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COMPARATIVE DOPPLER FLOW MEASUREMENTS OF THE ULNAR ARTERY AND OF THE POSTANASTOMOTIC RADIAL ARTERY IN RADIOCEPHALIC ARTERIOVENOUS FISTULAS TO DETECT STEAL SYNDROMES

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Objective: **This study aims to assess whether a comparison of the Doppler flow measurements of the ulnar artery and of the postanastomotic radial artery can help detect steal syndromes at the level of native dialysis fistulas of the wrist.**
Patients and methods: **We have prospectively analyzed 35 distal radiocephalic arteriovenous fistulas presenting with postanastomotic radial artery Doppler inversion of flow. The flows of the ulnar artery and of the postanastomotic radial artery have been measured and compared. Subsequent clinical examination to detect any sign of ischemia at the hand level was performed and the results of medical imaging were confronted with the clinical data.**
Results: **A steal syndrome was discovered in a total of 6 patients (17%), 4 patients out of 23 displaying an ulnar flow lower than the postanastomotic radial one and 2 patients among 12 with an ulnar flow higher than the radial one.**
Sensitivity, specificity, positive predictive value and negative predictive value of the test were 67%, 34%, 17% and 83%, respectively.
Paradoxically, the mean intensity of ulnar flow deficiency has been measured at 40% among true positive patients and at 70% among false positive ones.
We have not been able to identify any difference, be it in terms of systolic upstroke time, maximum systolic speed, telediastolic speed or in terms of global architecture of the curves between the Doppler waveforms of 4 true positive and 4 false positive patients.
Conclusion. **The comparative Doppler study of the flows of the ulnar and postanastomotic radial arteries does not enable us to detect steal syndromes at the level of wrist dialysis fistulas.**
Hence we consider that a systematic study of the postanastomotic radial artery flow, during routine Doppler examination of distal dialysis fistulas, proves superfluous.

Key-word: Fistula, arteriovenous.

Doppler Ultrasound (DUS) examination very often detects a postanastomotic radial inversion of flow without any noxious effect on hand vascularization in patients with a native dialysis fistula at the wrist: this is a mere steal phenomenon (Fig. 1). In some cases however, the quantity of diverted blood is so important that it induces a distal ischemia a.k.a. steal syndrome, whose clinical diagnosis may prove difficult (1, 2).

In order to help clinicians, we tried to analyze whether comparative Doppler measurements of the flows in the ulnar and in the postanastomotic radial arteries enabled us to assess their repercussion on the blood supply to the palmar arches. In other words, we wanted to know whether the Doppler quantification of the steal was correlated to its clinical impact.

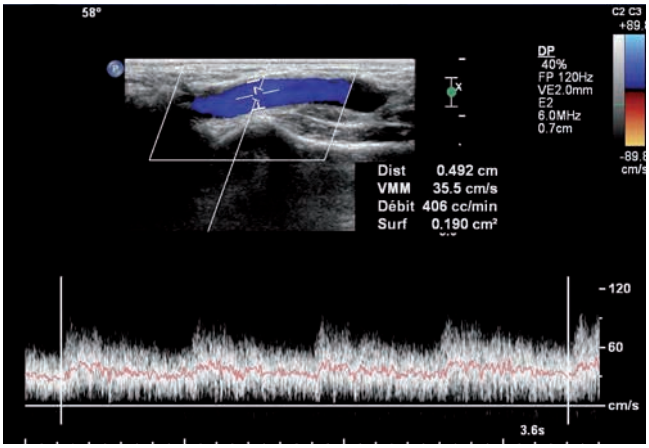

Fig. 1. — Color pulsed Doppler, sagittal view, of the radial postanastomotic artery at the wrist: the blood flow, measured at 400 mL/min, is retrograde (the hand is on the left of the picture). Since the patient is asymptomatic, it is a postanastomotic radial artery steal phenomenon.

Patients and methods

Patients

Our prospective study analyzed 35 patients, 8 women and 27 men, whose average age was 57 (20-84) and who had been dialyzed at the Centre Hospitalier de Luxembourg via a native fistula at the wrist. All of them had given their informed consent.

We knew from our DUS surveillance program of dialysis fistulas that their fistulas displayed a common peculiar characteristic, i.e. an inversion of the postanastomotic radial arterial flow reflecting at least a certain degree of blood diversion (3).

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Table I. — Staging of the ischemia related to the symptomatology.

Severity of the ischemia:	Symptoms:
I.	Cold hand or pain during dialysis.
II.	Pain at rest or numbness in the hand.
III.	Skin ulceration or sensori-motor deficit.

DUS analysis

The DUS examinations have been performed by the radiologists (N.V., I.M.) with a Philips iU22 device coupled with a 12-5 MHz linear probe, used in pulsed mode. The recordings, which took less than five minutes, were made prior to the dialysis sessions. The flow of the ulnar artery at the level of the wrist and the reversed flow of the postanastomotic radial artery were calculated automatically, in mL/min, over 3 or 4 cardiac cycles. The results have been recorded in a digital archive system. Doppler analysis criteria have been observed: adjustment of the impulsion repetition frequency, size of the gate (at least 2/3 of the vessel diameter) and angle of insonation between 30 and 70°. The color function has been used to detect vascular lumens.

The results for the 35 patients were gathered in a simple table.

Next we examined the Doppler curves of 4 true positive and 4 false positive patients and measured the systolic upstroke time, the maximal systolic speeds and the telediastolic speeds. Eventually, we compared the global architecture of the curves.

Clinical examination

Within a week after the DUS examination, the vascular surgeons (J.P., X.M.) examined each patient clinically. The positive clinical criteria were: a cold, colorless or numb hand, decreased amplitude of the arterial pulses, hand pain on or off dialysis, neurologic deficit or trophic changes. Differential diagnoses were excluded. The patients who did not display at least one of these symptoms were considered as free from steal syndrome and were thus labelled as "negative".

Results

For 23 of the patients, the fistulas displayed a retrograde radial flow higher than the prograde ulnar flow; only 4 of them (11%) had a steal syndrome. Among the other 12 patients (34%), whose ulnar flow was higher than the radial flow, we discovered two patent cases (6%) of steal syndrome.

The deficit or the excess of ulnar flow in relation to radial flow was then calculated in percentages. In 4 true positive patients we discovered an average ulnar deficit of 40% (range: 20-60%) whereas it reached 70% (range: 15-300%) in the 19 false positive patients.

The Doppler curves of 4 true positive and 4 false positive patients didn't show any difference in terms of systolic upstroke times and maximal systolic or telediastolic speeds. The global architectures of the curves were similar.

Discussion

The constant aging of the population results in an increase of the occurrence of vascular and metabolic disorders with an impact on renal function, such as arterial hypertension or diabetes, hence, a rise in the number of patients suffering from total renal failure and requiring renal transplantation or hemodialysis (2, 3).

Native fistulas are presently the modality of choice, before vascular prostheses and catheters, to dialyze patients awaiting renal transplantation or who cannot be transplanted (3). Yet, this method, imagined in the USA as early as 1966, has its limits and one of its most dreaded complications is distal ischemia (2). Though it occurs mainly at the level of upper-arm fistulas (5-10%), it can also develop after the construction of a wrist fistula (0.5-1%) (3-7).

Called DASS (dialysis associated steal syndrome) (2, 5), DHIS (distal hypoperfusion ischemic syndrome) (4), HISS (hand ischemia steal syndrome) (8), DAIIS (dialysis access induced ischemia syndrome) (7) or even HAIDI (hemodialysis access-induced distal ischemia) (9) in the Anglo-Saxon literature, blood diversion consists in fact of two distinct entities : the rather common steal phenomenon, where the postanastomotic arterial radial flow is reversed, without any concomitant downstream ischemic symptom and the much less frequent steal syndrome, where the retrograde flow is so important that it induces distal clinical signs of vascular arterial deficit (2).

Steal syndromes occur preferably in older, in female and in diabetic patients (2). Their mechanisms are complex and have not been thoroughly understood yet (7). First of all, the anastomosis of the artery to the vein, a low resistance system, implies de facto a vascular steal that is the more important as the fistula flow is high; this implies that brachial fistulas, which are known to have a larger flow, are more often burdened with steal syndromes than wrist fistulas (1, 4, 7, 9-11). The second mechanism of distal ischemia is a proximal or a distal stenosing arterial lesion, whether it be arteriosclerotic, favored by uremia, dyslipemia or even smoking, or diabetic microangiopathic (1, 4, 7, 12). The third offending mechanism is venous hyperpressure occurring when a significant stenosis develops in the venous segment of the fistula (4). A last contributing factor to distal ischemia is also mentioned: the secondary arterial hypotension during dialysis sessions (9).

The symptoms of steal syndrome include: coolness, pain, pallor and weakness of the arterial pulses. They may also cause amyotrophy, neurological troubles and skin ulcerations (2). A classification of the symptoms has been suggested, similar to that of Leriche and Fontaine for ischemia of the lower limbs (Table I) (1, 12). Paucisymptomatic forms generally develop rather quickly and their slow involution is the rule whereas severe attacks occur later and have a tendency to worsen (4).

The differential diagnosis of hand ischemia includes: carpal tunnel syndrome, arthropathy, reflexive sympathetic dystrophy and ischemic monomelic neuropathy. In these instances and contrarily to ischemia attacks caused by blood diversion, the hand remains warm (1, 4).

Steal syndromes are mainly detected at clinical examination using, among others, a test that checks whether the vascularization of hand and fingers improves during compression of the venous segment of the fistula (1). Since clinical diagnosis of steal may prove difficult, measurements of the digito-brachial

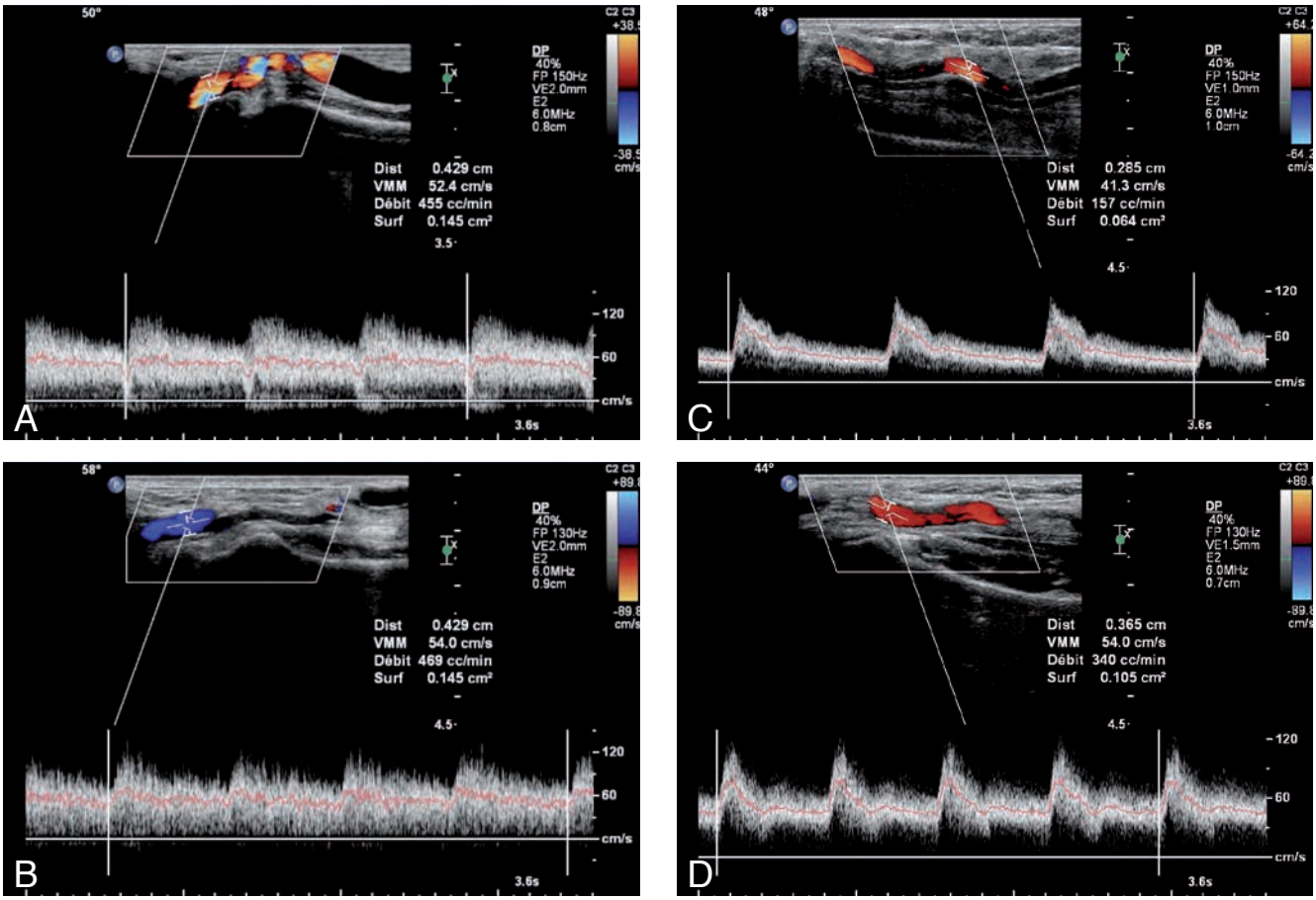

Fig. 2. — (same incidences as figure 1) the radial flows in these patients, one being symptomatic (A) and the other not (B), are reversed ; the patterns of the Doppler spectrums are perfectly identical.

C, D : color pulsed Doppler, sagittal view, of the wrist ulnar artery: the blood flows are orthograde (the hand is at left of the pictures) and the shapes of their spectrums look similar. The patient of figure C is symptomatic, whereas the patient of figure D is not.

index as well as Doppler measurements of velocity and outflow have been suggested but their usefulness remains doubtful (2, 4, 5, 7, 13).

Ideally, steal syndromes should be treated in order to increase the distal arterial flow without diminishing the fistula flow in an unacceptable way (1). Watchful waiting is the rule as long as the patient remains paucisymptomatic (4, 7). Decreasing the fistula flow by reducing the caliber of the draining vein of the fistula does not seem to be a good solution (5). Whenever possible, arterial dilation must be recommended (1, 6, 8, 12, 14). Surgical or endovascular procedures have been proposed, such as closing the pre- or postanastomotic radial artery (in case of hyperflow). DRIL, distal revascularization and internal ligation and RUDI, revision using distal inflow can be used with good chances of success (4, 10). Finally, as a last resort, closing of the fistula must be contemplated if its flow is lower than 400mL/min (10).

A DUS study of the postanastomotic radial artery flow is the ideal means to detect steal phenomena. Its interest remains, nevertheless, more than theoretical since these phenomena, by definition, prove harmless. We wanted to determine whether a comparative study of the flows of the ulnar artery at wrist level and of the postanastomotic radial artery in the course of a DUS examination enabled us to detect steal syndromes, even to assess their severity, in a timely manner. Therefore, we selected 35 dialysis patients presenting with a radio-radial wrist fistula with a permeable orthograde flow ulnar artery and a retrograde flow postanastomotic radial artery. The selection of the patients was made easier thanks to the DUS surveillance program of fistulas, set up by our institution several years ago and recommended by scientific consensus (3).

Our comparative study of the flows in distal arteries of the wrist does not prove productive in terms of sensitivity (67%), specificity (34%) or positive predictive value (17%). Its negative predictive value is the only one to get back some color, reaching 83%. Though we were expecting to discover higher ulnar deficits in true positive rather than in false positive patients, the average deficit was, paradoxically, much lower in the former group (Fig. 2 A-D). Finally, a sharp comparative spectral analysis of the waveforms of the 4 true positive and 4 false positive patients did not demonstrate any difference, be it in terms of systolic upstroke time, maximum systolic speed, telediastolic speed or in terms of curve architecture.

As to us, the poor capacity of DUS to detect steal syndromes is at least partially due to the role of arterial collaterals (Fig. 3), whose triggering is random and complex but can be extremely effective to feed distal arteries. Classical angiography or angio-MRI, whose interpretation remains more complex in our experience, are the gold standards and

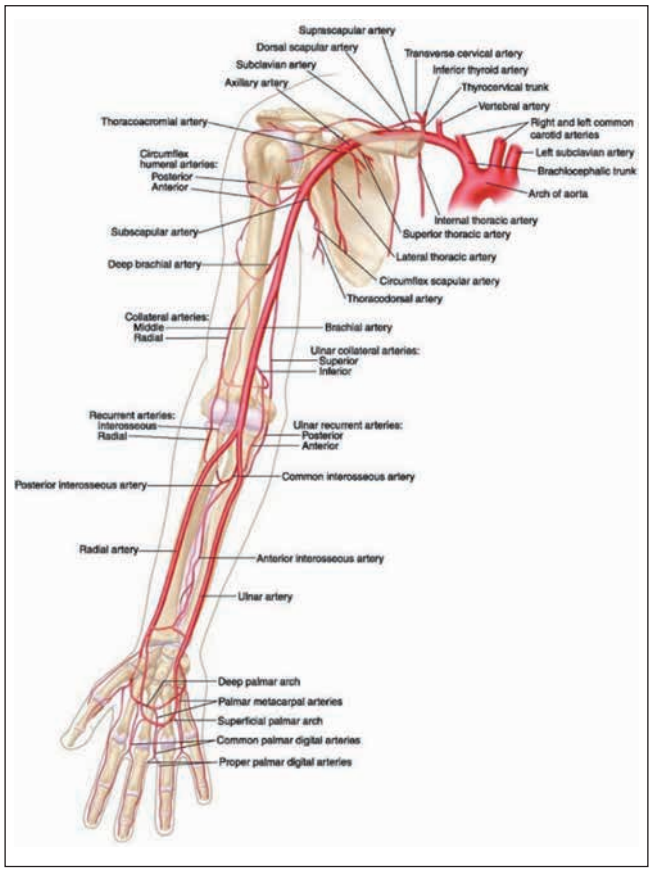

Fig. 3. — The upper limb arteries are widely collateralized: deep brachial artery, recurrent arteries of the elbow and common interosseous artery (source: Lippincott, Williams & Wilkins, Atlas of Anatomy).

underline, when all is said and done, the simplistic character of our comparative study and its lack of productivity. An exhaustive DUS of the collaterals would, theoretically, be possible but we consider it is virtually impossible to carry out in clinical practice since it is too time consuming.

This study demonstrates that the routine examination of the postanastomotic radial arterial flow of dialysis wrist fistulas is fundamentally unnecessary. We did know that it is useless with asymptomatic patients. It is also not recommended in case of steal syndrome since it is not capable of detecting or excluding its presence when dealing with a severe ischemia of the hand. It may be interesting to know, at the very most,

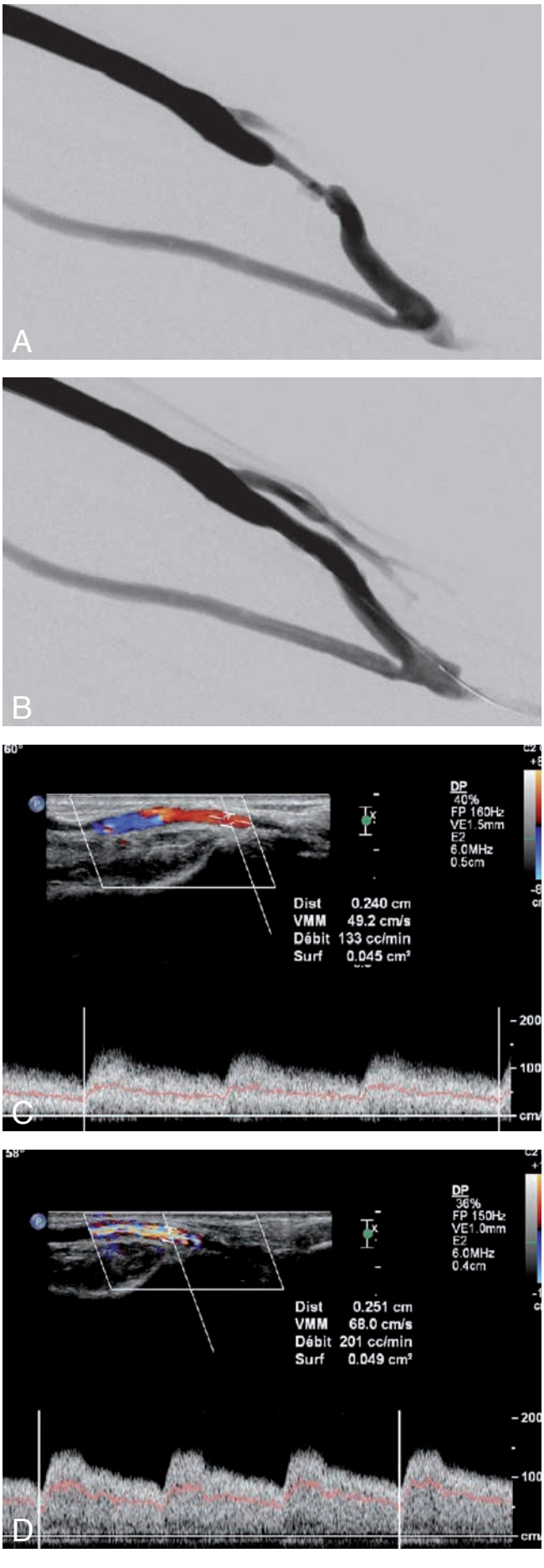

Fig. 4. — Digital subtraction angiography: the venous stenosis before (A) and after (B) dilation. C, D: color and pulsed Doppler, sagittal view, of the postanastomotic radial artery at the wrist of a patient with steal phenomenon, before and after venous dilation (the hand is at right of the pictures): the steal phenomenon increases, the reversed radial flow rising from 130 to 200 mL/min.

whether the postanastomotic radial artery is injured and could possibly be treated.

Some last words about steal phenomena and concomitant venous stenoses. After the completion of this study, we had to perform venous dilations on five of our selected patients who presented with a steal syndrome and whose fistula flows were decreasing dangerously because of the onset of tight venous stenosis. We wanted to verify whether the larger caliber of the vein was really responsible for the intensified steal syndrome and we performed DUS checks after the procedures. The arterial blood diversion had indeed increased but only in three cases out of five and no steal syndrome had appeared. As we have already mentioned, this was possibly due to the plasticity of collateral arteries (Fig. 4 A-D). Hence, we think that venous dilations can be considered with relative equanimity for patients presenting with a steal syndrome. It is true, nevertheless, that none of our patients was very old or suffering badly from cardiovascular diseases and that we should probably be more careful with particularly fragile patients.

Conclusion

DUS comparative study of the flows of the ulnar and of the postanastomotic radial arteries does not enable to assert or invalidate a steal syndrome in patients with a native dialysis fistula of the wrist.

Consequently, if the analysis of the postanastomotic radial artery discloses insignificant steal phenomena only, it proves perfectly superfluous, except in some rare well targeted cases.

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