PHYSIOLOGY

A New Statistic for the Evaluation of Respiratory Changes

THE design of oxygen facemasks for high-altitude service flying and for emergency use during the recovery phase of space flight presents special problems related to the pressure differences at the intra : extra-somatic boundary. Recent designs, such as the *S.P.*4 and the *M.*Mk.2 service masks (Airmed, Ltd.), show the first steps towards solving the basic problem by the provision of adjustable valve pressures operated manually by the crew member. Changes of expiratory valve function, however, produce concomitant changes in the respiratory system as a whole, and these in turn have been shown to affect both the physiological balance and the psychological processes of the wearer[1].

While these changes are not in themselves sufficient to interfere with crew functioning efficiency under normal flying conditions, they are likely to prove a factor in such circumstances as produce the 'break-off' effect[2], or in extreme altitudes likely to be reached in the near future. Evaluation of these changes cannot be made *in situ* without extensive telemetry and even then extraneous variables such as harness pressure, vibration, and so on, will interfere with the accurate monitoring of respiratory changes. However, measurement under laboratory conditions remains perfectly valid, and enables the more subtle changes which would otherwise escape notice to be detected.

The respiratory response is an extremely complex process in which significant changes in one function of respiration may be completely masked by some other compensatory mechanism which is brought into action at the same time. Such a process can completely nullify the externally recorded change in some respiratory measure. Thus, a typical response to sudden stress is the increase in myotonus which elevates the diaphragm by contraction of the abdominal muscles and thus reduces the intra-thoracic volume. However, the musculature of the thoracic cage may also be concomitantly involved leading to an expansion of the cage and increase in inter-thoracic volume. Obviously, if only one measure of respiration were being used, namely, the thoracic capacity, these two highly significant reactions would cancel themselves out and show little if any change in the recorded volume.

To overcome difficulties of this sort, it has been found that the most efficient measure of respiratory change consists of a battery which includes the following ten data: inspiration and expiration time, costal and diaphragmatic pressure, intra-tracheal and demand pressure, respiration and flow rates, percentage alveolar carbon dioxide, and *p*H rate of change in aqueous barium hydroxide through which the expiratory sample is bubbled. Three important ratios can also be extracted from this data, namely, costal : diaphragmatic, the I.E.R. and Christian Bohrs Ratio.

The advantage of a polydimensional measure is well known in biometrics, but the basic difficulty which always has to be met is the translation of the individual measures into some unidimensional form. In the present instance this difficulty has been surmounted by the derivation of a statistic D_R which provides a unitary, but comprehensive, measure of respiratory disturbance. The statistic itself is independent of the number of unitary measures involved and possessess the following characteristics: (1) provision of due weighting for intra-battery variation; (2) allowance for large numerical differences between the various units, for example, 78 mm pressure and 0·39 per cent carbon dioxide; (3) the acceptance of basimetric criteria, that is, it conforms to the principle that the significance of biometric values is proportional to their basal or resting levels; (4) inclusion of a numerical modifier to compensate for recording error.

This index of respiratory disturbance is given by the following equation:

$$D_R = \left\{ \left[\sum_{l}^{n} \{ \bar{M}_n \, |x_{nf} - (x_{no} + k_n)| \, (x_{nf} \cdot \bar{\Delta}_n)^{-1} \}^2 \right] N^{-1} \right\}^{1/2}$$

where D_R is the respiratory disturbance score; M_n, the norm for measure n; Δ_n, the mean change in n; x_{no}, the basimetric reading, that is, the original level of n; x_{nf}, the final reading of n; k_n, the constant for test n derived from mean recording error; and N, the number of tests.

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Isolation and Mechanical Maintenance of the Dog Brain

THE metabolism of the brain and the effect of various drugs on the central nervous system and its arteries have been investigated on brain preparations reported to be vascularly isolated[1–4]. Few of the investigators have established complete vascular isolation and given satisfactory proof of the brain's viability. Recently, White[5] *et al.* reported an anatomic isolation of the monkey brain which was capable of maintaining electrocortical activity for several hours when circulation was provided by a compatible donor monkey. We have described isolation and mechanical perfusion of a viable dog head[6] and now describe the neurogenic and vascular isolation and maintenance of the living dog brain.

The dog has a much more complicated cerebral blood supply than the primate, and extremely careful dissection is required to isolate the brain properly. The technical difficulty encountered in the isolation of the dog brain is outweighed by: (1) the moderate price of the dog as an experimental animal; (2) the ease of surgery on a larger animal; (3) the ready availability of large quantities of compatible donor blood. The preparation described possesses relatively normal electrocortical activity, a factor which we determined previously[6] to be the most sensitive criterion of brain viability.

Twenty adult mongrel dogs (12–18 kg) were used in this investigation. All animals received 60 mg of morphine 45 min before administration of 20 mg/kg sodium pentobarbital. Anaesthesia was maintained with supplementary doses of 60 mg of sodium pentobarbital. A cuffed endotracheal tube was inserted and the animal was ventilated with compressed air from a positive pressure respirator. During muscle sectioning a relaxant (gallamine triethiodide) was used. An intravenous drip (2 ml./min) of 5 per cent glucose in 0·2 per cent saline was given during the procedure through a cannula in the femoral vein. The femoral artery was cannulated to facilitate recording blood pressure.

With the dog in the prone position, a midline incision was made from the frontal sinuses to the spinous process of the fourth cervical vertebra. The temporal muscles and posterior muscles of the neck were reflected laterally exposing the calvarium and the posterior aspects of the first and second cervical vertebrae. Using a dental burr, five 3 mm holes were made through the skull for placement of lead frontal and parietal EEG recording electrodes and a thermistor for temperature measurement. The electrodes and thermistor were fixed in place with dental acrylic resin. A small polyethylene tube for measuring the pressure of the cerebrospinal fluid (CSF) was placed in the cisterna magna and secured with a purse string suture. CSF pressure was found to be a sensitive indicator of obstructed