Functional Radioangiographic Studies of Cerebral Vascular Haemodynamics
(Preliminary Report)

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Summary.
Routine cerebral radioangiography (Stage I of the cerebral serial scintigraphy) can be supplemented with a second examination done after mechanical or pharmacodynamic change of the cerebral haemodynamics. These can be quantitatively evaluated by the use of activity-time curves taken over specific brain regions. In the simplest case, the flow of radioactivity through the circle of Willis can be demonstrated after compression of one carotid. Hyperventilation and increase of the blood pressure slow down the A-V circulation time in normal patients and in the majority of tumor patients. Within the tumors themselves there is typically a relative decrease in the circulation time and, particularly with increased blood pressure, a considerable increase in the relative transport volume (Qrel). In several patients with primarily prolonged cerebral A-V circulation times, a paradoxical acceleration of the global circulation was observed. Our results in tumors and cerebrovascular diseases are comparable to those of other cerebral blood flow methods using diffusable radioactive substances and with contrast angiographic methods. However, the scintigraphic techniques do not require intra-arterial injections and can be used routinely in both hospitalized and ambulatory patients with no risk to the patient.

The measurement of regional cerebral blood flow (rCBF) with intraarterially injected diffusible radioXenon has contributed much to the understanding of abnormal circulation patterns in cerebrovascular diseases and brain tumors. (1, 2, references therein). This examination, however, is performed in only a few institutions and is not practicable as a routine procedure. Angiography, using non-diffusible contrast media, can also detect regional autoregulatory disturbances in the cerebral circulation when supplemented with functional tests [4, 5]. Nevertheless, arteriography is unsuitable for short term follow-up examinations and remains limited to those patients in whom the inherent risk is acceptable in view of the value of the expected results.

The brain scintigram — as opposed to the roentgenologic procedure — reveals parenchymal lesions in direct positive contrast. In addition, local alterations of the blood-brain barrier function (stage III), as well as shifts in the intracranial vascular pool (stage II), can be demonstrated. With cerebral radioangiography (CRAG = stage I of our serial examination [7, 8]) the passage of the non-diffusible Tc-99m-bolus remains visible into the parenchymal phase, thus giving this method high sensitivity, particularly for cerebral vascular lesions [6, 9].

Subsequently radioangiography has been carried out under various mechanical and pharmacodynamic influences which has led to the development of some functional tests of brain perfusion. These have been performed in 70 patients, in addition to the routine cerebral serial scintigraphy, and form the basis of this report.

Patients and Methods

Only patients with angiographically proven lesions are selected for the “double shot” radioangiography. In respect to the nature of the disease, the additional
radiation exposure, as the only risk inherent to these examinations, can be neglected. Twelve normal patients were selected in whom scintigraphic and angiographic examinations, as well as clinical follow-up, gave no evidence of disease in the cerebral circulation. Additional evaluations of the technical performance and the dependence of the results on age and cardiovascular status will be presented elsewhere.

Following the bolus injection of 15 mCi 99mTe as pertechnetate or sulphur colloid, Polaroid pictures are taken every 4 sec showing the activity passage through the arteries, parenchyma and veins of the head. This activity passage is quantitatively evaluated with activity-time curves using the Nuclear Chicago Direct Store System and “region of interest” technique. The curves are recorded analogically with a time-constant of 0.1 sec and afterwards averaged by eye. The area under the curve is a measure of the activity passage through the specific region. The planimetrically determined area under the tumor curve \( A_{\text{focus}} \) is then compared to that under the normal parenchyma curve \( A_{\text{normal}} \). This comparison of the two areas is shown with the quotient \( Q_{\text{rel}} = \frac{A_{\text{focus}}}{A_{\text{normal}}} \). In addition, the A-V circulation time, determined as peak to peak time, is calculated from the activity-time curves over the internal carotid arteries and sinus sagittalis.

The radioangiography can be repeated within a short time by utilizing two different radioactive substances. For the first series, technetium is injected as sulphur micro-colloid (pH adjusted to 6.7). Injection with the Oldendorf-technique [For reference see 6, 9] is tolerated well. This substance is rapidly taken up by the Kupfer cells in the liver, leaving the vascular system practically free of radioactivity. After \( \frac{1}{2} \) h the radioangiographic series is repeated using Te-pertechnetate. Both examinations are comparable since the physical properties of the isotopes, as well as their geo-