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Influence of autologous arteriovenous fistula on the blood supply to the hand in very elderly hemodialyzed patients

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Abstract: *Introduction:* **Arteriovenous fistula (AVF) creation for hemodialysis (HD) could predispose to local arterial insufficiency of the hand (steal syndrome). Patients with diabetes mellitus, peripheral arterial disease and elderly patients tend to have a higher risk of hand ischemia.**
Purpose and methods: **To estimate the influence of AVF on the blood supply to the hands in the elderly population and to identify steal syndrome cases by non-invasive diagnostics (finger photoplethysmography (PPG), pulse volume recording (PVR), Doppler analysis and pulseoxymetry). The evaluation was carried out in 25 random patients (10 females, 15 males) >75 yrs of age (79.6 ± 3.87 yrs), whose functioning autologous AVFs had been placed at least 1 month previously.**
Results: **Mean PPG and PVR amplitudes did not differ in statistical analysis ($p > 0.05$) between hands with and without an AVF. One patient (4%) with end-to-side anastomosis was diagnosed with steal syndrome (typical manifestation confirmed in PPG, Doppler and pulseoxymetry). Two other patients with high brachio-cephalic anastomosis presented subclinical steal syndrome (only low PPG and PVR).**
Conclusions: **Even in the very elderly, AVF creation should be considered due to a lesser influence on the blood supply to the hands. Non-invasive diagnostics used by us seemed to be useful in identifying steal syndrome after AVF creation. (The Journal of Vascular Access 2005; 6: 83-7)**

Key words: *Hand blood supply, Elderly, Hemodialysis, Steal syndrome, Arteriovenous fistula, Vascular access*

INTRODUCTION

The percentage of elderly patients among incident patients with end-stage renal disease (ESRD) on renal replacement therapy rose in Europe from 22% in 1985 to 48% in 1999 and from 14-29% among prevalent patients (1).
Beginning a hemodialysis (HD) program in the elderly population with ESRD is associated with many difficulties. Among them is obtaining permanent vascular access (VA). Due to lower complication rates and a reduced incidence of infection and hospitalization, arteriovenous fistulas (AVF) are the preferred VA type for HD. There are controversies concerning the possibility of autogenic fistula creation in the elderly (>65 yrs of age) hemodialyzed patients.
Despite the theoretical risk (advanced peripheral arterial disease and diabetes), in a few European facilities the success rate for AVF creation for chronic HD in the elderly is similar to the rates in younger patients (2-4).
In the presence of AVF, blood shunting from the arterial system can produce local arterial insufficiency and venous hypertension of the hand. These problems can be ascribed to a steal of blood from the hand arteries or to excessive shunting in the AVF. Patients with diabetes mellitus and peripheral arterial disease, especially the elderly, have a high risk of hand ischemia (5, 6). The type of fistula can also be relevant in the development of ischemia (4, 7). For the exclusion of steal syndrome and the evaluation of hand ischemia simple, non-invasive methods can be used such as plethysmography,

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pulse volume recording (PVR), Doppler wave analysis, and segmental blood pressures (BP) or pulseoxymetry.
The objective of this study was to estimate AVF influence on the blood supply to the hands in an elderly population (>75 yrs of age) of hemodialyzed patients, as well as identifying cases of "late onset" steal syndrome by non-invasive diagnostics.

SUBJECTS AND METHODS

The evaluation of the blood supply to the hands was carried out in 25 random patients (10 females, 15 males) >75 yrs of age, whose functioning autologous AVFs had been placed at least 1 month previously. They were all participants in the HD program of the Department of Nephrology and Transplantation Medicine, Wroclaw Medical University. Mean age was 79.6 yrs and the oldest female was 94 yrs (Tab. I). Reasons for renal insufficiency in our patient group were as follows: diabetic nephropathy (n=7), interstitial nephropathy (n=6), hypertensive nephropathy (n=5), glomerulonephritis (n=3) and other (n=4). The patients were not receiving vasoactive medication.
Two experienced nephrologists created the patients' fistulas using the following strategy. First, the typical fistula was applied to the wrist region, whereas in case of anastomosis failure it was done on a higher level, a few attempts if necessary. In cases of destruction or unavailability of the forearm vessels due to obesity, anastomosis with the proper modification was performed. The surgery was carried out under local anesthesia; the vessels were connected in 23 patients with the end-to-end technique and in two patients with the end-to-side method.
The evaluation of the blood supply to the hands was done using photoplethysmography (PPG) of all the fingers of both hands, PVR of the index finger and Doppler wave analysis of the radial and ulnar artery (PVL device, BioMedix, Minneapolis, MN, USA). In the cases indicating steal syndrome, pulseoxymetry was additionally performed. Patients had normal temperatures and all the examinations were executed in the same circumstances: supine position, room temperature at 24-25°C and with the hands positioned at the level of the heart. The diagnosis of steal syndrome was based on clinical manifestations and confirmed by demonstrating retrograde blood flow in the radial artery in Doppler wave analysis and a significant decline in amplitude in plethysmography (<5 mm), as well as the evaluation of finger tissue oxygenation.
Data are presented as mean ± SD. Differences between hands were examined with the Mann-Whitney U-test. A value $p<0.05$ was considered statistically significant. The procedures were performed using Statistica® software.

RESULTS

Table II depicts the mean PPG amplitude values of the fingers with and without the AVF. Statistical analysis did not show any significant differences in the mean values.
In one patient (4%), who had an end-to-side anastomosis, steal syndrome was discovered with typical clinical manifestations and was proved by further exams (plethysmography wave amplitude and PVR <4 mm, retrograde blood flow in the Doppler analysis, SaO_2 on fingers <88%; Table III). The patient had to have the fistula changed to an end-to-end anastomosis. With the new anastomosis, the discomfort discontinued. Two other patients with the high anastomosis (brachial-cephalic forearm looped transposition) presented subclinical steal syndrome (only low plethysmography wave and PVR amplitudes, without significant discomfort).

DISCUSSION

The elderly population with ESRD, which was excluded from HD programs in the past, is currently a rapidly growing group in the dialyzed population. Overall, the incidence in the 65-74 age group, multiplied in Europe three-fold and the prevalence four-fold over the period 1985-1999, while those in the >75 age group multiplied eleven- and twelve-fold, respectively. The 1- and 2-yr survival of elderly

TABLE I - PATIENT CHARACTERISTICS

Age (yrs)	79.6 ± 3.87
Sex (Female/Male)	10/15
HD treatment period (months)	30.5 ± 27
mode of autogenous fistula*:	
- radial-cephalic direct wrist access	20
- ulnar-basilic forearm transposition	1
- radial-cephalic (perforating vein) direct access	2
- brachial-cephalic forearm looped transposition	2
Mean amount of surgeries necessary for the access functional patency	1.5 ± 1
Hemoglobin (g/dL) (median)	10.8 ± 1.1 (11)
Albumins (g/dL)	38 ± 3.5
Kt/V (dialysis adequacy)	1.1 ± 0.2

*nomenclature according to recommended standards (8)

TABLE II - MEAN AMPLITUDES (mm) OF FINGER PPG

Finger	I	II	III	IV	V
Hand with AVF	14.7 ± 10	15.4 ± 14	17.2 ± 14	15.2 ± 10	17.4 ± 14
Co-lateral hand without AVF	15.9 ± 12	17.1 ± 13	18.9 ± 16	21 ± 19	19 ± 15
p value	0.82	0.68	0.72	0.52	1.00

patients on dialysis was 69 and 51%, respectively (1). Similar data have been reported from the US Renal Data System. These findings show that in the twenty-first century, ESRD is a growing geriatric problem (9).

The recently published guidelines firmly endorse the establishment of autogenous HD access among all HD patients, including the elderly population. Older individuals, diabetics and patients with peripheral arterial disease seem to be at increased risk for the development of "late onset" (over 1 month from fistula placement) ischemic steal syndrome.

There are only a few papers recorded on PubMed to date, which describe in numbers the changes in the blood supply to the hands after AVF creation for HD; indirectly, more data are provided by publications dealing with steal syndrome - a clinical syndrome resulting from the loss of distal circulation occurring when various local compensatory mechanisms fail. This creates a zone of arterial insufficiency distal to the fistula with the usual clinical manifestations of vascular insufficiency: pain, ischemic neuropathy, ulceration and gangrene (10). Various invasive and non-invasive methods have been used to diagnose arterial steal phenomenon. Preferable non-invasive techniques, such as systolic BP in the fingers, Doppler wave/spectral analysis, plethysmography, PVR and pulseoxymetry can be performed to investigate hemodynamic changes in the upper extremities after fistula creation (11-13). The BP in the fingers of the arm with the AVF is significantly lower than in the fingers of the other arm. This is explained by the increased arterial blood flow to the arm with the fistula, giving a physiological pressure reduction (12).

The high correlation between flow direction in the distal radial artery, thumb BP and thumb/brachial BP index (T/B index) have been demonstrated in patients with steal syndrome (6, 11, 12). The T/B indices in those with permanent radial steal syndrome were significantly low.

Recording digital pulse waves with PPG is a quick and easy technique that provides a semi-quantative method for the assessment of digital perfusion (14). Some findings indicate that the addition of pulse wave recording to pressure measurements increases the accuracy of assessment for critical limb ischemia (15). Dally and Brantigan (16) used a simple plethysmographic test, which accurately differentiated steal syndrome from other causes of ischemia, pain, or necrosis and allowed the surgeon to remedy the problem in a specific way.

TABLE III - STEAL SYNDROME FEATURES IN NON-INVASIVE DIAGNOSTICS - HAND WITH AVF

Amplitudes of finger PPG (mm)		Pulseoxymetry SaO_2 (%)
I	<5	88
II	<5	87
III	<5	90
IV	5-10	90
V	5-10	92

Pesola and Bugal (17) used pulseoxymetry, a rapid non-invasive method to evaluate tissue oxygenation in patients with AVFs without cyanosis or symptoms and they found no differences when comparing oxygen saturation between extremities. In other studies, pulseoxymetry has been found as a helpful adjunct in the evaluation of the painful hand after AVF creation (18). Halevy et al (19) noted low SaO_2 in patients having painful hands with a side-to-side AVF. By applying the pulse oxymeter to the patient's affected limb, it was possible to determine whether the pain was due to ischemia. The correction of the steal usually dramatically improves tissue oxygenation (17, 19, 20).

In our study, the incidence of limb-threatening steal necessitating revision was only 4%, which is in agreement with other studies even when proximal prosthetic AVFs were used (3, 4). One of our elderly patients, who had an end-to-side anastomosis, had clinical evidence of arterial steal syndrome with symptoms of pain, coldness and paleness. Further non-invasive diagnostics proved the diagnosis. Special attention was paid to the direction and quantity of flow in the radial artery, which was permanently retrograde. PPG and PVR amplitudes of the

fingers of the hand with the fistula were almost flat. Additionally, pulseoxymetry showed SaO_2 on fingers I-III <88% and on fingers IV-V 92%, which exceeded 10% collateral difference. Ligation of the radial artery distal to the fistula in the patient led to the disappearance of clinical symptoms and to the restoration of measured parameters.

The high (using the brachial artery) and side-to-side / end-to-side anastomosis seems to predispose to steal syndrome. In a recent study, the use of the proximal radial artery was suggested to diminish the risk of steal syndrome found more frequently when a brachial artery fistula has been performed (21, 22). In patients with side-to-side AVF, symptoms related to ischemia are reported to occur from 1.6-42% of the time (7, 23). In some patients, ischemia is better tolerated than in others and steal discovered by vascular laboratory testing in the absence of symptoms, as in two of our patients, is not an indication for remedial surgery (16).

As our experience (24, 25) and that of others (2, 3) demonstrates, functioning AVFs without impairing the blood supply to the hands in the elderly population can be achieved by using a variety of different surgical approaches.

CONCLUSIONS

Our studies show that even in the very elderly, native AVF creation should be considered because it does not significantly change the blood supply to the hands. Non-invasive methods such as plethysmography, PVR, Doppler wave analysis or pulseoxymetry seem valuable for the identification of steal syndrome after AVF creation.

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REFERENCES

1. Jager KJ, van Dijk PCW, Dekker FW et al. The epidemic of aging in RRT: an update on elderly and their outcome. J Am Soc Nephrol 2002; 13: 399A.
2. Ridao-Cano N, Polo JR, Polo J, Perez-Garcia R, Sanchez M, Gomez-Campdera FJ. Vascular access for dialysis in the elderly. Blood Purif 2002; 20: 563-8.
3. Staramos DN, Lazarides MK, Tzilalis VD, Ekonomou CS, Simopoulos CE, Dayantas JN. Patency of autologous and prosthetic arteriovenous fistulas in elderly patients. Eur J Surg 2000; 166: 777-81.
4. Berardinelli L, Vegeto A. Lessons from 494 permanent accesses in 348 haemodialysis patients older than 65 years of age: 29 years of experience. Nephrol Dial Transplant 1998; 13: 73-7.
5. Miles AM. Vascular steal syndrome and ischaemic monomeric neuropathy: two variants of upper limb ischaemia after haemodialysis vascular access surgery. Nephrol Dial Transplant 1999; 14: 297-300.
6. Wixon CL, Hughes JD, Mills JL. Understanding strategies for the treatment of ischaemic steal syndrome after hemodialysis access. J Am Coll Surg 2000; 191: 301-10.
7. Kinnaert P, Struyven J, Mathieu J, Vereerstraeten P, Toussaint C, Van Geertruyden J. Intermittent claudication of the hand after creation of an arteriovenous fistula in the forearm. Am J Surg 1980; 139: 838-43.
8. Sidawy AN, Gray R, Besarab A, et al. Recommended standards for reports dealing with arteriovenous hemodialysis accesses. J Vasc Surg 2002; 35: 603-10.
9. Dimitrios GO, Dimkovic N. Geriatric nephrology is coming of age. J Am Soc Nephrol 2003; 14: 1099-101.
10. DeCaprio JD, Valentine RJ, Kakish HB, Awad R, Hagino RT, Clagett GP. Steal syndrome complicating hemodialysis access. Cardiovasc Surg 1997; 5: 648-53.
11. Bernstein EF. Vascular Diagnosis 4th edn, St. Louis: Mosby 1993.
12. Nielsen SL, Lokkegaard H. Cold hypersensitivity and finger systolic blood pressure in hemodialysis patients. Scand J Urol Nephrol 1981; 15: 319-22.
13. Bos WJ, Zietse R, van den Meiracker AH, Schalekamp MA, Weimar W. Hemodynamic consequences of Cimino fistulas studied with finger pressure measurements during fistula compression. Kidney Int 1995; 48: 1641-5.
14. Zweifler AJ, Cushing G, Conway J. The relationship between pulse volume and blood flow in the finger. Angiology 1967; 18: 591-8.
15. Carter SA, Tate RB. Value of toe pulse waves in addition to systolic pressures in the assessment of the severity of peripheral arterial disease and critical

limb ischemia. J Vasc Surg 1996; 24: 258-65.
16. Dally P, Brantigan CO. Plethysmography and the diagnosis of the steal syndrome following placement of arteriovenous fistulas and shunts for hemodialysis access. J Cardiovasc Surg (Torino) 1987; 28: 200-3.
17. Pesola GR, Bugal N. Pulse oximeter analysis of peripheral cyanosis distal to an AV fistula. Am J Emerg Med 1996; 14: 268-9.
18. Odland MD, Kelly PH, Ney AL, Andersen RC, Bubrick MP. Management of dialysis-associated steal syndrome complicating upper extremity arteriovenous fistulas: use of intraoperative digital photoplethysmography. Surgery 1991; 110: 664-9.
19. Halevy A, Halpern Z, Negri M, Hod G, Weissgarten J, Averbukh Z, Modai D. Pulse oximetry in the evaluation of the painful hand after arteriovenous fistula creation. J Vasc Surg 1991; 14: 537-9.
20. Lin G, Kais H, Halpern Z, et al. Pulse oxymetry of oxygen saturation in the upper extremity with an arteriovenous fistula before and during hemodialysis. Am J Kidney Dis 1997; 29: 230-2.
21. Bruns SD, Jennings WC. Proximal radial artery as inflow site for native arteriovenous fistula. J Am Coll Surg 2003; 197: 58-63.
22. Murphy GJ, White SA, Nicholson ML. Vascular access for haemodialysis. Br J Surg 2000; 87: 1300-15.
23. Haimov M, Baez A, Neff M, Slifkin R. Complications of arteriovenous fistulas for hemodialysis. Arch Surg 1975; 110: 708-12.
24. Weyde W, Letachowicz W, Klinger M. Feasibility of a native arteriovenous fistula as the initial type of permanent vascular access in the majority of chronic haemodialysis patients. Nephrol Dial Transplant 1998; 13: 527-8.
25. Weyde W, Krajewska K, Kusztal et al. Native arteriovenous fistula creation in the geriatric population; own experience. J Am Soc Nephrol 2003; 14: 239A.