A Report

ON

THE EMPLOYMENT OF ETHER IN SURGICAL THERAPEUSIS.

WITH SPECIAL REFERENCE TO ITS USE IN SEPTIC
PERITONITIS, PYOGENIC ARTHRITIS, AND
GUNSHOT WOUNDS.

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Prior to March, 1914, I had for five years frequently employed ether as an antiseptic with a continually increasing confidence in its potency, particularly in the treatment of grossly infected wounds. My first experience was a personal one. During an operation for septic peritonitis consequent upon rupture of a gangrenous volvulus I cut my right forefinger somewhat severely. I tied a strip of gauze around the wound and completed the operation. I then rubbed the cut with a swab soaked in ether, and kept the finger in a bath of ether for ten minutes. The patient died eight hours later; my finger wound healed by first intention, notwithstanding the fact that the exudate swarmed with streptococci, *Bacilli coli*, and an unrecognized long, slender bacillus.

Encouraged by this evidence in favour of ether, I next tried its antiseptic action in two very septic buttock wounds.

(a) A farmer, gored by a young bull, was ripped open from the middle of the back of the thigh to a point 3 in. above the iliac crest. The sole treatment he received was the application to the huge wound of a treacle poultice! Five days later I saw the old man. His wound was greenish in colour and exceedingly fetid; his temperature was 103.6°; pulse feeble and intermittent, and he was muttering incoherently. Turning him on his face, I poured ether into the long, deep, grooved wound, and allowed it to boil away, filling up the groove as the ether evaporated for some minutes. Nearly a pint of ether was thus employed. I then loosely packed the wound with sterile gauze soaked in ether, and directed that the wound should be sponged with ether twice daily. Within twenty-four hours the patient's condition was all that could be desired, and the wound healed rapidly with a thick, rigid linear cicatrix.

(b) A man, aged 59, waking from a drunken sleep with urgent diarrhoea, sat down too forcibly on a chamber utensil. He was badly cut by the broken fragments of china, and the wounds of his buttocks, perineum, and thighs were fouled with faecal matter. I saw him forty hours later. I washed his numerous deep cuts with ether, and sutured them with horsehair. In spite of the fact that he had had no attention in the meantime, as he resolutely refused to leave his filthy lodging, that his bandages were grossly soiled with faecal matter, and that he had been drunk most of the intervening time, his wounds, when the stitches were removed on the ninth day, were found to be soundly healed.

These two cases, it will be admitted, were severe tests of the efficacy of an antiseptic. I may mention that in neither of these instances was a general anaesthetic employed: in the first, because the patient was in a condition in which the administration of an anaesthetic, in the prone position, would have been dangerous, and, in the second, for the reason that the man was very drunk. After these two results I used ether in a large number of cases. It would be wearisome to detail them, but I may give the following as instances:

1. Psoas and other tuberculous abscesses in which, after incision and flushing with normal saline solution, ether (an ounce and a half was the maximum employed) was introduced into the abscess cavity and the incision sewn up without drainage.
2. Abscesses, the result of appendicitis in which, after incision of the abscess, the margins of the wound were held open with retractors, and an ounce of ether was allowed to boil away in the abscess cavity.
3. Cases of gangrene or perforation of the appendix in which the neighbouring inflamed coils of intestine were washed with ether.
4. Compound fractures. In these cases the wound in the soft parts, the fractured ends of the bones and the torn medulla were freely washed with ether. In two of such cases the fracture was plated, with excellent result.
5. Carbuncles in which ether was injected not only into the slough, but three or four drops were also injected,

at intervals of about one inch, into the subcutaneous tissue just outside the carbuncle.

6. Tuberculous glands. Ether—three or four drops—was injected by means of a hypodermic syringe into every gland that was palpably enlarged.

7. Tuberculous synovitis of joints, especially the knee, wrist, elbow and ankle. In all these cases Bier's passive congestion was also employed. Here the best results were obtained in examples of tuberculous hydrops, first described by my old teacher, Professor König.

8. Septic wounds of the soft parts, in which ether surpasses, in my opinion, all other antiseptics.

9. Sinuses, which were filled with ether.

10. Cases of pyogenic osteomyelitis in which, after a gutter had been cut in the bone and all the infected medulla removed, the cavity was filled with ether, the incision in the soft parts being usually left unsutured.

11. Suppurating buboes, especially those due to chancroid (Ducrey's bacillus). Ether is also a perfect application to the chancroid itself.

12. In cases in which an incision had to be made through skin in a part in which asepsis is difficult to maintain—for example, in axilla or scrotum, or when the patient was very stout—I have washed the entire wound with ether prior to closing it.

In all the above instances, and in many others, I have been satisfied that ether was the best application at present known to me. In many cases the results obtained from ether surpassed my expectations, and in no single case, so far as I am aware, was it the cause of any harm to the patient. My faith in the value of ether as an antiseptic was therefore strong, and I was looking about for further applications of the method when, in the *Epitome of Current Medical Literature in the BRITISH MEDICAL JOURNAL* of March 14th, 1914, I found a reference to a report by Lucien Jeanneret of a desperate case of generalized peritonitis due to appendicitis, happily cured by the instillation on two occasions of 50 c.cm. of ether into the peritoneal cavity.

On reading the report of this case I found references therein to the work of Morestin, who, I then learnt, had since 1901 "systematically used ether in peritoneal infections." The results obtained by MM. Morestin, Témoins, and Jeanneret convinced me that it was permissible to leave ether in the peritoneal cavity instead of allowing time for its evaporation before closing the abdominal incision. Since studying the reports of the above-mentioned surgeons I have not hesitated to introduce 3 oz. of ether into the peritoneal cavity, to close the wound and, in cases in which I have employed a drainage tube, to occlude its distal end for three to four hours, so as to permit the ether to be entirely absorbed prior to the establishment of drainage. The results I have obtained from the use of ether introduced into the peritoneal cavity have convinced me that it is by far the best antiseptic agent at our disposal at the present time for the peritoneal cavity.

I now desire to record my experience of ether as an antiseptic agent, with special relation to its value in three conditions.

A. Infections of the peritoneal cavity and cases in which, in the course of an abdominal operation, soiling of the peritoneum has, or may have, occurred.

B. Cases of acute arthritis proved or presumed to be secondary to a pyogenic focus existing in the body prior to the onset of the joint affection.

C. In the treatment of severe, septic gunshot wounds.

A. ETHER IN PERITONEAL INFECTIONS.

I have introduced ether into the peritoneal cavity on sixty occasions, in fifty-nine patients (one patient was on two occasions subjected to this treatment). The cases may be summarized as follows:

- 2 of perforation of duodenal ulcer operated upon, the one eleven hours and the other seven hours after perforation.
- 4 of tuberculous peritonitis, 3 of which were of the ascitic type, 1 of the plastic type of the disease.
- 2 of intussusception; one rather an advanced case, the other of only ten hours' duration.
- 1 of perforation of gastric ulcer operated on fourteen hours after perforation.
- 3 of suppurating pelvic cysts: (a) ovarian dermoid; (b) two tubo-ovarian abscesses, which ruptured either before or at the time of operation.

- 4 of acute cholecystitis with opalescent fluid in the peritoneum; in one case the gall bladder had ruptured prior to operation.
- 2 of inflammation of Meckel's diverticulum.
- 6 of gastro-enterostomy in which, prior to closure of the abdominal incision, ether was injected into the peritoneal cavity.
- 2 of pyosalpinx that ruptured, one prior to, the other at the time of, operation.
- 3 of strangulated hernia: (a) Umbilical; (b) femoral; and (c) inguinal after reduction *en masse*. In all these cases the bowel was seriously damaged but viable.
- 2 of intestinal anastomosis: (a) Entero-enterostomy; (b) ileocolostomy. Ether was injected just prior to the closure of the abdominal incision.
- 4 of removal of the appendix vermiformis, 2 in the quiescent stage, 2 in the subacute stage, in all of which localized tuberculosis was found to be present in the neighbourhood.
- 1 of pneumococcal peritonitis and septicaemia.
- 24 of acute appendicitis, in the great majority of which pus (defensive or offensive) was present in the peritoneal cavity.

In all of the above 24 cases of acute appendicitis, the pulse-rate was above 100 and in several it was 120 to 140. Many presented examples of perforated or gangrenous appendix. I regret that, owing to the fact that many were operated on under conditions unfavourable for careful bacteriological investigation, a bacteriological report was obtained of the peritoneal exudate in only 16 cases. In 12 instances pyogenic organisms were found; in 11 of these the *Bacillus coli* was present, frequently in combination with other micro-organisms, especially streptococci and staphylococci. In one case the pneumococcus was present in pure culture.

Mortality.—Two of the 59 above mentioned patients died. I will relate briefly these two fatal cases. The notes are by C. J. Marshall, M.D., B.S.Lond.

CASE I.

H. W., male, aged 16, admitted with complaint of pain in lower abdomen for past four days; constipation and vomiting. On examination free movement of abdominal wall, no rigidity. On rectal examination there was a tender collar around rectum, high up. Diagnosis, pelvic appendicitis. Operation: low abdominal incision, turbid fluid in pelvis; appendix hanging over pelvic brim, removed. It was found to be normal but for injection of its serous covering; 30 c.cm. ether injected into peritoneal cavity. Incision sutured without drainage. The patient became delirious; temperature remained 103-104° F.; respirations rose to 40 per minute. Dr. Topley examined the blood and found it to contain pneumococci. The patient died comatose. The *post-mortem* examination showed generalized pneumococcal peritonitis. This case was a grievous disappointment to me. It was clearly one of pneumococcal peritonitis and pneumococcal septicaemia. I frankly admit it to be an unmitigated failure of the ether method, but I plead that it is the sole failure attributable to ether in my series of cases and that the dose of ether was too small. Dr. Topley suggests to me a more comforting explanation, namely, that the case was *ab initio* a pneumococcal septicaemia, and that the peritoneum was subject to continual reinfection from the blood stream.

CASE II.

E. G., aged 38, complained of abdominal pain, vomiting and absolute constipation for four days. On examination marked abdominal rigidity; temperature 102°, pulse 116, respirations 26. Diagnosis, appendicitis. Operation: appendix, perforated at distal end, removed; 10 oz. of pus, containing the *Bacillus coli*, escaped from peritoneal cavity; 2 oz. ether injected and incision closed. During the entire operation the patient, though in the hands of one of the best anaesthetists known to me, was a constant source of anxiety to both anaesthetist and surgeon. I ought to have remembered that frequently such unusual trouble means the onset of pneumonia. Sixteen hours later the symptoms of pneumonia were distinct, and the patient died forty-eight hours after the operation. Shortly before death the pulse was uncountable; respirations 52 and temperature 102°. The *post-mortem* examination revealed pneumonia of the whole of the lowest lobe of the right lung, but established, to my great satisfaction, the fact that the entire peritoneal cavity was free from all signs of inflammation, so far as the naked eye could discover. Owing to the fact that death occurred on one of the hottest days of the summer, and that delay in obtaining permission postponed the *post-mortem* examination unduly, it was not considered desirable to make a bacteriological examination of the peritoneal cavity. However, I have every reason to think, from naked eye examination, that the ether had, in this unfortunately fatal case, done its work efficiently. It was a great relief to me to feel that, though death had resulted (from pneumonia), the ether had achieved all that I expected from it.

I now turn to the consideration of the successful cases, giving five only, in which I think that the patient largely owes his or her life to the employment of ether:

CASE III.

(From notes kindly furnished by Dr. Whittingdale, of Sherborne.)

Miss B., aged 16. Fulminating case of appendicitis, with diffuse peritonitis. Temperature 102.6°, pulse 140. Perforated appendix removed; large quantity of pus in pelvis and lower abdomen sponged away; 4 oz. ether introduced into peritoneal cavity through a large drainage tube reaching to bottom of pouch of Douglas. Almost immediately after the introduction of ether the pulse-rate rose to 160. One ounce of ether was then withdrawn, with rapid improvement of pulse-rate. *Bacillus coli* and streptococcus found in peritoneal exudate. Recovery uneventful.

CASES IV AND V.

These two cases were operated on by me—Case IV with Drs. Halstead and Newling, of Sutton; Case V with Drs. Coldstream and George, of Brondesbury—within forty-eight hours of each other. In both instances the patient was a boy of 13 to 14 years old; the onset of perforative appendicitis was very sudden, temperature 102.6-103°, pulse-rate 140. Perforation was in each case probably accelerated by the maternal administration of castor oil. The large quantity of peritoneal exudate contained the *Bacillus coli* and pyococci. Recovery resulted in both cases after 3 oz. of ether had been instilled into the peritoneal cavity, though in Case IV a small abscess lying between coils of small intestine had to be evacuated twelve days after the first operation.

CASE VI.

Miss B., aged 23, operated upon September 9th, at Chesham, with the assistance of Drs. Churchill and Heron. Perforation of appendix and diffuse septic peritonitis. Appendix removed; much foul-smelling pus evacuated; 3 oz. of ether inserted into peritoneal cavity through the usual long drainage tube. For fourteen days this girl progressed in a most satisfactory manner. Then symptoms of intestinal obstruction occurred, which only passed off when operative intervention seemed obligatory. She had four further less severe attacks, from which she recovered, but on December 26th so-called faecal vomiting was noticed, and she was at once admitted into Charing Cross Hospital. On admission, the abdomen was somewhat distended, an indefinite, tender lump was felt in the hypogastrium and per rectum; temperature 102.6°, pulse 130. The abdomen was opened in the mid-line above the pubes. The mass previously felt was found to be the largest tubo-ovarian abscess I have yet encountered; it was in a condition of acute suppuration, and had already ruptured, the pus having a typically faecal odour. The abscess was surrounded by coils of small intestine densely adherent to its wall and kinked in an extraordinary manner. With the utmost difficulty the abscess wall was enucleated and some of the worst intestinal kinks straightened out. Further examination revealed a pyosalpinx on the left side. This was removed. Into the large cavity thus left 5 oz. of ether were poured and allowed to evaporate, all soiled intestinal coils being washed for some minutes in this ether bath. A large tube was then inserted down to the bottom of the cavity, and the abdominal incision having been sutured, 3 oz. of ether were poured down the drainage tube. Though the patient bore the operation well, and left the table with a pulse of 120, half an hour later I found her pulseless, with dilated pupils and respirations almost abolished. I fear that she had received an overdose of ether, that is, that the 5 oz. poured into the cavity had not evaporated when the wound was closed. I desire to call special attention to the fact that this patient and Cases III and VII were the only instances in which more than 3 oz. of ether were injected intraperitoneally, and these were the only cases in which symptoms of an overdose of ether were noticed. Fortunately in this instance artificial respiration soon enabled me to free the patient from the danger of excess of ether, and her further progress left nothing to be desired. Dr. Churchill has since informed me that when he first saw the girl she had a vaginal discharge. At the time of the first operation I am sure there was no hypogastric mass. I imagine she then had bilateral salpingitis, and that the suppurative of the Fallopian tubes was caused by the contact with *Bacillus coli* pus in the pelvis. Dr. Topley found *Bacillus coli* in pure culture in the pus.

CASE VII.

Dr. C., formerly house-surgeon at Charing Cross Hospital, was seized at Leigh-on-Sea at 2 a.m. with intense abdominal pain and vomiting. As symptoms increased in severity Dr. C. B. Wagstaff, having made the diagnosis of fulminating appendicitis, sent him the same day to the hospital and, I think wisely, gave him a hypodermic injection of morphine to enable him the better to stand the journey. I saw Dr. C. at 7 p.m. His temperature then was 102°, pulse 126. He appeared in nowise distressed, and I, overlooking the effect of the morphine, assured him that the appendix had not perforated, but advised its immediate removal as the attack was only of fifteen hours' duration, in order to prevent the possibility of perforation. To my astonishment and chagrin I found on opening the abdomen a large perforation of the middle third of the appendix, and a considerable amount of pus containing *Bacillus coli* in the pelvis. The appendix was removed. Four ounces of ether were introduced through the drainage tube reaching to the bottom of the pelvis. Dr. C. slept rather too soundly for eight hours after his operation, but made an excellent recovery. He is now serving as Surgeon R.N. with the Grand Fleet.

I have related these five cases of appendicitis with diffuse septic peritonitis in order to demonstrate the value of

ether as a peritoneal antiseptic. It will, I think, be admitted that they were all grave and anxious cases. Naturally in their after-treatment I employed the Fowler position and proctolysis, but I cannot but consider that the ether was, to say the least, a valuable adjuvant, and that without its help I should not have enjoyed the satisfaction of being able to record a recovery in every instance. Before leaving this subject, there are five matters to which I would call attention.

I. The dose of ether to be used. In my opinion 3 oz. is the maximum dose that can be safely left in the peritoneal cavity of the adult. On three occasions I have exceeded this amount—namely, Case III, in which I employed 4 oz. but was able to withdraw 1 oz. In Case VII I again used 4 oz., with the result that Dr. C. slept too soundly for eight hours, though no untoward symptom was occasioned. In Case VI I fear I gave an overdose, thinking that the whole of the 5 oz. with which I had washed the intestines had evaporated before I sutured the incision, and introduced a further 3 oz. Fortunately in this instance, too, owing to the employment of artificial respiration, no harm resulted. I have used 3 oz. in both male and female cases, and about that amount in children over 14. The youngest patient in whom ether has been thus employed was 2 years old. In this case (inflammation of Meckel's diverticulum) $\frac{1}{2}$ oz. of ether was left in the peritoneal cavity with good result. Mr. Stibbe informs me that in two children, aged respectively 5 and 9 years, in whose cases on opening the abdomen pus, and in one gas also, escaped, the introduction of 1 oz. of ether sufficed to bring about "uneventful recoveries."

II. The question of drainage. Here my rule has always been, "When in doubt, drain." When there has only been a soiling of the peritoneum with pus, infected bile or faecal matter for a short time, say three hours, I have generally closed the abdomen without drainage. When on opening the abdomen pus has been present I have almost always employed drainage for at least forty-eight hours. In my earlier cases I found that, having inserted the tube down to the bottom of the pelvis, it was frequently a matter of difficulty to inject the ether (even with the help of a syringe) after the wound was sutured. I soon discovered that if openings were made into the tube, one an inch, the other half an inch, above its pelvic end, this difficulty was entirely obviated, and the ether could be introduced by means of a funnel attached to the outer end of the drainage tube. To ensure the retention of the ether vapour in the abdomen it is necessary to suture the incision closely, especially around the tube. It is also obviously necessary to occlude the extra-abdominal portion of the drainage tube, which should be 18 in. long. I accomplish this object by clamping the tube with a forceps or by tying a knot in the tube itself. I maintain this occlusion of the tube for three or four hours; at the expiration of this period the nurse has instructions to remove the forceps or to cut the knot in order that drainage may be established.

III. The fallacy of estimating the gravity of the infection by the naked-eye character of the pus. I venture to utter a word of warning regarding this point. There are two varieties of pus: (1) Defensive, which may be thick and milky and yet be found to consist almost entirely of polymorphonuclear leucocytes whose function is entirely protective, and to be free from micro-organisms; and (2) offensive pus, which may be thin and barely seropurulent and yet contain virulent microbes. I have noticed the latter chiefly in streptococcal infections. I have no hesitation in stating that without a bacteriological examination the surgeon cannot correctly determine by eye alone the nature of the pus, though I admit that he may often recognize *Bacillus coli* infections with his nose!

IV. The post-operative course of the patient. I am convinced that this is more easy and free from discomfort than in similar cases in which ether has not been employed. I am also certain that the bowel recovers its tone earlier and that flatus is passed sooner, thus obviating in large measure the discomfort and even danger of extreme tympanites.

V. The part that ether plays in the matter. I frankly confess that I can give no adequate reply to this question. Prior to the investigations which Dr. Topley has so carefully carried out, I was convinced that ether acted as an

antiseptic agent, pure and simple. After studying his results this opinion is, I think, no longer tenable. The life-saving action of ether and its value in checking infection in the peritoneal cavity are, to my mind, matters that admit of no doubt, but its action is a complex one, upon which I am not qualified to speak dogmatically. As a practical surgeon I am at present more than satisfied with the results obtained and must leave the scientific explanation of its action to the bacteriologists and the pathologists. If I have to state my opinion, it would be that the action of ether in such conditions is a complicated one, in which factors of importance are (a) its antiseptic power, not only in killing many microbes, but also in inhibiting the growth of such as escape death; (b) its tonic action on the circulatory and nervous systems, which I believe steadies and strengthens these vital systems when suffering from toxin absorption; and (c) its influence in stimulating in some unknown way the defensive powers of the tissues. I admit that the above explanation may sound unscientific and that it is at best a partial one, but it is all that I can at present suggest.

B. INJECTION OF ETHER INTO JOINTS IN ACUTE ARTHRITIS PRESUMABLY THE RESULT OF METASTATIC PYOGENIC INFECTION.

At the very outset of my remarks on this important subject, which I venture to hope will revolutionize, in a manner entirely to the patient's advantage, the treatment of acute (pyogenic) arthritis, I wish to express my indebtedness to the writings of that great surgeon and incomparable teacher, Dr. John B. Murphy of Chicago, Honorary F.R.C.S., because, without the knowledge I had acquired from Dr. Murphy's lecture in his *Surgical Clinics* (August, 1912), I am convinced that my method of injection of ether into the articular cavities in acute arthritis would have proved a failure, whereas I now believe it will become the routine treatment in such cases. I therefore desire to make it clear that the introduction of ether into infected joint cavities is the sole innovation to which I lay claim, and that in all other matters of treatment I have followed the teaching of Dr. Murphy. In this lecture Dr. Murphy sums up the treatment of acute pyogenic arthritis tersely, thus: "Aspiration, no drain, Buck's extension." To this advice I would add, "Inject ether." Dr. Murphy states that "an infected joint is destroyed primarily through the accumulation and pressure of the products of infection held under tension in the joint as well as by the virulence of the infecting micro-organism." He adds, "Relieve the tension, and Nature does the rest." Dr. Murphy injects into the affected joint 10 or 15 c.cm. of a 2 per cent. solution of formalin in glycerine. He deprecates the employment of drainage of the joint as tending to lead to ankylosis, and emphasizes the value of efficient extension in overcoming the second element in producing ankylosis—namely, "the involuntary muscular contraction." In the *Surgical Clinics*, 1913, he states: "Remember every case of acute arthritis is a metastatic infection." With the remarks of Dr. Murphy above quoted I am in complete accord. I have now to relate six cases in which I employed the principle of non-drainage in cases of acute suppurative arthritis.

CASE I.

Acute suppurative arthritis of shoulder-joint due to gonococcal urethritis. No micro-organisms found in pus aspirated from the joint. Injection of a 2 per cent. solution of formalin in glycerine into the joint. Extension applied to the arm (8 lb.); recovery within seven days.

CASE II.

A stout alcoholic man, aged 58 years, had been ill for twenty-three days with abdominal pains and for six days with pain in the right knee-joint when first I saw him. Four hours prior to my visit he had passed per rectum a large quantity of pus; temperature 104°, pulse 138. Right knee-joint intensely swollen and tender. Aspiration of knee produced thick pus swarming with *Bacillus coli*; 20 c.cm. of 2 per cent. solution of formalin and glycerine injected into joint, and 20 lb. weight extension applied to leg. Next day temperature 101.6°, pulse 104; no pain in knee. Aspiration repeated, pus thinner. Third day, after aspiration of pus, 15 c.cm. of 2 per cent. formalin glycerine injected. For ten days aspiration and the injection of 5 c.cm. of this solution were employed on alternate days when temperature and pulse became normal.

Unfortunately, bony ankylosis of the knee-joint resulted, but surely the method cannot be blamed for the result, as doubtless destructive changes had occurred in the joint

prior to its institution. After this case I resolved to try the effect of the injection of ether by means of a syringe into the affected joint after aspiration of the pus.

The cases number four only; three concern the knee-joint, and one the right temporo-maxillary articulation.

In Cases III, IV, and V, the infection was presumably of metastatic origin; in Case VI it was the result of a stab wound. It must be admitted that in only one of the three former were micro-organisms discovered in the articular pus, but this is only what might have been expected. In metastatic joint infections the microbes are conveyed to the synovial membrane by the blood stream. They set up an inflammation in its substance, not on its surface, at the beginning. The pus that is found in the joint on early aspiration is in 90 per cent. of such cases defensive not offensive, that is, it is sterile. By the time that the microbes have found their way into the joint cavity the case is, to say the least, a late one for preventive treatment. I wish to draw special attention to this point as I have so frequently found in cases of pyogenic arthritis that the practitioner has been misled by a negative bacteriological report of the joint exudate, and thus valuable time has been lost owing to the neglect to institute early treatment. Case V is an excellent example of this difficulty because, on the first day of the arthritis, an excellent practitioner, after aspirating the joint and learning that the fluid it contained was sterile, considered the case rheumatic, whereas two days later the joint was distended with pus which swarmed with staphylococci. Two drachms of ether—the maximum dose employed—caused marked distension of the knee-joint cavity, and this amount should not, in my opinion, be exceeded. In Case V I injected 15 minims into the temporo-mandibular joint above the meniscus, and 3 minims into the smaller cavity below the meniscus.

CASE III.

A patient of Dr. C. J. Woollett was admitted into Charing Cross Hospital suffering from acute pyosalpinx. In accordance with my invariable rule, I left the patient to medical treatment, knowing how quickly the infectivity of the pus subsides in such cases, and how far safer, therefore, is late than early surgical treatment. The day after admission pain was experienced in the left hip, knee and ankle. It rapidly subsided in the hip and ankle, but the knee the next day presented the symptoms of acute pyogenic arthritis. Mr. W. Leslie, M.B., B.S., house-surgeon, aspirated the joint, and injected 30 minims of ether. Dr. Topley reported that the fluid removed contained pus cells; that no organisms were seen, and that the culture was sterile. Extension (7 lb.) was applied to leg. Within eight hours of the injection of ether the temperature fell 3.8°. On the sixth day, after three days' complete comfort, pain returned to the joint. Aspiration was at my suggestion repeated, a second injection of 1 drachm of ether was given, and extension increased to 19 lb. Complete recovery, with perfect movement of the joint, resulted. The report on the fluid removed by the second aspiration was: "No cells seen; sterile." Twenty-six days after admission a right-sided pyosalpinx was excised. It was distended with pus, now sterile. As it ruptured during removal, and was densely adherent to a loop of ileum, and as there had been soiling of the pelvic peritoneum with pus, 3 oz. of ether were poured into the pelvis, and the incision closed without drainage. Rapid recovery followed. This case was seen and treated in the earliest stage as it developed under my own observation.

CASE IV.

The note of this case, by C. J. Marshall, M.D., B.S. Lond., at that time my house-surgeon, is: E. K., aged 36, admitted for acute septic arthritis of right knee-joint. Temperature 103°, pulse 116. Knee-joint distended and acutely tender; immobility absolute. Aspiration of joint gave sero-pus; 2 drachms of ether injected, extension 20 lb. applied to leg. Temperature normal on the third day; joint had recovered complete movement on the twelfth day.

CASE V.

This was a case of suppurative arthritis of the right temporo-mandibular joint (staphylococcal). The patient was a man, aged 42, who, during his fifth attack of gonorrhoea, developed a periurethral abscess, due to stricture in the bulbous urethra. The abscess was allowed to burst spontaneously, and its drainage was clearly insufficient. Acute arthritis of the temporo-mandibular articulation resulted. Aspiration of the joint on the first day of admission gave a slightly opaque fluid, which was reported to be sterile. On the third day pain and rigidity of the jaw became extreme. I found the mandible slightly protruded and rigidly fixed by muscular spasm, and redness and swelling over the side of the face; temperature 103°. Under anaesthesia I aspirated a few drops of thick pus and injected 15 minims of ether into the joint above the meniscus and then 3 minims into the joint below this structure. The

pus aspirated from the joint contained *Staphylococcus aureus* in pure culture. Six hours after the injection of ether the condition of the patient was much worse. His pain was, he said, intolerable. Searching for an explanation I recognized that I had not applied extension. How to apply efficient extension to this joint was a puzzle, but a rough and ready way occurred to me which proved satisfactory. I obtained a piece of india-rubber about 1 in. square and $\frac{3}{4}$ in. thick, and under anaesthesia inserted this between the molar teeth. The effect of this extension was almost immediate relief of all pain. The joint was aspirated two days later, when disintegrated pus and staphylococci were found; 10 minims of ether were injected. So afraid was the patient that when the rubber was removed the pain would return that, in spite of my protest, he declined to have it removed until the fourteenth day, by which time his mouth was in a stinking condition, due to ulceration of the cheek and side of the tongue, owing to friction against the rubber. Seen two months later he could open his mouth normally, though, probably as the result of over-stretching of the joint, he was unable to bite firmly on that side.

CASE VI.

I was summoned to see a young man with streptococcal arthritis of the left knee-joint. I was told that he had fallen and cut his knee seven days before, but I am convinced he had been stabbed. On trying to investigate the history the patient bluntly informed me that if I asked no questions I should be told no lies. The patient was evidently very ill; temperature 103°, pulse 132. There had been only slight stiffness of the leg until the previous day, when his medical attendant had probed the joint through the wound. I painted the margins of the wound with pure carbolic acid and then excised them, suturing the wound firmly; 2 drachms of ether were injected into the joint and 20 lb. weight extension applied. During the night the patient, who declared his leg was being pulled off, insisted on the removal of the weight. Within five minutes he begged that it might be reapplied. The after-progress of the case was very satisfactory. The joint was aspirated on the third and fifth days, and on each occasion 1 drachm of ether was injected. Slight superficial suppuration of the skin wound occurred, but the patient left his bed on the seventeenth day with a freely movable joint, his sole complaint being that the knee "felt weak and wobbly."

CASE VII.

While this article is passing through the press a case of acute purulent arthritis of the shoulder-joint is in my wards at Charing Cross Hospital. A man who had suffered from a mild attack of pneumonia was admitted with acute arthritis of the shoulder-joint and intense inflammatory oedema of the arm. In spite of the fact that the arthritis was at least of seven days' duration and that the capsule of the joint had ruptured, allowing the pus to escape into the periarticular tissues, the injection on two occasions of a drachm of ether into the joint, together with continuous extension (7 lb.) has brought about an extraordinary improvement, as evidenced by the fact that the pulse and temperature have become normal, all pain has disappeared, and the inflammatory swelling has entirely subsided. Dr. Topley found the pneumococcus in pure culture in the pus aspirated from the joint.

C. ETHER AS AN APPLICATION TO GROSSLY INFECTED WOUNDS, WITH SPECIAL REFERENCE TO GUNSHOT INJURIES.

During the past four months I have, in three hospitals, had charge of a large number of wounded soldiers. As almost every wound was septic, and often grossly septic, by the time the patient arrived in hospital I have had ample opportunity of studying the results of such injuries and the comparative value of the various antiseptics in their treatment. I have no hesitation in expressing the opinion that ether has proved more satisfactory as an application than any other antiseptic. I will cite three cases of grossly infected wounds treated with ether.

CASE I.

An officer received, during a night bayonet attack, a large lacerated wound of the buttock. On admission, on the sixth day after being wounded, to the 4th London General Hospital, R.A.M.C.(T.) the wound was covered by a greenish, stinking slough. Temperature 103°. Fomentations were applied. A skiagram revealed the fact that the buttock was peppered with more than thirty fragments of the envelope of a rifle bullet. Two days later, under anaesthesia, the wound was washed with ether, loosely packed with sterile gauze soaked in ether, and some of the largest metallic fragments removed.

The temperature fell rapidly, and the wound began to heal nicely, but on the tenth day the patient had serious secondary haemorrhage, the blood soaking the mattress. Fortunately Lieutenant Ashe, R.A.M.C.(T.), was in the ward next to the patient's room. He plugged the wound with judicious firmness, and applied energetic pressure. On my arrival I had no hesitation in agreeing with Lieutenant Ashe that a haemorrhage of such amount could only come from the trunk of the gluteal artery. I therefore exposed this vessel and found that the artery, just as it was dividing into its superficial and deep

branches, had been punctured by a fragment of the metallic cover of the bullet. A silk ligature applied just above the hole in the artery cut through the softened vessel, and severe haemorrhage recurred. With considerable difficulty a thick silk ligature was passed around the vessel 1 in. proximal to the former ligature—that is, well within the bony pelvis. Both branches of the artery were next ligated, also with thick silk. The deep hole, reaching down to the point of ligation of the gluteal artery, was then filled with ether, the rest of the wound washed with the same, and gauze soaked in ether was used as a dressing.

The patient was removed from the theatre in a very feeble condition, and during the next twelve hours his temperature never rose above 96.8° F. For several days I suffered acute anxiety, fearing a recurrence of the secondary haemorrhage, and wondering what might happen to three thick septic silk ligatures at the bottom of the infected wound. The ether, however, did its work splendidly, and the wound cleaned and closed with remarkable rapidity. Nothing was ever seen of the silk ligatures, and on the thirty-fourth day the patient proudly informed me that he had "walked halfway down Bond Street."

CASE II.

A soldier, during a bayonet charge at Ypres, had the misfortune to be wounded almost simultaneously by a German bullet from the front and by British shrapnel from the rear. The latter wound was extraordinary in that the lowest 4 in. of the posterior wall of the recto-anal canal were blown away, leaving a cavity into which a closed fist could be easily introduced. On admission to Charing Cross Hospital the patient's condition was deplorable, and the stench from the wound was so horrible that the poor fellow told the ward sister that "he was not fit to be put into a clean bed." The vilely septic wound was washed at first twice, and then once, daily with ether. At the end of a month, during which time the pulse and temperature had been practically normal, the wound had healed, and, to my astonishment, a fair degree of continence of faeces has been secured. This was, I think, the dirtiest wound I have ever seen.

CASE III.

A soldier sustained a severe shrapnel wound of the soft parts of the leg. Washing with ether was the sole treatment employed in this very foul wound. Within two days the large infected surface had begun to clean, and rapid healing ensued.

Gunshot Compound Fractures.

I have not employed ether in the treatment of gunshot compound fractures to anything like the extent that I originally intended. It has, however, been used in six cases. The treatment adopted has been to enlarge, whenever necessary, the often small wound in the skin and soft parts down to the seat of fracture. The open wound has then been daily filled with ether, which has been allowed to evaporate. The results in all cases have been excellent, and I regret that I have not made more frequent use of the method. One merit of ether in the treatment of infected wounds deserves mention, namely, its action in dissolving fat, shared, to my knowledge, by no other antiseptic agent.

I desire to express my best thanks to Mr. C. J. Marshall, M.D., B.S.Lond., Surgical Registrar to Charing Cross Hospital, for his careful notes of the cases that were in my wards in that institution. The value of Mr. Marshall's notes is enhanced by the fact that the majority of these patients were under his immediate observation when he was my house-surgeon. I am also much indebted for notes of cases to Mr. E. P. Stibbe, resident medical officer to the Victoria Hospital for Children, to Dr. Whittingdale of Sherborne, and numerous other medical friends.

Before I conclude I desire to take this opportunity to refer to the "iodine treatment of wounds." I do so for the reason that I believe the paper on "Sterilization of the Skin by the Use of an Alcoholic Solution of Iodine," by my colleague Mr. W. S. Fenwick and myself, was largely responsible for the now almost universal employment of this method, and during the past few months some of my friends have said to me, "I am treating gunshot wounds with your iodine method." I beg to state emphatically that I have never recommended this use of iodine. I consider it painful, inefficient, and deserving of condemnation. Two of my friends who sustained large flesh wounds agreed that their worst recollection of this awful war was the brush with which the iodine solution was daily applied to their wounds, and my experience has been that many of the most septic wounds that have come under my care have been those which had been painted with iodine. Three soldiers, questioned by me regarding the amount of pain caused by ether, agreed that "it stung a bit for rather less than a minute."

The daily instillation of a drachm of ether into the bladder in an aggravated case of *Bacillus coli* cystitis, consequent upon a bullet wound of the cauda equina, markedly improved the condition and caused no pain to the patient.

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THE ACTION OF ETHER ON CERTAIN MICRO-ORGANISMS.

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In the preceding paper Mr. Waterhouse has reported the clinical results obtained by the use of ether in cases of various pyogenic infections. The following investigations were undertaken in order, if possible, to obtain some information as to the manner in which this substance acts.

THE BACTERICIDAL ACTION OF ETHER VAPOUR.

Bearing in mind that the body temperature is 2° C. above the boiling point of ether, and also that the area to be dealt with in such a condition as an infected peritoneum is large, it seems clear that the action of the ether vapour must play a large part in any results produced. An attempt was therefore made to determine the bactericidal action of ether in this state.

The method adopted was to bury a sterile 2 c.cm. ampoule in the lower part of an agar slope, so that the mouth projected above the medium. An even surface growth was obtained, the ampoule was then three-quarters filled with ether by means of a capillary pipette, and the mouth of the culture tube closed with a well-fitting rubber cork. Incubation was carried out at 37° C., and subcultures were made at intervals. The organisms were thus subjected to the action of saturated ether vapour at body temperature.

The organisms examined were as follows:

- B. coli*, 11 specimens.
Staphylococcus albus, 11 specimens.
Staphylococcus aureus, 7 specimens.
Streptococci, 9 specimens.
Pneumococcus, 3 specimens.
B. pyocyaneus, 7 specimens.

The results obtained show that ether vapour exerts a definite bactericidal action on all these organisms. The intervals after which subcultures remained sterile varied from one to forty-eight hours. The *B. pyocyaneus*, the *Pneumococcus*, the *B. coli*, and the *Streptococcus* appeared to be the most easily killed, since three hours' exposure sufficed to kill every specimen of the two former organisms, 8 out of the 11 specimens of *B. coli*, and 6 of the 9 specimens of *Streptococci*. The *Staphylococci* would appear to be more resistant; many specimens survived five hours' exposure, and 3 survived twenty-four hours. It is impossible to exclude the possibility that this difference in resistance may depend on a difference in the nature of the growth on agar rather than on any difference between the actual organisms.

THE BACTERICIDAL ACTION OF LIQUID ETHER.

An attempt was next made to determine how the action of ether in the liquid state compared with that of ether vapour. Considerable difficulty was met with, since it was found impossible to mix the ether and the organisms in such a way as to ensure even action. Many methods were adopted, but the only one which gave anything like uniform results was to mix a saline suspension of the organism (*B. coli*) with an equal quantity of ether by vigorous shaking in a sterile tube closed with a rubber cork. The ether rapidly separated after the shaking ceased; a sterile pipette was plunged through the ether layer and 0.1 c.cm. of the suspension was withdrawn and added to a tube of melted agar at 40° C. After being kept at this temperature for a few minutes to allow the complete