To Ralph M. Waters M.D.
with the compliments of
Robert Henry Ferguson M.D.

SURGICAL ANESTHESIA

In its relation to

IMMUNITY

BY

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Published by New York Medical Journal.

Reprinted by permission from the New York Medical Journal, Vol. XCV, No. 19, p. 987.

Reprinted with additional notes, 1924.

PUBLISHED BY

DEPARTMENT OF ANESTHETICS

E. R. SQUIBB & SONS, 80 Beekman Street, NEW YORK

SURGICAL ANESTHESIA*

In its Relations to Immunity and Allied Conditions, Together with a Statement of Recent Findings Concerning Olive Oil as a Speedy Restorer of the Patient's Power to Resist Infection.

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Two years ago the girl students of the bacteriological department of the University of Wisconsin put upon the stage a drama, entitled *In Germland* (1). The characters were bacilli and other microbes, and the plot turned upon the warfare between the germs of disease and the human race (2). Although this play was called a comedy, its prototype in life belongs to tragedy, and today scientific effort is endeavoring to change human existence from the latter to the former. Although such a presentation in the theatre is novel, a newspaper editorial article (3) says with truth concerning it: "It is undoubtedly justified by the importance of its subject-matter." Pathological germs are more destructive than ever hostile armies were, and modern medicine strives to devise effective means and methods to prevent any invasion of them or to destroy them if they are present.

Very early in the history of bacteriology rational modes of disinfection and antisepsis were established, but these dealt with microbes outside of the body. An

*Read by request before New York Society of Anesthetists, New York Academy of Medicine, March 6, 1912.

equally important, yet more difficult, problem was how to restrain the activity of pathological micro-organisms, which has been proved (4) to exist in all living beings. This presence of germs of disease in even apparently healthy bodies long remained a paradox. It was recognized, however, that frequently sickness was due to a sudden activity of these somatic germs, but this fact was only the more alarming, inasmuch as the cause of the sudden energizing was unknown.[1]

A suggestion toward a correct explanation was given in 1887 by Flügge and Nuttall (5), who showed that normal blood contained some bactericide. Further light on the subject was shed by Leclef and Denys (6), in 1895, when they found that in the *serum* of the blood there was some principle which, under certain conditions, at that time unknown, would so work upon bacteria as to render them objects of phagocytosis. Our knowledge was further extended by Mennes (7) in 1897. He proved that the immunity conferred by immunizing sera or bacteria was due to a more extensive phagocytosis, and that this increased phagocytosis was due to a modification of the serum of the animal, a condition caused by the presence of an immunizing agent.

The matter was cleared up, however, by the work of Wright and Douglass (8), begun in 1893. They developed and formulated the present theory of opsonins and bacterial vaccines. Today the opsonic index and its relation to immunity are so well understood that we can assert with Wright (9) that "We have in the power of raising the antibacterial power of the blood with respect to any invading microbe, out of all comparison the most valuable asset in medicine."

The condition to which I have just called attention is an invasion of the system by pathological micro-organ-

[1]A most interesting essay upon this subject in various phases is the lecture by Simon Flexner, M.D., of the Rockefeller Institute for Medical Research, entitled Natural Resistance to Infectious Diseases and Its Reinforcement, delivered at Columbia University and printed in the *Popular Science Monthly*, July, 1909; also *Annual Report*, Smithsonian Institution, 1909, pp. 723-738.

isms, which, although violent, irregular and unexpected, are none the less capable of being determined in both kind and extent. This sepsis is due, partially or wholly, to the inability of the serum of the blood to prepare the germ in such a way that the phagocyte will devour it. However, it may be counteracted, theoretically in all cases, practically in some, by introducing into the system proper bacterial vaccines.

There is, moreover, another condition in kind and mode of development, similar to that which has just been described, nevertheless, in important particulars, differing from it, especially in that it is created voluntarily. This condition is an impaired immunity, evidenced by a lowered opsonic index and pathological conditions not to be explained otherwise, due to the use of alcohol or of various narcotics, or of some of the inhalation anesthetics, particularly chloroform or ether. Its rationale has been recognized only quite recently, and already in one department of medicine, namely, anesthesia, attention to what is known concerning the condition has yielded important results. It is, then, to these drugs in their relation to the opsonic index, or the power of the patient to resist infection, that I will call your attention.

This matter is of special interest, because in the present status of medical knowledge anesthetists cannot help producing this state of lessened resistance, and a successful dealing with it not only concerns the reputation of both the surgeon and the anesthetist, but also is of vital importance to the patient.

While a complete treatment of the subject would demand a full discussion of the effect of opium and other narcotics on the opsonic power of the blood, here it must suffice to consider the influence only of alcohol, chloroform and ether on the opsonic index. Reflection upon this consideration will suggest the way to prevent that influence in some cases, while in those in which it cannot be avoided it will show how to overcome it successfully.

Cantacuzène (10), in 1898, demonstrated that opium

reduced in a marked degree the resistance of the body to typhoid bacilli. Snel (11), in 1903, published the results of his experiments with guinea-pigs relative to the effects of ether, alcohol and chloral on immunity. He found that these agents "suspend immunity temporarily; and, further, that the longer the period of anesthesia the shorter the process of infection."

It was, however, in 1904 that the important paper of Rubin (12) appeared.[1] Thinking over the experiments of Heidenhain, which showed that fibrinous pneumonia is not due directly to cold, and the fact that alcoholics have a predisposition to pneumonia, he began, in 1902, investigations of the influence of alcohol, ether and chloroform on natural immunity, and especially on the rôle that the leucocytes play in the defense of the organism against various infections. Out of ten experiments with alcohol, eight were positive in showing that "*alcohol* has a detrimental influence upon the resisting power of the animals. . . . Every narcotized animal succumbed to the infection," while four control animals completely recovered, four survived the narcotized animals by a considerable time, and "the controls exhibited other signs of resistance, e.g., higher leucocytic counts and better physical signs."

Ten experiments with ether showed that "*ether* administered in doses similar to those of alcohol is still more positive in its effect. The difference in leucocytosis between the etherized rabbits and the controls is also more marked" than in the experiments with alcohol.

Further, Rubin says, "The results of the *chloroform* series are not unlike those obtained with alcohol and ether." From these experiments the fact is established that a depression of leucocytosis and a vital interference with immunity exist when alcohol, ether or chloroform is in the system. However, some animals died with a fairly high leucocyte count.[2]

[1]For other important initiatory studies in the relation of alcohol to immunity see Bibliography 13, 14, 15, 16.

[2]See fifth of "Five facts," page 21 of this communication.

By a second series of experiments, to determine how such a high leucocyte count could be followed by death, it was found that either narcosis by alcohol, or anesthesia by ether, diminished in a marked degree the phagocytic power of the leucocytes, no matter how many were present.[1]

In a third series of experiments, to determine the chemotactic relation of alcohol and leucocytes, a negative result was obtained. In the tubes containing alcohol no leucocytes appeared, while the control tubes containing bouillon were filled with them. Rubin says: "This may help to explain why the leucocytes do not appear in as great numbers in infected animals that have been alcoholized as in those that have not, and those leucocytes that do circulate in the blood stream which contains alcohol are not able to perform their phagocytic function well. . . . This will perhaps also explain the difference in the leucocyte counts found in the periodical and steady drinker (12)." It might be reasonable to suppose that ether and chloroform would give similar results. I have omitted to test the latter narcotics, because they are so easily evaporated, and the results could not have been considered conclusive."

From the results of his work Rubin draws the following conclusions:

"1. Alcohol, ether and chloroform have a decidedly detrimental influence on the natural defenses against infection, and this lowering or suspension of the resisting power of the animal is not due to any apparent organic lesions . . . except such as are caused by the infectious material employed.

"2. The narcotics appear to affect directly the sub-

[1]In Rubin's list there are forty-four steady drinkers and sixteen periodical drinkers. The average leucocyte count for the former is 5200 and for the latter 6500. Rubin calls 7500 "the average normal number of leucocytes in each cubic millimetre, according to the best modern authorities." This, then, brings the "steady drinker" 2300 below normal and the "periodical drinker" 1000 below normal. "Differential counts made in twenty-five individuals show no change in the ratio of the different forms of leucocytes." Rubin: *Journal of Infectious Diseases*, pp. 438, 439, May 30, 1904.

stance or substances which inhibit the growth and toxic action of bacteria in the normal animal; and these substances are either the leucocytes themselves or something derived from them, or both.

"3. The period of detrimental action of the narcotic depends largely on the amount administered, the depth of narcosis, and the rapidity of the elimination (of the narcotic) from the system" (12).

4. Protection of the animal depends, not upon a hyperleucocytosis, but upon chemotactic and phagocytic qualities of the individual corpuscles, both of which are disturbed detrimentally by either alcohol, chloroform or ether.[1]

To the special importance of the third and fourth conclusions attention will be given below.

In 1907 Rubin (17) showed, further, that "a solution of 1 to 50 of alcohol, and 1 to 200 of chloroform, completely suspends phagocytosis *in vitro*." With gradual dilutions there is a gradual increase of phagocytosis, which, however, is not always proportionate to the amount of alcohol or chloroform present. "The effect of alcohol is practically lost at a dilution of 1 to 1,000, and of chloroform at 1 to 2,000." While he thinks that some of his experiments with carmin granules indicate that the opsonins are not[2] (12) concerned with this special failure of phagocytosis, he adds that "the influence of the agents in question (alcohol and chloroform) on the opsonins has not been studied so far" (17).

However, while Rubin's paper was in press, experiments regarding the effect of alcohol on the opsonins were actually going on, for Stewart, also in 1907, published his valuable report (18). He had confined him-

[1]See fifth of "Five facts," page 21 of this communication.

[2]See, however, the suggestion of Rubin, *Journal of Infectious Diseases*, i, 3, p. 437, May 30, 1904, line 26 of text, "*Quality* of the leucocytes has a certain connection with immunity," also p. 441, line 25 of text, "It would seem that the protection of the animals . . . depends upon both the number and *quality* of the white blood corpuscles," also lines 20 to Ex. 2. *Confer* 2, of summary, p. 444. Rubin really stumbled on the fact, but went on, passing it by without noticing it.

self to the influence of alcohol on the opsonic index, using for his drugs either port wine or Peruna, and for his subjects human beings. In summing up, he says: "Where alcohol was taken internally in the form of two ounces of port wine, the opsonic power of the blood was greatly lowered . . . the normal average index for the bacillus tuberculosis . . . was 1.17, for streptococci 1.12. The average of these same cases after the administration of the two ounces of port wine is 0.73 and 0.655, respectively, showing a drop in the opsonic power of 37 per cent. in the former and 42 per cent. in the latter."

In the cases in which Peruna was used, the average normal index for the bacillus tuberculosis was 1.12, for streptococci 1.09. For hours after the ingestion of two ounces of Peruna, the average index for the former was 0.133, for the latter 0.68, showing in the former a drop of over 88 per cent. in the opsonic power, and in the latter a drop of 36 per cent.

Dr. Evarts A. Graham has recently carried this work still farther. He has confirmed much of the work of his predecessors and had added to our knowledge of the ether side of the subject. In the early part of 1910 he made a preliminary report (19), and in 1911 he published his full paper (20). His experiments were of three sorts: *In vitro;* upon normal rabbits without operative measures; and on human individuals; these last presenting cases involving "fairly simple operative procedures, on comparatively healthy young adults with such factors as infection, hemorrhage, shock, etc., ruled out" (19).

Streptococci, pneumococci, staphylococci aurei, bacilli coli, bacilli typhosi, as well as carmin granules, were used. Doctor Graham found that while "no appreciable effect of the ether on the phenomenon of bacteriolysis was revealed" (20, p. 147), and that "ether seemed to have no appreciable effect" on agglutination (20, p. 149), after an ordinary ether anesthesia there was a reduction of the phagocytic power of the blood, which in the different experiments lasted over periods of from two days

to several weeks.[1] "This depression, apparently, was due to a direct effect of the ether on both leucocytes and serum, not to any effect on the bacteria themselves" (19).

All this work just described, besides suggesting much else of value, establishes three facts of great interest to anesthetist, surgeon and patient. *First*, anesthesia by ether or chloroform lowers the opsonic index, that is to say, reduces the power of the patient to resist infection, whether said infection was existing at the time of the operation, was started during the operation, or is a post-operative acquirement. *Second*, the bacteria are not materially affected either in number or activity by the anesthesia. *Third*, this impaired resistance or immunity is due to some action, direct or indirect, or both, upon both phagocytes and serum.

These findings are of prime importance. Surgical operations are needful, and surgical anesthesia by means of ether or chloroform is at present indispensable. Notwithstanding this depressing influence of ether on the opsonic index, there is no form of routine anesthesia today which is so safe, convenient, or otherwise so desirable. I believe that *if the ether be pure, any patient whose condition does not contraindicate the operation can take the ether, provided it be administered properly.* Nevertheless, in thus producing anesthesia, the anesthetist is obliged to reduce temporarily the patient's power to resist infection. Three questions, therefore, present themselves:

First. Is it possible to prevent wholly or in any degree this lowering of the patient's resisting power?

[1]For scientific completeness attention should be called to different findings by A. C. Rankin, M.D., of Montreal, as set forth in his article, The Effect of Anesthesia on the Opsonic Index, *Montreal Medical Journal*, xxxiii, 1, pp. 40-42, January, 1908. He says, "This investigation was undertaken to determine whether the administration of ether as an anesthesia lowered the resistance of the body to bacterial invasion." As a result he maintains "it was found that in every case the opsonic index of the individual patient gave no variation against either *Pneumococcus, Bacillus coli communis,* or *Staphylococcus pyogenes aureus.* After the anesthetic, even in those cases in which the anesthetic was poorly borne, and which showed considerable ether intoxication for some time following, no alteration in the phagocytic power of the blood was present."

Second. How may an inevitable depression be minimized?

Third. How may a lowered opsonic index be restored quickly?

In replying to the first question, only a few words are necessary, for at the present stage of our knowledge it is not possible wholly to prevent the lowering of the resistance to infection of a patient's blood, by an anesthesia by ether chloroform or ether.

In considering the second question, the following statement of Rubin (12) is important: "It seems that to produce a decided effect it is necessary to employ enough of the narcotic to produce *complete narcosis, even if that should last only a short time.*[1] And I have reason to believe that the longer the narcotization lasts the more complete and the longer is the suspension of immunity."

My clinical experience long ago led me to practically the same conclusion. My teaching has been, and still is, that *the increment of postoperative depression due to the anesthesia depends upon the* quantity *of the anesthetic which the patient absorbs rather than upon the length of time that the patient is kept under its influence.* Nevertheless, the duration of the anesthesia is always of *some* moment, and becomes *a very important* factor whenever the quantity of the anesthetic administered is greater than is necessary to keep the patient just relaxed.

In direct answer, then, to the second question, it may be said that two precautions are necessary:

1. *Make the anesthesia as short as possible*, by having surgeon, assistants, instruments and all else ready by the time the patient is anesthetized, and by removing the anesthetic just as soon as the operation will permit. There never need be more than a few minutes' waiting by any one, but if there is any delay, it is far better that the surgeon should wait than that the anesthesia should be protracted. Again, at the end of the operation the

[1] The italics are mine. R. H. Ferguson.

suturing of superficial tissues is not ordinarily interfered with by the beginning of the recovery of the patient. Therefore, under ordinary circumstances, the anesthetic should be removed, so that the patient is becoming conscious at the time the dressings are applied.

2. *Administer at any time during the anesthesia only a minimum amount of the anesthetic.* The open drop method by means of my inhaler (21) will make this desideratum easy of attainment.

If the anesthesia has been as short as possible, and the smallest quantity of ether compatible with a successful operation has been administered, the lowering of the opsonic index will be the least possible for that given case. All interference with phagocytosis, however, will not have been done away with. The patient's power to resist infection will be lessened, so that the third question, concerning the possibility of a prompt postanesthetic restoration of the opsonic index becomes of prime interest.

In reply to the third question, then, it may be said that a speedy postanesthetic raising of the opsonic power of the blood seems possible. To understand how this may be done it will be necessary to refer to the present accepted theory of narcosis. In 1899 Professor Hans Meyer, of Vienna, published two papers (22) setting forth his theory of narcosis. In 1900 Dr. E. Overton published a book (23) describing his theory of anesthesia; and in 1905 Meyer again stated his explanation (24).

These two theories agree, although they were worked out independently (24) of each other. Meyer (24) says: "As a result of these studies we arrive at the following explanation of narcosis: The narcotizing substance enters into a loose physico-chemical combination with the vitally important lipoids of the cell, perhaps with the lecithin, and in so doing changes their normal relationship to the other cell constituents, through which an inhibition of the entire cell chemism results. It also becomes evident that the narcosis immediately disappears

as soon as the loose, reversible combination, dependent on the solution tension, breaks up. It follows, further, that substances chemically absolutely indifferent, as the volatile saturated hydro-carbons, can act as narcotics. . . . This simple theory also explains the fact that all structures capable of stimulation, not only the cells of the nervous system, but all others, and all plant cells as well, are depressed by the narcotic members of this series; for in all living cells lecithin, a lipoid body, is to be found. And, indeed, the establishment of the fact that the effect on the lipoids by narcotics, such as ether and chloroform, is such as immediately to inhibit the vital processes of the cell, shows us that these lipoids are among the constituents essential to the life of the cell. . . . That many narcotics induce, not pure narcosis alone, but often show other distinct actions, as, for example, the occurrence of convulsions, which quite overshadow any narcosis present, is easily to be understood when one remembers that the narcotics may possess an affinity, not only for the cell lipoids, but for other cell constituents as well, and through some union with these concomitant effects quite different from narcosis may be induced." It is impossible to understand the Meyer-Overton theory and to follow the experimental work of Graham without recognizing that there must be some intimate relation between the facts underlying each. Some of Graham's (25) experiments were conducted to determine whether or not the fat solvent power of the ether is the property by means of which it is capable of inhibiting phagocytosis.

Nerking (26) had tried already similar experiments and made a preliminary report. He did not, however, go as far as Graham has gone, nor reach so simple and practical conclusions. Nerking (26), like Graham (25, 20), referring to the Meyer-Overton theory, says: "Starting from this opinion, the question involuntarily presented itself, How would an anesthetized animal behave if a longer or a shorter time after the induction of the anesthesia a solution of lecithin (say, in a solution of

common salt) should be introduced into the blood vessels? Is it possible in this way by introducing another supply of lecithin to tear the anesthetic loose from its union with the lipoids of the central nervous system?" He adds: "It is, in fact, possible to shorten or altogether suspend the anesthesia, if, not too long after the induction of the anesthesia, a solution of lecithin is introduced intravenously into the anesthetized animal with due precautions. I have worked with different anesthetics, and generally have been able to observe that in the case of animals to which a solution of lecithin had been administered the anesthesia lasted for a much shorter time than in the case of the control animals."

The last experiments of Graham were again *in vitro;* on etherized rabbits; and on human beings. For the first (a) fat was added to etherized blood, (b) ether was added to blood mixed with fat. In the rabbits the fat was injected subcutaneously. "In the human experiments five ounces (150 c.c.) of warm olive oil were passed slowly into the rectum through a tube immediately after the patient had returned from the operating room." In all instances control experiments were established, and these produced results the opposite of those obtained from the "fat" experiments. The findings are striking and important, namely, by ether in the blood.

1. Bacteriolysis is not appreciably affected.
2. Agglutination is not noticeably influenced.
3. In some way opsonification is inhibited.
4. Lecithin will not act as opsonin or as opsonic complement.
5. The bacteria themselves are probably not affected (27, 28).
6. The leucocytes probably are to some degree anesthetized by the ether in the serum.
7. The ether in the serum probably removes and holds in suspension some of the lipoids of the serum.

8. Ether in some way affects opsonin.

9. Ether in the circulation probably disturbs the equilibrium of the lipoids in the cells of the central nervous system (with this Meyer and Overton also agree).

10. Ether saturated with lecithin has no power to diminish phagocytosis.

11. Lecithin added to etherized blood will restore phagocytosis.

12. Only very small amounts of lecithin are necessary to restore phagocytosis.

13. Olive oil has practically the same qualitative effects as lecithin.

14. Larger quantities of olive oil than of lecithin are required to produce results.

15. *The injection of five ounces* (150 c.c.) *of pure olive oil into the rectum was followed after three to six hours by a restoration of phagocytic power,* while the injection of the same amount of physiological salt solution had no appreciable effect in shortening the period of phagocytic depression.

How this restoration takes place it is perhaps at the present time impossible to explain. That it is due to the direct action of the injected fat is evident, but whether the lecithin or the oil is taken up by the blood plasma and cells of the body and used as a substitute for the lecithin which has been removed, a condition which, however, seems in part improbable, or whether the fat introduced, circulating, takes up to itself sufficient of the ether to allow a restoration of the dissolved lipoids to the blood plasma and to the cells, it is not possible to say. *That the opsonic index, that is, the phagocytic power of the blood which was lost to a great degree by the inhalation of ether or chloroform, can be quickly restored by the proper use of olive oil is certain, and it is just as certain that without this oil it would not be quickly brought back, and also that there is at present no other known means of restoring it.*

In order to obtain results the oil must be absorbed *as oil* (see below), and that it is so absorbed from the lower bowel when injected high in the rectum is beyond question in the light thrown by several investigators upon the subject of rectal feeding.

Deucher (29) limits fat absorption by rectum to ten grammes a day under favorable conditions. Edsall (30) and Miller (31) have shown that "the quantity of fat absorbed (by the lower bowel) was fairly considerable" (32), but Edsall seems inclined to limit absorption to the ten gramme per diem (33) mark, although, according to Hamburger (34), the amount is greater. At all events, if five ounces of olive oil are placed in the lower bowel, at the smallest probable limit of absorption, enough will be absorbed to become a substitute in one way or other for the lipoids whose equilibrium in the cells and plasma has been disturbed by the ether.

Any oil that may be in the intestine in excess of that which has been absorbed, is not wasted. That one channel by which ether is eliminated from the system is the gastrointestinal tract seems beyond dispute. Ether, in traces, exists at times in the vomited contents of the stomach after an ether anesthesia when its presence in the stomach cannot be accounted for by its having been swallowed.

Müller (35) calls attention to the postanesthetic eructations of gas from the stomach smelling of ether, and I had reported to me in 1911 a case in which the large intestine was opened for a carcinoma of the sigmoid flexure. At times, when the actual cautery was in use inside of the gut, faint flashes were observed in the gut, thought to have been explosions of ether vapor which had gained access to the large bowel by excretion.[1]

Any ether vapor that may be thus in the intestine, as soon as the vapor tension in the system is lessened by excretion by the respiratory tract, will be reabsorbed, and thus keep down the opsonic index and tend otherwise to

[1] A statement based upon a personal communication to the author of this paper.

protract the anesthetic phenomena. Surplus oil in the intestine will absorb this ether vapor nearly as fast as it is excreted, and will, therefore, not only prevent the lengthening of undesirable postanesthetic phenomena, such as intestinal stasis and distension of the colon, which causes so much "backache," but also will allow a speedier restoration of the opsonic power of the blood and thus make a satisfactory recovery surer.

In order to obtain the best results in an endeavor to restore quickly the power of the anesthetized patient to resist infection, pure olive oil should be used. Mineral oils, such as those from petroleum, are not absorbed; animal oils are taken up only very slowly and sparingly; cottonseed oil does not seem to be absorbed as speedily as olive oil, nor to the same extent. On the other hand, clinical tests show pure olive oil to be trustworthy, and, for the purpose under consideration, no time should be lost by the use of other oils. It is this difference in the absorbability of the oils that renders olive oil not adapted for use in the abdominal cavity to prevent adhesions, while the pure animal oil of Crump, "extracted from the contained fat of the omentum and appendices epiploicae of cattle," is excellent for the purpose (36), but of no special use in restoring the opsonic index.

I must notice, therefore, one difficulty that confronts the anesthetist who would restore the bactericidal power of his patient's blood, namely, that of obtaining an olive oil which beyond question will be satisfactory. Not only is it hard to be certain that what is had is olive oil at all, but if it be an olive oil it is not easy to make sure that it is a good one. Crump (23) writes: "In the various hospitals in which we operate different brands of (olive) oil were used, and the resulting postoperative phenomena differed so widely that we began to investigate further the properties of the various oils of the market. Much to our surprise, we found olive oil a widely differing and unstable compound. We ascertained that the number of brands runs up into four figures, there being at least 300 brands of Italian oil alone. . . .

In 232 samples analyzed from 1 to 25 per cent. of fatty acid was present."[1]

For the use of the oil the anesthetist should always see to it that the oil, as well as instruments for administering it, are always at hand. The necessary instruments are: 1. A few stiff, soft rubber catheters from nine to ten millimeters in diameter (numbers 27 to 30 French scale), together with some gum elastic English bougies of sizes that will permit them to serve as obturators and stiffeners of the catheters, or small rectal tubes of no less diameters than the catheters may be used instead. 2. A six-ounce piston syringe with a point that will easily fit the catheters or rectal tube. The longer the barrel of the syringe, as compared with its diameter, the better, since it permits a slower delivery and also the deposit of less oil at each forward movement of the piston.[2]

As the failure of the syringe to work at such a time as when an endeavor to restore the opsonic index is made is not only disappointing, but may solve the problem of life or death for the patient, contrary to the surgeon's desire, great care should be used to have an instrument which will be always in order. After personal experience with many instruments, I have discarded all syringes with rubber or leather packings, and use only those made of heavy glass, with a packing made of asbestos, which can be soaked in any corrosive antiseptic solution, boiled, or heated in a Bunsen flame without detriment to the packing. The syringe should be large enough not to require refilling.

Having the armamentarium at hand, introduce the tube well up in the rectum, or into the sigmoid flexure if possible. Fill the syringe with the olive oil at about 106° F. Attach the syringe to the tube in the rectum and then inject the oil very slowly. I assign this work to a

[1]Olive Oil, Squibb, is an absolutely pure olive oil. I use it only and never yet has it failed to restore the power of the patient to resist infection. R. H. Ferguson.

[2]I use the McElroy 6-oz. Triumph glass syringe, with asbestos packing and catheter point. Rubber or leather packings are hard to keep in order and dirty the oil, hence should be avoided. R. H. Ferguson.

nurse, giving her careful directions to consume fifteen minutes in emptying the syringe. Or the oil may be given by the "Murphy Drip" method, but the dropping should be very rapid. It will sometimes be found advantageous to have the foot of the bed or the hips of the patient somewhat elevated.

This olive oil should be injected just as soon after the removal of the anesthetic as possible. If it is going to take fifteen or more minutes to complete the dressings, then the injection ought to be begun and completed during this time, i.e., before the patient is taken from the table, provided that the surgeon's work can by any possibility be made to permit it; but if in a few minutes the patient will be in his room, then the injection may be delayed until the patient is in bed.

While a postanesthetic injection of olive oil to restore the opsonic power of the blood may be given safely to all patients who have had the ordinary preparation for an operation, and whose intestinal tract is not needed for anything else, it ought to be used in every one of the following cases if the anesthesia has been by ether or by chloroform.

1. After every anesthesia for an operation undertaken for an acute septic condition, as, for instance, (a) acute pyosalpynx, (b) acute suppurative appendicitis, (c) traumatic sepsis, (d) perforation of the intestine in typhoid fever, (e) extensive abscesses, carbuncles, etc.

In such cases there is always some general sepsis left after the removal of the source of the infection, which the patient may not be able to withstand until the preanesthetic power of resistance has been regained without assistance.

2. After every anesthesia for an operation on a patient suffering with an acute or subacute infection, as, for instance, (a) bronchitis, (b) pulmonary tuberculosis, (c) influenza, etc.

3. After every anesthesia for an operation on a pa-

tient suffering from any chronic infection, as, for instance, (a) tuberculosis of skin, joints, or internal organs, (b) furunculosis, (c) gonorrheal arthritis, etc.

4. If any slip in the asepsis of the operation has been observed or even suspected. In these cases, the few bacteria introduced, although they would otherwise be of small consequence, may proliferate rapidly, and either kill the patient or compromise the results of the operation on account of the impairment of the patient's immunity by the anesthesia. Such a result should be anticipated and precluded by an injection of olive oil.

5. In every case liable to develop postoperative pneumonia. Which these cases are is obviously difficult to determine beforehand, but there are some factors which may suggest the precaution of the injection. For example, for a patient whose nose and throat are not clean, and, therefore, from which the pneumococcus may be aspirated into the lungs during anesthesia. Park and Williams (37) and their associates have obtained "typical pneumococci . . . in a large percentage of normal cases, in both city and country," which they examined. Longcope and Fox (38) say: "During the winter months the pneumococcus has a wide distribution, and at this time a large percentage of healthy individuals harbor virulent pneumococci in their buccal cavity. It is almost certain that some persons always have virulent pneumococci in their saliva," and, as Buerger (39) has shown, "The pneumococci occurring in the mouths of normal individuals possess the usual morphological and cultural characteristics observed in the organisms isolated from other sources."

A plain lesson from these findings is that the nose and throat of each patient presented for anesthesia should be thoroughly cleansed with some mild antiseptic solution just before the anesthesia, and I know from clinical evidence that such treatment not only at times has markedly decreased the percentage of postanesthetic lung complications, but also that for one service of a large

hospital it has reduced a fairly large percentage of post-anesthetic pneumonias to zero. However, the impaired bactericidal power of the blood is an independent condition of the development of postanesthetic pneumonia; therefore, the patient should be protected as much as possible by a prompt injection of olive oil.[1]

There are five facts to be borne in mind in regard to this use of olive oil:

1. Rectal injections of olive oil are of no use in preventing or combating ordinary infections. The inception and progress of such septicemias are not due to any disturbance of the equilibrium of the lipoids of the cells. Olive oil, absorbed by the large intestine, will restore the patient's power to resist infection only if such power has been lost on account of a suspension of phagocytosis due to the influence of alcohol, chloroform or ether on the equilibrium of the lipoids of the cells.[2]

2. The injection is most effective when the ether tension in the cells is greatest. This is late in the anesthesia, particularly at the time when the anaesthetic is removed. Therefore, no time should be lost, but the injection given just as soon after the anesthesia is over as is possible.

3. The olive oil cannot be given effectively by the mouth. So administered, it is saponified and digested as any fats are. To restore the opsonic index the oil must enter the circulation *as oil.* It must, therefore, be injected into the lower bowel.

4. Oil cannot be administered before the operation as a prophylactic. Whether the oil enters the cell and takes the place of the lipoids of the cell which have been removed by the anesthetic, which seems improbable, or

[1]Obviously there are causes of postoperative pulmonary difficulties quite apart from the aspiration of the pneumococcus or the staphylococcus into the lungs, causes dependent on the general preoperative condition of the patient or upon the operative procedure, and these may be so potent that a restoration of the opsonic index may not be able to overcome them.

[2]That is, the olive oil used as described merely undoes the damage the ether or chloroform has done.

whether the oil brought in contact with the cell takes up the ether in the cell and allows a restoration of the lipoid equilibrium, which is quite possible, has not yet been determined. It is, however, certain that the injection of the olive oil can do no good until the equilibrium of the lipoids has been disturbed.

5. There frequently will be after anesthesia an increased leucocyte count. The anesthetist should not allow himself to be deceived by this condition. Such an increased number of leucocytes does not mean a restoration of the power of the patient to resist infection, nor that the bactericidal power of the blood has not been diminished by the anesthesia. The damage to the patient from the anesthesia does not consist in any change of the number of the white corpuscles, but in the diminished phagocytic action of the leucocytes. In a war it matters not whether an army of one million or of one thousand men be sent to repulse invaders, provided that to none of the men any means of defensive or offensive warfare be furnished. So in the matter at hand, if the leucocytes can no longer perform their duties as phagocytes, a numerous leucocytosis is of no more use than a restricted one. It is not a question of numbers, but of efficiency of the leucocytes which are present.[1]

SUMMARY

In summing up the lessons to be learned from this study of the influence of alcohol, chloroform and ether upon the power of the body to resist disease, the following are points which should be emphasized.

1. Do not give alcohol in the infectious diseases (37). It is particularly bad in pneumonia and septic conditions (40).

2. For surgical anesthesia, administer at any one

[1] *Confer* Rubin. "Some animals died with a fairly high leucocyte count."

It should be noted that the postanesthetic rectal injection of olive oil restores the opsonic index only to what it was *before the anesthesia* —i.e., to above normal—to normal—to below normal, according as the case may have been before the patient was put to sleep.

time, during the anesthesia, as little of the anesthetic as possible.

3. Never use alcohol as a stimulant during or after an anesthesia if the opsonic power of the blood is of any importance.[1]

4. Make the anesthesia as short as possible. Begin to administer the anesthetic as late as circumstances permit and remove it just as soon as the operation will allow.

5. Use only a strictly pure ether or chloroform, lest impurities in the anesthetic augment the unavoidable depression.

6. *Take special precautions for asepsis and antisepsis* in all operations of any length. A very slight infection, which would not manifest itself under ordinary circumstances, may develop into a serious condition after an anesthesia because of the impaired resistance.

7. Inject six ounces of olive oil high up into the rectum in all septic cases, and in all others in which the patient's power to resist infection may be called into play.

8. Remember that time is an important factor in restoring the opsonic index; therefore, do not delay the administration of the oil.

9. In injecting the oil, "make haste slowly." The sudden deposit of six ounces of oil may cause it to be ejected, and all will have to be done over again. Give a slow, steady, continuous injection every time.

10. Use only pure, limpid olive oil. Absorption, to do the most good, must take place comparatively quickly. Therefore, take care to have at hand an olive oil free from stearins and other heavy oils, free fatty acids and other impurities.

11. If there is the slightest question whether to inject the oil or not, *inject it.* It can never do harm. Be on the safe side.

[1]This is a second reason against the use of alcohol in connection with anesthesia, especially that by ether. Alcohol acts on the system just the same as ether does; and if the patient's nerve centres are depressed by the ether, the alcohol cannot but continue or deepen the depression.

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