from the fact that a more thorough irradiation of the mediastinum is obtained there is no risk of necrosis of cartilage or bone, which may occur even with needles of low content buried in the near vicinity of these tissues. Heavy filtration is necessary—2 mm. of lead or its equivalent should be employed. Large doses must be given at a minimum distance of 15 mm. from the skin surface.

External application of radium has been discouraged as unsuccessful mainly by those who have not had sufficient quantities at their disposal, for inadequate doses of radium have been responsible for many so-called failures. External irradiation, however, has a very definite place in radium therapy, although it must be remembered that the skin is very sensitive and is easily damaged by rays which are insufficiently screened. In this country Mr. Stanford Cade has shown that the skin can be subjected to enormous doses in the "collar treatment" of secondary cervical glands by using heavily screened radium applied to a mould of "Columbia wax." The superficial layers of the skin peel off, but the skin heals rapidly, leaving a soft pigmented scarred surface, but no contraction. This effect on the skin must be caused by the continuous gamma radiation, which has this effect only when employed for long periods.

Pre- and Post-operative Radium Therapy.

This is still a matter for a great deal of investigation. It has been impossible to form any opinion as to its value from the study of cases treated at the Radium Institute, but there are reasons for supposing that many recurrences might be prevented if pre- and post-operative irradiation were more often employed. Statistics have been published to show that in patients who have had pre- and post-operative irradiation the outlook is better than in cases treated by surgical means alone. It has been erroneously stated that pre-operative radium treatment causes delay in healing, and affects the tissues in such a way as to make operation more difficult. Microscopical sections of irradiated tumours tend to show that it is unnecessary to postpone subsequent operation for more than a fortnight.

There is no doubt that recurrences appearing after prophylactic irradiation are very refractory to further irradiation. Similarly it is found that a second treatment of any neoplasm is less effective than the primary treatment. For this reason the first treatment should always be as thorough and vigorous as possible. If a second treatment is necessary the dose must be relatively smaller.

LITERATURE.

- Pinch: *Clinical Index of Treatment*.
Cade: Cancer of Tongue. *Brit. Journ. of Surgery*, vol. xv, No. 57, 1927.
Handley: Discussion on the Relative Values of Surgery and Radiation in Cancer of the Breast. British Empire Cancer Conference, 1928.
Keynes: Radium Treatment of Primary Carcinoma of the Breast. *Lancet*, July 21st, 1928.
Ministry of Health Reports, No. 51.

THE EFFECTS OF ANAESTHESIA, OPERATION, AND CERTAIN OTHER FACTORS ON GLYCAEMIA.

A PRELIMINARY INVESTIGATION.

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THE administration of glucose is an accepted procedure in the treatment of post-operative shock. The value of this treatment is now questioned, since it has been reported that hyperglycaemia occurs after operation. This investigation was undertaken to determine the effect upon the blood sugar of a surgical operation carried out under routine conditions, and to ascertain the factors which influenced any changes observed. The action of the administration of rectal and subcutaneous glucose salines was studied.

Investigation Carried Out.

Observations were made on patients who had been admitted to the wards and who all had the routine preparation, except in those cases admitted as emergencies for immediate operation. The last meal was on the evening

before operation, but the patient received a cup of tea early the next morning. Purging of the patient was restricted to a small dose of castor oil on the day previous to, and an enema on, the morning of operation.

In most cases the blood sugar was estimated before operation, and on many occasions after the commencement of the operation. In several cases the blood sugar was estimated again some days after operation under conditions similar to those which obtained on the day of operation, but, of course, without the mental strain which operation entails. In addition to the investigation of the blood sugar, patients have had a record of the pulse rate taken at corresponding intervals of time, and these readings have been graphed along with the blood sugar curve. In all cases we have noted: (1) The history of the illness, attention being especially directed to any points which might be suggestive of sepsis or of diabetes. (2) The general condition of the patient, especially any degree of shock or constitutional disturbance. (3) The nature and duration of the anaesthetic, together with the time and dose of any drugs administered.

Method.

Samples of venous blood were taken from the patients at various times. The estimations of the blood sugar were made by means of the Benedict picric method,¹ which allows of some delay between the obtaining of the sample and the carrying out of the estimation. The estimations which involved the comparison of fine degrees of colour were undertaken by one of us (E. M.) to avoid possible individual variation. Seventy-seven cases have been investigated and have been analysed.

Pre-operative Level of the Blood Sugar.

The average level of the blood sugar in a fasting healthy adult when estimated by this method is 120 mg. per cent.² In all our cases we examined the blood sugar before operation to enable us to establish a standard for each patient, and we found that the pre-operative level of the blood sugar varied considerably. The highest level which we have observed has been 227 mg. per cent., while the lowest level in our series was 84 mg. per cent.; the average reading obtained from the 73 cases analysed was found to be 124.3 mg. per cent. According to Pierce and Scott,³ who used MacLean's method of blood sugar estimation, the normal level of the blood sugar in a healthy adult lies between 95 and 99 mg. per cent. In view of these figures and the figures of Levi⁴ and Miss Potter⁵ (to which reference will subsequently be made), it seems to be a fair conclusion that there is a phase of hyperglycaemia before operation. An analysis of our cases suggests that the condition from which the patient was suffering had a considerable influence upon the level of the blood sugar.

We made a special analysis of those cases where the pre-operative level of the blood sugar was above the recognized maximum in normal people (160 mg. per cent.).⁶ We found that out of the 57 cases operated on under general anaesthesia 13 were above this high level of glycaemia, and averaged 184 mg. per cent. Of these 13 cases 9 were admitted as emergency cases—3 being duodenal perforations and 4 acute appendicitis.

The effect of various conditions is also borne out by Table I. We conclude that three factors are demonstrated

TABLE I.—*Pre-operative Blood Sugar in Various Conditions.*

Condition.	Cases.	Average Pre-operative Blood Sugar.
		mg. per cent.
Hernia and hydrocele	9	114.1
Acute appendicitis localized—that is, acute infection	12	137.0
Shock: fractured femur (2), concussion, strangulated hernia	4	160.5
General peritoneal infection: perforated duodenal ulcer (4), appendicitis	5	185.4
Various cases in which there was a well-marked focus of chronic sepsis	7	114.4
Various cases in which no obvious sepsis was noted	17	122.3

to bear influence on the glycaemia: (1) acute infection, (2) surgical shock, (3) peritoneal irritation. Nervousness is a factor in pre-operative hyperglycaemia, since such

operations as those for hernia and hydrocele, which we have found to be unassociated with pre-operative apprehension by the patients, have not a high blood sugar content.

Variation in Blood Sugar during Operation under General Anaesthesia.

Ethyl chloride, chloroform, and ether were the anaesthetics employed during routine operations. In only a few of our cases did the patients have an all-chloroform or all-ether anaesthesia. We have considered all these cases together because the reaction observed does not appear to depend on which of the above drugs was used. Fifty-seven cases were given a general anaesthetic, and had blood sugar curves prepared which show the relationship between the pre- and post-operative levels. Of these, 48 showed a rise in the blood sugar content, while 9 showed a fall. Over the whole of this series of cases the average rise in the blood sugar content as compared with the pre-operative

FIG. 1.—Graph illustrating blood sugar curve in patient operated on under general anaesthesia. Note similarity between pulse rate and blood sugar curves.

level was 44.96 mg. per cent., the greatest increase observed being 165 mg. per cent. and the greatest decrease 39 mg. per cent.

The observations showed that in the majority of the cases the reading of the blood sugar at the end of the operation and the administration of the anaesthetic was the highest obtained. The subsequent estimations approximated more closely to the pre-operative level. In no case, however, did we find any evidence of a period of hypoglycaemia, although we made systematic observations up to eight hours after the operation, and in some cases over a longer period—up to thirty-six hours. Investigations after eight hours, however, were considered to be vitiated by the number of complicating factors—for example, food, sedatives, restlessness, etc. Fig. 1 illustrates the type of curve obtained.

Post-operative Glycaemia.

In order to enable us to form an opinion of the post-operative variations of the blood sugar content, we com-

FIG. 2.—Composite graph. Points represent average of readings taken each hour. Dotted line indicates probable course of blood sugar—cf. Fig. 1.

pared the accompanying composite graph (Fig. 2), since it is apparent that specimens of blood cannot be withdrawn from patients after surgical operations with the frequency

and regularity which strict scientific investigation of this problem requires. The points on the graph represent the average of the readings taken at certain periods after operation. Thus, in 16 cases the average reading of the blood sugar one hour after operation was 28 mg. over the pre-operative level, while in 17 cases the average reading two hours after operation was 23 mg. over this level. For the first three hours of the post-operative period the points gave a regular curve, but thereafter the figures showed some variation. We believe this to be due to (1) the fewer readings on which the graph at these points was based, (2) the increasing number of factors which altered the condition of the patient. We suggest, however, that the dotted curve indicates the course which the blood sugar will follow after an operation under general anaesthesia in the average case.

Relationship between Duration of Anaesthesia and Hyperglycaemia.

We have found evidence that there is a relationship between the absolute rise of the blood sugar and the duration of the anaesthesia. Table II shows the figures

TABLE II.—Relationship of Duration of Anaesthesia to the Rise of the Blood Sugar Content.

Duration of Anaesthesia.	Rise in Blood Sugar (mg. %).	No. of Cases.
Up to 30 minutes ...	27	12
30-45 minutes ...	41	23
45-60 " ...	62	13
60-75 " ...	58	10
90 minutes ...	(38)	(1)
110 " ...	(47)	(1)

obtained from a series of 58 of our cases, and suggests that the more prolonged the anaesthesia the greater will be the increase of the post-operative over the pre-operative reading. Twelve cases have been investigated with a view to

FIG. 3.—Graph illustrating progressive rise in blood sugar during anaesthesia and operation.

ascertaining the changes which occur during the operation, and have nearly all shown a progressive rise in the blood sugar content. It has been noted in one or two cases where the anaesthetic had been administered for some time before the actual operation started that the rise in this period was very similar to the rise in the second period during which the operation was being actually performed. One typical graph to illustrate these points is given (Fig. 3). We did not find that the post-operative duration of the hyperglycaemia depended on the duration of the anaesthesia.

The Duration of the Hyperglycaemia.—The question of the severity of the operation and the duration of the anaesthesia with their relation to the blood sugar curve was brought specially into prominence by the statement of Levi¹ that the duration of the period of hyperglycaemia depends on these factors. We cannot confirm this statement. In our series of cases we found eight cases in which the hyperglycaemia was sustained for a longer period than our composite graph showed to be normal, but we have failed to find any common causal factor. The operations included severe surgical intervention such as amputation

of the breast and gastro-enterostomy, and also simpler operations like appendicectomy and herniotomy. We further investigated the question of the absolute rise in the glycaemia in association with the severity of the operation. We were unable to find any difference in the average levels of the hyperglycaemia in the cases of the more severe operations and those less severe, always provided that the operations were of approximately the same average duration.

Hyperglycaemia after Abdominal Operations.—We found that there was a greater rise in the blood sugar content after those operations where the peritoneum had been irritated than in those cases in which the peritoneum had not. Table III shows this fact.

TABLE III.—Relationship between the Degree of Hyperglycaemia and the Type of Operation.

Type of Operation.	Average Duration. (minutes).	Rise in Blood Sugar (mg. %).	No. of Cases.
Abdominal...	46	50.3	38
Extra-abdominal ...	54	39.35	17

Pulse Rate and Glycaemia.—We have been struck by the fact that the blood sugar curve and the pulse rate curve are very similar. This has held true not only for what we have come to regard as normal curves, but even where the curves were atypical. (See Figs. 1 and 4.)

Fall in Blood Sugar During Operation.—In 9 cases (15.8 per cent.) of the 57 cases analysed we observed a fall in the blood sugar content during operation instead of the usual rise. We believe that such a fall is associated in most cases with a high pre-operative level in the blood sugar content. It is to be noted that 6 of the 9 patients showing a fall in the blood sugar after operation are in the group of 13 cases with high pre-operative blood sugar levels (over 160) to which reference has already been made.

Cases Operated on with Spinal Anaesthesia.

Observations were made on 6 cases in which spinal anaesthesia was employed. We found the changes in the blood sugar content were not in conformity with those in which the patient had a general anaesthesia for operations of the same duration of time. The method of producing spinal anaesthesia was as follows: One hour before operation preliminary narcosis in the form of "twilight sleep" was induced by giving 1/4 grain of morphine and 1/100 grain of hyoscine. In one case where there was much excitement a further dose of 1/6 grain of morphine and

1/200 grain of hyoscine was given a quarter of an hour before operation. The spinal injection consisted of tropacocaine 0.075 gram in 3 cases, stovaine 1 c.cm. of 10 per cent. solution in 3 cases.

The degree of glycaemia was estimated just before the administration of the narcotic and at varying periods thereafter. Table IV shows the results obtained. From the readings it will be observed that there was a rise of the blood sugar during the operation in 4 cases and a fall in 2 cases—the average being a rise of 13.8 mg. per cent. This figure is very considerably lower than the corresponding one for operations performed under general anaesthesia. (Fig. 4.)

FIG. 4.—Graph illustrating effects of spinal anaesthesia.

Effect of Morphine and Hyoscine given before Operation.

The effect of hyoscine and morphine is also shown in Table IV. In 5 of these cases there was an average rise of 9 mg. per cent. In one case (No. 2) there was a distinct fall in the blood sugar, but we noted in this case that a very considerable degree of nervousness was allayed by the administration of the narcotic. We have also investigated the effect of morphine (1/6 grain) given before a general anaesthetic, and we have found an average rise of 19 mg. per cent. within one and a half hours. We would, however, point out that this small dose of morphine is not sufficient to control the excitement which is initially present and which is increased by the taking of the patient to the theatre, where the second sample has invariably been taken. The action of morphine is twofold; it is generally accepted that it raises the blood sugar, but we believe that in so far as it allays nervousness it may cause a lowering of the blood sugar.

Administration of Glucose after Operation.

In our series of cases we have had 6 patients in whom the post-operative shock was sufficiently severe to call for the administration of a subcutaneous glucose saline, which has been our previous routine treatment, 500 to 900 c.cm. of 6 per cent. glucose being given. We have been interested to note that the blood sugar, just before the administration of this glucose, in 2 cases was over 200 mg. per cent., while the average level was 174 mg. per cent. in the 6 cases. In another case glucose was given subcutaneously during operation, and at the end of the operation the blood sugar stood at 224 mg. per cent., but the patient was so shocked that an immediate blood transfusion was ordered. There is no doubt that glucose administered subcutaneously causes a rise in the blood sugar content; the average blood sugar content rose in our cases within one and a half hours by 68 mg. per cent.

Glucose enemata, which were given both as a routine measure in cases where stomach operations had been carried out and as the treatment for minor degrees of shock, gave much more variable results. We found that in a series of 7 cases the blood sugar level before giving the first rectal glucose was high (average 153 mg. per cent.). The readings after administration of enemata varied; in 4 cases there was a distinct rise, in 4 cases a distinct fall, and in one case little change. The highest increase observed was 33 mg., while the greatest decrease noted was 49 mg.

Levi⁴ has reported 10 cases in which he has investigated the blood sugar after operation. In all of these cases there has been noted a rise in the level of the sugar content,

TABLE IV.—Blood Sugar Changes in Cases of Spinal Anaesthesia.

No. of Case and Nature.	Blood Sugar before Narcotic Injection.	Blood Sugar after Narcotic before Injection of Spinal Anesthetic.	Blood Sugar after Spinal Anaesthetic before Operation.	Blood Sugar after Operation.	Subsequent Blood Sugar Estimation.	Rise of Blood Sugar during Operation only.
2. Excision of rectum*	170	120	125	175	—	mg. 40
21. Inguinal hernia ...	134	133	129	146	144	17
46. Hernia† ...	92	—	87	129	127 111 100	40
56. Amputation of leg	85	96	—	80	100	-16
53. Diabetic gangrene amputation†	83	103	—	116	—	13
59. Tuberculous knee; amputation through thigh	100	119	—	108	140	-11

* Patient shocked; given subcutaneous salines; was very nervous before operation.

† This patient was given a double dose of narcotics.

‡ Patient received post-operative treatment with glucose and insulin.

and he has found that the maximum rise occurs in the first reading taken after the operation, after which there is a gradual fall. Some of his samples were taken as long as forty-eight or seventy-two hours after the operation. In this series of cases the average pre-operative level was 133.4 mg. per cent., and the average rise in the reading, in the seven cases investigated, within half an hour of the completion of the operation was 29 mg. per cent.

Levi states that the duration of the rise depended on the duration of the anaesthetic and the severity of the operation. In our opinion there is not sufficient regard paid by this investigator to the effect of post-operative treatment as affecting the figures on which he bases these conclusions, and our own observations do not confirm them.

D. Potter,⁵ working in the gynaecological wards in Edinburgh Royal Infirmary on the chemical changes in the blood following on operation, showed that there was a distinct rise in the blood sugar content. The average initial reading which she obtained was 125.3 mg. per cent. (but it should be noted that these cases all received a small dose of morphine before the blood sample was taken), while the average rise in the sugar content was 35.3 mg. per cent. D. Potter comes to the conclusion that the hyperglycaemia is more dependent on the ether administered than on the excitement or asphyxia due to the operation.

Mackay⁷ has recently made two communications on this subject. He groups his cases according to whether the anaesthesia was of thirty or sixty minutes' minimum duration. The average figures which he obtained are quoted, since they show close similarity to our own results. In twenty cases with shorter anaesthesia the average pre-operative reading was 106 mg. per cent., and the average rise at the end of the operation 43 mg. per cent. In the group with longer anaesthesia the corresponding figures were 112 mg. and 104 mg. per cent.

Clinical Application.

We desire to draw attention to two indications in the treatment of cases which result from our investigations:

1. In the preparation of a patient for operation nervousness should be allayed. We have not sufficient data on which to found definite rules, but sedatives seem to be indicated.

2. The post-operative phase is accompanied by a raised blood sugar content, and therefore there is no necessity for the administration of glucose.

Conclusions.

1. Four factors at least predispose to a high pre-operative level of the blood sugar—namely, acute infection, peritoneal irritation, shock, and nervousness.

2. Following operations under general anaesthesia there is usually an increase in the blood sugar content, but there is never a hypoglycaemia.

3. The maximum rise is seen immediately after operation, and from this point there is a fall to the pre-operative level, which is approximately reached in eight hours.

4. There is a close relationship between the absolute rise of the blood sugar and the duration of the anaesthesia.

5. In cases of post-operative shock the blood sugar content is high.

6. In spinal anaesthesia there is evidence of only a small rise in the blood sugar content.

7. Absorption from rectal glucose salines does not lead to any constant change in the blood sugar readings.

We have to acknowledge our indebtedness to Professor John Fraser and Mr. George Chiene for permission to carry out this investigation of their cases, and to Professor Murray Lyon, in whose laboratory the chemical estimations were made. The expenses for this study were borne by a grant from the Moray Fund.

REFERENCES.

- ¹ Benedict, S.: *Journ. Biol. Chem.*, 34, 203, 1918. ² Murray Lyon, D.: Personal Communication. ³ Pierce and Scott: *Arch. Int. Med.*, 41, 586, April, 1918. ⁴ Levi, D.: *Brit. Journ. Surg.*, xv, 58, 284. ⁵ Potter, D.: *Quart. Journ. Med.*, xviii, 71, 261. ⁶ Gray, H.: *Arch. Int. Med.*, 31, 241, February, 1923. ⁷ Mackay, R. L.: *Brit. Med. Journ.*, 1928, i, 893; *Brit. Journ. Anaesth.*, 1, 15.

Memoranda:

MEDICAL, SURGICAL, OBSTETRICAL.

PRESSURE NEURITIS OF THE DEEP PALMAR BRANCH OF THE ULNAR NERVE.

I WAS most interested in reading, in the *Journal* of January 19th (p. 98), Dr. Wilfred Harris's communication under the above heading and his account of two cases, since during the past two years I have met with no fewer than four similar cases. Also, as with Dr. Harris, I was unable to find an adequate description of the condition in the literature of nerve injuries or neuritis. In two of my cases the exciting cause was fairly obvious—both were young men and keen motor cyclists. In both cases the right hand was affected, and, as with one of Dr. Harris's cases, the undue pressure had been brought about by gripping the handle-bar termination too tightly in the effort to control vibration. In the two other cases—one a lady aged 63 (right hand) and the other a medical man aged 57 (left hand)—it was difficult to determine with certainty the exciting cause. At the same time, the lesion, of sudden onset, was so clearly limited to the deep branch of the ulnar nerve that it was scarcely possible to imagine a cause other than trauma by pressure—especially after one had seen the two previous cases. The paralysis was limited entirely to abduction and adduction of the three outer fingers, adduction of the little finger, and adduction of the thumb. There was no loss of sensation in the ulnar area, while abduction and opposition of the thumb and little finger were unaffected. In the first case pressure might have been caused by the use of a garden trowel, and in the second by holding too tightly the handle-bar cork of an ordinary bicycle. Although the pressure was applied intermittently over a long period, the actual onset of the paresis was sudden in all four cases, occurring during the course of the night or one evening.

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CEREBRAL ANGIOSPASM.

I RECENTLY had under my care an interesting case of fugitive paralysis of the arm, presumably due to spasm of a cerebral arteriole. Since I find very little on the subject in the textbooks, or in contemporary medical literature, I venture to place it on record.

My patient was a medical practitioner, aged 71, of fairly good general health and careful dietetic habits. There was no history of syphilis. The blood pressure before the attack was 170 mm. maximum, 90 mm. minimum. At the termination of a two months' holiday in Europe, during which he may have eaten a little more than his usual restricted dietary, he was gathering figs with the head thrown back at an acute angle. He suddenly became aware that he had lost all movement in the left arm from the shoulder down to the fingers. He said he felt a little "funny" on the right side of his head when this happened, but neither the tongue nor the corresponding leg was affected. Movement began to return in the hand in the course of a quarter of an hour, and the paralysis had quite cleared up an hour or so later, leaving only a large anaesthetic patch over the deltoid muscle. This persisted for ten days or so, when it also cleared up, but an area of dysaesthesia (numbness and tingling) appeared on the left side of the occipital region. Six weeks later no trace remained. The patient mentioned that he had been suffering from precordial pain and, more recently, shortness of breath on effort, especially after eating. For the last six years he had noticed an intermittent limp on both sides, pointing to partial obstruction of the tibial arteries. The heart sounds were normal. There was nothing abnormal in the urine.

For several years past he has from time to time had scotomata in one or other eye. Sometimes the area obliterated was so extensive as to amount to blindness in one eye, but more often it was merely a large black or greyish patch in the field of vision. This lasted from a few minutes to half an hour, and then gradually cleared up; nothing abnormal was seen between whiles with the ophthalmoscope. This occurred mostly when travelling—that is to say, when his digestive organs had not had fair play owing to changes in his habits of life. This ephemeral occurrence was also no doubt due to spasm of a retinal arteriole.

O. K. Williamson¹ has recorded three cases of transient hemiplegia in elderly subjects, which he attributes to arterial spasm not lasting long enough to cause necrosis of

¹ *Journal of the Medical Association of South Africa*, May 26th, 1928.