

Scintigraphic and ultrasonographic assessment of the effect of lumbar sympathectomy upon chronic arteriosclerotic ischaemia of lower extremities

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Abstract

The aim of the study was an evaluation of the effect of one-sided lumbar sympathectomy in patients with peripheral vascular disease of lower extremity(ies), using perfusion scintigraphy with ^{99m}Tc-MIBI and ultrasound Doppler blood flow-rate measurements. A secondary aim was a comparison of the diagnostic efficacy of the two techniques applied.

The study was performed on 30 patients, studied prior to and early after one-sided lumbar sympathectomy. The scintigraphy yielded results indicating a statistically significant increase in perfusion of femoral and calf muscles ($p < 0.001$). Ultrasound investigation demonstrated significant ($p < 0.001$) increase of the maximal blood flow rate in the popliteal artery. Scintigraphic perfusion study yielded better agreement with the clinical evaluation than the ultrasound Doppler technique (83 v. 47 per cent, $p < 0.01$) and higher sensitivity in demonstration of improved blood supply (88 v. 36 per cent, $p < 0.001$).

Key words: lumbar sympathectomy, muscular perfusion scintigraphy, ultrasound measurements of blood flow rate

Introduction

Objective evaluation of therapy of arteriosclerotic occlusive disease of lower extremities is a very difficult task, due mostly to the temporal variability of symptom intensity or to spontaneous remissions. Patients' condition is being assessed mostly from results of the clinical examination. The latter utilises both the anamnesis (signs: numbness, paraesthesias, pain) but also evaluation of symptoms i.e. presence and strength of arterial pulsation and measurements of arterial blood pressure in the extremities. These data provide — as a rule — sufficient information when reconstruction surgery is considered and on patients' condition after reconstruction of the vascular blood flow, which leads in general to significant clinical improvement.

However, for some categories of patients there is a clinical need to apply less radical curative methods, which may lead to improvement of limbs' perfusion (e.g. lumbar sympathectomy, pharmacological treatment, balneological cure). Therefore there arises a concomitant need for non-invasive methods, utilising e.g. ultrasound and/or radioisotope procedures, for the evaluation of such a therapy.

At present the effectiveness of lumbar sympathectomy is a subject of dispute, and quite often pejorative opinions are being expressed. There have been several opinions, that lumbar sympathectomy increases merely the subcutaneous blood flow and leaves the muscular perfusion unaffected [1, 2]. The procedure itself is therefore applied principally in those patients in whom reconstructive surgery is non-practical.

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The aim of the study presented below was therefore to work out and/or to apply methods that could lead to an objective evaluation of the effectiveness of lumbar sympathectomy in patients with peripheral vascular disease of the lower extremities. The choice made was to apply perfusion scintigraphy of muscle groups of the lower limbs and Doppler-ultrasound measurements of arterial blood flow. The secondary aim was comparison of the diagnostic efficacy of these two modalities, taking established clinical methods for assessment of patients' condition as a standard.

Material and methods

The study was made on 30 patients (28 males and 2 females) with age from 26 to 71 years (av. 57), in whom chronic ischaemia of lower limbs, due to atherosclerosis, had been diagnosed. The diagnosis was based on clinical investigation supported by ultrasound and/or arteriographic procedures. In all of these patients lumbar sympathectomy was chosen as a therapeutic method of choice. Altogether, 30 extremities were evaluated before and after ipsi-lateral sympathectomy.

Clinical evaluation

As the reference for assessment of both visualising procedures a clinical evaluation was accepted. The latter included: pulse evaluation, determination of claudication and treadmill walking distance and arterial tension measurements in arteries of the lower extremities, with calculation of the Doppler ankle/arm index. The latter has been defined as a ratio of the maximal arterial tension in posterior tibial artery to that in the ipsi-lateral brachial artery.

As evidence of clinical improvement of the circulation in lower extremities after sympathectomy fulfilment of at least one of the following conditions was accepted:

- occurrence of the arterial pulse at the site where it had been absent before the surgery;
- elongation of the claudication distance by at least 100 m [3];
- increase of the value of the ankle/arm index by at least 0.1 [4].

Scintigraphy

Perfusion scintigraphy of muscle groups of the lower extremities was performed in all patients in the week preceding the sympathectomy and again 6 or 7 days after the surgery.

For the scintigraphy a ^{99m}Tc methoxyisobutylisonitrile complex ($^{99m}\text{Tc-MIBI}$) was used. The activity administered amounted to 370 MBq. The radiopharmaceutical was injected intravenously in course of a physical stress test on a cycle ergometer. The test started with a workload of 50 Watt (W); at each consecutive minute the load was increased by 25 W up to the moment of pain in the limb, or to the limit of 150 W. After reaching the individual limit the radiopharmaceutical was injected and physical effort continued for 1 min.

Scintigraphy was started 10 min after injection of $^{99m}\text{Tc-MIBI}$ and images were acquired in planar mode by means of a planar PICKER scintillation camera, coupled to a Max Delta 2000 computer. The patient was studied in a supine position and scintigrams of femoral and calf muscle groups were acquired in posterior projection. The images were acquired in a 64×64 matrix over a 5 min interval; in each scintigram the number of counts accumulated exceeded 3×10^5 .

The scintigrams were evaluated both qualitatively (visually) and quantitatively. The uptake of the radiopharmaceutical was judged in relation to the symmetrical region of the contralateral limb. Uniformity of activity distribution in femoral and calf muscle groups (60 regions altogether) was also qualitatively assessed.

The following visual criteria were accepted for change in blood perfusion of the studied region:

- improvement of the perfusion — a clearly visible increase in the uptake of the radiopharmaceutical (relative to region of the contralateral limb) and/or complete or partial disappearance of hypoperfusion-foci;
- lack of perfusion improvement — lack of a difference in intensity and uniformity of the uptake between the images of pre- and post-surgery scintigraphy.

Three nuclear medicine specialists had made a visual evaluation and the final result was established by reaching a consensus.

The quantitative assessment was based on calculation of a symmetry quotient (Qs) i.e. the ratio of a number of counts in the region of the limb at the side of sympathectomy (Fig. 1) to the corresponding region of the contralateral limb. Increased perfusion of the region was diagnosed when the difference between pre- and post-surgery Qs value exceeded the diagnostic threshold level, as defined below.

This diagnostic threshold level was calculated from two-fold recordings of 10 scintigraphic investigations of the lower extremities (in each case the patient had been positioned ab novo in the field of view of the camera). In the presurgery study in each patient two values of Qs for the femoral and calf regions were thus obtained, and the relative error for each patient and then the mean error for all measurements for each region were calculated. The decision threshold was taken as a mean of the individual Qs errors plus 2 standard deviations of the individual error distribution.

A positive effect of lumbar sympathectomy in relation to the extremity was diagnosed on the basis of perfusion scintigraphy when an improvement of perfusion was seen in at least one region of the limb (femoral, calf) either by means of a visual or quantitative assessment, or both [3].

Ultrasound assessment of the arterial blood flow

Ultrasound examinations had been performed in each patient on the same day as the scintigraphic investigations. They were made using an ultrasound machine USG 128 XP-10, manufactured by ACUSON, equipped with Doppler subunit, enabling colour valuation of the observed blood flow velocity distribution.

For evaluation of the results a Doppler flow index (DFIs) was used; it is defined as the ratio of the maximal flow rate in the studied vessel of the lower limb to the analogous maximal value for the brachial artery. The measurements in the lower extremities involved the femoral artery just above the onset of the deep femoral artery, and the popliteal artery at the level of the medial meniscus of the knee-joint.

As a criterion of improved blood flow resulting from the performed surgery, the one elaborated by Górski et al. [5], i.e. the change of flow character from a uni- to biphasic one and/or an increase in the flow-rate quotient above an experimentally established decision threshold [5], at least in one of the two measurement loci, was used.

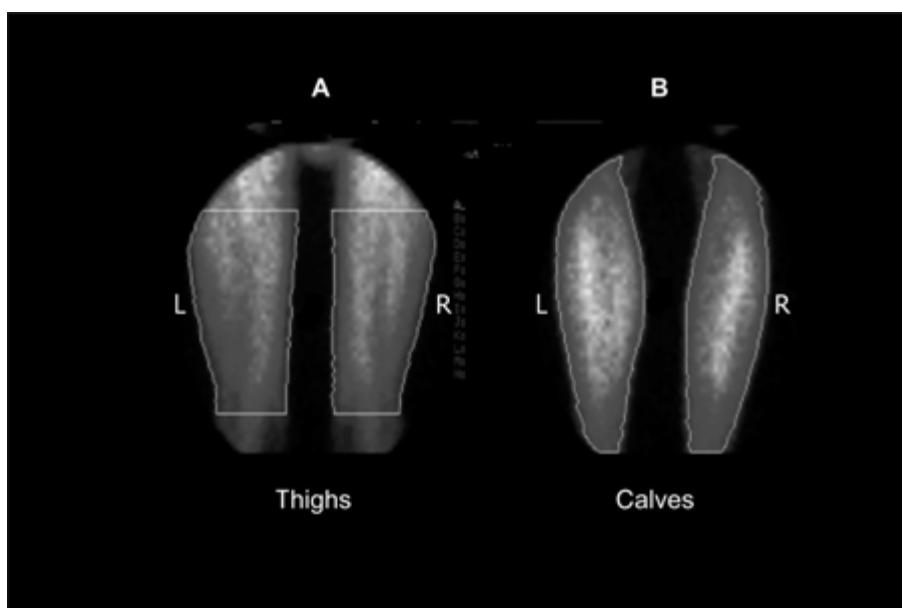


Figure 1. Scintigrams of calf and femoral groups of muscles (^{99m}Tc MIBI) with regions of interest: **A.** Thighs; **B.** Calves.

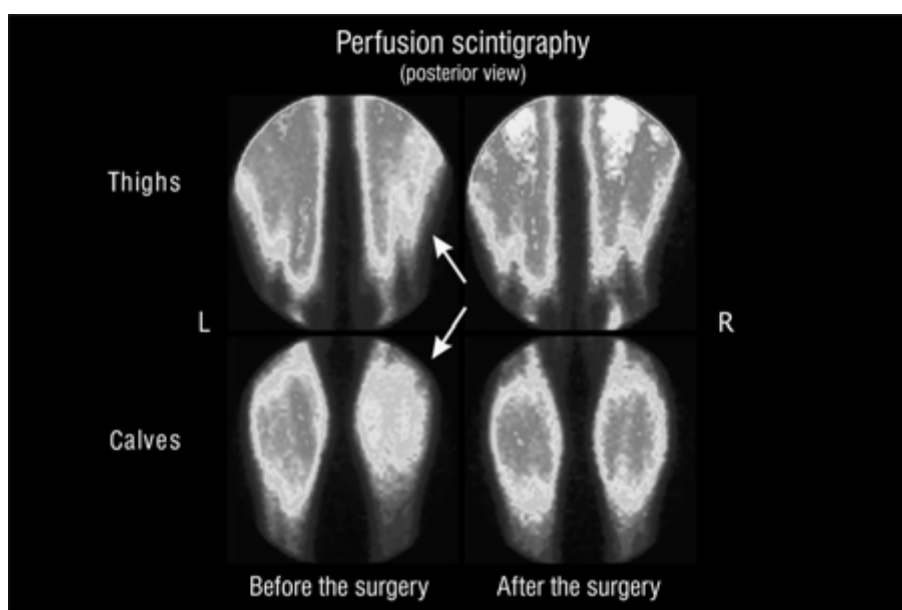


Figure 2. Stress perfusion scintigrams of femoral and calf muscle groups in a patient treated with unilateral lumbar sympathectomy. Before the surgery uniformly lower uptake of the radiopharmaceutical in the right thigh and calf (arrows). After the surgery normalisation of the scintigrams.

Comparison of results of scintigraphic and ultrasound examinations

Both the scintigraphic and ultrasound results of perfusion and blood flow-rate in each extremity were compared with the clinical evaluation, taken as a standard. On the basis of the criteria presented above, the results of the two methods were classified as concordant or discordant with the clinical judgement.

For statistical evaluation the t-Student test for related samples was used. In addition a concordance test of McNemara was applied.

Results

Before sympathectomy, on visual inspection of scintigrams, abnormalities in perfusion were detected in 40 out of 60 regions examined (67%). After surgery, normalisation of the images was clearly apparent in 20 regions, and partial improvement of the perfusion in 5 regions. A beneficiary effect of the therapy in the form of enhanced muscular perfusion (Fig. 2) could be demonstrated in 18 out of 30 extremities affected by the surgery (60%).

In the quantitative assessment, the arithmetic mean of relative errors of Qs indices (from double acquisitions) of the images amounted to 3.5 % (SD = 3.2%) for the femoral regions and to 2.7% (SD = 2.3%) for the calves. The recognition threshold for improved perfusion, according to the accepted criteria, amounted to the increase of preoperative values of Qs by 10 and 8% for femoral and calf regions, respectively.

At preoperative evaluation the mean Qs values were 99.2% (SD = 14.3) and 89.0% (SD = 19.4) in femoral and calf regions, respectively. After the surgery the increase of the mean Qs index in both regions was significant (p for both cases < 0.001). The mean values reached 108% (SD = 17.2) and 96.4% (SD = 22.6) for femoral and calf regions, respectively (Fig. 3).

Postoperative increase of Qs could be demonstrated in 14 and 13 regions, for femoral and calf muscular groups, respectively. An improvement of perfusion after sympathectomy was clear in 21 out of the 30 treated limbs. In six cases it affected both muscular groups, in 8 it applied to femoral and in 7 to calf regions solely.

Concordance of the assessment by means of the visual and quantitative procedure with the clinically assessed effects of sympathectomy was similar and reached, correspondingly, 77 and

80 per cent. A combined assessment of the effects of surgery, based on both visual and quantitative evaluation of the scintigrams was in agreement with the clinical assessment in 25 out of 30 treated extremities (83%).

Before the surgery mean values of the DFI index estimated by means of ultrasound for femoral and popliteal artery amounted to 0.79 (SD = 0.15) and 0.64 (SD = 0.20), respectively; after sympathectomy they increased correspondingly to 0.82 (SD = 0.14) and 0.86 (SD = 0.22) ($p < 0.001$) (Fig. 4). In 7 limbs there was a significant increase of the DFI index in the popliteal and in 3 limbs in the femoral artery. On the basis of accepted ultrasound criteria a beneficial effect of the therapy was found in 9 out of the 30 treated extremities. The ultrasound studies yielded results consistent with the clinical diagnosis in 14 out of 30 treated limbs (47%). Comparison of ultrasound and scintigraphic studies reveals that concordance of the latter with the clinical assessment of the therapy was significantly better than that of the former (83 v. 47%, $p < 0.01$).

In a clinical assessment of the effectiveness of the treatment a beneficial effect was noted in 25 out of 30 treated limbs. In the scintigraphic studies a marked improvement of the perfusion was observed in 22 and by means of ultrasound method in 9 extremities. The resulting sensitivity of both methods amounted to 88 and 36 per cent, respectively, and this difference is highly significant from the statistical point of view ($p < 0.001$) (Fig. 5).

Discussion

In the present study clinical assessment of patients' condition was accepted as a standard. Postoperative improvement was defined as a beneficiary change of at least one of the three parameters, i.e. elongation of claudication distance, increase in ankle/arm index and reoccurrence of the pulse wave. In view of the fact that a uniform and commonly accepted set of standards for evaluation of clinical condition in peripheral atherosclerosis has not yet been formulated, it was concluded that the accepted definition of improvement should allow us to detect real postoperative improvement of limbs perfusion, and therefore could serve as a yardstick for evaluation of the scintigraphic and ultrasound methods, as utilised in this study.

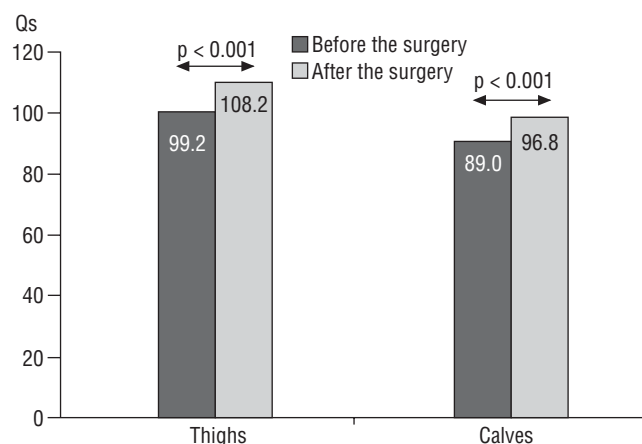


Figure 3. Mean values of the symmetry index (Qs) before and after sympathectomy (n = 30 extremities).

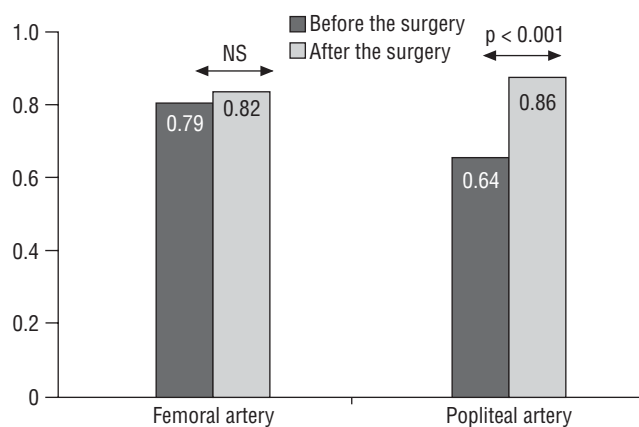


Figure 4. Mean values of the Doppler flow index (DFI) before and after sympathectomy (n = 30 extremities).

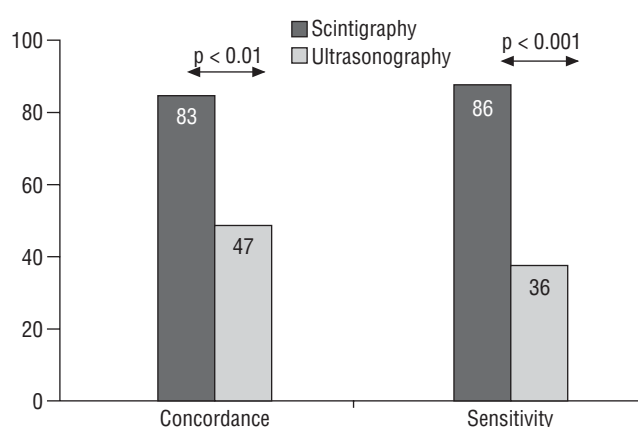


Figure 5. Concordance with clinical assessment of patient condition and sensitivity of the scintigraphic and ultrasound diagnostics.

Ultrasound with Doppler option has emerged as a basic diagnostic test for recognition of the chronic ischaemia of lower extremities. The method is also valuable in the diagnosis of complications in the early post-surgery period, particularly in patients who undergo reconstructive procedures. Ultrasound allows evaluation of the patency of vascular prosthesis, diagnosis of exudate, haematoma, pseudoaneurysm, fistula and last but not least functional evaluation of the reconstructed vessels. Advantages of this method include also its low cost, and wide availability, which therefore makes repeating of the investigations easy. In ultrasound Doppler studies the blood flow is assessed by description of its character and also by calculation of indices connected with the speed of flow and passage time of the sound wave [6]. The determinations are, however, subject to substantial uncertainty, and what is also very important they cannot be made under conditions of physical stress. Górski and his co-workers [5] demonstrated nevertheless the usefulness of the index of the Doppler flow index — used in this study — for evaluation of the effects of reconstructive surgery. Our studies have demonstrated, however, its limited value on the evaluation of the improvement in perfusion of the limb after lumbar sympathectomy. Even if a statistically significant increase of the flow rate could be demonstrated after the surgery, in the popliteal artery, the accordance of these results with overall clinical evaluation and sensitivity of detection of the improvement were pretty low. These limitations of the method are — most likely — due to substantial errors in ultrasound-related measurements, but also to the inability to use the method for assessment of stress-induced reserve of the flow-rate.

Initially, for scintigraphic studies of muscular perfusion, complex procedures of tissue clearance measurements had been applied. Later on, relative perfusion has been assessed using labelled microspheres, thallium chloride (TI-201), and eventually the ^{99m}Tc -labelled isonitrile compounds [7–12]. Respective PET-studies utilised for the purpose ^{15}O and ^{13}N labelled water and ammonia, and also rubidium (^{82}Rb) [13, 14]. These procedures are not practically available for such purposes in this country, and are highly expensive.

At present the radiopharmaceutical of choice is ^{99m}Tc -MIBI (methoxy isobutylisonitrile). The compound is commonly available, relatively cheap and widely used for assessment of myocardial perfusion. The complex is taken up rapidly and stays in the cells with practically no demonstrable muscular redistribution for 2–3 hours after intravenous injection. This behaviour makes studies of the relative muscular perfusion at the level of tissue microcirculation functional, both at rest and under conditions of physical stress [15–19].

Evaluation of the curative effects of sympathectomy by means of various radiopharmaceuticals did yield equivocal results. There were studies which reported a significant increase of the perfusion but others reported no measurable improvement of the blood supply [20–23]. So far, authors of this paper were unable to detect a study, which would assess the value of the ^{99m}Tc -MIBI scintigraphy for evaluation of effects of lumbar sympathectomy upon muscular perfusion in the lower extremities.

The qualitative-quantitative method of perfusion assessment, as applied in this study, seems sufficient for evaluation of the undertaken therapy, i.e. lumbar sympathectomy. It seems important that both qualitative (visual) as well as quantitative analysis, when performed separately, demonstrated a high degree of concor-

dance with the clinical evaluation. When juxtaposed with the Doppler ultrasound method the scintigraphic perfusion seems to possess higher diagnostic efficacy. It was able to demonstrate improvement of perfusion even in cases, in which no increase of the flow-rate in large arteries could be detected by means of ultrasound (D). Scintigraphy, which reflects limbs perfusion at the level of myocytes, has proved therefore to be an objective method for evaluations of the therapeutic effect of one-sided lumbar sympathectomy. One could also expect that after some modifications the method could be used for the evaluation of results of the conservative therapy, but this needs further studies [24].

Conclusions

1. Visual-quantitative evaluation of perfusion ^{99m}Tc -MIBI scintigrams of muscles of lower extremities under conditions of physical stress shows high sensitivity in detection of post-operative blood flow improvement after lumbar sympathectomy. Results of these evaluations are in accord with clinical evaluation of the therapy.
2. Doppler-ultrasound provides a chance for additional objective assessment of the effects of lumbar sympathectomy in patients with atherosclerotic ischaemia of lower extremities. However, the sensitivity of this method for the detection of perfusion improvement seems unsatisfactory.
3. By comparison, muscular perfusion studies by means of ^{99m}Tc -MIBI scintigraphy under conditions of physical stress seem superior to the Doppler ultrasound procedure for assessment of the effects of one-sided lumbar sympathectomy.

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