SOME CLINICAL ASPECTS OF ARTERIAL PRESSURE

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I esteem it a great privilege to have been asked to give a short address on "Arterial Pressure," a subject which, by reason of its widespread ramifications and recent developments, becomes of ever-increasing interest and importance, and I trust that you will prefer a practical issue, such as that which I have chosen, to a more profound or abstract theme. The more we study arterial pressure, the more we find it of the greatest service in daily practice. The aspects of it are, however, so manifold that I cannot do more than to attempt a brief synopsis of the most salient features.

DEFINITIONS OF BLOOD-PRESSURE.

At the outset it is essential to have a clear understanding of the terms that we employ. What, then, do we mean when we speak of "blood-pressure"? In the physiological sense not only does this term include arterial pressure, but also pressures which are intra-auricular, intra-ventricular, capillary and venous. In the physical sense blood-pressure is that pressure which the blood exerts at a given instant upon a given point in the circulatory system. In the clinical sense "blood-pressure" is loosely used in everyday language as implying solely arterial pressure, and sphygmomanometric readings, expressed as a set of figures representing the height in millimetres of a column of mercury or the equivalent in instruments calibrated from that source, constitute the generally accepted measure. In the pathological sense we have to deal with arterial pressures which may be either abnormally high or abnormally low.

Measurements of Arterial Pressure.

We measure arterial pressure with instruments, primarily to assess the efficiency or otherwise of the circulation, so as to gain an estimate of the nature of each problem with which we have to deal, and secondarily to glean other indications which are both psychical and physical. Personally, I find no instrument so reliable as an accurately-constructed mercurial manometer, such as the "Baumanometer," though general prac-
tioners often prefer a small dial sphygmonomanometer on account of its compactness and portability.

**Methods of Estimating Arterial Pressure.**

The four chief methods of estimation are: (1) Tactile. (2) Vibratory. (3) Oscillatory. (4) Auditory.

By the *tactile method* one notes cessation and return of the pulse by palpating the radial artery in the fore-arm whilst the brachial artery in the arm is undergoing compression. As usually practised, however, this method is inexact, and gives readings which are too low, as you will readily appreciate if you remember that the systolic pressure gradually falls whilst the diastolic pressure gradually rises from the level of the brachial artery to that of the radial. Nevertheless, this method is useful as a check on the auditory reading, which should never be lower than that of the tactile, although it is frequently higher.

The *vibratory method* is really a modification of the tactile one, and serves as a more effective check, since, by light palpation of the brachial artery below the point at which one listens, the thuds of the third sound phase are perceived by the finger as vibrations which cease after the last loud thud, thus denoting with accuracy the diastolic index.

The *oscillatory method* is possible only with delicate laboratory instruments writing with levers, and with clinical aneroids, in which the oscillations of a fine needle record various pressure heights on a dial. In difficult cases the oscillatory method affords valuable help.

The *auditory method* is the quickest, simplest, and most accurate yet devised, and is the one which I favour, with the brachial vibratory method, if required, as a check, or, should the brachial artery be deepseated, the radial tactile method gives a fair approximation if a correction for the diastolic figure be made by the addition of 5 mm. Hg. to the reading.

So much misapprehension exists as to the correct way in which an arterial pressure reading should be taken that, at the risk of appearing elementary, I propose briefly to outline the principles and practice of the auditory method, which is applicable to any modern type of instrument:

1. The patient’s arm, which is bared, should be allowed comfortably to lie with muscles relaxed upon a convenient support of such height that the armlet is on the same level as that of the heart.

2. The armlet should be evenly applied to the arm as high up as possible, so as to bring the lower margin well above the bend of the elbow. The middle of the pressure-bag should lie over the inner side of the arm, so as to ensure effective compression of the brachial artery.

3. Distract the patient’s attention by noting with the finger the rate and characters of the radial pulse.

4. Apprehensiveness on the part of a sensitive patient may be allayed by explaining that the band round the arm will tighten for a minute or so, but that this temporary pressure is quite harmless.

5. Rapidly inflate the pressure-bag to the level of about 110 mm. Hg.

6. Place the bell of the stethoscope over the brachial artery, just above the bend of the elbow on the inner side of the biceps tendon, when in the majority of cases loud thuds will be audible as the blood passes through that portion of the artery which is partially constricted by the armlet.

7. Quickly raise the pressure still further until all sound disappears.

8. Slowly open the release valve, noting accurately either the height of the mercury column or the figure on the dial at which the first definite click is heard. The first audible click on decompression following obliteration indicates the systolic pressure.

9. As the pressure is allowed gently to fall, the first one or two sharp clicks are succeeded either by a murmur phase of variable duration or by a longer phase of
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Clear sonorous thuds, which gradually reach a climax of intensity, finally becoming dull and muffled before total disappearance. The first dull sound following the last loud thud denotes the diastolic pressure. Hence the full sequence of sounds in a descending pressure are successively clicks, murmurs, thuds, dull sounds, silence. Such are termed the five phases of sound, and the points at which one phase becomes succeeded by the next are termed the five points of sound.

(i) The pressure is next allowed to fall to zero in order to permit any venous stasis to disappear in the compressed limb.

(ii) The first estimation should be regarded as a trial shot, and should be followed by at least two successive readings. Each complete estimation should not take longer than two minutes.

(iii) The third reading may usually be taken as the patient's basic or residual pressure, i.e., the lowest constant pressure reading, which is what one desires to record.

The figure obtained on the third reading can most easily be recorded in the case notes by the adoption of what I have termed "The complete arterial pressure picture," which includes:—

1. The figure for the systolic pressure.
2. The figure for the diastolic pressure.
3. The figure for the differential (pulse) pressure.
4. The rate and characters of the pulse.
5. The product of the differential pressure multiplied by the pulse-rate.

Thus, one obtains the following simple and compact formula:

\[
\frac{S}{D} \times D.P. : P.R. \times D.P. \times P.R.
\]

E.g. [140: 50 : 80 : 4,000]

All comparative observations should be carefully made in a comfortably warmed and silent room, with the patient's limb in the same relative position of rest; as far as possible at the same time of day, preferably midway between meals, on the same limb and with the same type of instrument, all psychical disturbance being brought to the irreducible minimum.

**Importance of the Diastolic Pressure.**

If we take any set of pressure figures, and upon these superimpose the corresponding pulse tracing, we shall then be able to infer that the left ventricle propels the blood in a series of rhythmic waves, the base of each wave corresponding to the minimal or diastolic pressure which exists during the resting time of the heart, whilst the crest of each wave corresponds to the maximal or systolic pressure which occurs during the contractile phase of the cardiac cycle. Arterial pressure, therefore, from respiratory, psychical or other causes may fluctuate widely and rapidly, especially at the systolic end of the scale, both in health and disease, even during the time of investigation. Hence the maximal and minimal levels between which arterial pressure rises and falls are in every case the important criteria we have to determine.

In the past attention has been directed solely to the systolic pressure, whilst the diastolic has been omitted, and even nowadays the majority of doctors when asked, "What is the patient's blood-pressure?" will give in reply a figure, e.g., 160 mm., at which they have arrived as the result of their investigation with some or other form of sphygmomanometer. Such approximation, whilst obligatory with older forms of instrument which were incapable of registering accurately the diastolic pressure, in the light of modern methods cannot be regarded as either clear or comprehensive. In other words, arterial pressure can never be regarded as an entity characteristic of the individual. One should never say, for example, that a given patient has "a blood-pressure of 160," for by thus limiting our vision to the systolic end of the scale we neither gain nor convey information of any appreciable value. If we wish to assess the state of the circulation, it is not sufficient merely to record the variable systolic
pressure whilst ignoring the far more constant diastolic, for such procedure resembles an attempt to solve a complicated equation of which only one factor is vouchsafed.

Let me illustrate this by the records of two actual cases. One, a case of aortic regurgitation, yielded a systolic pressure of 220 mm. Another case of granular kidney gave a systolic pressure of 180 mm. From these figures alone one would say that in the aortic case, owing to the higher pressure, the heart and arteries were subjected to greater stress than those of the case of granular kidney. But records of the diastolic pressure present quite a different point of view. The diastolic pressure of the aortic case was 60 mm., whilst that of the renal case was 140 mm., i.e., the arteries of the renal case were continuously kept on the stretch by a pressure of 140 mm. (which during systole rose to 180 mm.), whilst the diastolic pressure of the aortic case was 60 mm., i.e., less than half this amount, and it was solely during the brief interval of time represented by the upper part of the sharp systolic peak that the pressure reached a notable elevation. During diastole the arteries were far less stretched than normally. From a consideration of the above I hope to have made it clear that any conclusions as to prognosis or treatment based on systolic readings alone should be received with the greatest caution, since they are more likely to mislead than to help.

**Standard Arterial Pressures.**

(a) Differential Pressure.—I approach the subject of standard (i.e., normal, non-pathological) pressures from a different angle to the one usually adopted, so that thereby you may gain a clearer insight into pathological departures from these standards. First, let us consider the differential or so-called “pulse” pressure. This is not a real pressure, but the difference between the systolic and diastolic pressures. Nevertheless, it is of great value, since it forms a measure of the cardiac load. In adults of medium physique, from 20 to 55 years of age, the physiological range of differential pressure is from 30 to 55 mm., the standard for these ages being practically a constant figure of 44 mm. Any notable deviation implies that the load of the heart is either diminished or augmented, and one is thus enabled to draw important deductions.

(b) Diastolic Pressure.—This is the measure both of peripheral resistance and of vaso-motor tone and, as I have already indicated, is more valuable than the systolic reading, in that it is Marey’s "constant" element in arterial pressure, the transitory systolic elevations which constitute the pulse representing only an intermittent and superadded load. Standard diastolic pressures at age 20 may be taken as being 80 mm., thereafter increasing for each successive period of five years by 1 mm. up to age 60, at which age the standard diastolic pressure is 88 mm.

(c) Systolic Pressure.—The systolic pressure represents the greatest energy of which at a given moment the heart is capable, the height attained being modified by the degree of peripheral resistance. Systolic pressures vary within wide limits, apart from disease, in response to the activities and needs of the body. They are raised by psychical stimuli and by exertion, and are lowered by rest and fasting. Initial rises may occur as the result of food, alcohol and tobacco, to be succeeded by a fall, which also ensues when fatigue supervenes upon excessive exercise.

**High Arterial Pressure.**

I come now to high arterial pressure, and submit that the simplest way of attacking the problem is to regard hyperpiesis as including all types of raised arterial pressure, whether physiological or pathological, temporary or permanent, renal or non-renal. Subdivisions of this main heading fall naturally into two groups, hyperdynamia and hyperachthia. Hyperdynamia represents increase in driving force of the heart and great arteries from any cause (central
force), whilst hyperachthia represents peripheral increase of resistance from any cause (increased load). In physics all pressures are expressed in terms of force and load, and you will thus be able easily to appreciate how this simple classification of mine falls in with Gallavardin’s definition of arterial pressure in general as a force originated by ventricular contraction, maintained by the reaction to distension of the arterial walls, and regulated by the degree of resistance in the terminal portion of the arterial system.

For the sake of simplicity one may now take out of the high-pressure group the syndrome to which the late Sir Clifford Allbutt gave the name of hyperpiesia. This is a malady of considerable interest and importance in that it possesses individual features. Becoming manifest between the ages of 40 and 60, heightened systolic pressures of 160 or more and diastolic pressures of 100 or more occur as constant phenomena in association with left ventricular hypertrophy and changes in the vessels recognizable at autopsy as a diffuse hyperplastic sclerosis (G. Evans), but distinguishable on the one hand from evidences of renal sclerosis, and on the other hand from those of senile or decrescent atheroma. From renal sclerosis hyperpiesia is differentiated by its occurrence in robust and healthy-looking, often indeed plethoric, subjects, who for years may complain of no disability. Blood-urea is usually within normal limits, or only slightly in excess, and the urine shows at most only slight traces of albumin. Cerebral haemorrhage or cardiac defeat are the most frequent terminal events; uraemia is uncommon.

In hyperpiesia a heart-weight of 15 oz. is a common post-mortem finding. Death is likely to result from coronary atheroma with secondary myocardial changes, or from some intercurrent affection.

Senile atheroma does not generally show itself until about the age of 60, the arteries being tortuous and of all degrees of hardness up to the “pipe-stem” variety. Nevertheless, the arterial pressure is frequently not raised, nor does cardiac hypertrophy ensue to any marked extent.

Associations.—In any consideration of hyperpiesis it is essential to recognize its associations, and the only effective method of studying pure hyperpiesis is to begin with its manifestations as they occur in early life before degenerative processes have supervened. In children and adolescents, as well as in later life, there is one association, however, which is not degenerative. This is: (1) Hypertonia. Hypertonicity of the arterial wall is capable of producing either a temporary angiospasm, or, when true hypertrophy of the smooth muscle elements has followed, a permanent hyperpiesis. (2) Arteriosclerosis, and (3) Nephrosclerosis constitute the true degenerative changes of association.

Thus, from the foregoing you will observe that in the first place I have laid before you a classification of hyperpiesis based on fundamental physical laws, and secondarily, have linked with this its associations, in the hope that by tracing out the origins and course of hyperpiesis in such manner you will be enabled to differentiate the cases met with in daily practice.

Symptoms—High arterial pressure, as already noted, may in its earlier progress be symptomless. Subsequently the following subjective sensations in order of frequency may be encountered: Fullness, heaviness or pressure feelings in the head, aggravated by mental effort; dizziness; palpitation and precordial pain, amounting at times to angina; dyspnoea on exertion; drowsiness and disinclination for effort; impaired memory and concentration; irritability; insomnia; throbbing noises in the head, especially when recumbent; anxiety states with vague fears of impending disaster; gradual failure of vision or sudden blindness; neuralgia; migraine; epistaxis or haemoptysis.

Most of these symptoms are in reality
those of the associated conditions and are none of them pathognomonic.

Diagnosis.—Diagnosis should be based on family history, especially of rheumatism, gout, syphilis or alcohol; on personal history, not forgetting inquiry into antecedent infections, such as syphilis, occupation, habits of diet and sleep, emotional factors and worry. Next, a systematic examination of the patient should be made, particularly of the cardiovascular system, including the use of the sphygmomanometer. Ophthalmic investigation and tests of renal efficiency complete the examination.

Differential Diagnosis.—Always bear in mind that arterial pressure varies directly with body weight. Firstly, exclude the presence of syphilis. Secondly, determine by repeated tests whether a rise or fall in pressure is transitory or persistent. A few days in bed clears up transitory nervous forms. Thirdly, differentiate hyperpiesis from hyperpiesis and hypertension due to chronic renal diseases by blood-urea and renal efficiency tests; in chronic nephritis blood analysis shows a rise in the non-protein nitrogen, urea nitrogen, urea, uric acid, creatinine and indican, progressively with the severity of the condition. Normal figures for non-protein nitrogen are from 25 to 40 mg. per 100 c.c. blood. In advanced nephrosclerosis far higher values, even up to 400 mg., may obtain. In uræmia urea accumulates disproportionately to the other nitrogenous substances, so that urea nitrogen may rise to 75 per cent. of the total non-protein nitrogen. Ammonia nitrogen remains about normal, whilst the alkali reserve of the blood is more diminished in nephritis than in any other disease, and may fall to ten volumes, or in extreme cases to four volumes. My own observations so far show that arterial pressure bears no constant relation in height to blood viscosity, blood nitrogen nor blood cholesterol, although Heitz states that he has met with the highest cholesterol content in cases of extremely high systolic pressure with high diastolic pressure, and in renal disease even with a low arterial pressure. Basal metabolism is always raised, except in syphilitic aortitis.

Ætiology.—The causation of hyperpiesis is not yet settled. Hereditary and familial influences undoubtedly play a part, as also do protective and mechanical factors, but even so the majority of cases still require further explanation, which in my judgment is afforded by toxæmia, either induced by irritation of bacterial toxins, or by intoxication of endogenous or exogenous nature. It is probable that such toxæmias do not become operative in raising arterial pressure unless some basic disturbance of structure or of metabolism is present, most low pressures being associated with errors of assimilation, and most high pressures with errors of elimination. Thus, a hypo- or hypertonia may induce a corresponding secondary hypo- or hyperpiesis. It is well-known that in certain renal affections hyperpiesis, either transient or permanent, coincides with the bacterial infection or with the intoxication which induces the acute or chronic nephritis. Does hyperpiesis follow upon arterial changes or nephritis, or do arterial changes and nephritis follow upon hyperpiesis?

Consequent upon Aschoff's findings that at or about middle age the intima of arterioles begins progressively to degenerate, it has been suggested that the initial changes of hyperpiesis begin as an atherosclerosis of the lesser arterioles in various organs, and that these degenerative processes inherent to the individual promote as a compensatory measure a rise in arterial pressure. Such hypothesis, however, cannot be said to cover more than a small portion of the whole field, and there is considerable evidence to show that hyperpiesis is by no means entirely due to arterial degeneration. Similarly, only in greater degree, I hold that it is requisite for the advocates of a renal causation to prove their case.

Prognosis. — Speaking generally a fair
prognosis may be given as far as the middle stage, and often at the menopause, particularly in those patients with endogenous obesity. When cardiovascular symptoms are apparent, prognosis should always be guarded. High diastolic and differential pressures are invariably of serious import as frequently indicative of hyperpiesia or renal defect. A low systolic with a high diastolic pressure suggests cardiac inadequacy, whilst low systolic and low diastolic may denote either a simple low arterial pressure with diminished reserve, or may point to grave cardiac dilatation with lessened hyperachthia which, if unchecked, spells cardiac defeat.

**Control.**—I prefer to speak of control rather than of treatment, since it is not in every case that treatment is required. What, then, are the general principles of control? To this I would say that each case must be dealt with on its merits, for each presents its own peculiar problems. Every person has a range of arterial pressure within which he or she feels most at ease, and should the pressure be raised much above or fall much below these limits, discomforts or even actual distress may be experienced.

(a) The Hyperpetic Group.—A certain degree of hyperpiesia may be compensatory, and, in the absence of symptoms, does not call for attempts at reduction, the aim being to prevent further rise. Early and temporary hyperpiesia can generally be relieved by clearing up infective processes or toxic agencies, whether general or alimentary, and by correction of wrong habits of life. Diet, bowels and exercise should be regulated, and intake of food and fluids restricted; seasoned and re-cooked dishes, alcohol, strong tea and coffee should in general be forbidden. Foci of infection should be sought for and treated, particular attention being paid to the gastro-intestinal tract. Pyorrhœa, septic teeth, affections of the tonsil, gall-bladder, appendix and caecum should all be appropriately dealt with in like manner with those of the nasal sinuses and antra, and the pelvic viscera. Adverse psychical influences should be as far as possible eliminated, and mental and physical repose aimed at. Less work, regular hours and greater rest often work wonders: in fact, rest in bed on low diet at the outset of control will often have a prolonged effect in reduction of supernormal pressures, especially in nervous subjects.

(b) The Cardiovascular Group.—Here we are in the presence of very high pressures as a rule, a systolic of frequently well over 200 mm. with a proportionately less raised diastolic. Such persistently raised pressures are usually indicative of activity of atherosclerotic processes. Certain of these patients eat and drink too much, thereby getting into a condition of excess metabolism, and should be warned as tactfully as possible against any tendencies to excess. Exercise should be moderate, and all over-exertion avoided. Rest in bed, especially if the heart is working against excessive strain, is of great service in combination with eliminatory measures. Flatulence should be alleviated with wood charcoal together with magnesium carbonate and beta-naphthol. For atherosclerosis with cardiac weakness and premature contractions, no remedy is so effective as a compound pill of 1 gr. each of mercurial pill, digitalis and squill, with 2 gr. of extract of hyoscyamus.

(c) The Renal Group.—The renal group suffers from defective elimination, especially of nitrogenous waste products, and attempts to lower the heightened pressure so essential to maintain renal activity are not only ineffective but absolutely harmful. A quiet life, an equable climate, a warm and dry house, an unstimulating diet, light but warm clothing, are all advantageous. Elimination must be fostered, through the skin by hot-air or water baths, through the bowels by saline cathartics, and through the kidneys by limitation of strain upon them. It is a vexed question as to whether the kidneys can or should be flushed out, but my own experience is in accord with those spa
physicians who maintain that mineralized eliminant waters, such as those of Harrogate and Cheltenham, do good, whilst diuretic calcium waters, such as those of Bath and Buxton, are of service in plethoric, sedentary, and constipated types, as well as in some pale, thin, and nervous subjects.

As regards control in general, the idea that a high pressure must immediately be lowered by active drugs is wrong, and leads to drastic attempts to reduce it by means of nitrates, which, as I have said elsewhere, "in action are evanescent, and in removal of the underlying causes are futile. The opposite view that nothing can be done to relieve high pressures is equally erroneous."

Touching diet, my own belief is that far more benefit accrues from diminishing the total food intake to the minimum metabolic needs of the body than by rigid restriction of protein. Apart from cases in which renal elimination is at fault, ingestion of protein has little effect on arterial pressure. Similarly for salt, which in simple hyperpiesis does not raise the pressure, but is best avoided in cardiac, cerebral, or renal affections. Plenty of fresh fruits and vegetables should be given, always remembering that a well-balanced vitamin content is the important end at which to aim.

Diathermy and ultra-violet radiation have their appropriate uses. Lumbar puncture is of service in threatened or actual cerebral hæmorrhage, severe headache or uræmic convulsions, whilst in renal disease, venous stasis, and acute pulmonary òedema, rapid vena-section to 300 c.c., or more rapidly, brings down heightened pressures by 5 to 30 mm., the effect being maintained for a longer period by starvation for twenty-four hours.

Within the compass of a short paper one can but skim lightly, as it were, over the surface of a vast ocean, and, although fain to dive deeper beneath the surface, one can but take a bird’s-eye view of the numerous rocks and shallows and trust that, in spite of baffling winds and cross-currents, one may yet succeed in reaching shore.
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Postgrad Med J 1929 5: 7-14
doi: 10.1136/pgmj.5.49.7

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