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ORIGINAL ARTICLE

Adjuvant spinal cord stimulation improves wound healing of peripheral tissue loss due to steal syndrome of the hand: clinical challenge treating a difficult case

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Abstract

Hand ischaemia due to arterial steal syndrome is an infrequent, but potentially serious complication of arteriovenous fistula (AVF) for haemodialysis.
We present a case of hand ischaemia caused by steal syndrome in a 69-year-old haemodialysis patient, 10 months after a brachiobasilic fistula creation. The patient underwent multiple operations without resolution of hand pain and tissue loss. The implantation of an adjuvant cervical spinal cord stimulator allowed the patient to obtain complete hand pain relief and wound healing.
Probably, the diffuse microangiopathy typical of haemodialysis patients could be responsible for the persistence of ischaemic signs and symptoms after a surgical revascularisation. The effect of sympathetic blockade and the subsequent improvement of the arterial blood flow and tissue oxygenation because of spinal cord stimulation (SCS) can be useful to achieve complete ischaemic pain relief in order to enhance wound healing and to limit the tissue loss. In conclusion, the association of cervical spinal cord stimulation and surgical revascularisation could represent a valid option to treat a critical upper limb ischaemia following steal syndrome due to AVF.

Introduction

The creation of arteriovenous fistula (AVF) in the upper arm is an established form of therapy for patients affected by end-stage renal disease (ESRD) in haemodialytic treatment. Hand ischaemia due to arterial steal syndrome is an infrequent, but potentially serious complication of haemodialysis access procedure. All AVF shunt blood away from the distal arm, and physiological steal (reversed flow in the artery distal to the AVF) can occur in 70% of distal AVF and 90% of proximal AVF. However, symptoms of hand ischaemia (pain, paresthesia or gangrene) only occur in 1–2% of radiocephalic AVF and 5–10% of brachial artery fistulae (1–8). Several surgical options have been described for the treatment of the steal syndrome: ligation of the access, banding of the fistula and distal revascularisation.

The following case highlights the first successful combined approach of distal revascularisation and spinal cord

Key Messages

- hand ischaemia due to arterial steal syndrome is an infrequent, but potentially serious complication of arteriovenous fistula for haemodialysis
- the diffuse microangiopathy typical of haemodialysis patients could be responsible for the persistence of ischaemic signs and symptoms after a surgical revascularisation
- the use of spinal cord stimulation may reduce pain significantly and increase blood supply in patients

with refractory peripheral artery disease of the upper extremity
- this experience suggests that surgical revascularisation combined with cervical spinal cord stimulation can successfully treat critical upper limb ischaemia following steal syndrome due to arteriovenous fistula

stimulation (SCS) to managing the ischaemic steal syndrome due to a proximal AVF in the left upper arm.

Case report

A 69-year-old man affected by ERSD with creation of a left brachiobasilic AVF was admitted to the vascular surgery unit presenting left hand pain and cyanosis of the distal phalanx of the fourth finger of the left hand. He began to experience left upper extremity symptoms over the past 6 months, approximately 10 months after AVF creation.

His past history included smoking, diabetes mellitus, coronary artery disease treated with aortocoronary bypass and implantation of mechanical heart valve (therefore treated with dicumarolic drug).

Physical examination showed: left hand colder than the right, with gangrene of the distal phalanx of the fourth finger (Figure 1); presence of brachial pulse and absence of distal pulses; well-functioning AVF. Duplex ultrasonography showed ulnar artery occlusion, preocclusive stenosis of radial artery in the third median of forearm and well-functioning brachiobasilic AVF. In order to reduce pain and to limit the extension of tissue necrosis, we performed a brachioradial bypass using Omniflow II prosthesis (Bio Nova International, Melbourne, Victoria, Australia) associated with ligation of proximal artery [distal revascularisation interval ligation, (DRIL)], achieving a good immediate result.

After 4 months, the patient was admitted again to our institute because of the recurrence of hand pain accompanied by severe gangrene of the distal phalanx of the fourth finger; the prosthetic brachioradial bypass became occluded. Subsequently, the prosthesis was removed and a new brachioradial bypass was performed using basilic vein ex situ, with ligation of proximal artery (DRIL) (Figure 2). A postoperative medical therapy with prostanoids was performed for 2 weeks. After 7 months of ischaemic symptoms remission, he returned to our department for hand pain associated with gangrene of the fourth finger. Duplex ultrasonography examination and angiography showed patency of brachioradial bypass, absence of palmar arch and collateral branches, AVF high flow and consequently a right heart overload.

For this reason, he underwent banding of the AVF obtaining flow reduction through the vascular access, without resolution of hand pain and tissue loss.

A microcirculatory screening was performed with transcutaneous oximetry and the measurements were taken at the dorsal site of both hands. Initial transcutaneous oxygen pressure (TcPO2) value was 12·4 mmHg in the operated upper limb versus TcPO2 value of 25·2 mmHg in the other limb. Then, the patient was selected for a SCS trial with one lead

Figure 1 Gangrene of the distal phalanx of the fourth finger of the left hand.

(Octrode St. Jude Medical, St. Paul, MN) in the cervical (C3-C6) peridural space of the spinal cord through a thoracic needle placement that allowed the limitation of finger necrosis and complete hand pain relief (Figure 3). After 1 month, he underwent amputation of the fourth finger and implantation of definitive SCS. TcPO2 values showed a significantly increase just to 28·1 mmHg. We used low-molecular weight heparin (4000 anti-Xa units of enoxaparin twice daily) as anticoagulation medications.

During mid-term follow-up of 12 months, we observed complete healing of the amputation of the fourth finger; the patient did not present recurrence of hand pain and AVF continued to function normally (Figure 4A and B). Surgical revascularisation with adjuvant SCS permitted left-hand salvage. This combined technique can be useful to achieve complete ischaemic pain relief, also caused by hypotension during haemodialytic treatment, and to limit the tissue loss, mainly because of effects on the microcirculatory skin blood flow to improve tissue perfusion by the sympathetic vasoconstriction.

Discussion

Physiological steal with reverse flow in the arm artery distal to the AVF is common after the creation of a vascular access for haemodialysis because of the low vascular resistance of the access (6,9). The occurrence of ischaemic steal has been divided into early (less than 30 days after fistula creation) or late (30 or more days) presentations (6,10). Milder symptoms may resolve spontaneously, likely because of the development of collaterals to the hand, whereas later presentations are usually progressive (6,9). Under resting conditions, the high resistance of muscle feed arteries in the diastole causes a retrograde flow in the artery distal to the AV anastomosis and into the AVF. This 'physiologic' steal phenomenon can be observed in 73% of AVF and in 91% of access grafts (11). Approximately 75% of the blood flow through distal radiocephalic fistulae is supplied by the proximal radial artery, but 25% comes from a patent ulnar artery via the distal radial

Figure 2 Brachioradial bypass with basilic vein ex situ and ligation of the proximal artery [distal revascularisation interval ligation DRIL].

artery and palmar arch (12). In elbow fistulae, the periarticular arterial collaterals have the same impact. Pathological steal with continuous ischaemic symptoms can occur because of a combination of the three following mechanisms: proximal inflow disease, reduced collateral flow to the hand or distal outflow obstruction (13,14). It is more common in patients with proximal (brachial artery based) than distal (radial artery based) vascular access (15). The syndrome usually causes hand pain (on and off dialysis) and rarely loss of distal function and tissue death. At a conceptual level, the goal for managing steal syndrome must focus on increasing blood flow distal to the access to relieve ischaemia while preserving the lifeline of the patient. Several operative techniques are available to achieve this goal and the use of therapeutic strategies or combination of adjuvants can prevent the risk of major amputations in ischaemic syndromes of the limbs (10,16–19).

The simplest operative approach is the arteriovenous access ligation (20); however this procedure still might be used when

Figure 3 Cervical spinal cord stimulation (SCS) implantation.

the symptoms are apparent immediately after access creation and for cases that are unresponsive to other treatments and demonstrate advancing ischaemia. Fistula banding or plication aims to increase the resistance of the AVF to divert flow down the native artery. Treatment of arterial disease proximal or distal to the fistula is performed by percutaneous methods or by surgical revascularisation. Angioplasty for proximal disease is less invasive than open surgery, offering less morbidity and probably less mortality than surgery (21). Flow-limiting disease distal to the fistula can be treated by angioplasty (13) or by surgical bypass that may be part of a surgical revision of the fistula [DRIL, revision using distal inflow (RUDI), proximal arterial inflow (PAI)/proximal arteriovenous anastomosis (PAVA)]. SCS is an accepted therapeutic method for limb salvage, pain reduction, improvement of blood flow and healing of the ulcers in critical lower limb ischaemia (22). The efficacy of SCS on the vascular upper limb disease has been not completely evaluated. Bartels *et al.* demonstrate that the use of SCS reduces pain significantly and increases blood supply in patients with refractory peripheral artery disease of the upper extremity (23). In particular, the electrodes implanted in the epidural space stimulate sensory unmyelinated C fibres and myelinated Aδ fibres, through the activation of cell signalling causing a decrease in vascular resistance and an increase in local blood flow. In addition, SCS suppresses sympathetic vasoconstriction through inhibition of sympathetic nicotine transmission at the ganglionar level. Pain relief is mediated by the suppression of pain or nociceptive transmission and the release of opioid peptides such as met-enkephalin (24,25). The adequate surgical treatment of pathological steal syndrome in patients presenting a functional AVF in the upper limb, often

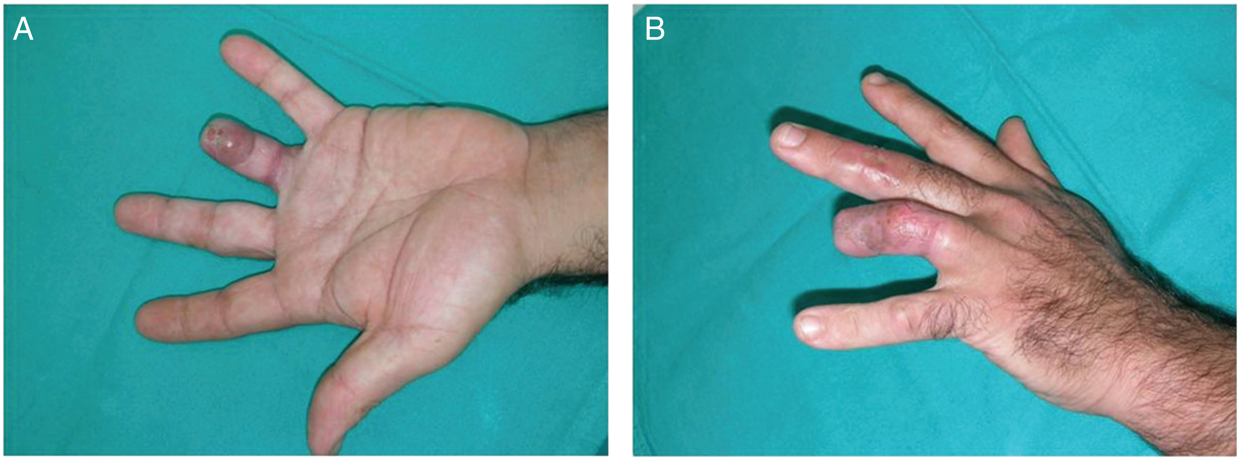

Figure 4 Complete healing of the amputation of the fourth finger of the left hand.

allows the maintenance of vascular access and the relief of ischaemic symptoms. Sometimes, the diffuse microangiopathy in these haemodialysis patients can lead to unsuccessful revascularisation.

This experience shows that surgical revascularisation combined with cervical SCS can successfully treat critical upper limb ischaemia following steal syndrome due to AVF. The effect of sympathetic blockade and the subsequent improvement of the arterial blood flow and tissue oxygenation due to SCS can be useful to achieve complete ischaemic pain relief in order to enhance wound healing and to limit the tissue loss.

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