show the first and to retain the last in the interest of some nervous sufferer on a cold, wet night at 3 o'clock.

In respect of medical ethics the case is very simple. Treat and think and speak of your brother practitioners as you would wish them to treat and think and speak of you.

Medical ethics are, indeed, so completely summed up in this single sentence as to make it quite unnecessary for me to read to you the section I had written on this subject. With high aims and aspirations, with true ethical, that is to say, brotherly feeling, and with constant consideration for the public weal, we shall each and all be worthy of the well-known description in Chaucer, and be "*veray parfit practisours*," though I hope it will not be said of us, as it was of that particular one, that

His studie was but litel on the Bible.

No! we will read "*Ecclesiasticus*," though not "*Ecclesiasticus*" only, in the hope that it may be said of each of us in the words of an old poet, who was writing of a good and brave physician of his day:

He holds no parley with unmanly fears,
Where Duty calls he confidently steers,
Faces a thousand dangers at her call,
And trusting in his God surmounts them all.

After Providence, ladies and gentlemen, reason is and must necessarily be our daily guide, for which cause it is consoling to recall the words of one of the greatest of French writers:

*La Raison triomphe de la mort, et travailler pour elle,
C'est travailler pour l'éternité.*

And if I have mentioned the word *la mort* it will but afford me the opportunity of concluding with my solemn conviction, as best expressed in the words of Longfellow:

There is no death! what seems so is transition;
This life of mortal breath
Is but a suburb of the life elysian,
Whose portal we call death.

Original Articles.

A CRITICAL NOTE UPON CLINICAL METHODS OF MEASURING BLOOD PRESSURE.¹

BY WILLIAM H. HOWELL, M.D.,
AND

MR. C. E. BRUSH, JR., BALTIMORE, MD.,

From the Physiological Laboratory, Johns Hopkins University.

THE recognized importance of a means for determining accurately the blood pressure in man under varying physiological and pathological conditions, has led to the invention of a number of instruments for this purpose. These instruments, though varying in form, make use of two fundamentally distinct principles, which are illustrated in the well-known methods of von Basch and of

Mosso. The idea underlying the method of von Basch is to determine the pressure necessary to obliterate the pulse, and his instrument is simply a means for arriving at a quantitative determination of this pressure, instead of relying, as is the case in ordinary practice, upon a subjective estimate of the pressure exerted by the finger in compressing an artery. Mosso's method, based on a principle proposed by Marey, consists in increasing the pressure on the outside of an artery until the pulse wave reaches its greatest amplitude. It is evident that this latter method will give a lower valuation than the former, and it is important to determine which method gives us the more accurate indication of the pressure relations in the interior of the artery.

In considering this problem it is necessary to bear clearly in mind that the pressure in the arteries varies greatly with each pulse wave. The extent of this variation with the heart beat is greater than is usually supposed. In the carotid of the dog Hürthle found, for instance, that each heart beat increased the pressure by as much as 100%, from 80 to 160 mm. of hemoglobin. In the

experiments recorded in this paper, and made by a different method, namely, with the use of maximum and minimum manometers, such an extreme variation was found only in the case of abnormally low pressures, produced by cutting both splanchnic nerves. Under what might be called normal or approximately normal conditions, in which the mean blood pressure in the aorta was over 100 mm. of hemoglobin, the increase caused by each heart beat varied between 15 and 58% of the pressure in between the pulse waves. The average of 20 separate observations, the details of which are given in the table included in this paper, gave a difference of 33%; that is, the aortic pressure was increased 33% by each pulse wave. It is convenient, following the general usage, to speak of the pressure in the artery at the maximum of the pulse wave as the systolic pressure, and of that at the bottom of the pulse waves, or between the pulse waves, as the diastolic pressure. According to the average figures given above, the variations in the pressure in the

¹ Read by invitation at the annual meeting of The Massachusetts Medical Society, June 12, 1901.

aorta of the dog are represented graphically in the accompanying diagram. In man, with his slower pulse, the variation with each heart beat is probably greater than in the dog. The true mean blood pressure for any artery is evidently the arithmetical mean between the systolic and diastolic pressures in that artery.

It is obvious from these statements that the method of determining the blood pressure by obliteration of the pulse wave must give, if accurately performed, the systolic pressure in that artery, and this undoubtedly is the result obtained with more or less accuracy by the method of von Basch and the variations of this method used by Potain, Hoorweg, Gärtner and others. It seems equally obvious, as has been pointed out by Sahli, that the principle used by Marey of ascertaining the pressure under which the artery will give its maximum pulsations must give the diastolic pressure. A glance at the above diagram shows that when the pressure on the outside of the artery is equal to the constant diastolic pressure on the inside, the arterial walls will undergo the maximum vibration with each pulse.

This interpretation of the result obtained by the method of Marey and Mosso was not verified by them upon the living animal, and as the method has been and is being used in this laboratory in various researches, an effort has been made to furnish this experimental proof. Walden published some incomplete results that were not conclusive, and the problem was therefore again tested more carefully. The result, it may be said, is to completely verify the *a priori* probability that the method properly carried out gives the diastolic pressure.

The method used to obtain this result was as follows: The two common carotids were exposed in a dog; one of them, the right carotid, was connected in the usual way with a mercury manometer writing its record upon a kymographion. Between the artery and the manometer, however, two Williams valves were so placed as to act, one as a maximum valve, the other as a minimum valve. By means of stopcocks properly arranged, the artery could be thrown directly into connection with the manometer, or through either the maximum or the minimum valve, so that at will either an ordinary record could be obtained or a record of the maximum or minimum pressure. The left carotid was ligated high in the neck, and dissected out for as great a distance as possible. This long stump was then placed in a modified plethysmograph, so that its pulsations could be recorded, and the pressure on its outer surface could be raised or lowered at will by means of a pressure flask. In most of the experiments made for the purpose under discussion, the plethysmograph, or sphygmomanometer, as it should be called, was made of the same pattern as was used by Walden. It consisted of a conical bag of peritoneal membrane lying in a wide glass tube. The large end of this bag was reflected over one end of the glass tube, and held in by a rubber

stopper pierced by a hole through which the arterial stump penetrated. The end of the stump of the artery was tied to the small end of the bag, and was anchored by running the cord to the other end of the glass tube, where it was kept in place by the stopper. The pressure flask was connected with the outer glass tubing, as was also a recording manometer. By this means the pulsations of the stump were transmitted to the recording instrument, and as the pressure in the glass tube was raised by elevating the bottle, the loose peritoneal membrane was pressed down upon the artery. As the pressure was raised the pulsations became larger and larger until the maximum was reached, and then smaller as the pressure was still further increased. This instrument and the method of placing the artery in it need not be described in detail, as it was afterward replaced by a simpler form, which had the further advantage that it could be used upon the same artery in which the pressure was being taken directly by the mercury manometer.

The construction of this second form of sphygmomanometer is readily understood from the accompanying diagram:

A A' represents the artery which, after being tied and cut, was drawn through the apparatus as represented, and then, on the peripheral side, either tied down in its normal position and extension, or connected with a manometer to record the internal pressure directly. B and B' represent small glass tubes inserted in each end into rubber stoppers placed in the larger glass tube. The ends of B and B' were connected by a membrane tube C made of peritoneal membrane and with a diameter about three times as great as that of B B'. The large outer glass tube had two openings, D and E; one of these, D, was connected with the recording apparatus to measure the size of the pulse; the other, E, was in connection with a pressure flask. By means of this latter the outer tube and the connections could be filled with water, and then as the pressure was raised the membrane C was forced down on the artery, if need be, until the artery was completely obliterated.

The pulsations of the artery in the sphygmomanometer were at first recorded by a mercury manometer, but it was soon found that with this apparatus there might be much uncertainty as to the pressure at which the greatest pulse was obtained; the maximum was not clearly marked, especially when the heart was beating rapidly, as after section of both vagi. The difficulty obviously lay in the inertia of the column of mercury, which prevented an accurate registration of

the quickly recurring pulse waves. The apparatus was therefore changed so as to introduce a Fick spring manometer, provided with a compound lever to increase its delicacy. Both the Fick manometer and a mercury manometer were connected with the sphygmomanometer, the former to register the size of the pulse wave, the latter to register the pressure on the artery. The procedure adopted was to register the blood pressure in the right carotid in the usual way on the kymographion, as also the maximum and minimum pressures. Then on the left side the pressure in the sphygmomanometer was raised about 10 mm. at each step, and the corresponding pulse wave was measured with the Fick manometer first, and then the actual pressure by means of the mercury manometer. The pressure was noted at which the maximum amplitude of the pulse wave was obtained, and then again the pressure in the artery on the right side was determined as in the beginning. With the Fick manometer there was never any difficulty in determining the maximum pulse, and the only error of importance in the measurements lay in the fact that the steps by which the pressure was raised in the sphygmomanometer were usually about 10 mm. apart, so that a slight over or under valuation was possible. The results obtained after the method had been perfected were as follows:

	Observation.	Diastolic pressure in R. Carotid, measured by the minimum manometer.	Pressure at which the maximal pulsations were obtained in the L. Carotid, as measured by the sphygmomanometer.
Exp. VII.....	A	156.5 mm. hemoglobin	155 mm. hemoglobin
	B	156 " "	157 " "
Exp. VIII.....	A	111 " "	112.5 " "
	B ¹	129 " "	129.5 " "
	C	82 " "	81 " "
	D	93.4 " "	85 " "
Exp. XI.....	A	106 " "	109 " "
	B	110.5 " "	110 " "

¹ Animal bled profusely.

The measurements made on the two sides were practically simultaneous, and the animal was under such even conditions of anesthesia that its pressure remained constant through considerable intervals. The agreement in the pressures on the two sides leaves no doubt that Marey's method of measuring the pressure at which the greatest amplitude of pulse is obtained gives very accurately, under the conditions of these experiments, the minimum or diastolic pressure. In the dog the two common carotids spring from the arch of the aorta close to each other, so that on each side what was measured was the aortic pressure at practically the same spot. It is important, however, to emphasize the fact that in estimating the pressure in the sphygmomanometer, measurements were made to the *base* of the pulse wave in the tracing showing the maximum pulse. In the experiments made by Mosso and his pupils with his form of sphygmomanometer it is not expressly stated whether the measurements were made to the bottom of the pulse waves or not,

or whether an average was taken between the bottom and top of the pulse wave. The implication, however, is that the measurement was made to the bottom of the pulse wave, as this measurement obviously gives the amount of the external pressure. One might suppose that the maximum pulse would give the full range of pressure from diastolic to systolic, and that, therefore, measurement to the middle of the pulse wave would give the true mean pressure. Such a supposition, however, is unwarranted, as it is not certain that the mercury column accurately records the full extent of the pressure change, and moreover the tension of the walls of the arteries and the surrounding tissues will prevent the full extent of the systolic pressure from being transmitted to the water in the sphygmomanometer. The method is adapted to measure only the diastolic pressure.

Mosso's method, as used upon man, consists in putting the ends of four fingers into a plethysmograph or sphygmomanometer of special construction, and determining the pressure, brought to bear on the outside of the fingers, at which the pulsations record their greatest amplitude. While it is quite possible, in this case as in the experiments described above, to use a Fick manometer to record the pulse, the necessary calibration of the instrument introduces both a difficulty and a source of possible error. It is much more convenient to use the mercury manometer to record both pressure and pulsations. In numerous experiments in this laboratory it has been found that if the proper care is taken to have rigid connections throughout, no difficulty is experienced in getting a clear maximum in the recorded pulsations as the pressure is raised. This fortunate fact is due undoubtedly to the relatively slow pulse in the human being. If for any reason the rate of the pulse should be greatly increased, then, as in the dog, there would probably be uncertainty in the determination of the true maximum, and it would become necessary to use some form of recorder more accurate than the mercury manometer.

While the Mosso sphygmomanometer gives an accurate determination of the diastolic pressure upon the naked artery, it remains uncertain whether this same quantitative result is reached when the human finger is used. It would seem that some of the external pressure must be used in overcoming the resistance of the tissues surrounding the arteries, and that therefore the final result reached must be too great by a corresponding amount. What this resistance amounts to cannot be stated, but it is evident that in observations upon the same individual it must constitute a constant factor and therefore disappear as a source of error in comparative measurements. von Basch has estimated the resistance of the tissues at 6 to 8 mm. of mercury and Potain at 10 to 20 mm. of mercury.

Another possible source of error in this instrument has been commented upon by Brush and Fayerweather in a recent paper. It lies in the

fact that the arteries in the ends of the fingers are probably small enough to participate directly in vasomotor changes. If these arteries should be thrown into active vasoconstriction, it is evidently possible that the local pressure within them, on the capillary side of the resistance, might be smaller, while general arterial pressure was increased. The authors quoted obtained results in their experiments on the blood pressure during sleep, which they could only interpret in this way, and were therefore obliged to construct a similar instrument to measure the pulsations in the large arteries of the wrist. Hill and Barnard's simple apparatus, which makes use of the same principle as the Mosso instrument, is constructed to take the pressure in the large arteries of the arm just above the elbow, and theoretically should give the diastolic pressure in these arteries. In the experiments made in this laboratory, however, the results obtained with this instrument have been irregular and inconstant, as compared with the results from the Mosso apparatus. This unfavorable result may be due to a want of delicacy in the recording apparatus, arising probably from the fact that much of the pulse is lost by the air transmission and the elastic walls of the bag and tubing.

The Mosso apparatus as arranged for the fingers is perhaps too complex for ready clinical use, but under the favorable conditions of the laboratory it can be used with facility, and apparently with reliable results as regards the diastolic pressure. It is generally assumed, however, that it is more desirable to know the mean pressure, and an effort was made to ascertain whether the Mosso instrument can be used for this purpose. The idea was that by raising the pressure in the Mosso sphygmomanometer to the point of complete obliteration of the pulse the systolic pressure would be obtained, and that by taking the arithmetical mean of this and the diastolic pressure, the true mean pressure would be given.

To test this point experiments were made upon the dog's carotid in the following way: One carotid was passed through the sphygmomanometer before described, and fastened securely on the other side in its normal extension; the carotid on the other side was connected directly with a mercury manometer provided with maximum and minimum valves. On one side the pressure was raised in the sphygmomanometer until the pulse was just obliterated, while simultaneously the maximum or systolic pressure on the other side was measured directly. It was found that the sphygmomanometer gave a reading of 184.5 mm., while the maximum manometer showed that the greatest pressure at that time in the arteries was only 156 mm., giving a discrepancy, therefore, of 28.5 mm. Part of this may be accounted for by the pressure necessary to overcome the rigidity of the walls of the artery, but according to all measurements this factor could not account for the entire difference. It would seem that even after the artery in the sphygmomanometer is completely obliterated, the pulse waves may still be recorded.

We may suppose that each sharp wave of pressure striking against the partially obliterated lumen at the entrance to the sphygmomanometer, or by giving a thrust to the artery, registers some pulsation. In other experiments which were made with the artery lying somewhat loosely in the sphygmomanometer, the pressure necessary to obliterate all pulsation in the instrument was 100 mm., and more above the true systolic or maximum pressure.

This interpretation of the too high result obtained with the sphygmomanometer was strengthened by a series of experiments in which the sphygmomanometer was placed on the left carotid, and the same artery on the peripheral side of the instrument was then connected with a mercury manometer provided with a maximum valve. The pressure in the sphygmomanometer was raised until no pulse got through to be recorded by the mercury manometer beyond. It should be added that to determine the point of disappearance of the pulse the float and pen were removed and the oscillations of the mercury were determined by the eye. As soon as the pulsations disappeared the pressure in the sphygmomanometer was noted, and then at once reduced to zero, and a reading made of the maximum pressure within the artery by means of the maximum valve.

The following results were recorded:

	Maximal or systolic pressure.	Pressure in sphygmomanometer at which no pulse could pass through.
Experiment XI.	157.5 mm.	162 mm.
XII.		
Observation I.	157 mm.	171 mm.
" II.	160.5 "	180 "
" III.	158 "	172 "
" IV.	158.5 "	171.5 "
" V.	164 "	173 "

In the first experiment the difference between the two readings is 5.5 mm.; in the second experiment, omitting Observation II, the difference varies between 9 and 14 mm. This difference is small enough to be accounted for by the extra pressure necessary to overcome the stiffness of the arterial walls. The dog in the second experiment was much larger than in the first, and his carotid was correspondingly larger and thicker walled. von Basch has estimated that in the human radial artery a pressure of 1 to 5 mm. hemoglobin is required to close the empty artery. The results given above indicate a greater rigidity in the case of the dog's carotid. It is quite evident from these experiments that the Mosso apparatus or similar plethysmographic contrivances cannot be used to measure the systolic pressure, a conclusion which has already been announced by Marey and by Colombo. The latter found that in individuals in whom the arteries in the fingers are relaxed, and give therefore a large pulse, the outside pressure must be raised to as much as 340-360 mm. to obliterate all pulsations.

The method of determining the arterial pressure in man by obliterating the pulse, according to the procedure employed by von Basch, Potain and

others, should give approximately the systolic or maximum pressure in the artery examined. This *a priori* conclusion has been verified experimentally by Potain with the aid of an artificial schema, and the experiments described above may be taken as a further verification of its substantial accuracy. Under all conditions, however, methods of this kind must give a somewhat supramaximal result, since some excess above the true maximum is required to overcome the rigidity of the walls of the artery. This factor, according to von Basch, is small for arteries of the size of the radial or temporal in man, but all criticisms of the method of von Basch, and the various modifications of it proposed, unite in showing that several sources of error combine to give a reading higher than the true maximum, so that Tigerstedt concludes that the error in the readings may vary as much as 32 to 78 mm. hemoglobin, a variation obviously too large for reliable results. These instruments have therefore not come into general use. The recent apparatus devised by Gärtner is, however, so ingenious, and withal, so simple and easily applied, that we may assume that it will be used very commonly in clinical work. The principle involved in the instrument is the same as in the method of von Basch. The end of the finger is made anemic by a rubber cap or ring, and the arteries are then blocked completely by a supramaximal pressure applied to the circumference of the finger through air pressure. As this pressure is gradually lowered a point is reached at which the blood stream breaks through and flushes the tip of the finger. Outside the attractive simplicity of the apparatus, the method differs substantially from that of von Basch in that the obliteration of the blood current, or rather the moment at which this obliteration is just overcome, is judged by the eye instead of by the sense of touch.

Evidently the theoretical considerations that apply to the von Basch instrument hold good in the main for the Gärtner. Gärtner himself contends that his instrument gives the mean pressure, but the experimental evidence that he offers is singularly inconclusive. It is quite possible that the blood pressure taken in the finger by the Gärtner tonometer might approximate the mean pressure, if it should so happen that the blood current did not break through the block promptly for some reason, such as the adhesion of the compressed arterial walls, but such an approximation would be accidental and uncertain. The probabilities, on the contrary, are that the figures obtained will be if anything higher than the systolic pressure, owing to the action of the same factors that bring about this result in von Basch's instrument; namely, the elasticity of the arterial walls, the resistance of the soft tissues surrounding the vessels, and the utilization of the velocity increment of the flowing blood. This probability is confirmed by the high figures reported for the arterial pressure in the finger when determined by this method, and also by the comparative experiments of Federn. This latter observer, using both the Gärtner tonometer and the von Basch

sphygmomanometer, reports that the former gave always the higher values. He attributes this result to a vasomotor effect arising from the process of making the finger tips anemic. It seems evident, therefore, that the Gärtner apparatus must be regarded as giving approximately the systolic pressure within limits of error not accurately determined, and that probably the result is always in excess of the actual figure. The experiments recorded above on the naked carotid artery of a dog, in which the outside pressure was determined at the point at which the pulse just ceased to record in the artery beyond the block, corroborates this point of view. It will be remembered that the pressure thus obtained was in excess of the systolic pressure by 5 to 14 mm. according to the size of the artery.

From the facts presented, therefore, we must conclude that of the two principles that have been used, one gives approximately the diastolic pressure, the other the systolic pressure. The arithmetical mean of the results of the two methods should give approximately the mean pressure. If either instrument is used alone it becomes a question as to which result gives the most important indication. To throw some light upon this question, a number of experiments were made upon dogs in which the diastolic and systolic pressures were determined directly, by means of maximum and minimum manometers, under varying conditions that influenced either the heart beat or vascular tone.

The results are presented in the accompanying table:

Observation.	Diastolic pressure.	Systolic pressure.	Mean pressure calculated.	Mean pressure directly determined by mercury manometer.	Rate per minute.	Amplitude.
Exp. X.	mm.	mm.	mm.	mm.		mm.
I.....	133	159	146	142.75	96	2.4
II.....	132	167	149.5	144.92	96	1.75
III.....	174	201.5	187.75	183.87	210	2
IV.....	172	199	185.5	182	210	2
Exp. XI.						
I.....	100	156	128	127.49	114	9.83
II.....	108	156	132	129.2	120	8.4
III.....	161	196	178.5	177.4	153	5.6
IV.....	165	245	191.5	185.46	132	6.9
V.....	133	180	146.5	141.69	132	4.81
VI.....	124	158.5	141.25	145.45	126	4.85
Exp. XII.						
I.....	112.5	158.5	135.5	133.35	87	17.35
II.....	111	159	135	133.5	84	17.7
III.....	110	157	133.5	133.77	84	16.87
IV.....	112	155	135	136	82	13.40
V.....	113	155	134	138.03	84	17.17
VI.....	129	140	134.5	134.5	234	1.25
VII.....	128	140.5	134.25	136	234	1.25
Exp. XIII.						
I.....	143	226	184.5	182.86	153	8.5
II.....	144	216	178	169	162	8.5
III.....	226	272	249	232.5	174	10
IV.....	188.5	258	223.25	226	171	10
V.....	101	187	119	124.75	162	5.25
VI.....	37	68.25	52.62	47.33	162	3.7
VII.....	36	70	53	51.75	162	3.7
VIII.....	35	71	53.25	53	162	4
IX.....	38.5	74	56.25	50.82	162	4
X.....	41	79	60	52.82	162	3.9
XI.....	45.5	78	61.75	57.24	162	3

* Severed both vagi.

* Severed both vagi.

* Severed vagi, and bled profusely.

* Severed both vagi.

* Severed left splanchnic.

* Severed right splanchnic.

An examination of the table seems to justify the following conclusions:

(1) The mean blood pressure as usually determined by means of the mercury manometer, corresponds with fair accuracy to the arithmetical mean of the maximum and minimum pressures.

(2) A rise of blood pressure occasioned by an increased heart beat (section of both vagi) affects the diastolic pressure to a greater extent than the systolic pressure.

(3) A fall of blood pressure occasioned by vascular dilatation (section of both splanchnics) affects systolic and diastolic pressures equally. In the section of one splanchnic, as will be seen from the table, the fall in pressure affected the systolic more than the diastolic pressure, but in this case the heart rate was also affected, whereas section of the second splanchnic did not affect the heart rate at all. The physical effect of a purely vascular change would seem to be shown best under the latter conditions.

(4) It is possible for the systolic and diastolic pressures to be affected in opposite directions, as is seen in Exp. XII, in which section of both vagi was intentionally accompanied by a profuse hemorrhage. In this case the mean pressure remained

unchanged, the diastolic pressure rising 16 mm. and the systolic pressure falling 15 mm.

It is desirable, of course, that these experiments should be extended to include a larger number of conditions. As far as they go they indicate that the general trend of arterial pressure, even under extreme conditions of cardiac or vascular changes, so long as these changes are not accompanied by hemorrhage, is given by instruments measuring either the systolic or diastolic pressure. Whether one or another form of instrument is used is a matter of convenience and accuracy. When possible it is most desirable that the results of one method should be checked by the other. As between the Gärtner and the Mosso instruments the former is by far the simpler, but the latter if properly used is probably more sensitive and exact. It is perhaps needless to add that neither instrument can be used successfully for comparative results without careful attention to details.

Many writers have emphasized the desirability of an instrument to measure mean pressures, but to the present authors the special importance of such an instrument seems doubtful. In the circulation the pulse wave disappears in the capillaries. At this point in the circulation, therefore, the systolic pressure, diastolic pressure and mean pressure all coincide. The relations of the three factors

may be represented in principle by such a scheme as shown above.

For comparative purposes it would seem to be a matter of indifference which of the three factors is known at any given point in the arterial system, provided the method used can be shown to give reliable results. For purposes of analysis and accuracy it would be much more desirable to have parallel records of the variations in systolic and diastolic pressure than a single record showing simply the mean, even if the latter measurement was possible. In our ordinary laboratory experiments we follow the latter plan, to be sure, but we would gain a much clearer insight into the details of vascular changes under varying conditions if the ordinary manometer record was supplemented by maximum and minimum tracings.

In the use of the Mosso apparatus on man the experience acquired in this laboratory shows that the following precautions are perhaps the most important for good results:

(1) All connections between the recording manometer and the sphygmomanometer should be rigid and inextensible to prevent loss of pulsations.

(2) The fingers should be warmed before placing them in the apparatus, or, as is our usual custom, the first water driven through the apparatus to remove the air should be very warm.

(3) If the heart beats are so rapid as to give an uncertain maximum, it is necessary to employ a spring recorder of some kind.

(4) The first results upon any individual are usually too high, owing doubtless to the psychical factor. Lower and more constant results are obtained when the subject has become accustomed to the procedure and is in a relaxed condition.

(5) In comparative observations the hands should always be at the same height to equalize the hydrostatic factor.

With the Gärtner tonometer the precautions just mentioned (4 and 5) are equally important. In addition, care must be taken in comparative observations to place the pressure ring on the same part of the finger; when over the joints of the phalanges, lower pressure may be obtained than when between the joints. Some attention must be paid also to the initial pressure in this pressure ring,—it is well in successive observations to start with initial pressures that are approximately equal. Finally, those who make serial observations upon human beings with these instruments, under normal or pathological conditions, must bear in mind the important fact, noted in a preliminary communication by Dr. Clelia D. Mosher, that in both men and women there are periodic oscillations of arterial pressure.

THE GRATWICK RESEARCH LABORATORY.—The Medical Department of the University of Buffalo, according to *American Medicine*, is in receipt of a gift of \$50,000 for the purpose of erecting a laboratory to be devoted entirely to research work. It will be known as the Gratwick Research Laboratory.