Treatment options for dialysis access steal syndrome

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Abstract
Vascular access-induced limb ischemia is a known complication of arteriovenous fistulas and grafts. Many techniques have been adopted to prevent steal in high-risk patients and to treat steal in cases of moderate ischemia not controlled with conservative management. A major factor guiding treatment is access flow volume. Management is different when ischemia is combined with the excessive flow in contrast to the combination with normal flow. We describe the most popular techniques encountered in the English literature as a part of a stepwise approach to treating dialysis access steal syndrome. In absence of ischemia, when cardiac issues emerge due to extreme access flow volumes, some of these techniques are also used to decrease flow and protect the heart. Patient’s history, focused clinical examination, color duplex ultrasound examination, pulse oximetry and an angiogram are essential tools to approach this entity.

Key words: arteriovenous fistula, aneurysm, ischemia, vascular grafting.

Introduction
During the last years many modifications of standard dialysis access steal-correcting techniques have been reported. Additionally, new endovascular options have joined the armamentarium.

Aim
We reviewed the English literature, and we report the most popular techniques included in a step-by-step approach to deal with dialysis access steal syndrome (DASS).

Material and methods
We searched for all studies including case reports, observational studies and interventional trials that reported intra-operative techniques to treat DASS. We considered studies published from January 1990 until April 2022. We included studies published only in English language. A systematic search for related studies was done on PubMed and Cochrane Database and the last search date was April 30, 2022. Search terms were “Arterio-venous fistula” OR “AVF” OR “Hemodialysis Access” OR “AVBG” OR “Brachio-cephalic fistula” OR “Basilic vein transposition” OR “Brachio-basilic fistula” AND “Dialysis access steal syndrome” OR “Steal syndrome” OR “Ischemia”. Information such as first author’s name, journal, year of publication, country of origin, intra-operative technique used, and site of arteriovenous fistula was extracted from studies.

Results
A total of 396 studies were retrieved after applying this search strategy. Two-hundred and twenty two were excluded because they were not relevant to the scope of this review. From the remaining 174 studies, 20 were chosen as more representative of the full spectrum of the currently used techniques. The majority of studies were retrospective case series or case reports. Briefly, intraoperative techniques described were variable: a) banding or plication, b) short graft interposition, c) revision using distal inflow (RUDI), d) distal revascularization with interval ligation (DRIL), e) proximalization of arterial inflow (PAI), f) prolongation of existing grafts, g) distal radial artery ligation (DRAL), h) anastomosis reduction, and i) ligation. These results can help vascular surgeons in decision making regarding the most applicable technique in every DASS patient.

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Discussion

For every patient who is a candidate for arteriovenous access formation, we proceed with a stepwise approach to minimize the risk of DASS. The first step is to take a history for the presence of diabetes, atherosclerosis, current or past use of central catheters, defibrillators or pacemakers. The second step is to perform a detailed physical examination, including palpation of radial pulses and blood pressure measurement in both upper extremities. A difference > 20 mm Hg is indicative of inflow stenosis, which must be corrected. An absent radial pulse does not preclude access formation. Consequently, we perform an Allen test, which may be aided with a hand-held Doppler and/or a pulse oximetry [1]. An abnormal test puts the patient in the high-risk group for DASS. Color Duplex ultrasound (CDU) is performed to gain anatomical information about upper arm venous size, patency and distensibility as well as arterial wall calcification and lumen patency. Based on the physical examination we perform selectively a preoperative angiogram with simultaneous angioplasty of any proximal subclavian or distal arm stenoses [2]. In the case of arm edema, prominent arm and/or chest veins or history of central venous catheter, venography is performed.

After AVA creation, if symptoms suspicious for DASS emerge acutely or in the long term, we proceed with physical examination. Compression of the AVA beyond the anastomosis restores radial pulses in case of absence. If not, severe forearm (or juxta-anastomotic) stenotic lesions must be suspected. Therefore, compression of the arterio-venous fistula (AVF) relieves the symptoms and restores the pulses if high flow is the only cause of DASS. Some consider that doubling of the digital waveform amplitude is considered diagnostic for DASS. Color Duplex ultrasound (CDU) determines if the access is normal or over-functioning. Access flow is closely represented from the brachial flow, which is measured 5 cm proximal to the anastomosis. Thus, the probe is placed away from the turbulent anastomotic flow. Afterwards, digital subtraction angiography (DSA) is performed to examine the presence of atheromatous stenoses or distal microangiopathy [2]. Percutaneous transluminal angioplasty (PTA) is indicated to correct any proximal stenotic lesions or lesions distal to the anastomosis. This maneuver may treat steal in nearly all patients with disease above the elbow but for below the elbow nearly half of the patients need secondary surgical intervention [2]. After manual closure of the AVF, an angiographic blush sign is considered essential to predict ulcer healing in the distal arm [4]. If symptoms persist, we proceed with ligation of any significant venous side-branches, if they are apparent in an AVF, to increase venous outflow resistance. Alternatively, transcatheter coil embolization may be performed.

If needed, we may proceed with more specialized procedures such as: a) banding or plication, b) short graft interposition, c) revision using distal inflow (RUDI), d) distal revascularization with interval ligation (DRIL), e) proximalization of arterial inflow (PAI), f) prolongation of existing grafts, g) distal radial artery ligation (DRAL), h) anastomosis reduction, and i) ligation. Banding, short graft interposition and RUDI are suggested for high-flow while DRIL, modified DRIL and PAI are suggested for normal-flow AVAs [3]. In some cases without arm ischemia, high-flow (> 2000 ml/min) has to be reduced to prevent or restore adverse AVF-induced cardiac sequelae.

After reviewing the English literature regarding treatment of DASS, we would like to emphasize some interesting points about the above-mentioned techniques: A. Banding:

I) A prosthetic band (synthetic PTFE) 10–30 mm in length is wrapped around the outflow vein, near the anastomosis (Figure 1A). In the past, the degree of banding was regulated intraoperatively by restoration of the radial pulse and preservation of thrill. Blind banding had poor results when no objective measure to determine the degree of stenosis was used [3]. It led to an unacceptably high rate of thrombosis (19%) and failure to treat symptoms (48%) [3]. But in our days, banding (BD) can be calibrated using intraoperative volume flow measurement with real-time CDU, measured 5 cm proximal to anastomosis [5–7]. Digital brachial pressure (DBP) > 50 mm Hg and DBI > 0.6 or waveform analysis has been used to prevent over-narrowing, intraoperatively [3]. Finger oximetry > 90%, restoration of radial pulse and relief of symptoms are further guiding parameters [6, 7]. Banding migration and proximal venous aneurysmal dilatation have been reported; thus band fixation is advocated [8]. The minimal accepted flow after banding to avoid AVA thrombosis is 400–600 for AVFs and 600–800 for grafts [5]. The post-stenotic turbulence was lower as the band was placed away from the anastomosis, about 2–3 cm [5]. A belt-shaped band has been reported that is of adjustable diameter according to flow until its final fixation [5].

II) Plication with metal clips or suturing along the outflow vein beyond the anastomosis over a Satinsky clamp.

Figure 1. A – Banding with a strip: a prosthetic PTFE-band is wrapped around the juxta-anastomotic outflow vein. B – Plication of the cephalic vein after careful adjustment of the Satinsky clamp position. C – Short interposition grafting 4 mm in diameter. D – Ligature banding.
tion to a mean diameter of 2.5 mm (2–3.5 mm). Some patients may require a target banding diameter slightly smaller than the forearm artery with sluggish flow (Figure 2 A). Shukla et al. suggest a target banding diameter slightly smaller than the forearm artery with sluggish or reversed flow. Basically, they create a 75% lumen reduction to a mean diameter of 2.5 mm (2–3.5 mm). Some patients needed recurrent banding. Secondary patency was 59% at 1 year [7]. Others have used intraoperative CDU and pulse oximetry for a modified MILLER technique, reducing the diameter by 60–80% based on Murray’s nomogram [3, 6]. BD is calibrated with brachial artery flow measurement. If it is extreme, the vein is rebanding. If it is inadequate, angioplasty with a larger balloon is performed or the ligature is retied at a larger diameter [7]. Kok et al. advise a 75% reduction in diameter without flow monitoring. They recommend reducing under half the juxta-anastomotic vein diameter. They used a 5 mm balloon for a 13 mm vein and, interestingly, very small incisions [6]. The philosophy of the MILLER BD is preserved in the extraluminal banding technique, but it is simplified. A balloon or dilator (4, 5, or 6 mm) is placed extraluminally alongside the empty outflow vein (after clamping or using a pneumatic tourniquet) (Figure 2 B). After ligature placement the balloon or dilator is removed, and the vein lumen is expanded after release of perfusion at the predetermined diameter. The degree of BD is calibrated intraoperatively by pulse and thrill [7]. Dilators are preferred over balloons because they are not denting [6, 7]. A diameter between 3 and 4.5 mm is considered sufficient to treat most steals [5–7]. The primary patency was 100% at 1 year. Others used dowels with 0.5 mm increments to achieve the precise flow of 500–800 ml/min with two ties at the same site through a small skin incision [5–7].

IV) Suture plication of the outflow vein (Figure 1 B). Staple aneurysmorrhaphy and BD with a 3.0 polypropylene tie over a 4 mm coronary dilator has been reported to treat Vascular access aneurysms (VAA) (> 1.5 cm in diameter) and concomitant steal. Calibration with brachial flow measurement with CDU was apparent [3]. Simple BD in these cases would lead to steal recurrence due to remodeling of the folded vein wall [3].

B. Interposition of a 3–4 cm long and 4 mm in diameter graft has been reported (Figure 1 C) [9–11].
PTFE grafts have a 43% thrombosis rate and the limb's viability is threatened; if there are bypass complications and no arm ischemia (Figure 2 D). PRAL is suggested in high-flow AVF with cardiac effects because of its larger diameter (Figure 5 B). A second technique reported the construction of a 5 mm forearm loop graft, 25 cm in length, after removal of a side-to-side brachiocephalic anastomosis [17].

Conclusions

This brief and concise reference of the available interventional and surgical techniques for DASS treatment should be kept in mind by every expert who deals with AVAs and their complications.
Disclosure

The authors report no conflict of interest.

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