Early Cannulation of Percutaneously Created Arteriovenous Hemodialysis Fistulae

Alexandros Mallios MD, William Jennings MD

Institut Mutualiste Montsouris Paris, France, University of Oklahoma College of Medicine, Tulsa, OK

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ABSTRACT

Objectives: An autogenous vascular access is associated with lower morbidity and mortality rates in addition to lower costs when compared to grafts or catheters. However, the time traditionally reserved for arteriovenous fistula (AVF) access maturation is problematic for some patients. Early cannulation in this report refers to AVF access within 1-14 days following fistula creation, with the goal of avoiding placement or allowing for early removal of a central venous dialysis catheter. We review our specific techniques and procedures to maintain a safe and functional AVF while allowing immediate cannulation when needed.

Methods: We reviewed all consecutive hemodialysis patients who underwent cannulation of a new AVF within two weeks after access creation. Each patient had a percutaneous proximal radial artery AVF (PRA-AVF) created at the juncture of the deep communicating vein and the proximal radial artery (PRA). Moderate flow PRA-AVFs were established using the percutaneous Ellipsys® AVF system, which creates a fused anastomosis through a single venous puncture using a simple ultrasound (US) facilitated guide wire technique. Standard intravenous plastic cannulas were used for immediate AVF cannulation along with US assistance when necessary.

Results: Eight patients underwent cannulation of a new AVF within two weeks of access creation to avoid catheter placement. Age range was 35 to 80 years (mean 65). Four were female. Three were obese and four diabetic. First cannulation was established within 1-14 days (mean = 8 days) in all patients. All had immediate cannulation success. No AVFs failed or had cannulation complications. US mapping with site marking was used for initial cannulation, aided by US guidance in two. Primary and cumulative patency rates were 88% and 100% at 4 mos mean follow up (range 2-7 mos). All individuals remain well with a functional AVF at the prescribed dialysis rate. No patient required a dialysis catheter placement and a single patient required a percutaneous angioplasty during the study period.

Conclusions: This preliminary report found that early AVF cannulation is both feasible and reliable for selected dialysis patients. The combination of percutaneous AVF creation with dialysis access using plastic cannulas, and US guided puncture when needed were key elements of success.

INTRODUCTION

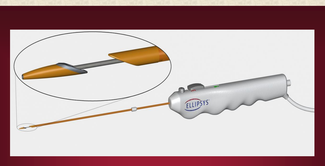
Hemodialysis using an autogenous vascular access is associated with lower morbidity and mortality rates in addition to lower costs when compared to grafts or catheters (1,2). However, the time traditionally reserved for arteriovenous fistula (AVF) access maturation has been a major point of contention for creating AVFs in some groups of dialysis patients (3). A three-month routine waiting period for first cannulation was common in past years but has now decreased to 4-6 weeks in many reports, although at least one report suggest two weeks maturation is safe (1,2,4,5,6). This time frame still requires a central dialysis catheter placement for many patients. Although not widely recognized, cannulation of AVFs has been accomplished successfully very early in the postoperative course by some dialysis access physicians (7). In fact, the first AVFs for hemodialysis created by Kenneth Appelle in 1965 were successfully cannulated without complication the day following surgery (8). Early cannulation in this report refers to AVF access within one to fourteen days following surgery. This immediate access AVF cannulation plan is used to avoid placement of a central venous dialysis catheter and is specific to the techniques and procedures outlined here.

METHODS

We reviewed all consecutive hemodialysis patients who underwent cannulation of a new arteriovenous fistula within two weeks of access creation. In addition to physical examination, each patient underwent a vascular ultrasound (US) examination by the operating surgeon during the initial evaluation prior to AVF creation (9). Patients were followed postoperatively in the surgery clinic at one and 6 month periods in addition to reports from the dialysis center nursing staff. Individual patients were re-evaluated sooner if the dialysis nursing staff noted any problem such as difficult cannulation, low flow rate, elevated dialysis pressure, recirculation, or post cannulation bleeding.

We recommend a radiocephalic arteriovenous fistula (AVF) at the wrist as the first choice for vascular access in patients where vessels are adequate and the AVF is likely to mature (10). These patients are a minority of the referrals seen in our practice. Our second choice and most common procedure for vascular access is a proximal radial artery (PRA) AVF (11). We now create PRA-AVFs using a percutaneous technique with proximal radial artery inflow and outflow via the deep communicating and cephalic venous systems (12). The Ellipsys® AVF device procedure creates a thermal fused anastomosis through a single puncture with simple US facilitated guide wire technique and has been previously described in detail (13). These new percutaneous AVFs may be matured during the same procedure with balloon dilatation if needed, yielding adequate flow for immediate cannulation and functional dialysis (14). A video of the procedure is available at http://avenumedical.com/news-release-2/ on the internet. Intravenous plastic catheter sheaths (IV-Cath) introduced over a rigid needle are standard care items for peripheral venous access. They are constructed of fluorinated ethylene propylene and have been reported in use for AVF cannulation within the first weeks following access creation (15). IV-Caths were used for immediate AVF cannulation for the patients in this report along with US assistance when necessary.

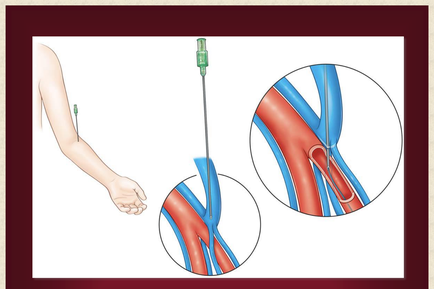
The percutaneous AVF procedures were performed at a university affiliated medical center outpatient department with regional block anesthetic. Primary patency was defined as the time (months) of uninterrupted patency and without intervention. Primary assisted patency was the time of uninterrupted patency after the original AVF construction when any intervention was necessary. Cumulative (secondary) patency was the time from the original AVF construction, until abandonment of the access or until completion of the study period, regardless of interventions or thrombosis. The Institutional Review Board approved this study.



Avenu Ellipsys® AVF System

- **-6 Fr single catheter**
- **-Over-the-wire single venous access**
- **-Ultrasound guided**
- **-Low power thermal fused anastomosis**

Thermal fusion power source



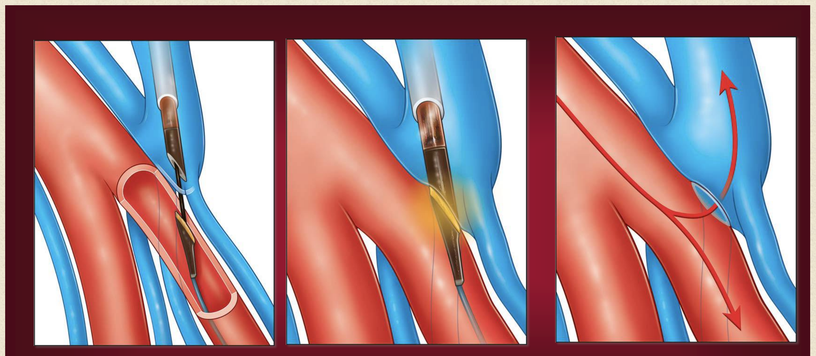
Venous access with the micropuncture needle and guide wire placed through the deep communicating vein and into the radial artery.

Key elements for success in early AVF cannulation:

- •Used selectively to avoid placement of a central venous dialysis catheter (or immediate removal of a problematic catheter).
- •The percutaneous proximal radial artery (PRA) Ellipsys® AVF creates a moderate flow/low pressure percutaneous AVF, avoiding surgical dissection, associated inflammation, and recovery period.
- •Initial cannulation with an intravenous plastic catheter sheath (IV-Cath) inserted over a ridged needle (not necessary after first few weeks).
- •Ultrasound cannulation guidance was used in two patients for the initial cannulation (an important benefit in individuals with deeper veins.

Technical Points Review:

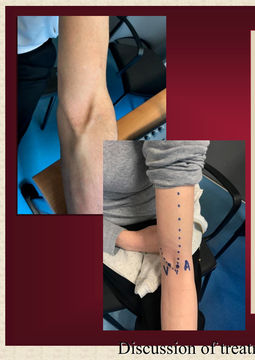
- •Echogenic needle tip, 21g micropuncture with echogenic tip.
- •Advance needle with US guidance in PRA.
- •Insert 0.021" wire.
- •Insert Terumo® Slender sheath 6fr (designed for radial artery access).
- •After sheath is in place, change to 0.014" wire for device/balloon insertion.
- •Insert Ellipsys® device until distal jaw is in PRA, gently retract to capture PRA, close device and activate to create automated fused anastomosis.
- •Device removed leaving wire in place.
- •2cm x 5mm balloon positioned in deep communicating vein and 4-6mm into PRA.
- •AVF procedure time is 6-10 minutes.



Creating a percutaneous proximal radial artery Ellipsys® AVF

4 days post Ellipsys ® AVF

One week post Ellipsys ® AVF



Early Cannulation with Ellipsys® AVF:

- •Avoidance of catheter in select patients.
- •Minimally invasive one-stage AVF.
- •High safety profile.
- •Time efficient procedure (10-15 min).
- •High patient satisfaction.
- •Excellent technical success and patency.
- •New possibilities in terms of vessel cannulation and avoidance of superficialization.

Discussion of treatment text goes here.

DISCUSSION

Central venous dialysis catheters offer immediate vascular access but carry the greatest risks of complications and highest overall costs (1,2,3). AVFs are the preferred method for hemodialysis access, however have traditionally required the longest time for maturation (3). Planned delay for initial cannulation of a new AVF for as much as three months was common in the past but not based on scientific study. Several investigations including The Dialysis Outcomes and Practice Patterns Study have shown that cannulation 4-6 weeks after AVF surgical construction was safe and did not impact access survival (4,5). Additionally, the DOPPS studies found cannulation after two weeks had no impact on survival of the AVF (6). However, none of these studies focused on a specific cannulation plan for immediate cannulation with individual techniques and procedures presented in this report.

PRA-AVFs create a moderate flow vascular access that has proven to be safe and effective in delivering adequate hemodialysis (11). Cimino, et al reported functional vascular access through moderate flow simple veno-venous cannulation was even possible for both inflow and return in 1962, prior to their creation of the first AVFs in 1996 (15). Lower flow volumes and access pressures offer several advantages including decreased risk of congestive heart failure, steal syndrome, post dialysis bleeding, and aneurysm formation. Moderate venous outflow pressures have been shown to correlate with AVF survival (16). Less intraluminal turbulence and vessel wall shear stress may also result in decreased stimulus for intimal hyperplasia with associated luminal narrowing and stenosis.

We feel initial cannulation with an IV-Cath inserted over a ridged needle is an important component of the success in immediate cannulation for our patients, however IV-Caths should not be necessary after one month if other considerations such as cost are noted (7). The percutaneous AV fistula creation leaves all surrounding tissue intact and avoids the local inflammatory component of a surgical incision. We now leave all outflow venous branches open unless a brachial vein enlarges to dominate AVF outflow. We carefully evaluate each outflow branch during postoperative examinations by doppler imaging and flow volume measurements, however none of the patients in this study required branch coil occlusion or ligation during the follow-up period. This approach had the particular benefit in some patients allowing easy initial dialysis cannulation of the medial cubital and median cephalic veins within the cubital fossa. The sites close to the new AVF site would not be immediately available if a surgical incision was needed for standard AVF construction.

Our review found that the combination of creating a moderate flow percutaneous PRA-AVF (avoiding surgical dissection, associated inflammation, and recovery period) with IV-Cath puncture (using ultrasound guidance when needed) allowed immediate AVF access within 1-14 days (7,17). Even those patients in need of dialysis the day following AVF creation had complication free cannulation. We feel that many central venous catheters may be avoided with these techniques. It is important to note that creation of an Ellipsys ® PRA-AVF utilizes the deep communicating vein for the anastomosis and should not preclude a distal radiocephalic AVF if the vessel(s) enlarge and are later deemed adequate. In addition, PRA-AVFs may well develop bidirectional outflow, affording forearm cannulation sites in addition to the targeted proximal cannulation zone.

Minimizing the use of central venous catheters with the associated expense of placement and the cost of frequent dysfunction, infections, and hospitalizations associated with catheter related bacteremia should make a significant impact in the overall cost of providing safe dialysis access. In addition, a pathway for many patients to have an autogenous access created for immediate use may avoid the need for early cannulation AV grafts in selected patients.

We believe the availability of Ultrasound used when appropriate for a difficult cannulation will more than pay for the cost of the device while markedly improving nurses and technicians cannulation skills and insuring a single anterior AVF wall puncture. Ultrasound guidance for initial AVF cannulation is often very helpful in obese patients with deeper veins (17). Avoidance of infiltrations and hematomas will be a cost effective measure and significantly improve dialysis patient's well-being. Buttonhole cannulation is frequently used in our institution's dialysis unit and is helpful in some of these patients where immediate cannulation length is limited. Percutaneous PRA-AVFs were created for many other patients where immediate cannulation would have been utilized, however they had not started dialysis or came to us with a catheter in place. This review has limitations common to all retrospective investigations and these results should be confirmed by larger prospective studies.

RESULTS

Eight patients underwent cannulation of a new AVF within two weeks of access creation. Each patient had an Ellipsys ® percutaneous AVF created at the juncture of the deep communicating vein and the PRA (13,14). Age range was 35 to 80 years (mean 65 years). Four (50%) subjects were female. Three (30%) were obese and four (50%) were diabetic. First AVF cannulation was initiated within 1-4 days (mean = 8 days) in each patient. Table 1 shows distribution of cannulation timing. All patients had immediate cannulation success (Figure 1). No patient had access failure during the study period. The initial cannulation was aided by US guidance in two patients. All individuals remained dialysis catheter free. Primary and cumulative patency rates were 88% and 100% at 4 months of average follow up (range 2-7 months). All patients remain well with a functional AVF at the prescribed dialysis rate. No patient required a dialysis catheter placement and a single patient required a percutaneous angioplasty during the study period. Sixty patients underwent creation of an Ellipsys® percutaneous PRA-AVF during the study period. Although this report involves those individuals where early cannulation of a new AVF prevented dialysis catheter placement; other patients were referred with a catheter in place, had not yet started dialysis, or were stable and able to wait longer to initiate dialysis. We feel these other patients would also have been candidates for early cannulation if needed.

Table 1. Timing of early AVF cannulation

Patient	Timing of Cannulation (Day post creation)
1	4
2	4
3	1
4	8
5	12
6	5
7	10
8	12
Average	7

CONCLUSIONS

This preliminary report found that early AVF cannulation within two weeks is both feasible and reliable for selected dialysis patients. The combination of percutaneous AVF creation with IV cannulation plastic catheters and ultrasound guided puncture when necessary were key elements of success, making central venous dialysis catheters unnecessary in these patients.

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