Numerical Indices of Cardiovascular Status

By

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Abstract — Résumé — Аннотация

Numerical Indices of Cardiovascular Status. The increasing development of digital techniques in physiology opens up the possibility of expressing cardiovascular status as a single number. Three initial steps are required before the data are combined; the selection of suitable parameters to be measured, the transformation of the measurements into numerical form, and the assignment of a weighting factor to each variable.

The heart rate, blood pressure, cardiac output and peripheral vascular resistance are obvious candidates for this treatment, and it is probable that a reliable estimate of the functional state of the circulation can be derived from them alone. This paper will describe some of the ways in which information can be obtained in the desired form, and the advantages and limitations of the analytical method.
Physiological information is usually obtained in an analogue form, either as a continuous recording or as sporadic observations of a particular variable. The electrocardiogram is an example of the first type, and the arterial blood pressure, as measured by the indirect methods, is an instance of the second. In either case the data must be converted into numbers before they can be interpreted fully. It is true that subtle alterations in the shape of a wave-form or the amplitude of a pulsation can readily be appreciated by a trained eye, and that reasonable deductions can be drawn on the basis of experience, but the detailed analysis of changes depends upon the manipulation of the original information after it has been converted into digits.

The extent of the treatment required varies widely both with the source of the data and with the use to which they are to be put; to obtain the heart rate from a tracing of the ECG involves no more than the use of a ruler and a table of reciprocals, but to express even a single complex of the same ECG as a series of numbers which will define its character accurately is a lengthy and sophisticated exercise. Analyses of the latter kind require the use of a large computer and they may usually be performed at leisure, but it can be argued that simple analogue-to-digital conversion, followed by elementary computation, has much to offer in the assessment of the cardiovascular status of an astronaut. If it is accepted that the object is to provide an index of function, rather than a comprehensive appraisal of the circulatory system, the problems of dealing with the information are greatly eased.

Three basic questions must be answered before an analysis can be attempted. First, which aspects of cardiovascular physiology provide the best overall measure of efficiency? Secondly, can these parameters be measured directly, or must some less satisfactory but more readily obtainable alternative be selected? Thirdly, what property of each chosen variable will, when expressed in numerical form, give the most useful index of function? The second of these may be worded somewhat differently; given that a source of information is readily available, what light does it throw upon the behaviour of the circulation? In space flight so far, the first question has been largely obscured by the answer to the second, while the third has hardly been considered at all. The difference between those problems may be illustrated by an artificial example.

It is obviously desirable to know the state of oxygenation of the myocardium, but this cannot be measured directly. The only source of evidence of myocardial anoxia is the electrocardiogram, and the best measure which it can provide for this purpose is given by the displacement of the S-T segment. If the sole purpose of the study were the detection of coronary insufficiency, then this difference in voltage between this segment and the baseline would be a sufficient numerical index. It is apparent, however, that the ECG is capable of providing information of other kinds about the state of the cardiovascular system, and the rarity of coronary infarction in space flight has hitherto made S-T shifts of secondary importance.

Much argument has raged concerning the circulatory parameters which ought to be recorded, but the choice of methods has, in practice, been limited. The ECG is universally accepted as a method for the measurement of pulse rate, if of nothing else. Blood pressure can be recorded intermittently by techniques based upon pulse detection or upon the clinically acceptable auscultatory procedure. In some Soviet flights the kinetocardiogram and the seismocardiogram have been used. At an earlier Symposium (Howard 1962), reasons were advanced for choosing four channels of cardiovascular information; namely, heart rate, blood pressure, cardiac output, and peripheral blood flow. This paper will discuss possible ways in which these data may be obtained and utilised.