How is the Full Length to be Maintained?

The Thomas teaching is that it is easy to pull the leg to its full length, and equally easy to keep it there by tying it to the splint. But the two ends of the bone are not directly grasped by the splint, and all sorts of variations of tension are permitted by it. In the first place, the hold on the tuber ischii is shifted every time the skin over that promontory is attended to. Then it is shifted when the leg is raised for dressing purposes. If the leg is lifted until the knee is 9 in. from the bed, the distance of the knee from the tuber ischii is increased by 1 in., that is, the adjustment of a fracture which originally had 2 in. shortening is varied by 50 per cent. When the slings are removed from under the thigh, the tension is increased by the weight of the sagging limb tied by its two ends. And lastly, there is the stretching or slipping of the plaster attachment to add a fourth element of variability to the extending force. If, instead of tying the limb to a rigid bar, it is pulled upon by a constant weight of 15 lb., all these variations are done away with. The pelvis is tied to the top of the bed by a perineal band round the sound thigh, and the leg is slung off the bed. Then there is always 15 lb. extension, whether the buttocks are moved or whether the leg is elevated, or whether the slings are removed for dressing.

I would protest against the Thomas system being described as constant extension and the weight pull as intermittent. Such a statement is simply begging the question. How can a system be described as constant extension when it is subject to five distinct variations? First, the extension is often not done all at one sitting, but added to by tightening the straps day by day. Secondly, it is altered when the thigh ring is moved from its purchase on the pelvis for cleaning purposes; thirdly, it is altered whenever the leg is lifted and the ring leaves the tuber ischii; fourthly, it is altered whenever the dressing slings are undone; and fifthly, it is altered if ever the plaster stretches or slips.

On the other hand, if extension be by a weight acting through a cord running over a pulley, how can this be intermittent? If the man moves down the bed or up the bed the weight moves with him, but its pull does not vary, neither does its direction. Slipping or stretching of the attachment does not vary the weight or the extension.

It is stated by the Thomas school that there is less tension on a limb extended to its full length and held by a rigid splint than when it is held at the same length by a weight; and, further, that when the weight is used the tension varies. Now, both these statements are without proof. I know, when once a femur has been pulled down to its full length by a weight of 15 lb., that 10 lb. is enough to maintain this length. But what is the tension on the straps of a Thomas splint when the leg is at full length? I cannot say, because I have never seen this condition obtained, but if 10 lb. is needed to balance a contractile force, when applied by weight, is not this a measure of the tension which must be exerted by the fixed system? Again, the tension required by the Thomas system is greater than that employed by a weight with the knee semiflexed, because the Thomas splint has to overcome the maximum tension of the hamstring muscles, whereas in the cradle, the knee being bent, these muscles are out of action.

As to the tension in the weight system varying, I have already shown that it cannot be either more or less than that of the extending weight. But it may be said that the muscles spasmodically contract. If this were so, then with the same extending force the length of the leg would be constantly altering. But the weight remains the same, the tension remains the same, and the length of the leg remains the same.

I cannot accept Mr. Aitken's suggestion that his quoting a single case is a satisfactory answer to my objections. I do not doubt for a moment that Mr. Aitken could bring forward many brilliant results obtained by the use of a Thomas splint in his hands as used for fractured femur. I believe that even I could obtain good results from it. But why should one use a system which requires a splint to be fitted for each patient and which then has no less than five variables tending to failure when one has at hand a simple and constant system with none of these drawbacks?

I ought also to have mentioned the fact that whilst the Thomas splint imposes rigidity upon the knee, the weight

system allows this joint to be exercised throughout the treatment.

Mr. Aitken speaks of my using great weights, weights up to 25 lb. But I only use such a weight for an old fracture, for which Mr. Aitken employs pulley blocks, giving, I suppose, over 100 lb., and then he repeats the employment of this "great weight" on several occasions. I never use more than 25 lb., and this very rarely; 15 lb. is the routine weight for recent fractures, and it is reduced to 10 lb. within a week. But, apart from all theoretical considerations, it is urged that weight extension is a constantly painful process as compared with the Thomas splint. I can only meet this with a direct negative, and my proof is close at hand. I have now a considerable number of cases of fractured femurs under treatment by weight extension, and all of them had a preliminary trial of a Thomas splint. I most cordially invite Mr. Aitken to visit these patients and ask them for an expression of their experiences. In the meantime let me simply state that the idea of "reflex starting pains" is quite mythical.

The Thomas Splint.—All advocates of Thomas's splint for fractured femurs lay great stress upon the point that the ring should fit the patient's thigh so that it rides snugly upon the tuber ischii instead of lying across the perineum. Now this is a fatal objection to its routine use in military surgery. The splints cannot be fitted to the patients at casualty clearing stations, and it is, I think, a matter of common observation that what is done is to use a size which fits no one, that is, a size of ring much too large. In one case which I know, in which the ring fitted originally, the splint had to be removed under an anaesthetic, owing to the fact that the limb had swollen subsequent to its application.

In conclusion, I would cordially endorse the spirit of Mr. Aitken's article, which he opens by saying that we are all concerned chiefly in helping to find the best methods of treatment, and not in making attacks upon one another. The results of weight extension treatment have been recorded with the fullest details by many surgeons. For example, by Bardenheuer, by the authors of the Balkan splint, and in the present war by myself, among others. May I, with the utmost respect, ask some advocate of the Thomas splint to do the same? Thomas's pioneer work was done before the discovery of the x rays, and I venture to suggest that if, after this discovery, any advocate of his system had proved by radiography that a large proportion of good results had been obtained by it, it would not have lapsed into being regarded by most surgeons as an obsolete and unsatisfactory method. But now, when the Thomas splint is being used by the thousand, there is ample opportunity for this demonstration. I would urge any surgeon who believes in this method to publish one hundred, fifty, or even ten consecutive unselected cases, illustrated by skiagrams, to show us what are the results obtained.

THE MECHANISM OF SALINE DRESSINGS.*

BY

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SINCE the onset of the war the publications of Sir Almroth Wright on the use of saline solutions for dressings¹ have caused a secession of many of the adherents of the old antiseptic school. This is partly due to the disappointing results obtained by the use of antiseptics and the failure to sterilize wounds by this method; for a greater success has been expected by the surgeons from their experience in civil practice.

The new treatment has come into very extensive use in England and in France, but there has been little discussion of the theoretical and experimental evidence indicating its use as a dressing for wounds, with the exception of the publications of its chief advocate, Sir Almroth Wright.

According to the recent publications of Sir Almroth Wright, the activity of salt solutions depends on their "phylacagocic" character—that is, their capability of "bringing the protective elements of the body, blood

* From the laboratories of the Robert Walton Goelet Research Fund.

fluids and leucocytes, into application in the wounds." Strong and weak salt solutions are included in these dressings, and their action varies according to the salt concentration.

WHAT IS CLAIMED FOR SALINE DRESSINGS.

A. *Hypertonic saline** is termed a "lymphagocic agent," and the mechanism of its action is described under the three phases of "physical action," "physiological action," and "the effect on the condition of the wound and microbial infection."

The physical action is stated to be chiefly a process of diffusion. It is stated that by this action water and albuminous substances are attracted to the surface of the wound. The statement is made that there is nothing in the wound like an animal membrane to filter out albuminous substances, and that therefore the laws of osmosis do not apply.

The physiological action of strong salt solution is described as bringing about the disintegration of leucocytes and the liberation of trypsin, which process permits autodigestion. This furnishes a medium favourable for bacterial growth as soon as the excess of salt is removed. Strong salt solution is said, further, to paralyse or repel the leucocytes by exerting a negative chemio-taxis.

The effect on the condition of the wound and microbial infection is stated to be due to a combination of the physical action and the physiological action, and also the inhibitory effect exerted directly on the pyogenic organisms themselves by the 5 per cent. salt solution.

As a result of the physical and physiological action, the autodigestion of sloughs is said to be expedited in the wound, and they are assumed to be readily loosened from living tissue by the outward current of "blood fluids."

B. The action of *physiological saline* is then described. This is stated to be physiological only in its tonicity or total content of crystalloids. There is, of course, more sodium chloride in it than in the blood, and sodium chloride will pass into the tissues in exchange for other salts which will pass out. This is presumed to be the cause of its "leucocytagogic" action.

DISCUSSION OF CLAIMS FOR SALINE DRESSINGS.

Is Sir Almroth Wright's hypothesis that "neither in the earliest stage of the wound where the tissues lie exposed, nor yet in the later stage, when the walls are infiltrated, have we in the wound anything in the nature of a membrane which could filter out albuminous substances"? correct? In his interesting little book on *Wound Infections* (1915) we find the statement: "Granulation tissue is composed of continuous layers of cells." Also "The cell wall is a quasi-impenetrable membrane" (p. 58). This sounds much like the description of an osmotic membrane. Apparently it was at that time so considered, for a little further on (p. 71) the statement is made: "Five per cent. solution of common salt mixed with one-half per cent. of sodium citrate . . . brings into play osmotic forces and 'draws' the lymph out of the walls of the wound." We are left in some doubt as to whether the principles of osmosis are held to apply or not to apply to the action of salt solutions on wounds.

Where do the bactericidal constituents of the discharge come from? We cannot consider the action of salt solutions on the tissues *en masse*. We must consider the action on the individual cells, each with its semi-permeable cell wall, as well as the action on the free fluids circulating between the cells.

It seems not unreasonable to assume that the bulk of the body fluids in the neighbourhood of the wound must be within intact cells or intact blood and lymph vessels, and only a comparatively small amount present in ruptured cells or cut intercellular spaces and lymphatics. Therefore it appears that we must have to deal with the laws affecting the passage of fluids through an animal

membrane (osmosis) as well as with the laws affecting the interchange between fluids in free contact (diffusion). In addition, we must consider how the physiological activity (secretion) of the cells is acted upon by the dressing.

1. What is Effected by Osmosis?

If we cannot eliminate the process of osmosis as one of the physical reactions between the tissues and salt solutions, we must see what can be expected of it in the case of salt solutions of various strengths.

As far as there is an interchange of soluble bodies between the great mass of *individual cells*, including the endothelium of blood and lymph vessels, and a dressing solution, it is governed by the laws of osmosis or secretion.

A dressing containing only sodium chloride and water is *hypotonic* for the albuminous substances, among which are the antibacterial agents of the body. No alteration in the concentration of the salt will alter the fact that there is a tendency toward the attraction of water by these substances into the cells, and a tendency for the same substances to osmose into the protein-free salt solution. Since, however, their osmotic motion is almost entirely restrained by the semi-permeable cell wall, their osmotic pressure results chiefly in attracting water. As far as they do pass through the cell wall in response to differences in osmotic pressures, they do so equally, no matter what the salt concentration, there being no albuminous substances in the dressing solution to exert a counter pressure for these substances in the cells.

Colloids and gells may attract and retain water from a saturated salt solution. Presumably those in the cells may do the same from 5 per cent. saline. The balance of water in the tissues depends, therefore, as far as the laws of osmosis are concerned, on the relative amount extracted by the salts in the dressing solution and attracted by the albuminous substances retained within the cells.

Now, the rate of osmosis of water and salt through an animal membrane such as the cell wall is proportionate to the difference of their concentrations on the two sides of that membrane. There will therefore be a rapid extraction of water and inward migration of NaCl at first. The rate of interchange will decrease until the difference between the concentration of salt outside and inside of the cell is equal to the difference between the concentration of salt inside the cell and in the blood and lymph by which the salt is carried away. If the dressing solution is kept at a constant concentration and the blood and lymph circulation is sufficient to carry off salt as fast as it passes into it, a point will be reached where a stable maximum concentration of salt is established within the cell with a uniform rate of migration of salt through the cell from dressing solution to blood stream and a uniform rate of passage of water outward. This concentration point will be midway between that of the dressing solution and that of the blood.†

At this point, however, the attraction of the albuminous substances for water will be exerted, and the cells will attract water to satisfy their separate, positive osmotic pressure. Regulated by the same law which governs the rate of interchange between salt and water, the water will (at first) pass into the cell and on into the blood at rates proportionate to the differences between the protein content of the dressing solution and of the cell, and between the protein content of the cell and that of the blood stream. Since the protein content of the cell cannot easily escape (albuminous substances osmose only very slowly through an animal membrane), this balance is established when the protein concentration in the cell becomes one-half that of the blood—that is, when the amount of water in the cell is doubled. The body fluids and the dressing solution may be considered as unchanging solutions, since their constant renewal prevents any

* Since this paper was sent for publication "A Memorandum on the Treatment of Wounds by Physiological Methods" (Sir Almroth Wright, *BRITISH MEDICAL JOURNAL*, June 3rd, 1916) has appeared, in which the previous claim of the stimulation of tryptic digestion by hypertonic saline is apparently abandoned, and an inhibiting effect admitted. The oedema which may result from the accumulation of salt in the granulations is also mentioned, and the previously emphasized conception of the drawing power of salt for albuminous substances, except in so far as they are brought along with the current of water, is apparently dropped.

[Dr. Kenneth Taylor's paper was received for publication on May 22nd, 1916.]

† It may be desired to find the theoretical concentration of NaCl in the cell as far as the laws of osmosis apply. If the NaCl concentration of the dressing solution be represented by S, that of the blood by B, and that of the intermediate cell by C, the ultimate maximum NaCl concentration in the cell may be expressed by the formula $C = \frac{S+B}{2}$. In the case of continued application of 5 per cent. NaCl solution this will be about $\frac{5+0.6}{2}$, or 2.8 per cent.; with "physiological" saline solution $\frac{0.8+0.6}{2}$, or 0.7 per cent.; with salt free solutions $\frac{0+0.6}{2}$, or 0.3 per cent.

alteration in character. The variations will occur in the substances within the restraining membrane of the cell wall. In the following formulae A represents the albuminous substances present in approximately equal concentration in the circulating body fluids and within the cells. The arrows represent the direction of migration of each substance—the larger arrows the more rapid, the smaller the slower migration. Arrows of equal size represent migration at equal rates. The relative concentrations of each substance, when the dressing solution is first applied, are shown by the signs $> = <$. The "established reaction" represents the arrival at a stage when the concentration of the intracellular constituents will no longer vary unless the constitution of the body fluids or the dressing solution be altered.

	Body Fluids.	Cell Fluids.	Dressing Solutions.
1. Hypertonic Saline.			
Before reaction ...	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} = \\ \text{A} = \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} \\ \text{A} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} < \\ \text{H}_2\text{O} \end{matrix}$
Beginning reaction ...	$\begin{matrix} \text{H}_2\text{O} \rightarrow \\ \text{NaCl} \leftarrow \\ \text{A} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} \\ \text{A} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \rightarrow \\ \text{NaCl} \leftarrow \\ \text{H}_2\text{O} \end{matrix}$
Established reaction ...	$\begin{matrix} \text{H}_2\text{O} \rightleftharpoons \\ \text{NaCl} \rightleftharpoons \\ \text{A} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} - \text{H}_2\text{O} \\ \text{A} + \text{H}_2\text{O} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \rightleftharpoons \\ \text{NaCl} \rightleftharpoons \\ \text{H}_2\text{O} \end{matrix}$
2. Isotonic Saline.			
Before reaction ...	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} = \\ \text{A} = \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} \\ \text{A} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} = \\ \text{H}_2\text{O} \end{matrix}$
Beginning reaction ...	$\begin{matrix} \text{H}_2\text{O} \rightarrow \\ \text{NaCl} \leftarrow \\ \text{A} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} \\ \text{A} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \rightarrow \\ \text{NaCl} \leftarrow \\ \text{H}_2\text{O} \end{matrix}$
Established reaction ...	$\begin{matrix} \text{H}_2\text{O} \rightleftharpoons \\ \text{NaCl} \rightleftharpoons \\ \text{A} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} \\ \text{A} + \text{H}_2\text{O} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \rightleftharpoons \\ \text{NaCl} \rightleftharpoons \\ \text{H}_2\text{O} \end{matrix}$
3. Hypotonic Saline.			
Before reaction ...	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} = \\ \text{A} = \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} \\ \text{A} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} > \\ \text{H}_2\text{O} \end{matrix}$
Beginning reaction ...	$\begin{matrix} \text{H}_2\text{O} \leftarrow \\ \text{NaCl} \rightarrow \\ \text{A} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} \\ \text{A} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \leftarrow \\ \text{NaCl} \rightarrow \\ \text{H}_2\text{O} \end{matrix}$
Established reaction ...	$\begin{matrix} \text{H}_2\text{O} \rightleftharpoons \\ \text{NaCl} \rightleftharpoons \\ \text{A} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \\ \text{NaCl} + \text{H}_2\text{O} \\ \text{A} + \text{H}_2\text{O} \end{matrix}$	$\begin{matrix} \text{H}_2\text{O} \rightleftharpoons \\ \text{NaCl} \rightleftharpoons \\ \text{H}_2\text{O} \end{matrix}$

The chief result to be anticipated in a hypertonic saline dressing is, therefore, an ultimate increase of NaCl and water within the cell. If at any point the hypertonic solution be removed or replaced by iso- or hypo-tonic solutions, an additional inrush of water will occur from the dressing solution and body fluids to satisfy the excess of salt deposited.

By applying the same laws to the case of isotonic saline, it becomes evident that it is chiefly the osmotic pressure of the albuminous substances which is exerted, and which will result in an increase of water within the cell. There should be a little increase of the NaCl concentration due to its slight excess in the dressing solution.

In the case of hypotonic solutions, the positive pressure of both the NaCl and the albuminous substances will be active, with a more rapid inrush of water and a gradual extraction of the salt.

Thus the end result of the prolonged use of any protein-free watery solution will be an increase of water within the cell—early in the use of the hypotonic saline, later with the hypertonic solutions. Any great increase in concentration of NaCl in the cell due to the hypertonic, and also a diminished concentration due to the hypotonic, can, together with the watering of the protein content, only serve to check or permanently inhibit its physiological response to the stimulus of the injury and the infection.

No increase in albuminous bactericidal substances in the wound is to be expected from the process of osmosis. It is useless to attempt to influence the osmotic motion of albuminous substances by increasing the salt content of the dressing solution. They will osmose very slightly in any case, but in so far as such osmotic motion occurs it will take place just as rapidly into weak as into strong salt solution. Hypertonic saline is not a "lymphagocic" but a hydrogocic agent.

2. What is Effected by Diffusion?

Sir Almroth Wright does not admit that the great mass of intact cells is affected in any way by the use of saline solutions. He apparently does not consider the exchange of salts and water through the endothelial cells of the blood vessels and lymph channels to be subject to the laws of osmosis. The "lymphagocic" action he assumes to be entirely a process of diffusion.

Now we know of no physical law from which it may be deduced that NaCl exerts a positive attraction for albuminous substances. In fact, it has been demonstrated in this laboratory by Mr. H. E. Magee that when a weak saline solution of egg albumen is brought into direct contact with solutions of NaCl no greater migration occurs into 5 or 10 per cent. salt solution than into physiological saline. When the albumen was incorporated into agar, allowed to set, and saline solutions of various concentrations superimposed, the same results were obtained except in the case of saturated NaCl solution. In the latter, albuminous substances appeared in greater amounts than in the 0.85 per cent., 5 per cent., and 10 per cent. solutions, probably due to the obvious shrinkage of the agar and the expression of its content.

When two solutions are in direct contact and there is no selective animal membrane between them, no more restraint is placed upon the movement of salts and colloids than upon the movement of water. The interchange must take place without inducing, in the fluids, any current which might bring with it albuminous substances.

Of course there is a natural diffusion of these substances into any solution which contains them in lesser concentration. The proportion of NaCl is immaterial. It is only the proportion of albuminous substances which counts.

Sir Almroth Wright places considerable confidence in what he terms the "physiological action" of the hypertonic solution when applied to the wound. The solution is admitted to produce certain undesirable results in the wound. It is said to repel the leucocytes in the neighbouring tissues. It is said to break up those in the surface of the wound. This disintegration of leucocytes (and other cells?) frees trypsin, which is admitted to digest ("corrupt") the lymph in the discharge, making it a favourable medium for bacterial growth. The rapid multiplication of bacteria is assumed, however, to be inhibited by the antiseptic action of the strong saline.

The digestion of the sloughs by the trypsin is claimed to proceed, causing their rapid separation. It is assumed that trypsin will act in 5 per cent. saline. This concentration is sufficient to markedly reduce its action *in vitro*. Many ferments are inhibited by an excess of NaCl. We have found in a series of *in vitro* experiments that peptic digestion proceeds rapidly in 0.85 NaCl solution, a little more slowly in weaker salt solutions, and is almost entirely suppressed in 2.5 NaCl solution. Tryptic digestion we found to be most active in the weak salt solutions, to fall off rapidly in solutions of over 1 per cent., and to be almost completely suppressed in 5 per cent. concentrations. The only remaining physiological action with which the hypertonic solution is accredited is, then, that of breaking up and "paralysing or repelling the leucocytes." It is reasonable to assume, however, that considerable interference in the vital processes of the cells will occur as a result of the marked alteration in their salt and water content. It is unsafe to assume that such antibacterial albuminous bodies as may be present in the discharge retain their activity in a menstruum of 5 per cent. NaCl.

As to the beneficial action of 5 per cent. NaCl as a very weak antiseptic, there is no dispute.

3. What is Effected by Secretion?

It appears to us that little increase in the discharge of bactericidal substances can be expected as a result of osmosis and diffusion. Is not the greater part of the antibacterial substances secreted by the cell in its reaction to irritation by specific substances? Increased secretion of albuminous substances is one of the chief phenomena of inflammation. It is probably to this process that we must look for the source of most of our antibacterial agents. We must be careful not to interfere with this reaction by too great alteration of the salt content of the tissues.

SUMMARY.

(a) What, then, may be expected from the use of a strong salt solution in a wound?

By a process of osmosis water is extracted from intact cells, blood vessels, and closed lymph spaces. The same interaction increases the NaCl content of intact cells and those lymph spaces which may be slowly drained. When the strong salt solution is diluted or withheld, a rapid increase of water within the cells is to be anticipated. If continued for a long period, the colloid constituents of the cells imbibe water and the basis of oedema is established. A small amount of dialysable albuminous substances will emigrate from the cells, due to the absence of such substances in the dressing solution. This emigration will be unaffected by the NaCl concentration of the solution.

By a process of diffusion an interchange of NaCl and water will occur between the free fluids in the intercellular spaces and cut lymph channels which are in contact with the dressing solution, resulting in a concentration of the salt in these fluids.

At the same time a slow diffusion outward of all soluble proteins and other bodies (with the exception of NaCl) will occur, due to their absence in the dressing solution. Again, the NaCl concentration will not affect the rate of diffusion of these substances, nor will an outward current be produced by the interchange of NaCl and water and thus carry with it the free lymph. There remains the normally brisk reaction of secretion upon which we have to fall back for the desirable increase in antibacterial substances. This may be seriously inhibited by the excess of NaCl in the cells.

The migration of leucocytes will be checked and those on the surface of the wound probably destroyed.

The tryptic digestion of sloughs will be suppressed.

The character of the antibacterial substances secreted or diffusing into the wound may possibly be so altered as to become inactive by their dilution and solution in strong salt solution. The activity of the bacteria may be slightly reduced by the antiseptic action of NaCl in concentrations of 5 per cent. or more.

(b) What is to be expected from "physiological saline"?

The amount of osmosis is negligible as far as the interchange of NaCl and H₂O is concerned; there will be only a slight increase in the NaCl content of the cells. There will, however, be the same positive osmotic pressure of the albuminous substances within the cells resulting in the attraction of water. Therefore the waterlogging of the tissues will occur if the solution be used for a long period.

The process of diffusion will allow of an equal outward movement of soluble proteins as in the case of hypertonic saline solution.

The secretion of the cells will proceed without serious interference by the dressing solution until the gradual accumulation of water diminishes their power of reacting.

The migration of the leucocytes will proceed normally or be increased and their beneficial activities remain unaltered.

The tryptic digestion and dissolution of the sloughs in the wound will proceed at its maximum rate, free from the inhibition of strong salt solution.

The character of the antibacterial albuminous substances, diffusing or being secreted in the surface of the wound, will be unaltered.

(c) What is to be expected from hypotonic saline?

By the process of osmosis the combined positive osmotic pressure of the salts and proteins within the cells will be exerted. The result will be a rapid extraction of salts from the cell, and a rapid accumulation of water, with the early establishment of a waterlogged condition.

The process of diffusion will allow of an equal outward movement of soluble proteins as in the case of hypertonic and isotonic solutions. In addition, there will be a similar emigration of NaCl. The secretion by the cells will be interfered with as a result of the extraction of salts and the rapid accumulation of water. The migration of leucocytes will be checked.

The tryptic digestion of the sloughs will proceed a little more slowly than with isotonic solutions, but much more rapidly than with hypertonic.

The character of the antibacterial substances will probably be altered, and possibly be rendered inactive by dilution and solution in an abnormal menstruum.

CLINICAL EVIDENCE.

What clinical evidence is there of the success of the treatment with hypertonic salt dressings? Aside from the claims of its author, there have been scattered reports in its favour appearing in various medical journals. There is also a strong minority which is disappointed in the treatment. It is claimed that the infection is not diminished and that the wound is left in poorer condition by its use than would have been the case if it had been left alone. Attempts are made to reinforce the weak antiseptic action of the high NaCl content by the addition of a more active germicide. This is merely additional evidence that it has proved unsatisfactory.

We have seen it used rather extensively, and have not been convinced that it produced the results claimed for it. The saprophytic bacterial flora persisted quite as long as with the ordinary methods of antiseptic treatment, and the separation of sloughs did not appear to be appreciably hastened. We have, in addition, felt that oedema of the tissues around the wound occurred more frequently after the use of hypertonic saline than with other dressing solutions, possibly as the result of an increased deposit of salt. Furthermore, the recuperative reaction in the wound appeared to be retarded.

CONCLUSION.

The clinical superiority of the treatment by hypertonic saline dressings does not appear to be so decisive that the theoretical and experimental objections to their use can be disregarded.

The theoretical indications for the use of salt solutions appear to be based on an untenable hypothesis of the structure of the tissues about the wound, and an erroneous interpretation of physical and physiological laws.

Certain characters possessed by hypertonic NaCl solution are theoretically undesirable in a dressing solution, and their harmful action can be demonstrated experimentally and clinically.

Certain desirable results claimed to be effected by the use of hypertonic NaCl dressings cannot be demonstrated *in vitro*.

The chief beneficial character held by strong salt solutions, aside from the cleansing property possessed by all watery solutions, is their mild antiseptic action.

A detailed investigation of the specific character of special antiseptics may be a more profitable undertaking than an exclusive concentration upon the physical and physiological properties of sodium chloride.

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¹ BRITISH MEDICAL JOURNAL, October 30th, November 6th, and November 13th, 1915. ² *Ibid.*, November 6th, 1915, p. 676.

RECENT EPIDEMIC OUTBREAKS OF ACUTE
POLIOMYELITIS.

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It seems to be clearly established that acute poliomyelitis has only in comparatively recent years appeared in epidemic form. The first definite and clear reference in the literature to an epidemic outbreak occurs in 1881, when Bergenholtz recorded the occurrence of 18 cases in one district in Northern Sweden; but it was not until the appearance of Medin's well-known record of 43 cases in Stockholm in 1887 that attention was called to the subject. Since that time outbreaks have been more frequent and ever-increasing in extent. In 1899 Wickman reported 54 cases in Stockholm, and in the same year Leegaard described an outbreak, also of 54 cases, which had occurred at Bratsburg in Norway, between July and October. Wickman's excellent record of his observations in over 1,100 cases in Sweden in 1905-6, his accurate description of the various clinical types met with in that epidemic, and of the *post-mortem* findings in the fatal cases, mark a great advance in our knowledge of the disease. In the same years—1905-6—Norway also suffered severely, about 1,000 cases being reported.

In Germany small outbreaks had been reported from time to time since 1886; the first large outbreak there

* Abridged from a paper read before the society.