Distal revascularisation with interval ligation (DRIL): an experience

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ABSTRACT

INTRODUCTION The global increase of chronic renal failure has resulted in a growing number of patients on haemodialysis using arteriovenous fistulas (AVFs). By virtue of their very function, AVFs at times shunt blood away from regions distally, resulting in an ischaemic steal syndrome. Distal revascularisation with interval ligation (DRIL) has been described as a procedure to treat symptomatic ischaemic steal. We present our experience in the management of this complication.

PATIENTS AND METHODS Six patients with severe ischaemic steal were treated using a DRIL procedure between May 2004 and June 2007. There were three males and three females, all with elbow brachiocephalic AVFs. Symptoms ranged from severe rest pain to digital gangrene. Published results from international studies of 135 DRIL procedures were also reviewed.

RESULTS Vascular access was maintained along with the elimination of ischaemic symptoms in the six patients using an ipsilateral reversed basilic vein graft. Interval ligation of the distal brachial artery was performed at the same time. All patients showed immediate and sustained clinical improvement of symptoms with a demonstrable increase in digital pulse oximetry.

CONCLUSIONS DRIL is a beneficial treatment option that has proven successful at alleviating ischemic steal symptoms and preserving vascular access. This avoids placement of central lines, its associated risks, and the need to create an alternative sited fistula.

KEYWORDS

DRIL – Ischaemic steal – Revascularisation – Fistula – Interval ligation

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The global increase of chronic renal failure has resulted in a growing number of patients on haemodialysis using arteriovenous fistulas (AVFs). The very nature of a functional AVF requires the diversion of blood away from its normal pathway, returning it back into the venous system without passing through and perfusing its intended capillary beds. Therefore, the aim for fistula formation is to establish equilibrium between adequate fistula flow, to ensure maturation of the graft and allow adequate dialysing pump speed, whilst ensuring perfusion of the tissues distal to the fistula, namely the hand and forearm.

We describe the condition of steal syndrome, the options in management, practicalities of the distal revascularisation with interval ligation (DRIL) procedure and our experience in the West Midlands (UK) with the DRIL procedure in six patients with severe symptomatic ischaemic steal.

Patients and Methods

Steal syndrome is the condition of arterial insufficiency distal to a permanent haemodialysis fistula. It has been reported to

occur in only 1–8% of patients but results in significant clinical problems.^{1–6} Steal syndrome occurs as a result of an imbalance between adequate fistula flow and distal perfusion. This can occur in the context of either excessive diversion into the fistula venous system in the presence of normal peripheral vasculature or a normally acceptable level of fistula diversion in the presence of peripheral vascular disease in the hand and forearm. In isolation, the peripheral vascular disease may be asymptomatic; however, in the presence of a fistula, the supplying palmar arch may be insufficient leading to steal symptoms. The grading of ischemic steal ranges from 0 to 3 in order to standardise the point of intervention.⁶

Grade 0 No steal.

Grade 1 Mild (cool extremity with few symptoms but demonstrable by flow augmentation with access occlusion) – no treatment required.

Grade 2 Moderate (intermittent ischaemia only during dialysis/claudeication) – intervention sometimes needed.

Table 1 Summary of all DRIL cases

Patient Number	Sex	Age (years)	Cause of renal failure	Co-morbidities	Fistula position	Outcome
1	F	63	Diabetic nephropathy	IDDM, hypercholesterolaemia, hyperparathyroidism	Left brachiocephalic	Successful
2	M	57	Left renal artery ligation	Ex-smoker, hypertension, hypercholesterolaemia	Left brachiocephalic	Successful
3	M	69	Polycystic renal disease	PMH not available	Left brachiocephalic	Successful
4	M	32	Diabetic nephropathy	IDDM, hypertension, hypercholesterolaemia, hyperparathyroidism	Left brachiocephalic	Successful
5	F	42	Pyelonephritis	Hypertension	Left brachiocephalic	Successful
6	F	27	Goodpastures syndrome	Hypothyroid	Left brachiocephalic	Successful

Grade 3 Severe (ischaemic pain at rest/tissue loss) – intervention mandatory.

The clinical assessment of steal syndrome is often difficult as other factors like concomitant peripheral vascular disease and peripheral neuropathy can influence the clinical picture. A warm hand with a palpable ipsilateral radial pulse distal to the fistula suggests a problem other than steal. However, the converse is not true. An absent radial pulse in a fistula patient does not necessarily indicate steal syndrome. This is supported by a study⁷ in which one-third of the 180 patients included had an absent radial pulse yet only 7 developed clinical symptoms of ischaemic steal.

The diagnosis of ischaemic steal has been a topic of much debate, with several methods suggested. The four main methods include photo-plethysmography, pneumatic-plethysmography, Doppler ultrasonography and digital pulse oximetry. These all monitor the waveform produced by blood flow within the digital arteries. A pronounced increase in waveform amplitude following manual external fistula compression is described.⁸ This external pressure effectively removes the fistula from the systemic circulation and returns blood-flow along its 'natural' pathway, thereby confirming a diagnosis of fistula-induced steal.

In considering interventional surgery for symptomatic steal, there are two requirements – the preservation of uninterrupted vascular access and resolution of the distal ischaemia.³ Current techniques aim to satisfy these requirements, in the most simplistic, readily available and reliable manner, with the exception of fistula ligation which sacrifices the fistula in order to eliminate steal, but with construction of a new fistula in an alternative location, either on the ipsilateral or contralateral arm. The approach to intervention can be

Figure 1 Fistula before intervention. **Figure 2** Photograph displaying the bypass graft as indicated by arrow.

divided into two groups, one based on reduction of fistula flow by increasing its resistance, and the other by increasing the blood supply to the artery distal to the fistula.

Surgical approaches can include banding of the fistula, clipping, insertion of a tapered graft or undertaking the DRIL procedure.

Surgical technique

The DRIL procedure was first described in 1988 by Schanzer *et al.*⁹ However, it has not been widely adopted because of concerns about its complexity and long-term efficacy.¹ The DRIL procedure consists of two parts (Figs 1 and 2):

1. Distal revascularisation is achieved with a bypass graft which has its origin from the graft artery, above the AVF, and ends with an end-to-side anastomosis, again to the graft artery but just distal to the AVF.
2. Interval ligation is the simple cutting and tying of the graft artery distal to the AVF but proximal to the bypass graft anastomosis.

The bypass graft provides a low-resistance pathway that runs in parallel to the artery, thus reducing the total system and more specifically, the peripheral resistance.

Results

In our unit, five DRIL procedures were completed with a further procedure in another unit following consultation with ours. Details of these patients are given in Table 1.

All six DRIL procedures were successful with no complications and no recurrence of the steal symptoms. All patients had severe, symptomatic, ischaemic steal not responsive to conservative measures such as the use of gloves, anti-platelet agents and reduction in anti-hypertensive medication or increase in the dry weight. All patients underwent pre-operative angiographic assessment of ischaemic steal.

All patients underwent surgery using the ipsilateral reversed basilic vein harvested as discussed above as the choice of conduit. In all patients, the symptoms of ischaemic steal resolved with immediate effect and vascular access

Figure 3 Pre-operative angiogram of patient 4 illustrating steal.

Figure 4 Post DRIL angiogram of patient 4 illustrating area of brachial artery ligation, bypass graft and preserved flow through cephalic vein.

Table 2 DRIL outcomes from eight separate studies and our patients

Reference	Patients (n)	Cure [n (%)]	Improvement [n (%)]	No change [n (%)]	DRIL patency (%)	Vascular access (%)	Follow-up [months (range)]
Schanzer <i>et al.</i> (1988) ⁹	3	3 (100)	N/A	0 (0)	100	100	34 (1–96)
Haimov <i>et al.</i> (1996) ¹¹	23	20 (86)	3 (17)	0 (0)	95	FAV 100 ; PTFE 45	24
Katz and Kohl (1996) ⁸	6	5 (83)	1 (17)	0 (0)	100	100	7
Berman <i>et al.</i> (1997) ³	21	21 (100)	N/A	0 (0)	100	94	18
Lazarides <i>et al.</i> (1998) ⁷	7	7 (100)	N/A	0 (0)	100	85	Not reported
Stierli <i>et al.</i> (1998) ¹²	6	2 (33)	4 (66)	0 (0)	100	100	Not reported
Knox <i>et al.</i> (2002) ¹	52	30 (55)	14 (25)	6 (11)	86	80	32 (24–48)
Sessa <i>et al.</i> (2004) ¹³	18	13 (73)	5 (27)	0 (0)	93	100	16 (5–48)
Our patients	6	6 (100)	N/A	0 (0)	100	100	

Adapted from Sessa *et al.*¹³

was maintained without the use of central venous lines or creation of alternative fistula.

The improvement in flow is demonstrated quite elegantly in the angiograms carried out pre- and postoperatively on patient 4 in Figures 3 and 4.

Discussion

In order for DRIL to be effective, several technical points must be observed. Extensive pressure monitoring within the arteries and veins discovered a region in the artery, just proximal to the arteriovenous anastomosis, called a pressure sink.⁹ At this point, the arterial wall has a muscular and elastic nature and pressure is maintained but varies along the artery, which is significantly different to the uniform pressures found in a rigid pipe. This occurs about 1 cm proximal to the arteriovenous anastomosis. The lower pressure found in this area is a result of the lower venous pressure on the opposing side of the anastomosis, allowing rapid drainage of the proximal artery. For this reason, if the bypass graft used in the DRIL procedure had its origin in this pressure sink area, graft flow would be low and, therefore, fail to meet the requirements needed to perfuse the hand adequately. Several reports suggest the graft origin should be 3–5 cm proximal to the inflow anastomosis so to avoid the pressure sink area but permit entry via the same incision.^{3,9,10} Graft choice is surgeon-dependent, with both preferential autogenous vein (brachial, cephalic or long saphenous) and prosthetic graft shown to be successful.¹⁰

Several studies have been undertaken to evaluate the DRIL procedure as summarised in Table 2. As can be seen from Table 2, although the numbers of patients undergoing the DRIL procedure are relatively small, the preservation of

access is excellent with either a total cure or improvement in symptoms in the majority of patients.

Conclusions

Our unit's experience with the DRIL procedure is extremely favourable and our outcomes have been excellent. Critical to the DRIL procedure being successful is establishing the correct diagnosis initially and paying close attention to technical notes as detailed above. If these are followed, however, the authors believe this to be an excellent method of treating the symptoms of ischaemic steal while maintaining vascular access.

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