A method of estimating intracranial decompensation in man

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A new method of estimating intracranial decompensation in man is described. An on-line computer system is connected to an intracranial pressure (ICP) monitoring system to compute regression plots of mean ICP vs standard deviation; standard deviation is used as a measure of ICP instability. Two zones with distinctly different slopes are a characteristic feature of these plots. It is thought that the changes of slope signify intracranial decompensation.

KEY WORDS • intracranial pressure • pressure monitoring

The aim of this work was to develop a clinically useful method of evaluating the extent of decompensation of the intracranial system caused by intracranial hypertension. The determination of a suitable indicator to describe the status of the intracranial system still remains an unresolved problem. Changes in the level of intracranial pressure (ICP), caused by such factors as arterial pulsations and respiration, might be a useful source of information; by analysis of these changes it can be established whether the system being examined has entered the so-called warning zone.

Clinical Material and Method

Ten patients were monitored in the intensive care room after craniocerebral trauma or neurosurgical operations. The total time of observation was about 280 hours. The ICP was measured through a catheter placed in one of the lateral ventricles. Measurements were made every 5 minutes for a period of 10 seconds at a rate of 10/sec, and the results were analyzed by computer.

The data in each 10-second period were averaged to obtain the mean value of ICP and its standard deviation. For example, after 24 hours of observation 288 mean ICP values and standard deviations are obtained. Next, the mean values are grouped, as in a histogram, at 2 mm Hg intervals. All the standard deviations in each ICP interval are averaged. The data thus obtained are used in a regression plot illustrating statistically the relationship between mean ICP and standard deviation. Standard deviation is considered to be a measure of ICP variations. New data from the patient allow continuous updating of his regression plot.

Illustrative Cases

Figure 1 shows typical regression plots obtained in three different patients by the...
FIG. 1. Typical regression plots from three patients. **Left:** No decompensation; standard deviation (SD) = 0.02. **Center:** Weak decompensation; SD = 0.01 in Zone A and 0.05 in Zone B. Transition point D ~ 20 mm Hg. **Right:** Marked decompensation; SD = 0.07 in Zone A and 0.58 in Zone B. Transition point ~ 18 mm Hg. Top horizontal column, DEV, gives the values of standard deviation corresponding to the value of the plotted points on the ordinate; bottom horizontal column, ICP, gives the successive intracranial pressure levels (in 2 mm Hg steps on the abscissa) for which the standard deviations were calculated; middle column, NOM, gives the number of standard deviations computed at each level, from which the mean standard deviations plotted above were obtained.

The regression plots of the other seven patients corresponded to one of the three types of plot described above, and there was good correlation between clinical status and regression plots in most cases. However, one of the plots was incomplete due to disturbances during monitoring and could not be correlated with the patient's clinical status.

Figure 2 shows parts of a typical ICP plot at three different levels of basic ICP corresponding to the three zones of the regression plot. The complete regression plot is shown on the right. The ICP plot corresponding to Zone A shows stability of mean ICP at about 8 mm Hg, ± 0.8 SD (Fig. 2 upper left). The observer can see from the change of slope at D (Fig. 2 center left), at which moment the intracranial system begins to lose its compensating abilities. The value of mean ICP at which this transition takes place is called the critical value of the intracranial system. If the ICP moves above the critical value it means...
Monitoring of intracranial pressure

FIG. 2. Regression plot showing marked decompensation (right) is broken down into different levels for Zones A, standard deviation (SD) = 0.08 (upper left); intermediate transition stage D, SD = 1.6 (center left); Zone B, SD = 3.2 (lower left). See legend to Fig. 1 for description of regression plot (right). Ordinates of the three plots on the left describe ICP; M is the mean ICP for the complete 10-second periods, parts of which are shown in the three plots (the value of M is indicated in the columns to the left of the ordinates).

that the intracranial system has reached the warning zone and medical action is required. Our studies have shown that the critical value may differ in different patients, and must therefore be determined individually in each case. There is also evidence that the character of the regression plot may vary with time.

Figure 3 shows a cumulative regression plot computed from results obtained in the 10 patients studied. This plot has been drawn only for the sake of illustration and shows that the changes in slope are significantly related to increases in ICP. However, a cumulative plot would be of no diagnostic value in the actual determination of the status of an individual patient's intracranial system.

Discussion

Intracranial decompensation is caused by a number of factors that affect the volume of various components of the intracranial system. The basic value of ICP is affected by

FIG. 3. Cumulative regression plot of readings from all 10 patients shows general relationship of mean ICP to slope changes. Standard deviation in Zone A = 0.01, and in Zone B = 0.08. See legend to Fig. 1 for description of regression plot.
such factors as pulsating variations in the volume of cerebral blood vessels caused by cardiac function, and regular changes in venous outflow caused by respiration.

The regression plot is related to the so-called pressure-volume curve, but the method of obtaining these two plots is quite different. The regression plot uses physiological variations in intracranial blood volume, such as arterial pulsations, and respiratory changes in venous outflow. Using physiological factors is safer than injecting artificial cerebrospinal fluid. The construction and use of regression plots during observation of patients in the intensive care room do not necessitate any additional procedures that might have an undesirable effect on the patient; the plot is computed by the intensive care system from data already collected for the purpose of intensive neurosurgical care.

Continuous on-line patient monitoring is necessary to update the regression plot. Most artifacts can be eliminated statistically by continually supplementing the plot with new data flowing in from the patient. Our observations have shown the clinical usefulness of the method, particularly in postoperative intensive care. The method is fast and can be safely employed in clinical practice to help determine the degree of disturbance of the central nervous system by increased ICP before other symptoms of intracranial hypertension become evident.

References


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