had ceased. It was then planned to kill the animals by asphyxia, give artificial respiration, make rhythmic pressure upon the thorax over the heart, and at the same time administer adrenalin in saline solution into the jugular vein. By this means, adrenalin might, through the feeble artificial circulation, be brought into contact with the walls of the blood vessels, causing their contraction, thereby increasing the blood pressure, which in turn might re-establish the coronary circulation, which in turn might re-establish the action of the heart. By this method animals apparently dead for various periods up to fifteen minutes were restored to conscious life again.[19] The circulation and the respiration in dogs electrocuted by a shock of 2300 volts of an alternating current were re-established.

SUMMARY.

In many instances the control of the blood pressure is synonymous with the control of life itself. Surgical shock is an exhaustion of the vaso-motor center. Neither the heart muscle, nor the cardio-inhibitory center, nor the cardio-accelerator center, nor the respiratory center, are other than secondarily involved. Collapse is due to a suspension of the function of the cardiac or of the vaso-motor mechanism. In *shock* therapeutic doses of strychnin are inert, physiologic doses are dangerous or fatal. If not fatal, increased exhaustion follows. There is no practical distinction to be made between external stimulation of this center, as in injuries and operation, and internal stimulation by vaso-motor stimulants, as by strychnin. Each in sufficient amount produces shock, and each, with equal logic, might be used to treat the shock produced by the other. Stimulants of the vaso-motor center are contraindicated. In *shock* cardiac stimulants have but a limited range of possible usefulness, and may be injurious. In *collapse* stimulants may be useful because the centers are not exhausted.

Saline infusion in *shock* has a limited range of usefulness. In *collapse* it may be effective. The blood tolerates but a limited dilution with saline solution. Elimination takes place through the channels of absorption. Its accumulation in the splanchnic area may be sufficient to fix the diaphragm and the movable ribs, causing death by respiratory failure. Saline infusion in shock raises but cannot sustain the blood pressure.

Adrenalin acts upon the heart and blood vessels. It raises the blood pressure in the normal animal; in every degree of shock; when the medulla is cocainized, and in the decapitated animal. It is rapidly oxidized by the solid tissue and by the blood. Its effects are fleeting; it should be given continuously. By this means the circulation of the decapitated dog was maintained ten and one-half hours. In excessive dosage there is a marked stimulation of the vagal mechanism. Due caution must be exercised.

The pneumatic rubber suit provides an artificial peripheral resistance without injurious side effects, and gives a control over the blood pressure within a range of from 25 to 60 mm. mercury. By the combined use of artificial respiration, rhythmic pressure upon the thorax and adrenalin injected into the jugular vein, animals which were apparently dead as long as fifteen minutes were resuscitated.

[19] See Fig. XVII.

ON ROUTINE DETERMINATIONS OF ARTERIAL TENSION IN OPERATING ROOM AND CLINIC.[1]

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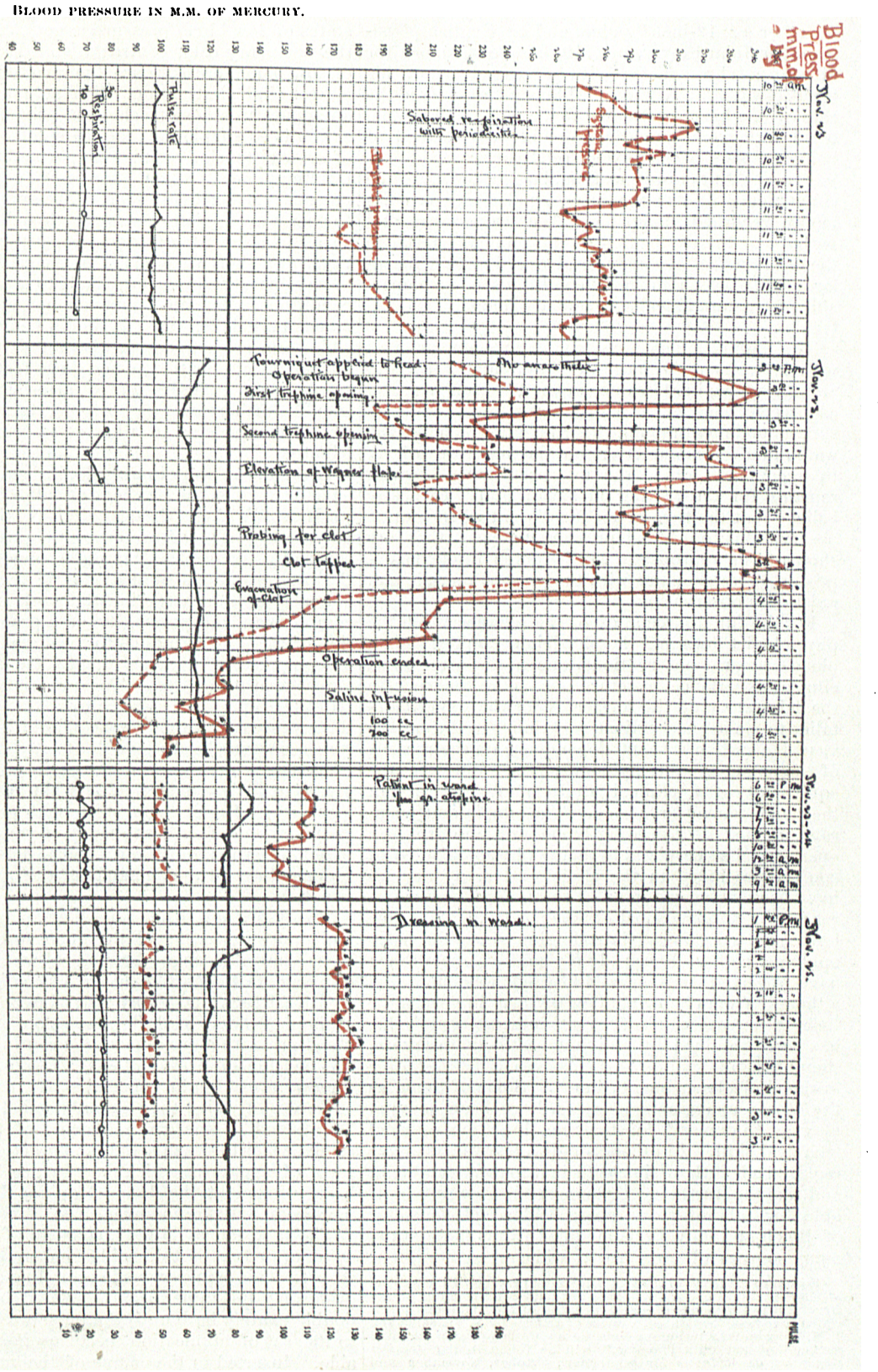
THERE has been a long-felt want in the surgical operating room, possibly even more than in the clinic, for some practical form of apparatus which will give with facility numerical equivalents for variations in pulse tension, and by means of which consecutive observations on this quality of the pulse may be diagramatically charted.

During a critical operation the hearsay dependence which the surgeon must place on the palpating finger of the anesthetist for a knowledge of the cardiac strength of his patient may oftentimes be one of his most trying responsibilities. Were it possible, therefore, under such circumstances for him to be told with the definiteness which figures alone can give, or for him to read by a glance at a plotted chart that the strength of the cardiac impulse, irrespective of its rapidity, was keeping at a normal level or was affected in one way or another by certain manipulations, not only would this feeling of responsibility be much lightened, but the operative procedure might oftentimes be modified with a consequent lessening of its risks.

It by no means behooves us to disparage the value of an educated touch as a means of estimating vascular qualities, but the tactile and muscular sense, no matter how well trained, must give way to some method more precise, especially when serial observations for purposes of demonstrating alterations taking place from day to day, hour to hour, or moment to moment are demanded. For this an instrument of precision is needful, and it may be said in passing that no amount of training in palpation of the arterial pulse will educate the muscular sense as well and as quickly as when there is an associated use made of some form of sphygmomanometer. In place of the loose and indefinite terms applied to degrees of tension one learns to interpret them with some measure of numerical accuracy, and recognizes a "weak" or "compressible" pulse as one with a tension perhaps of 80, a "hard" or a "bounding" pulse as one, for instance, of 260.

The belief is more or less prevalent that the powers of observation so markedly developed in our predecessors have, to a large extent, become blunted in us, owing to the employment of instrumental aids to exactness, and the art of medicine consequently has always adopted them with considerable reluctance. Take for example the two instruments upon which we place today our chief reliance for obtaining ordinary routine clinical data — the thermometer and the watch. Although the former instrument dates back to the time of Galileo, and was used by him as a means of estimating body temperature, the necessity of thermometric observations in disease had no widespread clinical recognition until after the publication of Wunderlich's classical monograph in 1868. Today one wishes to know, not as in pre-Boerhaavian times solely by manual palpation that there is a more or less evident pyrexia, but the degrees or fractions of degrees of variation, which our instrument of precision alone can supply. Galileo, also,

[1] Read by invitation at the Boston Medical Library, Jan. 19, 1903.



Four fragments from blood-pressure chart of a case of apoplexy in which systolic and diastolic pressures were recorded. Heavy line between 130 blood pressure and 90 pulse-rate taken to represent normal abcissa. Solid charted line represents pulse rate. Broken lines represent blood pressure: upper = systolic; lower = diastolic. PERIOD I. — Condition before operation with a vagus pulse of high tension. PERIOD II. — Operative period with extraordinary drop in pressure consequent upon evacuation of blood clot. Pulse-rate not affected. Cessation of vagus stroke. PERIOD III. — Normal levels immediately after operation. PERIOD IV. — Condition two days after operation. Perceptible return of vagus stroke. Slight rise in systolic pressure, without particular alteration in mean pressure.

by shortening or lengthening the arm of a pendulum until it would oscillate synchronously with the pulse-rate, learned to speak with some accuracy of a "10-inch" or a "12-inch" pulse, and an English physician, Sir John Floyer, in 1710, had constructed for himself a chronometer with a second hand, his "pulse-watch"; but not until long afterward did the rate of the heart-beat come to be universally registered with some numerical definiteness instead of being spoken of merely as relatively "rapid" or "slow." At the present time, largely owing to the convenience of our timepieces, pulse-rate is commonly recorded alongside of the temperature and perhaps of the respiration on our clinical charts, to the utter neglect of a numerical record of that vascular quality which in many conditions is incomparably of greater clinical consequence, namely, arterial tension.

The familiar query is raised. Are we not surfeited with instruments of accuracy in clinical work, and are not approximate values in the long run as useful as precise ones? I can only reply that there is no superabundance of simple instruments which like the watch and thermometer enable the nurse or orderly to accumulate data, the interpretation of which remains for the visiting physician, and I earnestly believe that the time is not far distant when routine observations on blood pressure in cases that are shown to be appropriate will be taken in our hospitals in correspondence with the present thermic and pulse-rate observations.

For the full appreciation of the reliance which the physiologist does and the physician should place on blood-pressure observations, one needs after some clinical experience to return once more for work in the laboratory of the former. For the experimentalist to make observations pertaining to the cardio-vascular system without dependence on the records of manometer and kymographion would be the equivalent of a clinical study of fevers without thermometric observations. The simple and accurate method of recording blood pressure from an open vessel so serviceable to the physiologist is, of course, precluded in the clinic, and many devices have been suggested in substitution for it. For one reason or another most of the instruments which have courted clinical introduction since the early appliances of v. Basch (1887) and Potain (1889) have received only a half-hearted welcome, and although from one or another of them in spasmodic fashion information of great interest and value has been obtained by individual skilled observers, they have not made for themselves a lasting place in the clinical armamentarium[2]. Some of them, as the Mosso sphygmomanometer, have been so complex as to demand for their manipulation especial technical skill. In others single observations have required a length of time sufficient to condemn them, and, like the Hurthle plethysmograph, are only adaptable for laboratory purposes. The sphymometer of Bloch and its various modified forms possess too many sources of error for a widespread adoption.

[2] For those desirous of a careful historical *résumé* of the subject of blood-pressure estimations, together with a description of the structure and principle of action of some of the numerous forms which have been introduced, a series of articles by N. Vaschide and J.-M. Lahy on "La technique de la mesure de la pression sanguine particulièrement chez l'homme," will be found in the *Archives Générales de Médecine* for September, October, November and December of 1902. An extensive bibliography accompanies this important "Revue spéciale" of the subject.

The Gärtner tonometer, otherwise a most valuable instrument, possesses disadvantages for the reason that the circulatory activity in the fingers during states of low blood pressure is not sufficient to give the necessary color contrasts, and these very states of low blood pressure are the ones demanding the closest clinical attention. The actual needs are for an apparatus whose mechanical principle and application is so simple that the mere act of registration of arterial tension requires no particular preliminary training, and in which there is the least possible personal coefficient of error. The apparatus should, furthermore, register tension with sufficient celerity so as to allow of a frequent repetition of observations in a short time, since in the critical moments of any operative procedure likely to upset circulatory conditions, alterations in tension from moment to moment are called for. It should be as free as possible from annoyances or discomfort to the patient during its application, since these factors in themselves may reflexly affect arterial tension. It should, furthermore, be portable, durable and sufficiently inexpensive to allow of its widespread distribution.

In the line of work in neurological surgery, which I have been given the privilege of following in Professor Halsted's clinic, the desirability of the routine employment of a blood-pressure apparatus is perhaps especially apparent. Having become dependent on the interpretations of manometric tracings for the outcome of some experimental work upon cerebral compression, the possibility of a practical application of these observations to the diagnosis of stages of compression in man without some corresponding aid seemed prohibited. The propriety, also, of instituting operative procedures for the relief of these processes without concomitant blood pressure tracings seemed questionable, to say the least. Various forms of apparatus experimented with had given but little satisfaction, and not until the instrument, which I shall demonstrate with some apologies, as it is already familiar to many of you, was brought to my attention in its own home, did any of them promise to meet the demands of the operating table situation.

Two years ago, while on a tour among the Italian University towns, I had the good fortune in Pavia to be shown through the medical wards of the old Ospidale de S. Matteo by Dr. Orlandi, a colleague of Riva-Rocci, and to my great interest found that a simple "home-made" adaptation of the latter's blood-pressure apparatus was in routine daily use at the bedside of every patient. I think at the time they were making an especial study of chlorosis, in examples of which the clinic abounded. Thanks to Dr. Orlandi, I was given a model of the inflatable armlet which they employed, and practically the same form of apparatus which was in use in Pavia has been utilized at the Johns Hopkins Hospital with increasing satisfaction ever since.

The instrument, in part, consists of a distensible cylinder or tire of thin rubber covered with a linen jacket. This cylinder, while encircling an extremity, preferably the upper arm, is inflated by means of a double cautery bulb until the pulse-wave, peripheral to its seat of application, becomes no longer palpable. Inserted in the course of the rubber tubing, which connects the bulb and tire, is a simple upright

mercury manometer, which records the pressure of the air in the cylinder necessary to obliterate the pulse. The principle is the same, therefore, as in many other varieties of sphygmomanometer, and the apparatus differs only in some important details from the appliance described by Hill and Barnard. The particular form of the instrument I have to demonstrate is somewhat more carefully constructed than the home-made ones we have heretofore employed, and possesses the advantage, following a suggestion of Dr. H. W. Cook, of having a disjointed manometer tube, enabling it to be enclosed in a smaller compass.[3]

It is presumable that this apparatus by no means represents what will be the final form of clinical sphygmomanometer, for there are numerous criticisms, chiefly on the ground of inaccuracy, which may justly be raised against the Riva-Rocci instrument. It can be seen at a glance that there must be considerable variation of tension as measured in different individuals, according to the amount of panniculus or muscle covering the vessel which is being compressed, as well as upon the degree of thickening and rigidity of the arterial walls themselves. This objection, although deserving of consideration, may for the time being be waived on the ground that the record of variation in arterial tension in a given case, with its gradual fall or rise under different circumstances, represents the objective point of most of our observations rather than comparative records made upon different patients.

Another very proper objection to this form of instrument, which the physiologist naturally raises, is that it records systolic pressure or tension at the crest of the pulse-wave alone, and does not give the mean or average arterial tension. And, as a matter of fact, Drs. Cook and Briggs have shown that the diastolic pressure after a little experience may be registered with this apparatus on the plethysmographic principle, by recording the level at which there is the greatest visible pulsation in the column of mercury when the tube between the manometer and bulb is compressed. The studies of Howell and Brush have shown that this level of greatest pulsation, on which principle the Mosso, the Hill and Barnard and other sphygmomanometers operate, corresponds with the diastolic rather than mean blood pressure, as heretofore presumed by most investigators. Dr. Erlanger has skillfully combined the two forms of systolic and diastolic apparatus in a way which renders it possible, as in the Hill and Barnard apparatus, to establish with some degree of accuracy the absolute mean of blood pressure.

For the purposes, however, to which we have chiefly put the apparatus, the record of systolic level has amply sufficed to give us the data we desired, and the conditions in which alterations in systolic level are unaccompanied by a more or less equivalent alteration in mean level (*cf.* accompanying chart) are sufficiently unusual in clinical cases to render them for the time being relatively unimportant. If it is a desirable thing, as it seems to be, to register blood pressure as a routine in the clinic as well as during many of the critical medical or surgical operative procedures, it is advisable, for present purposes at least, to use the simplest, although it be a somewhat inaccurate instrument, and the errors of the Riva-Rocci apparatus are more than compensated for by its ready applicability to most clinical demands. Long experience has taught us when frequent observations on the pulse-rate and temperature are of especial clinical value. It will require time as well to indicate with definiteness the conditions in which blood-pressure observations are of the greatest utility, and many a long chart will be plotted seemingly to no purpose before there is a final selection of conditions wherein it will be considered negligent to omit these observations. When these conditions have become more or less roughly determined by the everyday use of some simple form of instrument like the one under discussion, its possible errors should doubtless be controlled by the observations taken on same apparatus which is more accurate from the physiologists' standpoint and by those individuals who have become especially skilled in its manipulation. At present one barely knows what cases to select, what ones to pass by. New facts of interest from a purely physiological point of view, or, what is to us more essential, of prognostic, diagnostic or therapeutic value to the clinician, are constantly being brought to light.

It will be impossible, in the short time allotted, to more than suggest some of the lines of observation which are deserving of especial attention. There are, of course, many maladies usually characterized by a hypo- as well as others by a hyper-tension of the arterial blood stream, and tabulations of the pressure levels commonly found in these diseases have been made by Potain and others. Such records may be of considerable value for purposes of differential diagnosis, as, for example, between states of simple albuminuria and those of actual chronic nephritis, or again between the hemiplegia of intracranial hemorrhage and that of cerebral softening. There are other clinical states which are associated with great cardiac instability, shown by the variation in strength of successive contractions, and no form of apparatus will record in a satisfactory way the irregularities such as may be found, for instance, in certain severe cases of Basedow's disease. Alterations in blood pressure, nevertheless, which occur with a definite rhythm, such as those which occasion or accompany periodic respiratory phenomena, as of the Cheyne-Stokes type or those which, for example, characterize the pulsus parodoxus, are easily recognized by the apparatus which has been described.

It is, however, rather from notations on the variations of tension from time to time in an individual case than with the mere fact of an average hyper- or hypo-tension in the given disease, that we derive the greatest benefit from these pressure records.

Their prognostic and diagnostic value are shown in many conditions of falling pressure, whether of mechanical, toxic or nervous origin; in case of hemorrhage or when there has been a great depletion of fluids due to persistent vomiting or diarrhea; when during the course of acute or prolonged fevers evidence of cardiac failure is beginning to

[3] Elmer and Amend of 205 3d Avenue, New York, have made for Dr. Cook and put upon the market a serviceable form of the Riva-Rocci apparatus. An equally useful instrument can be easily home made, provided the rubber armlet is secured from some source. Dr. Crile tells me that he has used a small standardized anaëroid barometer inserted in place of the mercury manometer in an instrument of the Riva-Rocci pattern. This brings the instrument into still closer structural relationship with the Hill and Barnard apparatus.

show itself [4]; when there is existent or impending shock or collapse. Similarly useful are records in cases in which the reverse takes place, namely, a progressive rise in tension, such as occurs in some acute intracranial processes and in states of renal insufficiency.

Their therapeutic value is perhaps even more apparent as one is enabled to accurately estimate not only the degree of stimulant or depressant effect which a given procedure or drug may have upon the cardiac activity, but also to follow the duration of its action. In no other way is it possible for us to learn the actual therapeutic results of stimulation; to appreciate, for instance, the inadequacy of saline infusions as a means of raising blood pressure; to learn the uses and limitations of alcohol, strychnia, digitalin and nitroglycerin; to study the effects of that remarkable substance, adrenalin, which may possibly become of therapeutic value in cases of profound shock.

I think that Dr. Cook has been the first to put to any practical application the principle of stimulation in accordance with blood-pressure records. During a summer service among numerous cases of cholera infantum he found it practicable to leave orders for stimulants of one sort or another, to be administered in accordance with the blood-pressure observations, which the nurse herself regularly made on the cases that were seriously ill. Thus, without waiting for the personal advice of the attendant, oftentimes occasioning serious delay, on a fall of blood pressure to a certain subnormal level, a saline infusion or a given dose of digitaline was to be administered, to be followed, if the pressure did not shortly return to and remain at a safe level, by a certain amount of strychnia, for example. The advantages of such a routine are quickly apparent, and orders for stimulants may thus be left with the same definiteness as are the directions for a bath in case the pyrexia of typhoid fever exceeds a certain degree of temperature. Similarly, when a depressant effect of drugs is desired to alleviate symptoms associated with hypertension, treatment may receive its indication from something more definite than the mere palpation of pulse tension.

The beneficial effect of rest treatment for those nervous disorders which are associated with a high tension can be best appreciated by accompanying blood-pressure observations. An illustration, also, of what recumbency can do for the high tension of arterial sclerosis is shown by this chart, which Dr. McCrae has privileged me to show you. It represents the blood-pressure record of a patient who entered Dr. Osler's service a few months ago with an aortic aneurism and a general arteriosclerosis of an advanced degree, associated with the usual vascular hypertension. Under a rigid Tufnell treatment the blood pressure, as can be seen, has fallen from its previous great height to a level considerably below normal, where, averaging between 95 and 110, it has remained for the past two months. It is evident that the pulse rate, although considerably diminished, has not been affected by the treatment in so striking a way. It can be readily understood that a diminution in the vigor of the cardiac contraction is of even greater importance in this form of treatment than the lessening of the number of pulsations, and by means of control observations on blood pressure in this particular case, after a level of hypotension had once been reached, it was found possible to make concessions to the patient and to relieve him in a measure from the severe regulations of the treatment, according as it was found that their withdrawal had but a slight and transient influence in increasing the arterial tension.

There are many operative procedures, also, which fall to the lot of a physician, such as the aspiration of effusions of one sort or another from the serous cavities, the occasional accidents associated with which may be avoided by concomitant registrations of blood pressure. Thus the well-known fall in pressure which follows the withdrawal of a large amount of fluid from the abdomen may be recognized before a dangerous level of pressure has been reached. So, also, the abstraction of blood in cases of hypertension associated with various maladies may be definitely regulated and the therapeutic effect of the procedure best appreciated by an accurate numerical estimation of tension during venesection.

In the surgical operating room procedures which tend to upset in any way the cardio-vascular apparatus, whether directly by loss of blood, or indirectly through insults to its nervous mechanism, will be recorded with fidelity, and if harmful their continuance or repetition avoided. As stated elsewhere, I feel assured that by placing reliance on the blood-pressure charts kept during critical operations in the past year, it has been possible to anticipate and ward off severe conditions of surgical shock, and indeed in some instances to save lives. A great number of blood-pressure reactions known to the physiologist as occurring in animal experimentation it has been possible to demonstrate on man with some degree of conformity. The general tendency of a rise in blood pressure during ether administration and the frequent fall during chloroform anesthesia show graphically the danger of narcosis induced by the latter drug. Chloroform is commonly advocated as the anesthesia of choice in intracranial operations, on the ground that its use is associated with less likelihood of hemorrhage. The fall in blood pressure explains this diminished tendency to bleed, and at the same time points out the danger of the drug. A sorry experience has led me to abandon chloroform for this reason in craniotomies, as well as in other operations. In a similar way comparative observations on blood pressure might enable us to determine the less dangerous of two or more methods of operating, when different procedures to accomplish the same end are advocated by schools or individuals.

All things considered, operations conducted under painstaking hemostasis, even though performances of great magnitude and requiring long manipulation, as the complete Halsted operation for carcinoma of the breast, may be unassociated with alterations in arterial tension. If, however, many or large nerve trunks are encountered or require handling during operations, marked variations may be occasioned. These are dependent upon the reflex effects of afferent sensory impulses, and it

[4] Certain recent experimental observations from Curschmann's clinic tend to show that the circulatory disturbance in acute infectious diseases is brought about by a peripheral vasomotor breakdown rather than from cardiac failure. Plässler und Rolly, Münch. Med. Woch., 1902, October, p. 1737.

has been seen on certain occasions that during recovery from anesthesia, and some time after the completion of a severe operation, which apparently had been unassociated with evidences of shock, that there may be a reflex fall in pressure of considerable degree, occasioned by the pains and discomforts which are felt during the restless period of returning consciousness. The weak pulse seen under these conditions, according to our charts, receives its best stimulant from small doses of morphia, which are quieting, prevent restlessness, and so check the inflowing sensory impulses.

In further conformity with experimental observations one sees that traumatism of sensory nerves when an individual is in normal condition will be accompained by a rise in blood pressure. This reflex rise is especially well marked during such operative procedures as the stretching of a nerve for neuritis or the forcible dilatation of the anus for the treatment of fissure or preparatory to a hemorrhoid operation. When one sees recorded the great rise of pressure which may occur under these circumstances, the occasional hemiplegia which has been known to follow supposedly simple operations of this sort need be no cause for wonderment. In case of fatigue or exhaustion of the nervous system from repeated stimuli, instead of this normal rise, a fall will occur, and in case the pressure is already low, as in conditions of traumatic shock, this additional depressor response may be sufficient to insure a fatal outcome. The value of blocking nerves by the injection of cocaine in prevention of such reflex disturbances has been emphasized heretofore by Dr. Crile and myself.

In operations upon the central nervous system, perhaps more than in any others, are blood-pressure observations of great value. The reactions which occur as a normal response to varying degrees of intracranial pressure may suffice not only to serve as a timely warning of the necessity of operative interference, but may also show during those surgical procedures which necessitate compression or elevation of a portion of the brain, the extent to which the process may safely be carried. In spinal surgery, especially in operations carried out in the upper part of the cord, shock may play such an important part in the reactions that the warnings gained by pressure records are of great use. In cases of transverse lesions of the spine, the few records I have had the opportunity to make have tended to show that there is an early elevation of tension in low segmental lesions, a lowering of the same in high lesions. This would be expected, since in the former case the splanchnic nerves presumably are stimulated, while in the latter case they are cut off from their central connections with a consequent loss of control over the great vascular territory of the abdomen. The great fall in pressure which often follows the subarachnoid injection of cocaine would be enough to deter any one who has made blood-pressure observations on these cases from employing this much-discussed method of anesthesia. It is not impossible that the shock commonly seen in these cases is due to an intraspinal paralysis of the vasomotor nerves controlling the splanchnic territory rather than to the general toxic effect of the drug which has reached the general circulation.

In abdominal surgery there is a great field for observations on pressure, owing to the importance of this same splanchnic vascular territory. The removal of large abdominal tumors by a resultant flooding of the vessels may seriously affect the heart on "*die leere Pumpe*" principle of Goltz. Evisceration or extensive intra-abdominal manipulations, especially when conducted in the upper quadrants, may produce a rapid fall in pressure, whether reflexly, by sensory stimuli coming from the parietal peritoneum, or in consequence of the direct insult to the vasomotor terminals, and only by pressure observations at the time can the extent of vascular disturbance be appreciated and so possibly checked before irremediable shock has been occasioned.

Further illustrations without number might be cited. What has already been said may suffice to show that in most of the departments of clinical work, whether devoted to internal medicine itself or surgery or neurology or obstetrics or psychiatry, etc., will these routine observations be found of practical utility in diagnosis, prognosis and therapy.[5]

Afterword. — There is one word I should like to say in conclusion, and before leaving this clinico-physiological subject.

For reasons that possibly are not far to seek there seems to have taken place during the past few decades a gradual withdrawal of interest on the part of the clinician from his quondam interest in research along the lines of experimental physiology. Clinical medicine has offered an arm to pathology and her handmaid bacteriology, and the old companion is passed by for the most part unnoticed. Morbid anatomy is courted on every hand; morbid physiology is but little heeded. To the student, from my own recollection, this is especially evident, and although there may and must be a lingering memory of physiological principles which clings to his mind, there is little if anything said or done in most schools during his period of bedside instruction to point out the physiological effects of processes of disease, much less to stimulate him with any personal keenness for the pursuit of knowledge along the physiological highway. Few medical teachers like Sahli, whose clinico-physiological course is one of the most widely attended exercises in Berne, or like Krehl, whose textbook on "*Pathologische Physiologie*" is probably well-known to many of you, make a systematic effort to emphasize the physiological background of the clinical picture. Few surgeons to-day, like Kocher, Horsley and Dr. Crile, have devoted themselves extensively to the solution of clinical problems by adopting methods of physiological research. Would it not be well if what is done for the student during his clinical years in the way of instruction in morbid anatomy, and encouragement toward original work in this department of "general pathology," could with equal thoroughness be done for morbid physiology?

Although seemingly but a small factor in this direction, if the introduction of some method of instrumental estimation of blood-pressure changes in clinical cases does nothing other than serve to

[5] A lantern-slide demonstration was given of numerous plotted blood-pressure records, illustrating the reactions of many operative procedures of therapeutic measures and of conditions of disease. A single example accompanies this article.

keep the student's mind alive to the physiological principles of the circulation and to make clinical observations on the cardio-vascular apparatus more nearly in accord with his earlier experiences in the physiological laboratory, its routine use needs no greater justification.

CYTO-DIAGNOSIS: A STUDY OF THE CELLULAR ELEMENTS IN SEROUS EFFUSIONS. A PRELIMINARY REPORT.

BY PERCY MUSGRAVE, M.D., BOSTON,

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SINCE 1882 the investigation of cellular elements in serous fluids has been carried on by various observers, namely, Erlich, Quincke and others, but to Widal and his pupil Ravaut we are indebted for the knowledge gained by the systematic study of the cells in these effusions. The earlier observers aimed their investigation chiefly at the diagnosis of malignant disease, but Widal studied all the cells and their relative proportions, in order to determine the cause of effusions from serous membranes. Since Widal's original article in 1900, many observers in France have contributed to the literature of this subject. In this paper the writer will confine himself, however, to a consideration of the cellular elements found in pleural effusions.

The technique. — The technique divides itself into three operations; namely, (1) obtaining the liquid, (2) obtaining the sediment, and (3) finally making preparations and staining the sediment. Of the first it is not necessary to speak, as the ordinary methods of paracentesis commonly employed are sufficient.

To obtain the sediment, the liquid is placed in the ordinary centrifuge tubes, and centrifuged at about 2,500 to 3,000 revolutions per minute, for three to five minutes. The tubes can then be inverted, and the liquid poured off without disturbing the sediment, which is usually firmly packed at the bottom of the tube and more or less adherent. The few drops of fluid then remaining are stirred with a platinum wire, in order that a homogeneous mixture may result and the cells in the sediment be uniformly distributed throughout the small amount of liquid. This mixture is then spread on thoroughly clean cover slips by means of the platinum loop. The spreading should be done by moving the loop in constantly enlarging circles from the center outward, in order to get a uniform spread. Spreading a drop between two cover slips, as practised with blood, is not advisable, because the cellular elements are dragged to the outer edges of the preparation, and also, on account of the friability of the cells, they are apt to be more or less altered in shape and broken up.

The above procedure is entirely sufficient for making a good preparation from fluids immediately after withdrawal from the body, but, if the fluid has stood any length of time, coagulation will sometimes embarrass the operator. If coagulation has begun, the fibrinous clot will entangle many of the cellular elements, especially the polynuclear leucocytes. The simplest procedure to avoid the above difficulty is to defibrinate by shaking with small glass beads for from five to ten minutes. This causes the clot to contract, squeezing out the entangled cellular elements, and the clot itself, if not already more or less firm, will be broken up into very small particles. It is then necessary to let the liquid stand for a few moments, until most of the fibrin, at least the larger masses, have settled, and then to decant and centrifuge as before. It is therefore obvious that the sooner the liquid is centrifuged, the easier it will be to make clean preparations. However, a fair idea of the different proportions of the cells may be obtained even as long as twenty-four hours after the withdrawal of the fluid, if it has been gathered aseptically in sterilized receptacles.

The cover-slip preparations already described should not be heated in order to dry them, as this causes contraction of the film and more or less distortion of the elements, often quite well marked in cases dried at too high a temperature. These cover-slip preparations can be stained, as Widal has described, with hematoxylin and eosin, or preferably, as the writer believes, with Leichman's blood stain. If hematoxylin and eosin are used, fixation is first necessary, with equal parts of alcohol and ether. Erlich's triple stain has also been used, but the heating necessary to obtain the best results by this method alters the size and shape of the cells, and also makes a preparation which is rather difficult to decolorize properly. Wet preparations can be made in the usual way, by placing a drop between slide and cover slip. Both forms of preparations should be examined with an oil immersion lens.

Enumeration of the cellular elements per cubic millimeter has also been practiced, but is of doubtful value.

Descos, in an exhaustive article on the subject in the *Revue de Médecin* for September and October, 1902, has reviewed the work up to that date, and, following the lines laid down by Widal and other observers, has been able to give us a certain number of what he calls cystologic formulæ.

In making up these formulæ we have to consider, in the first place, the red blood corpuscles, which exist in almost all fluids, from those that are almost purely serous to those which may be regarded as hemorrhagic.

Second, the white corpuscles, the relative enumeration of which is the essential part of cystology, are found in varying numbers. All the forms of white corpuscles, with the exception of myelocytes, have been observed in serous fluids. The polynuclears do not ordinarily present any differences from those found in blood, except that they are usually smaller in size, and with Leichman's stain have the same appearances. Of the polynuclear leucocytes, we find neutrophiles, eosinophiles and mast cells. Any of these varieties may be more or less altered, depending upon the age of the fluid and the producing cause. Both varieties of mononuclear leucocytes occur. The large mononuclear cells are at times difficult to distinguish from the endothelial cells about to be described.

Third, the endothelial cells are desquamative elements, cast off from the serous surfaces. Their relative size is usually enormous as compared with the other elements found. These cells may occur