g-4. Experimental Study on Local Circulation in the Brain: Especially on the Brain Stem Circulation by Polarographic Measurement of Oxygen Tension

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As it has been proved that the oxygen electrode made of enamelled copper wires worked as a blood flow meter highly sensitive and responsive at any required time, on which we reported previously, we employed it to perform polarographic measurement of local circulation of the dog brain.

Some interesting knowledge obtained from above experiment was listed below.

1. In the case of hypotension due to exanguination, autoregulation was not recognized in the subcutaneous circulation, but it was certain that there was autoregulation in local circulation of each part of the brain, which is active in the cerebral cortex and the cerebellar cortex and less active in the thalamus.

2. Adrenagic action and cholinagic action upon the dog caused the subcutaneous blood flow to move clockwise, while local circulation of each part of the brain to move counterclockwise indicating the work of autoregulation in it as far as they were observed on a pressure-flow curve.

3. When the intravascular pressure was made increased by the aorta clamp the change of local blood flow of each part of the brain was shown with a counterclockwise movement of the pressure-flow curve as well as by the adrenagic action. By either procedure to increase the intravascular pressure, there existed in the brain stem circulation two points where a certain increase of blood flow and the decrease corresponding to it occurred simultaneously.

4. The fact that the brain stem circulation was easier to be affected by blood pressure than the cortical circulation was due to vascular resistance of the thalamus smaller than that of the cerebral cortex or cerebellar cortex, which was suggested on the pressure-flow curve.

g-5. Quantitative Estimations of Cerebral Collateral Circulations as a Measure of Predicting Intolerance to Carotid Ligation

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Cervical carotid artery ligation continues to be a valuable procedure for the

treatment of intracranial aneurysms. Unfortunately, however, it carries a 30% morbidity from cerebral ischemia. Preoperative studies using either angiograms or Matas test have been inconclusive in predicting which patients will or will not tolerate carotid ligation.

The purpose of this paper is to introduce our new device for predicting intolerance to carotid ligation by the use of ^{133}Xe clearance method.

Injection of radioactive inert gas, ^{133}Xe , dissolved in saline into the international carotid artery and external counting over the frontal, temporal, parietal and temporo-occipital regions with well collimated scintillation detectors allow to measure the regional clearance rate of this isotope.

Regional clearance curves thus obtained can be analysed into two exponential components by analysis on a semilogarithmic graph (Fig. 1). Using equations shown in Fig. 2, one can estimate regional cerebral blood flow in ml/100 g./min.

If the ipsilateral common carotid artery is occluded by finger compression immediately following the injection of isotope, saturated isotope in the ipsilateral carotid distribution would be cleared by collateral blood flow from the contralateral internal carotid or basilar circulations. Thus, one can make quantitative estimation of cerebral collateral circulation.

In eleven patients, most of them having cerebral aneurysms, double measurements of regional cerebral blood flow were performed before and during carotid compression. Mean blood pressure showed a significant increase from 92.0 to 105.1 mm of Mercury by carotid compression, while regional cerebral blood flow decreased from 42.8 to 38.3 ml/100 g./min. in average.

Regional cerebral blood flow during carotid compression remained in the range from 86.9 to 92.4% of the steady state values, although mean arterial blood pressure was increased to 114.4% to compensate the reduction of blood flow. When these values are compared with the results obtained from the control group, the decrease of regional cerebral blood flow during carotid compression is statistically significant. (Fig. 3)

Fig. 1. A case of Pseudobulbar paralysis rCBF of the left Frontal semi-logarithmic Analysis

$$(1) \text{ CBF} = \frac{lg + lw}{lg/fg + lw/fw} \times 100 \text{ (cc/100g/min.)}$$

$l = y \text{ intercept of each curve}$
 $f = \lambda/T_{0.6} \times 0.693 \text{ (cc/g/min.)}$
 $\lambda = \text{partition coefficient of Xe}^{133}$

$$(2) \text{ CBF} = \frac{lg + lw + -Ht}{lg/fg + (lw - Ht)/fw} \times 100 \text{ (cc/100 g/min.)}$$

$Ht = \text{remaining activity}$

Fig. 2.

rCBF of 2nd Measurement in % to 1st

	Carotid Compression	Control	
Front.	86.9(± 9.1)	94.0(±6.8)	↓ P<0.05
Temp.	88.3(±10.0)	98.4(±7.2)	↓ P<0.025
Pariet.	92.4(±10.3)	100.9(±7.8)	↓ P<0.05
T.-O.	88.2(± 9.3)	98.8(±8.9)	↓ P<0.05

Fig. 3.

CCR of 2nd Measurement in % to 1st

	Carotid Compression	Control	
Front.	76.0(±8.7)	95.5(±7.1)	↓ P<0.001
Temp.	77.4(±9.1)	99.8(±7.2)	↓ P<0.001
Pariet.	80.9(±8.8)	100.5(±7.4)	↓ P<0.001
T.-O.	77.3(±8.2)	100.0(±9.7)	↓ P<0.001

$$\text{CCR (Cross Circulation Rate)} = \frac{r\text{CBF}_1}{r\text{CBF}_2} \times \frac{\text{MABP}_2}{\text{MABP}_1} \times 100\%$$

1: Values during compression

2: Values at steady state

Fig. 4.

In order to eliminate the influence of compensatory rise in blood pressure on cerebral blood flow, cross circulation rate (CCR abbr.) was calculated by using the equation shown in Fig. 4. The CCR of each region was also proved to be significantly lower when compared to the rate calculated in a similar way in the control group. (Fig. 4)

It is the essential purpose of this study to establish a method to predict which patients will or will not tolerate carotid ligation. Angiograms under

contralateral carotid compression and Matas test have been available for this purpose without conclusive results as already mentioned above. With our new technique, however, one can estimate quite accurately the precise values of collateral blood flow to the hemisphere undergoing carotid ligation.

With demonstration of some patients having cerebral aneurysms, we came to the conclusions as follows:

With demonstration of some patients having cerebral aneurysms, we came to the conclusions as follows:

1) The method introduced in the present study is a very valuable procedure which can accurately predict intolerance to carotid artery ligation.

2) Cross circulation rate appears to show good correlation with anatomical findings obtained from cross compression angiograms.

3) The only decisive factor to predict intolerance to carotid ligation is not CCR but regional cerebral blood flow during carotid compression. 30 ml/100 g./min. in average is thought to be the critical value.

4) With a collateral flow below the critical value, carotid ligation is not a choice of operation. If intracranial direct attack is selected as a procedure, cares should be taken for temporary clips not to apply for a long time.

g-6. Analysis of Cerebral Circulation Curves obtained with an Intravenously Injected Radioisotope

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The authors attempted to analyse the cerebral circulation curves which were obtained by intravenous injection of a non-diffusible radioactive indicator. The curves were recorded through a pair of gamma-ray detectors which were symmetrically directed over the forehead.

An estimation of the density and width of the bolus was achieved by the simultaneous recording of a radioaortogram through another gamma-ray detector placed over the sternum. The ratio of the height of aortic peak (P) to that of the bottom of downward slope (H), i.e., P/H , gives an estimation of the density of bolus. The time-interval between P and H (P-H time) was arbitrarily designated as the width of bolus. Furthermore, by the radioaortogram, we were able to find out any eventual cardiopulmonary dysfunction which, of itself, causes an apparent abnormality of the circulation curves. Time-intervals between the aortic peak and the peaks of right and left circulation curves were measured. This aorta-to-peak time, which is almost equal on both sides in normal subjects, was unilaterally prolonged or shortened in some cases of arterial occlusions and brain tumors, in a head injury and in an carotid-cavernous sinus fistula.

On a cerebral circulation curve, the ratio of the height of peak to that of