Investigations of Quantitative Radioisotope Circulation
(thesis)

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UDMHSC
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2004.

INTRODUCTION

In nuclear medicine, quantification is a basic problem when in a given tissue the distribution of tissue activity or the time changes of activity have to be determined. If in a state of balance we want to draw conclusions to some kind of pathological phenomenon from the change of the distribution of activity, this can be done more precisely if we assign parameters to the differences of activity; also, the description of any kind of process is more exact if we do it with a mathematical model. On the one hand, the problem is that the models used for the description of physiological processes are based on simplified, only approximately adequate hypothesis, on the other hand, the description is made even more inadequate by the difficulty in the determination of certain parameters in the case of in vivo examinations. The easiest way of assigning a parameter to a distribution or a time process is doing so with relative parameters. This is usually sufficient in everyday clinical practice, however, it only makes approximate estimation possible so it causes loss of information. The use of absolute parameters makes possible much more objective comparison. The description of processes with absolute parameters is made more difficult by distortions happening in the course of making radioisotope images (tissue radiation loss, scatter), as well as the statistical character of radioisotope decay. A further problem may be in a lot of cases the complicated, prolonged gathering and evaluation process that can be hard to adapt in clinical practice.

The aim of this study is the elaboration of circulation examination models, their introduction into everyday practice, and practical evaluation that can easily be adapted to clinical practice.

In the course of my present study, I report on the experiences gained in three fields:

1. Quantitative cerebral blood perfusion reserve examinations with 99mTc-HMPAO in asymptomatic neck artery narrowing.
2. The method of static 99m-Tc-DTPA hand perfusion examinations and quantification for “cold hands” examinations.
3. The methodology of dynamic 99m-Tc-HSA hand perfusion examinations and the possibilities for the assessment of the safer removal of the radial artery.

Questions Raised:

1. By using quantitative cerebral perfusion scintigraphy elaborated by our research team, we sought answers to the following questions among patients suffering from asymptomatic carotis stenosis, migraine patients, and healthy volunteers:

- Is there a difference of relaxed hemispherical blood perfusion between the groups?
- Is there a difference between the groups with hemispherical blood perfusion measured under the effect of acetazolamid?
- Can a difference be observed regarding the blood perfusion of different cerebral regions in a resting state?

- Is there a difference between the blood perfusion measured in a resting state and under the effect of acetazolamid of the hemisphere with stenosis and the hemisphere without stenosis in patients with carotis stenosis?
- Can a change be measured following carotis endarterectomy in the reserve capacity of the hemispherical cerebral blood perfusion?

2. The elaboration of an economical isotope diagnostic method for the quantitative assessment of the microcirculation of the hands for the examination of "cold hands".

- Is there a difference in the finger-palm ratio measured from the first perfusion image series from the static series of images?
- Is there a difference between the finger-palm ratio of the right hand and that of the left hand among the examined patients?
- Is there a difference between the finger-palm ratio of the healthy individuals and the patients with typical primery Raynaud syndrome?
- Is there a difference between the finger-palm ratio of the patients with active and inactive MCTD (mixed connective tissue disease)?

3. The elaboration and evaluation of isotope dynamic hand blood circulation for the assessment of the safer radial removal of the artery in the heart surgery patient group.

- Can the difference be measured in the blood supply of the fingers between the state of clamp and relaxation of the radial artery?
- The comparison of the measured parameters with routinely applied Allen test.
- What is the finger/palm quotient like in the group of patients waiting for coronary operation?
- Can the change in the circulation of the hand be measured with hand perfusion method following the radial removal?

THE METHODOLOGY OF QUANTITATIVE CEREBRAL PERFUSION SCINTIGRAPHY

1. Acquisition protocol:

We inject bolus- like 600 MBq Tc-99m-HMPAO through a branule inserted in an elbow vein of the patient lying on back and kept in a low-stimulus environment for at least ten minutes. We did the tests with a Helix SP6 (Elscint) two-detector gamma camera. At the moment of injecting the radiopharmacon we started acquisition a 70x1 second anterior direction dynamic image series in a way that in the field of view including the skull the aorta curve region should also be included. Following this, an hour later, we took a tomographic images of the brain with a 128 by 128 image disintegration gathering 120 projection images on a curve of 360 degrees (on the projection with an image part size 2.95 mm, and on the reconstructed sections 3.69 mm). For the determination of the reserve capacity we injected 15 mg of acetalozamide per body kilo, then the patient received the radiopharmacon at the maximum effect of the medicine, 15 minutes later. The rest of the protocol is the same as described at the examination in a state of relaxation.

2. Digital image analysis

a. We made special difference images for marking of the aorta curve and the cerebral hemispheres.
b. With semi-automatic method we determined the aorta-brain transit time.
c. We performed Patlak-analysis this way determining the amount of blood flooding into the cerebral hemispheres.
d. Using the CBF averages of the cerebral hemispheres, the cortex regional CBF was performed with Lassen correction.

PATIENTS**:**

1. For the study of cerebral blood perfusion caused by the narrowing of the artery carotis interna we examined 12 patients (11 men and 1 woman) whose carotis interna narrowing was measured with angiography at least on one side over 70 percent and therefore were registered for carotis interna endarterectomy. However, in the verebral arteries and in the intracranial arteries there was no significant narrowing. Their average age is 59.5 years (44-70). We excluded from the study patients with hypertonia and diabetes and also those in whose anamnesis cerebral occurrence was present. We only analyzed the cerebral perfusion examination of patients who were considered symptom-free on the basis of neurological examinations. 10 patients were examined for symptoms caused by degenerative arterial disease in their lower limbs, while in the case of two patients coronary revasculation was planned and the routinely performed carotis duplex ultrasound examination drew the attention to the narrowing of the carotis interna. We performed the HMPAO-SPECT examinations in a state of relaxation and under the effect of acetazolamide immediately two weeks preceding the operation. The patients were personally informed of the examination and every one of them gave their preliminary consent to the operation, too. In the case of 6 patients right-side carotis endarterectomy was performed, in the case of 5 patients left-side carotis endarterectomy was performed. In the case of 1 patient the operation was contraindicated from cardiological point of view. Post-operative complications were observed in three cases (two neck haematoma, one right-side central facial paresis). In all three cases total spontaneous recovery set in.

We called in the patients for control acetazolamide provocation HMPAO-SPECT tests in average 23 (17-27) months later. 4 patients fell out of the follow-up monitoring (1 died of acute myocardial heart-attack during the follow-up period, while 3 patients could not be followed). With 8 patients during the follow-up period no neurological occurrence set in.

II. For studying cerebral blood perfusion caused by migraine.
Simultaneously, 13 patients, with whom no organic cerebral circulation diversion could be detected with radiological methods (CT, carotis duplex-us) suffering from migraine (7 women, 6 men, average age: 30.2 years (15-52), we performed the basic and Diamox provocation examinations.

III.Healthy control group.
With university ethical permission 12 healthy adults (5 women, 7 men) were included in the control group. Their average age was 24.6 years (22-36). They volunteered to undergo the examinations following detailed preliminary information. In the case of the healthy volunteers we only performed the acetazolamide provocation HMPAO-SPECT examination to expose them to a smaller radiation load.

RESULTS**:**

A. Global hemispherical cerebral blood perfusion:

1. The CBF values measured during the basic examinations ($p>0.1$) did not depend on the group while the CBF values measured under the effect of acetazolamid provocation significantly depend on the group (ANOVA $p<0.001$).
2. The CBF average measured during the basic examination was higher in migraine patients (55.8±12.9 ml/min/100g) than in the patients with carotis stenosis (49.9±9.49 ml/min/100g) (average±SD).
3. During acetazolamid provocation there was no significant difference between the average of the CBF reserve values of the healthy individuals (68.5±9.79 ml/min/100g) and the migraine patients' (67.5±12.19 ml/min/100g).
4. However, we measured significantly lower CBF reserve values (49.6±9 ml/min/100g) in patients with carotis narrowing compared with the healthy individuals ($p<0.001$).
5. The CBF of migraine patients measured under acetazolamid provocation was significantly higher than the basic values ($p<0.05$).
6. In the patients with neck stenosis there was practically no difference between the basic value and the values measured under Diamox effect ($p>0.1$). This indicates the lack of cerebral vascoreactivity.

B./ Regional blood perfusion:

1. We did not notice a significant difference between the right and left hemispherical
   blood perfusion of the patients with carotis stenosis.
2. Similarly, we did not find any significant difference between the hemispherical blood perfusion values measured on the effected side (where there was a 70 percent carotis int. narrowing) and those of the side without a hemodynamically significant narrowing.
3. Examining the blood perfusion of the seven regions of the cerebral map under acetazolamide effect, we experienced that the blood perfusion values of the effected side are lower than the blood perfusion values of the uneffected side on a regional level, but the difference between them is not significant. ($p>0.1$).

C. Blood perfusion data following endarterectomy:

1. In average 23 months following the operation we found that the blood perfusion values measured on the operated side with Tc-99m-HMPAO-SPECT examination under the effect of acetazolamid were 48.9±7.5 ml/min/100g in average, and the values of the non-operated side were 47.6±9.5 ml/min/100g.
2. On the basis of our examination, therefore, the reserve capacity did not improve in average 23 months following the operation ($p>0.05$).
3. Following the operation, we did not find any significant improvement of the reserve capacity either on the operated side or on the non-operated side on the basis of the data of the regional blood perfusion.

THE EVALUATION OF THE METHOD: (in the reflection of our own results)

Nowadays there are several methods of measuring the cerebral blood perfusion, among which the Tc-99m-HMPAO-SPECT tests are widely used. The cerebral perfusion SPECT examination performed with 99m-Tc-HMPAO has been a routine method of assessing regional cerebral blood circulation disorders in several neurological and psychiatric diseases for years. So far the evaluation has mostly been done visually, comparing the regional relative activities. The radiopharmacon, following injecting, dissolves fast in proportion with the blood perfusion in the brain and because of its slow washing off, the distribution image stays permanent for a long time, so it is suitable for quantitative measurements. Despite the fact that the evaluation of acetazolamide reactivity done with qualitative measurement is considered low-sensitive and low-specific for assessing the narrowed cerebrovascular reserve- its positive predictive value is only considered 50 percent- in everyday practice this method of evaluation is the most widespread. This maybe due to the fact that the majority of the methods of estimating quantitative cerebral blood perfusion are partly time consuming and are difficult to gain access to (SPM methods), are not suitably reproducible (ROI methods), or expensive (PET methods, Xe-133 examinations). The quantification method we offer uses as reference the hemispherical perfusion values, calculated from the dynamic data of the inflow image series to make quantitative the activity distribution projected on the cylinder surface, so besides the hemispherical perfusion parameters, cortex regional data can also be gained that can be characterized with ml/min/100g units, it is accessible in everyday practice, and serves with reliable data.

Vascular diseases form a large part of neurological diseases. The narrowing of the neck artery is one of the manifestations of progressive arteriosclerosis. This disease is more common with smokers, the obese, and older people but other risk factors also include diabetes mellitus, hyperlipidaemia, hypertonia, and stress. This disease often starts as part of a systemic disease, so coronary arteries, limb arteries, etc. can also be involved. According to North -American and European multi center studies carotis endarterectomy decreases the occurrence of ischemic stroke on the same side. Pre- and post-operative mortality is not high according to literary data – 1.6 –5.6 percent –depending on the fact that the patient already had vascular occurrance before the operation. Because the definitely decreased or missing cerebral perfusion reserve capacity is an especially big risk for the patient, not only with carotis operations but also situations needing a bigger load (like long anesthesia, heart surgery, etc.) it seems reasonable to assess precisely the blood perfusion reserve before interventions of this kind. It depends on a lot of factors to what extent can the other arteries take over the blood supply in the case of an artery blockage. These are the following: the spaciousness of the anastomosis, the dilatation capacity of the wall of the artery, local pressure conditions, differences in pressure, general circulation conditions, the speed of the formation of the blockage. We applied acetozolamide provocation to assess the blood perfusion change created by cerebral perfusion reserve capacity, i.e. vasodilative stimulus. Acetazolamide raises the cerebral blood flow by the dilatation of the small arteries.

Despite the significant one-side stenosis basic blood perfusion values close to the normal value without side difference and the difference of regional blood circulation indicate that in the slowly formed processes of the body the cerebral artery system is capable in relaxed state. However, under load, because of the lack of blood perfusion reserve capacity or its seriously narrowed condition – which was also verified by our examination – the danger that the increased blood supply need will not be met is bigger.

Several studies verified that there is a significant correlation between the decreased perfusion reserve capacity and the risk of repeated cerebral ischemic

occurrence in patients who had a cerebral stroke before. The annual occurrence rate of repeated cerebral stroke on the same side with patients with narrowed cerebrovascular reserve capacity is estimated to be 11-18 percent, in contrast with the patients with maintained reserve capacity where it is only 0-2.2 percent. Though it is without doubt that the probability of another cerebral stroke is higher with patients with symptoms than with the ones without symptoms, the question arises whether the recurring cerebral stroke is really caused by the narrowed reserve capacity and why symptomatic ICA stenosis patients are less endangered, because the disease or the lack of cerebrovascular reserve capacity are also measurable in this group of patients.
In our small group of patients in every case the decrease or lack of acetazolamid reactivity was verified, and during the almost two-year follow-up period no cerebral stroke happened. The role of surgical intervention in this case is questionable. According to observations, reserve capacity decrease is not a permanent phenomenon. Following occlusive disease of the big cerebral arteries the spontaneous improvement of the damaged haemodinamics depends greatly on the condition of the collateral circulation. With a patient suffering from systemic arteriosclerosis, not only on the level of the large arteries but also on the level of the medium-sized and small arteries, the disease can manifest itself. In cases like this, not in every case, expected the improvement of the reserve capacity following the endarterectomia performed on the carotis interna. Though our results did not reassure that the carotis endarterectomia has a positive effect on the cerebral reserve capacity, however, it had a preventive effect on the formation of cerebral stroke. It is assumable that if we know the state of the cerebral circulation of the patients better, those with greater risk of cerebral ischemia can be filtered, this way their treatment and follow-up monitoring can be made safer. The quantitative non-invasive SPECT measurement of the cerebral perfusion reserve and the monitoring of the efficacy of the various treatments in everyday practice are advisable for patients suffering from cerebral vasoocclusive disease. An intensive increase has been observed in recent years also in national practice in the number of revascularization intervention in carotis arteries including interventions, too. This is why there would be an even greater need for performing multipolar studies for monitoring the changing of cerebral perfusion reserve capacity following carotis surgery, either on symptom-free patients or on patients with symptoms.

ISOTOPE HAND-CIRCULATION EXAMINATIONS:

I. Applying STATIC HAND-PERFUSION with Tc-99m-DTPA for the examination of “cold hands”.
   a. Data gathering: The examination does not need any preparation. The patient lies on the back under the gamma camera with hands raised above the head, fingers together, palm on the surface of the collimator. In a vein in the back of the leg we injected 400 MBq 99mTc-DTPA (dietilen triamin-pentaacetat) bolus-like. The images were taken with low-energy parallel caliber colliamator-applied with an MB 9200-type gamma camera (Gamma Works). Simultaneously with the injection, we started a 60 X 1 s. series of images, then immediately – after the setting in of the balanced state – we took a three-minute-long static image.
   b. Image processing: We used two images for the computerized ROI marking, the total image of the first 60

one-second images, and the early blood pool image. In the partial image and the static image we marked the region of the palm and fingers II-V. Regarding that on the basis of the clinical data during the Raynaud-attack, the thumb is quite rarely involved and supposing that considering these data makes the sensitivity of this method worse, we left out finger I of the ROI (region of interest) marking. As the proportion of the total hits, the number of the fingers and palm region we set up the Finger-to-Palm ratio (FPR).

PATIENTS:

We examined 48 patients who, on the basis of clinical data, formed three groups. In Group One, the data of ten healthy control persons are indicated. With the patients of Groups Two and Three, the 3-phase discoloring of the fingers – Raynaud Syndrome – caused by some stimulus was observed. With 15 patients of Group Two the clinical symptoms of MCTD (mixed collagen tissue disease) were observed while 23 patients of Group Three met the criteria of primary Raynaud Syndrome because the manifest disease was unable to be indicated during the two-year follow-up period in their case. In the MCTD group of patients, 6 were in an active state (II/B), which meant from a laboratory point of view, a higher sedimentation, leukopenia, increased creatinin kinase level, positive Waaler-Rose test, C-reactive protein presence, and active arthritis. On the basis of the normal results of the above examinations, the other 9 MCTD patients were in a clinically inactive state (II/A). Before the examination, the patients did not undergo any circulation improvement treatment. Every patient was examined after being informed. We received a university ethical permission for the performance of the examinations.

RESULTS:

- There is not a significant difference between the partial total of the first perfusion image series and the FPR values calculated from the static image ($p>0.05$).
- We did not notice any significant difference between the FPR values of the right and left hands either ($p>0.1$), therefore, in the following statistical processing, we examined the data of both hands together.
- The FPR value depends on the disease ($p<0.001$), i.e. which group we put the patient in.
- We observed the lowest FPR value in the primary Raynaud Syndrome patient group. The highest FPR value was observed in the group of healthy individuals. The FPR value of the patients with primary Raynaud Syndrome proved to be significantly lower than that of the healthy individuals ($p<0.0001$), what is more, the difference from MCTD patients also proved significant ($p<0.05$).
- The FPR value of MCTD patients in an active state proved to be lower than the values of the patients put in the inactive state ($p<0.05$).

DISCUSSION:

Raynaud Syndrome is a common circulation disorder of the hand of which a characteristic symptom complex is a discoloration of the fingers in attacks to cold and/or emotional effects. Raynaud Syndrome is traditionally divided into primary and secondary forms. In primary Raynaud Syndrome, the circulation disorder of the

fingers manifests itself as an individual disease, in contrast with the secondary type where this is manifested together with another – usually immunological – disease. There are several methods available today for the diagnosis of the several microcirculation disorders and the damage of the hand, which however, only provides information of certain parts of the microcirculation. The following conditions have to be met for the examination methods considered ideal for the microcirculation: It should not be invasive; it should be well-reproducible; it should preferably characterize the microcirculation data with a wide range of quantitative data, besides focal, described microcirculation differences it should provide information on the total microcirculation condition of the hand. And finally, it should be economical and repeatable. At present, no optimal clinical examination method is available which would be suitable for the follow-up of the patients from all the above respects.

In recent years laser-Doppler has become more and more widespread, even more laser-Doppler scanner, which seems to be promising for measuring superficial microcirculation. However, similarly to thermography, it only describes superficial skin circulation. It is doubtless that there is a correlation between superficial microcirculation and deeper muscle tissue perfusion, though we do not have exact information regarding the character of this correlation. Maybe in the future the key will be the examinations carried out by the combination of the isotope and the laser-Doppler.

On the basis of our results, we can successfully distinguish by determining a simple quotient the healthy hands from the ones whose circulation – either organically or functionally – is damaged. In a few cases, even the information provided by the image in itself was significant when serious regional perfusion disorders were detected. The introduction of the finger/palm ratio with examinations carried out in larger groups of patients will be suitable for judging the seriousness of the disease and also for the follow-up monitoring of the therapy, especially in cases where the circulation of the fingers is symmetrically involved and no regional perfusion disorder can be detected. We think that the hand circulation examination carried out by us with DTPA, an isotope diagnostic method has the following clinical advantages:

1. This method is non-invasive. It can be carried out in the available isotope diagnostic laboratories without making any new investment.
2. The radiation load is minimal and does not exceed regular camera's renographic radiation load (1.6 mSv effective dose).
3. It provides an opportunity to assess microcirculatory disorders of the hand with images and also quantitatively.
4. Presumably it is suitable for monitoring all the therapeutic interventions and treatments that influence the microcirculatory relations of the fingers. The disadvantage of this method is that it is not suitable for provocation examination (e.g. cold water provocation) because of the flooding of radiopharmacon into the extracellular space. We recommend its routine application and widespread introduction into angiological practice.

II. DYNAMIC HAND PERFUSION SCINTIGRAPHY:

METHOD:

A. Pre-operative examination: The examination requires no preparation. The patient places hand with palm down on the collimator of the turned up

camera. Preceding the injection of the radiopharmacon, we blocked the radial artery and the ulnaris artery with a special clamp made for this purpose on the points of contact of the pulse; we controlled the stoppage of the flooding with a manual Doppler meter distally from the clamp. We injected about 400 MBq Tc-99m-HSA in the right cubital vein bolus-like. We noted the exact activity before injecting and the activity remaining in the syringe and the time of the measuring on a form. We performed the examination with a gamma camera. MB9200 (Gamma Works) applied with a parallel collimator. Simultaneously with the injection, we started the gathering of 240 X 1 second dynamic series of images. In the 30^{th} second of the series of images, we released the clamp of the ulnaris artery on both sides while the radial artery stayed clamped. We released the radial arteries in the 120^{th} second. The examination following this release lasted till the 240^{th} second in the same position.

B. Post-operative examination: The patients similarly to the pre-operative examination put their hands on the collimator of the upturned camera. The injection of the approximately 400 MBq Tc99m-HSA also happens through the winged needle inserted in the cubital vein. We registered the amount of activity in the syringe before and after the injecting and also the measuring time on a form. Simultaneously with the injection, we took 240 X 1 second images.

PATIENTS:

We examined 45 patients waiting for coronary bypass surgery: 10 women and 35 men. Their average age was 51.6 years (29-67). We excluded the patients in whose histories a hand injury was present. On the basis of questioning the patients, those who reported a sense of disorder in their fingers, discoloration caused by cold, or joint pain, movement restriction, were also excluded as well as if the color Doppler examination detected circulation disorder in the radial artery and/or in the ulnaris artery. We did not classify the patients according to the dominance of the use of the hands. With each patient, before the isotope examination, always the same examiner performed the modified Allen test on both hands. At Allen test, we set the normal recoloration limit at 10 seconds.

33 patients were operated on until the date of the statistical analysis, out of which with six patients both-sided with 12 patients only left-side, radial graft was processed, with 15 patients no radial use took place.

9 patients accepted the call-in for control examination following the operation, three of who were used for both sided, 6 patients were used for only left-side radial artery use.

DATA ANALYSIS:

a. Evaluation of pre-operative examination:

The evaluation took place with the help of computerized program DIAG (Digital Data Analysis for Gamma Cameras) by analyzing the hands separately. In the final quantitative data analysis, 66 hands were involved (due to non-analyzable data resulting from fidgeting of the hands during the examination, missing data, and the refusal of the patients to cooperate). In the summarized image of the 1-second images, we marked the region of the palm and the fingers. Finger 1 was excluded from the indication due to its special blood supply and nerve system. The analysis

also took place visually according to the shape of the time-activity curve, and also quantitatively by determining the radial and ulnaris perfusion integral in the following way. We derived the extent of the ulnaris and radial perfusion from the proportion of the areas under the determined parts of the graft, both in the region of the fingers and that of the palm. We defined from this the ulnaris perfusion ratio and the values of the radial perfusion ratio, respectively. Besides, we determined the finger/palm ratio (FPR) with each patient, by which we described the microcirculation of the fingers.

b. Post-operative analysis:

We introduced a new parameter for the comparison of the condition before and after the operation. We made partial summary images by adding the 150-240 images of the partial dynamic series of images, then we set the regions of the palm, fingers II-IV, the total and maximum activity taken up with the injected activity expressed in %/cm2 from the images taken after the operation.

RESULTS:

a. The results of the pre-operational examination.

During the statistical analysis, we analyzed the hands together. We could not analyze appropriately the scintigraphy of 2 patients because of the fidgeting during the examination. So from the further processing, we excluded these 2 cases.

With the physical Allen test, we measured the recoloration period to be under 10 seconds in the case of 48 hands, while in 18 cases, it was longer. On the basis of the shape of the time-activity curve, the patients were divided into two groups. In the majority of patients, following the releasing of the artery ulnaris, the activity of the fingers and the palm suddenly increased. In a short time, it reached the maximum. Then, the state of balance set in; following the release of the radial artery the activity of the fingers did not change any more. In the minority of the examinations, however, following the release of the ulnaris artery, the activity of the fingers and the palm just increased slowly and following the radial artery, it increased further.

The finger/palm ratio (FPR) typical in the relaxed condition of the microcirculation of the fingers was not different between the patients in the positive or the negative group. The FPR in the negative Allen test was 0.589 ± 0.114. In the positive group it is 0.597 ± 0.113 ($p>0.05$).

The perfusion indexes calculated for the region of the fingers are as follows: After the release of the ulnar artery (ulnar perfusion index) in negative Allen test patients: 63.94 ± 26.973, and in positive Allen test patients: 36.33 ± 33.020. Following the radial release (radial perfusion index) in the negative Allen test patients: 97.21 ± 10.697, and in the positive Allen test patients: 88.56 ± 12.326.

The ulnar perfusion rate of the fingers in the prolonged recoloration time patients was significantly lower ($p<0.001$), but also the palmaris ulnaris perfusion rate was also significantly lower in this patient group. There was not any difference between the perfusion rates ($p>0.05$).

On the basis of the finger/palm ratio (FPR), we measured FPR values under 0.45 in the case of 8 hands, which indicates low finger microcirculation similar to the patients with Raynaud Syndrome. However, out of these patients, on the basis of the Allen test, in the case of only 2 hands we measured prolonged recoloration time. In the

other cases, in correlation with the result of the Allen test, though we measured low FPR value during the dynamic hand perfusion examination, by releasing the ulnar artery, the activity balance of the fingers took place before releasing the radial artery.

b. The results of the post-operative examinations.

In the course of the control examination following the operation, we did not find any difference in the regions of the palm, fingers II-V, finger I, and finger V, compared with the preoperative examinations between the maximum activity and the total activity values expressed in % cm2 (at the comparison of every parameter $p>0.05$).

DISCUSSION, CONCLUSIONS:

Since Carpenter first applied radial artery for coronary bridging operations, in general heart surgery centers this artery is widely used for total artery revascularization due to the positive early and mid-range results. The artery supply of the hand is provided by two large arteries: the radial artery and the ulnar artery. There are two larger connections between the two arties: the arcus palmaris superficialis and the arcus palmaris profunda. In case this anastomosis system is developed, the clogging of one of the arteries (removal) does not cause a significant disorder in the circulation of the hand because the amount of the blood flooding through the artery on the opposite side reaches the small arteries supplying the fingers through the arcuses. In case the connection is not sufficient or is missing, the removal of one artery, e.g. the radial artery, can lead to the ischemia of the fingers. Despite the fact that most authors give account of mainly neurological and sensational disorders, especially in the early post-operative phase, the circulation disorder of the fingers can also be expected. Filtering method for assessing if the radial artery can be removed without damaging the circulation of the hand. This is used, although at the 6-second recoloration limit the sensitivity of the Allen test is only 54.5%, although its specificity is 91.7% and its diagnostic reliability is 78.5%. If we set the recoloration limit lower, the sensitivity can be increased but the specificity gets worse.
So there is a great need for more objective examination methods like this which are suitable either individually or evaluated together with the Allen test to assess whether the artery ulnaris and its collateral network are suitable for ensuring appropriately the circulation of the hand. Several non-invasive and more invasive techniques have been tried with this purpose, which is proved by several publications edited in recent years. In Debrecen since 1988, the radial artery has more and the radialis was used. Despite the great number of interventions, there are few postoperative complications, however, there was a justified need of the clinical staff for such a non-invasive method, which could be used for the safer removal of the radial artery together with the Allen test as a filtering method.
The Tc-99m-HSA used in our method stays intravasalis following the intravenal injecting. In the set region the activity measured, the given time is proportional with the blood content in the given region. On the basis of the time-activity curve, we divided our patients into two groups. In our opinion, with the patients whose activity level of the fingers II-IV did not increase further after the release of the radial, the blood supply through the artery ulnaris is dominant and they have an appropriate collateral network. However, if following the release of the radial, the increase of the level of the activity of the fingers is measurable, it makes us draw the conclusion that also the radial artery contributes significantly to the appropriate blood supply of the fingers or the anastomosis is not appropriate between the two systems. However, it does not mean directly that with these patients the radial artery cannot be removed. We think if in such cases the use of the radial artery is inevitable, the follow-up monitoring of the patient should be stricter. Though from the few post-operative

examinations it is impossible to draw an appropriate conclusion, it is remarkable that following the operation we could not detect any sign of the decrease of the blood stream in the regions of the palm, fingers II-IV, or finger I and finger V with our patients we considered to have “good ulnaris circulation”.
Our examinations indicate that there is no direct correlation between the “cold fingers” and the ulnaris circulation, so the question arises if the removal of the radial is really contra-indicated in the case of the Raynaud Syndrome. On the basis of our results we think that the method worked out by our team is a sensitive indicator of the Allen test. It provides an objective, archive document, which is indispensable for the follow-up monitoring and can be well used.

SUMMARY
It is said that the hand and the brain are our most “human” organs. Without our hands we could not have become humans and even the smallest cerebral disorder immediately affects our human character. The blood supply of these two organs are very common, they provide the basis of numerous diseases. However, there are only few methods of diagnostics at our disposal in everyday life that could be appropriate in every respect. In our study we made an attempt to elaborate and introduce such methods in everyday diagnostic practice.

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