severe faucial and laryngeal second doses of from 12,000 to 16,000 units will be required in a goodly number.

In many very severe faucial cases second doses, usually varying from 16,000 to 20,000 units, will be required, but occasionally it will be advisable to repeat the first-day dose in 24 hours or less if the faucial swelling and cellulitis have increased, and to give a second dose of 20,000 units should there be no improvement by that time. Cases suffering from laryngeal diphtheria with no faucial or nasal involvement seldom require more than the 18,000 units. Nasal diphtheria with membrane but no faucial involvement, and conjunctival diphtheria with no faucial involvement, seldom require a second dose. A discharge from the nose, whether blood-stained or not, in which is found the diphtheria bacillus but no membrane formation, seldom requires antitoxin treatment.

Importance of Recumbent Position.

It is of very great importance that the patient should be in the recumbent position in bed. He should lie flat on his back and unless the disease is mild not even a pillow should be allowed; a mild case may be allowed a soft pillow. The period for which it is necessary to maintain the recumbent position varies greatly with the severity of the attack, but it is wise, except in the mildest forms, to regard the minimum as three weeks, and in very severe cases up to six or even nine weeks. The mildest forms should be recumbent for at least 15 days.

When it is considered safe to move the patient from the flat position the process must be very gradual, the heart being watched with care, and should it be affected by the change return to the recumbent position must be resorted to. In moving the patient from the flat, give only one pillow for a few days, then a second, and so on until the patient may be allowed to lounge in an easy chair at the bedside for half an hour. Even when he is up and about the heart must be watched for some time and the patient put back in the recumbent position if necessary. If this is carried out carefully sudden death in convalescence will occur very rarely indeed.

Some may wonder how one can expect a child to lie flat in bed for weeks, but actually the child suffering from diphtheria will do so readily and almost without exception. With rare exceptions it will be the fault of the nurse, not of the child, if there is difficulty. With the adult, however, difficulty may arise, and considerable persuasion is sometimes necessary. The ordinary case may be carefully moved on his side for changing or blanket bathing, but in a case in which early heart failure is likely the blanket bathing must cease from about the seventh to the fifteenth day, and only those parts sponged which entail no movement of the patient. Every precaution must be taken to avoid unnecessary movement. This complete rest in the recumbent position is laid down as essential by all who are experienced in the disease, and it follows that local treatment of the throat should not be done. It is difficult to depart from a treatment which has been carried out almost from time immemorial, but my experience of local treatment of the throat in infectious diseases is quite unsatisfactory. Even in scarlet fever, whether septic or not, I gave it up some 12 years since, except in the adult, who likes it, and my experience is that in the ordinary case of scarlet fever no difference results, while I think the septic cases on the whole do better, and they certainly do as well. Now in scarlet fever there may be a difference of opinion, but in diphtheria I do not think there should be, for local treatment of the throat must interfere with the complete rest which is essential.

The nursing of diphtheria requires special training, and the requisite nurse is by no means always procurable; indeed, nurses whom one would call capable of diphtheria nursing are scarce. Therefore it is necessary for the practitioner when dealing with this disease to tell his nurse not only what to do but also what she must on no account do.

EFFECTS OF HOT AND COLD APPLICATIONS TO THE SURFACE OF THE BODY

ON THE TEMPERATURE OF THE MUSCLES, LIVER,
KIDNEYS AND BRAIN.¹

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IN a previous communication² it was shown that the application of heat to the surface of the thigh causes, in the rabbit, an immediate rise in temperature, which spreads laterally for about 20 mm. and penetrates into the muscles for about the same distance, when the application is about 10° C. hotter than the skin. On heat being applied to the surface of the abdomen, at a temperature difference of 15° C. and over a broader area (one-fourth of the abdominal surface), temperature changes were observed to a depth of 75 mm., the lateral spread being 20 mm. That the rise in temperature is mainly dependent upon actual conduction of heat through the tissues, and not due to vaso-dilatation, is evidenced by the fact that the temperature attained in the tissue is considerably above that of the blood, which was recorded in all the experiments by placing a second thermo couple in some deep situation in the body some distance from the place of application of the heat.

In the present communication we desire to report further observations of the same general nature concerning (1) the effect of cold applications on the cutaneous and deep temperatures of the thigh; (2) the effect of heat and cold on the temperature of certain abdominal viscera, viz., the kidney and the liver; (3) the effect of heat and cold on the temperature of the brain. The technique was precisely the same as in the previous experiments, the duration of the period during which the applications of heat or cold were made being about one hour in practically all the observations. The same applicator was used as for muscle. It has a diameter of 33 mm.

I. Effect of Cold Applied to the Skin of the Thigh (Gluteal Region).

The effect produced on the subcutaneous temperature by local cold is very marked, and is immediately evident, as shown in Table I., in the experiments of which two thermo couples were used, one immediately under the applicator and the other at some distance from its edge. With a difference in temperature of about 20° C. between the applicator and the skin, a fall of about 13°–14° C. occurred under the applicator, and with a difference of about 23·5° C. the fall was 17 and 18·3° C. In all cases the drop in temperature was very sharp at first, taking about five minutes to reach to within 1·5° C. of the temperature ultimately attained (see Fig. 1). After removal of the cold the temperature of the skin rose at about the same rate as it had fallen.

Regarding the extent of lateral spread of the cooling, it was found that with temperature differences of from 16°–23° C. this was usually evident at any distance up to 25 mm., but not so at 30 mm. This conforms well with the results obtained for lateral spread of heat, in which case, with temperature

¹ This investigation is being conducted under the auspices of the Research Committee, Medical Services, Department of Health, Ottawa.

² Macleod, J. J. R., Self, A. R., and Taylor, N. B., THE LANCET, 1920, ii., 645.

differences of about 12° C., spreading to about 20 mm. was observed.³ the needles were placed one of them under the skin and the other in the muscles. In four observations (Table II.), in which the applicator was at a temperature of 21°-23·5° C. below that of the muscle, there was a fall of from 3·9° to 4·7° C. at a depth of 11-15

To study the depth at which the cooling penetrates,

³ Loc. cit.

TABLE I.—*Lateral Spread of Cold.*

Date of expt.	Temp. applicator.	Distance of second needle from applicator.	Temp. of skin, second needle.	Difference between temp. of applicator and skin.	Temp. reached under applicator.	Amount of fall.	Temp. reached at distance.	Amount of fall.	Remarks.
21/6/20	°C. 12·3	mm. 30	°C. 35·5	°C. 23·3	°C. 18·5	°C. 17·0	°C. 35·5	°C. 0·0	—
23/6/20	13·0	20	34·0	20·0	20·0	14·0	33·0	1·0	—
18/6/20	13·0	18	36·8	23·8	18·5	18·3	32·0	4·8	Gradual fall at distance with no recovery.
11/6/20	14·3	25	35·0	20·7	22·0	13·0	34·0	1·0	—
10/6/20	12·3	22	29·0	16·2	25·0	4·0	27·8	1·2	—
25/6/20	12·5	22	26·0	13·5	—	—	22·4	3·6	Great difference between skin temps.

TABLE II.—*Effect of Cold on Leg.*

Date of expt.	Temperature of applicator.	Temperature of muscle.	Difference between temperatures of applicator and muscle.	Temperature reached in muscle.	Fall of temperature.	Depth of thermo-couple.
12/7/20	°C. 14·0	°C. 37·5	°C. 23·5	°C. 32·8	°C. 4·7	mm. 12
13/7/20	15·0	37·6	22·6	33·5	4·1	15
16/8/20	16·4	37·5	21·1	33·5	4·0	12
17/8/20	15·7	37·9	22·2	34·0	3·9	11

TABLE III.—*Effect of Heat and Cold on Liver.*

Date.	Temp. of applicator.	Temp. of liver.	Difference between liver and applicator.	Temp. reached in liver.	Temp. in liver 10 minutes after removal of heat.	Extent of rise or fall.	Depth of—thermo couple.		Remarks.
							from skin.	from surface of liver.	
5/1/21	°C. 48·0	°C. 39·0	°C. 9·0	°C. 39·4	°C. 39·4	°C. 0·0	mm. 32	—	} Gradual rise.
6/1/21	47·5	37·7	9·8	38·2	37·8	0·4	12	—	
10/1/21	48·0	36·9	11·1	38·3	38·1	0·2	19	4	
	47·C	38·9	8·7	39·3	39·1	0·2	19	4	
11/1/21	48·0	37·4	10·6	38·0	37·9	0·1	34	2	} Gradual—needle 5 mm. from edge of applicator.
12/1/21	48·0	37·5	10·5	39·0	38·7	0·3	29	5	
13/1/21	47·9	37·8	10·1	39·0	38·6	0·4	32	12·2	} Rapid, then gradual. Very slight rise at first.
14/1/21	47·9	37·7	10·2	37·9	37·7	0·2	26	5	
28/2/21	11·5	36·65	—25·15	35·1	36·5	—1·55	18	—	—
18/3/21	20·4	36·21	—15·81	35·4	36·2	—0·8	19	—	—
15/3/21	16·2	36·90	—20·78	34·5	36·5	—2·0	19	—	—
15/3/21	16·35	37·4*	—21·05	33·65	37·4	—3·75	31	—	—
14/3/21	13·6	35·7	—22·1	34·25	35·8	—1·55	19	—	—

* Temperatures in liver and muscle gradually rising.

TABLE IV.—*Effect of Heat and Cold on Kidney.*

Date.	Temp. of applicator.	Temp. of kidney at start.	Difference temp. between kidney and applicator.	Temp. reached in kidney.	Temp. in kidney 10 minutes after removing heat.	Extent of rise or fall.	Depth of thermo-couple.	Remarks.
25/1/21	°C. 47·8	°C. 36·6	°C. 11·2	°C. 37·9	°C. 37·6	°C. 0·3	mm. 29	Rose quickly at first, then slow muscle temp. slowly rising. Gradual, muscle constant.
24/1/21	48·0	35·3	12·7	36·5	36·3	0·2	30	} Quick at first, then gradual.
21/1/21	48·2	37·3	10·9	37·9	37·9	0·0	28	
20/1/21	48·2	37·4	10·8	38·0	37·8	0·2	29	
19/1/21	48·1	37·4	10·7	37·9	37·7	0·2	21	
18/1/21	47·9	37·5	10·4	38·2	38·0	0·2	19	} Gradual from start.
17/1/21	47·8	35·7	12·1	37·2	37·1	0·1	23	
16/2/21	16·4	37·4	—21·0	36·5	37·1	—0·6	29	Slow.
21/2/21	20·5-20·15	37·75	—17·0	37·75	37·75	0·0	34	} Point of needle through kidney.
22/2/21	12·3-10·8	37·3	—25·8	36·25	37·0	—0·75	25	
23/2/21	12·0-11·75	38·1	—25·3	37·85	38·05	—0·20	27	
25/2/21	13·0	37·45	—24·45	37·0	37·10	—0·1	19	
24/2/21	12·0	36·6	—24·6	34·9	36·6	—1·7	27	

FIG. 1.

mm. from the surface. We have not as yet determined the maximal depth to which this effect, or that of heat, might penetrate.

II. Effects of Heat and Cold on Liver and Kidney.

Liver.—The thermo couple was inserted in the liver through a small skin incision along the lower border of the costal margin, the applicator being placed over the lower ribs. The exact position of the needle in the liver was determined by post-mortem examination. As might be expected from its great vascularity, the changes in temperature in this organ, for equal differences in temperature between the applicator and the body, are decidedly less than in muscle when heat is applied. This will be evident by comparison of the figures in Table III. of this paper with those of Table III. in the previous paper.⁴ In making the comparison it should be

FIG. 2.

the liver is given in Fig. 2. The effects of cold are much more marked. Although this fact is mainly due to the much greater difference between the temperatures of the applicator and body, it would appear that there is some critical temperature difference below which the cold has a progressively greater influence. This may be due to vaso-constriction.

Kidney.—Under conditions that were, in general, the same as in the case of the liver, similar results were obtained, at least for heat. Although the temperature rose more or less continuously throughout the whole period of application this was due in every case mainly to a rise in body temperature (Table IV.). Considered on this basis—i.e., comparison of final temperature reached with that ten minutes after removal of the applicator—the temperature in the kidney, at whatever depth, never

TABLE V.—The Brain: Effect of Heat and Cold.

No. or date.	Temp. of applicator	Initial temp. of brain.	Difference between temp. of applicator and brain.	Temp. reached in brain.	Temp. 5 minutes after removal of applicator.	Extent of change.	Depth of thermo-couple from surface.	Position of thermo-couple.	Remarks.
° C.	° C.	° C.	° C.	° C.	° C.	° C.	mm.		
104	42.3	37.6	4.7	38.2	37.5	0.7	17	Deep surface right crus.	—
103	44.2	36.75	7.45	37.8	36.3	1.5	13	Superficial to o-o chiasma.	—
2944	46.1	38.7	7.4	39.3	39.1	0.2	18	Deep surface of pons.	—
382	45.5 (abt.)	36.5	9.0	37.35	36.5	0.85	16	Between corp. quad.	—
11	48.0	38.4	9.6	39.5	39.0	0.5	14	Deep in left crus.	Temp. muscle rose.
1	47.9	37.0	10.9	38.5	37.6	0.9	15	Centre right o-o chiasma.	Temp. muscle rose.
11	48.3	37.4	10.9	40.1	37.6	2.5	13	Right frontal lobe.	—
1	48.25	37.8	10.45	38.6	38.2	0.4	16	Deep in pons.	—
27/1/21	48.0	38.5	9.5	39.25	38.5	0.75	15	Deep in right thalamus.	—
26/1/21	48.0	37.15	10.25	38.25	—	—	14	Left of o-o chiasma.	—
106	40.5	35.65	4.85	36.2	35.2	1.0	17	Deep in right optic thalamus.	Temp. muscle fell.
389	15.0	36.7	— 21.7	36.6	36.2	—	16	Base of brain ant. to pons.	Temp. muscle fell.
388	18.5	35.25	— 16.75	31.5	34.9	— 3.4	14	Deep surface of right crus.	—
390	18.7	37.5	— 18.8	35.2	37.5	— 2.3	13	Region of left optic thalamus.	—
393	25.5	36.1	— 10.6	34.7	38.6	— 3.9	14	In right optic thalamus.	Temp. muscle fell.
392	23.0	36.75	— 13.75	34.85	36.1	— 1.25	15	Upper surface of right crus.	Temp. muscle fell.
385	10.7	36.55	— 25.85	32.65	36.1	— 3.45	13	Base of brain near optic chiasma.	—
391	21.2	36.70	— 15.5	34.0	36.3	— 2.3	13	Lateral ventricle right side.	—
387	17.5	36.25	— 18.75	34.1	35.2	— 1.1	16	Near right corpus quadrigeminus.	Temp. muscle fell.
386	10.75	36.2	— 25.45	32.2	35.5	— 3.3	14	Tip of right frontal lobe.	—
18/2/21	29.2	36.6	— 7.4	35.85	36.2	— 0.75*	14	Lateral ventricle.	—

* Difference between initial temperature and temperature reached by applicator.

noted that the extent of temperature change is given in the present report as the difference between the final temperature reached and the temperature ten minutes after removal of the applicator.

This procedure was necessary because the body temperature became slightly changed during the hour or so of heat or cold application, whereas this was not observed to be the case, as a rule, with muscle. A typical curve of the effects of local heat on

rose more than 0.3° C., even when the applicator was 12° C. higher than the body temperature.

With cold, in which case greater differences in temperature were possible, the effect on the kidney was of the same order as for heat, but in one case it amounted to a fall of 1.7° C., as judged by comparison of the temperature ultimately reached and the recovery temperature. In all these observations the body temperature, recorded in a muscle, either kept constant or fell a small fraction of a degree.

⁴ Loc. cit.

The general conclusion drawn from these experiments is that it is not possible to cause any significant change in temperature in the liver or kidney by the local application to the surface of the body over either viscus of applicators that are about 10° – 12° C. warmer than the viscus. When the applicator is 20° – 25° C. colder than the body the fall of temperature is quite marked in the case of the liver, but usually is insignificant in the case of the kidney.

Effect of Heat and Cold Applied to the Head on the Temperature of the Brain.

In all observations on the brain the temperatures were also taken deep in the muscles of the thigh and in the majority of cases no significant change was observed to be produced on body temperature as a result of the application of heat or cold to the head. In certain cases, however, such occurred, when it was usually in the same direction as the temperature of the applicator. In practically all cases the temperature in brain and muscles bore the same relationship to each other after removal of the applicator as before. It will be observed (Table V.) that application of even moderate degrees of heat—viz., 4.7° and 4.85° C. above body temperature—caused a rise of over one-half degree at a distance of 17 mm. from the surface. With the applicator 7.4° C. warmer than the brain the temperature in the latter rose through 1.5° C. at a depth of 13 mm. and through 0.2° C. at 18 mm. The remaining observations in the table show a satisfactory correspondence between the depth of the thermo couple in the brain and the extent to which the temperature rose. It may be concluded that heat penetrates from the surface into the brain much more than it does in the case of the liver or kidney, although apparently not so much so as into muscle. The changes in temperature are also very prompt both at the beginning and end of the period of application, as is shown in the curve (Fig. 3). In this regard also the results are decidedly

FIG. 3.

Cold application over A. Temperatures: A, in brain 14 mm. from skull surface; B, in hip 18 mm. deep.

different from those obtained in the liver and kidney.

The result following cold applications are comparable with those following heat, thus, with temperature differences of 7.4° C. and 10.6° C. the brain cooled 0.75° C. and 1.4° C., respectively, at a depth of 14 mm. Sometimes these effects were still more pronounced (e.g., Exp. No. 393). When lower temperatures were used the fall in brain temperature became very marked indeed; thus it fell through 3.3° and 3.45° C. at a depth of about 14 mm., when the applicator was at a temperature of about 25° C. below that of the body. A knowledge of this fact must be of importance therapeutically. The temperature changes were as prompt as when heat was applied.

AN ANOMALOUS RESPONSE TO DIRECT FARADIC STIMULATION OF A NERVE

AT RE-EXPLORATORY OPERATIONS.

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DURING the past two or three years re-exploratory operations have been performed upon a number of patients suffering from injury to peripheral nerves, because no satisfactory recovery of function has followed the primary surgical procedure of end-to-end suture or the insertion of a nerve-graft. The results of these examinations of the site of the original operation and the histological investigation of pieces of nerve excised, where re-suture is found to be necessary, are likely to furnish us with very valuable information about regeneration and the factors which may influence the normal development of new conducting channels.

At the re-exploratory procedures a number of surgeons have been surprised to find that on direct faradic stimulation of the nerve trunk a response has been obtained in muscles supplied by the nerve below the lesion, although no voluntary power had ever been detected or any faradic response elicited in the muscles at numerous clinical examinations of the patient immediately preceding the second operation. Several attempts have been made to explain the occurrence of this astonishing and somewhat misleading phenomenon, but so far as I am aware no very satisfactory evidence has been advanced to support the theories suggested for its causation.

An opportunity recently presented itself to me of studying a patient exhibiting this phenomenon, and the conditions found presented a possible explanation, for which further support was subsequently found in a second patient. Since this unusual occurrence of a response in certain muscles on direct faradic stimulation of the nerve trunk may lead to errors in treatment and prognosis, it seems wise to place my findings on record without further delay, in order to see if the experience of others in the future may support or disprove the explanation put forward in this paper.

Private J. H. received a gunshot wound of the left forearm on Sept. 9th, 1916, and this injury was followed immediately by complete loss of conduction in the ulnar nerve. Since no recovery occurred after the wound had healed soundly the nerve was explored on April 4th, 1917, by Mr. H. Platt, who found complete division of the nerve trunk and a gap of 1 inch on resecting the ends. As the manoeuvre of displacement of the ulnar nerve in front of the internal condyle of the humerus had not then become a routine procedure in cases where an extensive defect was encountered, it was decided to insert a graft from the radial nerve.

The patient was under observation after operation for a period of nearly two years, when he was boarded out of the army and left the district; up to that time there was no clinical evidence of any conduction through the graft, and the condition of this patient up to that point was included in a recent paper in *THE LANCET*.¹ He reported at hospital again in December, 1920 (44 months after the insertion of the graft), when there was paralysis, accompanied by wasting and loss of faradic response, of all the intrinsic muscles of the hand supplied by the ulnar.

Being away at the time I did not get an opportunity of making a personal examination until after the performance of the second operation. In view of the above findings he was admitted to the Grangethorpe Hospital and Mr. Platt re-explored the ulnar nerve in the region of the previous operation on Dec. 18th, 1920. Mr. Platt has very kindly furnished me with the following report of the operation: "The ulnar nerve was exposed widely in the forearm through a long incision and the nerve traced up from the wrist to the site of the previous operation. The distal part of the nerve was well-developed but seen to expand slightly as the graft was approached. Faradic stimulation of the distal part caused a definite response in part of the flexor brevis pollicis, in the adductor pollicis, and abductor minimi

¹ Stopford, J. S. B.: The Treatment of Large Defects in Peripheral Nerve Injuries, *THE LANCET*, 1920, ii., 1296.