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Multidisciplinary Team Approach to End Stage Dialysis Access Patients

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Abstract

Background—The Hemodialysis Reliable Outflow (HeRO) access device is a permanent dialysis graft used in patients with central venous obstruction. Given the complexity of care related to end-stage dialysis access (ESDA) patients, a multidisciplinary approach has been employed to achieve operative success of HeRO graft placement.

Methods—The single-center retrospective review included adult patients that were seen in ESDA clinic who underwent a HeRO graft placement from September 2010 to September 2014 under the care of a team consisting of a nephrologist, an interventional radiologist, and a surgeon. The effectiveness of the multidisciplinary approach was evaluated using outcome variables including successful HeRO graft placement, operative complications, the rate of obtaining central venous access, and advanced endovascular maneuvers performed by interventional radiology to obtain central venous access.

Results—A multidisciplinary approach has been used in 33 ESDA patients. Access to the right atrium was achieved in 100% of cases. 58% of patients required advanced endovascular maneuvers in the interventional radiology suite in order to obtain central venous access. Successful HeRO graft placement was achieved in 94% (31/33) of the study population. No intra-operative complications were encountered. Median primary and secondary patency rates were 83 (IQR: 45–170) days and 345 (IQR: 146–579) days per HeRO graft placement, respectively. Primary and secondary patency rates at 60 days were 70% (23/33) and 79% (26/33), respectively.

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Conclusions—In this difficult patient population, a multidisciplinary team can provide a unique and collaborative approach to HeRO graft placement in patients with complex central venous outflow obstruction.

Keywords

Dialysis access; venous outflow obstruction; Hemodialysis Reliable Outflow dialysis device; HeRO graft

1. Introduction

End stage renal disease (ESRD) is a major public health concern as the incidence is increasing at a rate of 5% each year [1]. There are over 400,000 patients with ESRD that require three times a week, in center hemodialysis [1]. This patient population consumes over 40 billion Medicare dollars annually [1]. The more time patients are on hemodialysis, achieving and maintaining vascular access becomes more difficult adding to the cost this patient population accrues. Tunneled dialysis catheters (TDC) are often required to bridge the time while a graft or fistula matures for safe and sustainable dialysis access. The more frequent and longer duration that patients require TDC, the chance of developing central venous outflow obstruction increases making upper extremity arteriovenous access more difficult to maintain, which is especially important given the movement away from catheter dependent dialysis [2].

In patients with limited dialysis access options secondary to upper extremity venous outflow obstruction, the traditional options include long term TDC or a thigh graft. However, the Hemodialysis Reliable Outflow (HeRO) dialysis device can provide an opportunity for an upper extremity subcutaneous arteriovenous dialysis graft in patients with upper extremity venous occlusive disease. The HeRO access device is composed of venous outflow and arterial graft components tunneled completely subcutaneously [3–5]. The device is inserted surgically and accessed percutaneously similar to other dialysis grafts. Unlike traditional upper extremity hemodialysis grafts, the HeRO graft requires endovascular placement of the venous outflow component. Given the complex patient population and associated venous outflow obstruction, training in endovascular techniques is required for HeRO graft placement. Therefore, a multidisciplinary approach has been employed to improve operative success of HeRO graft placement at our institution where access surgeons do not have dedicated training in endovascular techniques. The aim of this study is to describe a multidisciplinary approach in HeRO graft placement in ESDA patients.

2. Methods

2.1 Multidisciplinary Process

Due to the complexity of ESDA patients, a multidisciplinary team approach inherently maximizes the expertise of multiple specialties to work towards the best treatment outcomes for patients. The multidisciplinary team consists of a nephrologist, an interventional radiologist, and an access surgeon. Operative allocation of hemodialysis access cases at Vanderbilt University Medical Center (VUMC) is non-endovascular trained transplant surgeons. Patients with suspected venous outflow stenosis or obstruction are referred to the

ESDA clinic by a nephrologist (Figure 1). Prior to their clinic visit with the access surgeon, a computed tomography (CT) angiogram/venogram is obtained and reviewed for anatomical considerations by the interventional radiologist (Figure 2). The surgeon and radiologist jointly determine laterality and an operative plan for HeRO graft placement. This plan may include using an existing chest access catheter for placement of the outflow portion of the HeRO, or creation of an entirely new access that may traverse or avoid the central venous stenosis identified on the CT Venogram. In this patient population, the new access may require the use of specialized techniques by the interventional radiologist, which are beyond the scope of the transplant surgeon. This could include thrombolysis, recanalization across a stenosis using a guide wire, sharp recanalization with a needle, or radiofrequency ablation tip wire.

On the day of the procedure, access to the right atrium is first achieved in the interventional radiology suite, utilizing one of the aforementioned techniques. The interventional radiology suite is used to perform the endovascular component of HeRO graft placement at our institution rather than a hybrid operating room due to the scheduling unavailability due to resource allocation of the hybrid operating room to non-access operations. Following catheter placement into central venous system, the patient is transported to the operating room with an occlusive dressing over the venous puncture site to secure the catheter. In the operating room, the placeholder catheter that was initially placed in the IR suite is exchanged for a 19F venous outflow component. Once the venous outflow component is successfully placed into the central venous system, the ipsilateral brachial arterial is exposed and the arterial inflow anastomosis to the HeRO graft is performed. The patient is discharged the same day following surgery. Postoperatively, the patient returns to clinic for evaluation to ensure appropriate tissue incorporation prior to HeRO cannulation for hemodialysis.

2.2 Patient Population

The single-center retrospective review included adult patients that were seen in ESDA clinic who underwent a HeRO graft placement at our institution from September 2010 to September 2014. All patients that are referred to ESDA clinic have limited dialysis access options due to complicated venous outflow anatomy limiting the function of existing arteriovenous access or rendering the patients dependent on a TDC for hemodialysis. All patients had adequate brachial artery diameter for the inflow arterial component. In the study population, HeRO grafts were salvage attempts at achieving upper extremity dialysis access. Patients with alternative options for dialysis such as peritoneal dialysis or upper extremity grafts were not evaluated in ESDA clinic and therefore not included in the study cohort. Patient factors considered prior to attempting HeRO placement: 1) exhaustion of all upper extremity venous access or peritoneal access, 2) suitable venous and arterial anatomy for placement, 3) physiologic suitability for the procedure and increased cardiac venous return, 4) ability to return to this venous access center for all subsequent procedures.

2.3 Data collection

This retrospective, medical chart review was conducted for thirty-three patients who received a HeRO graft. Information outlining the complexity of the patients' dialysis access

history (Table 1) includes length of time on hemodialysis at the time of the operation, prior failed arterial-venous access, TDC dependency at the time of HeRO graft placement, and venogram findings (Table 2) appreciated during operative planning for HeRO placement. The effectiveness of the multidisciplinary approach was evaluated using outcome variables including successful HeRO graft placement, operative complications, and advanced maneuvers performed by interventional radiology to obtain central venous access (Table 3). The institutional ethics review board approved the study.

2.4 Outcomes

The efficiency of care provided by the multidisciplinary team was defined by successful placement of HeRO graft in the operating room. Secondary outcomes evaluating the effectiveness of a multidisciplinary team approach include the rate of obtaining central venous access in the setting of complex obstructive central venous anatomy, operative complications and the need to perform advanced maneuvers by interventional radiology to obtain central venous access. The endovascular maneuvers considered advanced were those requiring central venous access via a chest wall collateral vein, angioplasty to transverse a stenosis, lumen recanalization across a thrombosis, embolization of a collateral vein due to extravasation during the endovascular component of the procedure, or those requiring advanced ultrasound techniques to obtain central access (i.e. ultrasound guided supraclavicular approach to access the subclavian vein). Long term outcomes include 60 day primary and secondary patency rate, median primary and secondary patency rate, number of interventions performed at our institution required to remain patent, and infectious complications.

2.5 Statistical Analysis

The statistical analysis was performed with the use of SPSS software (SPSS for Mac, version 22.0). Means and standard deviations were calculated for continuous data. Percentages were calculated for categorical data.

3. Results

3.1 Demographics

A multidisciplinary approach for HeRO placement has been used in 33 ESDA patients from September 2009 to September 2014. Demographic analysis (Table 1) showed that the study population was 67% male and 82% African American with a mean age of 52.9 (+/- 13.0). The mean length of time requiring hemodialysis was 97.8 months (+/- 74.83) prior to operative intervention. The etiology of end stage renal disease largely was secondary to hypertension (55%) and diabetes (19%). All patients had a history of a failed arteriovenous access procedures prior to being evaluated in ESDA clinic per our inclusion criteria. Thirty-three percent (11/33) of the patient population failed peritoneal dialysis prior to being evaluated for HeRO placement. 5 patients (5/33) had a prior failed thigh graft at the time of HeRO graft placement. Five patients (5/33) were listed for renal transplantation based on institutional criteria. 91% of the study population was dependent on a TDC to receive hemodialysis at the time of the operation.

3.2 Outcomes

Successful HeRO graft placement was achieved in 94% (31/33) of the study population (Table 3). The two unsuccessful cases resulted from an inability to exchange and upsize a placeholder catheter located in a chest wall collateral vein for the 19F venous component of the HeRO graft. Of note, these patients did not have a patent IVC to allow stiff wire retrograde dilatation the access site and the patients' central venous system could only be accessed via a chest wall collateral vein due to significant central venous thrombosis (Table 2; red numbers represent the unsuccessful HeRO graft placement). Right atrial access obtained by interventional radiology, however, was achieved in all patients (33/33) in the study population. Obtaining access to the right atrium required advanced maneuvers performed by interventional radiology in 58% (19/33) of the patient population (Table 3). There were no operative complications to report.

Median primary patency rates was 83 (IQR: 45–170) days with a primary patency rate at 60 days of 70% (23/33). Median secondary patency rates was 345 (IQR: 146–579) days with a secondary patency rate at 60 days of 79% (26/33). On average, 2.62 interventions per HeRO graft were required in the study cohort. Twenty-one percent (7/33) of the patients experienced an infectious complication.

4. Discussion

Multidisciplinary health care teams have been shown to improve efficiency of care and clinical outcomes[6–11]. Utilizing the expertise of multiple specialists enhances the overall care delivery for the patient. A structured coordination of care through the rapid exchange of information within a multidisciplinary team to develop an individualized treatment plan in complex patient populations improves the quality of care delivered[9, 12, 13]. ESDA patients have multiple medical issues requiring treatment from a diverse group of specialties. The aim of this study was to describe a multidisciplinary team approach in the management, operative workup and placement of HeRO grafts in ESDA patients.

A standardized referral protocol helping to concentrate expert care delivery provides the initial benefits of a multidisciplinary team approach for ESDA patients. The resulting rapid flow of information between providers expedites the coordination of the treatment plan. A CT venogram that is obtained prior to the patient's clinic visit is reviewed with an interventional radiologist and a decision regarding operative approach is determined in conjunction with the patients' physical exam and prior surgical history obtained by the access surgeon. The coordination of care is further highlighted by the patients experience on the day of the procedure. The patient initially reports to the interventional radiology suite for the first step of the procedure, placing a placeholder catheter into the central venous system, which was achieved in the entire patient population. The specialized techniques performed by the interventional radiologists contributed to the high success of obtaining right atrial access. In 58% of the patient population, an advanced endovascular technique was performed. These techniques are outside the scope of practice for access surgeons our institution allowing improved success of HeRO graft placement within a multidisciplinary approach. Of the patients that required advanced maneuvers, 29% and 19% required angioplasty and recanalization, respectively, to transverse a severe venous stenosis or

thrombosis in order to achieve central venous access. A chest wall collateral vein rather than the subclavian vein, external jugular vein or internal jugular vein was cannulated to allow placement of the venous component of the HeRO graft in 43% of the population that required advanced endovascular techniques. In one patient, embolization of a collateral vein was required due to extravasation during the central venous catheter placement. This single misadventure should not preclude the use of collateral veins highlighted by the high percentage of cases that a chest wall vein was used for successful HeRO graft placement in our patient population. In the operation room, the placeholder catheter is exchanged for the venous component of the HeRO graft, as well as completion of arterial inflow anastomosis to the HeRO graft. There were no operative complications in the study population, and the only two unsuccessful cases resulted from an inability to exchange the placeholder catheter located in a collateral vein for the 19F venous component of the HeRO graft. The benefits of combining the specialized skill sets offered by an access surgeon and interventional radiologist provide a clinical and operative platform to treat and manage more patients with complex venous outflow anatomy in a clinical landscape similar to the academic setting at our institution where hemodialysis access cases are performed by transplant surgeons rather than vascular surgeons trained in endovascular techniques.

The multidisciplinary team approach described in this manuscript is one option that can be used to maximize HeRO graft placement. At many academic centers, transplant surgeons perform the access operations. In other hospital settings with a different allocation for access cases, a vascular surgeon could simplify the process by performing both the advanced endovascular maneuvers, as well as the vascular component of the access case. However, at our institution, the expertise offered by nephrology, access surgery and interventional radiology during the care of ESDA patients provides a collaborative platform for HeRO graft placement; thereby increasing the number of operative candidates and subsequent placement of HeRO grafts in patients with complex central venous outflow obstruction at our institution. The applicability of the multidisciplinary team approach is further highlighted by the high rate of successful HeRO graft placement (94%) in this difficult study population.

Depending on the operative approach and team organization, HeRO graft placement is important option for ESDA as data have indicated that these devices are safe and effective for hemodialysis patients [3, 14, 15]. The benefits of HeRO graft placement reported in the literature include reliable patency rates, lower infectious complications compared to alternative end stage options such as thigh grafts and tunneled dialysis catheters, and excellent dialysis flow rates [3, 4, 14, 16, 17]. Based on a previous cost-analysis that showed decreased costs with a 23% average savings per year associated with HeRO grafts when compared to tunneled dialysis catheters [2, 3], increasing the number of patients determined to be operative candidates and the subsequent high rates of successful HeRO graft placement in turn leads to decreased overall costs in ESDA patients. In contrast to this early data, recent studies have reported conflicting clinical outcomes[18–20]. Torrent et al retrospectively evaluated 41 patients and showed a 6-month and 12 month primary patency rate of 30.4% and 8.4%, respectively[19]. The secondary patency rate at 6 months and 12 months was 81.6% and 53.7%, respectively, requiring 2.84 procedures per HeRO graft[19]. These reported patency rates are substantially lower than the 164 patient, multicenter trial

that noted a primary and secondary 12 month patency rate of 60% and 90.8%, respectively, with 1.5 procedures required per HeRO graft per year[17]. These most recent reports, as well as the results examining durability in our study, highlight that HeRO grafts should be considered only as salvage hemodialysis options in ESRD patients.

The limitations of this single center study are related to the retrospective nature of the data collection. More specifically, these limitations include patient and data selection bias. Additionally, there was not a control group evaluated to determine the operative efficiency and cost differences of a multidisciplinary team in the treatment of ESDA patients compared to individual provider based care such as a vascular surgeon with endovascular training.

Conclusion

In this difficult patient population, a multidisciplinary team can provide a unique and collaborative approach to HeRO graft placement in a clinical landscape similar to the academic setting at our institution where hemodialysis access cases are performed by transplant surgeons rather than vascular surgeons.

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Dr. Kensinger contributed to the design, acquisition of data, analysis and interpretation of data, writing, and approval of the final manuscript. Dr. Brownie contributed to the acquisition of data, analysis and interpretation of data, editing of the final manuscript and approval of the final manuscript. Dr. Bream contributed to the interpretation of data, editing of the final manuscript for important intellectual content and final approval of the submitted version. Dr. Moore contributed to the design, interpretation of data, editing of the final manuscript for important intellectual content, and final approval of the submitted version.

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Figure 1.

An overview of the care coordination of the multidisciplinary team approach and subsequent operative placement of HeRO grafts in ESDA patients.

Figure 2.

Computed tomography venography (CTV) of a patient who underwent HeRO graft placement. The CTV identifies numerous collateral vessels in the chest wall draining via intercostal veins to the azygos. The superior vena cava is occluded by calcification and fibrous material with reconstitution distal to the occlusion via the azygos vein (*Red arrow: thrombosis at the junction of the left innominate vein and superior vena cava; yellow arrow: collateral chest wall vessels*).

Table 1

Patient demographics of the study population.

Patient Characteristics	
Age	52.9 (+/- 13.0)
Gender	
Male	67%
Female	33%
Race	
African American	82%
Caucasian	15%
Hispanic	3%
Etiology of Renal Disease	
Hypertension	55%
Diabetes	19%
Lupus	5%
Polycystic Kidney Disease	2%
Obstructive Uropathy	2%
Focal Segmental Glomerulosclerosis	2%
Calcineurin Inhibitor Toxicity	2%
Hereditary Disease	2%
Human Immunodeficiency Virus	2%
IgA nephropathy	2%
Unknown	5%
Mean length of time on hemodialysis (months)	97.8 (+/-74.8)
Tunneled Dialysis Catheter Dependent	91%
History of Failed arteriovenous access	100%

Table 2

Overview of the endovascular procedures to obtain central venous access in the study population with corresponding computed tomography venogram results (*abbreviations: Tunneled Dialysis Catheter: TDC; SVC: superior vena cava; IVC: inferior vena cava; red numbers represent the unsuccessful HeRO graft placement*).

Patient	Description of the endovascular component of HeRO graft placement	Computed Tomography Venous Results	
1	Not technically demanding	N/A	
2	Not technically demanding	1	Mild transient holdup of contrast at the subclavian veins
		2	All central mediastinal veins remain patent with no intraluminal filling defects
3	Not technically demanding	Left innominate vein occlusion with collateral flow through the azygos vein	
4	Angioplasty of the left innominate vein	1	Stenosis of the left innominate vein with collateralization through the chest wall
		2	Bilateral thoracic inlet obstruction
5	Severe SVC stenosis requiring angioplasty	Severe SVC stenosis	
6	1 Angioplasty of SVC	1	Innominate vein and SVC stenosis with numerous mediastinal and chest wall collaterals
	2 Collateral vein access into SVC	2	Bilateral subclavian vein stenosis
7	Not technically demanding	1	Near complete occlusion of the proximal right subclavian and right innominate vein
		2	Mild to moderate left thoracic subclavian vein inlet narrowing
8	Angioplasty of SVC	Severe central stenosis of the right brachiocephalic vein and SVC	
9	Angioplasty of the left innominate vein	Severe stenosis of the left innominate vein	
10	Not technically demanding	1	Occluded right external and internal jugular vein
		2	Stenosis of bilateral brachiocephalic veins
11	Right chest wall collateral vein was cannulated to achieve central venous access	1	Bilateral subclavian vein occlusions
		2	Occlusion of IVC at hepatic veins
12	Right chest wall collateral cannulation into central cephalic vein to achieve central venous access	SVC occlusion	
13	Right chest wall collateral vein was cannulated to achieve central venous access	1	Complete occlusion of the upper extremity central venous system and mediastinal vessels with chronic superficial collaterals
		2	Patent SVC
14	Stiff guide wire used to traverse stenosis and thrombosis of SVC in order to achieve central venous access	1	Right subclavian vein occlusion
		2	Thrombosis at the bifurcation of the right and left innominate veins
15	1 Complete occlusion of the SVC requiring the use of a previously placed TDC catheter for access across venous occlusion	1	Bilateral axillary and innominate vein occlusion
		2	Occlusion of the left internal jugular vein and subclavian

Patient	Description of the endovascular component of HeRO graft placement	Computed Tomography Venous Results
2	Extravasation from collateral vein requiring coil embolization	3 Complete occlusion of upper SVC
16	Ultrasound guided placement at the right internal jugular and subclavian confluence (supraclavicular approach)	1 Complete occlusion of the left subclavian and innominate vein 2 Occluded right internal jugular and short segment of right subclavian vein
17	Not technically demanding	Occlusion of bilateral subclavian veins, extending into the left axillary and internal jugular vein
18	Used a previously inserted left internal jugular catheter secondary to occlusion of alternative options	1 Bilateral axillary/subclavian vein occlusion 2 Right internal jugular vein occlusion 3 Left innominate vein occlusion
19	Not technically demanding	Left subclavian/innominate vein occlusion
20	Right chest wall collateral veins used to access central venous system	1 Bilateral internal jugular and right subclavian occlusion 2 Collateral cannulation into right atrium
21	Right chest wall collateral veins used to access central venous system	Severe stenosis of the left brachiocephalic vein
22	Not technically demanding	1 Left innominate vein occlusion 2 Right internal jugular occlusion
23	Used access from previous TDC	Bilateral proximal subclavian vein occlusions
24	Not technically demanding	1 Subtotal narrowing of the left subclavian vein 2 Severe narrowing on the right subclavian vein 3 Right innominate and internal jugular occlusion 4 Severe SVC stenosis
25	Sharp recanalization and angioplasty across SVC thrombosis	Focal occlusion of the SVC at the junction of the right innominate and left brachiocephalic veins
26	Not technically demanding	1 Right internal jugular thrombosis 2 Strictures in the left subclavian vein 3 Narrowing of the right innominate vein
27	Catheter was placed through severe stenosis at the confluence of the right subclavian vein and innominate vein	Severe central stenosis at the confluence of the right subclavian and brachiocephalic veins
28	1 Venous access obtained through anterior intercostal collateral vein 2 Collateral vein diameter too small to pass HeRO catheter into right atrium despite balloon dilations	1 Chronically occluded proximal SVC 2 Bilateral subclavian and innominate vein occlusion 3 Collateral flow into distal SVC
29	1 SVC thrombosis could not be re-cannulated for dilator advancement 2 Right internal mammary vein was used for catheter placement into right atrium, however unable to upsize to HeRO venous component	1 SVC thrombosis 2 Occlusion of the right subclavian vein

Patient	Description of the endovascular component of HeRO graft placement	Computed Tomography Venous Results	
30	Right chest wall collateral veins used to access central venous system	1	Complete occlusion of bilateral innominate veins
		2	Occlusion of right subclavian vein
31	Catheter was placed via exchange from a previous left internal jugular TDC	1	Bilateral narrowing of central subclavian veins
		2	Complete occlusion of right brachiocephalic vein
32	Right brachiocephalic vein recanalization		Occlusion of the right innominate vein
33	Not technically demanding	1	Occlusion of the left innominate vein
		2	Stenosis of the right innominate vein

Table 3

Efficiency metrics evaluating the effectiveness of a multidisciplinary team approach.

Outcomes	
Successful HeRO placement	94%
Operating room complications	0%
Right atrial access	100%
Need for advanced endovascular maneuvers	58%
Maneuvers performed:	
Central vein angioplasty	29%
Chest wall collateral vein access	43%
Central venous cannulation	19%
Need for collateral vein embolization during catheter placement	5%
Advanced ultrasound guide placement (i.e. Supraclavicular approach)	5%