EFFECTS OF CRANIAL TREPANATION TO FUNCTIONING OF CEREBROVASCULAR AND CEREBROSPINAL FLUID SYSTEMS.

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INTRODUCTION

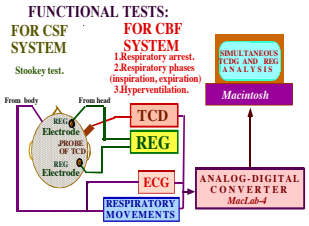
Craniotomy has a long history and is of interest for a numbe f reasons. With respect to circulation of blood through the br ain, th cull integrity has been shown to be important for its norma nctioning. Disturbance of this integrity should influence the ratio o ne function of the vascular and cerebrospinal fluid (CSF) systems o ne brain, and, therefore, the circulatory and metabolic maintenance o s function. Craniotomy is usually performed during neurosurgery nd the trephine opening remains, as a rule, in the post-surgical period is obvious that the disturbance of the skull integrity caused b rephination radically changes the intracranial hemo-dynamics and CS ynamics. However, these changes and their consequences have bee oorly studied. Thus, there are still no distinct pathophysiologica dications for leaving the trephine opening unclosed for some perio fter surgery or for its closing immediately at the end of surgery or fo prescribed period after it. One aspect of craniotomy is of specia nterest. It belongs more to the realm of archaeology than to that o hysiology or medicine and relates to some findings of skulls datin om two to three thousand years ago with evidence of craniotomies is difficult to say what the aim of such craniotomies was; however here is an opinion that they were performed for medical purposes. I ny case, direct evidence has been obtained recently that subjects 40 0 years of age may have a significantly decreased capacity of the CS ystem. Therefore, changes in the hemodynamics and CSF dynamic aused by craniotomy may be beneficial for the circulatory an etabolic maintenance of the brain activity.

The present study is focused on the effect of craniotomy on hem and CSF dynamics. We should note, that this study is, to ou nowledge, one of the first fundamental physiological studies o raniotomy. Investigation of this problem is not simple, because it i ecessary to monitor both CBF and CSF mobility and their indice hich together reflect cranial compliance. A special methodology ha een designed for this purpose.

METHODS

Craniotomy may influence the function of the intracranial hemodynamics and CSF dynamics, as well as the interaction of these

transcranial Doppler sonogram (TCDG) in basement of MCA and th neoencephalogram (REG) with electrodes in the fronto-mastoid position o ne same data carrier, analysis of the results during the cardiac cycle at res nd under the conditions of functional load, and comparison of the result efore and after craniotomy. The instrumental complex for this researc onsists of a special analogue-digital converter (PowerLab 4), which enable attern, phase and spectral analysis of the TCD and REG recordings on IAC G-4 (OS-10.4.2). Additionally, it allows simultaneous recording o espiratory chest movements and ECG to be uploaded to a MAC G -4 a epresented by the scheme below.

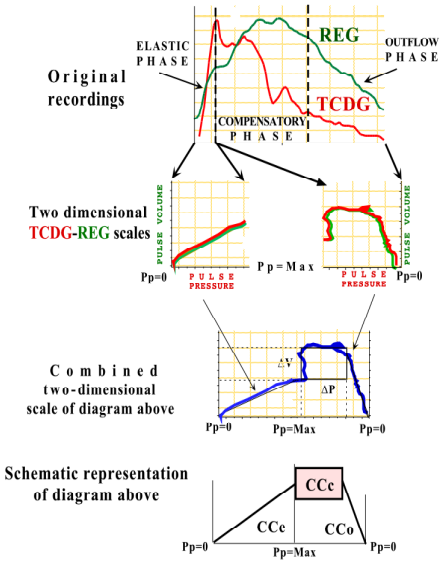


Schematic diagram of the instrument complex, functional tests an ositioning the TCD probe and REG electrodes for CBF and CSF studies i ne hemisphere .

Evaluation of the pressure-volume relationships during the cardiac cycl ave enabled the determination of three inter-dependant 'intervals' of eac ulse cycle, which reflect different processes inside the cranium:

1. The initial interval is a rapid, nearly linear, increase of pulse pressur which lasts from 0.05-0.15s and perfectly reflects the *elastic properties* of th ranium (index CCe).
2. Immediately following the peak of pulse pressure follows a secon nterval representing a *compensatory* process which reflects CSF movement ndex CCc).
3. The third and final interval of the pulse cycle represents the venou lood *outflow* from the cranium (index CCo).

These three time intervals, which together add up to about one second epresent three distinct but inter-dependant intervals of the pulse-drive ovements of the blood and CSF that occur in a single heartbeat.



Principle of analyzing of TCD and REG recordings, which include transformation from amplitude/time scale to TCD/REG scale.

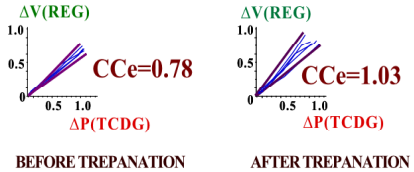
RESULTS

Our research has shown that trepanation, the removal of a piece of bon from the skull, practiced since pre-history, can be an effective means o restoring the elasticity of the cranial system. Making an opening in the cranium dramatically increases the indices of CCe. This significant increase in CCe afte trepanation is based on the increased potential of the cranium to expand i response to an increase in ICP. This added potential of flexibility is brough about by the membranes surrounding the brain.

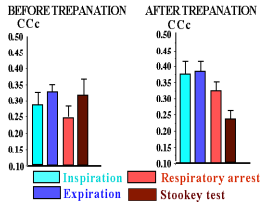
The percentage contribution of the *predominantly* different liquid media t CCe are preserved at the same level as that prior to trepanation - around 27% although the results of the functional tests showed that the relativ contributions of the arterial blood, venous blood and CSF did indeed change.

Making a skull opening also contributes significantly to the CSF mobilit during the CCc interval. These data correspond to already demonstrate results obtained using cine phase contrast MRI and using MRI (signal voi phenomena). An opening in the skull bone allows for a redistribution of th CSF movement from between the ventricles and the spinal sac in the intac skull to predominantly between the ventricles and the subarachnoid space i the trepanned skull.

Response to functional tests used in the investigation of CCc shows that th capacity of the system to accept changes in venous volume during this interva is about 30% greater after trepanation than before.

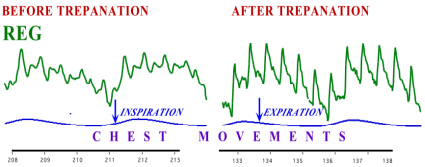


Averaged CCe values, recorded before and after trepanation.



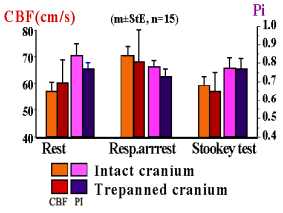
Changes in CSF mobility (changes in CCc) by different functional tests

The values of these changes were derived from the computer-processe ecordings that made it possible to clearly demonstrate the volume/pressur elationship in the cranium. This data, was additionally confirmed by observin ne fluctuation of the pulse amplitude before and after trepanation. These dat so show that comparison of the amplitude of intracranial volume fluctuation ay have an important diagnostic role which indicates the limited volum apabilities of the cranium and could be used as an indication for trepanation.



The role of changes in the volume inside the cranium during respiratory chest movements before and after cranial trepanation

Our investigations have established that the increased elasticit roduced by a 4 cm^2 opening in the skull does not cause the normal limits o erebral blood flow to be exceeded. In other words, cranial openings of thi ze are safe in that their effects do not exceed the upper limits of 6 l/minute/100gms of brain tissue.



Changes of blood flow in MCA and the pulsatile index after trepanation

We also observed significant effects of trepanation on CBF. However nalysis of the individual responses to trepanation has shown that if CBF wa ithin normal ranges before trepanation, it didn't change after trepanatior ut if CBF was below normal before trepanation it increased afterwards.

CONCLUSION

In summary, we can conclude that alterations in the integrity of the sku aused by craniotomy significantly affect the intracranial hemodynamics an SF dynamics. We may interpret the data of our study as an increase in th nctional activity of these physiological systems. As a result, the volume o rterial blood flowing into the skull during systolic elevation of arteria ressure increases, which results in an increased supply of the brain tissue wit xygen. Craniotomy changes the dynamic relationship between the liqui edia - arterial and venous blood and CSF, thus contributing to optimizatio f the functional mechanism responsible for the circulatory and metaboli upport of the brain activity. Because the most brain diseases are related t isturbances in its hemo- and/or CSF dynamics and, as a result, to disturbanc the oxygen supply to the brain cells, we can suppose, with some caution, ossible therapeutic effect of craniotomy in some diseases.