CASUAL AND BASAL BLOOD PRESSURES

IV. THEIR RELATIONSHIP TO THE SUPPLEMENTAL PRESSURE WITH A NOTE ON STATISTICAL IMPLICATIONS

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In an article entitled *Casual and Basal Blood Pressures in Essential Hypertension* (Alam and Smirk, 1943, b), two statements were made in the discussion upon which it is desired to offer further evidence.

1. " It seems desirable to regard the casual blood pressure as made up of two parts, namely, the relatively stable basal blood pressure and a variable supplemental pressure. The supplemental pressure is the part of the casual blood pressure that is elevated as the result of the patient's physical, mental, and emotional activity, chiefly the latter; the elevation of the basal blood pressure in essential hypertension requires some other explanation." This statement that the supplemental pressure varies and the basal pressure is relatively constant refers, as is indicated in the last sentence, to the individual and not to comparisons between different individuals. Measurements of the basal pressure, whatever technique be adopted to obtain it, aim at removing these known causes of variation and at measuring a pressure that has been obtained under standard conditions of mental and physical rest. There is a high probability, therefore, that basal readings obtained under standard conditions will be more constant for the individual than casual readings taken under a variety of conditions. This has now been shown, experimentally, by Kilpatrick.

2. " The lability of the blood pressure in a case of essential hypertension may be judged by the degree of difference between the casual and basal pressures." In Fig. 4 of the paper referred to above the relationship of this difference, which we call the supplemental pressure, to the casual and basal pressures is set out graphically. It was suggested by the authors that the patients with the higher supplemental pressures are in general those with higher casual blood pressures, but their basal pressures are no higher than those of essential hypertension patients with lower supplemental pressures.

The object of the present paper is to describe some further observations that confirm the views previously expressed as to the relationship of the basal and supplemental pressures in essential hypertension, to study this relationship in health, to rediscuss the conditions under which the basal blood pressure should be measured, and to make reference to the significance which this conception has in relation to the statistical analysis of the ordinary casual (clinical) readings of the blood pressure. The opportunity is taken of referring to a comment by the editor of the *British Heart Journal* upon a statement in a previous paper (Alam and Smirk, 1943, b), which was to the effect that our results shown in Fig. 4 did not seem to support one of our conclusions.

The basal and supplemental pressures have a practical importance which should make their separate determinations a matter of clinical routine in certain classes of patient.

METHOD

Measurements of the casual and basal blood pressures were made in healthy men and in patients with essential hypertension by the method described by Alam and Smirk (1943, a).

The results together with some of those already published are analysed statistically. Experiments were made also on the effect of modifying the conditions under which the basal blood pressure is measured.

A method for determining the basal blood pressure has been recommended by committees appointed by the Cardiac Society of Great Britain and Ireland and the American Heart Association. In essence their recommendation is that the blood pressure should be measured after preparation of the subject similar to that used for basal metabolic rates. Alam and Smirk provided evidence of the need for a deliberate emotional desensitization of the subject to the presence of the observer and to the procedure of sphygmomanometry.

Observations on the relative importance of these procedures have been made as follows. Patients were fasted overnight for between 10 to 12 hours and, next morning, were transferred in their beds to a quiet, warm room where they rested for a period of half an hour. At the end of this time the observer entered, adjusted the sphygmomanometer, and measured the blood pressure. This pressure is the basal blood pressure as defined by the above-mentioned societies. The measurements of the blood pressure were then continued without intermission for a further period of half an hour in order to secure whatever additional fall of blood pressure could be obtained by the method of emotional desensitization already described.

Results and Discussion

The Relationship between the Levels of the Casual, Basal, and Supplemental Blood Pressures in Healthy Males

The casual, basal, and supplemental blood pressures were measured in a number of healthy young males of European extraction and also in Egyptian males, using the method described by Alam and Smirk (1943, a). The relationship between the casual blood pressure and the supplemental pressure is set out in Fig. 1. It is seen that for the systolic pressure, higher

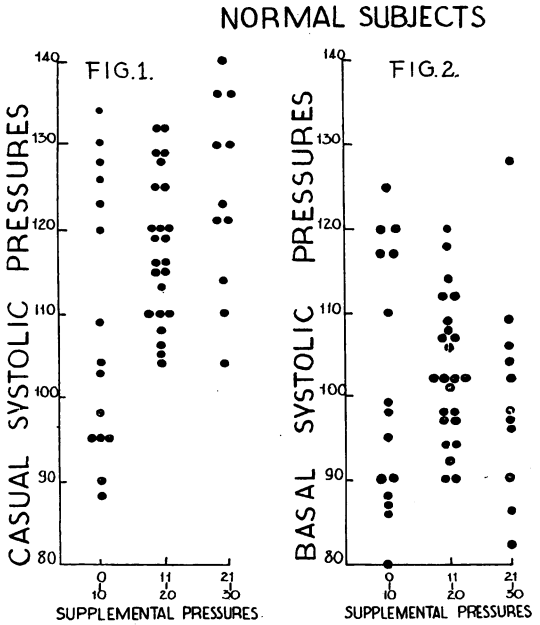

FIG. 1.—The ordinate gives the casual systolic pressure in millimetres of mercury for each of the 50 normal subjects. The subjects are arranged in three groups according to the magnitude of their supplemental (casual *minus* basal) pressures, viz. 0–10, 11–20, 21–30 millimetres of mercury. It is seen that subjects with a high supplemental systolic pressure have a better expectation of having a high casual systolic pressure.

FIG. 2.—The ordinate gives the basal systolic pressure in millimetres of mercury for the 50 normal subjects represented in Fig. 1. The subjects are arranged in three groups according to the magnitude of their supplemental (casual *minus* basal) pressures, viz. 0–10, 11–20, 21–30 millimetres of mercury. It is seen that a high supplemental systolic pressure does *not* increase the expectation of the subject having a high basal systolic pressure.

casual readings occur among patients with higher supplemental systolic pressures and lower casual readings tend to occur among patients with lower supplemental pressures. The relationship of these casual and supplemental pressures has been worked out by statistical methods and is significant, the correlation coefficient being +0·48. A similar relationship was found to exist between the casual and the supplemental diastolic pressures, the correlation coefficient being +0·50.

In Fig. 2 is set out the relationship between the supplemental and the basal systolic pressures in this same series of subjects. It is evident from the figure that when we compare the basal pressures of subjects whose supplemental pressures are high with those whose supplemental pressures are low we find the distribution of the basal pressures are much the same in the two groups. Any difference between them is not statistically significant, the correlation coefficient being −0·07. A similar analysis has been made of the relationship between the basal and supplemental diastolic pressures and a similar absence of relationship is established, the correlation coefficient being −0·11.

The Relationship between the Levels of the Casual, Basal, and Supplemental Blood Pressures in Patients with Essential Hypertension

In Fig. 3 is set out the relationship between the supplemental and the casual systolic pressures in a group of patients with essential hypertension. Some of the patients are those whose pressures were set out in Fig. 4 of a previous paper (Alam and Smirk, 1943, b), and the remainder are new cases. The general trend of the results is the same for the two sets. It is seen that groups of patients with higher supplemental pressures have as an average higher casual blood pressures and vice versa. The relationship between the supplemental pressures and the basal pressures for the two series of individuals is summarized in Fig. 4 of the present paper. It is found that groups of patients with hypertension selected for their high supplemental pressures do not have appreciably higher basal pressures than do groups of patients with hypertension who are selected for their low supplemental pressures. The figures when analysed statistically show no significant correlation between the heights of the supplemental systolic and of the basal systolic pressures, the correlation coefficient being −0·06; nor between the supplemental diastolic and basal diastolic pressures, the correlation coefficient being −0·08.

Statistical Significance of these Results

Where C=casual blood pressure, B=basal blood pressure, and S=supplemental blood pressure: C=B+S.

Now it has been shown that within a uniform class of individuals, e.g. all normals or all patients with essential hypertension, the statistical expectation of an individual having a high or low value of B is not influenced by the value of S. That is to say, if from a group of individuals we select out those who have high values of B and those who have low values of B the average values of S will not differ significantly in the two groups; (shown experimentally above).

Therefore, as C=B+S, a group of patients selected for their higher range of basal pressures will be found to have a higher range of casual pressures. Likewise a group selected for their higher range of supplemental pressures will be found to have a higher range of casual pressures. A group selected for high values of the casual pressure will contain a preponderance of those in whom a high basal pressure happens to have coincided with a high supplemental pressure. A low casual pressure will occur when a low basal pressure coincides with a low supplemental pressure.

Now, if a random series of blood pressure readings are subdivided into groups, the first group containing the highest casual blood pressures, the second group the next highest, and so on down to the lowest group; then since C=B+S and B and S are independent variables

it follows that the highest values of B and of S are associated together in the first group and the lowest values associated in the lowest group. In the middle groups both B and S cover a wide range, but the average B and the average S are both of intermediate magnitude.

This way of arranging results inevitably brings about a juxtaposition of high basal with high supplemental pressures and of low basal with low supplemental pressures. The juxtaposition has been pre-determined by the ordering of results in descending order of magnitude

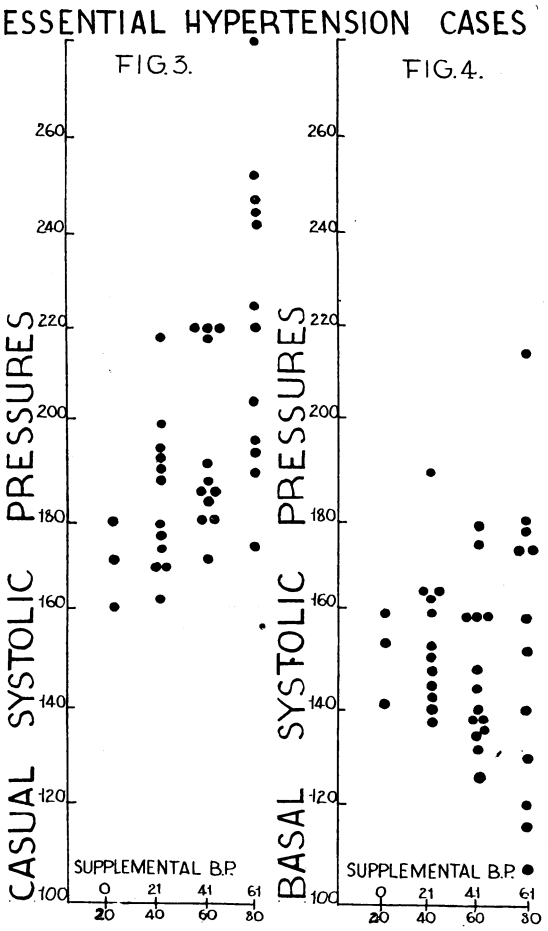

FIG. 3.—The ordinate gives the casual systolic pressures in millimetres of mercury for each of the 39 hypertensive subjects. The subjects are arranged in four groups according to the magnitude of their supplemental (casual *minus* basal) pressures, viz. 0–20, 21–40, 41–60, 61–80 millimetres of mercury. It is seen that subjects with a high supplemental systolic pressure are more likely to have a high casual systolic pressure.

FIG. 4.—The ordinate gives the basal systolic pressures in millimetres of mercury for the 39 hypertensive subjects represented in Fig. 3. The subjects are arranged in four groups according to the magnitude of their supplemental (casual *minus* basal) pressures, viz. 0–20, 21–40, 41–60, 61–80 millimetres of mercury. It is seen that a high supplemental systolic pressure does *not* increase the expectation of the subject having a high basal systolic pressure.

of the casual blood pressure and the juxtaposition has no biological significance whatsoever. This somewhat inconspicuous error in selection is apt to lead to rather fundamental differences in the conclusion drawn.

Let us consider the following purely numerical example. Take the following 12 values of B: 120 120, 130 130, 140 140, 150 150, 160 160, 170 170; now let the values of S be 20 for one and 60 for the other of these paired values of B. Thus, in our artificial example, the distribution of the values of S does not bear any relation to the value of B 20 60, 20 60, 20 60, 20 60, 20 60, 20 60, the values of C being equal to B+S are as follows: 140 180, 150 190, 160 200,1 70 210, 180 220, 190 230. Arrange these results in order of magnitude of C:

C	B	S	C	B	S	C	B	S
230	170	60	190	170	20	170	150	20
220	160	60	190	130	60	160	140	20
210	150	60	180	160	20	150	130	20
200	140	60	180	120	60	140	120	20

Average the 4 highest, 4 middle, and 4 lowest values of the table and we obtain:

	C	B	S
High group	215	155	60
Middle group ..	185	145	40
Low group	155	135	20

Thus we have a series of averages in which casual, basal, and supplemental pressures show parallel variations.

It is very tempting from such an analysis to draw the conclusion which was drawn by the editor of the *British Heart Journal*, from a similar analysis which he made, in commenting upon a previous publication of Alam and Smirk, namely, that there is a relationship between the levels of the basal and supplemental pressures. This relationship, however, does not exist, the figures in the numerical example being so chosen that there should be no such relationship. It follows, therefore, that this statistical method as used by the editor is inapplicable. The parallel increase in the values of basal and supplemental pressures in the above table and in that published by the editor in his comment are the result of using a method of selection which pre-determined the final result.*

Mr. Williams, statistician to the economics department of the Otago University, has been kind enough to work out for me the correlation coefficients of various relationships.

TABLE I

VALUES OF CORRELATION COEFFICIENTS

	No. of cases	Correlation coefficients			Squares of coefficients	
		Rbc	Rcs	Rbs	R^2bc	R^2cs
Normal systolic	50	0·84	0·48	−0·07	0·71	0·23
Normal diastolic	54	0·77	0·50	−0·11	0·59	0·25
Hypertensive systolic	39	0·75	0·61	−0·06	0·56	0·37
Hypertensive diastolic ..	37	0·75	0·59	−0·08	0·56	0·35

In the above table Rbc represents the relationship between basal and casual pressures, Rcs the relationship between casual and supplemental pressures, and Rbs the relationship between basal and supplemental pressures.

With normal pressures, systolic and diastolic, and hypertensive pressures, systolic and diastolic, the expectation is that individuals with the higher basal pressures are more likely to have high casual pressures and vice versa. The chance of the blood pressure figures, upon which these relationships are based, occurring by coincidence are less than 1/100,000 for each of the above four groups and taking all four sets together the chances of the relationship being coincidental must be less than one in ten million. There is also a direct correlation between the height of the supplemental pressures and the expectation of high casual pressures in all four groups. The chance of this happening by coincidence in the normal groups is less than 1/50,000 for each group and for the hypertensive groups is less than 1/100,000. Taking the four groups together the chance of coincidence is quite negligible.

Within the four groups studied, however, basal and supplemental pressures are independent

* " I am glad to publish this paper especially because it appeared to me that Fig. 4 of the paper by Alam and Smirk (1943, b) did not convincingly show that the basal and the supplemental pressures were independent variables. The further statistical analysis submitted in this present paper, however, seems conclusive evidence that this is so."—EDITOR.

variables. That is to say, in none of the four groups does possession of a high or low supplemental pressure increase or diminish appreciably the expectation of a high basal pressure. While the view is expressed that the basal blood pressure is an independent variable when we compare the different members of a *group* of individuals, yet this statement is in no way inconsistent with the view expressed earlier that, in the absence of any marked physiological change, the basal blood pressure of an *individual* is relatively constant for that individual.

The squares of the correlation coefficients for the relationship of casual to supplemental pressure are appreciably higher for the hypertensive groups (systolic and diastolic) than for the normal group (systolic and diastolic). This indicates that the supplemental pressure forms a significantly higher proportion of the casual pressure among the hypertensive than among the normal group.

Improvements in the Method of Measuring the Basal Blood Pressure

A comparison has been made in a series of 13 subjects of the level of the basal blood pressure. (1) Determined by the method recommended by the committees of British and American cardiologists; in essence this consists of preparation of the patient in the manner laid down for basal metabolic rates prior to the measurement of the blood pressure. (2) Immediately after this measurement the procedure of emotional desensitization recommended by Alam and Smirk, 1943, a, was applied with the object of determining whether this additional procedure caused a further decrease in the level of the blood pressure. (3) The patient then had breakfast, assumed normal ward life, and later on in the day returned for the measurement of the basal blood pressure by the procedure recommended by Alam and Smirk. That is to say the procedure of emotional desensitization was carried out without having the patient in the basal metabolic state.

The results are set out in Table I. It will be seen that rest and emotional desensitization produce blood pressures which are similar to those obtained by the procedure recommended by the committees of British and American cardiologists. The combination of the two procedures, however, appears to give still lower values for the basal blood pressure than the use of either separately. It seems improbable that much lower values of the basal blood pressure will be obtained by other procedures, but it is not unlikely that minor improvements can be effected.

TABLE II

COMPARISON OF METHODS OF MEASURING BASAL BLOOD PRESSURE

Subject	Casual blood pressure	Basal blood pressure by three methods		
		Method of cardiological committees	Method of emotional desensitization	Combination of two methods
D	192/118	188/100	182/124	164/98
C	122/86	122/86	110/79	106/68
J	118/54	96/58	106/52	92/54
McN	98/66	106/64	94/75	96/60
Mu	130/74	132/76	110/77	122/74
Mo	104/74	98/62	94/64	80/62
S	134/90	130/90	112/80	128/88
Wi	122/66	128/68	118/55	124/66
Ma	114/78	106/78	110/76	92/78
N	120/60	106/70	110/58	94/61
O	122/68	112/68	116/58	110/65
W	130/76	114/74	116/68	112/70
Me	116/72	92/60	106/68	90/65
Average . .	124·8/75·5	117·7/73·4	114·2/71·8	108·5/69·9

Summary

The casual blood pressure may be regarded as the sum of the basal blood pressure and the supplemental pressure; this last represents the degree of blood pressure elevation above the basal level due to whatever degree of physical, emotional, and supra-basal metabolic activity is present at the time of blood pressure measurement. The basal pressure is the pressure measured at a time when physical, emotional, and metabolic activity are reduced to a physiological minimum. In cases where it is impossible to do this because of restlessness or emotional tension, the reading obtained should not be described as basal. Failure to obtain the true basal reading will not always be apparent to the observer especially when, as is most commonly the case, the failure is due to emotional reasons.

Both normal and hypertensive subjects with a high basal pressure have a greater statistical expectation of having a high casual pressure than do those whose basal pressure is low. Likewise those with high supplemental pressures have a greater statistical expectation of a high casual pressure than do those whose supplemental pressure is low.

In comparing one individual with another the basal and supplemental pressures on the other hand are independent variables in the sense that the level of the basal blood pressure in an individual is no guide to the probable level of the supplemental pressure.

Most statistics concerning the level of the blood pressure are concerned with the casual readings. The fact that when comparing one individual with another, within a comparable physiological group, the casual blood pressure is to be regarded as the sum of two independent variables has statistical implications which are discussed.

The supplemental pressure forms a significantly higher proportion of the casual pressure among patients with essential hypertension than among normal subjects.

An improved method is recommended for determining the basal blood pressure.

I wish to express my thanks to Miss Fulton for technical assistance.

References

Alam, M., and Smirk, F. H. (1943, a). *Brit. Heart J.*, **5**, 152.
—— (1943, b). *Ibid.*, **5**, 156.
Kilpatrick, J. A. Personal communication.