue, at first tender and soft, becomes firmer and contracts, while the blood vessels disappear, and the sides of the wound are firmly united by a thin layer of connective tissue. The epithelium of the skin in the meantime grows over the surface, and in from seven to ten days time union is completed. This is the ideal condition to aim at in the treatment of operation and other recent clean cut wounds. The resulting scar is slight, and in time almost disappears.

"*Union by blood clot*" is very similar to union by first intention, the only difference being that more or less blood clot is interposed between the sides of the wound. This clot forms a medium or mould, into which the cells from the plasma-covered sides of the wound penetrate and develop into connective tissue as above described, the epithelium growing over the surface in the same way. Though this process of union is not visible from the surface, when the edges of the wound are brought into close approximation, it is the way in which many, perhaps even the majority, of deep or extensive wounds, unite in their deeper parts.

"*Union under a scab*" is again a very similar process, in slight or superficial wounds, in which the edges are not approximated. The exuded lymph or blood dries up and forms a crust under which union takes place, as above described. The epithelial cells grow in from the sides underneath the scab, which dries up and scales off when union is complete.

"*Union by granulation or second intention*" takes place when anything prevents the healing of the wound, in the ways above described, such as want of proper approximation of the edges and sides of the wound, or the presence of septic organisms which cause swelling and inflammation even if the wound is closed in the first instance. Lymph is poured out as before, followed by the migration of numerous leucocytes, which in time form a thick lining of so-called granulation tissue. This is simply many layers of cells, closely adherent to one another, and permeated by fine capillaries, which give it its characteristic rosy appearance. These cells on the surface tend to grow in little lumps or granulations, from which appearance its name is derived. In the process the superficial cells frequently die, and form pus, but no pus and only a little clear serum exudes from a granulating wound, rendered aseptic by suitable treatment. As the granulations develop they fill the wound until its surface is level with the surrounding skin, sometimes indeed they will even project above the level of the skin. The epithelium from the edges of the skin now grows over it. At first the epithelial cells are few and arranged in a thin layer, and the red vessels are clearly visible through them ; gradually as they become more numerous and thicker, they have a bluish, and later, an opaque white appearance. These three zones, of colour are clearly visible at the margin of a granulating sore. Meanwhile the deeper cell layers of the granulation tissue are developing through the stage of spindle cells into fibrous tissue, which gradually hardens and contracts, drawing the softer tissues together in the process. During the course of union by granulation, which is a very gradual process in extensive wounds, there is not infrequently more or less profuse suppuration from the presence of septic organisms, (though this is by no means a necessary concomitant in union by granulation), and the patient is subject to the discomforts and danger of septic absorption if to nothing worse. When once the barrier of healthy granulation tissue is complete, however, this danger is greatly minimized. In extensive granulating wounds, the subsequent contraction of the newly formed fibrous tissue may be a very serious matter, causing great deformity. There are, it is clear, many and great disadvantages in this method of healing; apart from the special dangers, the length of time it takes and the drain on the patient's strength, are serious drawbacks.

"*Union by the junction of granulations*," or *by third intention*," as it is sometimes called, is a further mode of healing, brought about by the approximation of the sides of a granulating wound. It is not free from risk unless the granulating wound is practically aseptic, as otherwise septic matter may become pent up and result in severe local inflammation, or even general infection; it should, however, be borne in mind, and with aseptic precautions can be frequently employed with great advantage. A good instance of this form of union is the closure of the track, left by the removal of a drainage tube, after the cavity it was designed to drain has closed up. This can be brought about by the pressure of properly adjusted dressings, but it needs circumspection in practice.

Local conditions inimical to union by first intention are either physical, or pathological. Physical causes include the following—

(a) Incomplete approximation of the edges of a wound from defective suturing, or of the sides from defective bandaging.

(b) The presence of blood clot, gauze packing or drainage tubes.

(c) The want of rest or mechanical irritation.

(d) Chemical irritation and excessive serous discharge from the use of too strong antiseptics.

Pathological causes include—

(a) a defective blood or nerve supply, and

(b) the presence of septic organisms.

Sepsis is by far the most important local cause of the failure of primary union. As was seen in the previous chapter, the pyogenic cocci, by their presence and growth, produce irritating toxins, which cause excessive serous exudation, peptonize and destroy the leucocytes and tissues, and cause local suppuration and, possibly, general infection. The toxins of saprophytic bacteria, besides being capable of producing unpleasant symptoms from their absorption, may seriously impair the natural resistance of the tissues, and thus indirectly aid purely pathogenic bacteria.

The local conditions then favourable to the healing of wounds are the reverse of these. They include—

(*a*) The proper approximation of the edges with sutures.

(*b*) Of the sides by nicely adjusted dressings.

(*c*) Dryness, insured by the closure of all bleeding points, and the prevention of serous exudation, by avoiding the use of unduly irritating antiseptics, in the wound itself.

(*d*) Physical rest.

(*e*) A good blood supply, and

(*f*) Asepsis, most important of all conditions.

CHAPTER IV.

Antiseptic and Aseptic Methods.

The word "antisepsis" is compounded of two Greek words, *anti*, against or antagonistic to *sepsis*, decomposition. The word "asepsis," also derived from the Greek language, signifies the absence of decomposition, or the condition of sterility. "Antisepsis" is therefore the means to the end "Asepsis." The term "antiseptic" should strictly be applied to anything which destroys or checks decomposition, or, surgically speaking with reference to the treatment of wounds, to anything which destroys or checks the growth or activity of pyogenic or pathogenic bacteria, already present in a wound.

The term "aseptic," on the other hand, should strictly be applied to anything which is sterile, or, surgically speaking with reference to the treatment of wounds, to anything which will not produce septic processes, and which thus ensures the absence of pyogenic or pathogenic bacteria from wounds.

Now both these terms are commonly used in a specialized, but strictly speaking incorrect sense, with regard to surgery; antiseptic surgery signifying the use of chemical antiseptic means for the production of asepsis, aseptic surgery the use of physical antiseptic means for the same end.

This incorrect nomenclature seems to have arisen in this way. When Lister inaugurated his system, sepsis was so common that it was regarded as the normal condition in the healing of wounds, his system was directed to combating this state of affairs, and the term "antiseptic" therefore seemed the most appropriate; but when sterilization by heat was adopted by some surgeons in preference to sterilization by chemical means, a distinctive term was adopted to distinguish their methods from Lister's and the expression "aseptic" was used. The term "aseptic," of course, covers both systems, and in the true sense is equally applicable to both, inasmuch as they both aim at the same end, *viz.*, the maintenance of an aseptic condition of wounds made through the unbroken skin, and the prevention of sepsis, from the time the wound is inflicted, to the time it is soundly healed, by the application of different antiseptic means or methods. The special senses in which these terms are used have had the sanction of common usage for some time, and though they are misleading they had a certain convenience in practice. The time has come, however, when they may well be given up, as will be made clear later.

Antiseptic agents then, taking the wider view, may be divided into two classes: (1) chemical and (2) physical antiseptics. The former class includes a large variety of substances, *e.g.*, phenol or carbolic acid, many salts of mercury, chlorine, iodine, salicylic and boric acids, permanganate of potash, alcohol, etc., and a number of patent or proprietary preparations, containing cresols, such as izal, cyllin, lysol, and others too numerous to mention.

The latter, or physical antiseptics, are only extreme heat, either dry, or moist in the shape of steam or boiling water. The value and practical application of both these classes of antiseptics varies greatly, and will be considered later. The erroneously so-called antiseptic school relied in the past chiefly on the former, the aseptic school on the latter means.

Antiseptic surgery in its special sense, then, was the best application of chemical antiseptics for the prevention of sepsis in wounds, and three conditions had to be accepted for its intelligent practice, *viz.*—

(1) That septic processes in wounds are the result of the presence and the activity of certain micro-organisms ;

(2) That they are introduced from outside, on the hands, instruments, or by the medium of the air, or, in short, by anything that comes in contact with a wound ; and

(3) That the proper use of chemical antiseptics destroys these micro-organisms, and prevents their access to wounds, or so weakens any that may gain access, that their growth and power for evil are prevented.

In accordance with these propositions it was the practice to prepare everything for use at an operation

—sponges, ligatures and instruments—by steeping them in strong chemical antiseptic solutions.

The skin was prepared by thorough scrubbing with soap and hot water, and well rubbed with a strong antiseptic solution, and next a moist dressing impregnated with some antiseptic was placed on it for some hours beforehand. Before and at the time of operation the instruments were immersed in an antiseptic solution, and the hands of the surgeon and the assistants were steeped in antiseptic lotion after thorough washing, and frequently rinsed in the same during the operation. Towels wrung out of antiseptic lotion were so arranged round the site of the wound, that nothing which came in contact with the wound could inadvertently touch possibly septic objects, such as the patient's clothing. Antiseptic lotions were used to wash out the wound from time to time, and when the operation was completed the skin was dusted with some insoluble antiseptic powder, and antiseptic dressings where thickly applied. These dressings were allowed to remain for some days, in the confident expectation that they would form with any discharges a sufficiently powerful antiseptic solution to arrest the growth of any micro-organisms that might gain access after their application during the process of healing, and thus prevent infection of the wound.

Chemical antiseptics, it is clear, play an important part at every stage of these proceedings. Not only are they used before and after operation, but their frequent employment during operation ensures that any bacteria which may alight from the air on anything in the neighbourhood of the wound are at once fixed and weakened, if not actually destroyed, by the antiseptic solution with which everything is wet, or, in short, accidental aërial infection is by this procedure guarded against.

This is a brief summary of the so-called antiseptic technique until recently. In the main details it is the practice at the present day, but certain modifications have been introduced, which will be referred to later.

It was so simple and its results were so good, that it appeared to leave little to be desired. This indeed was not always the case. Chemical antiseptics had certain objections in practice. Formerly, there is no doubt, they were used by some only too freely ; instances of toxic poisoning from absorption in wounds, especially extensive wounds, were by no means unknown, with occasionally fatal results ; besides many of them are irritating to wounds and to the hands and skin in strong solution. In abdominal surgery particularly, they were found objectionable both on account of the danger of absorption, mentioned above, and also from their irritating effects on the peritoneum. The argument in fact seemed true that their use so interfered with the natural power of resistance or more likely with the absorptive power of the membrane, as to aid the septic processes they were designed to prevent (given that septic matter inadvertently found access). Certain surgeons therefore gave up the use of antiseptic lotions in abdominal surgery and used merely sterilized water or saline solutions instead.

This paved the way for the so-called "aseptic" surgery, the main detail of which is the use of physical antiseptics, *i.e.*, heat, instead of chemical means. Its advocates argued that, as it gave such good results in operations on the peritoneum, it was equally applicable to wounds or operations on less delicate structures.

Some fifteen years ago then, this system began to be more widely adopted in place of chemical antiseptics. Instruments were rendered sterile by boiling in water, dressings were similary sterilized with hot air or steam, and plain boiled water was used for irrigating wounds during an operation. The system was not so easy to carry out, as it looked at first sight, on account of the lack of proper appliances. Gradually these were perfected and the matter greatly simplified in consequence.

Firstly, various ingenious patterns of sterilizers, both for boiling instruments and steaming dressings were invented. Next, as it was found that wooden handled instruments were damaged by boiling, instruments made of metal only were introduced. With a view to facilitating the cleansing of instruments, changes and improvements were made in their construction. Serrations and irregularities of the surface, were abolished as far as possible to avoid the lodgment of gross dirt. For the old screw joint of forceps, etc., detachable joints were substituted, by means of which the instrument can be disjointed and each blade and the joint thoroughly cleaned. Metal boxes for keeping instruments in, replaced the old velvet-lined ones, which seemed specially designed to harbour dust and dirt. Improvements in the pattern of hospital and operation room furniture were also effected. Glass and iron or brass alone were used in their construction, which can be easily cleaned, and on which gross dirt cannot lodge without being at once detected. In short, the aim of the aseptic school was to reduce the possibility of the lodgment of dirt and foreign matter on all instruments and other articles coming in contact with a wound to the lowest possible limits and to render their cleansing as simple a matter as possible.

All these changes and inventions were distinctly working to a good end, (though perhaps an unnecessary amount of ingenuity and money has been expended on elaborate aseptic furniture) and the advocates of the so-called aseptic system deserve the credit of having turned attention to them, and of the advantages that have been reaped from their introduction. True to their theory that chemical antiseptics are not only unnecessary but positively harmful in practice, they gave up the use of medicated dressings and chemical lotions and used only sterilized dressings and sterile lotions for irrigating wounds. Catgut ligatures and sponges which are damaged by boiling, were discarded for silk ligatures and swabs of sterile absorbent wool, and for the final disinfection of the hands and skin they adopted alcohol. In this they were not quite consistent as it is in certain strength a powerful antiseptic. The difficuly of rendering the hands perfectly sterile further led many to adopt the use of gloves of cotton or india-rubber sterilized by heat.

Three conditions had then to be accepted for the intelligent practice of aseptic surgery—

(1) That septic processes in wounds are the result of the presence and growth of certain micro-organisms ;

(2) That they are introduced from outside on instruments or anything that comes in contact with a wound, but that the air is practically never a medium for their introduction ; and

(3) That the proper use of physical means of antisepsis, *i.e.*, heat in one form or another destroys these organisms and prevents their access to wounds.

The natural corollary of this last proposition is that physical means of securing asepsis, *i.e.*, heat, being sufficient for the object in view, chemical antiseptics are unnecessary. Further, they urge that the latter are best avoided on account of their irritating properties, which damage the tissues, weaken their natural powers of resistance, cause excessive serous exudation and delay union. After operation they maintain that merely sterile gauze dressings are quite sufficient to filter off and so prevent the access of any micro-organisms, while from their porous character any discharges quickly dry and give no foothold to bacteria, and that therefore chemical antiseptic dressings are unnecessary and have objectionable irritating properties.

It will be observed that the two former propositions are the same, with the exception of the comparative importance of the air as a medium for infection, and that the only difference is the means adopted for the prevention of sepsis in wounds through the unbroken skin. *There is no difference of principle involved in this, it is merely a difference of method, and the term "aseptic" is therefore equally applicable to both systems.*

Those who trust to sterilization by heat urge in support of their last condition and its corollary, that their results are every bit as good as those of surgeons who employ chemical antiseptics. They even go further and say that in certain fields of surgery, notably in abdominal surgery, their practice is the only admissible one, and that what applies in this applies equally in other fields of surgery, and that their method is the scientifically correct one. In short, their attitude is theoretically unassailable. There is doubtless a solid basis of fact behind these contentions, and as a result of these arguments, the wholesale and injudicious use of irritating chemical antiseptic lotions in wounds has been greatly restricted. But granting all this as true in practice other considerations intervene.

To obtain these excellent results perfect conditions are absolutely necessary. A mistake would mar the whole. This implies the existence of a perfect equipment for sterilization by heat, a perfectly trained staff of assistants, and the most constant and assiduous attention to details. Such a desirable combination is only to be found in certain public and private hospitals. In private houses and many hospitals, particularly in the out-patient or casualty departments, it is equally impracticable. It is unnecessary to labour the point ; many a concrete instance will readily occur amongst the exigencies of general practice.

Where then is the line to be drawn between the two systems ?—and how far may the practice of securing asepsis by heat alone, be abandoned in favour of obtaining and maintaining asepsis by chemical means ? Before answering this question the conditions favouring sepsis through wounds of the unbroken skin must be more fully inquired into.

During an operation the paths by which the infection of the wound may take are the instruments, sponges or swabs, ligatures, lotions, drainage materials, the patient's own skin, the surgeon's or his assistant's hands, and lastly, by the air. The first five can be sterilized either by heat or chemical antiseptics, with absolute certainty, and all are agreed as to the necessity for this. The patient's skin and the hands cannot of course be sterilized by heat ; the question of their preparation is so important that it is considered in a later chapter, and does not further concern us at present. Incidentally it may be remarked that in the experience of many surgeons, most instances of virulent wound infection have been traced to catgut ligatures, or to infected hands ; this no doubt is due to the practical difficulties of securing their thorough asepsis in practice.

Excluding these the air therefore, as a medium of infection, only is left. It cannot, of course, be sterilized by heat, and the question of its infectivity has given rise to much discussion. It naturally varies greatly under different circumstances, and isolated experiments by exposing dishes of nutrient media to the air of various operation rooms and cultivating and counting the colonies of bacteria that grow thereon, prove nothing beyond the fact that the air in the particular instance is more or less germ free, or the reverse. As a matter of fact in this way a considerable number of bacteria have been shown to exist in the air in most instances ; while the majority are doubtless saprophytes, pyogenic bacteria have also been shown to exist too. The only safe conclusion is, *that the air may be a source of infection*, though not to anything like the extent which used to be supposed. Moreover, the improved hygienic condition of operation rooms at the present time has doubtless lessened this risk. The chances of direct aërial infection in a wound are therefore small. The chances of indirect aërial infection, however, *i.e.*, infection of instruments, towels, swabs or lotions or of the hands by the air, and so of the wound when they come in contact with it, must necessarily be greater, presenting as they do a much larger surface than the wound itself.

Now the main difference of method depends on the way in which this possibility of aërial infection, direct or indirect, is regarded. Those who trust to sterilization by heat disregard it; those who rely on chemical antiseptics, while admitting that its frequency and importance have been overrated, still maintain that it may be a possible source of infection, and as such is worth while guarding against. They therefore provide a safeguard against indirect aërial infection by the use of antiseptic lotions in which the instruments, etc., are immersed, the towels and swabs moistened and the hands rinsed from time to time, and against direct aërial infection by irrigating the wound with weak antiseptic lotions. This practice the adherents of physical asepsis condemn, maintaining that the irritation thus caused to the wound is a greater evil than the presence of a few bacteria in it with which unirritated tissues can easily cope.

After operation aërial infection of wounds may again take place. This the latter again maintain may be disregarded with impunity, trusting to sterile dressings to filter off any bacteria in the air, while the former employ dressings prepared with antiseptics, and under certain circumstances use antiseptic dusting powders for dredging on the skin round about.

Now this practice of using merely sterile dressings appears to be the weakest link in the chain. A little discharge may in spite of careful dressing escape to the edge of the dressings and so afford a track for the access of bacteria to the wound or a good medium for the growth of bacteria that may lie hidden in the deeper layers of the epidermis, and find their way to the surface. The heat and moisture under dressings in certain parts of the body, *e.g.*, the groin, is considerable, and these are ideal conditions for bacterial growth. If the skin is dusted with some inhibitory antiseptic powder and the dressings contain some antiseptic, they will form a sufficiently powerful solution with any discharges or the body sweat to arrest bacterial growth under either of these circumstances, until the wound has healed and the possibility of infection has passed. With merely sterile dressings there is no such obstacle and the wound might become infected in consequence.

The only argument that can be urged against the use of antiseptic dressings is that they are irritating to the wound and to the skin. It is clearly impossible that they can irritate a closed wound, and antiseptic dressings in their improved form are not irritating to the skin either. These objections therefore carry no weight whatever.

The ideal dressing is doubtless an impervious covering or scab, but this will not always permit of pressure when necessary. Though gauze dressings may be objectionable from an ideal point of view, this applies equally to merely sterile as well as medicated gauze. *The final conclusion as to the use of antiseptic dressings must be, that while they are harmless, they do afford an additional safeguard against wound infection after operation ;* and further in actual practice they have a direct practical advantage in obviating the necessity for changing the dressings frequently, which is not only a great saving of time and trouble, but also lessens the chances of subsequent infection at the time dressings are changed. The outcry against antiseptic dressings by those who rely on merely sterile ones seems to be a very spurious affair indeed, and appears to be largely based on the fact that their use would lay them open to the charge of inconsistency.

The next weakest link is the use of merely sterile towels, instruments and lotions during an operation. Any bacteria that may fall on them are carried unweakened to the wound, and though this danger may be slight in a well appointed operation room, it is certainly not to be disregarded when operating in less favourable surroundings. If, on the other hand, the instruments are lying in, and the towels are wet with antiseptic lotion, bacteria falling on them will be weakened if not actually destroyed ; it is impossible to deny this, during the course of a long operation contact is something more than momentary and antiseptics have time to exert their action. Moisture too prevents particles of dust or cotton fibre flying about and thus keeps it out of the wound, and though this may not be a matter of much importance, it is in direct consonance with the views of those who deprecate the use of chemical antiseptics. Finally, the use of towels moist with antiseptic lotions, is clearly harmless when they are properly arranged, even supposing they do no good, and this cannot be urged as an argument against their use.

Similarly with regard to the surgeon's hands, rinsing with antiseptic lotions is safer than trusting to sterile lotions which have no germicidal or inhibitory powers whatever. If rinsing is necessary at all, the objection to weak antiseptic lotions for the purpose will hardly hold water, plain sterile water or saline solutions are irritating too, (unless normal saline solution is employed,) and the evil effects on wounds of the small amount of weak antiseptic fluids that may get into them appears to have been greatly exaggerated.

The routine use in short of antiseptic lotions for instruments, towels and hands during an operation, and afterwards of antiseptic inhibitory dusting powders and dressings affords an automatic safeguard in the event of the accidental presence of micro-organisms in spite of all precautions (a safeguard which does not exist with the use of merely sterile lotions or dressings), and is a rational prophylatic measure open to no practical objections.

A more doubtful point is the comparative value of weak antiseptic or merely sterile lotions for sponging or irrigating aseptic wounds. Weak antiseptic lotions may have a mild inhibitory effect but are irritating in direct proportion to this. Plain sterile water is practically as irritating, and has no inhibitory effect whatever. Normal saline solution is quite unirritating, but has no other recommendation, and may favour bacterial growth a little. All these fluids, physically speaking, cleanse a wound equally well. A solution of the difficulty may be found in the use of a sterile lotion of boric acid, or better still of boro-glyceride, which combines the unirritating properties of normal saline solution, with mild inhibitory properties of its own. If the operation is not a prolonged one and the wound presumably aseptic, irrigation of any kind is certainly unnecessary and is better dispensed with entirely.

If it were possible that the antiseptic action of heat could last after its application had ceased, those who rely on it would have a very strong case indeed in their argument against the employment of chemical antiseptics, but as this of course is an utter impossibility, their objection to chemical antiseptics seems to be based on little better foundation than the reason that they are not heat and are therefore objectionable. While the importance of not interfering with the natural powers of resistance of the tissues is not to be denied, the irritating effects of antiseptic lotions have been greatly exaggerated and the fact too must not be lost sight of, that the natural power of resistance of the tissues was not competent to defend them before the days of antiseptics, and away from the perfect conditions for ensuring asepsis by heat that exist in well equipped hospitals, they are not more likely to display these unusual powers at the present time or in the future, under the less favourable conditions of ordinary life.

To summarize these conclusions. Good antiseptic dressings are unobjectionable, and have certain practical advantages over merely sterile ones. Antiseptic lotions outside the wound during an operation are unobjectionable, and do afford an automatic safeguard againt indirect aërial infection, a safeguard which is non-existent with merely sterile lotions.

Irrigation is best avoided, but when necessary as its action is chiefly mechanical, sterile boric lotion is preferable to anything else in a presumably aseptic wound, combining as it does mild inhibitory with quite unirritating properties.

For the sake of clearness and contrast, too sharp a distinction has purposely be drawn between the so-called antiseptic and aseptic methods. At the present time the practice of the two schools which gave rise to much acrimonious discussion in the past is insensibly merging into one another. On the one hand surgeons who employ antiseptics in one form or another, before, during and after operations, now regularly boil their instruments, silk ligatures, swabs and towels, while many employ steam sterilization for their antiseptic dressings, and other articles. Further, the routine use of antiseptic lotions for the irrigation of wounds has been largely given up ; at all events, with solutions of such strength as can fairly be called irritating. On the other hand surgeons who rely on physical means of ensuring the asepsis of their instruments, dressings, etc., use chemical antiseptics when necessary for asepticizing their sponges and catgut ligatures, the patient's skin and their own hands. Practically the dividing line may be drawn at the use of antiseptic lotions and dressings during and after operation on the one hand, and merely sterile lotions and dressings on the other.

It eventually comes down to a question of practicability and convenience in meeting the exigencies of actual practice, and the simplest means are after all the best for everyday use, as they are most likely to be employed with success and are therefore the safest and most reliable. The successful treatment of wounds depends more on the care with which details are carried out than on the actual methods adopted. The results of surgeons who pursue methods differing in details leave little to distinguish between them, but it must be remembered that many of them work under ideal conditions of physical antisepsis in perfectly equipped public or private hospitals, and some allowance must be made for this fact. Where these ideal conditions are not obtainable other means, *i.e.*, chemical antisepsis have to be relied on, to some extent at all events.

The concensus of opinion or fashion of the present day is in favour of disinfection by heat. The pendulum has swung far in this direction, perhaps as far as it will, and some reaction may be expected. The requirements and exigencies of aseptic surgery in India, unquestionably demand the use of antiseptics to the extent indicated above.

PART II.

PRACTICAL DETAILS OF ASEPTIC SURGERY.

PRACTICAL DETAILS OF ASEPTIC SURGERY.

CHAPTER V.

OPERATION ROOM AND FURNITURE.

In the following pages the procedure to be followed in actual practice will be detailed, though theoretical questions cannot be avoided altogether, they will only be discussed as far as is necessary to elucidate practical details. In the previous chapter it was shown that the so-called antiseptic and aseptic methods are both directed to the same end, the means to that end only differing, though in many particulars, the details are practically the same. The methods of each then will be included without distinction under the common heading of "Aseptic Surgery." It is obviously difficult to lay down rules of procedure applicable to all circumstances ; for instance, the want of a steam sterilizer renders it necessary to fall back on other devices, *i.e.*, boiling or chemical agents for asepticizing towels, etc. ; but a general review of the whole subject will be attempted and the selection of details must be left to individual judgment. Certain main principles must be borne in mind, and the degree of success attained will depend on the care with which these principles are carried out in practice, though the actual methods employed may vary greatly.

To ensure success previous preparation in many ways is absolutely necessary. The preparations for an operation should merely be the finishing touches in a whole system of preparedness. Dressings cannot be prepared, ligatures sterilized, and everything got ready in half an hour. The operation room will first be considered.

Operations can, of course, be performed in almost any kind of room or building. Whether they should be is quite another question. In a hospital with any pretensions to being up to date, a separate room is indispensable, for two main reasons; firstly, that everything required can be kept at hand in it, and, secondly, that a room solely set apart in this way is not so liable to contamination with dust and gross dirt and can be kept clean.

The two chief points in a good operation room are thorough ventilation and a good light. A minimum of at least three persons are usually present at an operation, *viz.*, the operator, the patient and an assistant, more frequently there are four or more persons present. This implies a considerable fouling of the air during a prolonged operation. The room should be a detached building if possible, with a minimum floor space of 12 by 16 feet, 16 by 20 feet is better, and 20 by 24 feet is not too large for a fairly big hospital. Ventilation should be provided for by clerestory windows close under the ceiling, the light is not in this way interfered with, and there is less likelihood of the entrance of dust.

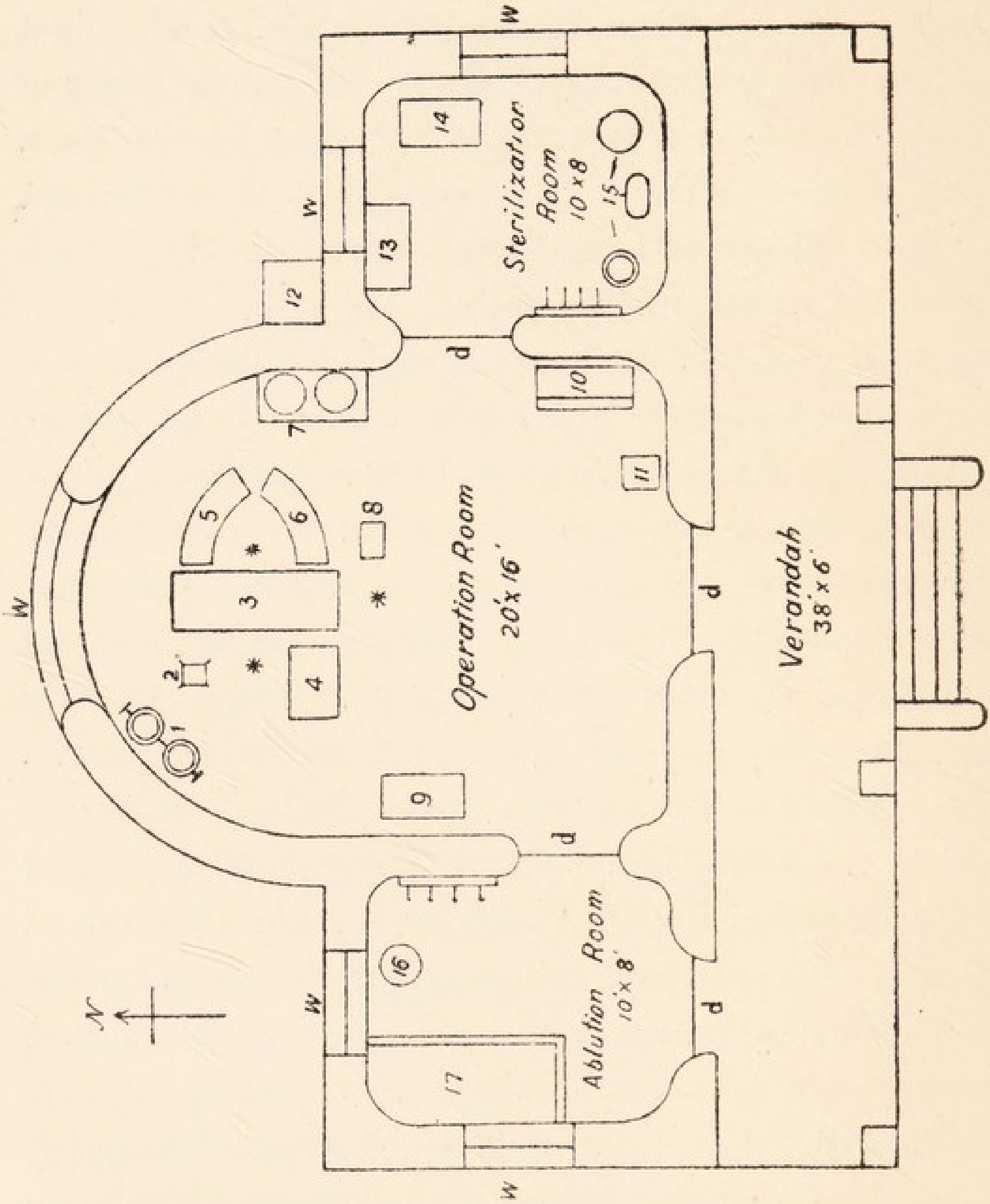
Next to ventilation, light must be provided for; no good work can be done in the dark. The light should be steady and not glaring. A large window, at least 6 feet high by $4\frac{1}{2}$ feet wide, is the best arrangement, the sill or lower end should be not less than $3\frac{1}{2}$ to 4 feet above the level of the floor. The window should, if possible, look to the north; next to this an easterly aspect is best, southerly and westerly aspects are the worst.

A skylight in the roof is the next best plan, but it is more expensive to erect, and if used for ventilation too, it is difficult to keep watertight. Still a room with a bad light can often be most easily improved by the addition of a skylight. The worst of all possible lights is produced by a profusion of windows or doors on every side. They not only give a bad light, but interfere with wall space, and doors particularly admit a good deal of dust and foreign matter. Other things being equal, it would be preferable to operate in a dark room by artificial light. The enclosed end of some verandah makes a bad operation room as a rule, it is generally dark and ill-ventilated and is not infrequently a mere makeshift. For night work a "Sunlight" hanging lamp is the best. It casts no shadows and gives a powerful light. It is rather difficult to keep it in order however.

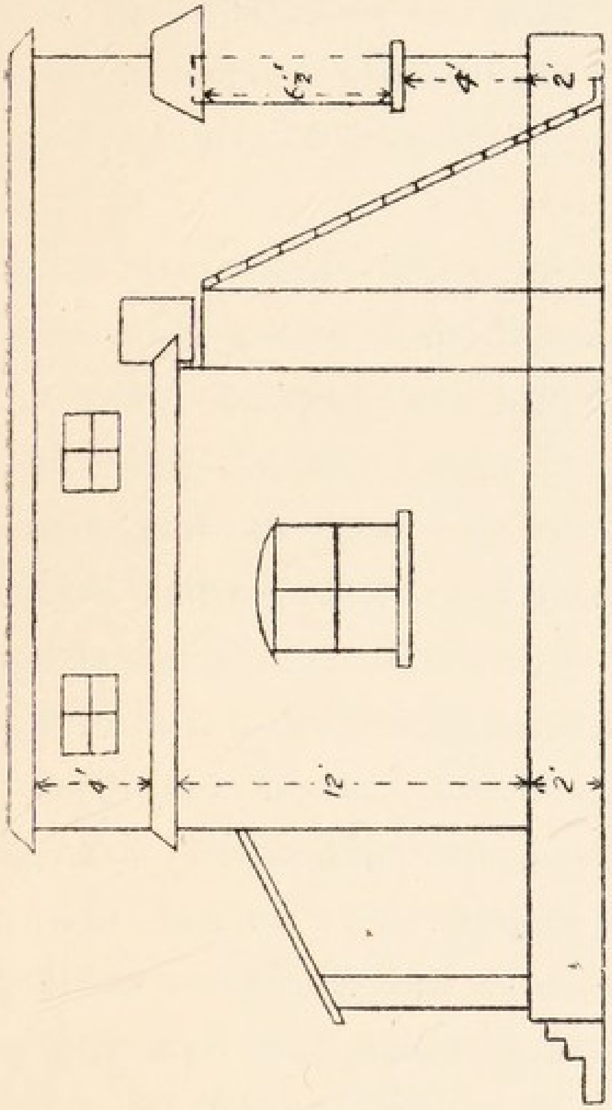
Useful additions to an operation room are two smaller rooms, 8 feet by 10 feet or 10 feet by 12 feet in floor space. One is used for the sterilization of

Ground plan of Operation Room, etc., showing arrangement of tables and furniture, for operation.

Scale 10 feet to 1 inch.



w. Windows. *d.* Doors. 1. Bottle stand. 2. Irrigator or douche stand. 3. Operation table. 4. Table for assistant. 5 & 6. Curved instrument tables. 7. Washbasins, with taps. 8. Chloroformist's table. 9. Instrument almirah. 10. Wallstand for jars, etc. 11. Small almirah for dressings, towels, etc. 12. Cistern on platform outside building. 13. Sink, with tap. 14. Table. 15. Sterilizers. 16. Washbasin. 17. Ablution platform with tap. *** Positions of the operator, assistant and chloroformist.



Side elevation of Operation Room, showing clerestory windows and cistern for water on platform outside, with ladder.

Scale 10 ft. to 1 inch.

instruments, etc., and the other for ablutionary purposes, for patients and dressers. In larger hospitals a third room for anæsthetizing patients is a convenience, but it is unnecessary in smaller hospitals. The other rooms are practically essential to ensure that the operation room is kept clean and fresh. If they are not available the verandah should be used for sterilization and ablutionary purposes.

The plan on pages 58 and 59 shows how these details may be provided for.

All modern operation rooms are constructed with a view to rendering them easy to keep clean, and certain devices should be kept in mind when a new room is under construction ; when once it is finished it is not always easy to introduce these improvements. There should be no flat surfaces or ledges on which dust can collect, all angles should be rounded, including the angles the walls make with the floor. (Contractors or their employés are a very conservative race, and unless they are watched and these details insisted on during the actual building, they are only too likely to omit them.) The roof should, if possible, be flat and pucca ; if it is a tiled roof there should be an inner lining of flat pucca tiles. The greatest abomination in an operation room is a ceiling cloth which shakes in every breeze and discharges a free shower of dust on everything below. Existing ceiling cloths can easily be replaced by a good mat lining to the tiles, which should be painted white ; though not so good as an inner lining of flat tiles, it is certainly an improvement. For a height of $4\frac{1}{2}$ or 5 feet from the floor there should be a waterproof dado. Glazed tiles add greatly to the cost of construction ; a cheap and equally efficient substitute is a dado of cement, coated with some waterproof paint, or paint-varnish, of which there are several kinds obtainable. This paint should always be white, as it at once shows any dirt, and affords a better light.

The points of a good floor are : (1) smoothness of the surface ; (2) non-absorbentness ; (3) hardness or good wearing qualities ; and (4) a slight slope to the point of exit for fluids. Details of materials are more fully considered in the appendix to this chapter. To facilitate the cleansing of the floor, an opening for the escape of fluids should be provided. Small drainage holes are apt to get blocked up, while larger ones admit dust. The best plan is to make the door sill level with the floor, and use the door as an exit for fluids. If the sill in an existing room projects above the level of the floor, as is usually the case, it should be converted into a removable one for this purpose. Gullies or depressions in the floor for drainage purposes often defeat their own object.

In the only room available for operations in many hospitals, all these details may be impossible of attainment, but ceiling cloths can always be substituted by white painted mats, the floor made pucca and a pucca dado erected. The operation room floor, should occasionally be flushed with disinfectants and the dado be well scrubbed with the same.

The fittings of the operation room must next be considered. Provision for an ample supply of water is of the first importance. In the absence of a regular pipe supply other devices have to be resorted to. The best substitute is a cistern on the roof which can be filled by a small hand force pump. The next best is a similar cistern on a raised platform 8 to 12 feet in height outside the building, with a ladder or flight of steps to enable it to be filled by hand. Pipes should lead from these cisterns to the washbasins and a sink within. If the cistern is beyond the resources of a hospital a galvanized iron drum, capacity 8 to 12 gallons, on an iron stand does very well, and can usually be made locally at a small cost. Expensive fittings are both unnecessary and undesirable. Enamel iron basins of fair size on enamel iron stands are cheaper than fixed porcelain basins, and, being removable, are more easily cleaned and are therefore preferable. A galvanized iron sink on a similar stand, which is also removable, is a convenience in the sterilization room. Various ingenious devices in the way of foot taps or other mechanical contrivances have been invented for controlling the flow of water without using the hands. They are refinements which, though useful, are certainly not indispensable, as the same end, *i. e.*

the prevention of the contamination of the hands while they are being washed, can be ensured by much simpler means. Instead of the ordinary bib-cock or fixed tap, taps with a *removable* key or handle should be obtained. This brass key or handle can then be boiled at any temperature with the instruments, and handled with impunity during the process of washing. The fixed taps ordinarily in use are bound to become infected in use, handled as they are by dirty hands, and the operator who in a moment of forgetfulness turns off the water after cleansing his hands, may at once re-infect them and undo all the trouble he has taken. The use of a sterilized key or handle prevents this possibility absolutely.

Nothing is more unsuitable than earthen *gurrahs* for storing water in for surgical purposes. They should never be used.

Hot water is indispensable in an operation room, and in the absence of any better arrangements, a large enamel iron kettle which can be boiled on a kerosine oil stove should always be part of the equipment. A "Salamander" water heater is a simple and inexpensive apparatus for a more ample supply of water, and may well be included in the list of equipment of all in-patient hospitals.

The furniture of a simply but fairly equipped operation room includes the following articles. Individual tastes vary a good deal, and judgment can be exercised as to the necessity for certain articles, but this list will furnish a guide as to what will be found useful :—

1. An operation table, complete with drain and pail to catch waste fluids.

2. A curved instrument table, for the operator's use.

3. An oblong table, with a lower shelf, for the assistant's use.

4. An almirah, or cupboard, for instruments.

5. A set of three shelves, or wallstand, for glass jars and other articles.

6. A stool for operations on the perineum.

7. A smaller almirah, or locker, for keeping dressings and operation towels in.

8. One or two removable enamel washhand basins on stands. These are practically a minimum.

To complete the list the following may be added :—

9. One or two spare refuse pails.

10. A revolving bottle stand for stock lotions.

11. Irrigation apparatus, *i.e.*, either a Cripps' irrigator complete with rope pulleys, etc., or a large enamel douche can, complete on its own stand, with a bowl for the glass nozzle.

12. A second curved instrument table.

13. A table for the chloroformist.

14. A footstool for patients.

Nos. 4 and 7 can be included in the same piece of furniture.

Nowadays operation room furniture is made of metal and glass, the frames of polished brass or of iron enamelled white, the shelves of plate glass. The construction is as simple as possible, with a view to ease in cleaning it, and the materials used are non-absorbent and easily cleaned, and any dirt which lodges on them is at once detected. The chief objection to them is their cost, which is prohibitive to smaller institutions. Such elaborate furniture is really not a matter of practical necessity, still it has the advantage of setting a high standard of cleanliness and neatness which is not to be despised.

A useful substitute is furniture made only of plain sheet and angle iron, finished by painting it with white paint or enamel. Any good mistri can make it in the bazaar, and the cost should not be more than half as much again as that of ordinary wooden furniture. (For practical details of construction see appendix to this chapter.) Wooden furniture painted white, with square legs and plain surfaces, and shelves or tops covered with sheet zinc, is nearly as good and perhaps a little easier to obtain. Existing furniture of old pattern can be simply converted in this way, thus saving the expense of new articles.

Other articles of equipment required are as follows :—

1. A nest of two or three sterilizers of different sizes for instruments, with a detachable receptacle for steaming dressings above.

2. A set of instrument dishes of enamel iron, glass or porcelain, one large, one medium, and two

small, 16″ by 12″, 12″ by 9″ and 9″ by 6″ respectively. Depth not less than 1½″.

3. Three to six bowls of enamel iron or glass, capacity at least 3 pints, for lotions.

4. A zinc or enamel iron mug, depth 6″, for artery forceps.

5. A glass ligature box, with three or four reels for silk ligatures.

6. A glass box for needles.

7. Three to six large glass jars, with covers, for dressings, sponges, tubing, etc.

8. Three or four bottles for stock lotions, capacity 1 or 2 gallons (in the absence of a revolving bottle stand).

9. A set of enamel iron pus basins.

10. Two glass and vulcanite dredgers for iodoform and cyanide dusting powders.

11. Two nailbrushes and pieces of pumice stone in glass jars of their own.

12. A pot or jar for soft soap.

13. A jar for carbonate of soda.

14. Half to one dozen towels. These should be marked with a Maltese cross for use at operations only. Those used for septic cases should be further distinguished with a capital "S" and reserved for this purpose only.

15. A steam sterilizer with a petroleum lamp. In its absence a fair sized dekchi or boiler for towels, and a small enamel iron saucepan with a handle for swabs.

The only expensive thing in this list is the steam sterilizer. Good work can be done without it, but it is of great use, and should be part of the equipment if possible. Nailbrushes are absolutely indispensable, one for the surgeon and one for his assistant. When not in use they should be kept in antiseptic lotion, after cleansing them by immersion in the hot soda solution when the instruments have been removed from the instrument sterilizer. When the bristles become worn and soft they should be replaced. The life of cheap ones are short, and it is cheaper in the long run to buy good wooden-backed ones, they are stiffer too and more efficient. Pumice stone is most useful, and materially aids and quickens the process of cleansing the hands, it too should be boiled in the sterilizer.

The number of trays and bottles, etc., must vary with individual taste, the lower figure given above may be taken as the minimum. Glass jars are invaluable for storing dressing swabs, sponges, tubing, etc., in an aseptic condition for use at any time, they should have overlapping covers, as stoppered lids admit dust.

Things which an Operation Room should **not** *contain.*

Pegs to hang clothes on ; books, blankets or bedding ; weighing machines ; splints and various articles of surgical outfit ; bedpans, urinals, and spittoons ; odd boxes, packages of lint, tow, etc.; dirty bottles and drugs of various kinds ; stomach

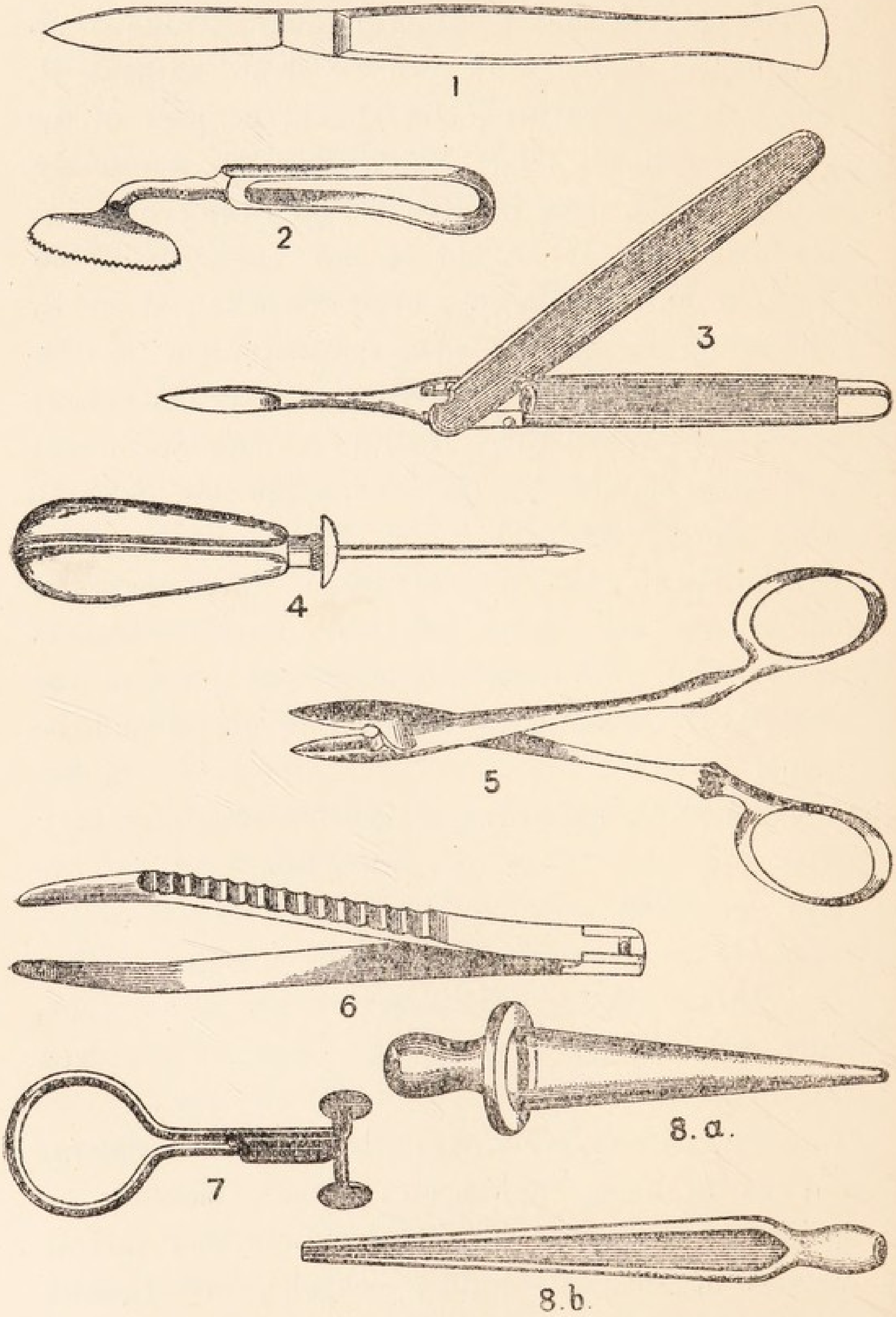


Fig. 1.—Aseptic Scalpel, metal handle.
,, 2.—Aseptic Skull Saw (Horsley's).
,, 3.—Aseptic Pocket Knife, detachable handle (a good pattern). Illustration shows handle in position for closing.
,, 4.—Aseptic Trocar and Cannula, all metal.

Fig. 5.—Aseptic Artery Forceps (Jordan Lloyd's), detachable joint (a good pattern).
,, 6.—Aseptic Dissecting Forceps, showing detachable joint.
,, 7.—Clip for tubing.
,, 8 (*a* & *b*.)—Glass nozzles for irrigation.

pumps and enema syringes ; the velvet-lined cases of instruments, etc., etc.

A few words on the selection and care of instruments. These should nowadays always be of aseptic pattern ; this is a matter of real practical importance. Knives of metal, forged in one solid piece ; scissors and forceps (even dissecting forceps) with detachable joints ; saws with take-off backs and handles ; trephines with metal handles and bevelled teeth ; irrigation nozzles of glass with clips for rubber tubing ; taps are most objectionable. When ordering new instruments, cases should be avoided as much as possible ; if they are necessary, plain wooden cases with metal racks, or better still, all-metal cases should only be obtained. Velvet-lined cases are "anathema." Hypodermic and other syringes should be of glass only, or with glass barrels mounted in metal frames, so that the whole thing can be taken to pieces and each part thoroughly boiled.

The care of instruments is important, their treatment before and after use will be referred to later. (*vide* Chapters VI and IX.) There is no disguising the fact that their proper care involves a considerable expenditure of time and trouble, which *must* be taken or they will inevitably spoil even if unused for long periods. Instruments should always be kept in a dry state. The old plan of thickly smearing instruments with oil or vaseline is to be strongly deprecated. There are no advantages to be gained from it while there are several good reasons to be urged against the practice :—

1. Vaseline frequently contains an appreciable quantity of water, and the steel rusts in consequence of this.

2. Vaseline, unless specially sterilized, invariably contains micro-organisms.

3. If sterile when applied, it acts as a regular germ-trap, and affords an attractive resting-place to any that may be floating about in the air.

4. Vaseline-smeared instruments are most difficult to clean. Even when they are boiled, the stuff forms a scum on the surface of the water, some of which adheres to the instruments as they are lifted out.

5. When they are not boiled, but merely wiped before being placed in antiseptic lotion, the antiseptic is unable to penetrate the vaseline that is only too likely to be still adhering to them, and consequently, does not asepticize them thoroughly.

6. Unboiled and untreated with antiseptics (though this of course should never be the case), they are about the most septic things that can be put into a wound. *The practice of using vaseline or oil should therefore be abandoned.*

Instruments can be kept from rusting even in a damp climate by thoroughly rubbing them with a dry cloth at stated intervals. For this purpose there is nothing better than a " selvyt " cloth previously heated to ensure its dryness ; it polishes them in a way that an ordinary cloth cannot do, and has the great advantage over chamois leather that it can be boiled and so sterilized without damage. In cleaning instruments in this way care must be taken that they are not touched by hand, or they will rust to a certainty. Lumps of calcium chloride in a wide-mouthed open bottle help to keep the air in the instrument cupboard dry, particularly in wet weather. A thin coating of spirit varnish saves much trouble in keeping instruments only occasionally used from rusting.* It is readily removed by dipping them in rectified or methylated spirit before use.

One word as to the preservation of india-rubber articles. It is not generally known that the best way of keeping them from becoming dry and cracked is by exposing them to the vapour of kerosine oil, this can easily be done by hanging them up in a cupboard or tin at the bottom of which a small jar or gallipot of kerosine oil is placed.

APPENDIX

Practical Details of Operation Room and Furniture Construction.

In building a new operation room it is easy by settling beforehand what is wanted, to have it carried out, but alterations in the course of the work are costly and generally unsatisfactory. The surgeon is to a great extent dependent for information as to technical details on the advice of the architect or engineer. A few hints may therefore not be out of place.

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* Prepared by dissolving shellac ½oz. in rectified spirit 1 pint.

Expense is always an important consideration, and though the materials selected should always be the best of their kind, as this is most economical in the long run, it does not follow that the most expensive materials have a marked advantage over less costly ones.

Walls.—A dado 4½ to 5 feet high of some smooth material impervious to water is desirable. There is no object in covering all the wall up to the ceiling in this way, it adds considerably to the cost, and in the long run is not likely to be any easier to keep clean, than a plastered wall which can and *should* be white-washed once or twice a year. The two materials which are commonly recommended for a dado are glazed white tiles and good cement plaster covered with white enamel. Of the two the latter is the best. The objection to tiles are firstly the high cost, secondly the presence of joints between them, and thirdly the tendency they have to bulge and become loosened under the trying extremes of an Indian climate. A good Portland cement dado or white cement dado covered with white enamel or silicate paint, is uniformly smooth, lasts better, and is far cheaper. It should be thoroughly polished before the paint is applied.

Reliable paints are "Velure" and "Porcelain Paint" or the silicate paints, "Hall's Patent Washable Distemper" and "Paripan." The two latter are comparatively cheap, and may be used up to the roof with advantage.

Floors.—The great desideratum about a floor is its non-absorbent qualities. Sheet-lead answers this important characteristic perfectly; it is, however, dingy in appearance and perhaps difficult to obtain. Slabs or tiles have the objection of joints. They include Italian marble, glazed tiles of various kinds, slates, and patent stone. Marble gives a beautiful appearance, but is proportionately costly, and apart from the objection of joints is, to some extent at all events, absorbent. Glazed tiles, while quite non-absorbent, are full of joints; there are many varieties obtainable. Slates are open to the same objection, are slightly absorbent and very dingy in appearance. Patent stone is similarly jointed, and very absorbent, which puts it out of court at once.

Portland cement is everywhere obtainable, lasting, and comparatively cheap. Its objections are its dingy appearance and its somewhat absorbent qualities. Still, taking it all round it is the best material for the purpose on account of its cheapness, accessibility and freedom from joints. It should be not less than ½ inch in thickness, and the floor should be thoroughly rammed and carefully soled before it is applied. If this is not done it will crack and break, and patch repairs are then useless, and the whole floor must be relaid. Its slightly absorbent qualities can be overcome by coating it with "Szerelmey Stone Liquid," when every objection but its rather dingy appearance is done away with. A very lasting floor is made by mixing Portland cement with some kind of oil, but the secret appears to have been lost. I have seen such a floor 40 years old as good as the day it was laid down. Polishing the cement with oil renders it more durable and less absorbent. Materials which should never be used and which are mentioned only to be condemned, are sand or lime plasters, brick on edge and unglazed tiles.

Furniture.—As mentioned in the previous chapter this can be cheaply and efficiently constructed with angle iron and thin sheet iron, the whole being finished with white "Velure" paint. If galvanized iron sheets are used instead of ordinary iron, the cost of paint is saved, and an equally serviceable article is obtained, which wears better in constant use. The framework of angle iron must, however, be painted, and "Sapolin aluminium" paint may be preferred to white enamel, velure or porcelain paint for this purpose. Its silvery frosted appearance closely resembles galvanized iron, and it is claimed to wear well and prevent rusting, and is more suitable for out-patient department use than white enamel.

The following dimensions and hints as to construction may be found useful in obtaining new furniture.

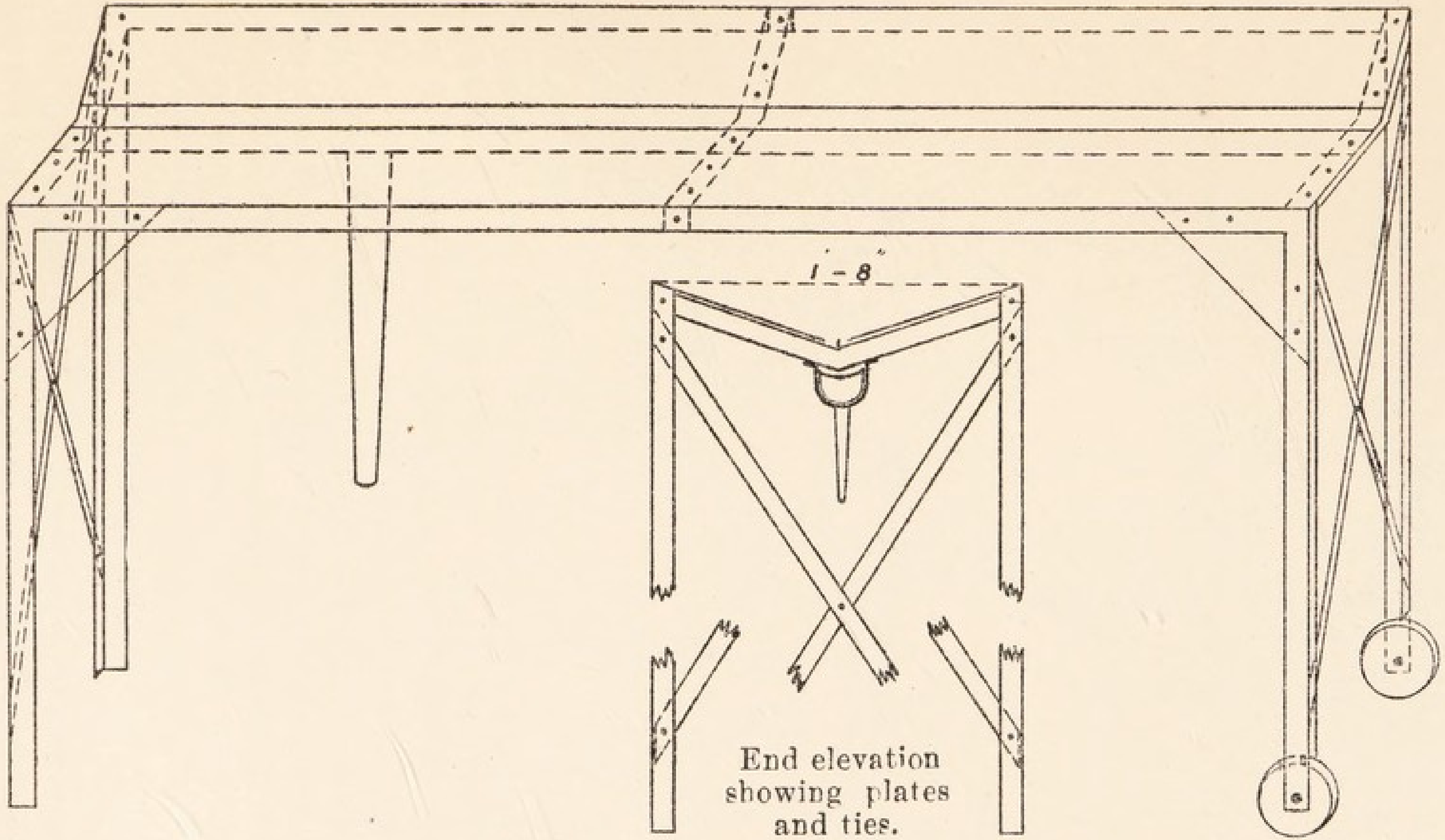
Operation table.—Height 3 feet to 3 feet 3 inches. Length 6 feet to 6 feet 3 inches. Breadth 20 inches. *This last is a fixed measurement.* Tables as a rule are made much too broad. 20 inches is ample for even a big man. On too broad a table the subject is apt to slip away from the operator, and to thus expose a large surface unprotected with towels. It is very tiring too to work with the arms extended, and in pulling the subject back into a convenient position the hands are liable to become infected, and the careful arrangement of towels upset and aseptic precautions spoilt.

Flat-topped operation tables answer the purposes of small or outdoor hospitals well. They are made like the ordinary iron bedstead of $1\frac{1}{4}$ inch angle iron and the legs and frame on one side being made out of one piece of iron, connected at the ends and centre by means of cross pieces with the frame of the opposite side. The top of galvanized sheet iron 1-16th of an inch thick is then riveted on to this frame, the edges exactly fitting it. For stability corner plates are fixed in the angles the legs make with the frame, and two cross connecting ties of flat iron 1 inch wide, join the upper end of one leg to the lower end of the opposite leg at either end of the table.

A self-draining table can be made on similar lines. The only difference is that the top, instead of being in one piece, is made of two plates, each $9\frac{1}{2}$ inches wide, sloping downwards towards the centre line to a point $1\frac{1}{2}$ or 2 inches below the horizontal line connecting their outer sides. The connecting pieces are bent to an obtuse angle for this purpose, and underneath the gap 1 inch wide between the plates along the whole length of the table, is suspended a semi-cylindrical drain of zinc sheeting, with a perpendicular waste pipe fixed at a point, some 18 inches from its foot end, which discharges fluids into a bucket placed underneath it. This table is perhaps more convenient for major operations in hospitals with indoor accommodation. A frame for placing the patient in Trendelenberg's position can easily be fixed on it, and slots can be added at the foot end for holding crutches for operations on the perineum. Figs. 9 and 10.

Tables.—Fixed height 33 inches. Dimensions of top may vary, 20 by 30 inches is a useful standard size. A second shelf below, at a distance of 18 inches clear, is a convenience. Frame and legs of $\frac{3}{4}$ inch angle iron, top and lower shelf of galvanized sheet iron $\frac{1}{32}$nd of an inch thick. Corner plates of sheet iron give extra stability. Fig. 12.

SELF-DRAINING OPERATION TABLE.



Figs. 9 & 10.—Height, 3′ to 3′ 2″. Length, 6′. Width, 1′ 8″. Each plate $9\frac{1}{2}''$. Opening between 1″. Legs and frame $1\frac{1}{4}''$ L iron. Ties **1″** flat iron. Plates, $\frac{1}{16}''$ galvanized iron. Frame and legs, enamelled white. Detachable zinc drain underneath.

Curved instrument tables are very convenient for the operator. All articles lie immediately under his hand as he sweeps it round in search of anything. Two such tables as are about to be described, with their front ends parallel with the operation table, and their inner corners touching behind him completely cut him off from undue crowding.

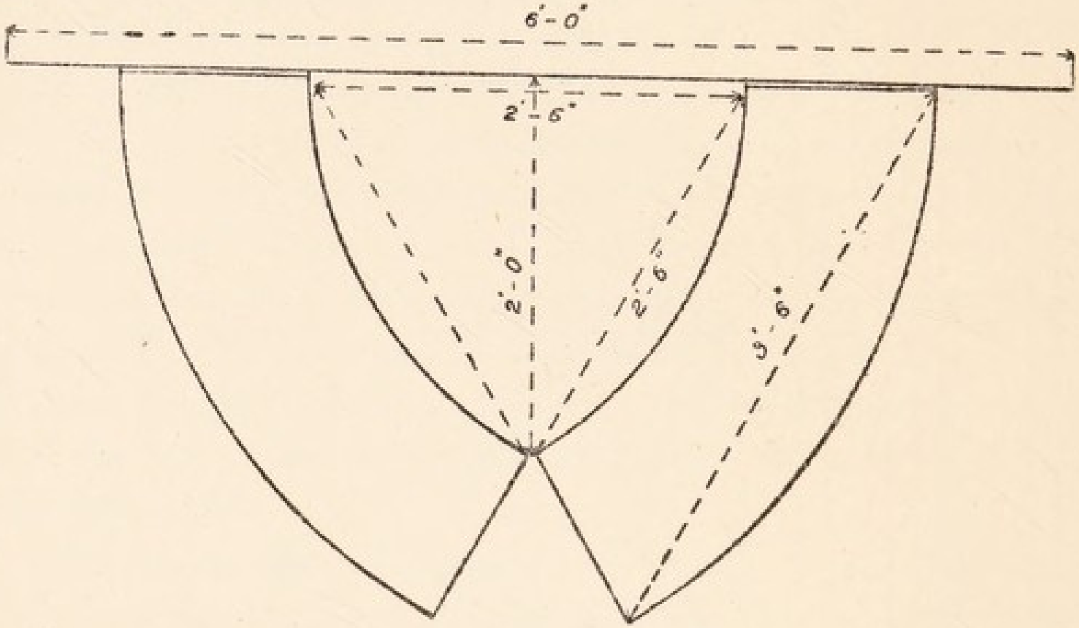


Fig. 11. Plan of 2 tables arranged for operation.

DIMENSIONS.—Height 33 inches. The top 13 inches wide is the outer segment of a circle with a radius of 3 feet 6 inches. Distance in a straight line across the top between the back corners 3 feet 6 inches; between the front corners 2 feet 6 inches. A second shelf below is unnecessary but can be added, if desired. Frame and legs of $\frac{3}{4}$ inch angle iron, top $\frac{1}{32}$ inch galvanized sheet iron. A fifth leg in the centre of the back or outer curve gives greater stability, an opposing leg to this is only in the operator's way. Its absence is compensated for by a triangular plate fastened underneath the centre of the table, and fixed to the back central leg for a depth of 12 inches (very similar to the centre-board of a sailing boat). Corner plates and a tie of $\frac{1}{2}$ inch flat iron connecting the legs at the ends and along the outer curve at a height of 6 inches from the ground complete the table. The front is open, a tie here is only in the operator's way. Fig. 13.

Instrument cabinets vary greatly, the following dimensions will be found generally suitable. Fig. 15.

Height 4 feet 6 inches. Breadth 2 feet 6 inches. Depth 16 inches. Contains three removable shelves, 8 inches apart, besides the

INSTRUMENT TABLE.

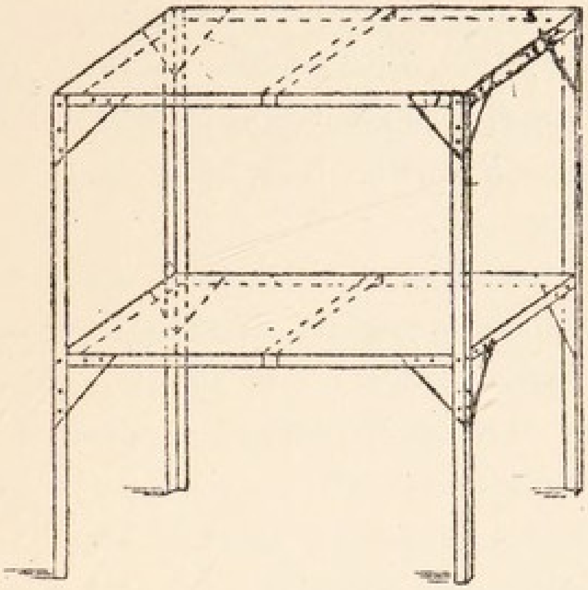


Fig. 12.

Height, 33″. Top, 20″ × 30″. Legs and frame, $\frac{3}{4}$″ L iron. Top, shelf and plates, $\frac{1}{32}$″ galvanized iron. Frame and legs white enamelled. Interval of 18″ between shelves.

CURVED INSTRUMENT TABLE.

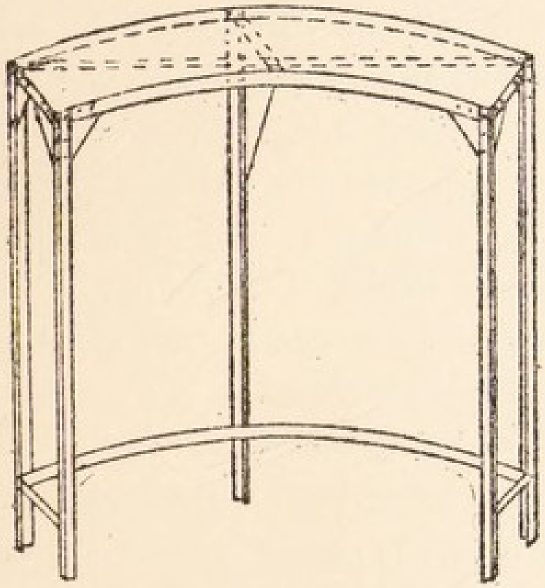


Fig. 13.

Height, 33″. Top, 13″ wide.

Outer curve segment of circle radius, 3′ 6″. Frame and legs, $\frac{3}{4}$″ L iron. Ties, $\frac{3}{4}$″ flat iron. Top, $\frac{1}{32}$″ galvanized iron. Triangular plates at corners and below. Frame and legs white enamelled.

BEDSIDE LOCKER AND TABLE COMBINED.

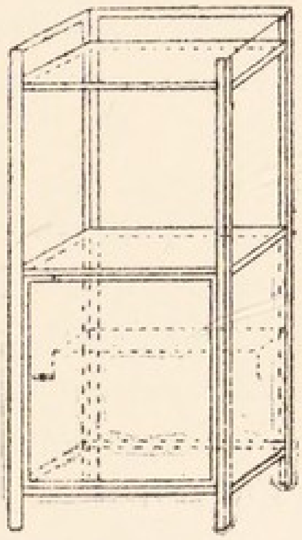


Fig. 14.

Height, 33″. Cupboard 15″ cube $\frac{1}{2}$ shelf inside. Interval of 12″ between shelf and top of cabinet. Space above and below 3″. Frame and legs, $\frac{3}{4}$″ L iron. Shelves and sides, $\frac{1}{32}$″ galvanized iron, or wire gauze sides. Railing $\frac{1}{2}$″ flat iron.

floor. Below this again is a separate shelf with door forming a subsidiary locker or cupboard for dressings, towels, etc. Frame $\frac{3}{4}$ inch angle iron, legs or uprights $1\frac{1}{4}$ inch angle iron. Side shelves and doors $\frac{1}{32}$ inch galvanized iron. The shelves must be stiffened underneath with strips of $\frac{1}{2}$ inch flat iron. Corner plates as above described.

A smaller cabinet or locker which will serve the purpose of a bedside locker or dressing cabinet, is as follows :—Fig. 14.

Height 33 inches. Breadth and depth each 15 inches (*i. e.*, 15 inches square). Locker 15 inches cube (with a central shelf) is so fixed that its lower frame is 3 inches clear of the ground, while 12 inches above its top is fixed a shelf of sheet iron. The upper ends of the legs are connected with a bar of $\frac{1}{2}$ inch flat iron, at the back and sides thus forming a railing round the top shelf. Frame $\frac{3}{4}$ inch angle iron, sides, etc., $\frac{1}{32}$ inch galvanized iron or gauze.

Chloroformist's and operator's *stools and footstools* can be constructed of $\frac{3}{4}$ inch angle iron legs and frames, and tops of $\frac{1}{16}$ inch galvanized iron on exactly similar lines to ordinary wooden stools.

Basin or Chilumchee Stands.—Height 33 inches. These can be very readily made with three or four legs of $\frac{3}{4}$ inch angle iron, connected at the top with a circular band of $\frac{1}{2}$ inch flat iron, and stiffened with cross ties of flat iron arranged diagonally 6 inches from the bottom. Such stands can be made of any diameter to suit any sized basin, and are very light, strong, and simple. One or two smaller basins can be placed at intervals of 12 inches below, resting on small projections for the purpose.

Wallstands or Shelves.—A most useful piece of furniture the utility of which is hardly sufficiently appreciated. Height $4\frac{1}{2}$ feet. Breadth 3 feet 6 inches. Three shelves, the upper one, 8 inches wide, the two lower ones, 14 inches wide. Clear interval of 18 inches between each shelf. The upper shelf is fixed 3 inches below the top of the uprights and a small railing of $\frac{1}{2}$ inch flat iron encloses it on three sides. Fig. 16.

Uprights of 1 inch angle iron, frames of $\frac{3}{4}$ inch angle iron. Shelves of $\frac{1}{32}$ inch galvanized sheet iron. A centre leg or upright of 1 inch flat iron behind with corner plates of sheet iron give stability.

COMBINED INSTRUMENT CABINET
AND DRESSING LOCKER.

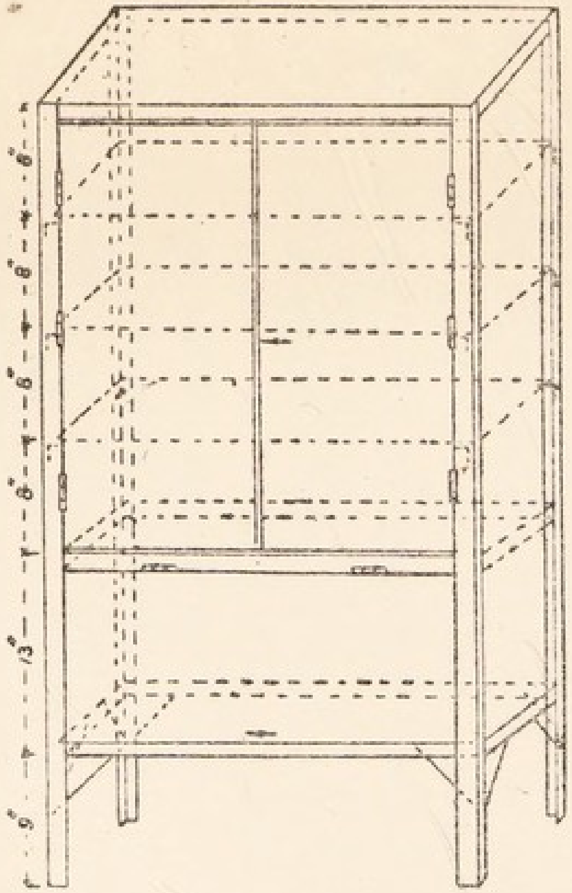


Fig. 15.

Height, 4′ 6″. Depth, 1′ 4″. Width, 2′ 6″. legs $1\frac{1}{4}''$ L iron. Frame $\frac{3}{4}''$ L iron. Plates $\frac{1}{32}''$ sheet iron.

WALL STAND.

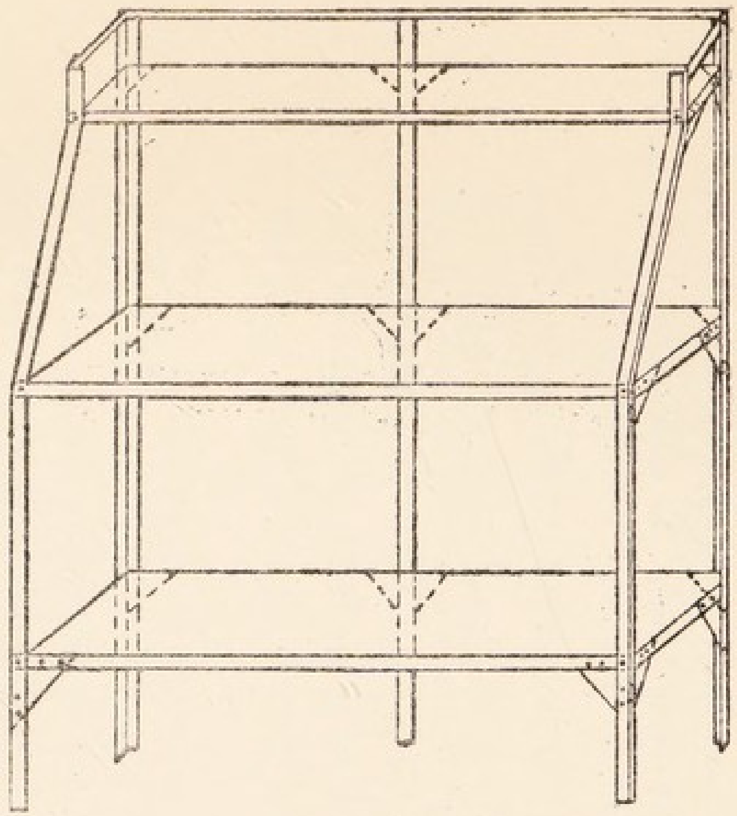


Fig. 16.

Height, 4′ 3″. Width, 3′ 6″. Top, 8″ deep. Lower shelves 14″ deep. Legs 1″ L iron. Frame $\frac{3}{4}''$ L iron. Shelves, $\frac{1}{24}''$ galvanized iron. Frame and legs white enamelled.

Douche Stand.—The following simple stand answers the purpose of more elaborate contrivances. In form it is merely an elevated stool, with a second shelf halfway up, for the vessel in which the nozzle of the douche lies. In appearance it closely resembles a flowerpot stand.

Height 5 feet 9 inches. Top 6 inches square. Second shelf 8 inches square, halfway between the top shelf and the ground. The increased size of this shelf allows for the "spread" of the legs and confers greater stability. A third shelf can be added, if desired, at a clear interval of 18 inches below the central one. Frame and legs of $\frac{3}{4}$ inch angle iron, shelves of $\frac{1}{32}$ inch sheet iron.

Though a little foreign to the subject in hand, I take this opportunity of describing a very cheap, comfortable and serviceable surgical bed known as the Alipore pattern bed; it is simply the ordinary angle iron bed with a woven galvanized iron wire mattress, in place of the usual crossbands of thin flat steel. The wire netting is first woven on a wooden frame a little smaller than the bed for which it is intended, and then fastened to the under surface of the bed frame with screws and nuts, securing a tie of $\frac{1}{2}$ inch flat iron to the frame, the edge of the wire net being caught between the two. Finally the curved angle iron strut is placed in position underneath, which forces out the sides of the bed frame and gives the necessary amount of tension. The strain on the wire is great, and it must not be less than $\frac{1}{16}$th of an inch in diameter, $\frac{1}{14}$th is stronger. Thick mattresses are unnecessary with such beds—a durrie is all that is necessary; they do not easily harbour vermin, and are readily rid of them if they do; in more ways than one they thus lend themselves to cleanliness. Existing beds with angle iron frames can be converted at small expense to this pattern. White enamel gives a much brighter and cleaner appearance to beds in a surgical ward than the tar with which they are frequently coated. Previous to painting old beds, *the tar should be burnt off.* Scraping is both tedious and unsatisfactory; it is impossible to remove it by this means where the surface is uneven, and the paint is discoloured in consequence, wherever any traces of it remain.

CHAPTER VI.

Antiseptic Agents.

Before considering the preparation of articles for surgical use, it may be well to discuss the means of doing so ; antiseptic agents have been briefly alluded to before, but as they have their limitations in use their action and application may be given in greater detail.

Physical antiseptics. Heat.—For surgical purposes this is most easily employed in the shape of boiling water, or the moist heat of steam. The temperature of boiling water, *viz.*, 212F. or 100C., will kill the pyogenic cocci in five to ten minutes. In practice ten minutes is sufficient for the sterilization of instruments, swabs, towels, or saline solutions for immediate use, but water intended to be stored for use after some time, must be re-boiled again after the lapse of some hours, to ensure its sterility.

Instrument sterilizers are simply receptacles for boiling instruments ; they are made in many patterns, of various materials, enamel iron or zinc are as suitable as any, but a cheap sterilizer which will answer all requirements, can be improvised from an old kerosine oil tin in the bazaar. Its essential points are that it should be long enough to hold any instrument lying flat at full length, and deep enough to ensure that, when it is two parts full of water, the instruments are covered by water at all points. A fairly close fitting lid is an advantage, as it prevents boiling over, and by preventing the free escape of steam to a limited extent raises the pressure, and also

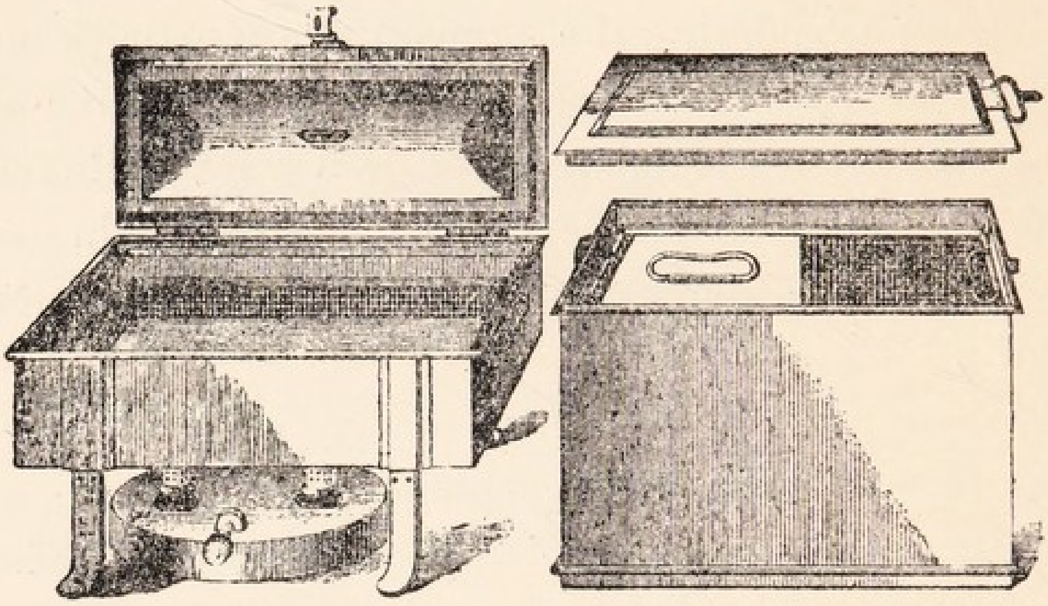
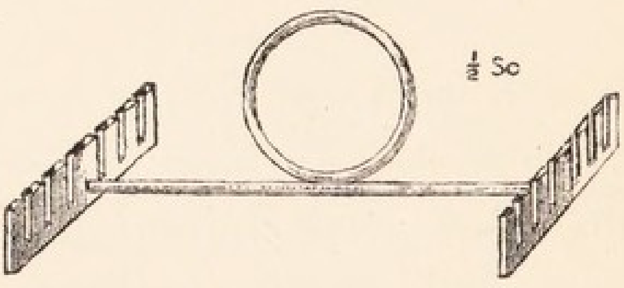


Fig. 17 (a). *Fig. 17 (b).*

COMBINED STERILIZER FOR INSTRUMENTS AND DRESSINGS.

The lower part is used for sterilizing instruments in soda solution, the upper part is perforated at the bottom and is made to fit the lower; the dressing and bandages are placed in the bandage boxes, and after being sterilized by the steam may be removed and kept in boxes until required for use.

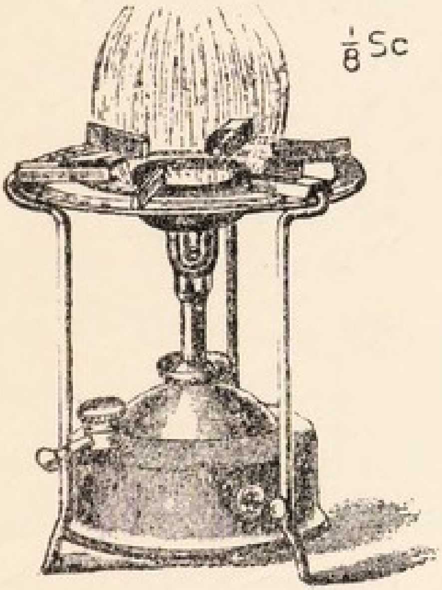
Fig. 17 (c).



Rack for Knives for use in sterilizer.

the boiling point of water; there should, however, be a small outlet for steam. The lamps supplied with sterilizers usually burn methylated spirit, and frequently do not give out enough heat, the best lamp for the purpose is a "Primus" kerosine oil stove, which is powerful and economical in use. For economy in time and oil it is well to have two or three sterilizers of different sizes: a large one for amputating knives and saw, 16ins. by 8ins. by $3\frac{1}{4}$ins., a medium sized one for minor operations, 12ins. by 6ins. by $2\frac{1}{2}$ins., and a small one for eye instruments, 7ins. by 5ins. by $1\frac{1}{2}$ins. A perforated tray with projecting handles and a separate pair of T-shaped wire hooks or lifters is a great convenience in a

Fig. 18.



Primus Kerosine Oil Burner.

sterilizer, by means of it all instruments can be at once lifted out together after boiling, and placed in cold lotion. For boiling towels a fair sized dekchie is as convenient as anything, while for boiling swabs a small saucepan, of enamel iron, is the handiest thing possible ; the excess of water is easily poured off, and the swabs can then be tipped into cold lotion.

In sterilizing instruments in actual practice, the water should be boiling briskly before the instruments are placed in it, both to ensure that they are boiled for a full ten minutes, and also because any air that the water may contain is driven off by preliminary boiling, and the rusting of steel is thus minimized. It is an excellent plan, also, to dissolve some commercial carbonate of soda, commonly known as "washing soda," in the water. This has three advantages, it prevents (1) the rusting of steel instruments, and (2) the blackening of plated instruments in hard water, and (3) a boiling alkaline

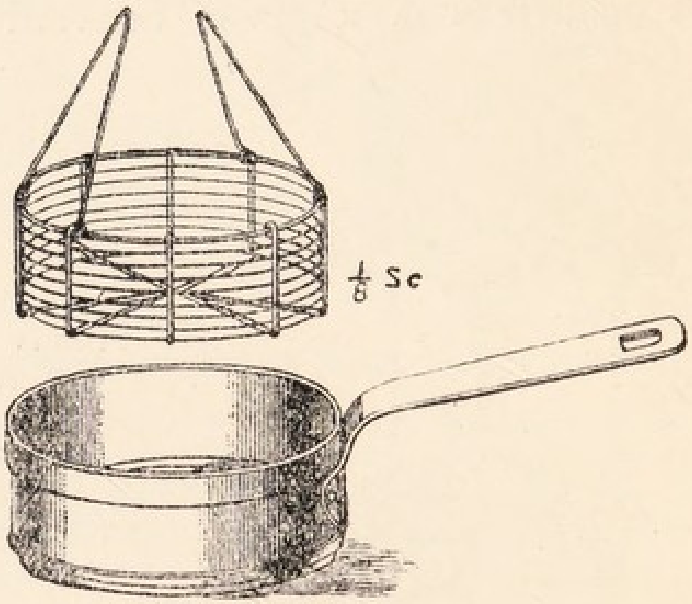


Fig. 19.

Saucepan for swabs with wire cage.

solution is far more actively germicidal than plain boiling water. It has been proved that the pyogenic cocci, though more resistent than many bacteria, are killed in five minutes by boiling in a 1per cent. solution of carbonate of soda, which apparently acts by dissolving their chitinous envelope, and thus exposing them freely to the heat. Even anthrax spores are rapidly devitalized, though they are almost the most resistent known. A further advantage is that any fatty or greasy particles adhering to the instruments are completely removed. One and a half drachms to the pint of water, makes roughly a 1 per cent. solution, and this is sufficient. Bicarbonate of soda may be substituted, but is not so active. Prolonged boiling takes the keen edge off knives; to prevent this the blades of scalpels may be wrapped in lint or some cotton material, or they may be dipped into pure carbolic acid cyllin or lysol for one minute, in preference to boiling them. It should always be borne in mind, that instruments after being sterilized by boiling in this way, may be immediately re-infected by contact with dirty hands, or other contaminated objects.

Steam.—This has been shown by Koch, Klein, and others to be a more active germicidal agent than plain boiling water, though some doubt has been thrown on the experiments of the latter even, that anthrax spores are destroyed by exposure to it at a temperature of 212F. under ordinary atmospheric pressure in fifteen minutes, while Koch's conclusions who found five minutes sufficient if the exposure was complete are still more doubtful. The non-sporing bacteria, including the pyogenic cocci are much less resistent to it, and are killed with certainty, in ten minutes, and probably in a much shorter time if the exposure is complete. Under pressures greater than that of the atmosphere steam probably acts more rapidly, but whether this is due to its greater degree of saturation, or to the greater ease with which it penetrates is doubtful. Articles removed from superheated steam come out dry; if the steam is merely saturated, a certain degree of dampness is present. This from a surgical standpoint does not matter, and this more or less complete dryness is a practical

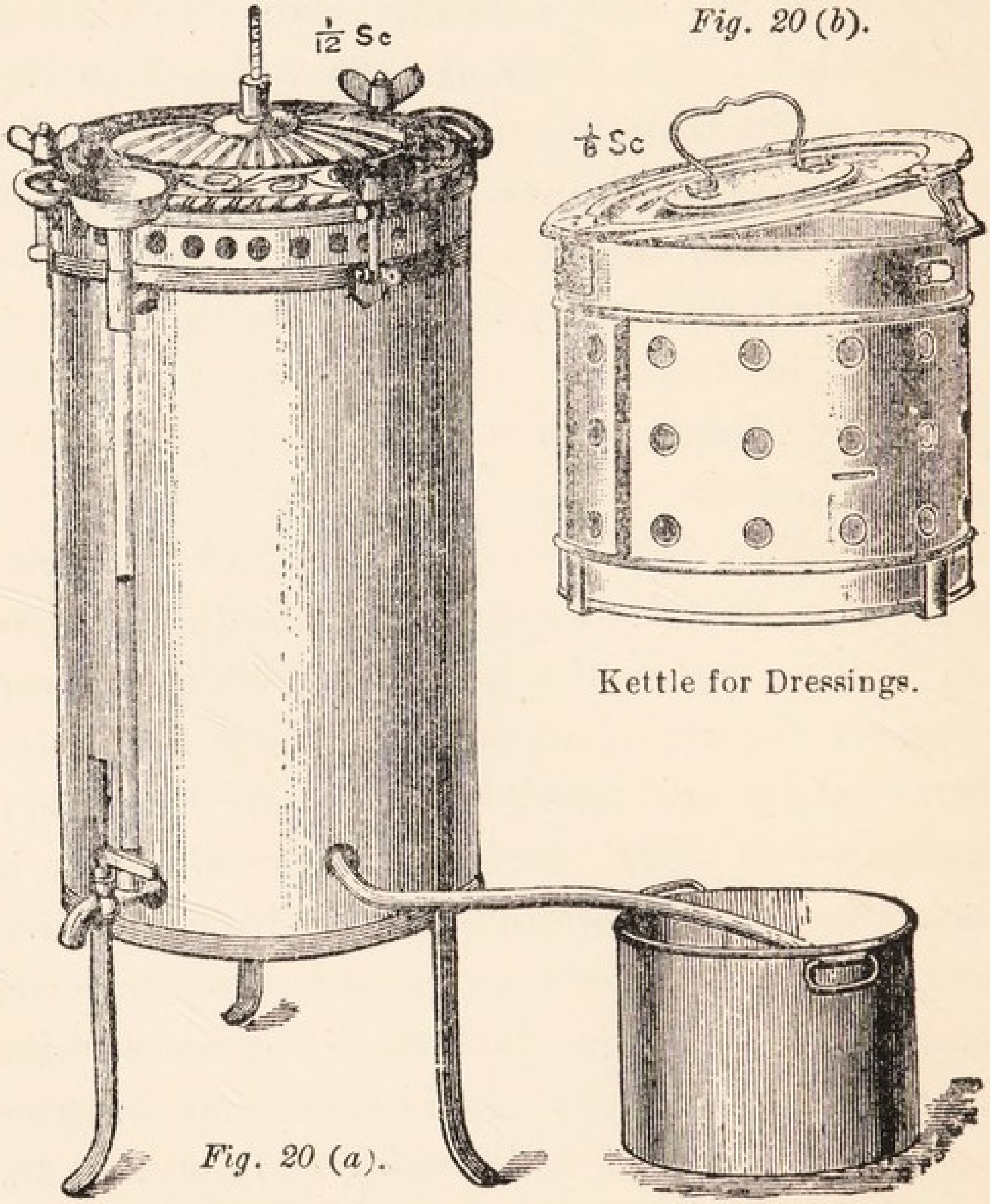


Fig. 20 (b).

Kettle for Dressings.

Fig. 20 (a).

Schimmelbusch's Steam Sterilizer for Dressings, Towels, etc.

convenience and an advantage that steamed articles have over articles sterilized by boiling, which, of course, are dripping wet.

To permit of the thorough access of steam to all parts of the fabric to be sterilized, the air that it contains must be driven off first, which means that in practice when using a low pressure sterilizer, an appreciable time must be allowed to ensure of this, and therefore articles must be exposed in the sterilizer for a much longer time than ten minutes. A good rule is to allow at least ten minutes to bring the water to a brisk boil, ten minutes to permit of the thorough saturation and penetration of the steam, and ten minutes more for thorough exposure of the articles to be sterilized to its action, or half an hour in all, which, however, is a minimum. This is not a rapid process, but is necessary with the simpler forms of sterilizers within the means of smaller hospitals. More expensive ones with special contrivances for creating a vacuum, and constructed to withstand higher pressures, act more quickly of course, but are proportionately costly.

In packing a sterilizer with articles to be disinfected, they must not be rolled tight, and a little space should be left between each package, this greatly facilitates the thorough penetration of the steam ; another point to remember is that swabs and dressings should be enclosed in separate bags or wrappers ; they can then be removed or handed up to the surgeon without being touched by hand.

In large and well equipped hospitals with a system of steam pipes, it is the simplest matter possible to sterilize with steam, and has much to say to the vogue which antisepsis in this way has acquired of recent years.

The simplest form of steam sterilizer is a metal box, with a false bottom lined with wire gauze, which fits on to the instrument sterilizer. It is, of course, a very low pressure one, and in use must be allowed to boil for at least twenty minutes after the instruments have been removed from the water beneath. The vertical sterilizers in common use, consist in their simplest form of two cylinders with the lower end closed, one fitting inside the other in such a way that there is a space between the two for the reception of the water to be boiled. The inner cylinder is open at the top, while the outer one is closed when in use by a tight-fitting lid. There is a pipe for the escape of steam from the bottom of the inner cylinder. In use the steam generated from the water in the space between the two cylinders, heated by a lamp below the outer one, passes over the top of the inner one, down through its contents and out by the pipe into a bowl of cold water which condenses it. In more elaborate patterns the waste steam after circulating in this way, is automatically condensed and returns as water to be boiled over again, thus obviating the necessity of replenishing the water after the process has been begun. Taps and valves for raising and regulating the pressure can also be introduced, and an outer cylinder of asbestos is a useful addition for maintaining the heat of the sides of the outer cylinder, and thus superheating the steam. This all means extra expense and necessitates some more or less skilled attention in using them. If desired such sterilizers are supplied with kerosine lamps in place of the usual gas burners.

A steam sterilizer is not a necessity as excellent results can be obtained without one, but it is a great convenience in practice. It is best used to asepticize articles at leisure, which can then be stored in airtight receptacles against the time they are needed for use. Kettles to fit the sterilizer for placing articles to be sterilized in, can also be obtained. After removal from the sterilizer they can be closed. Articles thus disinfected are immediately re-infected by contact with contaminated objects, and during an operation it is well to maintain the condition of asepsis thus produced, by wetting towels and other articles exposed to the air with antiseptic lotion. In the absence of a steam sterilizer, asepsis of fabrics must be attained by boiling or the use of chemical antiseptics.

Dry heat is of little practical use in surgery. It takes a much longer time to act than moist heat particularly on spores, and has to be applied at far higher temperature than the boiling point of water. A typical example of the use of this form of heat is the sterilization of the catgut in cumol, xyol, etc., and even the heat of boiling water or steam must be considered to be dry heat unless they get *full* access to the structures or fabric exposed to them.

The intense heat of fire is the most efficient and rapid germicidal agent known, but its application is very limited. Though steel is damaged by it, platinum or irido-platinum instruments may be at once sterilized in the flame of a spirit lamp without injury to them. For the destruction of infected dressings or infective discharges, there is nothing so certain as fire, and a destructor in which they can be burnt is an invaluable article of hospital equipment, otherwise they should be burnt in the ordinary way.

The limitations of moist heat as an antiseptic agent may be summarized as follows :—(1) that it requires a definite time to act, and (2) that this action ceases the moment articles are removed from it. They would hardly seem worth mentioning, but there is a tendency in practice to disregard them. The immersion of an instrument for a few seconds in boiling water, is apt to be looked on as sufficient, and dressings once sterilized are also apt to be considered sterile for an indefinite period, no matter what dirty objects they may have touched in the interval.

Chemical antiseptics.—There are a great variety of these in constant use, which have stood the test of experience, and their number is daily being added to. They act in various ways ; some by their directly poisonous effect on bacterial life, others by their chemical action on the media in which bacteria flourish. The more direct their access to the bacteria, the more certain their action, anything which prevents this curtails their utility. In the presence of gross dirt, and particularly of fatty or greasy particles, most of them are practically inert, or at all events, are very much impaired in activity. Before employing them then, there is a substance which prepares the ground and which should always be used beforehand, it is therefore mentioned first, to give it the position it should occupy in actual practice. This is nothing more nor less than *soap*.

The detergent and cleansing properties of soap, depend on its action in emulsifying fats. Chemical antiseptics act feebly if at all in the presence of grease or fat, and watery solutions of them, have no greater solvent effect on grease or gross dirt, than that of the water in which they are dissolved ; it is a matter of every-day experience the solvent power of cold water is very small indeed. To give antiseptic agents a fair chance of acting, then it is *imperative* to remove as far as possible all gross dirt first, by the free use of soap. *The importance of this mechanical cleansing cannot be too much insisted on.*

But in addition to its mechanical action, soap possesses definite, though mild, antiseptic properties of its own. When used in the ordinary way, this action is too feeble to produce any decided antiseptic effect, as the solution is too dilute, and the time of contact too short. The commoner kinds of soap contain an appreciable quantity of free alkali, this so far from interfering with their usefulness, aids it, as the alkali saponifies fatty particles. The alkaline basis of hard soaps is soda, of soft soaps potash, and soft soap is particularly useful on account of its greater solubility, and the excess of alkaline salts that it contains.

Soft soap made with olive or linseed oils, generally known as "green" soap, is largely used by many experienced surgeons. The cheaper kinds of toilet soaps ordinarily obtainable in the bazaar, are very inferior to good household or bar soap, on account of their insolubility. The dearer toilet soaps, too, are not suitable for surgical purposes, as they are frequently "superfatted," besides being very carefully neutralized. Certain soaps containing pumice stone in fine powder, are especially useful for cleaning instruments, as they polish the metal in a way that ordinary soap cannot do.

There are also many medicated soaps on the market, with much vaunted properties ; many are unreliable because the antiseptic is present in far too small a quantity, others because it is not soluble in water or is easily decomposed. Probably reliable medicated soaps are biniodide of mercury and potash soap, containing from 1 per cent. to 3 per cent. of the antiseptic, cyllin hard soap containing 15 per cent. of cyllin and carbolic soap containing not less than 10 per cent. of carbolic acid.

Phenol or carbolic acid deserves mention first, as it was the antiseptic originally used by Lister, and has maintained its position to the present day. In a pure state it consists of fine white crystals, turning red on exposure to air. It has a great affinity for water, forming an oily-looking hydrate, but when more water is added to this, it only dissolves to the extent of 1-15, and floats on the surface. To make a solution, hot water must be added in small quantities at a time, and thoroughly shaken after each addition. Its advantages are cheapness and accessibility, and the fact that it does not damage steel or plated instruments. Its disadvantages are its volatility, toxicity if absorbed in excess, and its corrosive and irritating properties in a pure state or strong solution, on the skin and tissues. Impure forms are more soluble, more toxic, and more irritating than the pure acid. In a watery solution of 5 per cent. strength, or 1-20, it is said to destroy the pyogenic cocci in 5 to 10 minutes, provided of course, that it gets full access to them. Acidulated solutions with 1 per cent. hydrochloric acid are more active than ordinary aqueous ones. In weaker solution it has a decided inhibitory though feeble germicidal action. It combines readily with oil and glycerine, but such solutions are practically inert, and carbolic oil, though so frequently used, has no antiseptic action at all, and should not be used. Solutions in pure glycerine are almost inert, but an aqueous solution of glycerine has antiseptic properties. It may here be noted that sterile pure glycerine or boroglyceride may be used as a lubricant in place of oil pure or carbolized. At the present time, carbolic acid is not much used in the preparation of dressings, or as a lotion to irrigate wounds to any extent, but as a lotion for immersing the hands, and keeping instruments in during operations and for storing ligatures, sponges, etc., it is still employed. In very septic conditions, such as carbuncle, pure carbolic acid is valuable for its corrosive and powerfully antiseptic action. It may be usefully replaced in most instances by the preparations of higher distillates of tar mentioned below.

Mercury salts.—Perchloride of mercury, or corrosive sublimate, is one of the most powerful antiseptics that exist. Its advantages are cheapness and accessibility. Its disadvantages are its poisonous and irritating qualities and its instability in the presence of albuminous and alkaline fluids ; with the former it combines to form a practically inert albuminate of mercury and it is immediately decomposed by the latter into the inert oxide. It is also irritating to the tissues in strong solutions, and damages steel and especially plated instruments. Solutions of 1-500 or 1-1000, destroy the pyogenic cocci in a few minutes, and though spores resist its action longer, it has a powerful inhibitory action on their growth, even in such weak solutions as 1-10000. For irrigating wounds, no stronger solution than 1-2000 should be used, and 1-5000 or more is safer. Dressings prepared with it are fairly efficient but apt to irritate the skin, if there is much discharge. The addition of 1 per cent. hydrochloric acid, prevents to a very great extent its precipitation by albumen and consequently increases its antiseptic power. The addition of an equal part of ammonium chloride, to a solution of mercuric chloride, also renders it more stable, a double salt ammonio-mercuric chloride (sal-alem-broth) being formed, which is very soluble, but irritating. As the germicidal action of corrosive sublimate depends on its chemical decomposition, it is doubtful if this double salt can be so active ; on the other hand the activity of the unstable sublimate is greatly neutralized in practice by its ready combination with albumen. A lotion of 1-20 carbolic containing a 500th part of perchloride of mercury, familiarly known as "the strong solution" is used by some surgeons, for disinfecting the hands, and the patient's skin, it is, however, very irritating to some skins.

Mercuric iodide, or biniodide of mercury, a red salt, is made by the precipitation of corrosive sublimate with potassium iodide. It is insoluble in water, but soluble if an equal part of potassium iodide is added to it. A double potassi-mercuric iodide being formed. It is claimed to have twice the germicidal power of mercuric chloride, and is not decomposed with alkalies nor does it combine with albumen, to form an albuminate and is consequently less likely to be absorbed and less poisonous. In a solution of 1-500 of 70 per cent. alcohol, it may be used to disinfect the hands and skin. The soluble double iodide is obtainable in the form of solid pellets, under the name of "Iodic Hydrarg." It is probably the most powerful chemical antiseptic that exists and is used by many surgeons in place of sublimate lotions for washing the hands and irrigating wounds in the strength of 1-2000 or 1-4000. If the pure salt is not at hand, it may be readily prepared by adding iodide of potash to perchloride lotion, until the red precipitate formed is dissolved. But the resulting lotion is nearly twice as strong. Thus 1-1000 perchloride lotion treated with potassium iodide produces biniodide lotion 1-600, and must be diluted accordingly. It may well replace perchloride in the preparation of dressings and lotions, the only objection being its slightly greater cost (*vide* appendix to this chapter).

Mercuric cyanide is a powerful germicide, but too poisonous for use in surgery. Combined with zinc to form a double cyanide of zinc and mercury, it was introduced by Lister to prepare a gauze dressing. The composition of the salt which should contain 1 molecule of mercuric cyanide to 4 molecules of zinc cyanide, is somewhat variable, a fact which may impair its reliability in practice from a deficiency of mercuric cyanide. This double cyanide is quite unirritating, and though feebly germicidal only, has a very powerful inhibitory action on bacterial growth. As a dusting powder after the completion of an operation, before the application of the dressings, it is of definite value, on account of its inhibitory action.

Izal.—This is a proprietary preparation, of definite antiseptic value. In appearance it is a yellowish brown fluid, and when mixed with water, in which it is insoluble, it forms a milky white emulsion.

It is sold in the pure state, and also in emulsion, containing 40 per cent. of pure izal. In composition a mixture of various complex bodies, it contains a large percentage of the higher phenols. It is made from the tarry oil which condenses in the process of carbonizing coke in closed ovens. Its advantages are its stability and non-poisonous qualities, further it is unirritating in dilute emulsion, and does not damage steel. Lotions of izal, 1-400 destroy the pyogenic cocci in 5 to 10 minutes, and 1-1000 has powerful inhibitory powers.

Lysol.—This is also a proprietary preparation, and enjoys a great reputation in Germany, where it is made. It is a sherry brown, transparent, syrupy fluid, produced by mixing certain tar oils, with fat, and saponifying it with an alkali (carbonate of potash) in alcohol. It is therefore for all practical purposes, a liquid soap, and forms with water a clear frothing fluid. With hard water it gives a precipitate of lime salts, but its action is not impaired on this account. It is unirritating, in dilute solution not very poisonous and does not damage instruments. Its solutions are slightly sticky or soapy, and consequently adhere to the skin, which is an advantage in practice. In solution as weak as 0·3 per cent. or less than 1-300, it destroys pyogenic cocci, and a solution of 1-100 or less is therefore an efficient antiseptic.

Cyllin.—This new form of creolin, is in appearance a deep brown syrupy fluid with an empyreumatic odour and is a remarkably powerful antiseptic and disinfectant agent highly spoken of by many trustworthy authorities. It is apparently a combination of the products of the higher distillation of tar, with an alkali (soda) and possibly a fat. It is said not to contain cresols and readily forms a milky emulsion with water in any proportions. It is stable and even in strong solutions comparatively unirritating. It has been proved to be eleven times as powerful a germicide as carbolic acid, on the bacillus typhosus, and a solution of 1-500 destroys the pyogenic cocci in 5 to 10 minutes. One of the great advantages claimed for it is its non-poisonous qualities; this with its stability, unirritating properties, and high germicidal powers apparently render it one of the most reliable antiseptic agents obtainable. Solutions of 1-100 to 1-500 would appear to be most convenient in use.

Izal, lysol and cyllin are probably largely composed of the higher phenols or cresols as they are called. These are insoluble in water, and the method of preparation is designed to overcome this insolubility, by combining them with alkalis, or converting them in a very general sense into a soap, which renders them soluble or at all events miscible with water, in the form of a fine emulsion.

Boric acid is a feeble antiseptic with practically no germicidal and only mild inhibitory properties. It is unirritating, and mildly astringent, and on this account is useful where stronger but more irritating antiseptics are contra-indicated. It is of use in ophthalmic surgery, and dressings medicated with it, and applied moist have superseded the old-fashioned poultice. It is useful as a dusting powder both in a pure state and also when mixed with more actively antiseptic powders. Solubility 1-30 of cold water, 1-3 of hot water, and 1-4 of glycerine. Boroglyceride, a commercial preparation, made by dissolving boric acid in glycerine at boiling point, and heating till all excess of water is driven off, is a very convenient preparation, for general use. It is claimed to be tri-boro-glyceryl, that is it consists of equal parts of boric acid and glycerine, in close combination after some oxygen and hydrogen has been got rid of ; how far it again splits up into boric acid and glycerine when water is added to it is not known. The official glycerinum acidi borici is a somewhat similar preparation, containing roughly 1½ part of boric acid to 2½ of glycerine. The extensive use of boric acid in dressings, etc., is due to its inhibitory effect on saphrophytic micro-organisms, and though it is too feebly antiseptic to have much effect on pathogenic bacteria, this action is of any unquestionable value.

Iodine and chlorine are also powerfully antiseptic ; their uses will be referred to again. Chlorine in the form of hypochlorous acid is one of the most powerful agents known, killing anthrax spores in less than one minute. It is readily prepared by adding 1 per cent of strong hydrochloric to a 1 per cent solution of permanganate of potash, chemicals within the reach of all dispensaries. Its drawbacks are that it is readily decomposed and so rendered inert in the pre sence of easily oxidizable matter, and its staining properties. Thorough mechanical cleansing with soap and water should therefore precede its use, while the stain can be removed by washing in solutions of oxalic or dilute sulphuric acid.

Another mode of preparation designed to overcome these drawbacks is the addition of roughly 1 per cent of strong hydrochloric acid to a roughly 4 per cent solution of persulphate of ammonium. This must be allowed to stand for four days to admit of the formation of hypochlorous acid, oxidation taking place more slowly than in the permanganate solution. This solution is colourless and less easily decomposed by oxidizable organic matter. It remains active for several weeks. Its chief uses are the disinfection of sponges and the hands.

Nesfield has proved the reliability of free chlorine and iodine in rapidly sterilizing waters, and has prepared the necessary ingredients in the form of pellets, which should be of great practical use for surgical purposes.

Other antiseptic agents which act by virtue of their oxidizing powers are permanganate of potash, peroxide of hydrogen, and alphozone, the latter a patent preparation claimed to be powerfully antiseptic. Some few others will be mentioned later, when their special use is discussed.

Alcohol. Hardens animal tissues by the extraction of water for which it has a great affinity, and coagulates albumen. It used to be thought that any antiseptic properties that it possesses depend to a great extent on these qualities. It has come into prominence as an antiseptic on account of its use by certain surgeons in place of other chemical agents. Opinions as to its value as an antiseptic have varied greatly from time to time, and even now it is difficult to assign the place it should occupy. All observers from Koch onwards are agreed that it will not destroy anthrax spores even after an immersion of weeks, and it seems probable that the preservative action of absolute alcohol and rectified spirit has been confounded with, or mistaken for its antiseptic action. Tolerance, too, seems to be more easily established in the case of alcohol, particularly when in dilute solution, than with other germicidal agents ; this fact may explain to some extent the varying opinions as to its value.

The experiments of Leedham Green throw much light on the vexed question of its utility. He found that its germicidal powers were greatest when diluted to 70 per cent. ; below this percentage they varied directly with the extent of the dilution, and above this percentage inversely, until absolute alcohol has comparatively little germicidal power. 70 per cent. alcohol he found killed non-sporing bacteria in from 2 to 5 minutes, with the proviso that it had ready access to them, and he considers it more actively germicidal than 1-1000 solutions of perchloride and biniodide of mercury. Its action is further alluded to in Chapter VIII. It is too irritating for use in wounds in any thing like a strong and therefore efficient solution, and its cost is prohibitive if extensively used. This latter difficulty may be met by the use of methylated spirits, which is simply alcohol with 10 per cent. of methyl alcohol or wood spirit added, for manufacturing purposes only, to escape the necessity of paying excise duty. Methyl alcohol is also antiseptic. To make a 70 per cent. dilution, 30 ounces of water must be added to 100 ounces of methylated or rectified spirits, 25 and 75 parts are near enough in practice.

Iodoform.—A yellow crystalline powder, with a penetrating unpleasant odour. It was introduced and widely used on account of its supposed powerful inhibitory properties. It is not germicidal, and its inhibitory powers were much overrated; it has, however, some specific action on tubercular and venereal conditions. It was shown by Behring, that its beneficial effect is due to its action in combining with the toxins produced by pyogenic cocci, and rendering them inert, thus preventing general toxic conditions, and enabling the tissues to deal with the micro-organisms. Cadaverine or the alkaloid of certain sapropytic bacteria when injected into the tissues causes suppuration, but after mixture with iodoform this no longer took place. In septic wounds or conditions it is therefore of great value, though not for the reasons supposed when it was introduced. Its routine use as a dusting powder in aseptic wounds, is pointless if not actually harmful, yet as a dusting powder it has valuable sedative properties especially when the skin is irritated or inflamed. Severe toxic effects have followed its use in wounds, in excessive quantities. For use it should be asepticized by boiling in water, or by standing in 1-20 carbolic for 24 hours and then drying. Iodine in small quantities is liberated in wounds. Substitutes for iodoform, are aristol and calcium iodate, which depend for efficiency on the iodine they liberate on decomposition. Solutions of iodine are powerfully antiseptic, but their use is limited to irrigating septic cavities or wounds.

Formalin.—This is the commercial form in which formic aldehyde is obtainable; it is an aqueous solution, containing 40 per cent. of the gas. It has a very pungent odour and is irritating to the eyes, but is not poisonous. Solutions of 1 per cent. are said to kill the pyogenic cocci in 50 or 60 minutes. It has even a more powerful hardening effect on animal tissues (albumen and gelatine), than alcohol. Its uses in surgery are comparatively limited, and will be referred to later.

Glutol, amyloform, and iodoformin, are compounds of formaldehyde, with gelatine, starch, and iodoform, respectively, in the form of powders, and are intended for dusting septic wounds; formaldehyde, and iodine in the case of the last named, being liberated gradually as they undergo decomposition, in the wound.

General conclusions are difficult to draw, but the fact has been clearly established that there are several fairly reliable antiseptics, besides carbolic acid and mercurial salts. Carbolic has the great disadvantage of roughening the skin of the hands, and its toxicity is also a drawback. Mercurial salts share to a great extent in these disadvantages, and blacken the skin with regular or prolonged use. Of them biniodide of mercury is the most stable and consequently the most reliable in practice for use as a lotion, if the perchloride solution is used it should be acidulated with 1 per cent. hydrochloric acid. Izal, lysol, and cyllin are free from these objections to some extent, that is they are not irritating when used in solution or emulsion of suitable strength, though still powerfully germicidal. They may well supersede the use of carbolic acid for steeping instruments in and moistening towels and dressings, besides being less irritating, they are stable and non-volatile.

All antiseptics should be used in carefully measured dilution, and not in any haphazard way. There are many others, some of which are doubtless efficient, others by no means so in the strength in which they are recommended. In practice when a mild antiseptic is required, boroglyceride is most convenient, from its ready solubility in water, while boric lotion is rather troublesome to prepare. Substitutes for iodoform are chiefly valuable for the avoidance of the objectionable and penetrating odour of the drug.

For clearness and to avoid unnecessary repetition in coming chapters, the different solutions which may be used for different purposes are enumerated here. Solutions given under heads (*b*) and (*f*), will be termed "strong antiseptic lotions," (*a*), (*c*) and (*e*) "weak antiseptic lotions," and the use of these terms will imply that any of the solutions thus described may be employed indifferently for the purpose stated.

(*a*) For rinsing the hands during operation, and flushing the skin. Sublimate acidulated, salalembroth, or iodide of mercury solutions 1-2000 or 1-4000. Izal, lysol or cyllin 1-400.

(*b*) For sterilizing unboiled instruments. Carbolic 1-20, izal, lysol or cyllin 1-100.

(*c*) For immersing the instruments in, and moistening towels, or dressings, carbolic 1-40, izal, lysol or cyllin 1-400.

(*d*) For irrigating aseptic wounds, boric lotion 5-10 grains to the ounce, or boroglyceride 1 or 2 drachms to the pint.

(*e*) For irrigating septic wounds. Mercury lotions 1-2000 or weaker, izal, lysol, or cyllin 1-200 or weaker.

(*f*) Alcohol 70 per cent with or without mercuric biniodide 1-500 and the stronger solutions of carbolic, izal, lysol or cyllin can be used for storing articles in for preservation, also mercurial lotions 1-500 strength.

APPENDIX.

NOTE ON THE PREPARATION OF BINIODIDE OF MERCURY LOTION.

THIS can be made in two ways :—(1) by taking the pure salt and dissolving it in a solution of potassium iodide, or (2) by adding potassium iodide to a solution of mercuric chloride (sublimate or perchloride of mercury). The drawbacks to the first method are (1) that the salt may contain some mercurous iodide, which will materially alter the strength of the solution, and (2) that it is not generally stocked in dispensaries.

To make a 1-1000 solution of the mercuric iodide by the first method, the proportions by apothecaries' weight are, mercuric iodide 8·75 grains to 20 ounces of water, plus the necessary amount of potassium iodide to dissolve it, which is 6·5 grains roughly. This is at once obvious from a simple calculation based on the chemical formula and the atomic weights.

Thus, Mercuric Iodide + Pot. Iod. = Potassi-mercuric Iodide.

$$\underset{(454)}{HgI_2} + \underset{(332)}{2KI} = HgI_2, 2(KI).$$

As 454 : 332 : : 3·75 grains mercuric iodide : x grains of potassium iodide, which works out at 6·40 grains.

As a matter of fact in practice an excess of potassium iodide, does not matter, except on the score of expense, and is even advisable in tap or hard water. The soluble soloids containing 8·75 grains of the double salt, give with a pint of water a solution of 1-1,000 of biniodide, but a weaker solution of mercuric iodide, *viz.*, about 1-1700.

The second method of preparing it from a perchloride solution is simpler for dispensary purposes; but here a caution is necessary.

If a 1-1000 solution of perchloride is taken, and a sufficiency of potassium iodide is added, the resulting strength of mercuric iodide in solution (*not of biniodide*), is 1-600.

A simple calculation based on the chemical formula and the atomic weights, again shows this at once.

Merc^c. Chlor. + Pot. Iod. = Merc^c. Iod. + Pot. Chlor.

$$\underset{(271)}{HgCl_2} + \underset{(332)}{2KI} = \underset{(454)}{HgI_2} + \underset{(149)}{2KCl}.$$

As 271 : 454 : : $\frac{1}{1000}$ perchloride : the proportionate amount of mercuric iodide in solution, or (disregarding the units).

$$\frac{450}{270} \times \frac{1}{1000} = \frac{1}{600}.$$

(Of course an extra quantity of potassium iodide omitted in the above equation must be added to dissolve the mercuric iodide, but though necessary as a solvent it is disregarded in considering the germicidal strength).

The 8·75 grains of mercuric chloride taken (8·75 grains to 20 ounces of water = 1-1000) produce on the addition of potassium iodide an excess of mercuric iodide, by 5·8 grains, thus :—

as 271 : 454 : : 8·75 grs. : x grs. $\frac{450}{270} \times 8{\cdot}75 = 14{\cdot}58$ grs.

$14{\cdot}58 - 8{\cdot}75 = 5{\cdot}83$ grs.

In the same way to find the exact quantity of perchloride required to produce 8·75 grains of mercuric iodide (or 1-1000)

as 454 : 271 : : 8·75 grs. mercuric iodide, : x grs. perchloride,

$\frac{270}{450} \times 8{\cdot}75 = 5{\cdot}25$ grs. of perchloride.

We therefore arrive at the fact, that *to produce a solution containing 1-1000 of mercuric iodide*, an excess of potassium iodide must be added *to a solution of perchloride of mercury containing 5¼ grains to 20 ounces of water.* The exact amount of potassium iodide being 6·4 grains to form mercuric iodide, and 6·4 grains more to dissolve it when precipitated, or nearly 13 grains in all, *i.e., about 2½ times as much potassium iodide as perchloride of mercury.*

The dispensing formula, in approximately correct quantities is,

Ry. Hydrarg. Perchlor.	grs.	V.
Pot. Iodid.	„ grs.	XIII.
Aquae. ad.	oz.	XX.

Shake till a clear solution is formed.

Or, as the amount of iodide is negligible and the amount of perchloride only is of importance,

Ry. Hydrarg. Perchlor.	grs.	V.
Pot. Iodid.		q.s.
Aquae. ad.	oz.	XX.

Dissolve the former, and add the latter until the red precipitate is dissolved.

The following table may be useful for ready reference.

Hydrarg. Perchlor.	Water	Pot. Iod.	=	Biniodide containing Merc. Iod.
5 grs.	20 oz.	q.s.	=	1-1000
*10 „	„	„	=	1- 500
20 „	„	„	=	1- 250
50 „	„	„	=	1- 100
1 oz. 1 dram	„	„	=	1- 10 or 10%

* Is the strength of the official liquor, and is easy to remember and convenient as a stock solution. Anything stronger requires more careful dilution for use than it is likely to get. Solutions should be coloured red to distinguish them.

I have given this note *in extenso*, as there are great discrepancies in the various formulæ recommended. The name biniodide is strictly correct, but the strength is usually (not always) expressed in terms of mercuric iodide, the active ingredient. It is desirable that this should always be the case, for if the strength is (strictly correctly) stated in terms of biniodide, the strength of the active ingredient is reduced by more than a half.

The following formula for "Pixol," a cheap and easily prepared substitute for phenyle and allied compounds will be found useful for such purposes as flushing floors, placing in pus bowls, spittoons, etc.

Coaltar	... ...	3lbs.
Soft soap	... ...	1lb.

Mix thoroughly with a stick, and add slowly whilst stirring.

Caustic Potash	... ...	3½oz.
Water	... ...	36 „

For use 1 part with 19 of water= 5% pixol.

(Dispensing Made Easy. Sutherland. Modified.)

Its disinfecting powers are probably not great.

CHAPTER VII.

Preparation of Articles for Surgical Use.

A word of caution is necessary, before going into details. Before preparing any article for surgical use, the hands must first be carefully cleansed by one or other of the methods detailed in Chapter VIII. In the following pages it will be taken for granted, that this is always done as a matter of course.

Sutures and ligatures.—The most generally useful materials are silver wire, silk, horsehair, catgut, and silkworm gut. Silver wire of various sizes is a very convenient suturing material, both by reason of its strength and the ease with which it can be prepared. For use boiling it in the instrument sterilizer for 10 minutes, or placing it in strong antiseptic lotion for half an hour, is sufficient preparation.

Silk, which can be obtained in many sizes, is the most universally useful material, for both sutures and ligatures. It is easy to sterilize, and requires no special preparation, beyond thorough boiling. Its only objection in practice as a ligature, is that it is very slowly absorbed, and if it should become the focus of infection and set up suppuration, this continues indefinitely until the removal of the ligature. This, however, is not the fault of the material but of its preparation, or rather want of preparation. Sterile silk causes no irritation, even though it may lie in the tissues for weeks or months. Its careful preparation is therefore a matter of the first importance. A satisfactory plan in practice, is to boil it for half an hour in hanks, as it is received from the makers, next to wind it on the glass reels of the

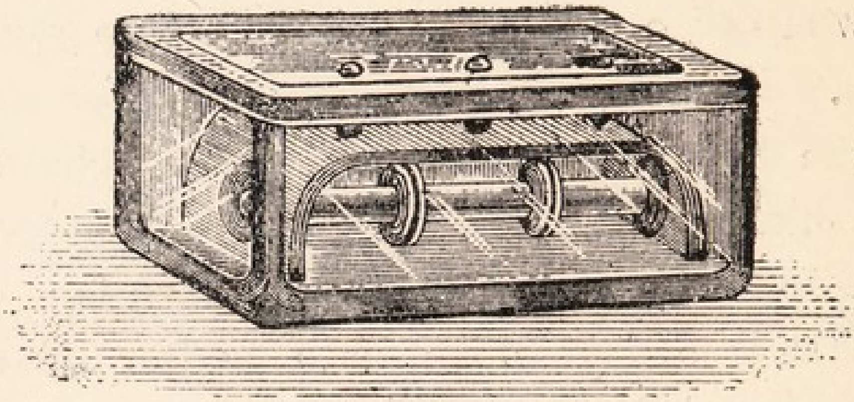


Fig. 21.
Glass ligature holder with 3 reels.

ligature box, and boil it again for at least 10 minutes. The reels should then be stored for use, in some strong antiseptic lotion, but if carbolic is used, it must be changed occasionally. This plan is very simple and efficacious, if it seems desirable it can always be boiled afresh with the instruments, before use. Too frequent boiling, however, or boiling in alkaline solutions is apt to make it rotten, and weaken it too much for use.

Horsehair should be sterilized by boiling or by prolonged immersion in some antiseptic solution. It is ideal suturing material for small or superficial wounds on account of its non-absorbent qualities, and is particularly useful in out-patient practice. Unless it is properly sterilized, however, it will cause stitch abscesses.

Silkworm gut is preferred to silk by some for sutures. In spite of its hard and apparently unabsorbent texture, it is by no means so safe as it may look at first sight. Water does not easily penetrate it and the heat of boiling water must therefore be regarded as dry heat, and applied for a considerable time, *i.e.*, not less than half an hour. The gut sold by the makers as sterile stored in absolute alcohol is by no means safe, and it must always be sterilized afresh for use. It may be stored for use in strong antiseptic lotion, or in 70 per cent. alcohol preferably with a 500th of biniodide of mercury added.

Catgut is a very convenient material for ligatures on account of the ease with which it is absorbed in the tissues and it was originally introduced on this account. It is composed of the submucosa of sheep's entrails, twisted into the form of a cord, which is then oiled and polished for use. It is obviously a very septic material before it is thoroughly sterilized, and this process is rendered the more difficult by the fact that it cannot be boiled without destroying it. Being composed of soft animal tissue it is readily penetrated by leucocytes, and disappears from a wound in a very short time, and has on this account to be hardened for use; it is not therefore—if in the first instance sterile—so likely to become a secondary focus of infection as silk which remains in a wound indefinitely.

The difficulty of sterilizing it is evident from the number of ways which have been suggested. Lister, to whom its wide use is largely due, first kept it in carbolized oil after hardening it in a solution of chromic acid, and this is one of the forms in which it is frequently issued by the makers, even at the present day. Apart from the fact that an oily solution of carbolic acid has no antiseptic action it is very inconvenient for use, as the oil must first be got rid off by washing with soap and water and immersing in ether, before sterilization is effected. It should, of course, never be used in this oily condition; it is impossible to tie ligatures tightly in the first place, while the evils of oily or greasy substances in surgery have already been pointed out. It is mentioned only to condemn it.

A better form is Lister's dry sulpho-chromic catgut prepared and hardened in a solution of sulphurous and chromic acids. The hardening process also disinfects it but perhaps not quite thoroughly, at all events it should never be used in its dry state as it is received from the makers, but should be stored in carbolic acid lotion 1-20 for at least one week before use, a day or two is not long enough for safety, and the lotion should be changed once or twice a week. Carbolic acid has certain hardening properties and the gut keeps fairly hard in this solution; if it has a tendency to become soft this may be corrected by the addition of a little chromic acid 1 per cent. or $\frac{1}{2}$ per cent. of formalin. Alcohol 70 per cent. may be used in preference, with a 500th of mercuric biniodide for greater safety.

Other quicker ways of sterilizing catgut are heating it in alcohol (Jellet) in xylol, (Mayo Robson) or in cumol (Kronig) in a closed box under pressure, for some time. These methods require special apparatus and are not very suitable for small hospitals. Cumol is an oil obtained by the distillation of tar, boiling point 170F.; it is brought to a temperature just under boiling point and maintained at this heat for nearly an hour. The excess of cumol is driven off by exposure to dry heat in a closed oven. Benzine, which used to be used to get rid of the oil, has no antiseptic properties and has been known to re-infect the gut (Kelly). Vallack suggests heating in turpentine which has a high boiling point, and is generally accessible.

Another method is simple and easily applicable. (Dudley's modified). Remove all grease by immersion in ether.

Immerse in 4 per cent. formalin solution from two to three days according to the thickness of the gut.

Wash thoroughly in water.

Boil in water for at least half an hour. Store in 70 per cent. alcohol with a 500th of mercuric biniodide.

Formalin in this strength so hardens the gut that it is not damaged by subsequent boiling, but it is much more slowly absorbed in the tissue, and its special advantages are thus to some extent lost. This method is as simple as any, and the plan of antisepticizing the dry sulpho-chromic gut in carbolic 1-20 for one week before use, are recommended as simple and reliable in practice.

Moschcowitz (Annals of Surgery, September 1905) strongly recommends dry iodine catgut prepared thus. The catgut as bought from the dealers, *i. e.*, without removing the fat, is lightly wound on a spool preferably in a single layer, and is then immersed for 8 days in a solution of iodine 1 part, potassium iodide 1 part, distilled water 100 parts. Stored dry in an aseptic jar for use. (Drying may be hastened by placing a small pot of strong sulphuric acid in the jar). The gut is blackened and has the characteristic odour of iodine. It is slightly stiff but does not kink or curl up. Its tensile strength is great, and it is not too quickly absorbed in the tissues. It is claimed further that *it is practically not infectible, by accidental contact-infection.* The simplicity, cheapness and general practicability of the method are strong recommendations, and render it one of the best methods available.

Generally speaking the use of catgut in smaller hospitals is best given up in favour of silk, which answers all requirements and is much easier to be sure of. If there is any doubt as to the sterility of a sample of catgut it should on no account be employed until carefully sterilized.

The way not to keep ligatures! is to store them in a box, wrapped up in paper, as they are received from the makers, and, when they are required for use, to merely soak them in lotion for a few minutes. This formality—for it is nothing else—does *not* sterilize them, and is hardly better than using them dry, without any pretence at preparing them. Such a practice is simply courting disaster.

Sponges.—Their advantages and disadvantages, are both dependent on their powerfully absorbent qualities. No artificial substitute, and many have been tried, approach them in this respect. They are costly, and somewhat tedious and difficult to clean, particularly during an operation when they get clogged with coagulated fibrin. In small hospitals their use is best abandoned. Still they are frequently bought, and presumably used on occasion, so the methods of preparing them may be given.

For the sake of clearness, the process is detailed in steps.

(1.) The sponges, folded in a towel, are well pounded to break up calcareous lumps.

(2.) Thoroughly rinsed and squeezed in several changes of water.

(3.) Placed in hydrochloric acid solution, (1½ drachms to 1 pint) for 24 hours.

(4.) Thoroughly washed in water.

These preliminary steps are common to all methods. First plan.

(5.) Placed in carbonate of soda solution 1lb. to 1 gallon (or ½ seer to 6 seers), for 24 hours, and thoroughly rinsed and squeezed in it.

(6.) Washed with water.

(7.) Stored in carbolic lotion (1-20) for at least one week before use.

This plan can be used to clean sponges after operation, in this case, step (5) must be very thoroughly carried out, to rid them of all coagulated fibrin.

Second plan. (Borham's), recommended by Grieg Smith.

(5.) Placed in hyposulphite of soda solution ($\frac{1}{2}$lb. to 1 gallon (or $\frac{1}{2}$ seer to 6 seers), sufficient for 10 to 12 sponges, to this 4 ounces of oxalic acid dissolved in water is added, and the sponges are rapidly squeezed and rinsed.

(6.) Thoroughly rinsed in several changes of sterile water, till all milkiness disappears.

(7.) Stored in carbolic lotion (1-20) for use.

This plan may also be adopted after operation. Chemical reaction takes place, oxalate of soda, sulphur dioxide and free sulphur being formed, with small quantities of sulphuric acid, which will rot the sponges, if they remain for more than a few minutes in contact with it. The sodium oxalate rapidly dissolves out any fibrin, the sulphur dioxide is both an antiseptic and a bleaching agent. The milkiness is due to suspended sulphur, and its disappearance is a good working test that the sponges have been thoroughly washed.

Third plan (Kelly's).

(5.) Placed in a hot saturated solution of permanganate of potash.

(6.) Decolorized by placing in a hot saturated solution of oxalic acid.

(7.) Placed in lime water to neutralize the oxalic acid.

(8.) Thoroughly washed in water.

(9.) Placed in a solution of perchloride of mercury (1-1000) for 24 hours.

(10.) Stored for use in carbolic lotion (1-20).

The oxalic acid used in this process, besides bleaching the sponges, which are stained a deep mahogany brown, acts as a powerful antiseptic. Step No. 7 renders the removal of the acid more rapid, but can be dispensed with, as may step No. 9. The carbolic lotion in which the sponges are stored, should be changed every week or oftener.

Sohimmelbusch recommends that sponges should be put in a linen bag and be entirely submerged in a solution of 1 per cent. carbonate of soda at just below boiling point, and left lying in it for half an hour whilst it gradually cools. A large mass of soda solution should be used so that it may cool slowly. He states that sponges saturated with anthrax spores and pus were sterilized by this method. (Vallack.) This seems a very handy and rapid way of sterilizing them; for greater safety they may be transferred to fresh soda solution for some hours before storing them in antiseptic lotion, or putting them moist in glass jars.

Other solutions for disinfecting sponges, are a 1 per cent. solution of permanganate of potash to which 1 per cent. of strong hydrochloric acid is added. (Kronig and Paul.) This solution kills anthrax spores in 30 seconds, and depends for its activity on the presence of hypochlorous acid. Its staining action is an objection to its use, and to obviate this Andrews and Orton have advocated the use of persulphate of ammonium which forms a colourless solution with strong hydrochloric acid, which will kill anthrax spores in the space of 1 minute.

The strength of their solution is as follows :—

Persulphate of ammonium, 37 grms. (1 oz. $1\frac{1}{4}$ dr. or 4 p.c.)

Water distilled ... 950 cc ($33\frac{1}{2}$ oz.)

Strong hydrochloric acid 11 cc (3 dr. or 1 p.c.)

The acid is added to the aqueous solution of persulphate and allowed to remain for at least four days, preferably six, before it is ready for use, as the oxidising action takes place slowly. After a period of one month it loses its efficacy. Preliminary thorough mechanical cleansing is as necessary by this method as in any other. The solution softens and eventually disintegrates a sponge after three or four weeks' immersion, but for renovating and bleaching old sponges an immersion of two to three days is not too long. For ordinary sterilization a space of 1 hour is ample. These methods for simplicity and rapidity are a great advance on those previously detailed.

The way not to keep sponges.—In the dry state, at the bottom of any old box or almirah, with other miscellaneous articles, with no further preparation for use than a perfunctory wash in plain water, or lotion. It is far better to discontinue the use of sponges, in small hospitals, and some substitutes should always be used in septic cases.

Substitutes for sponges.—Swabs of absorbent cotton wool, are very generally used for this purpose. There is one advantage attaching to this plan, *viz.*, that they are thrown away after use. They are by no means so useful as a good sponge, and they are open to the objection that some fibres of cotton may be left in the wound. This may be obviated, by tying up in gauze suitably sized pledgets of absolvent wool, or better still pieces of gauze crumpled up.

The preparation of gauze and absorbent wool will be considered shortly, and it only need be remarked here, that the former is by far more readily absorbent than the latter. The worst material for swabs is the ordinary cotton as it is bought in the bazaar. Quite apart from its septicity, which alone forbids its use, it has no absorbent qualities at all, on account of the natural oil contained in its fibres, until this is removed by boiling it with an alkali.

Dressings, their preparation and storage.

A word as to the materials used for this purpose. Lint, gauze and absorbent cotton wool answer all ordinary requirements. Plain lint should never be used for dressing wounds, this is a relic of the preaseptic days. Lint is most useful for the application of cold lotions, or ointments, and for lining splints, and other surgical purposes, but in the aseptic treatment of wounds it nowadays has no place. Medicated lints are made, and these do not, of course, come under this restriction, but they are an unnecessary luxury for small and poor hospitals. For the actual dressing of wounds, the necessities are limited to gauze and absorbent wool.

At the present time no dressing that is not medicated with some efficient chemical antiseptic, or properly sterilized before use, should ever be applied to a wound. This may seem a platitude, but it cannot be too often insisted on.

In a previous chapter reasons have been given for the use of proper dressings, which act as an automatic safeguard against subsequent accidental infection of clean wounds; it need only be reiterated here, that, however well merely sterile dressings may meet the necessities of modern and perfectly equipped hospitals, elsewhere, in hospital and general practice in India, antiseptic dressings are an absolute necessity.

What then are the qualities of a perfect antiseptic dressing? We cannot do better than go to the fountain head for an answer to this question. In Lister's own words: "An external antiseptic dressing, to be ideally perfect should have four essential qualities. It should contain some thoroughly trustworthy antiseptic ingredient; it should have that substance so stored up, that it cannot be dissipated to a dangerous degree before the dressing is changed; it should be entirely unirritating; and it should be capable of freely absorbing any blood or serum that may ooze from the wound." . . . "The agent we have found the most satisfactory as the antiseptic ingredient of the dressing is the double cyanide of mercury and zinc." . . . "It fulfils the condition of persistent storage." . . . "It is at the same time practically unirritating." . . . "When mixed with serum and corpuscles, it prevents putrefaction in smaller quantity than any other antiseptic with which I am acquainted." . . . "The double cyanide answers the purpose in half the quantity that is necessary with corrosive sublimate." . . . "And when I add that it (*i.e.*, double cyanide gauze) is all that can be desired in absorbing power, you will see that it approaches very closely to our ideal."

These words were uttered more than twelve years ago, and no better substitute for zinc and mercury cyanide gauze has since been introduced, they are therefore true at the present time. Medicated gauzes bought from the makers are expensive things ; it is, however, quite easy at the cost of a little time and trouble, to make them at any dispensary, and the method of preparing them is therefore given in detail.

The gauze is a loosely woven cotton fabric commercially known in England as "butter or cheese cloth," in India it is called "mulmul" and is obtainable in almost every bazaar. The more loosely woven and flimsy the texture, the better its absorbent qualities ; fortunately these fabrics are also the cheapest. The cheapest bazaar mulmul is the best material then, it varies in price from Re. 1-4 to Re. 1-8 or more a *than* of 18 yards.

The process is simple and is given in steps.

(1.) The gauze should first be cut up in convenient lengths (6 yards is the most suitable in practice), and thoroughly washed to get rid of all starch, etc., with which it is dressed for sale, and rinsed with clean water.

(2.) Folded longitudinally twice (this makes it four folds in thickness), and while still moist passed through the antiseptic solution preferred for medication, by rolling it up from one end while steadying it from the other, care being taken to ensure that every part is thoroughly saturated.

(4.) Lightly pressed and either hung up to dry, or laid in a horizontal position.

(5.) When dry, or better still while slightly moist, it should be rolled up if possible sterilized, and stored in air-tight boxes, or if moist in glass jars.

To economize the solution in place of taking an excess in step (2), the exact amount of fluid necessary to impregnate it may be used ; but in this case the gauze must be thoroughly kneaded and squeezed in it, and after this has been done as thoroughly as possible it should be folded up moist and allowed to remain for an hour or so, to enable the antiseptic to become evenly diffused throughout the fabric.

All kinds of antiseptic gauzes can be prepared in this way ; there are, however, some practical points which it is useful to know.

To begin with 6 yards of dry gauze weighs approximately 4 ounces, and absorbs 12 ounces of fluid, while 2 ounces is sufficient to just moisten it. In practice 10 ounces of medicated solution is a convenient unit to work with, when the gauze has been previously moistened, and in the following directions it will be taken for granted that this has been done.

To make cyanide of zinc and mercury gauze 54 grains of the salt to 10 ounces of water are required to produce a dressing, containing 3 per cent. by weight of the antiseptic, the strength adopted by Lister. The salt is quite insoluble in water, and must be first triturated with a pestle and mortar, and kept constantly agitated by stirring while the gauze is being passed through it. It makes a suspension and not a solution, and for this purpose 1-20 carbolic lotion is better than plain water. Further, and this is a point of the utmost practical importance, the fluid must contain a dye which fixes the particles of the salt, to the fabric ; without the dye when the dressing is dried, the cyanide at once shakes out as a fine dust. Lister first tried hœmatoxyllin for this but found an aniline dye, the hydrochlorate of mauveine, commercially known as pure rosaline, the best.* The fixation of the salt was a matter which

* The composition of the double salt is apt to vary ; it can be obtained pure and stained ready for use, from Messrs. Morson and Co., 14, Elm Street, Grays Inn Road, London (late Southampton Row).

presented the greatest difficulty, and it was only after many long continued experiments and failures, that Lister "to his great joy," found that the dye which he employed for distinguishing the dressing, served the double purpose of fixing the salt as well. For further details the reader is referred to the original articles in the *British Medical Journal*, 9th November 1889, 4th January 1890, and 18th February 1893. The dressing prepared in this way, was submitted to severe tests, which could not be exceeded in actual use, and found to answer the important condition of "persistent storage." It may be noted here that though this dressing possesses very powerful inhibitory qualities, its germicidal power is low, it should therefore, if possible, be sterilized before use, and the portion placed in contact with the wound, should be wrung out of weak antiseptic lotion (other than mercurial lotion) which acts as a sufficiently powerful germicide for the short time it remains moist. Mercury lotions will not do for this purpose, as they produce a triple salt of very irritating qualities, and impair the inhibitory action of the double cyanide.

To make sublimate or perchloride of mercury gauze, a 1-500 solution of the salt is strong enough to produce a gauze containing $\frac{1}{2}$ per cent. of the antiseptic ; anything stronger than 1-250 is apt to prove too irritating to the skin if there is much discharge and the $\frac{1}{2}$ per cent. gauze answers very well in practice. It is usual to colour the gauze with a little indigo or aniline blue, to distinguish it in practice. This dressing which was used by Lister for many years and eventually discarded by him after many attempts to improve it, in favour of the cyanide dressing, is still widely used. Though it is not an ideal dressing, in that it does not answer the conditions of persistent storage, and lack of irritating qualities, yet the accessibility and cheapness of the drug, and the ease of preparation, render it peculiarly suitable in these respects, to the needs of small and poor hospitals. In practice the portion placed next the skin should always be wrung out of carbolic or other antiseptic lotion (excepting, of course, mercury lotion), to rid it of the excess of the chemical, and also to ensure the temporary presence of an efficient germicide as the weaker solutions are chiefly inhibitory in their action. The admixture of chlorides forming a double salt renders it more stable, but also more soluble and irritating, gauze prepared with salalembroth solution is objectionable in practice, though wool perhaps may be better prepared in this way.

Biniodide of mercury dressings may be similarly prepared, and would certainly appear to be a great advance, both in efficiency and in their less irritating properties. They should be dyed red to distinguish them.

To make boric gauze, 1 ounce of boric acid to 10 of water is sufficient for 6 yards. The water must be hot as the solubility of boric acid in cold water is so low (1-30 only). The addition of carbonate of magnesia 1 drachm to each ounce of boric acid, increases its solubility, as does the addition of glycerine. When dry the powder is very liable to dust out, this may be prevented by dissolving one or two drachms of gum acacia in the solution, or better a weak solution of starch may be used for the same purpose, which makes the dressing a little bit stiff but does not interfere with its utility.

The following is a useful formula in practice :—

Take of	boric acid ...	... 1 ounce.
,,	carbonate of magnesia	... 1 drachm.
,,	powdered gum acacia	... 1 drachm or
,,	(powdered starch	... ½ drachm).
,,	pink aniline dye	... a sufficiency (3 to 5 grains).
,,	boiling water	... 10 ounces.

Directions.—Triturate the gum or starch in a pestle and mortar with an ounce or two of water, add the remainder of the water boiling hot and stir. Pour this over the remaining ingredients and stir till they dissolve. Immerse the gauze in the solution while it is still hot. This is sufficient for 6 yards of gauze.

It is usual to colour boric dressings rose pink, to distinguish them.

To make iodoform gauze.—For 6 yards of gauze moistened with water take ½ pint of hot water, and mix it with hard soap until a good lather is produced, stir into this 2 ounces of finely powdered iodoform with a glass rod. When thoroughly mixed, take the roll of gauze and knead it thoroughly in the emulsion until the iodoform is evenly incorporated in the fabric. Dry partially and while still moist roll it up and keep in a glass jar. Carbolic lotion 1-40, or lysol 1 per cent. may preferably be used instead of plain water in making the soap solution.

Another method. U.S.A. Pharmacopœia. Ry. iodoform 10, ether 40, alcohol 40, tr. benzoin 5, glycerine 5, gauze, a sufficient quantity. Dissolve the iodoform in the ether, then add the remaining ingredients ; immerse in a weighed quantity of this solution the exact amount of gauze required to absorb it all. Dry horizontally in a dark place. Preserve in air-tight receptacles.

Von Billroths formula is : Iodoform grms. 50 ($1\frac{2}{3}$ oz.), glycerine grms. 50 ($1\frac{2}{3}$ oz.), alcohol (95 per cent.), grms. 400 ($12\frac{1}{2}$ fluid oz.). Iodoform is first triturated with glycerine, and the alcohol then added. This is sufficient for 10 metres, *i.e.*, nearly 11 yards of gauze. Iodoform gauze should contain not less than 20 per cent. of the drug.

Any other medicated gauzes can be made in a similar way, by the processes above described, but these will cover all practical needs.

Absorbent cotton wool is the second most commonly used material for dressing wounds. Its efficiency depends to some extent on its absorbent qualities, though these are by no means so great as it is generally credited with. Its one great advantage is that it affords firm but elastic pressure when properly applied, over gauze dressings, and acts as an efficient filtering medium of the air, thus preventing the access of septic organisms, while it absorbs discharges to some extent. The absorbent wool obtainable from the makers is a beautifully finished product, its cost is a drawback ; a cheap and fairly efficient substitute can be prepared locally for hospital use, in the following way. The cleanest bazaar cotton should be got, it is best to have it specially picked and cleaned as it is a slow and troublesome process. To render it absorbent the natural oil contained in the fibre must be removed by boiling it in an alkaline solution, in the following proportions :—

(1.) In 1 gallon (or 6 seers) of water dissolve 2 ounces (1 chittak) of washing soda, immerse in this 1lb. (½ seer) of picked cotton and boil it slowly for two or three hours.

(2.) Rinse thoroughly in water till all traces of the alkali are washed out, tested by red litmus.

(3.) The wool still moist should then be placed in the medicated solution, and thoroughly squeezed and rinsed in it.

(4.) Lightly pressed and put aside to dry.

(5.) It must then be picked and carded, and

(6.) Stored for use in air-tight tins, if possible it should previously be sterilized. The solutions given for the preparation of gauze will do, but perchloride wool may advantageously be prepared with a stronger solution 1-250, and with the double salt, salalembroth.

Boric acid is very liable to be shaken out in the process of carding, it is well therefore to dredge some fresh powder over the wool, when the carding is finished. Wool prepared in this way, though it cannot compare with the manufactured product, is both reliable and serviceable, and very cheap.

A word as to the best means of storing sponges, gauze and wool for use. Wide mouthed glass jars are the best receptacles for the purpose, with glass covers instead of stoppers. Sponges after sterilization by one of the methods above given are best wrung out of izal, lysol, or cyllin lotion 1-500, and stored in this moist condition in glass jars, they are then ready for use at any time without further attention. If moistened with or stored in carbolic, this

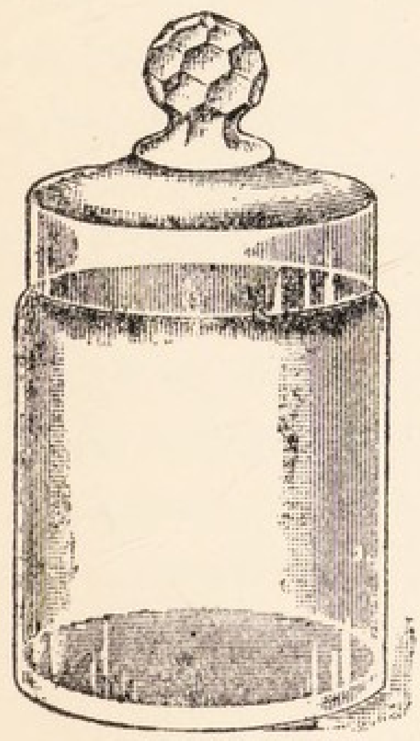


Fig. 22.

Glass jar with drop over lid for storing dressings, etc.

will disappear in time and in carbolic lotion they are apt to rot. Gauzes, especially iodoform gauze, should be kept in the same way. Swabs of gauze made up ready for use may be treated in the same manner, especially if a steam sterilizer is not available; if they can be sterilized, however, this should be done in a linen bag which should be placed in the glass jar bodily, and only opened when the swabs are wanted for use. By preparing swabs in this way they will always be at hand in case of an emergency. Wool, too, can be stored dry in glass jars, but as it does not come in contact with a wound its sterility is not a matter of prime importance, when it is impregnated with some efficient antiseptic. It can be kept in air-tight cylindrical boxes of tin or better zinc.

CHAPTER VIII.

Preparation of the Hands and Skin.
The Surgeon's Dress.

The question of sterilizing the hands is one on which many divergent views are held, some even deny the possibility of it. This variation of opinion was conspicuously illustrated at a meeting of the British Medical Association in 1904, the proceedings of the surgical section are reported in some detail in the *British Medical Journal*, October 1904. These varying opinions are all entitled to respect as the matured views of practical surgeons. The divergence is explicable from the different point of view from which the subject is approached, some look at it from a bacteriological standpoint, others from a clinical one, as judged by the results they obtain in practice. While the bacteriological test is more scientific and exact, the character and extent of the experiments still appears too limited to justify all the conclusions drawn from them, and the distrust with which the conclusions drawn from clinical experience alone, are regarded. This will be considered in greater detail later, in the meantime common ground can be found in the insistence with which all urge the importance of a good cosmetic condition of the hands, and of *thorough preliminary mechanical cleansing* with soap and hot water.

From the experience of many observers, the "personal factor" has much to say to the ease with which hands can be sterilized. Hairy, coarse or rough hands are hardly susceptible of it, especially if the nails are long or broken, while in others sterilization is easily attained. The hands then should always be kept in as good a cosmetic condition as possible, not only should scratches and abrasions be avoided but also chapping and roughness from the injudicious use of strong antiseptics or alcohol. For this purpose the use of such emollients as glycerine and lanoline is recommended. The former is far preferable it has, especially when combined with boric acid, some mild antiseptic properties, while lanoline has none and the objection to greasy substances has already been alluded to. Vaseline should never be used. Little frayed bits of epidermis should be snipped off as close as possible, and the hardened edges of skin round the nailbeds should also be regularly removed. For getting rid of rough epidermis, stains and gross dirt, there is nothing so useful as a piece of pumice stone with which the hands should be well rubbed while covered with soap lather. Sea sand, pumice or marble soaps cannot compare with it. The nails should be kept cut quite short, not projecting in fact more than a few millimetres beyond the pulp of the finger. If they are longer than this, it is in practice a most difficult matter to remove inkstains, for instance, from beneath them. Nail cleaners of any kind are a mistake ; as Keetley points out, their use only deepens the furrow beneath the nail, and renders it more difficult to clean thoroughly. With short nails the use of soap and a nailbrush is all that is necessary. Nail files are also a mistake, as their use leaves a roughened edge, polishing with pumice stone is best.

Gross contamination with septic matter should always be avoided. It is very rarely necessary to touch septic objects or discharges with the bare hands, instruments can generally be used instead, or if the hands must be used to palpate a septic surface, in many cases it is possible to protect them with antiseptic gauze. In the comparatively rare instances in which septic contamination cannot be avoided, the hands should be rinsed in antiseptics as quickly as possible, before the septic matter is fixed.

Ordinary wearing gloves have been known to be a source of virulent infection. Galabin quotes an instance in which successive cases of puerperal infection occurred in the practice of a medical man, and in spite of his temporarily desisting from practice, did not cease until it occurred to him that his gloves might be infected, and he discarded them. The moral is obvious.

No operation should be performed with a suppurating wound or sore on the fingers. An abrasion on the back of the hand should be sealed up with collodion, or protected with moist antiseptic gauze, in the operator's as well as the patient's interest, but except in a case of emergency an operation should not be performed under these circumstances.

Next to consider the actual purification of the hands. The skin of the hands does not ordinarily contain much grease, and fat solvents such as turpentine or ether are unnecessary, except under exceptional circumstances. Macewen and others assert that sterility can be attained by the use of soap and hot water; Lockwood has found this to be the case at times. Leedham Green and others strenuously deny the possibility.

Keetley obeys the following rules:—"Use a large basin nearly full to the brim with hot water, to which liquor potassæ is added to soften it, enough should be added to make it feel soft (almost greasy). Soak the hands and wrists in this for half a minute, then scrub the hands with a nailbrush well soaped for three minutes. The nailbrush must be kept in

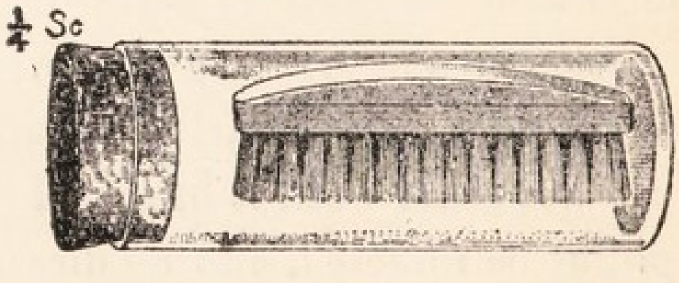


Fig. 23.
A simple pattern of nailbrush receptacle.

carbolic lotion. In cleansing the hands particularly scrub the fingernails, and the palmar surface of the hands and fingers. Time is an essential element in the process, the above are minima but sufficient in practice. It is a question of not only using time, but of not abusing it. For example it should not be wasted in laboriously scrubbing the backs of the wrists or staring at the fingernails or the backs of the hands, as if bacteria were fleas and could be caught between the finger and thumb. Nothing is more futile than scrubbing the hands while they are immersed in the water or while water is running over them. Either plan wastes the soap instead of utilizing it. There is no object in adding antiseptics to the water, it merely wastes them."

There is a very general consensus of opinion in favour of soft or "green" soap, which contains an excess of alkaline potash salts, it is easy to spread and convenient in practice. The following practice may be recommended :—Soak the hands in very hot water rendered alkaline with liquor potassæ or carbonate of soda, for half to one minute. Smear the hands with soft soap all over, and lather them thoroughly by taking up a few drops of hot water at intervals. Rinse, (in running water if possible). Next scrub the hands thoroughly with a nailbrush, taken from its own jar of antiseptic, and well smeared over with soft soap. Particular attention must be paid to the nails, the web of the fingers, and the palmar surface of the hand and fingers. Rinse. Soap the hands once more, this time rubbing them well with a piece of pumice stone while lathered. Rinse once more.

The whole process should not take less than five minutes, ten minutes is preferable for the inexperienced.

Septic absorption has been known to take place through the skin of the fingers, damaged by the too vigorous use of the nailbrush, and though this bespeaks caution, it is no argument against the thorough cleansing of the hands.

The next step, *viz.*, the actual disinfection of the hands is the one about which there is such a wide divergence of opinion. Before considering the methods in detail, it will simplify the subject to briefly examine the nature and limitations of the bacteriological tests to which the hands are subjected after attempted sterilization. The skin of the hands is touched, rubbed, or scraped with some object which is then dropped into sterile agar. Schleich rubbed the skin with a platinum loop, and then made stab cultures. Furbinger used sterile bits of hard wood which were then dropped into the culture media. Leedham Green uses similar slips of ivory with slightly roughened surfaces with which the hands are rubbed and the point passed under the nails. Haegler, short lengths of ligature silk, with which the hands were treated in the same way. Lockwood and others scrape the epidermis or snip off small portions of it, and sow them in culture media. The agar test tubes are then placed in an incubater at the temperature of the body, and the number of colonies developing is counted after the lapse of some days. No growth shows absolute sterility, but Schaeffer and Leedham Green prefer to class the absolutely sterile and those tubes which show only 20 colonies or under as "practically sterile;" those which show 80 or under as "moderately infected;" and those which show more than 80 as "severely infected."

Much depends on technique, and the different results of different observers are doubtless to differences in this. For instance slight traces of antiseptics or alkaline soap, will exert an inhibitory effect on the growth, while a light touch or a snipping from one finger only, are clearly less effectual tests than a good rubbing. The difficulties in short are almost insuperable and the limitations of their practical value are great. No approximate estimate even of the number of bacteria detachable from the hands during an operation can be made; nor do these tests reveal anything as to the virulent or innocuous character of the micro-organisms. They are, in other words, poor quantitative and still worse qualitative tests.

Instead of testing the normal hands, these tests have been applied after attempted sterilization of hands artificially infected by immersing and rubbing them in a culture of some known bacteria. Such tests, though instructive as regards the comparative disinfecting power of different antiseptic agents or methods, have still less practical application in actual surgery, as no one in his senses would dream of thus infecting his hands. Kronig and Blumberg and since them some other observers have gone further, and after infecting the hands with a culture of a pathogenic bacterium (micrococcus tetragenus), and attempted sterilization, inoculated mice with the hand scrapings. They argued that the mere growth of bacteria signified nothing, *unless they were pathogenic and virulent.* The practical difficulties are, of course, much greater, and though the results must be received with caution, in *principle* the method is a practical attempt to solve the question. This method might be usefully combined with the ordinary culture one. The weakening effect of chemical antiseptics on the virulence of pathogenic micro-organisms, as well as their inhibitory effect on their mere growth in culture media, might in this way be ascertained. Until this is done the wholesale condemnation of the utility of antiseptics is—to say the least of it—premature.

The agents or methods adopted in sterilizing the hands may be divided into three groups; this classification is convenient, but must not be taken too literally as the methods overlap.

(1) Chemical antiseptics in aqueous solution.
(2) Chemical antiseptics and alcohol.
(3) Alcohol only.

English surgeons still widely use aqueous antiseptics. Lister relied on carbolic acid pointing out that it was capable of combining with fat and had greater penetrative powers than other substances. Macewen uses it still. Watson Cheyne and Burghard employ a lotion of 1-20 carbolic with 1,500th of sublimate added, familiarly known as "the strong mixture," in which the hands are immersed for two minutes. It is certainly strong—too much so for many skins.

Sublimate lotion in varying dilution is extensively used by many, its limitations have been given (*vide* Chapter VI). Biniodide of mercury lotion used by some, might usefully replace it.

Lysol 2-100 or 4-100 has a wide popularity. Izal and cyllin 1-100 have also been used.

Permanganate of potash 1-100, and afterwards a hot saturated solution of oxalic acid to bleach the hands, was first introduced by Kronig and Paul, and is highly spoken of by Kelly. The addition of strong hydrochloric acid 1-100 to the permanganate solution, increases its germicidal power greatly, by the production of hypochlorous acid.

Andrewes and Orton have suggested a solution of ammonium sulphate with 1 per cent. of strong hydrochloric acid as a substitute for the above, as being more stable and free from staining properties. Hypochlorous acid is again the active agent. Stimson and Weir in America, and Wanless in India, use a paste of chloride of lime and washing soda, nascent chlorine being set free as the result of chemical action, for two minutes. It is claimed to thoroughly disinfect the skin, the chlorine penetrating to the deepest layers. Wanless admits it is damaging to the skin and other antiseptics are also used. (For details *vide Indian Medical Gazette*, November 1901.)

Chemical antiseptics and alcohol are more widely used in Germany, though many English and American surgeons have adopted the process. A very extensive literature has been published on the subject in Germany, where it has attracted much notice.

Furbinger was the pioneer of this method, 1888, and his original method was as follows :—

(1) Hands scrubbed for one minute with soap and hot water.

(2) Rubbed for one minute with alcohol not less than 80 per cent strength.

(3) Finally washed for one minute, before the spirit has evaporated ; with sublimate lotion 1-500.

Furbinger started the use of alcohol as he noticed that aqueous solutions ran off the skin, especially if it is greasy, without thoroughly wetting it, and thought by substituting alcohol he could get contact of the antiseptics with the bacteria in the skin. Haegler extended the time of these respective steps to 5 minutes, with much improved results.

Lockwood uses a 1-500 solution of biniodide of mercury in 75 parts of rectified spirit and 25 of water,* in which the hands are soaked for 2 minutes, a further sojourn he thinks unnecessary and perhaps harmful to the skin, the hands are then rinsed with

* This gives 68 per cent. alcohol, not 75 per cent. as might be supposed.

biniodide lotion 1-2000 or 1-4000 which is used throughout the operation.

Pearson (*British Medical Journal*, September 1905), modifies this by rubbing the hands after washing with pieces of gauze soaked in methylated spirits for 3 minutes (dehydration), and then rubbing for 2 minutes with Lockwood's solution in a similar way.

Stoney (Practitioner February 1906) following Harrington (Annals of Surgery, October 1904) soaks his hands for 3 minutes in 1-1100 sublimate 60 per cent. alcoholic lotion acidulated with 5 per cent. of strong hydrochloric acid. Harrington's solution was about 1-1600 sublimate in 70 per cent. alcohol with 5 per cent. of strong hydrochloric acid.

Reineke, Ahlfeld and others came to the conclusion that the third step in Furbinger's process gave worse results, and omitted it, using only absolute alcohol and rubbing the hands with it for 3 to 5 minutes.

Finally Mikelucz to shorten the process combined the spirit and the soap.

Next as to the results of these methods as tested above. The advocates of each naturally claim superiority for their own particular method, but the experience of others does not support their contentions. Briefly aqueous antiseptic solutions have been found not to sterilize with any certainty, some say not at all. After the permanganate and oxalic acid method Kelly quotes experiments by Welch, who passed silk threads through the deeper layers of the skin and obtained a pure culture of the staphylococcus epidermidis albus. The strong mixture is too damaging to most skins, as is the lime and soda process. Andrewes and Orton's solution has not been tested on the hands, though it is said to destroy anthrax spores in less than a minute.

Alcohol and antiseptics have given the best results. Haegler's modification of Furbinger's method proving the most successful in the experience of many different observers. Haegler got 89 per cent. of successful results in the case of his own normal hands, Leedham Green agrees that this is about the maximum percentage of success that can be obtained. Lockwood found that 38 times out of 39 his house surgeons' hands were sterile after his method, and says that with increased experience lack of success is rare. Pearson, by his modification in 18 normal hand experiments, found sterility in 8, and practical sterility in 10 instances. Stoney on twenty occasions on each of which three tubes were inoculated before operation and three afterwards, obtained sterility in 116 tubes out of the 120. Once a tube was infected by silk used, and on the other three occasions the growth was a non-pathogenic sporing bacterium. In 81 tubes inoculated after sterilization by Furbinger's method modified by using 1-500 aqueous biniodide in place of sublimate and extending the time 72 were sterile, 1 was infected with S. aureus and 8 with S. albus.

Ahlfeld's hot water and spirit has not given nearly such a high percentage of successes as Haegler's (Furbinger's modified) in the experience of many observers; while spirit and soap together have been found much less reliable.

Leedham Green with a view to testing conflicting opinions, made a large number of varied and laborious experiments, the details of which are given in his book on the "Sterilization of the hands;" it also contains a complete bibliography on the subject, and will well repay perusal. As it is the nearly last word on the subject to date, a very compressed summary of his conclusions is given here. He finds that it is impossible to sterilize the hands—

(1) by mechanical purification with soap and hot water,

(2) by the use of fat solvents in addition,

(3) by the added use of aqueous solutions of antiseptics, *e. g.*, sublimate or biniodide 1-1000, carbolic 1-40, or lysol 2-100,

(4) by the use of antiseptic soaps, biniodide or lysol,

(5) by the permanganate and oxalic acid method,

(6) or by the use of spirit soap.

(7) That hot water and soap followed by the use of alcohol for five minutes gave better results, but that these were by no means perfect including 36 per cent. of failures.

(8) That the personal factor and cosmetic condition of the hands had much to say to success.

(9) That Furbinger's method modified thus was best,

(*a*) Scrubbed 5 minutes with soap and very hot water, and a nailbrush.

(*b*) Rubbed with methylated spirit for 3 minutes.

(*c*) Scrubbed for a minute or two with sublimate 1-1000 in 70 per cent. alcohol.

(*d*) Finally rubbed dry and polished with an aseptic cloth.

(10) That hands thus sterilized become more and more infective when wetted and sodden.

(11) That it is a grave error to suppose that hands *no matter how strongly infected, can be sterilized with certainty even by the best method*, the difficulty increasing in direct ratio to the resistance of the micro-organisms.

(12) That there being no certain method, the use of rubber gloves is desirable when the nature of the operation permits.

Incidentally he found that alcohol possesses in certain dilution remarkable bactericidal powers. That 70 per cent. dilution was the most powerful, more so than aqueous biniodide solution 1-1000 on the pyogenic cocci, which it destroyed in from 2 to 5 minutes, given that it got complete access. That higher percentages of alcohol were less and less efficient, until absolute alcohol had practically no germicidal power at all.* That sublimate solutions in alcohol up to 70 per cent. dilution were far more bactericidal than corresponding aqueous solutions, and that they also had greater germicidal powers than plain 70 per cent. alcohol on resistent spores. He attributes the efficacy of alcohol in sterilizing the hands to its hardening action on the epidermis chiefly, though it has a powerful germicidal action too.

The *rôle* that alcohol has been credited with by different observers is interesting ; it was first employed by Furbinger as a fat solvent. Next it was used as a medium for antiseptics on account of its supposed greater penetrative properties ; it has undoubted germicidal powers in dilution, and Schaeffer notes its cleansing and particularly detergent action in removing sodden epithelium, while its hardening action, according to Leedham Green, is more important. Probably it acts to some extent in all these ways, *i.e.*, it is more penetrating than water, and has detergent, hydrolytic, astringent, and (when diluted) antiseptic properties.

The picture presented by these experiments is very suggestive ; no matter what method is adopted, so long as the hands are wet and the epithelium in a sodden state, a regular rain of bacteria is

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* Other observers have noted this, including Koch. The dilutions recommended are as follows :—

Minervini	...	... 70 per cent.
Haegler ...	...	... 65 „
Epstein ...	...	... 50 „

falling from them, and apparently they are in most instances at all events in a living condition. The skin is admittedly a hot bed of bacteria, though that of the hands is less so than in other parts of the body, because it contains less fat and the hands are more frequently washed. No method of sterilization will prevent this rain of bacteria except alcohol, and this becomes useless directly the hands are wetted. Kronig in 1894 denounced sterilization with alcohol alone as "apparent sterilization," and apparently with a great show of reason. One obvious lesson to be drawn from this, is that *all wounds, aseptic or septic, should be touched with the bare hands as little as possible.*

These experiments, however, though conclusive as far as they go, do not go far enough for the needs of practical surgery. Two questions have to be settled: first, the nature of the micro-organisms, whether pathogenic or not; and, secondly, the weakening effect, if any, of chemical antiseptics on their virulence, if they are really pathogenic. The micro-organisms most commonly present in the skin are probably saprophytic and non-pathogenic, or if pathogenic, then non-virulent. Great diversity of opinion exists on the point, Watson Cheyne, and others believe the number to be greatly overrated, though admitting that the pyogenic cocci are frequently present in the more superficial layers, and particularly where the skin is rough, uneven, thick or sodden, and are very liable to be found in the furrows round the nail bed. Others take a different view and think the skin is ordinarily infected with virulent pyogenic cocci, extending deeply into the sebaceous and sweat glands. It is difficult to believe that this is the case in the normal skin of healthy persons, and still less so of the skin of the hands. If this were so septic infection would be far more frequent than it is, and the clinical experience of practical surgeons shows that it is more a theoretical than an actual danger. It is rather the fashion to say that clinical experience counts for nothing, it seems doubtful if this is really so. How is it that such excellent practical results are daily obtained, by methods which, according to the scrutiny of bacteriological teaching, are totally imperfect ?

The second question, *viz.*, the value of antiseptics in reducing the virulence of pathogenic organisms is equally important from a practical point of view. Leedham Green's experiments with artificially infected hands would lead to the inference that their effect is very small, on account of the difficulty of thorough access. He makes, however, one very pregnant admission. To quote his words (the italics are his own). "Although under ordinary circumstances all micro-organisms will have developed within six days, this is not always the case *if the bacteria have been in contact with a powerful antiseptic.* Where such contact has occurred, the micro-organisms are often inhibited in their growth for a considerable time, and are only recognizable as colonies a fortnight or more after incubation."

Though power of growth is not synonymous with virulence, it is not very far fetched to hope that the inhibition of the one may go hand in hand with the reduction of the other.

His experiments with artificially infected hands are of great value in showing the extreme difficulty which attends the real sterilization of thoroughly infected hands, but his method of infecting them, was far more thorough than any infection likely to occur in practice, while his antiseptic solutions were by no means so strong as those used by many surgeons.

Stoney's experiments are of great interest. Not only did he test his hands after sterilization, but also after operation, a thoroughly practical measure. After operating on septic cases he found that a shorter preparation was sufficient to re-sterilize the hands, which points to the fact that, after contamination effected under ordinary circumstances, sterilization is neither impossible or so difficult to effect as is generally supposed. A fortunate accident showed that the high percentage of acid had an important bearing on success, for when on one occasion dilute acid was substituted by mistake the tubes were infected with a pathogenic growth. His method is open to one fair criticism, *viz.*, that he did not neutralize the sublimate with ammonium sulphide. That the amount, if any, introduced in to the tubes was too small to affect unweakened micro-organisms, he proved by re-inoculating the same tubes a week later with silk knots tied with unsterilized hands; this was followed by abundant growth. Gloves he considers necessary when the operator comes in contact with true septic matter, such as in dressing septic cases, and also for the unfortunate individuals whose hands cannot tolerate alcohol or antiseptics.

Final conclusions.—Dogmatism always proverbially dangerous would be more than usually so on such a vexed question, and I put forward the following propositions with all due diffidence.

That in the present state of our knowledge,

(*1*) *the impossibility of sterilizing the hands has yet to be proved.*

(*2*) *The best method is dehydration with 90 per cent. alcohol followed by the application of dilute alcoholic solutions of antiseptics, which are invariably preferable to aqueous solutions.*

(*3*) *The best alcoholic dilution is from 65 to 70 per cent.*

(*4*) *The best antiseptics are (a) sublimate acidulated with 5 per cent. strong hydrochloric acid, and (b) mercuric iodide.*

(*5*) *The stronger the solution and the longer the time of application that can be employed without damage to the skin of the hands, the more certain the result.*

(*6*) *These points can only be decided by individual practical experience.*

Practical details based on these conclusions are :—

(1) *The hands should be immersed in or rubbed with rectified or methylated spirits applied on sterile gauze, for 2 minutes.* (*Immersion is preferable, rubbing more economical*).

(2) *Next they should be immersed in or rubbed with one of the following dilute alcoholic antiseptic lotions, for 3 minutes. Sublimate 1-500 or 1-1000 acidulated with 5 per cent. of strong hydrochloric acid. Biniodide 1-250 or 1-500* (*expressed in terms of mercuric iodide, vide appendix, chapter VI*).

(3) *To prepare the alcoholic solution take 3 parts of rectified or methylated spirit, and 1 part of water, plain or acidulated as the case may be.*

(4) *The strength of the solutions and the time of application must be varied to suit individual idiosyncrasies, this can only be decided by the effect on the hands ; the above may be taken as minima.*

(5) *The nail furrows in particular should be carefully rubbed with a piece of gauze steeped in the lotion.*

Since this was written Sarwey (1905) as the result of 1,500 tests continued over a space of four years has come to the important conclusion ; "*that it is impossible to achieve absolute sterility of the hands with any method of hand disinfection now known ; and experiments which tend to prove otherwise are misleading, for all such contain some error in technique which invalidates the result.*" Sublimate ethyl and methyl alcohols gave better results than aqueous solutions of various antiseptics, but his best results were obtained with basilol alcohol, lysoform alcohol, chlor-methyl-ethyl-ether, bleaching powder and hydrochloric acid, and 5 per cent. formalin. The last three are not practicable on account of their irritating properties.

Considered from the point of view of absence of irritating properties, comparative harmlessness, and cheapness, as well as efficiency, he thinks that either 2 per cent. lysoform or sublamine alcohol should be preferred.

They may be used as substitutes in step 2, given above.

It is clearly advisable also to keep up the effect of chemical antiseptics during an operation, by frequently rinsing the hands in antiseptic lotion, biniodide 1-2,000 or 4,000 preferably, if sublimate lotion is used it should be acidulated with 1 per cent. strong hydrochloric acid. As mercurial lotions blacken plated instruments, cyllin or izal lotion may be preferred. Alcohol has the practical disadvantage of being too damaging to the hands and irritating to the wound. Sterile water is pointless except for its purely mechanical action, as it has no antiseptic properties and keeps up the sodden condition of the skin.

The use of gloves.—By this is meant the use of india-rubber gloves. Cotton gloves advocated and used by some are interesting from an historical point of view only. They remain sterile only so long as they are dry, and were found to be rapidly infected with bacteria shed from the hands when wetted.

The chief, indeed it may be said the only objection to rubber gloves, is the way in which they interfere with the fine sense of touch, so absolutely essential in many operations. Whatever may be urged to the contrary, this puts them out of court at once in operations where unimpaired tactile sensation is necessary, for instance in suturing the intestine. This does not apply with the same force to amputations or the removal of tumours or other operations which will readily suggest themselves. The thinner gloves are preferable, and though more easily torn are cheaper than the thicker and heavier ones, a practical advantage to poor hospitals. The objection that a prick with a needle renders their use futile, argues a want of manual dexterity on the part of the surgeon. In septic cases they both protect the operator himself, and prevent the infection of his hands in view of subsequent aseptic operations. Macewen uses them for this purpose. Even if they are not worn during an aseptic

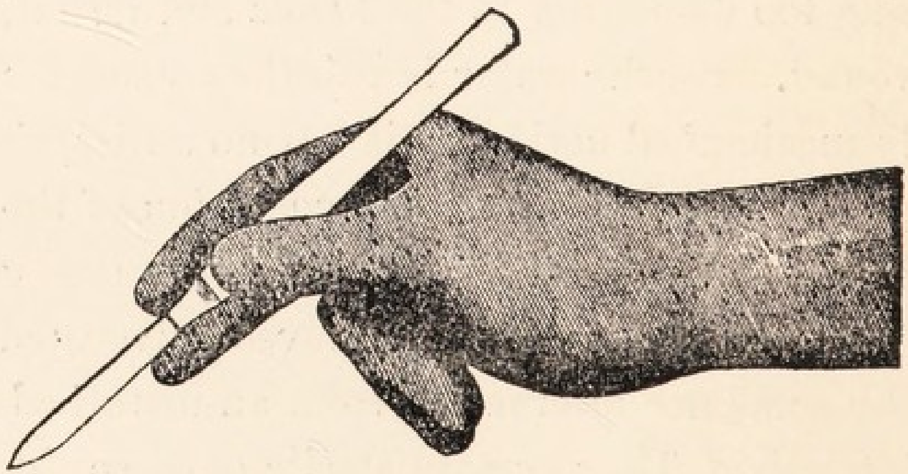


Fig. 24.

McBurney's India-rubber Operating Gloves.

operation they are very useful to pull on for preliminary manipulations such as arranging the patient.

For assistants they are of great value, both because the nature of their duties increase the chances of hand infection, and also because as Keetley points out, many assistants do not properly appreciate the importance of asepsis and fail to sterilize their hands, or forget to rinse them frequently during an operation unless reminded. Probably most operators have experienced the uncomfortable sensation at times, that their assistants' hands are not all they could desire.

Gloves complicate the technique but little, and may at times save laborious attempts at hand sterilization. For preparation they can, if necessary, be boiled, and should be kept in antiseptic lotion. Pulling them on is facilitated by smearing the hands with a little soft soap, or rubbing them with soapstone.

The preparation of the patient's skin at the site of operation, is a matter of great importance and one of the most responsible duties of the house surgeon or resident medical officer. Though in many situations the skin is easy to clean, this is not the case where it is thick, hairy, or ordinarily in a moist condition ; the axilla, groin, and scalp are on this account particularly difficult regions to prepare. The process is very similar to the preparation of the hands, and necessary modifications need only be detailed. On account of the greasier state of the skin of the trunk and limbs, fat solvents must be used between thorough washing, turpentine is cheapest and best for the purpose. In addition the part should always be shaved except in the case of children. The great object is to remove all grease and sebaceous matter. In very dirty skins the application of a soap poultice for some

Fig. 25.

hours is an excellent measure. This is merely a thick layer of soft soap spread on lint like ointment, and applied to the part. Where the epithelium is very thick and rough, Lockwood uses a sharp spoon to remove it during the soaping process. The too vigorous use of the nailbrush (though very necessary at times), should be guarded against and prolonged rubbing with soap on gauze more resorted to.

After this mechanical purification the part should be well douched and treated in the same way as the hands (*vide* above). Before applying the dressing, it is well especially if the skin is coarse or the part hairy, to dredge it with an antiseptic dusting

Fig. 26.

powder which should be well rubbed into the pores and roots of the hairs. Boric acid 6 parts, double cyanide of mercury and zinc 1 part, is a good dusting powder, but if a sublimate dressing is to be applied, the double cyanide must be omitted.

For the dressing a piece of gauze some 6 to 8 folds thick moist with carbolic acid lotion 1-40 is probably the most efficient, on account of its penetrating power, but the ease with which it is absorbed constitutes a distinct danger in the case of children, and for them at all events some other antiseptic dressing is preferable; cyllin or izal lotion may be substituted, or ordinary sublimate gauze. The gauze is then covered with a piece of oiled silk, jackonet, or gutta-percha tissue, overlapping it well all round. Wool is next applied and the whole fastened with a bandage. In preparing the skin in this way a region of at least four inches from the site of the wound on every side should be treated. When previous preparation is impossible, the same procedure, except the dressing, should be adopted.

This includes nearly all the preparations that must be undertaken before everything can be considered complete, and a few words on the surgeon's dress will finish them. The most convenient dress for India, is a long apron of white drill or stout calico extending from the throat nearly to the feet.

It should be fastened round the neck with a yoke or band of the same material buttoning behind, and round the waist with tapes tying behind. The edges of the apron drop from the mid-axillary line just behind the iliac crests, and leave the back uncovered. It should have half sleeves extending when loose to a point $1\frac{1}{2}$ inches below the bend of the elbow, and a tape should be run through a hem at the bottom. When in use these tapes are drawn tight and fastened above the flexed elbow joint, the slack of the sleeves overlaps a little, and thus affords ample room for the shirt sleeves to lie covered, without uncomfortably constricting the arms. An apron of this kind can be washed, boiled, or sterilized, with much greater certainty than a macintosh apron, and protects every part of the clothing in a way that it is almost impossible to secure with the latter. The assistant should wear a similar apron. For dressers a long jacket extending well down to the hips with half sleeves fastened in a similar manner is sufficient. A duplicate set of these garments for each person, is necessary in practice.

CHAPTER IX.

Preparation for Operation and Precautions to be observed during and after.

At the time of operation if the preparation of the site of operation has been carried out, it only remains to put in practice the directions given with regard to the sterilization of the instruments, swabs, towels, dressings and hands. If a steam sterilizer is available, the dressings should first be placed in it, next the swabs, both in their own bags or wrappers, after them the towels, and the aprons on the top, the lid is then tightly fastened, and the lamp lighted. This must be done at least three-quarters an hour before the time of operation.

If there is no steam sterilizer, the towels and swabs must be boiled, and the sterilization of medicated dressings and aprons must perforce be omitted. After lighting the instrument sterilizer, the instrument trays and bowls for lotions should be arranged on the tables in convenient positions and filled with lotion. There should be a separate tray for needle, sutures, needle-holder, and scissors and a mug for artery forceps, and a basin of lotion each for the operator and his assistant, in addition to the instrument tray and bowl for swabs.

By this time the water in the instrument and other receptacles will be boiling, and the instruments, etc., should be placed in them. (In the absence of an instrument sterilizer the instruments must be immersed in some strong antiseptic lotion for half an hour instead).

To save time the patient may at this point be brought in and anœsthetization begun. The operator and his assistant having first removed their coats and donned their aprons outside, now commence the preparation of their hands. The instruments after boiling for ten minutes in plain water, or five minutes in 1% per cent carbonate of soda solution, should be removed from the sterilizer in the tray, and placed bodily in the dish of lotion ready for them. They are better transferred now by the operator himself, but in any case they must not be touched by unprepared hands, and if the dresser does it, he must use a pair of sterilized forceps for the purpose. The sterilizer should be kept boiling. Next the towels and swabs are removed from their sterilizers and immersed in suitable lotions ready for them; they too must not be touched by unprepared hands during removal. If the medicated dressings have been steamed in a sterilizer, they should be placed in the closed kettles or receptacles on a table against the time they are wanted.

The patient should by this time be anœsthetized, and the dresser, or some one not assisting at the operation, cuts through the bandages retaining the antiseptic dressing in position, and removes them leaving the actual dressing in place. The operator wrings the towels lying in antiseptic lotion as dry as possible, and arranges them round the field of operation in such a way that, all possible contact of the hands or instruments with the patient's clothing or the table is obvitated during operation. In doing so unless he is wearing gloves for these manipulations, he must of course be careful that he does not inadvertently touch or grasp anything except through the medium of the towels. The assistant removes the dressing, gives the skin a final rub with biniodide spirit lotion, and a douche with some weaker lotion, and if considered necessary rubs in some cyanide and boric powder, dredged on to the skin by the dresser, and the preparations are complete.

During the course of an operation there are certain precautions to be observed. The operator and his assistant should from time to time rinse their hands in a bowl of some weak antiseptic lotion provided for this purpose. Acidulated sublimate or biniodide of mercury lotions 1 in 2,000 or 4,000 are equally good. Izal or cyllin 1 in 400 may be preferred, and may also be used for steeping the instruments and towels in, thus obviating a multiplicity of different lotions. Carbolic lotion can not be used for rinsing the hands, as it is too irritating both to the skin and also to the wound, which is almost bound to receive some of it. A drawback to mercury lotions too is that the plated instruments are liable to be blackened with the lotion the hands are rinsed with. In lifting instruments from the tray of lotion in which they are lying, it is well to let any excess of lotion run off by holding them perpendicularly for a few seconds, before putting them in to the wound, this both prevents unnecessary irrigation, and also the obscuring of the surgeon's view with fluids.

Neither the operator or his assistant should on any account touch any unsterilized object ; the temptation to do this is at times great, but must on no account be indulged. If it is necessary to handle anything which is not sterile, it must be grasped through the medium of a towel moist with antiseptic lotion of which there should be spare ones for the purpose. If anything is inadvertently touched, the hand must be thoroughly rinsed in antiseptic lotion before continuing. The assistant should confine his attention to sponging and holding instruments out of the way, or using the retractors; he should not touch any part of the wound with his fingers, unless at the operator's express direction ; by so doing he just doubles the numerical chances of infecting the wound with his fingers even if he is wearing gloves.

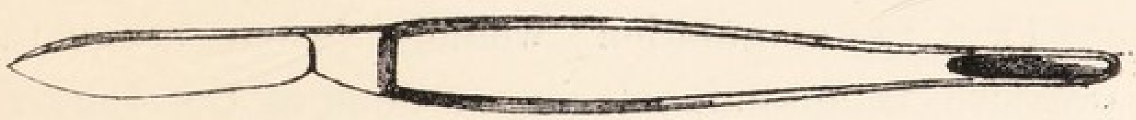
Any instrument that the operator may require, *he should pick up himself;* if he does want anything that is out of reach, *it should be handed up to him in its tray or receptacle ;* a special mug for artery forceps is on this account of great service. Dressings similarly should be handed to him *in their kettle or wrappers. Needles should on no account be threaded by anyone but the operator or his assistant,* and in handing or picking them up threaded, the slack of the thread should rest in the palm of the hand and not be allowed to hang down and touch contaminated objects. If an unsterilized instrument is required (though this should not often be the case) it can be immediately disinfected by immersion in pure carbolic acid or lysol for one minute, or by boiling for five minutes if a soda solution is used, or for ten minutes in plain water.

One definite source of aerial infection, which has not been previously alluded to, is from the mouth, especially if the teeth are carious or some other cause of oral sepsis exists. During operation therefore breathing should be conducted through the nose, particularly when bending over a wound, and speaking should be avoided in this position. In coughing or sneezing the face should of course be directed away from the wound. During a pause in the operation, or if the wound is an extensive one, it should be protected from unnecessary exposure to the air with a swab or sponge, this should be done automatically by the assistant. From time to time the operator *and his assistant* should rinse their hands in antiseptic lotion, even if gloves are worn this is a wise precaution.

In short it should be the constant care of the operator and his assistant that the condition of asepsis is maintained throughout the operation until the final dressing is put on. Such solecisms as scratching the head, twirling the moustache, stroking the beard or feeling the patient's pulse are serious falls from grace which will sooner or later carry their own damnation with them. The cultivation of what has been aptly called the "aseptic conscience" will alone prevent such obvious lapses from aseptic routine. It is a frame of mind which makes the possessor of it instinctively and automatically shrink from any possible source of septic contamination of his wounds, or anything which he touches them with, and it is as necessary in an assistant as in the operator himself.

A few words as to technique. The knife must be sharp, if not it will bruise and tear the tissues instead of cutting them cleanly, and may so lower their vitality as to turn the scale against them in the event of the wound being accidentally infected. The plan of having only one knife and keeping its edge keen by a few touches on the stone, as recommended by Jordan Lloyd and Grieg Smith is an excellent one, if the surgeon has the necessary knack of sharpening it.

Fig. 29.



Jordan Lloyds' knife with straight dissector.

Dissection with two pairs of dissecting forceps is a good plan if only planes of tissues are to be separated, they should not be employed to tear through structures in place of cutting them.

The use of lotions to irrigate a wound is a vexed question. The drier wounds are kept the better, and if everything that comes in contact with it is aseptic, irrigation is unnecessary and consequently better avoided; it is a great mistake to load lax tissues, *e. g.*, the scrotum, with fluids which cannot be expelled and cause unnecessary thickening afterwards. This does not apply to large cavities which are much more easily cleaned with fluids than by wiping them, and much less damaged in in the process. Personally I use the swabs boiled and laid in sterile boric lotion and squeezed dry before application to the wound, the lotion, if necessary, is used for irrigation, and I have had no reason to complain of the results; boroglyceride is convenient for making the solution quickly, and is less irritating than plain sterile water. (*Vide* Chap. IV.)

Drainage. This is generally unnecessary in aseptic wounds, if the use of strong chemical lotions (particularly carbolic), which set up free serous oozing, is avoided. Cheyne and Burghard give the following as the chief conditions in which it seems desirable :—

(1). In amputation wounds, when adequate pressure is unattainable on account of the danger of interfering with the blood supply of the flaps.

(2). When a cavity is left, and on account of anatomical or other conditions, pressure cannot be firmly applied.

(3). When the patient is thin and the amount of subcutaneous fat is small so that pressure cannot be applied without the risk of sloughing. (These cases can be summarized under the rule that drainage is generally necessary when adequate pressure cannot with safety be applied.)

(4). When the patient is very fat, there is a risk of the wound filling with oil which interferes with primary union.

(5). When there is a risk of sepsis.

When there is sepsis or a risk of sepsis, rubber drainage tubes should always be employed, otherwise in an aseptic wound a strand of 8 or 10 horsehairs, or a flat slip of gauze or better oiled silk asepticized by boiling, is sufficient to drain off any excess of serous exudation. Such a drain, if the wound remains aseptic, may be removed on the third or the fourth day.

Before applying the dressing, it is well in hairy situations to dredge the skin with boric acid powder, either plain or in the proportion of 6 to 1 of cyanide of zinc and mercury. Iodoform so frequently used is as remarked before quite pointless in the case of aseptic wounds, nor is it necessary to put powder in to the wound itself, if union by first intention is aimed at. Cyanide or sublimate gauze dressings should be wrung out of 1 in 40 carbolic lotion or other weak non-mercurial antiseptic lotion preferred, both to provide a temporary efficient germicide, and in the case of sublimate dressings to wash out any excess of the salt in the folds next the skin ; the moist gauze too, clings much better, and as the moisture dries up in the course of a very few hours, the dressing is practically a dry one. Over this moist gauze a sponge wrung out of antiseptic lotion, and squeezed as dry as possible, may be placed. It affords perfect elastic pressure and goes far to keep the wound dry. In a well regulated hospital it is well worth keeping a supply of sponges for this purpose only, though the difficulty of cleansing them properly during an operation frequently militates against their routine use for sponging purposes.

The remainder of the dressings are put on dry, gauze should be liberally used and wool only to fill up interstices, and form a layer under the bandages. The surface surrounding the wound should be freely covered, and particular attention should be paid to the direction any oozing is likely to take, and dressings placed to receive it.

The bandages should be as firmly applied as is consistent with safety, and it is an excellent plan if interference with them on the part of the patient is anticipated, to fix them with strips of strapping or resin plaster. The only objection to the wider adoption of this plan is the expense involved.

After an operation performed with these precautions, the dressing may be confidently left untouched for ten days, unless tubes or other drains have to be removed, but the question of after treatment will be dealt with in another chapter.

After operation the instruments should be scrub bed with soap and water, (the finest sapolio is best,) then boiled, wiped dry, polished with a wash-leather or selvyt cloth and put back in the instrument cupboard. Boiling is unnecessary after aseptic cases, but if a regular routine is not followed, the dresser is apt to omit doing so after septic cases, on the plea of ignorance, and the cupboard may become infected in consequence. The towels are collected and put aside to be boiled. They should not be thrown on the floor or used to polish pus bowls, etc. The basins should be scalded, and if there is a steam sterilizer of sufficient size, they may with advantage be steamed in it.

CHAPTER X.

After Treatment of Aseptic Wounds and Aseptic Precautions in the Wards.

An operation wound made under the precautions detailed in the previous chapter, should heal by first intention, and in this case it is better to leave the dressings untouched for a week or ten days. After certain operations, *e.g.*, radical cure of hernia, when too early movement may be harmful, they may with advantage be left still longer, *i.e.*, for two or even three weeks. If a drainage tube or gauze drain has to be removed, the dressing should be changed on the fourth day. The soakage of discharges through the dressings to the surface, is *not* an indication for a change when reliable antiseptic dressings have in the first instance been applied, unless the discharge is excessive. A slight staining of the bandages is easily produced by the gradual diffusion of a small amount of fluid through the dressings, and in this case it is only necesssary to apply some more antiseptic wool over the original bandages, and fasten it with another one.

Other indications for early dressing, in addition to those above mentioned, are much pain or discomfort with or without a rise of temperature, and a rise of temperature to 100F. or over, for twenty-four hours.

In the first case some patients are more sensitive than others, and feel the pressure of the dried and hard dressings on the skin, or there may be a collection of pent up serum distending the wound. This especially in children is quite sufficient to cause a rise of temperature, without any septic complication whatever. A rise of temperature maintained over twenty-four hours is very suggestive of the onset of septic mischief, though in India, where a large number of the subjects of operation are also the subjects of a latent malarial taint, it is not likely to be due to this cause. In case of doubt then the dressings should be opened, and the wound examined, if this is done under strict aseptic precautions the risk is negligeable, and far better undertaken before any septic infection has had time to extend. The disadvantages of an early change of dressings are, firstly, a risk of infection, and, secondly, the mechanical disturbance of the wound, with a possibility of slight hæmorrhage into its deeper parts.

The aseptic precautions to be observed in the wards are practically those detailed for operations, they are perhaps on the whole more difficult to carry out on account of the greater temptations to error, yet with care and vigilance this can easily be guarded against. Certain practical points have to be borne in mind and the routine once inculcated is not difficult to maintain.

In the first place there should be a separate set of dressing instruments, dressings and appliances for ward use only ; it is not safe or fair to use the operation room equipment for this purpose, nor equally is it right to use the out-patient equipment either.

A lotion bowl-stand on castors for three basins of strong and weak antiseptic lotions and boric lotion is a great convenience to wheel from bed to bed, and the equipment should include a dressing carrier for ward use only, with a pair of dredgers for iodoform and cyanide and boric powder. A jar of pure carbolic acid or lysol should be provided for the immediate disinfection of instruments. The instruments should include amongst the usual articles required, a pair of Lister's sinus forceps which may well replace on all occasions, the old-fashioned dressing forceps.

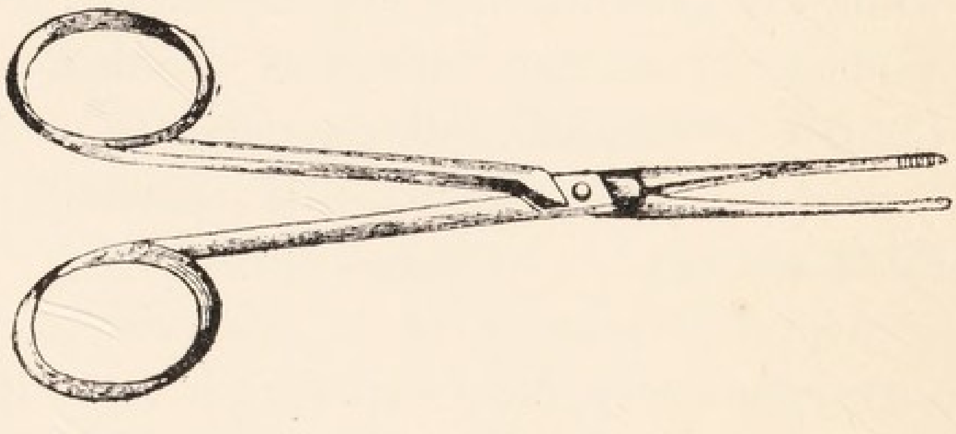


Fig. 30.
Lister's Sinus Forceps with aseptic joints.

A separate pair of large ward scissors should be provided for cutting bandages, and used for no other purpose at all. Dressing aprons are just as necessary as in the theatre. A douche can with a glass nozzle and clip for the tubing, and a macintosh sheet are also needed.

The instruments should be boiled before use and placed in carbolic or other antiseptic lotion as usual, in fact as strict aseptic methods are called for in the wards as in the theatre. The house surgeon should prepare his hands in the same way, and towels wrung out of weak antiseptic lotions should be arranged to prevent contact with the bedclothes. The presumably aseptic cases should be dressed first, and those known to be septic reserved till last of all.

The dresser cuts through the bandages and removes them and the more superficial dressings, he should also arrange the macintosh sheet in such a way that all fluids run off into the vessel provided on the floor, without wetting the bedclothes or the patient's clothing, and should also hand up any articles required *in their own receptacles.*

After dressing each case the house surgeon should rinse his hands or gloves, if he is wearing them, in some antiseptic lotion before proceeding to the next. *As far as possible instruments should only come in contact with a wound, or septic material.* There may be exceptions to this rule, but they should be few and far between and the importance of its strict observance in practice can hardly be overrated. Instruments can be quickly and certainly sterilized when infected ; this is not, however, the case with the hands, though their disinfection if undertaken immediately by rubbing in strong antiseptic lotion, is not so impossible of attainment as is generally supposed, particularly when the contamination is lightly effected, and the septic matter is neither rubbed in nor allowed to remain on the hands for long. Infected instruments after wiping with a swab, should be placed point downwards in the jar of pure carbolic acid or lysol provided for the purpose for one minute.

How to dress a wound.—If the discharge is slight in amount the more superficial layers of the dressings, can be readily lifted off, and then by steadying the single layer in immediate contact with the skin with the left hand, the upper layers can be peeled off *en masse* with the right. This process is rendered easier and practically painless to the patient, by placing swabs of wool wet with lotion, at the angle formed by the layers of gauze to be separated. This simple manœuvre is much more efficacious in thoroughly moistening and softening the gauze stiff with dried blood, than letting a stream of lotion flow over it, as much of this runs straight off without wetting the hardened dressing at all. If there has been considerable discharge, and the dressings are matted together in a hard mass, this process must be repeated layer by layer until the last one is reached, great care being exercised to prevent any direct traction on the skin, by the steadying action of the second hand. If the dressing is very stiff and hard the whole mass may be plastered with wet wool until it is thoroughly softened, and the above manœuvre then carried out. The final layer now moist and soft is easily peeled off the skin.

The appearance of an aseptic wound is very characteristic. There is no sign of inflammation or tension on the stitches, the line of incision and the skin on either side is discoloured with a little dried blood of a brownish colour, and on wiping this away the fine line of the incision is faintly visible. The wound should first then be cleansed with a swab of wool wet with weak antiseptic loton, and after protecting it with a piece of moist gauze or a swab, the surrounding skin is gently wiped with antiseptic lotion. If necessary the stitches may next be removed by snipping them as close to the skin as possible on one side ; it is better even to make a little gentle pressure on the skin, with the flat of the scissor blades and snip through the stitch at a point which was embedded in the skin, gentle traction with the forceps on the opposite side, bringing the suture away.

It may here be remarked that sutures are often removed too soon, aseptic stitches can do no possible harm, and it is better to wait until the wound is consolidated. The dressings are now replaced in the same way as after operation, with the exception of the sponge which may be omitted. If a drain has to be removed, this is also done at the first dressing, and is not replaced, unless there are signs of sepsis. The sinus or gap left, will heal by union of granulations, under the firm pressure of the bandages.

Sometimes on dressing a wound which has been causing discomfort, it will be found quite aseptic, but the skin is raised in a more or less globular way. This is due to a collection of serum. To relieve it is only necessary with the flat end of the probe used as a spatula, to gently separate the lips of the wound for a few lines in length, at the most prominent point; on so doing a gush of clear serum escapes, and the tension is immediately relieved. It may at times be necessary to divide or remove one stitch to admit of this. To economize dressings any unsoiled wool may, if it is antiseptic in the first instance, be used again to finish the outer dressing before applying the bandages. The treatment of septic wounds is considered in the next chapter.

CHAPTER XI.

THE TREATMENT OF SEPTIC WOUNDS AND PROCESSES.

So far the induction and maintenance of asepsis and the consequent prevention of sepsis, in operation and other clean wounds has been considered. Many wounds, however, are already in a septic condition, before they are seen by the surgeon, or if not actually septic are so contaminated with gross dirt and foreign matter, that it is only a question of time before they become so, unless they are suitably treated. Operations, too, have to be performed for conditions and diseases complicated by sepsis, and unless special precautions are taken, what is only a very localised infective process before operation, may result in a great extension locally or even in general infection.

The general principles which must guide practice under these conditions differ in some degree from those underlying the practice of surgery in the production and treatment of aseptic wounds. While the latter methods are still indicated for the preliminary steps, they may be supplemented in the actual treatment of septic wounds and processes ; or in other words while sterilization by heat or chemical means are just as necessary in maintaining the aseptic condition of everything that comes in contact with a septic wound, much can be done by the judicious use of chemical antiseptics, and attention to free drainage.

Those who trust only to drainage and the use of sterile dressings, and discard the use of chemical antiseptics in any shape or form, on the supposition that they are harmful on account of their irritating properties, are frightening themselves by a bugbear of their own raising, and throwing away a powerful weapon in the treatment of sepsis. I say this advisedly as there is a growing tendency in this direction, and it is a backward step to the conditions which obtained before Lister inaugurated his system with such beneficent results.

As already stated perfect asepsis, whether obtained by physical or chemical means, is absolutely necessary in the treatment of septic conditions ; the tissues already weakened by septic invasion, are in a worse condition to withstand any fresh infection. If on the other hand fresh infection is prevented, and the tissues are placed in the best position for the unfettered exercise of their natural powers of resistance the invading bacteria are quickly killed off and the septic process ceases.

Septic discharges frequently copious and free, are a most attractive breeding ground for saprophytic bacteria, and the toxins they produce in their growth are very irritating and harmful to the tissues already struggling with pathogenic organisms. The use of unirritating chemical antiseptics, such as boric acid and the double cyanide of zinc and mercury, will unquestionably keep a septic wound free from their attacks, or quickly clear them off if they have gained access. But in addition to their action in this way, there is no doubt that these substances, when kept in close contact with wounds do exert a powerful inhibitory action on the pathogenic bacteria themselves. This is too often overlooked or wilfully denied on the strength of certain laboratory experiments, but clinical experience shows its truth.

Another fact liable to be overlooked is that the evil effects of bacterial invasion are directly due to the toxins they produce in their growth; neutralize them and the organisms are powerless for harm, and are quickly destroyed by the bacteriolytic and phagocytic powers of the body cells and fluids.

Now in iodoform we have a chemical substance that acts in this very way, *i.e.*, by neutralizing toxins and thus preparing the way for the destruction of the septic organisms themselves. Of course the living tissues must do this, but the argument that chemical antiseptics have no power to help, and more that the irritation they cause is inimical to tissue action is absurd. On the face of it which is preferable, to leave the tissues to be peptonized and destroyed by the toxins of the invading bacteria, or by neutralizing them to help them in their struggle? Even if chemical antiseptics have some irritating effect (which is by no means necessary if they are judiciously employed), can this be compared with the harmful effect of the toxins themselves? While there is no doubt that the routine use of strong lotions for irrigating septic wounds is unnecessary, it is equally certain that the judicious use of even strong antiseptics in septic conditions is under certain circumstances highly beneficial, while their routine use in dressings is unquestionably of the highest value. (I am tempted to instance the case of severe burns, which rapidly become septic in the absence of antiseptic dressings, but the practical application of these considerations will be given later).

Another most important measure in the treatment of septic wounds or processes is the provision of free drainage. Closed wounds which have become septic must be immediately opened and treated as open wounds under suitable dressings, the discharges then quickly run off or are absorbed in the dressings. It is the penning up of such septic fluids which is so harmful and produces such disastrous results both constitutional and local. In cases of virulent infection usually associated with widespread cellulitis and very severe constitutional symptoms, the relief of tension by numerous small incisions, and moist warmth in the form of a hot bath, are steps which best afford relief by quickening up the circulation and improving the blood and lymph supply, and materially aid the tissues in their struggle with septic organisms, while warm moist dressings on septic sores or wounds, act in the same way. The mechanical action of carbolic lotion in inducing free runs discharge, and thus flushing the affected part with lymph, though nowadays often condemned as an evil, may not unlikely be of real value, and may account for the great reputation it had when septic processes were oftener seen. With these preliminary remarks, the consideration of practical details may be undertaken.

The preparation for operation of cases in which septic conditions already exist, will first be considered, next the special precautions to be observed during operation, the after-treatmemt of such cases, and of operation wounds which may have become infected ; and finally the treatment of accidental wounds, which are either septic or in a fair way to become so, when the subjects of them attend for treatment.

Typical septic conditions in which operation is called for are, an acute abscess, an ulcerating cancerous sore, gangrene or extensive cellulitis necessitating amputation and a septic fistula leading to one part of a mass of tuberculous glands. In all these instances, the preparation of the site of operation is the same as previously detailed (*vide* Chapter VIII,) the skin must be washed and shaved for some distance round the site of operation, and a moist antiseptic dressing covered with some waterproof material put on. Where a septic breach of the surface exists, this should be freely powdered with iodoform, and a separate piece of gauze applied to it ; if a sinus exists this should be well plugged with a separate piece of gauze, the temporary damming back of any discharge will do no harm, the object being, in these instances to prevent as far as possible, the contamination of the surrounding skin for a few hours before operation. In such cases it is well to change the dressings an hour before the operation, repeating at the same time, the cleansing process in its entirety. If the discharge is very profuse, it is better to make an attempt to clean it up to some extent, by the application of moist antiseptic dressings changed two or three times a day, for some few days before the operation is done ; this, however, is not always possible.

At the time of operation, if the line of incision does not pass through the septic tissues, *e. g.*, in amputation for gangrene, the limb should be swathed in moist antiseptic towels, placed over the bandage : or in the removal of an ulcerating cancer of the breast, the dressing should on no account be removed from the ulcerating sore, but should be covered with a few more layers wrung out of some strong antiseptic lotion, for greater safety. In this way the operation in either case may be performed under practically aseptic conditions.

If on the other hand the line of incision must pass through septic tissue an attempt should be made to remove it in toto by free incision or if this is impossible to disinfect or remove it, before wounding other parts, by free scraping with a sharp spoon, and washing away a *is* at once. For this purpose a flushing curette is invaluable.

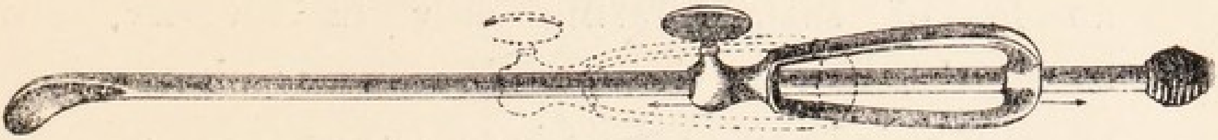


Fig. 31.
Dunn's Flushing Curette.

The edges of infected skin should also be snipped away with scissors, and the part well rubbed with liquefied carbolic. The instruments used for this preliminary procedure must, of course, be placed on one side, and not used in the subsequent stages of the operation.

Though scraping operations can hardly be considered radical, yet the fact remains that they are frequently successful. Wright suggests that this may be due to the absorption of bacterial elements, and the consequent raising of the opsonic index, and that such absorption is precisely what might have been expected to take place, after surgical procedures which freely open the lymph spaces. Cheyne remarks that it is at least as likely, that the removal of the greater part, at any rate, of the substances which were entering the blood and depressing the index, is the real explanation. Possibly both suggestions are true in part; the more thorough the removal the greater the chances of success, though the actual mechanism is uncertain.

It may sometimes seem advisable to make an attempt to thus cut short a septic process, by the free removal of all the infected tissue, and subsequent treatment under antiseptic dressings. Typical examples of this, differing only in severity, are carbuncle, and a chronic abscess, or sinus. The procedure is in these cases is to scrape away all the diseased tissue. Partial measures may end in disaster by giving septic matter free access to the surrounding tissues or even to the general circulation. A sharp spoon or curette must be used, blunt instruments are useless as they only tear and do not remove the septic tissues. After thorough scraping and flushing the sinus or abscess cavity may be closed, and an attempt at union through blood clot may be made. In treating a carbuncle on this plan, this must be followed up by the free application of liquefied carbolic acid, well rubbed in. This is both a powerful antiseptic and an escharotic, and free serous discharge follows its use. Antiseptic dressings are then applied, and in a few days when the sloughs separate, a healthy granulating surface will appear. The after-treatment is as above detailed.

Septic or even suspectedly septic wounds must always be drained.—If the wound is a deep one or very septic it is safer not to suture it at all, but to plug it with iodoform gauze from the bottom, and apply the usual surface dressings on the top. If the wound can, however, be safely closed in part after providing for free drainage, more or less partial suturing hastens the process of healing, and is usefully employed. Practical experience alone is the guide in such cases. A good rule is :—When in doubt treat as an open wound. For securing really efficient drainage there is nothing approaching rubber tubes in ordinary wounds. Gauze and horsehair act well enough, when only a little serous oozing is anticipated from a small wound, but if the discharge is purulent, gauze is a very bad drainage material, and is much more likely to dam it back than help it off. Gauze packing round drainage tubes has an advantage in hastening the process of granulation by mechanical irritation. For small wounds, *e. g.*, of the scalp or face, a slip of oiled silk makes an excellent drain.

Rubber tubes should have a few oval holes cut in them at intervals, on opposite sides of the tube, they need not necessarily extend right down the depth of the wound, which may delay union in the deeper parts. The external end must be cut off flush with the surface of the skin, this is important as otherwise they act very poorly. As a precautionary measure it is sometimes advisable to suture them to the integument, to prevent them slipping out. For the drainage of deep cavities, *e. g.*, an abscess of the liver it is better to transfix them with a safety pin, placed at right angles to the line of the incision to prevent them disappearing into the cavity.

Another practical point to remember is that, *two medium sized tubes in close juxtaposition drain a cavity much more efficiently, than a single large tube.* In placing them in position, close attention should be paid to the direction which discharges are likely to take when the final bandages are adjusted. It is no good for instance, to drain a scrotal wound through the lower end, when it is finally tilted high above the upper end of the incision, by bandaging it to the thigh. Before applying the dressings it is well in septic wounds, even if an attempt is made to secure partial primary union, to dust the interior with iodoform or in extensive wounds with iodoform and boric powder 1 part to 6, and to plug them with iodoform gauze, or with cyanide gauze dusted with the powder. In all septic wounds the free use of iodoform or its substitutes, in the wound and on the surrounding skin, is a rational measure before the final dressings are applied. These are the same as detailed in Chapter IX with the exception of the sponge. In extensive wounds, or in the case of children, the danger of carbolic acid absorption, must be borne in mind, and only dilute solutions used for moistening dressings, or some other non-toxic antiseptic lotion should be substituted, these must be used also for irrigating the wound.

After treatment of septic operation wounds.—If the discharge is profuse or it is desired to remove a temporary gauze plugging, and substitute a drainage tube, the dressing may be changed after twelve hours, otherwise it may be left till the following morning. In dressing the wound next day, there is no necessity to remove the whole of the gauze plug, if there is much discharge it will come away quite easily, but if not, its removal only causes unnecessary pain and it may be left, the upper portion only being cut off; the wound should be freely irrigated with a weak antiseptic lotion, and after cleansing the surrounding skin with some stronger antiseptic and dredging it with iodoform and boric powder, the dressings are again applied, preferably moist and covered with jaconet or some waterproof material. Septic wounds should be dressed exactly in this way daily, until the discharge has practically stopped, when once in 48 hours is often enough. As improvement takes place, dry dressings may be used instead of moist ones and boric gauze may, with advantage, be substituted for iodoform, or other gauze dusted with iodoform powder and finally when it is granulating well, boric ointment spread on lint may be used, of half or a quarter the strength of the official ointment. Drainage tubes should be shortened gradually, and thoroughly washed in strong antiseptic lotion before being replaced.

Operation wounds that have become septic must be treated on similar lines. Pain and a rise of temperature will point to the necessity of removing the dressing. When this is done the wound, if securely infected, will be seen to be red and swollen with great tension on the stitches. The object now is to secure free drainage, and to this end the stitches must be cut and the wound opened from end to end. It is better not to irritate the wound by irrigation with strong lotions at this time, if irrigation is deemed necessary to clear out clot, or discharges retained in deep pockets, it should be done very gently with hot boric lotion ; the dressings should then be applied *moist* with boric or some weak antiseptic lotion, and covered with jaconet or gutta-percha tissue, over which a thick layer of wool is placed and the whole lightly bandaged. Instead of cyanide or sublimate gauze, boric gauze may be used as being less likely to irritate. This moist dressing which acts as an aseptic poultice should be changed twice or three times a day, until the acute inflammation has subsided, and the discharge is free, later as this subsides it is better to resume the dry dressing above described. Open septic wounds improve quickly under those means and as the discharges flow off easily there is but little chance of septic absorption.

In a case of less severity it may be sufficient to remove one or more stitches, and to insert a drainage tube after which the dressings are re-applied as above directed. If stitch abscesses only are found all that is necessary is to remove the offending sutures, without opening the wound. In some cases there may be evidence of thickening and inflammation, but no sign of pus-formation, in these instances it is well to await developments provided that the constitutional symptoms are not severe ; it is not unlikely that it will prove to be merely plastic inflammation the result of mechanical irritation of the tissues. Injudicious interference with the wound will only delay union, but at the same time this waiting attitude must not be pushed to an extreme, and if at subsequent dressings there are unequivocal signs of suppuration, the wound must be opened and drained at once.

The objects to be aimed at in the treatment of septic wounds are briefly :—

(1). Free drainage.

(2). Avoidance of mechanical or chemical irritation.

(3). Avoidance of fresh infection, by ensuring the asepsis of everything brought in contact with them.

Practical details of treatment are in addition—

(1). The use of *moist* unirritating antiseptic dressings, during the stage of acute inflammation, and free discharge.

(2). The use of iodoform or one of its substitutes which neutralize toxins, and thus indirectly help the tissues to cope with septic organisms, and

(3). Later the employment of dry antiseptic dressings.

Fresh accidentally inflicted wounds.—These may be incised, lacerated or contused wounds, though frequently a greater or less degree of contusion may complicate the two first. An attempt may always be made to get an incised wound of the face to heal by first intention, as the resulting scar is then less disfiguring, and as wounds of the face heal well on account of the good blood supply. It is well to insert a drain of a few horsehairs, particularly if the wound has been wiped with carbolic lotion. Incised wounds in other situations if sutured are better drained. If no attempt is made to promote primary union and they are treated as open granulating wounds, this may be unnecessary unless the wound is a deep one.

Such wounds when contaminated by contact with the clothing, must be freely cleansed by swabbing and washing with a strong antiseptic lotion and the skin round thoroughly cleansed with soap and water applied with a nailbrush; this treatment, though necessary, is apt to cause considerable serous discharge which necessitates drainage; this is of less inportance as such wounds cannot safely be closed. Incised wounds of the scalp are very liable to become septic, on account of the condition of the epidermis in this situation, which is usually thickened and scaling, and harbours micro-organisms; they require very thorough cleansing both on this account, and also in view of the serious consequences that may ensue, if they become septic. The hair should be cut close or shaved for some distance round, and the scalp scrubbed with a nailbrush and soap, and then freely rubbed with some strong antiseptic lotion. Next the wound should be dusted with iodoform, and the scalp round it with cyanide and boric powder moistened with 1-20 carbolic to make a paste which should be rubbed into the roots of the hairs, the usual antiseptic dressings are then applied.

Lacerated and contused wounds must, as a rule, be treated by the open method, and allowed to granulate from the bottom, the tissues are so damaged that the application of sutures is a useless proceeding, apart from the danger of penning up septic discharges. Frequently such wounds are grossly contaminated with soil, dust and dirt, which is so intimately ground into the wound that it is a matter of the greatest difficulty to clean them. This must be done in the most thorough manner. If scrubbing with soap and a nailbrush and antiseptic lotion is insufficient, the patient should be placed under an anæsthetic and the wound scraped with a sharp spoon. Tags or shreds of torn tissues must be cut away with the scissors, and lacerated structures, such as tendons, nerves or muscles sutured. Free drainage must be provided for, and the wound dressed antiseptically as above described. If there is any reason to suspect the onset of tetanus, a prophylactic dose of tetanus anti-toxin, if available, should be administered subcutaneously.

Accidental wounds already septic.—These are frequently seen in a fearful state of neglect, stinking abominably from the presence of saprophytic micro-organisms, and at times infested with maggots. Their seriousness depends on the extent to which septic matter is pent up. If the wound is superficial throughout, septic absorption is comparatively limited, but if there are deep pockets in which discharges are locked up, serious constitutional disturbance accompanies the local condition, and general infection may follow.

When the wound is superficial it must be cleansed in the manner above described, and well rubbed in addition with turpentine to dislodge maggots, if they exist. It should be then freely powdered with boric and iodoform powder, and moist antiseptic dressings covered with oiled silk or gutta-percha tissue should be applied. If on the other hand the mischief extends more deeply, after thoroughly scrubbing the surface and adjoining skin with soap and strong lotion, all sinuses or pockets must be laid open and drained. The object is to convert the deeper parts into an open wound, and thus prevent absorption. Maggots, when present, must be dislodged by the free application of turpentine wherever they are found, and after thorough scraping and flushing, the whole surface should be well rubbed with liquefied carbolic acid. The wound is then dressed with moist antiseptic dressings under gutta-percha tissue, after dredging it freely with boric and iodoform powder. If necessary drainage tubes must be inserted in any of the deeper parts, where discharges may otherwise collect. Such septic wounds must, of course, be dressed frequently until the discharge lessens in amount, and granulation sets in, when dry gauze dressings may, with advantage, be substituted for the moist ones.

While on the subject of septic wounds, a practical point in the prevention of pyœmia may be mentioned. This disease usually begins as a local septic phlebitis. If this is recognized in time, and the affected vein can be ligatured, this should be done. This operation, performed, of course, under strict aseptic conditions, well above the affected part with excision of a portion of the vein between ligatures, affords the best and perhaps the only chance of saving the patient's life. This is an antiseptic measure in the truest sense of the term, but strict precautions must be taken to ensure perfect asepsis, or it will fail.

CHAPTER XII.

Aseptic Precautions in the Casualty Room or Out-patient Department.

All that has been written about the necessity for asepsis, in the operation room and the wards, applies equally in out-patient practice. It is indeed—if such a thing were possible—even more important to be careful and particular about aseptic precautions in the out-patient room, because the conditions are so much more favourable to sepsis. Many patients attend with wounds in an already septic state, and the chances of the accidental infection of clean wounds are therefore great.

There is no real reason why the results of minor operations performed in the out-patient department should not be every bit as successful, from an aseptic point of view, as the more serious major operations done in the operation room provided that adequate arrangements are provided and a careful routine is laid down and systematically carried out. The fact that the conditions are more unfavourable should only imply the necessity for greater care and vigilance, and should not induce a despairing frame of mind, which regards all such attempts as trouble thrown away.

It is for this reason that a separate chapter has been devoted to the consideration of this aspect of aseptic surgery, though it will involve the repetition of much that has been said already in previous chapters.

The conditions then that obtain in the out-patient or casualty departments, render stricter adherence to Lister's methods necessary, aerial infection here is a definite danger, which cannot be disregarded with impunity. Reliance has therefore to be placed on the use of chemical antiseptics, during operations, and the dressing of wounds, whether septic or not.

The proper equipment is the first thing to be considered; it should include the following articles :—

(1) An operation table.

(2) An instrument table, or, better, two.

(3) A stool and a footstool.

(4) A receptacle for storing water and a large kettle or vessel for boiling it.

(5) A large washhand basin and stand.

(6) A nailbrush and pumice stone, in their own jar.

(7) Soap, preferably soft soap, in a special gallipot or jar.

(8) A small instrument sterilizer and lamp with an upper partition for steaming dressings.

(9) Two instrument trays of enamel iron.

(10) At least three enamel iron basins, two medium sized for lotions and one smaller for swabs.

(11) Three or four large Winchester quart bottles with stoppers, for stock lotions.

(12) A dressing carrier, with a small jar of pure carbolic acid, or lysol and two dredgers, one for iodoform and the other for cyanide and boric powder.

(13) An aseptic dressing case, including a sharp spoon or curette.

(14) A 4oz. dressing syringe, or preferably an enamel douche can, with tubing, clip, and glass nozzles complete.

(15) A set of pus bowls or trays.

(16) A pail for soiled dressings with a lid.

(17) A pair of large scissors for cutting bandages.

(18) An adequate supply of antiseptic dressings.

For minor operations a macintosh sheet, six towels with a special mark, and a glass ligature holder, are required in addition.

With this equipment, satisfactory work can be done ; the supply of bowls may vary, but it is better to have too many than too few, and the above may be taken as a minimum.

The instrument sterilizer is a very necessary article of equipment, and can be cheaply improvised out of an old kerosine tin, in the bazaar. The dresser or medical officer should also have a coat or apron with half sleeves, as above described, for use during the work of dressing.

The daily routine is pretty much that detailed for operations, except that as no steam sterilizer is usually available, the steaming of dressings, etc., has to be dispensed with. The dresser should boil the instruments and set out the bowls, trays and lotions in the same way ; cleanse his hands thoroughly as detailed above, and put the instruments into the tray of carbolic lotion 1-40 or other antiseptic and swabs into 1-2000 biniodide or other reliable antiseptic lotion, boric lotion is too feebly so to be trusted. He is now ready to begin.

Practical points to remember are, that the large scissors should only be used to cut bandages and never dressings. The fingers should never touch wounds or septic matter unnecessarily, the instruments should be used for this purpose and at once sterilized by wiping and immersion in the jar of pure carbolic acid afterwards. If septic matter is touched the hands should be immediately rinsed and rubbed in strong antiseptic lotion. Soiled dressings, pus and discharges, should be immediately thrown into the pail for the purpose and on no account on the floor. A little antiseptic should be put into the pus bowls before receiving discharges, and they should be rinsed with more after emptying them. After dressing each case, the dresser should rinse his hands in the bowl of lotion provided before proceeding to the next.

Antiseptic lotions and swabs must be freely used for washing all wounds, as many are septic, and all in some danger of becoming infected, and in this important particular the practice differs from that advocated in aseptic on uncomplicated wounds. The treatment of septic wounds was detailed in the previous chapters, and it need only be remarked here, that antiseptic dressings, (the layers next the skin, being moistened with antiseptic lotion) must be freely applied, with antiseptic wool on the top.

There is here no question of their comparative utility,—*they are an absolute necessity*, in out-patient practice.

No unmedicated dressing should be allowed in the out-patient or casualty room. If from misplaced motives of economy it is so allowed, to pack the outside of the dressings, it will inevitably be used in time, for making swabs, or for application on the wound itself; the extra cost of making medicated wool and gauze is so small that expense can never be urged as a reason for not employing them.

At the end of the morning's work the instruments should be boiled, dried and put away and all bowls scalded with boiling water. This may sound rather complicated,—in practice it is the simplest routine possible; it simply consists in observing ordinary cleanliness, and in the free use of antiseptic lotions for washing the wound, the hands, skin, swabs, instruments and anything else that may come in contact with it.

For minor operations exactly the same preparations and precautions are called for, as detailed in Chapter IX, including, of course, the preparation of the field of operation, by the arrangement of towels moist with antiseptic lotion.

In view of the difficulty of keeping the hands aseptic, during the manifold manipulations rubber gloves are unquestionably useful. If used after applying the first layers of dressing they should be removed and thrown into antiseptic lotion, while the remaining dressings and bandages are applied with the bare hands. The gloves are then resumed after removal of the bandages of the next case to be dressed. In this way contamination of the hands is avoided and the risk of conveying septic material from one wound to another is reduced to a minimum.

CHAPTER XIII.

Some Special Methods, and their Application for Certain Operations.

The rapid sterilization of small instruments is quickly and certainly done by either immersing them in liquified carbolic acid for one minute, or by boiling them in liquor potassii in a test tube over the flame of a spirit lamp. This is the most convenient plan to adopt for the sterilization of such small things as steel hypodermic needles, Southey's tubes, or a hydrocele cannula and trocar. Irido-platinun hypodermic needles are preferable to ordinary steel ones, as they can be heated to redness in the flame of a spirit lamp without damage; though their cost is four times that of ordinary needles, they are practically indestructible and in the long run more economical, besides being safer.

Wounds of mucous surfaces in the buccal or pharyngeal cavities, Lister recommended should be brushed lightly with a solution of chloride of zinc 40 grains to one ounce. This by it's escharotic action produces a whitish firmly adherent slough, which opposes an effectual barrier to the access of bacteria until the process of healing by granulation is sufficiently advanced, to obviate infection when the slough separates. Wright has also suggested with the same object in view, painting mucous surfaces with a 2 per cent. formalin-gelatin solution. Such a solution, he says, quickly sets "forming a tenacious elastic skin." Staphylococci according to his experiments "have been rapidly devitalized when imprisoned under a skin of formalin-gelatin." His method of preparing it is as follows: A 15 or 20 per cent. solution of gelatin in a test tube is liquefied by immersion in hot water. To prevent pain this is first painted on the wound or abrasion. A volume of formalin equal to 1-20th of the bulk of the remaining gelatin solution is then added to it, and this is rapidly painted on before it has time to set. Wright used it with success in hæmorrhagic oozing from the gum in the case of a hœmophiliac, which had persisted for weeks in spite of the local application of adrenalin. He suggests that by painting the skin before operation with it, that it might furnish the aseptic surface which is required, and might be found useful in sealing up aseptic operation wounds. It would certainly appear to be useful in covering denuded surfaces both mucous and cutaneous, as it sticks much more closely than collodium. For abrasions and granulating sores it makes a most efficient covering, and healing "under a scab" practically takes place; it is further a very elastic scab, and permits of considerable movement without any cracking and has besides, according to Wright's experiments, definite antiseptic properties. Iodoform, boric acid, or double cyanide powders, can be incorporated with it, and its durability can be increased by laying one or two layers of gauze on it, painting them with more of the solution and rubbing it in well, with the finger before it sets. For wounds of the face this is a most useful dressing.

Other substitutes for collodion are "velvril" and a mixture of hard paraffin 20 per cent. in xylol. Leedham Green mentions the latter as useful for preventing hand infection, more especially when the operation is a short one, and it may prove especially useful in filling the furrows round the fingernails, where disinfection is particularly difficult. Velvril is a cellulose compound soluble in acetone. For dressing purposes it is supplied in the form of thin films, which can be boiled in water without injury. In dressing a wound with it the skin must be wiped with a swab dipped in acetone, and the surface painted with velvril solution. The piece of film is then applied, covered with wool and firmly bandaged. Left to itself it will adhere firmly for ten or twelve days and can then be peeled off. If it is necessary to remove it before this time, this is done by moistening it with a damp cloth or swab when it can easily be peeled off by seizing it by one edge. (For details *vide Lancet*, January 1903.)

The aseptic treatment of burns.—Burns of the second degree, in which only the superficial layer of the skin is involved, are best treated by puncturing the blisters at their most dependent part, to let off the excess of serous exudation, and then by applying mild antiseptic ointments. Healing takes place most painlessly and rapidly in this way, when the blistered epidermis is not removed. For small burns in which the blisters have been inadvertently removed or rubbed off, probably the best plan is the application of a saturated solution of picric acid on gauze or lint, which should be pretty frequently changed. Besides being antiseptic it coagulates albuminous fluids and forms a protective covering to the denuded nerve endings in the papillary layer of the skin, and thus relieves the acuteness of the pain. In burns of this degree, which do not extend beyond the papillary layer, the danger of septic absorption is slight, and healing takes place pretty quickly.

It is in burns of the third and fourth degrees, when the true skin is in whole or in part destroyed that the maintenance of strict asepsis is so essential. This is often most difficult on account of the extensive surface involved, and the accompanying shock, which renders it advisable to disturb the patient as little as possible. After a burn the vitality of the tissues underlying the affected part is greatly lowered, and consequently such wounds heal slowly ; while the natural resistance of the tissues to bacterial invasion is greatly impaired, the free albuminous discharge affords a peculiarly suitable medium for bacterial growth ; it is in this class of wounds that the presence of saprophytic bacilli is particularly in evidence, evinced by the foul odour in the discharges and dressings.

First a word of caution should be given against the use of carron oil and flour dusting powder frequently recommended. The first is a filthy application, and is probably responsible for death from septic troubles in many cases; the second is objectionable too, as besides being in all probability very septic, it forms with the discharges crusts under which purulent fluids are pent up and absorbed. *Neither of these two applications should ever be employed, and the popular fallacy about them and water dressings should be combated as far as possible.*

The patient should be placed under an anæsthetic if possible to avoid further shock, and the burnt surface should be thoroughly cleansed with soap and water, and washed with some non-toxic antiseptic solution. Carbolic and sublimate lotions are unsuitable on account of the danger of absorption, and general toxic poisoning, if used their application should be quickly concluded. Izal and cyllin lotions are free from these objections as is biniodide lotion to a less extent. An antiseptic dressing should next be applied, and for this purpose there is nothing better than the double cyanide gauze; the layer or two next the skin should be moist with izal or cyllin lotion and the remainder should be put on dry. This dressing may be left in position for three or four days, or even longer if no signs of sepsis occur, and is best removed in a warm bath, when the parts should be gently irrigated with weak antiseptic lotion and the dressing again applied. As granulation proceeds boric ointment dressing may be substituted. Burns which have become septic, if extensive are best treated in warm baths by day, and at night when the patient is removed from the bath, a moist boric gauze dressing under guttapercha tissue should be applied, until healthy granulating surface appears.

Aseptic treatment of empyema involves one or two practical points, though in principle it does not differ from aseptic practice generally. In the first place it is often difficult to be sure that a pleural effusion has become purulent ; it is well therefore before aspirating the pleural cavity to be prepared for the complication of pus in it, and for immediate operation in this event. The best practice is to ensure free drainage by the removal of a portion of a rib, preferably the seventh in the posterior axillary line, an inch to an inch and a half is quite sufficient for the object in view. The pleura is next incised and a *double* drainage tube should always be inserted. At the time of opening the pleural cavity no attempt should be made to irrigate it, on account of the grave danger of shock. In 24 hours it should be irrigated with boric lotion at the temperature of the body, and after the lapse of two or three more days, tincture of iodine one drachm to the pint may be substituted for this. The strictest aseptic precautions must be maintained at the time of operation, and at subsequent dressings and irrigation, when the purulent discharge will disappear in a surprisingly short time. The tubes can then be shortened and finally removed and the sinus allowed to close, which it will do very quickly. A long probe should be cautiously passed at the time of dressing, if there is any reason to suspect the present of pus shut off by adhesions. Pads of medicated sawdust are a cheap and efficient dressing for absorbing the free discharge.

Aseptic treatment of hepatic abscess hardly deserves special mention, and the excuse for doing so, is the paramount importance of the maintenance of strict asepsis during and particularly after operation, at the subsequent dressings. What may be considered normal liver pus is free from the presence of pyogenic cocci, and if their access can be prevented (as it certainly can with care and vigilance) the necrotic process which Rogers has shown to be due to the amoeba coli, ends in a comparatively short time. I have more than once seen in a rather limited experience of this disease, the purulent discharge cease in from two to three weeks, though a large cavity still existed from which there was only a little clear serous discharge. If on the other hand pyogenic infection is superimposed on the amoebic process, the danger to life is greatly increased, and the case drags on in a very protracted way, necessitating possibly counter openings to drain the cavity, and not unlikely ending in death from hectic fever or exhaustion.

At the time of operation if parietal adhesions do not exist, the peritoneal or pleural cavities must be cut off from the chance of infection, by gauze plugging, this by its irritating effect on the serous membranes, sets up simple inflammation and the formation of adhesions which prevent subsequent infection of these cavities. The abscess should be opened with a pair of Lister's forceps by Hilton's method, and a double drainage tube should be inserted. If the chest wall is traversed it is best to remove a portion of a rib to ensure free drainage. At subsequent dressings free irrigation should be employed, at first with boric lotion, later with iodine lotion, and a solution of iodoform in pure ether may still later be injected into the abscess cavity; the ether sometimes causes a little burning or smarting, but quickly evaporates at the temperature of the body and does no harm, the iodoform remains in the cavity and exercises its beneficial action. In this way it is possible to introduce iodoform into deep and extensive cavities with ease and certainty. Antiseptic gauze dressings must be freely applied to absorb the abundant discharge, wool, however absorbent, and tow are of little use for this purpose, the thick liver pus makes its way quickly to the edge of dressings underneath it; sawdust pads are a cheap and efficient substitute. The dressings must be frequently changed at first, twice or oftener if necessary in 24 hours, later once a day, and still later when the discharge has almost ceased every two or three days will be often enough. The drainage tubes must be retained until the cavity has closed.

The antiseptic treatment of chronic abscesses.—When small and superficial the best plan is to dissect out the whole abscess sac, as if it were a sebaceous cyst, and close the incision with stitches. If it should be inadvertently ruptured in the process the wound must be very thoroughly irrigated with some antiseptic lotion, powdered with iodoform and may then be stitched up as before. In larger or deeper lying abscesses it is frequently impossible to remove the wall of the sac entirely; in this case as much as can be, should be dissected away and the interior surface of the remainder should be thoroughly scraped and douched with a flushing curette. The cavity should be wiped dry, and either a little iodoform powder or an emulsion 10 per cent. in glycerine, should be introduced and the wound sutured. Firm pressure should then be applied to bring the sides of the cavity in as close approximation as possible ; to this end a small sponge wrung as dry as possible out of some antiseptic lotion, should be placed on the first folds of gauze and covered with more gauze dressing. Success will depend on the thorough removal of all tuberculous material, and the strictness of the aseptic precautions adopted ; if the skin above the abscess is affected it must be removed too between two elliptical incisions. The wound should heal by first intention, but in these cases a little serous effusion may not unlikely require letting out at the first dressing (*vide* Chapter X). This plan is a great advance on stuffing the cavity with gauze and allowing it to heal by granulation.

Psoas abscesses cannot be treated in this way on account of their great depth, the general principle of dealing with them is nevertheless the same. An incision is made over the lowest point where the abscess presents large enough to admit of the introduction of a curette, and of the free exit of fluids and *débris*, the abscess cavity is then freely scraped and douched, care being taken to reach every part of the interior as far as is possible. In scraping the front wall the close proximity of the iliac vessels must be borne in mind, and the manipulations though thorough must be done gently.

The cavity should next be thoroughly mopped out with swabs on the end of a long sponge holder, to soak up any lotion remaining and wipe away any particles of tuberculous matter loosened but not detached. For irrigation a weak biniodide lotion 1 in 6000 may be used, or better 1 in 500 izal or cyllin lotions which are not toxic.

From half to one ounce of sterilized iodoform emulsion 10 per cent. in glycerine is then injected into the sac, and the incision is closed by sutures which should include the fascia as well as the skin.

The wound will usually heal by first intention, and one operation may be sufficient to effect a cure. If this is not so, after the lapse of some weeks deep fluctuation may be detected, and if this extends the operation should be repeated in all its details. On incising the sac some brownish serous fluid containing iodine and crystals of iodoform will escape. A third operation may be required, but the method is a very great advance on the older plan of incising and draining the abscess, though it can be cured in this way if strict aseptic precautions are taken, it takes many months as a rule.

The aseptic treatment of bullet wounds.—These wounds are not often met with in civil practice and much misapprehension exists as to the proper way of dealing with them when they do occur. In the case of wounds with high velocity weapons the bullet usually passes through the tissues and makes its exit at once, the existence of a second wound showing conclusively what has happened.

Uncomplicated perforating bullet wounds of the soft parts should be treated by simply applying an antiseptic dressing after cleansing the surrounding skin with soap and an antiseptic, and then immobilizing the part. Such wounds treated in this way heal up rapidly without any septic trouble whatever as a rule. As a measure of first aid, when antiseptic dressings are not available any clean cotton material may be used instead, the blood quickly dries on it and seals up the wound in a very efficient manner.

Such wounds should on no account be washed with plain water, probed, syringed or drained.

Complicated perforating bullet wounds must be treated on ordinary surgical principles ; they may include such conditions as severe comminuted fracture, or arterial hœmorrhage from some large vessel, etc., but even in these cases an antiseptic dressing should be applied at the earliest possible opportunity until the preparations for operative interference are completed. Damage to a large artery is fortunately a comparatively rare occurrence, the elastic vessels seem to be pushed aside by the bullet and thus escape injury, though from the situation of the external wound such a complication may appear almost inevitable.

Perforating bullet wounds of the abdominal cavity come under a special heading. The rule of civil practice (always assuming that adequate arrangements exist) is to perform a laparatomy in these cases. If on the other hand there are no adequate arrangements, the rule of military surgery in the field must be followed ; an antiseptic dressing must be applied, a full dose of opium administered, and the patient kept as still as possible.

In non-perforating bullet wounds when the bullet is lodged somewhere in the tissues there is room for greater difference of opinion. The condition is obvious from the existence of one wound only. Now bullets by their presence in the body give rise to remarkably little disturbance as a rule, if the wound is kept aseptic under a suitable dressing; ill-advised attempts at removal are far more likely to cause trouble than the foreign body itself. In these days, the use of the Röntgen rays if the apparatus is available, makes the location of the bullet a comparatively easy matter. Before this is done the wound should first be dressed antiseptically. If the bullet is found to be lying in an easily accessible position, it should be cut down upon and removed *by the shortest possible route.* In the absence of the necessary apparatus, the wound should be similarly dressed first before anything further is attempted, and careful palpation should be made to see if the bullet can be located in a superficial situation. Supposing this is so, the bullet should as before be cut down on and removed by the shortest route. If, however, it cannot be found, the wound may be cautiously probed under strict aseptic precautions and the bullet, if found, may be extracted by the track it entered, the original wound being incised if necessary to permit of this. In removing the bullet it should always be borne in mind that a fragment of clothing may have been carried into the wound too, and if so must, if possible, be removed as it is far more calculated to originate septic trouble than the bullet itself.

Supposing on the other hand that the attempt to find the bullet with the probe fails, *no prolonged attempts at doing so should be made, but the part should be immobilized under an antiseptic dressing,* *with a view to securing aseptic union. Drainage should not be employed.* This is very likely to succeed if the manipulations have been carried out aseptically, and the patient will be no worse off for the failure of the attempt beyond the moral effect produced by the knowledge that he has a bullet in his tissues. This is of less consequence at the present day, as it may be subsequently discovered with the Röntgen rays, when a suitable opportunity occurs and extracted. The rule of practice for non-perforating bullet wounds of the abdomen is the same as that of perforating wounds given above.

To summarize these directions. In the treatment of all kinds of bullet wound hasty and ill-judged interference is to be deprecated. An antiseptic dressing should be applied at the first opportunity and the part immobilized. If the bullet has lodged and an attempt at extraction is considered advisable, this must be done under strict aseptic precautions. Whether successful or not, drainage should not be employed, and an attempt should be made to secure primary union or union through bloodclot by immobilization under an antiseptic dressing.

If in spite of all precautions septic mischief does occur, the wound must be treated on ordinary antiseptic principles detailed in Chapter XI., incised, and drained, and if necessary counter-openings made.

Aseptic precautions in operations on the bladder.— In addition to the usual aseptic routine preparation of the site of incision, instrument, etc., urinary antiseptics should, if possible, be administered by the mouth for a day or two beforehand. They include benzoate of ammonia, salicylates, boric acid, urotropine and hetol. At the time of operation as strict aseptic precautions are necessary as at any other operation. The urine should be drawn off, and a measured quantity of saturated boric lotion injected. After lateral lithotomy the bladder should be drained through the perineal wound, by a rubber tube wrapped in double cyanide gauze, which is the most powerful inhibitory dressing, while the mechanical irritation of the gauze quickly promotes the growth of granulations. Later iodoform gauze may be substituted for this. Once the barrier of granulations is complete, the danger of septic infection or absorption is greatly minimized. A soft rubber catheter should also be worn. The administration of urinary sterilizers should be continued for five days or a week.

Suprapubic cystotomy.—The main object is to ensure the rapid aseptic primary union of the wound, in spite of the mechanical difficulties attendant upon the anatomical arrangement of the part; the dangers of the operation are thus reduced to a minimum. A short description of the operation is therefore given.

The bladder should be fully distended with boric lotion and the urethra occluded by compression with the fingers or a tape. This is a most important preliminary step in facilitating the subsequent steps of the operation. A rectal bag is unnecessary and not without danger, the finger of an assistant will do all it can with safety. The incision through the parietes is best made a few lines to the side of the median line. Space is very limited, and the Scylla of the peritoneum above and the Charybdis of the postpubic connective tissue below must both be carefully avoided. If the former is wounded it must be sutured at once. The knife must be sharp, and all tearing of the loose cellular tissue with the forceps must be guarded against. When the bladder is clearly exposed it is best steadied with a sharp hook passed transversely through the muscular wall only, at the upper angle of the wound. While the organ is thus held up, the incision is made into it immediately below this point, by a downward stab with a Syme's knife. This should divide the mucous coat at once, which is very liable to be pushed before the point of the knife, the escape of fluid will show this has been successfully done. The incision is then completed by carefully cutting in a downward direction, strictly in the median line for one inch. It is only too easy to make a diagonal incision, and a longer one is not necessary at first. Still holding the hook, the curved end of a wire retractor should be placed longitudinally in the bladder wound, turned through a quarter of a circle, and firmly placed in the lower angle. It is then handed over to an assistant who keeps it in position by holding the free end over the pubes. This both dilates the wound and fixes the organ, without damaging the tissues. The sharp hook transfixing the bladder wall is then removed. Transfixion of the lips of the bladder wound with silk threads is objectionable.

After the removal of the stone or growth, a full sized india rubber drainage tube, without holes and at least six inches long is placed in the bladder through the incision. The organ should grasp it closely, if necessary one or more catgut sutures should be placed to ensure this, through the muscular wall only and *drawing the cut edges into contact, not inverting them.* The bladder should then be sutured to the under surface of the parietes by four catgut ligatures including the muscular coat only, two parallel to the wound, and one at right angles to either end. This closes any adventitious or possible pockets. Finally the skin is sutured so as to grasp the tube as closely as possible. The tube is now slightly withdrawn to prevent the end resting on and irritating the mucous membrane of the bladder, and fixed in this position by a suture to the skin, which should not pass through the lumen of the tube. The skin should then be freely dusted with boric and double cyanide powder, well rubbed in to the roots of the pubic hairs. The usual dressings are then applied, including a small sponge over the lower part of the wound lying below the tube (which passes through them) covered with oiled silk or some waterproof material and fixed with a bandage. The tube is then cut to a suitable length and the end covered with a sponge, fixed with a second bandage. A soft catheter should be worn also. Stitching up the bladder wound in its entirety, though at times successful, is terribly risky, and should never be done.

This is the ideal state of things, all the urine comes out by the tube, or the catheter and none leaks into the wound or dressings. The danger to be guarded against after operation is the septic infection of the wound by decomposing urine. This is minimized by attention to details as above given during operation, and subsequently (1) by attention to the catheter and the tube which are liable to become blocked by clot particularly during the first 24 hours ; (2) by wringing out the sponge placed at the end of the tube in antiseptic lotion and frequently changing it ; and (3) by the continued administration of urinary sterilizers by the mouth for a week. If pain is complained of, the wound must be at once examined, and if puffy or inflamed the stitches removed, and a drainage tube inserted. Gauze packing should never be employed, the object is to remove the urine as quickly as possible, and not to make any pockets for its lodgement.

The tube as a rule acts well for three or four days, until the wound has begun to unite in its deeper parts, and granulation tissue has formed round it. Syphonage may be employed, but is more complicated and liable to be interfered with by ignorant patients. At times it acts only too well by drawing the mucous membrane against the end of the tube and thus stopping the free flow of urine. By the fourth day leakage is very liable to take place by the side of the tube, and allow all urine to escape into the dressings. Beyond causing a good deal of unnecessary discomfort and necessitating frequent change of dressing, it is not a serious matter as the wound is proof against infection by this time. Colt

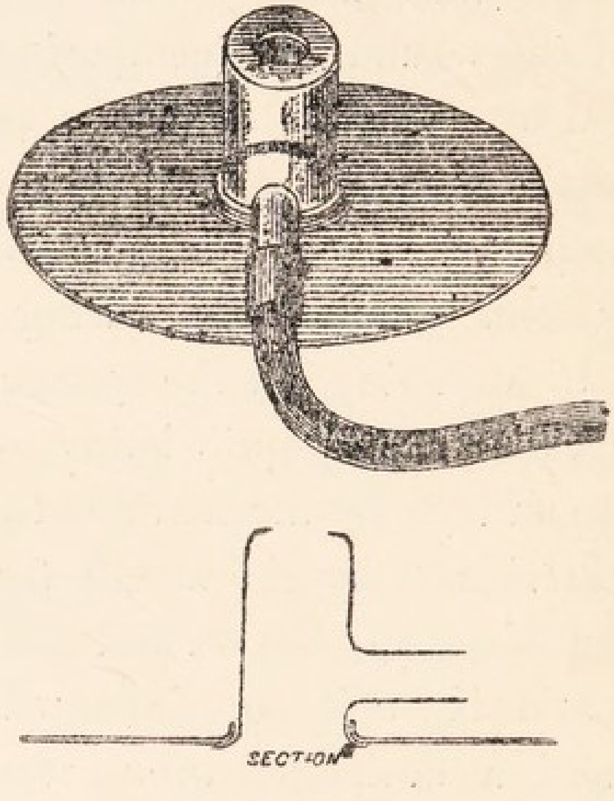


Fig. 32.

Colt's dressing for sapropubic cystotomy on fourth day.

(vide *Lancet*, 4th November 1905) has devised a plan by which this leakage can be prevented. It consists of a **T.**-shaped glass tube with a flange below and an airhole above held in position by a piece of rubber sheeting hermetically sealed to the skin with india rubber solution (*vide* illustration). By its use he claims that urine runs freely away under its own pressure through a long tube connected with the smaller arm.*

Aseptic precautions in operations on the abdominal cavity.—The most important point next to ensuring the asepsis of everything brought in contact with the peritoneum and the wound, is the avoidance of damaging the peritoneum with irritating lotions. Sponges or swabs should be wrung out of sterile boric lotion 5 grains to 1 ounce, or boroglyceride lotion 1 or 2 drachms to the pint. The intestines should be protected with flat sponges or cotton pads moist with the same solution, and if the abdominal contents have been much interfered with it is well to thoroughly flush the peritoneal cavity, with this boroglyceride lotion at a temperature of 100° F. This is best done by pouring it in with a jug or bowl, 2 or 3 quarts of fluid may be introduced in this way, and when the excess of fluid has been allowed to run off, by rolling the patient to one side, any remaining in the recesses of the cavity should be removed by sponges or swabs on long holders. In septic cases an attempt should be made to cut off the rest of the peritoneal cavity from the chance of infection, by the arrangement of sponges or preferably sterile gauze plugs, while the septic source is being dealt with. This should be most carefully wiped and irrigated, and great care should be exercised to prevent the contamination of the parietal wound, in withdrawing the swabs or sponges. If any doubt

* Obtainable from Messrs. Down Bros., London.

exists as to the possible infection of the rest of the peritoneal cavity, after dealing with the source of infection, it is better to irrigate it thoroughly in the manner aforesaid, than to leave any possible infective material behind. When general peritonitis exists, the most thorough irrigation in the above manner is the only step that will save life. In removal of appendix the cut lumen of the tube should be touched with pure carbolic acid before suturing the peritoneum over it unless removed by the thermo-cautery.

Septic cases should always be drained, or even suspectedly septic cases. For this purpose Keith's glass drainage tubes are best, and the syringe and rubber tube should be sterilized by boiling before removing fluids from them. In septic cases as an added precaution, Grieg Smith recommended leaving one or two drachms of pure boroglyceride in the most dependent pocket, *e.g.*, in the recto-vaginal pouch, in septic cases as an added precaution. If signs of general peritonitis develop after an abdominal operation, the wound should be opened and the peritoneal thoroughly flushed with hot boro-glyceride lotion.

Plain sterilized water or normal saline solution are recommended by some surgeons, the former is certainly irritating to the delicate endothelium of the peritoneum, and the latter, though unirritating, possesses no antiseptic properties whatever. Boro-glyceride in weak solution is therefore preferable, as it is equally unirritating and has definite though mild inhibitory powers.

Aseptic precautions in ophthalmic surgery.—Until recent years this branch of aseptic surgery was comparatively neglected ; its importance, however, can hardly be overrated, as probably more eyes are lost through sepsis after operation, than from all other causes put together. It will not be overstating the truth to say that the maintenance of strict asepsis, is of equal, if not greater, importance than manual dexterity in eye work. This is particularly the case in India where so many patients are the subjects of chronic conjunctivitis. The local anatomical conditions of the conjunctival sac also are greatly in favour of the spread of septic mischief and the growth of micro-organisms, presenting as it does a warm moist closed chamber, an ideal condition for bacterial growth.

Two chief reasons seem to have influenced or caused this attitude in ophthalmic surgery : (1) the fear that the use of strong antiseptics would damage the delicate tissues of the eye, and (2) the apparent impossibility of sterilizing the ciliary margins. The fact, also, that so large a proportion of operations were successful, without any particular precautions, may have had something to say to it too. The first reason has been shown to be based on an entire misapprehension, the second is hardly worthy of serious notice, while the third is no argument against the endeavour to obtain even better results. An eye with any sticky discharge from the conjunctival sac, may be safely regarded as septic, and to operate in this condition is to court disaster. Though it is desirable that patients should be kept in hospital for at least 24 hours before operation, this is by no means essential to success or even possible in a large number of cases, and H. Smith, whose experience is probably unrivalled, does not consider it necessary.

The routine preparation is practically the same as for operation elsewhere. The eyelids and skin of

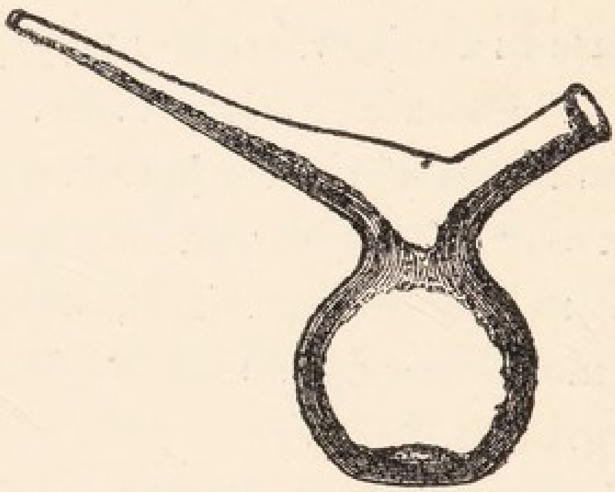


Fig. 33.

Jessop's Eye Irrigator for Disinfecting before Operation.

the forehead, cheek and side of the nose, must be thoroughly washed with soap and water, and the eyelashes should be cut as short as possible along the outer third of the upper lid. The conjunctival sac should then be freely irrigated with sublimate lotion, 1 in 2,000 to 1 in 3,000, and the edges of the lids should be well rubbed with the same lotion. The previous instillation of a few drops of sterile cocaine solution is advisable, as it causes some smarting. A moist sublimate gauze dressing is then applied and covered with guttapercha tissue, and the whole is fixed with a bandage. Before operation this is removed and the conjunctival sac is again irrigated with sublimate lotion, 1 in 2,000 after the instillation of cocaine.

The use of sublimate lotion in this way causes a certain degree of hyperœmia with the exudation of mucus, which should be wiped with sterile swabs. This mechanical effect of sublimate is probably of greater importance than its germicidal action ; it is unlikely that such a weak solution acting for so short a time can exert a very marked antiseptic effect, but no doubt the exuded mucous carries off in it many micro-organisms lying on the mucous membrane or in the surface epithelium, or mouths of the glands. The only objection to the use of sublimate lotion, appears to be that it may excite iritis after operation. This may be obviated by douching the sac with some sterile alkaline lotion, *e.g.*, lime water or bicarbonate of soda, which decomposes the perchloride of mercury forming the comparatively inert oxide. (For further details *vide* Herbert's Cataract Extraction.)

The instruments should, of course, be sterilized by boiling, and as the keenness of the knife is liable to be spoilt in the process, a better plan is immersion in 70 per cent. alcohol for five to ten minutes after boiling in soda solution for one minute only. All lotions and drops must be sterilized by boiling. Stroschein's apparatus is very convenient for this. After operation the usual antiseptic dressings should be applied, the first layers being moistened with some weak antiseptic. The usual aseptic precautions must, of course, be taken at subsequent dressings.

The importance of strict asepsis is the greater in these cases, because if septic iritis does occur there is little to be done except the free instillation of atropine

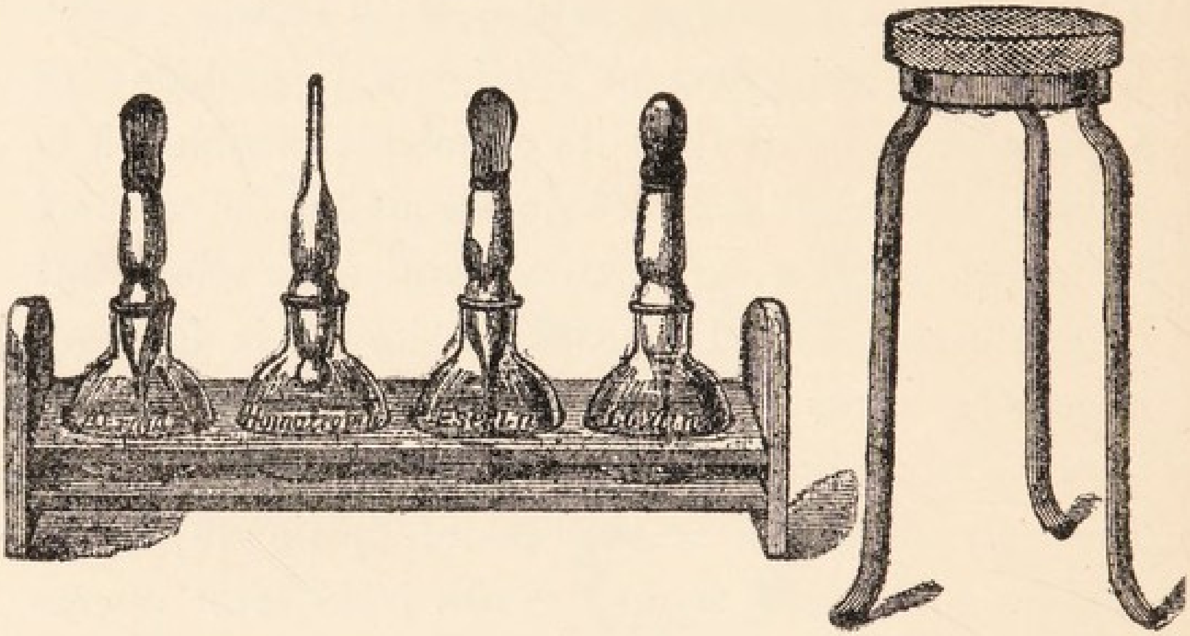


Fig. 34.
Stroschein's Drop Bottles, for sterilizing Ophthalmic Solutions.

which may check it if it is given in time; but when once definite septic inflammation is set up the chances of recovery without considerable impairment of vision, if not total loss of sight, are very remote indeed. Fixing the bandages with resin plaster or strapping, is *par excellence* indicated after the extraction of a cataract, especially in the old, to prevent interference with the dressings.

The disinfection of mucous membranes is regarded by many as a practical impossibility, but experience in the treatment of the conjunctival sac in the manner above detailed shows that there is some misapprehension on the point, and the plan has been found so successful in eye surgery may well be given a trial in other parts, *viz.*, the rectum vagina and the mouth. It is not unlikely to give satisfactory results, especially if it is combined with free wiping and mechanical cleansing, particularly in the vagina to get rid of all mucous liable to be retained in the folds and recesses of the organ, with a final free douching with sterile bicarbonate of soda lotion.

Finally one word of caution may be given in applying the principles of aseptic surgery in practice. Immobilization of the wounded part and the careful fixation of dressings, avoidance of unnecessary damage to the tissues by the use of blunt knives, and provision for the free escape of all discharges by drainage, though arrogated to the position of essential principles of aseptic surgery by some, are really fundamental principles of general surgery, and as such their importance must never be lost sight of, in the details of aseptic practice.

Calcutta, May, 1906.

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