

## The “DRIL” Procedure – A Neglected Way to Treat the “Steal” Syndrome of the Hemodialysed Patient

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### Abstract

**Background:** The ischemic “steal” syndrome complicates angio-access in a growing number of hemodialysed patients. Until now, operative attempts (fistula ligation or banding) to treat this problem have met with only limited success.

**Objective:** To assess the results of DRIL (distal revascularization-interval ligation) procedure in treating the “steal” syndrome.

**Methods:** A retrospective review (1996–2002) was conducted of all 11 patients who underwent the DRIL procedure in two tertiary care hemodialysis units.

**Results:** Two patients were excluded because of inadequate medical documentation. All of the nine patients remaining suffered from overt atherosclerotic disease, six had diabetic nephropathy and four were smokers. The arteriovenous access, which led to the “steal” syndrome, was proximally located in all (antecubital in 8, thigh area in 1). “Steal” symptoms included hand pain, paraesthesia, neurologic deficits and gangrenous ulcers. DRIL was technically successful in all patients. There were no perioperative deaths. Immediate and complete relief of pain was achieved in eight of the nine patients. One patient with gangrene later required a transmetacarpal amputation. No patient required hand amputation. During follow-up (range 1–26 months) hemodialysis was continued uninterrupted using the problematic AVA in all patients. Thrombosis occurred in the AVA in only two patients after the DRIL procedure at 9 and 24 months postoperatively, respectively. Three patient deaths were unrelated to the DRIL.

**Conclusions:** In selected patients the DRIL procedure is a safe and effective way to treat the “steal” syndrome. AVA patency is not compromised by this operation. Preoperative angiography, before and after manual compression of the AVA, is crucial for the proper selection of patients who will benefit most from the DRIL procedure.

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The angio-access-induced “steal” syndrome in the hemodialysed patient is a paramount problem faced by clinical nephrologists. After creation of an arteriovenous access these patients may develop severe hand pain, neurologic deficits and distal finger gangrene [1,2]. Also, the number of upper limb amputations due to critical ischemia of the hand has climbed significantly over the last few years in the chronically hemodialysed population [3,4]. Attempts to correct this problem include “banding” or “tapering”

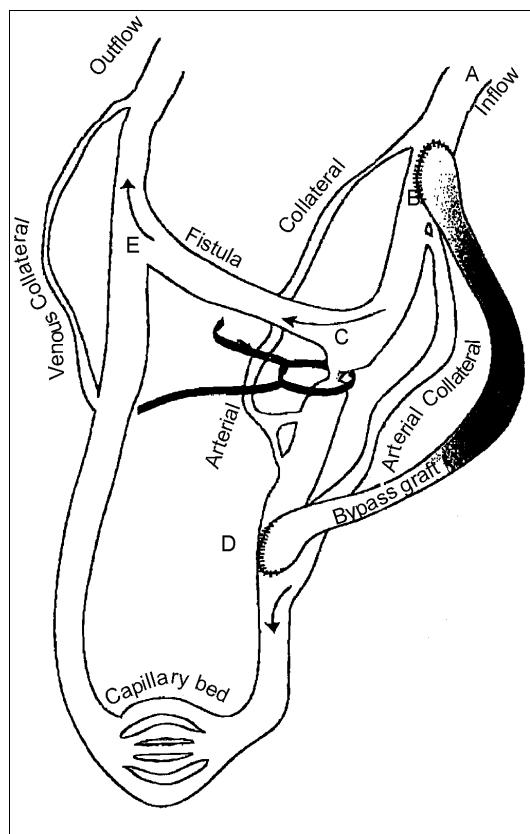
of the involved access, often with unsuccessful results and thromboses within the AVA [2,5,6]. Ligation of the problematic AVA is nearly always successful in alleviating pain, but this leaves the patient without a permanent access and necessitates the use of a temporary dialysis catheter with its inherent morbidity and mortality.

Since its initial description by Schanzer et al. in 1988, a number of vascular surgeons published their experiences with the distal revascularization-interval ligation procedure as a means of combating the “steal” syndrome [1,2,6–9]. Despite these reports of excellent success in relieving ischemic symptoms while maintaining access patency, the technique continues to receive scant recognition among nephrologists. In the last 6 years the DRIL procedure was carried out in 11 of our patients. This retrospective study attempts to detail the pathogenesis of the “steal” syndrome and reviews both the history of the DRIL operation and its results in our unit. Based on our experience, it appears that this procedure should become an accepted approach in treating the “steal” syndrome.

### Patients and Methods

Between January 1996 and October 2002, the DRIL operation was performed on 11 patients in two different hospitals. Inadequate medical data excluded two patients from this study. In the remaining nine patients, who form the basis of this study, relevant points were extracted from the medical files and/or the patient. These included: age and gender, primary renal disease, presence or absence of diabetes mellitus, a history of tobacco abuse, evidence of overt atherosclerosis (cerebrovascular, cardiovascular or peripheral vascular disease), time on hemodialysis, the total number of AVA performed in the ipsilateral problematic arm, type and location of the AVA that produced the steal syndrome, time to development of the steal syndrome after construction of the AVA, clinical manifestations of the “steal” (pain, neurologic deficit, gangrene), time after the construction of the AVA to the DRIL procedure, results of the DRIL (immediate postoperative complications, pain relief, return of pulses, gangrene “healing,” neurologic improvement), duration of access patency after the DRIL, and patient outcome after DRIL (alive or not, and whether the cause of death was related in any way to access-related problems).

DRIL = distal revascularization-interval ligation  
AVA = arteriovenous access



**Figure 1.** The DRIL procedure, showing native vessels, dialysis access and the position for both the bypass graft and the arterial ligation associated with the operation. Reproduced from Wixon et al. [10].

### Operative procedure

When feasible, the patient underwent hemodialysis on the day before the operation. Preoperative intravenous cefazolin (1 g) was given on the morning of the operation and general anesthesia was administered. The surgical details are given in several publications [1,2,6,10]. In brief, a bypass (usually a reversed segment of the saphenous vein) is constructed from the inflow artery 5 cm proximal to the AVA to an artery (not necessarily the same artery) 3–4 cm distal to the AVA. The native artery is then ligated between the origin of the AVA and the distal bypass anastomosis [Figure 1].

Postoperative AVA patency and the new bypass graft patency were confirmed by the presence of an audible thrill and bruit over the existing access [2,7]. Dialysis was continued uninterruptedly on the second postoperative day using the existing AVA. (Figure 1).

### Results

Demographic details of the nine studied patients are presented in Table 1. Six patients had presumed diabetic nephropathy. All patients had evidence of atherosclerotic disease. Four patients were active smokers.

All problematic accesses were proximally located [Table 2] – antecubital in eight and thigh in one. Two AVA were endogenous fistulae, seven were bridge polytetrafluoroethylene grafts. In six patients no previous access had been used in the problematic limb;

**Table 1.** Demographic characteristics of the studied patients

Age (yrs)	66 ± 18
M/F	4/5
Nephrologic diagnosis	
Presumed diabetic nephropathy	6/9
Chronic interstitial disease	2/9
Renovascular disease	1/9
Generalized atherosclerosis	9/9
Diabetics (Type II)	7/9
Active smokers	4/9

**Table 2.** Problematic access details for the studied patients before the DRIL procedure

<b>Endogenous fistula</b>	
Brachial artery-cephalic vein	2/9
<b>PTFE graft</b>	
Brachial artery-axillary vein	5/9
Brachial artery-cephalic vein	1/9
Femoral artery-femoral vein	1/9
<b>Previous ipsilateral AVA</b>	
None	6/9
One	2/9
Two	1/9
<b>Time from problematic AVA to DRIL</b>	6.6 ± 2.8 months

PTFE = polytetrafluoroethylene

thrombosis of a previous distal fistula occurred in two patients and of two fistulae in one patient. Mean time after creation of the problematic AVA to the DRIL procedure was 6.6 ± 2.8 months (range 2–12 months)

Clinical manifestations of the steal syndrome included hand pain (in nine patients), pallor and a cool distal extremity (in six.), absent distal pulses (in six.), paraesthesia (in three), and sensory and motor loss in one patient. In at least five patients pain appeared immediately after construction of the elbow AVA. Late onset of pain occurred in two patients; in one it appeared after a successful bridge graft thrombectomy. Pain required constant narcotic therapy in at least two patients. In most patients pain worsened during hemodialysis. Digital gangrenous ulcers developed in four patients. The patient with a femoral artery vein loop bridge graft developed critical ischemia of the foot with a chronic heel ulcer. Osteomyelitis was noted in one patient.

At surgery, eight reversed saphenous vein grafts and one contralateral cephalic vein were used. There were no perioperative deaths. A significant wound infection occurred in the patient with the thigh AVA and took 6 months of local therapy to heal. Eight patients had immediate and complete relief of pain, while partial relief was evident in the one remaining patient. Distal pulses returned in five of six patients. Of the four patients with preoperative gangrene, one later required transmetacarpal amputation of a finger. In the other three patients the gangrene led to spontaneous autoamputation of a distal phalanx within a mean period of 5.0 ± 2.1 months (range 3–6 months).

Mean patient follow-up was  $12.3 \pm 10.6$  months (range 1–26 months). By the end of the follow-up period seven patients had functioning AVA ( $11.1 \pm 17.0$  months). Thrombosis of the AVA occurred in two patients 9 and 24 months after the DRIL operation. Three patients died during the study, two of them with a functioning AVA, but the causes of death were unrelated to the DRIL procedure in all three (*Escherichia coli* sepsis, temporary access sepsis, unknown). Following the DRIL procedure, adequate dialysis was maintained in all patients on a thrice weekly basis.

## Discussion

After creation of an AVA, reversal of arterial blood flow distal to the access occurs in 70–90% of patients, but arterial collaterals maintain distal perfusion and the patient remains asymptomatic [5,8]. However, a lack of adequate collaterals coupled with the sudden drop in resistance to flow established by the shunting of blood into the low pressure venous circulation in the case of a native fistula, or through a low resistance prosthetic graft, will produce the “steal” syndrome [6,7,9,12]. This occurs in 5–10% of hemodialysed patients, most of them being elderly, diabetics and/or smokers [1,2,7,9–11]. Other important risk factors for the “steal” syndrome include use of a bridge graft, especially in the antecubital area, and the presence of multiple AVA in the involved limb [10]. Most often the steal syndrome manifests with immediate post-operative pain, although approximately 33% of patients’ symptoms develop at a later time as AVA flow increases or as distal arterial disease worsens [2,3,7,10]. Pain can worsen during dialysis as a result of intradialytic hypotension, causing a further decrease in perfusion pressure to already compromised distal arteries [6]. Manual compression over the AVA often leads to a marked relief of pain in the affected hand and diminished Doppler waveforms seen in both radial and ulnar arteries [1,2,7,8,10].

Timing of the surgical correction in the “steal” syndrome is controversial. If no neurologic deficits are present, then 80% of patients will have spontaneous and significant pain relief 1 month postoperatively [1,7,8]. Therefore, surgery is indicated when: a) severe pain or other symptoms fail to ameliorate after 1 month, b) the appearance of digital gangrene [2,7] or presence of neurologic deficits [13]. Previous attempts at surgical correction of the “steal” met with only modest success [2,9]. Ligation of the AVA provides immediate improvement in distal perfusion and pain, but leaves the patient without an angio-access. In a radiocephalic fistula, paradoxical ligation or coil embolization of the radial artery distal to the fistula will prevent retrograde flow and eliminate the steal [5,14]. Banding of the arterial anastomosis, tapering of the arterial anastomosis or lengthening the graft itself can theoretically lead to an increased resistance within the AVA, thereby decreasing “steal” [2,5,12,15,16]. However, it is difficult to determine the exact amount of narrowing required without compromising AVA function, and access thrombosis is common after these procedures [6,10].

The DRIL procedure, first performed by Schanzer et al. in 1988 [1], is based on a sound physiologic rationale for the treatment of the “steal” syndrome [1,10]: “A bypass from the artery proximal to the AVA to an artery distal to the AVA is created. Construction of such a

bypass reduces the ratio of resistance between the peripheral circulation and the AVA, and directs a greater proportion of blood toward the periphery. To prevent arterial retrograde flow, the access artery is ligated just distal to the AVA” [10]. In 1988, Schanzer and co-workers [1] first used the DRIL procedure on three hemodialysed patients, two of whom were diabetics. Immediate pain relief was obtained in all patients. Patency of the access was not compromised for 1 month, 6 months and 8 years respectively [1]. In 1992, Schanzer and his group again published their results. This time 14 patients (13 diabetics, 12 antecubital bridge grafts) were included [7]. Immediate pain relief was noted in all patients; one patient with advanced gangrene at the time of operation underwent forearm amputation 1 year after undergoing the DRIL [7]. Of the 12 bridge grafts, 80% were patent at 1 year. The two endogenous fistulae were both functioning about 1 year after surgery [7]. By 1996, Schanzer’s group had performed the DRIL on 23 patients: 19 patients had complete resolution of symptoms and AVA patency at 1 year was 75% [17]. In 1996, Katz and associates [2] operated successfully on six patients. Immediate hand perfusion was evident in all six, ischemic symptoms resolved completely in four, and distal gangrene that had been present preoperatively in one patient “healed” within 3 months. All accesses remained patent for periods ranging between 2 and 18 months [2]. In 1997, Berman et al. [6] operated on 21 patients over a 31 month period; 14 were diabetics and finger ulcers developed in 6. Limb salvage and maintenance of a functional AVA were achieved in 100% and 94% respectively at 18 months [6]. In 1998, Lazarides et al. [8] performed DRIL in seven patients. Decision to operate was based on clinical symptoms and/or “a systolic pressure index” greater than 0.6. This team operated almost immediately after fistula surgery [8]. Ischemic symptoms resolved completely. There was no limb loss and six of seven AVA were patent at a mean follow-up of 1.5 years. Berman’s group further published their results in 2002, this time in 52 patients – undoubtedly the largest work on the DRIL procedure [9]. Only three patients experienced postoperative pain that necessitated access ligation. The AVA patency rate was higher than 80% at 1 year. In selected patients with severe distal arterial disease, a bypass alone without distal ligation may restore adequate hand perfusion [10].

In conclusion, the DRIL provides an added collateral artery, significantly improves distal perfusion and has no deleterious effects on the AVA in patients with the “steal” syndrome. This operation should be seriously considered as the treatment of choice in patients with an unrelenting steal syndrome. Although manual compression is a near-diagnostic test for the presence of the “steal” syndrome, the surgeon should always obtain a preoperative angiography of the entire arm before performing DRIL [5]. Such an angiography should be taken before and after manual compression of the arteriovenous graft [9]. It will provide anatomic details regarding possible proximal and peri-access arterial stenoses and will also detail patency of the distal arterial tree. In this way the correct surgical procedure can be undertaken [5]. If the DRIL procedure is considered to be the most appropriate therapy available, it should be carried out at an early stage, preferably before digital gangrene develops or at least immediately after its appearance [4].

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