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Percutaneous transluminal angioplasty (PTA) of supra-aortic arteries especially the internal carotid artery

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Summary. We present our experience with 105 patients in whom percutaneous transluminal angioplasty was performed in 112 stenosed or occluded supra-aortic arteries. Symptoms of cerebrovascular and/or vertebrobasilar insufficiency were present in 104 of the 105 patients. The angioplasty was successful in 35 stenoses of the internal carotid artery, 2 stenoses of the common carotid artery, 1 stenosis of the external carotid artery, 15 stenoses of the vertebral artery, 3 stenoses of the innominate artery and 44 stenoses of the subclavian artery. There were only 4 minor-complications (2 haematomas, 1 transient ischemic attack, 1 small thrombus of the internal carotid artery which was detected by 111-indium platelet scintigraphy and treated by thrombendarterectomy before the appearance of neurological symptoms). All patients were symptom free after angioplasty. During the observations period of 3 to 109 months (average 58 months) there were only two cases with re-stenosis after subclavian angioplasty. The results of more than 700 personal and international published percutaneous transluminal angioplasties of supra-aortic arteries are presented. The results suggest that angioplasty of supra-aortic arteries is an effective method. On strict definition of the indications, the complication rate for angioplasty of the supra-aortic arteries is not likely to be higher than that for operative treatment.

Key words: Angioplasty – Carotid artery – Vertebral artery – Supra-aortic arteries – Stroke – Cerebrovascular insufficiency

Percutaneous transluminal angioplasty (PTA) of the pelvic, leg, coronary and renal arteries is now routinely carried out in many centres, but PTA of the supra-aortic region is a matter of controversy and is only undertaken with reluctance because of the danger of a possible embolism. The first reports of successful attempts at the dilatation of carotid stenoses were reported in 1980 by Kerber et al. and Mullan et al. [1, 2]. Neither publication aroused much international interest. However, when Mathias reported a successful carotid dilatation in 1981 the publication was received with a wave of indignation and criticism [3–5].

This report will review published reports of the PTA of supra-aortic arteries in the light of personal experience.

The PTA method

The current vascular situation is clarified angiographically by means of a transfemoral sonde consisting of a F5 or F6 diagnostic catheter, an extended guide wire (200–250 cm) is then inserted into the stenotic vessel. After the guide wire has been inserted into the poststenotic region the diagnostic catheter is replaced by the dilatation catheter using the wire as a guide. When the dilatation segment has been located in the stenotic region the dilatation balloon is filled with a contrast medium-water mixture from a pressure syringe and the stenosis is dilated. The dilatation requires a pressure of 3 to 12 atm depending on the type of catheter. The time taken to inflate the catheter is 20 to 30 s, when dilating stenoses of the internal carotid artery 5 to 10 s. Two to three dilatations are usually required to bring about complete enlargement of the stenosis.

Dilatation catheters supplied by William Cook Europe A/S (Denmark), Medi-tech/Boston Scientific (Germany) and Schneider (Austria) are usually used in our establishment. Subtotal occlusions are dilated successively. The Cordis Corporation (Florida, USA) F4–PTCA balloon catheter, which can be used with a dilatation pressure of up to 12 atm is particularly useful for the initial dilatation. The balloon diameters employed are 4 to 10 mm depending on the diameter of the vessel.

The PTA is carried out under heparin protection (10000 U heparin).

When carrying out PTA of cerebral arterial stenoses it is necessary to monitor heart and brain function by ECG and EEG or by means of the somatosensory evoked brain stem potential. If pathological electroencephalograms are observed then perfusion should be undertaken with homologous blood via the internal lumen of the dilatation catheter. This method has been described elsewhere [6].

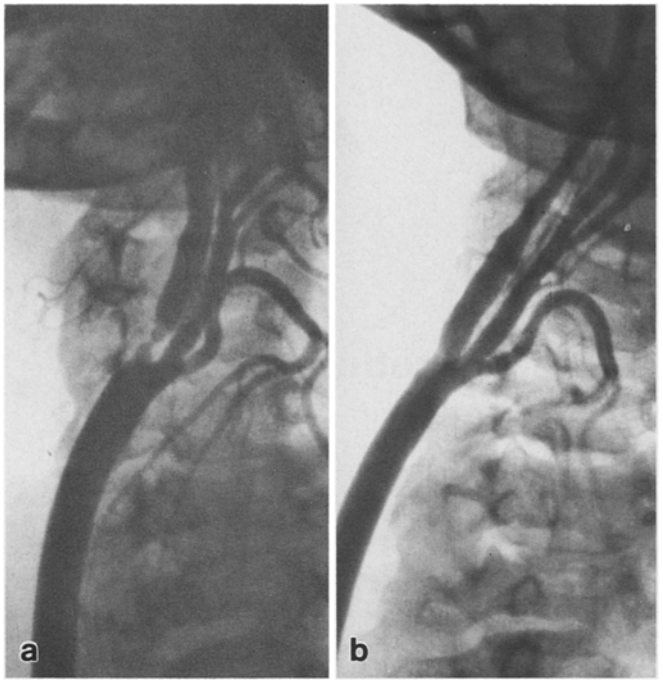

Fig. 1 Subtotal occlusion of the right internal carotid artery (RAO-projection) before (**a**) and after PTA (**b**)

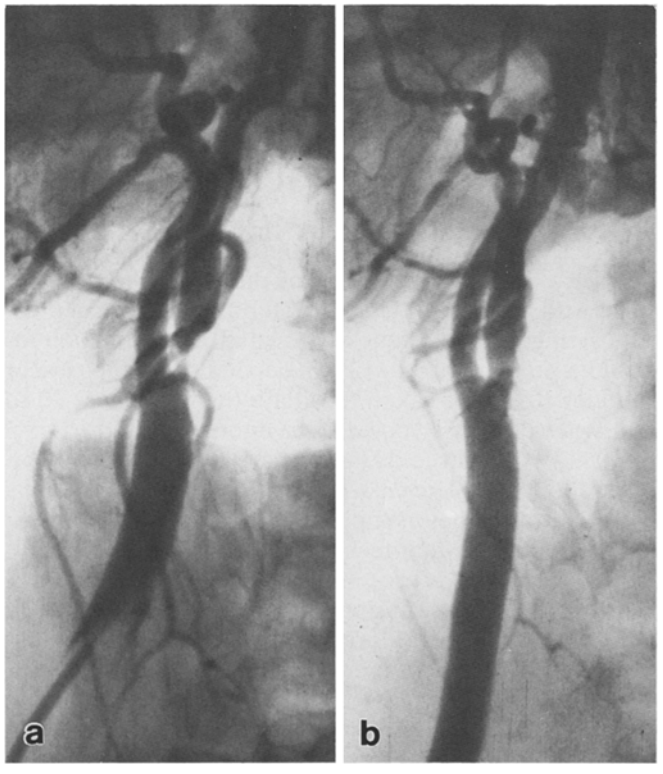

Fig. 2. Subtotal occlusion of the right internal carotid artery (LAO-projection) before (**a**) and after PTA (**b**)

The possibility of fresh thrombotic depositions is excluded by 111-indium platelet scintigraphy before PTA, with controls up to 2 days post PTA [7]. Since it is not always possible to pass high degree stenoses of the subclavian arteries with a dilatation catheter after insertion of a transfemoral sonde, access is achieved in such cases via a transaxial sonde after puncture of the nonpalpable axillary artery under ultrasonographic guidance.

Angiographic control is carried out for documentation purposes after successful or unsuccessful PTA. Nonionic contrast media (Ultravist/Schering AG, Berlin, FRG); Omnipaque/Nycomed A/S, Norway) are employed for angiographic imaging. Postoperative treatment is carried out with platelet aggregation inhibitors or oral anticoagulants.

Patients and results

We have carried out PTA on 105 patients with 112 supra-aortic arterial obliterations with a primary success rate of 95.2% in the case of stenotic changes. The patients were aged from 33 to 79 years, the average age was 54 years. PTA was applied in 51 subclavian obliterations (44 stenoses, 7 occlusions) and 61 stenoses of arteries supplying the brain (carotid artery: 43, vertebral artery: 15, innominate artery: 3).

Symptoms of cerebrovascular, vertebrobasilar and/or brachial insufficiency were present in 104 of the 105 patients. Only one patient was asymptomatic.

Successful dilatation was carried out on

- 35 stenoses of the internal carotid artery (Figs. 1–3)
- 2 stenoses of the common carotid artery
- 1 stenosis of the external carotid artery with homolateral internal occlusion with perfusion of the hemisphere exclusively retrograde via the ophthalmic artery,
- 15 stenoses of the vertebral artery,
- 3 stenoses of the innominate artery and
- 44 stenoses of the subclavian artery.

Recanalization of a total of 7 occlusions of the subclavian artery was only successful in one case (15%).

PTA of high grade stenosis was also successful after local thrombolysis in one female patient with a fresh post-stenotic thrombosis of the subclavian artery in the 1st segment and symptoms of 4th degree brachial insufficiency (resting pain, finger tip necrosis). The patient was virtually free from pain only 15 minutes after the commencement of the local thrombolysis. The lethality and morbidity after PTA of supra-aortic arterial obliteration was 0% in our patients. There were no major complications; minor complications occurred in 4 patients.

There were:

– Two extensive haematomas in the region of the puncture site, which resolved without further complication under conservative therapy.

– A TIA that resolved spontaneously and which was due to spasm in the siphon region attributable to the PTA of an internal stenosis.

– A small thrombus on the wall of the internal carotid artery occurring after an unsuccessful attempt to introduce the dilatation-catheter into a subtotal internal occlusion and which was detected by 111-indium platelet scintigraphy before the appearance of neurological symptoms. On thrombendarteriectomy it was possible to verify a fresh prestenotic thrombus 4 mm in diameter which had

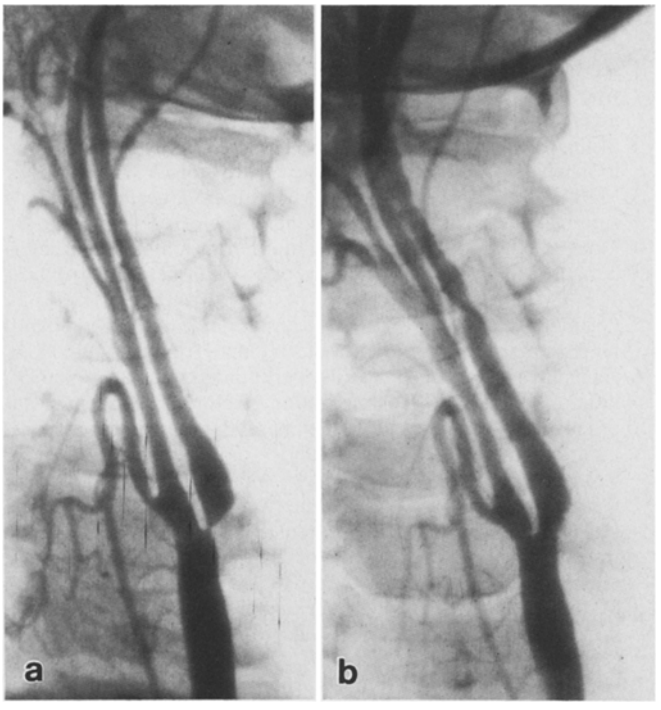

Fig. 3. Subtotal occlusion of the left internal carotid artery (LAO-projection) before (**a**) and after PTA (**b**)

not yet occluded the lumen. The postoperative recovery was without complication.

An analysis of previously published results on PTA of supra-aortic arteries revealed comparable results. The reported lethality was 0%. Major complications with permanent damage (pareses) were reported in 0.5% of cases and minor complications in 3.5%. Haematomas in the puncture region, thrombosis of the subclavian and iliac arteries, thrombo-embolism in the finger arteries and transitory neurological symptoms, which were unimportant prognostically, were regarded as being minor complications. The results of PTA attempts in more than 700 cases are summarized in Table 1.

During a follow-up observation period of 3 to 109 months (average 58 months) there were only two cases with re-stenosis after subclavian PTA, and in the case of one patient this was permanently removed by means of a second PTA. A carotico-subclavian by-pass, set up in the second patient, ceased to function within 12 months as a result of thrombosis, so that a second PTA is envisaged here too.

Re-stenosis in the arteries supplying the brain can be excluded by ultrasonic tomography and duplex sonography. Transitory ischaemic neurological attacks did not re-appear during the period of follow-up.

Discussion

The primary success rate for PTA of supra-aortic arteries is reported as 94–97% in the international literature and, thus, corresponds to that obtained in other vascular regions [6, 8]. The complication rates reported, the lethality of 0% and a morbidity (major complication rate) of 0.5%, make it appear that PTA in the supra-aortic region is also a possible alternative to correction by vascular surgery [6, 8–14].

PTA of the subclavian artery is always indicated when a haemodynamically significant stenosis has been indicated by vertebrobasilar and/or brachial symptoms. The frequently occurring steal phenomenon makes the danger of an intracerebral or intracerebellar embolism very small even for stenoses of the 1st segment [8–10, 15–17].

Our own and published results allow the conclusion that PTA rather than surgical correction is the method of choice for the treatment of symptomatic stenoses of the subclavian artery.

The results obtained by PTA of subclavian occlusions, however, are unsatisfactory, with a world-wide success rate of 15–30% [6, 8, 18], so that the treatment of choice remains operative correction. PTA should only be attempted with patients in whon the risk from operative intervention is unacceptable.

Pathological anatomical studies reveal that over 95% of stenoses of the vertebral artery are circular, smooth-walled and free from ulceration, so that they are suitable for PTA [18], complications of the PTA of exit stenoses of the vertebral artery are very rare with 0% lethality and morbidity and a minor complication rate of 4%. The complications primarily consist of transient disturbance of vision and, in one case, an early thrombotic occlusion but this was not reported to lead to any worsening of the symptoms [8, 9]. The long-term results with 80–90% cure or appreciable improvement also speak for PTA as the method of choice for the treatment of symptomatic vertebral stenosis [13, 15].

The application of PTA in the region of the carotid artery is still controversial. On the basis of our own favourable results and of an analysis of those published in the literature it can be assumed that, on strict definition of the indications, the complication rate for PTA of stenoses of the carotid artery is not likely to be higher than that for operative treatment [6, 8, 11, 19, 20].

It is the authors' opinion that PTA of stenoses of the arteries feeding the brain is indicated when:

Table 1. Published and personal results of PTA of supra-aortic arteries

Region	PTA-attempt	PTA-success (%)	Complications (%)	
			major	minor
Subclavian artery	436	419 (96,1%)	0,2%	4,1%
Vertebral artery	136	129 (94,8%)	0%	4,0%
Carotid artery	177	165 (93,2%)	1,7%	2,3%
Innominate artery	25	25 (100%)	0%	0%
Total:	774	738 95,3%	0,5%	3,5%

1. there are unequivocal symptoms of stenosis,
2. a haemodynamically significant stenosis can be demonstrated, which is very probably answerable for the symptoms and
3. certain morphological criteria are fulfilled.

These morphological criteria are:
1. circular stenoses extending over a short length,
2. smooth delineation of the stenosis with no indication of ulceration, heavy calcification or thrombotic deposits,
3. exclusion of fresh cerebellar, brain stem or cerebral infarction,
4. no constriction from outside and
5. no additional kinking present.

These morphological criteria make the following examinations necessary:
1. ultrasonic tomography or duplex sonography for noninvasive diagnosis and assessment of the degree of stenosis,
2. rheoencephalography or better, emission computer tomography for measurement of the blood flow disturbance in the cerebrum and cerebellum,
3. computer tomography or magnetic resonance tomography to exclude fresh infarction,
4. 111-indium platelet scintigraphy to exclude fresh thrombotic deposits,
5. angiography to verify the stenotic changes and to exclude the presence of additional kinking.

The application of PTA to ulcerated stenoses of the carotid artery cannot be advocated, since even if a latex balloon, which occludes the internal carotid artery, is used, like that employed by Theron [19], it is still only possible to reduce the risk of thrombo-embolism by a certain degree. The intimal lesions produced by the latex balloon and the increased liability to spasm associated with these lead to additional dangers for the patient.

To advantages of PTA of supra-aortic arteries over vascular surgery may be counted.
1. ready execution and successful application even to postoperative stenoses,
2. possibility of utilizing PTA for peripheral stenosis of the internal carotid artery, which is not accessible to operative invasion,
3. ready repeatability,
4. no or very little stress for the patient,
5. brief interruption of blood supply to the brain which can be avoided by perfusion,
6. appreciably lower costs and shorter period of hospitalization,
7. surgical correction is usually possible if PTA fails,
8. PTA is advantageous for patients with several affected vessels and can be employed on patients at risk from other conditions.

One of the basic requirements for carrying out PTA on arteries supplying the brain is a team, made up of vascular surgeons, internists, neurosurgeons, interventional radiologists, which provides the indications for conservation, vascular surgery, neurosurgical or intervention radiological therapy in each individual case.

Occlusion and ulcerated or severely calcified stenoses of carotid and vertebral artery are not indications for percutaneous transluminal angioplasty and should be treated effectively by surgery.

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