experimentally to exist between the first two factors. Rose Bradford demonstrated that a diminution in the amount of kidney substance led to an increase in the urine production by the remaining tissue, and it can be shown in the case of the isolated kidney of the dog that functional removal of a part of the kidney leads to an increased flow of urine from the remainder, and that this increase in urine flow is accompanied by just those changes in composition which occur when the perfusion pressure to the kidney is raised. A diminution in the anatomical reserves of the kidney is thus partially or completely compensated by an encroachment upon the functional reserves, in that the pressure stimulus to secretion becomes more effective, and polyuria of varying intensity results. This is of interest, since the excretion of urea and of substances eliminated by a similar mechanism is dependent mainly upon the amount of kidney substance, that of chloride mainly upon the rate of urine flow.

We may, then, recognize theoretically three main types of renal failure corresponding to the primary involvement of one of the reserve factors indicated above. That type, resulting from a severe diminution in the number of renal units, would be expected to be the most serious, since the disturbance could be rectified only by profuse regenerative changes. Renal failure resulting from a fall in the magnitude of the pressure stimulus or in the tone of the secretory units might well be of temporary duration and susceptible to therapeutic intervention. Is it possible that the primary involvement of each of these theoretical factors in the decrement of renal reserve has its clinical and pathological counterpart in polyuria with cirrhosis of the kidney, in oedema with parenchymatous nephritis, and in nephritis associated with toxæmia?

The three factors mentioned are possibly indissolubly involved in any given case of renal impairment, but their recognition may indicate the principles upon which any test of renal function should be based and the limitations to which its interpretation should subscribe. Since our present knowledge of the physiology of urine secretion suggests that the most important factors upon which the successful mobilization of the reserve of the kidney would seem to depend are the number of renal units and the pressure stimulus to secretion, a systematic investigation of the effects of some substances which, in the normal kidney, increase this number and pressure, might reasonably be supposed to give some indication of the magnitude of these reserves. Caffeine is such a substance. It was shown by Richards and his colleagues that this drug increased the number of active glomeruli in the frog's kidney, and it can be shown in the case of the isolated kidney of the dog that the increased flow of urine is explicable in terms of an increased effectiveness of the pressure stimulus. These facts suggest that the systematic employment of this drug under controlled conditions in nephritis might throw some light on the capacity of the kidney to perform extra work. A large response would point to a correspondingly large functional reserve, a small response to a small current reserve, which might or might not increase with the lapse of time. It will be of great interest to hear the experiences of members of this Association in the use of this drug, and their views as to the significance of the results obtained.

With regard to the employment of substances eliminated by the kidney as a test of renal function, it would seem that the surest indication would be given by the results of the administration of urea or other bodies eliminated by a similar mechanism, such as phenol red. And in this connexion it would seem advisable to take the amount eliminated over a given period of time at any given concentration of the substance in the blood plasma compared with that eliminated under similar conditions by the normal kidney as an index of the current reserves of the kidney. But the practical application of the present state of our knowledge of renal function and renal adaptation to the evolution of methods of assessment of renal reserve is fraught with difficulty, and it should prove most instructive to hear from those who are interested in this problem which tests they employ and the interpretation they are inclined to place on the results obtained.

RADIUM TELETHERAPY: CLINICAL EXPERIENCE WITH A TEMPORARY "BOMB."*

BY

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AND

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WHEN it became possible to employ a gram of radium as one unit, at a distance from the skin of 10 cm., the staff of the Westminster Hospital (to nine of whom we tender thanks for permission to use their notes and cases) had already constant personal familiarity with interstitial and surface methods. This practical experience had taught, or driven home, lessons others had learned. First and foremost was the paramount importance of screenage; but there were also the capabilities of small total doses; the difficulty of gauging sensitivity, or regulating doses, by histological appearances; the diversity between immediate response, especially of primary growths, and ultimate prognosis; the difference in the response of glandular metastases from tumours themselves not very dissimilar in their response at the primary site; the want of a reliable means of increasing, differentially, the sensitivity of cancer cells, or of influencing their metabolism; the conviction that cure of disseminated cancer must probably not be looked for from focal irradiation.

Whilst, on the one hand, it was learned that a patient with advanced fixed fungating cancers of both breasts and extensive glandular metastases, seemingly near her end, might resume what appeared to be radiant health; on the other hand, a patient with a rapidly advancing cancer of the vulva and vagina, in the moment of satisfactory success as to her "growth," might die—of what? The necropsy supplied no answer, and the rest is speculation. It was found, as others had found before us, that anaemia was an inconstant factor, often amenable to control by administration of liver; that irradiation of the liver was accompanied by severe disturbance in the gastro-intestinal tract, and disorder of its own functions. As to the skin, it was known that, with exceptions, it was possible to steer clear of lasting injury, and that warnings, generally speaking, are timely. So far as it already burdens the lymphatic vessels and glands in relation to a growth, sepsis is a grave menace to success. Neuritis in the presence of sepsis about a nerve trunk, or actual invasion of the sheath by growth, is to be feared even with well-screened radium; and particularly in the case of the mouth and jaw.

On commencing work with a provisional teletherapy apparatus, it was not entirely an advance into an unexplored field—partly because others had been there long before us, partly because interstitial methods inevitably involve irradiation of the tissues surrounding the mass in which needles were implanted, and at least no obvious harm has come, in our cases, from screened rays reaching the tissues of and round the uterus and rectum, the colon, the breast, the cervical glands, and other parts. In teletherapy, however, unless very narrow beams can be directed with great accuracy on a growth, important structures, such as the heart, the spleen, the liver, the ovaries, the bone marrow, the thyroid, the thymus, and so on, must at times be irradiated. Always there must be a considerable intensity, and a considerable dose, of irradiation upon subcutaneous and more important intervening tissues. In cases treated by teletherapy the element of infective oedema is generally absent, but in local extensions the lymphatics are often blocked, and it is to reach infiltrating extensions, as well as primary growths difficult of access, or visceral metastases, that the method lends itself.

As to the difficulty of obtaining a valid intensity at the depths required for visceral growths, a preliminary physical inquiry could start from the observation that when certain growths were needed, notwithstanding an irradiation

* Sequel to the article by Francis Rock Carling, B.Sc., published in the *British Medical Journal*, May 11th, 1929, p. 845.

inadequate from the physical point of view as to homogeneity, yet the whole tumour would disappear. Clearly, then, a dose and an intensity inferior to that aimed at and striven for must sometimes be effective. Why? Because the dose needed had been overestimated? because the secondary radiations were more potent than had been believed? because an effective alteration of the metabolism of the great mass of the growth could effect, in the same sense, the adjacent imperfectly changed cells? or because the healthy cells surrounding were no longer overwhelmed into defencelessness? or because of reasons too fanciful to put to paper?

It is true that Regaud, Failla, Sluys, and Cheval have employed very large amounts of radium in their bombs, but Forsell, Malet, Perussia, and others use amounts of less than the gram we had available. To lock up one gram of radium (to say nothing of three or four) in an apparatus, even one giving a twenty-four hours' service, requires some justification. It is very satisfactory, with needles and seeds, to see a primary growth disappear, and to be able sometimes to banish signs of glandular implication. Many patients are thus rid of an intolerable discomfort or disability, or of evidence, such as a discharge or a lump, that affects their minds; but while the patient may thus be spared suffering and anxiety, the surgeon is not freed from gloomy forebodings, and constantly meets severe disappointment. Patient after patient, free from the primary lesion, comes back with visceral metastases, perhaps with fresh evidence in the lymphatic glands, occasionally with recurrence in, or immediately adjacent to, the primary site. Either the dose was insufficient in intensity or in extent, or lacking in homogeneity, or too short in duration, or too intense, or too long, or the spacing of the exposures was wrongly timed. Inevitably the need arises for some means of reaching the visceral deposits; of covering a whole lymphatic field uniformly; as well as some other means of dealing primarily with growths from the outset unsuitable for needling.

The teletherapy apparatus in a general hospital is a means of treating patients, and only in a secondary sense a method of investigation of the powers of radium so applied.

It is difficult to make selection of a particular type of growth or of particular stages in its progress; it is not possible to restrict treatment to teletherapy alone; men and women present themselves for relief in the hope of cure, often when their vital powers are already grossly impaired, and hitherto none have been rejected who were not obviously dying. The patients so far treated have been those with growths that do not lend themselves to any other form of radium application; those with growths which clearly need something in addition to interstitial, cavitary, or surface treatment; those with growths which by their volume and extent preclude homogeneous irradiation by local methods; and those who, having been treated surgically, receive prophylactic irradiation. The great majority of the patients would be classed as hopeless, and a number were already within sight of the grave.

It is difficult to envisage radiation as "curing" cancer in any other manner than through normal physiological processes of defence or repair, rejuvenation, or restitution. Radium might be employed merely to necrose the malignant cells, but the cautery, escharotics, coagulation, or the knife are cheaper, safer, and less uncertain. The energy from screened radium supplying all but pure gamma rays is actually very small in quantity, and of that more reaches the normal tissues than the growth, except in very favourable anatomical circumstances. Can we believe that all the benefit is derived from action on the cancer cell? Is not a part due to beneficial action on cells of the invaded tissues—if not on more distant units? The work of Dominici as far back as 1909 already suggested that that might be the case.

Perhaps, then, the energy received by the tissues surrounding a growth, when the cone or cones of rays from a "bomb" cannot be accurately adapted to the exact contour of the tumour, far from being wasted, may prove of great value.

Our notions of dosage, though based upon experience with interstitial and surface work, have been purely

empirical. Forsell and others have discovered certain general truths—as, for example, that "a certain minimum of absorbed irradiation in a given time is necessary to secure healing of a given type of tumour," but it is as yet far from easy to measure the amount absorbed; that certain maxima must not be exceeded if the whole organism is not to be damaged; that, other things being equal, the dose should be as concentrated, as to time, as may be, to minimize the duration of exposure to metastasis; and that an interval should not be so long as to give opportunity for the malignant process to re-establish itself. It is difficult, however, to translate these principles into figures. In the first place it was necessary to ascertain what dose the skin would stand with impunity in the conditions—a gram of radium at 10 cm. distance—so that the dose possible through one port of entry might be known. So far 50 gram hours have resulted at the worst in a slight pigmentation of the skin with a trifling alteration of texture; though the parts do not pit, the skin has lost a little suppleness as if slightly swollen. The brownness does not persist more than a week or two, and no loss, even of epidermis, has resulted. With, say, four ports of entry then 200 gram hours may be given without danger; but in the circumstances of our present use of the bomb it is rarely possible to give more than four hours a day, and this means a month's treatment, for ordinarily the radium staff are deliberately excluded from the premises on Sundays. Clinical experience quickly showed that the dose possible, under the conditions concerned, for deeply seated small tumours, such as a carcinoma of the oesophagus and of the bronchus, was inadequate. This agreed with calculation. On the other hand, growths such as carcinomata of the pyriform fossa proved susceptible and showed early changes, with great betterment; but there the short distance beneath the skin surface makes a much greater intensity possible. No ill effect on cartilage has been observed. Dosage has actually varied from 12 to 150 gram hours.

The first fifty cases treated have been:

Carcinoma:

Larynx	...	...	...	...	...	...	3
Pharynx	...	...	...	...	...	...	4
Tongue and mouth (extensions)	...	...	...	...	...	...	4
Oesophagus	...	...	...	...	...	...	2
Ovary	...	...	...	...	...	...	2
Cervix	...	...	...	...	...	...	3
Vulva	...	...	...	...	...	...	2
Renal	...	...	...	...	...	...	4
Breast (recurrences and metastases)	...	...	...	...	...	...	5
Testicle (multiple metastases)	...	...	...	...	...	...	1
Prostate, parotid, lung, rectum, and colon—one each	...	...	...	...	...	...	5

Sarcoma:

Of bone	...	...	...	...	...	...	4
Other	...	...	...	...	...	...	8
Cerebral tumours	...	...	...	...	...	...	3

50

Taking these by classes it may be said of:

(1) The tongue and mouth cases treated for local or glandular extensions, that they have done badly; they were in any case the hopeless failures of other methods. There has been temporary improvement, but the effect has been limited to slight delay in downward progress.

(2) The larynx and pharynx cases have been the most satisfactory; they hold out definite hopes of success when the best dosage has been ascertained.

(3) The oesophagus is beyond our range unless the post-cricoid growth be included, but it belongs in this respect to the previous group.

(4) The uterine and ovarian cases were failures, but were all the subject of extensive abdominal invasion.

(5) Of the renal cases the same must be said—the results are merely palliative.

(6) Breast recurrences can be kept in check, even when very extensive, but previous deep x-ray therapy may be a formidable handicap.

(7) Vulval glandular extensions do not prove nearly so sensitive as the primary growth.

(8) Osteogenetic sarcomata have not shown more than quite temporary recession; other round- and spindle-celled growths are more promising.

A few sample cases may be briefly mentioned.

Case 1.—An instructive case of epithelioma of the whole area of the buccal surface of the left cheek, invading the lower and upper alveolar borders back to their junction. A mass of growth was protruding upon the skin surface covered only by a thin pellicle. After twenty-five hours' exposure the lump had disappeared, and was represented by a deep dimple; the skin surface of the cheek, slightly browned and a little inelastic, was intact over the whole area. It was then possible to give a cavitary treatment to the ulcerated mucosal surface, and all appeared well, but in less than a month—and one week after an injection of D4S—a new "lump" appeared beneath the skin close to the original fungation, and a hard mass, rapidly growing at the angle of the jaw involving the masseter, as well as enlarged cervical glands.

The first response was remarkable; not only did the fungating mass disappear, but the normal dermal tissues were re-formed. Why, then, the sudden re-emergence? One possibility is that the cavitary dose upon the top of the teletherapy damaged the stroma and vascular apparatus and permitted surviving lethargic cancer cells to regain dominance. Another is that it was wrong to administer lead just at that stage. Two other cases suggest the inadvisability of approximating lead injections too closely to irradiation. Cheek epithelioma, however, is notoriously difficult to treat satisfactorily by any means, except in quite early stages.

Cases 2 and 3: Retroperitoneal Sarcoma.—These two cases, one a known subject of endothelioma of lymphatic glands, who by operation and medium x-ray therapy for other regions has been kept alive for three years, came back with a large retroperitoneal tumour in the epigastrium; the other, a retroperitoneal tumour disclosed at operation, believed to be a lymphosarcoma (but without biopsy). Both proved radio-sensitive. In the one case the mass disappeared after 40 gram hours; in the other it was reduced to less than one-third its size forthwith, but shows a tendency to enlarge again and again when treatment is stopped. The latter patient feels so well, in general health, that it is very difficult to persuade her to spend the necessary time and trouble in coming to the hospital for treatment. She has had 100 gram hours.

Case 4.—This case was one of an immense and bleeding round-celled sarcoma of the neck, filling the space from acromion to mastoid, the patient being in a desperate state of cachexia with anaemia, dyspnoea, and dysphagia. Under treatment by radon and surface appliance, with certain heavy metal injections, the mass was reduced to a thick induration covered with skin. After six months nodules began to appear in the skin, and teletherapy was begun. The general condition of the patient has been well maintained at the high level attained after the original treatment, and the cutaneous masses, though they have not disappeared, have diminished in size. There is no evidence of visceral metastases. A slight loss of weight seems to be of no particular significance.

Case 5.—A case (under the care of Mr. Stanford Cade) of metastases (in the liver and elsewhere) from carcinoma of the breast. The patient received 18,000 mg. hours in the hepatic region, but the treatment had to be discontinued, and death occurred soon after cessation. In this case, certainly, liver function was already seriously impaired by actual destruction, and direct irradiation added to the effect.

Case 6.—A case of extensive metastases from carcinoma of the left breast, in the right breast, chest wall, pleura, left axillary, and supraclavicular glands, which failed to yield to interstitial treatment and received no surface application. "Bomb" treatment was followed by immediate ease, cessation of pain, and remarkable return of well-being, lasting, however, only a few hours after each application. Final result not yet known (June 20th).

Case 7.—This patient (under the care of Mr. Chubb), suffering from post-cricoid carcinoma, was quite unable to swallow, was too weak to get out of bed, and weighed only 4 st. 10 lb. After insertion of radon in January, 1929, she began teletherapy on March 9th, and has received so far 110 gram hours. She is well, runs about briskly, weighs nearly 7 st., and, beyond a slight hoarseness, seems quite well (June 20th).

Case 8.—This patient (under the care of Mr. Arthur Evans) had carcinoma of the larynx with very large fixed glands in the neck; after 700 mg. hours interstitially for the glands, he received 38,000 by teletherapy. The laryngeal growth disappeared, and his general condition, which was grave, has improved so remarkably that, although now (June 20th) he has a pedunculated recurrence from the right cord, he declares himself very well indeed.

Case 9.—This patient (under the care of Mr. Stanford Cade), a case of carcinoma of the pyriform fossa, has made a striking recovery, and will be, with other similar cases, the subject of a special report by Mr. Cade.

An important result in general has been relief from pain. It is not always maintained, especially in cases involving bone. Some of the ameliorative effects of irradiation may be immediate; betterment as to pain and discomfort often surprises by its rapid occurrence. Perhaps it is only a psychological effect, but it is grateful, nevertheless, to the sufferer, and often persists longer than would be expected if purely psychological. Appetite is often im-

proved, but where the liver is involved or suffers, nausea and vomiting may interfere with the taking of food. Whilst most patients experience a grateful well-being, some suffer from serious depression, which, however, is only temporary if progress is made. Sleep is usually improved, many patients sleeping undisturbed whilst in position on the apparatus. Ten patients have died during the six months.

CAUSES OF UNSUCCESS.

Insufficiency of irradiation intensity; wrong or improperly spaced dosage. Harmful effects upon the blood and haemopoietic system, necessitating cessation of treatment. Depression of function of glands, liver, kidneys, thyroid, and pancreas, with deterioration of general health. These are the subject, at present, of special investigation by Dr. F. D. M. Hocking.

The effect upon the blood seems to differ slightly in carcinoma and sarcoma cases. In the latter the red count may increase, with a slight falling off of the white cells. In the former the red count falls, but the haemoglobin decreases less, so that the colour index tends to rise. The quantity of urine passed during the period of irradiation is diminished—a consideration of importance in connexion with the blood estimations.

When the first fifty cases so far treated are reviewed, what can be said of the effects?

The many very advanced cases have not gained materially, and in one or two instances the surgeon in charge has noted the impression that the neoplastic process has been hastened. There is, however, no proof that the development has been more rapid than the terminal rush downhill often seen in such cases apart from irradiation. That the effects of irradiation are purely local is evidenced by the steady march, even whilst one group of metastases is vanishing, of others beyond the field of irradiation.

The growths capable from their situation of receiving irradiation of high intensity have shown the best results—those, that is to say, in the pyriform fossa, the post-cricoid region, abdominal and cervical glands; but it must be remembered that the last group includes some that are susceptible of satisfactory treatment by x rays even of medium penetration.

For dealing with carcinoma and administering a dose of adequate intensity in a short enough time, there seems little doubt that the amount of radium necessary is greater than our present supply, and we have seen nothing to suggest that by greater intensity the organs or tissues will be seriously damaged. Modifications in our apparatus promise us greater efficiency, but we need at least another gram.

So long as the amount available is no more than a gram, it will probably be advisable to restrict its curative use to cases of carcinoma at a depth not greater than 6 cm. Very susceptible tumours may more cheaply be treated by x rays. Prophylactic use after surgical operation seems well warranted. Preliminary treatment in cases of doubtful operability should also be tried.

The following note on radium teletherapy is by Mr. Leslie-Spinks, who has personally made the majority of adjustments of patients for treatment.

Note by A. J. LESLIE-SPINKS, M.A., B.M., Ch.B.

The structure and mechanism of the temporary "bomb" in use at Westminster Hospital has already been described in a previous paper (vide *British Medical Journal*, May 11th), but perhaps some account of the routine followed in its use may be of interest. Before any patient is treated with this apparatus a drawing is made to scale of the lesion and its situation in the body, and an intensity chart is applied to this drawing. By means of this chart the intensity of irradiation at the growth when approached from various parts of entry can be ascertained, and the best way of treating the growth decided upon. Though the calculations are made for conditions in which the source of irradiation is at a distance of 10 cm., yet with the apparatus at our disposal it has been necessary, in many cases, for purely mechanical and anatomical reasons, considerably to exceed this focal distance, with the result that the intensity actually received at the lesion has been much

diminished. This fact may in part account for our lack of successful results in some cases. In the permanent apparatus now under consideration measures are being taken to overcome this difficulty. The results obtained in those cases (for example, intra-abdominal or mammary or cutaneous neoplasms) in which the lesion is accessible to the full intensity have been so much more favourable than in those in which, either for anatomical reasons or on account of the patient's comfort, the distance has had to be increased, that it would appear that a smaller apparatus is necessary for dealing with some lesions.

The "bomb" is in use continuously for twenty-four hours daily for six days each week. During the day out-patients are treated, and during the night in-patients, the average time given to each case being two hours. It has been found that most patients are very nervous during their first period of treatment, but that on the second and subsequent occasions they are quite reassured and comfortable. The majority of our patients sleep quite peacefully, and say that their sense of comfort and well-being is increased while they are on the "bomb" and for some time afterwards. Thus it is no great hardship for the patients to leave their beds in the wards and go to the "bomb" at night. Two patients have even said—and it has been confirmed—that they slept better while having their treatment than when in bed in the ward.

When the patient is put on the stretcher the "bomb" is adjusted as near as possible to the correct focal distance at the port of entry decided upon, the patient is made comfortable, and in the majority of cases falls asleep in a short time. The ports of entry are changed on alternate days, and in this way not only is the danger—and this is apparently very slight—of damage to the skin minimized, but the intensity at the growth is increased.

Periodical examinations of the blood are carried out, as are tests of liver function and other biological tests, and in this way the effects of irradiation on the organism as a whole are controlled. A register is kept and discussed at a weekly meeting of the staff, at which the past week's results are examined and the programme for the succeeding week is decided upon.

SPINOCAIN: THE CONTROLLABLE SPINAL ANAESTHETIC.*

BY

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To discuss the clinical features of spinocain would seem somewhat far-fetched. Dr. Frank A. Kelly of the Grace Hospital, Detroit, Michigan, has worked with the solution from its early experimental days, and he, I believe, will gladly enlighten you as to its clinical advantages. With your permission I will endeavour to enumerate some of the theories we had concerning spinal anaesthesia and explain the reasons for our conclusions.

Since the introduction of painless surgery our dreams have been an ideal anaesthetic—one that would abolish pain completely, be reliable and certain in its action, constant in duration and intensity in direct ratio to the amount employed; one that would not alter the normal secretions of the body; one that would not affect respiration and circulation; one that would be free from all complications brought about by the action of inhalation anaesthetics, such as pulmonary oedema, bronchitis, pneumonia, lung abscess, acidosis, distension, ileus, acute circulatory failures, etc.; one that would not materially disturb the central nervous system. Such an anaesthetic should essentially be non-toxic, be simple of administration, lessen morbidity, and abolish anaesthetic mortality altogether. However, such an anaesthetic is still a dream. The reality is our present-day anaesthesia, the deleterious effects of which are an ever-growing concern of thoughtful surgeons.

The short time allotted to this paper does not permit going into the problem of the causes of anaesthetic morbidity and mortality. It should be pointed out, however, that the problem is a part of the great problem complex of cardio-respiratory physiology and pathology, that has remained largely unsolved to our very days.

However, we know that it is through their interference with the normal cardio-respiratory correlation that anaesthetics cause their ill effects. We see the phenomena of cardio-respiratory decompensation ensue as soon as the anaesthetic action reaches and depresses higher central nervous elements regulating respiration and circulation, regardless of whether the anaesthetic was inhaled through the lungs or injected into the subarachnoid space in a manner enabling it to diffuse in a cephalic direction. The respiratory embarrassment as manifested then in the degree of anoxaemia, or the circulatory collapse as manifested in the degree of hypotension, is in both cases directly proportionate to the action of the anaesthetic. The functions involve central nervous mechanisms upon which the effect of the anaesthetic varies greatly even from one individual to another; it is therefore beyond our power to estimate or control. In this lack of control lies the source of all complications of anaesthesia, caused by the anaesthetic, regardless of whether inhaled or injected. The action of the anaesthetic depends on its diffusion. To control diffusion of the anaesthetic thus becomes the paramount goal of all anaesthetists.

The fatalities of respiratory embarrassment or circulatory collapse at the time of operation, are not to be compared with the secondary mortality, which is 99 per cent. of the whole as compared to a scant 1 per cent. of a primary mortality. How many anaesthetists or surgeons can truthfully say that they have had 100 consecutive cases without some post-anaesthetic complication, such as shock, bronchitis, pneumonia, lung abscess, distension, ileus, acute cardiac or gastric dilatation, albuminuria, suppression, or acidosis; many or all of which may be directly attributable to a partial or impaired respiratory or circulatory dysfunction?

The surest method of eliminating anaesthetic complications is by the use of local or conduction anaesthesia. Unfortunately its art is not familiar to all of us, nor is the method adaptable for all operative procedures. But, with a combination of these and controllable spinal anaesthesia, any operative procedure may be carried out with greater protection to the patient and better facilities to the surgeon. To eliminate the possibility of respiratory and circulatory disturbance, permit me to suggest a spinal anaesthetic that will not diffuse with the spinal fluid, one that can, with the proper technique, be placed under the direct control of the operator.

As we have known spinal anaesthesia in the past it produces hypotension. In fact, so great is the circulatory depression that one well-known author in America states that "the radial pulse cannot be felt by the finger, nor can it be detected by the ear when the arm is subjected to the pressure of the cuff of the sphygmomanometer." This extreme drop in the blood pressure is due to diffusion of the anaesthetic fluid cephalically. If the anaesthetic fluid is confined to the lumbar spine there is no change in the blood pressure; if it reaches the first thoracic the pressure becomes *nil*. If the nerves controlling the diaphragm and intercostal muscles are anaesthetized, respiratory embarrassment arises. If it reaches still higher levels the sympathetic cardiac accelerators are anaesthetized, and unrestricted vagus action slows down the heart. Extreme pallor, nausea, vomiting, a cold clammy sweat, a feeling of pressure over the precordium, thirst, air-hunger, and the fear of impending danger are the alarming symptoms such diffusion of the anaesthetic causes.

With an endeavour to overcome any or all of these objectionable symptoms of an otherwise ideal anaesthetic a series of experiments were conducted to ascertain the physiology and the physiological action of the various drugs advocated for spinal anaesthesia. We attempted to bring the anaesthetic under the control of the operator, to prevent uncertainty as to the parts involved, to stabilize the intensity and regulate the time of anaesthesia, to diminish the tremendous drop in blood pressure, to minimize nausea and vomiting, to abolish cold sweats and

* Read in opening a discussion in the Section of Anaesthetics at the Annual Meeting of the British Medical Association, Manchester, 1929.