

ORIGINAL ARTICLE

# Hybrid surgery versus percutaneous mechanical thrombectomy for the thrombosed hemodialysis autogenous arteriovenous fistulas

Jong Hee Hyun, Jong Hoon Lee, Sung Il Park<sup>1</sup>

Departments of Surgery and <sup>1</sup>Radiology, Kwandong University College of Medicine Myongji Hospital, Kwandong University College of Medicine, Goyang, Korea

**Purpose:** For the successful treatment of thrombosed autogenous arteriovenous fistula (AVF), we designed and performed a hybrid surgery. Its clinical outcomes were compared with those of percutaneous mechanical thrombectomy, retrospectively.

**Methods:** Forty cases of thrombosed autogenous AVFs underwent hybrid surgery, whereas 19 cases received percutaneous mechanical thrombectomy. Hybrid surgery consisted of surgical thrombectomy, balloon angioplasty and/or additional surgical angioplasty. Percutaneous mechanical thrombectomy included catheter-introduced thrombus aspiration, balloon angioplasty and/or stenting. Procedure related outcomes such as technical success rates and primary patency rates were analyzed, retrospectively. **Results:** There were no statistically significant differences between the two groups in terms of demographic data of the patients including age, gender, diabetes status, and frequency of antiplatelet use, as well as the characteristics of thrombosed autogenous AVFs such as access age, site, type, and length of time between thrombosis and AVF creation ( $P > 0.05$ ). Technical success rates (92.5% vs. 68.4%,  $P = 0.005$ , respectively) and primary patency rates (85.9% vs. 36.8% at 6 months, 81.1% vs. 26.3% at 12 months, 81.1% vs. 21.1% at 18 and 24 months respectively, log-rank test,  $P < 0.001$ ) were significantly higher in the hybrid surgery group. In terms of cost analysis, supply cost was not different ( $P = 0.065$ ), but total cost was statistically lower in the hybrid surgery group ( $P = 0.019$ ). **Conclusion:** Hybrid surgery showed better technical success rates and patency rates in the salvaging of thrombosed autogenous AVFs than in percutaneous mechanical thrombectomy.

**Key Words:** Arteriovenous fistula, Hybrid surgery, Thombosis

## INTRODUCTION

Autogenous arteriovenous fistula (AVF) has been recommended more than other hemodialysis access using artificial graft. The cost of maintaining autogenous AVF is less expensive than artificial access because of lower surgical morbidity, mortality, incidence of infection and good

patency rate [1]. However, when autogeneous AVF was occluded by thrombosis, the salvaging procedures for revascularization didn't show satisfactory results. The National Kidney Foundation Dialysis Outcomes Quality Initiatives suggests that choosing the method of salvage procedure depends on the ability of each institution [2].

To improve the technical success rates of thrombosed

Received January 26, 2011, Accepted April 23, 2011

Correspondence to: Jong Hoon Lee

Department of Surgery, Kwandong University College of Medicine Myongji Hospital, Kwandong University College of Medicine, 697-24 Hwajeong-dong, Deokyang-gu, Goyang 412-270, Korea

Tel: +82-31-810-7432, Fax: +82-31-810-7329, E-mail: hartsol@kwandong.ac.kr

© Journal of the Korean Surgical Society is an Open Access Journal. All articles are distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

autogenous AVFs salvage and to prolong the patency rates, two treatment modalities of both surgical and endovascular treatment have been combined and performed in the same operative setting in our institution since June 2008. The experiences in treatment of thrombosed autogenous AVFs were reviewed and the outcomes of two salvage procedures of the hybrid surgery and the percutaneous mechanical thrombectomy were compared.

## METHODS

### Study design

Fifty nine patients with thrombosed autogenous AVF were included. From March 2005 to May 2008, 19 patients were managed with percutaneous mechanical thrombectomy and from June 2008 to August 2010, 40 patients were managed with hybrid surgery. The medical records of consecutive patients with thrombosed autogenous AVFs who underwent hybrid surgery or percutaneous mechanical thrombectomy were reviewed. Among the multiple thrombectomy procedures in patients during the study period, only the first procedure was included. Arteriovenous fistulas with artificial graft, even composite fistulas including a polytetrafluoroethylene graft segment, venous transposed AVFs and AVFs treated with pharmacological thrombolysis were excluded.

The radiologic image records were reviewed to identify the location of vascular stenosis in each patient. The patients' demographics including types of vascular access, age of AVFs, length of time between thrombosis and salvage procedure, operating time, technical success rates and procedure related complications were collected.

Technical success rate was defined as the successful restoration of AVF flow with uneventful dialysis after the procedure. Primary patency was calculated from the date of the initial salvage procedure to the next subsequent access intervention. Under the circumstance where the majority of patients were referred from other dialysis centers and referred back after successful treatment, patency rate was estimated by telephone survey and patency was confirmed by successful dialysis. Fistula follow-up was censored for patient death, transplant, and change of dialysis

modality. This single center retrospective study has been approved by the Institutional Review Board.

### Hybrid surgery

All procedures were performed under the local anesthesia. An approximately 2 to 3 cm transverse skin incision was made over non-punctured fistulated vein. The vein was dissected from the surrounding tissue and controlled with a vessel loop proximally and distally. A transverse venotomy was made and the distal thrombus was removed with forceps and/or a 4 or 5-F Fogarty balloon catheter (Edwards Lifesciences LLC., Irvine, CA, USA). In cases where the thrombectomy was incomplete, the remaining thrombus was removed by manual squeezing the venotomy opening. In patients with central vein stenosis, the thrombus was aspirated using a 5-F glide catheter (Terumo Co., Tokyo, Japan). Afterwards, a 7-F introducer (Terumo Co.) was introduced via distal fistulotomy opening and a fistulogram was taken to identify the etiology of the blood flow blockage and remnant thrombus. The proximal fistulogram was taken in the same manner. If remnant thrombus was found at fistulography, manual squeezing and passes of thrombectomy catheter were repeated. After thrombectomy, luminal were confirmed by fistulography. When stenotic lesions were identified by fistulography, a 0.035-inch angled guide wire M (Terumo Co.) was introduced and passed stenotic lesions to the central vein distally or to the artery proximally. Systemic heparinization was done (50 IU/kg) via the fistulotomy using 5-F glide catheter into the central vein. Balloon angioplasty was performed to correct the stenotic lesions using 6 to 12 mm noncompliant balloon catheters for draining vein and central vein, and 4 to 6 mm for juxta-anastomosis. If the stenotic lesions were completely corrected after balloon angioplasty in the fistulogram, the venotomy was closed with 6.0 polypropylene sutures. Whenever balloon angioplasty failed, surgical angioplasty including anastomosis revision, interposition or jump graft, and patch angioplasty, was additionally performed. After completion of endovascular or surgical angioplasty, a completion fistulography was taken and the restoration of blood flow was confirmed (Fig. 1). All procedures were performed in an operation unit, and fistulography was obtained using

OEC 9900 Elite; C-arm fluoroscopy (GE OEC Medical Systems Inc., Salt Lake City, UT, USA).

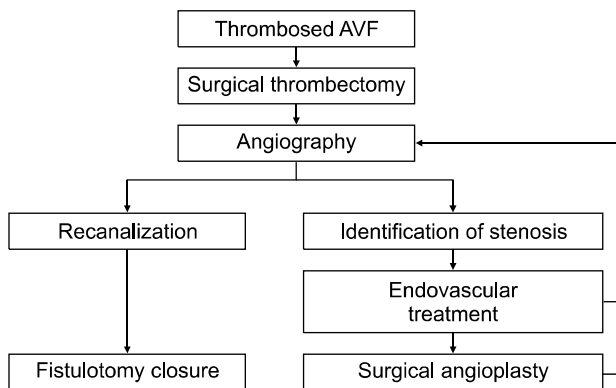
### Percutaneous mechanical thrombectomy

During the percutaneous mechanical thrombectomy, the thrombosed autogenous AVF was initially cannulated immediately proximal to the arterial anastomosis with 18-gauge needle. Mechanical thrombectomy was achieved with a Trerotola device (Teleflex Inc., Limerick, PA, USA). The AVF was accessed for a second time towards the arterial anastomosis. A glide wire was passed into the arterial circulation, and a Fogarty balloon catheter was passed

over the wire beyond the arterial anastomosis and pulled back to dislodge the occluding clot. Once the thrombus had been cleared and blood flow re-established, a digitally subtracted angiogram of the fistula was performed to evaluate for stenotic lesions along the venous outlet track or central circulation. If a hemodynamically significant lesion was encountered, an angioplasty balloon was inflated at the level of the stenotic site. In two patients with central venous stenosis refractory to angioplasty, stents were deployed. Hemostasis was achieved using a modified purse-string suture technique.

### Statistics

Patients treated with hybrid surgery and percutaneous mechanical thrombectomy were compared using Student's t-tests for continuous variables and chi-square test for categorical variables. The patency outcomes were calculated using the Kaplan-Meier method and patency rates were compared with the log-rank test. SPSS ver. 16.0 (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis. All continuous variables are expressed as means  $\pm$  standard deviation.  $P < 0.05$  was considered statistically significant.



**Fig. 1.** Schematic diagram for the operative processes of hybrid surgery for thrombosed autogenous arteriovenous fistulas (AVF).

**Table 1.** Overall characteristics of the two study groups, hybrid surgery and percutaneous mechanical thrombectomy

Characteristic	Hybrid surgery (n = 40)	Percutaneous mechanical thrombectomy (n = 19)	P-value
Patients' characteristics			
Age (yr)	57.9 $\pm$ 17.3	61.9 $\pm$ 15.9	0.405
Sex, female	17 (42.5)	9 (47.3)	0.725
Diabetes	18 (45.0)	6 (31.6)	0.327
Anti-platelets	13 (32.5)	9 (47.4)	0.270
AVF characteristics			
AVF age (mo)	53.7 $\pm$ 52.7	34.8 $\pm$ 22.6	0.157
Right/Left side (n)	3/37	0/19	0.220
AVF type			0.749
Radial-cephalic	23 (57.5)	12 (63.2)	
Brachial-cephalic	16 (40.0)	7 (36.8)	
Ulnar-basilic	1 (2.5)	0 (0)	
Length of time between thrombosis and salvage procedure (day)	2.3 $\pm$ 3.0	1.3 $\pm$ 0.6	0.190

Values are presented as mean  $\pm$  SD or number (%).  
AVF, arteriovenous fistula.

## RESULTS

### Overall characteristics of patients

The clinical characteristics of the patients treated with hybrid surgery and those treated with percutaneous mechanical thrombectomy were compared in Table 1. The variables of patients' age, sex, diabetes status, or frequency of anti-platelets use did not significantly differ between the groups. Moreover, the other variables of the access age, side, type, and mean duration of thrombosis were also not significantly different between the groups ( $P > 0.05$ ).

### Angiographic findings and procedure-related outcomes

All the thrombosed autogenous AVFs were found to have a stenosis that was believed to be the primary cause of fistula failure (Table 2). The primary lesion was at juxta-anastomosis in 24 of 59 AVFs (40.7%), at draining vein in 30 (50.8%), and at central vein in 5 (8.5%). Only 17 of 59 AVFs (28.8%) had a single stenotic lesion, and the mean number of stenosis per each AVF was not statistically different between the two treatment groups ( $2.1 \pm 1.2$  vs.  $2.3 \pm 0.9$ ,  $P = 0.651$ , respectively).

In the group of patients treated with hybrid surgery, the primary lesions were treated with mainly balloon angioplasty followed by surgical thrombectomy. However, 11 of 40 AVFs (27.5%) in the hybrid surgery group, required additional surgical angioplasties, such as anastomosis revision ( $n = 7$ ), patching ( $n = 2$ ), interposition grafting ( $n = 1$ ),

or curettage for intraluminal old fibrous thrombus ( $n = 1$ ). In the percutaneous mechanical thrombectomy group, all of the lesions were treated with balloon angioplasty, with two patients undergoing adjunctive stent placement for the recoiling central venous stenosis.

Procedure time was similar between the groups ( $108.1 \pm 47.9$  min. vs.  $115.6 \pm 63.5$  min.,  $P = 0.624$ , respectively). Technical success rates were higher in the hybrid surgery group than that in the percutaneous mechanical thrombectomy group (92.5% vs. 68.4%,  $P = 0.005$ , respectively). The rescued AVF could be used immediately after the operation or on the next day.

There were three technical failures in the hybrid surgery group. Two were caused by complete occlusion of central venous outflow, which prevented the guide wire passing through it. One failure was caused by tight stricture near the cephalic arch resistant to balloon angioplasty. In the percutaneous mechanical thrombectomy group, the cause of failure included incomplete thrombectomy; the remaining thrombus was shown in the angiography ( $n = 4$ , 66.7%), and the inability to pass a guide wire through stenotic lesions ( $n = 2$ , 33.3%). In either group, there were no procedure-related complications that required additional treatment. Bleedings caused by vessel tearing during balloon angioplasty, were successfully controlled by balloon tamponade and/or external compression in both groups.

The percutaneous mechanical thrombectomy group showed a tendency for longer hospital stay but was not statistically significant ( $1.0 \pm 2.0$  days vs.  $2.3 \pm 2.9$  days,  $P = 0.058$ , respectively).

**Table 2.** Angiographic findings of thrombosed autogenous arteriovenous fistulas

Angiographic finding	Hybrid surgery (n = 40)	Percutaneous mechanical thrombectomy (n = 19)	P-value
No. of stenosis	$2.1 \pm 1.2$	$2.3 \pm 0.9$	0.487
Primary stenosis <sup>a)</sup>			0.915
Juxta-anastomosis	17 (42.5)	7 (36.9)	
Draining vein	20 (50.0)	10 (52.6)	
Central vein	3 (7.5)	2 (10.5)	
Artery	0 (0.0)	0 (0.0)	—
No stenosis	0 (0.0)	0 (0.0)	—
Aneurysmal change	8 (20.0)	4 (21.1)	0.925

Values are presented as mean  $\pm$  SD or number (%).

<sup>a)</sup>Stenosis that was believed to be the primary cause of fistula failure.

**Table 3.** Comparison of procedure-related outcomes of hybrid surgery and percutaneous mechanical thrombectomy

Procedure-related outcomes	Hybrid surgery (n = 40)	Percutaneous mechanical thrombectomy (n = 19)	P-value
Procedure time (min)	108.1 ± 47.9	115.6 ± 63.5	0.624
Technical success rate (%)	92.5	68.4	0.005
Hospital stay (day)	1.0 ± 2.0	2.3 ± 2.9	0.058
Complications, n (%)			
Vessel tearing	7 (17.5)	3 (15.8)	0.870
AVF infection	0 (0.0)	0 (0.0)	—
Arterial embolism	0 (0.0)	0 (0.0)	—
Cost analysis			
Supply costs (₩)	3.75 × 10 <sup>5</sup>	5.71 × 10 <sup>5</sup>	0.065
Total costs (₩)	1.56 × 10 <sup>6</sup>	2.03 × 10 <sup>6</sup>	0.019

AVF, arteriovenous fistula; ₩, won (Korean monetary unit).

In cost analysis, the costs for the supply units were not different ( $3.75 \times 10^5$  won vs.  $5.71 \times 10^5$  won,  $P = 0.065$ , respectively), but total costs were statistically lower in the hybrid surgery group ( $1.56 \times 10^6$  won vs.  $2.03 \times 10^6$  won,  $P = 0.019$ , respectively) (Table 3).

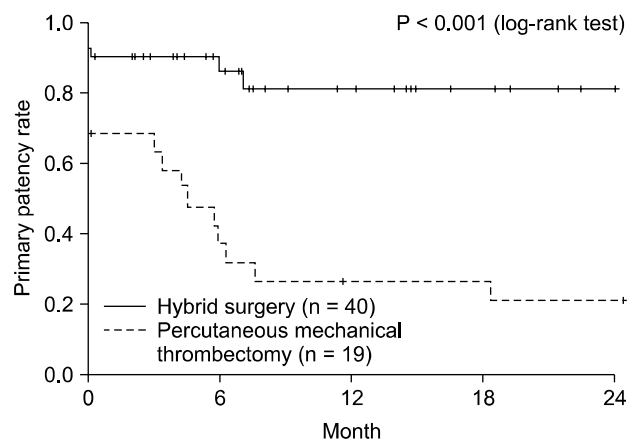
### Primary patency rate after salvage procedure

Fifty (84.7%) patients could be followed for 6 months; 42 (71.2%) patients for 12 months; 30 (28.8%) patients for 24 months. The mean duration follow-up after salvage was  $15.8 \pm 8.1$  months. The primary fistula patency rate after salvage was significantly better in the hybrid surgery group than in the percutaneous mechanical thrombectomy group (log-rank test,  $P < 0.001$ ) (Fig. 2). Primary patency of salvaged AVF by hybrid surgery was 85.9% and 81.1% at 6 months and 12 months, respectively. No additional event was recorded until 24 months. Primary patency of salvaged AVF by percutaneous mechanical thrombectomy was 36.8%, 26.3% and 21.2% at 6 months, 12 months, and 24 months, respectively.

## DISCUSSION

The aim of this study is to compare the outcomes of two patient groups with thrombosed autogenous AVF treated with hybrid surgery and percutaneous mechanical thrombectomy.

An increasing number of patients with renal failure are requiring long-term dialysis for 5 to 10 years or even



**Fig. 2.** Kaplan-Meier primary patency rate curve treated with hybrid surgery and percutaneous mechanical thrombectomy describing 2-year follow-up of thrombosed autogenous arteriovenous fistulas.

longer. If the clotted vascular access is routinely abandoned, there will be a large number of patients in most dialysis populations who will exhaust the more desirable upper extremity access sites and require alternate sites such as the leg or chest wall. In some patients, all available sites may eventually be used, prohibiting further hemodialysis. Therefore, salvage of thrombosed vascular access is also important due to the limited resources of blood vessels available for the creation of new access and the sparing hemodialysis catheter needed during access maturation [3].

Most clotted AVFs have one or more underlying stenotic lesions, a complete thrombectomy in conjunction with angioplasty of the stenotic lesions should be required to

successfully treat the AVF thrombosis and to save the previous dialysis access site [4].

Traditionally, the treatment of thrombosed AVFs consisted of surgical thrombectomy followed by local revision of the access. It is often difficult to completely remove the thrombus adjacent to an anastomosis of the fistula and an aneurysm within the fistula, which can prevent it from passing the thrombectomy catheter. Therefore, surgical thrombectomy of autogenous AVFs is often thought to be a challenging and fruitless endeavor.

Several comparative studies of surgical versus endovascular treatment of thrombosed accesses have reported that surgery was superior to endovascular treatment in terms of success rate and long-term patency rate, although endovascular treatment has been used worldwide because of its convenience [5-8]. However, clots could be retained in multiple areas of aneurysmal dilatation, and the major cause of technical failure included incomplete thrombectomy after percutaneous procedures. During hybrid surgery, clots, even large pieces of thrombus, contained in aneurysm, could be removed feasibly by manual squeeze, multiple passes of thrombectomy catheter and surgical curettage. After the procedure, luminal patency could be confirmed using angioplasty.

Most episodes of access thrombosis coincide with the presence of stenosis. It is necessary to detect its sites and to correct the lesions promptly for access salvage. The surgical revision of thrombosed AVFs is often considered a struggle for the vascular surgeon because it is difficult to accurately detect and completely correct stenotic lesions.

Although Jain et al. [9] have reported improved technical success rates of percutaneous mechanical thrombectomy (76.0%) for thrombosed autogenous AVFs recently, primary fistula patency was fairly short-lived, and the fistula required repeated interventions to achieve long-term survival. Though the technical success rate (68.4%) and primary patency rate (36.8% at 6 months) of percutaneous mechanical thrombectomy in our institution were comparable to other reports, more improved results were needed. Therefore, we have tried to develop a new salvage technique that is able to improve technical success rates and primary patency rates. Surgical revision at the time of thrombectomy, as directed by fistulography, has been

demonstrated to improve patency rates [10,11]. Combined surgical thrombectomy with endovascular treatment for salvage of thrombosed autogenous AVFs have been introduced and reported reasonable success rates (7 of 10, 70%) compared to others [12].

To obtain the synergy effect of both surgical and endovascular treatment and to improve the technical success rate, hybrid surgery has been used for thrombosed autogenous AVFs salvage in our institution since June 2008. Hybrid surgery is able to remove thrombus feasibly in the surgical fields and correct underlying causative lesions disclosed by the intra-operative fluoroscopy. As a consequence, hybrid surgery has shown much-improved technical success rates (92.5%), and higher primary patency rates than percutaneous mechanical thrombectomy in other reports [9].

The most substantial contribution to a cost difference might have been due to significant differences in technical success or complication rates because the need for repeated procedures would likely overwhelm the moderate per-procedure costs, as could excess hospital stay and other costs of treatment complications. We demonstrated a significantly increased total cost for percutaneous mechanical thrombectomy as compared with hybrid surgery. It is difficult to explain that the cost differences reflected the procedure itself because significantly different technical success rates were found between the two groups. The major components of this cost analysis were repeated or additional procedures and prolonged hospital stay. Moreover, surgery is priced relatively low in Korea.

Hybrid surgery for treatment of thrombosed AVFs has several advantages. First, the thrombus could be removed more feasibly than percutaneous thrombectomy. Second, endovascular treatment could be performed in both proximal and distal vessels with a single skin incision and fistulotomy. Third, endovascular or surgical angioplasty was possible by the accurate detection of the stenosis site by fistulogram during surgery. Lastly, this operation setting permits easy conversion to surgical angioplasty.

Our study has some limitations, which include too small a number of case population to reach the relevant conclusions from these promising results, though autogenous AVF thrombosis is a relatively uncommon event than



is graft thrombosis.

In conclusion, salvage procedures for thrombosed autogenous AVFs could be performed in an operation unit under the intra-operative fluoroscopy to define the cause of AVF thrombosis and to determine the method of appropriate revision. In this study, hybrid surgery showed higher a technical success rate and primary patency rate than those of percutaneous mechanical thrombectomy, thereby, avoiding the need for placement of a dialysis catheter.

## CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

## REFERENCES

- Allon M, Robbin ML. Increasing arteriovenous fistulas in hemodialysis patients: problems and solutions. *Kidney Int* 2002;62:1109-24.
- Vascular Access 2006 Work Group. Clinical practice guidelines for vascular access. *Am J Kidney Dis* 2006;48 Suppl 1:S176-247.
- Palder SB, Kirkman RL, Whittemore AD, Hakim RM, Lazarus JM, Tilney NL. Vascular access for hemodialysis. Patency rates and results of revision. *Ann Surg* 1985; 202:235-9.
- Green LD, Lee DS, Kucey DS. A metaanalysis comparing surgical thrombectomy, mechanical thrombectomy, and pharmacomechanical thrombolysis for thrombosed dialysis grafts. *J Vasc Surg* 2002;36:939-45.
- Dougherty MJ, Calligaro KD, Schindler N, Raviola CA, Ntoso A. Endovascular versus surgical treatment for thrombosed hemodialysis grafts: a prospective, randomized study. *J Vasc Surg* 1999;30:1016-23.
- Marston WA, Criado E, Jaques PF, Mauro MA, Burnham SJ, Keagy BA. Prospective randomized comparison of surgical versus endovascular management of thrombosed dialysis access grafts. *J Vasc Surg* 1997;26:373-80.
- Shatsky JB, Berns JS, Clark TW, Kwak A, Tuite CM, Shlansky-Goldberg RD, et al. Single-center experience with the Arrow-Trerotola Percutaneous Thrombectomy Device in the management of thrombosed native dialysis fistulas. *J Vasc Interv Radiol* 2005;16:1605-11.
- Rajan DK, Clark TW, Simons ME, Kachura JR, Sniderman K. Procedural success and patency after percutaneous treatment of thrombosed autogenous arteriovenous dialysis fistulas. *J Vasc Interv Radiol* 2002;13:1211-8.
- Jain G, Maya ID, Allon M. Outcomes of percutaneous mechanical thrombectomy of arteriovenous fistulas in hemodialysis patients. *Semin Dial* 2008;21:581-3.
- Ponikvar R. Surgical salvage of thrombosed arteriovenous fistulas and grafts. *Ther Apher Dial* 2005;9:245-9.
- Turmel-Rodrigues L. Dilatation and declotting of arteriovenous accesses. *Ther Apher Dial* 2003;7:244-51.
- Palmer RM, Cull DL, Kalbaugh C, Carsten CG, Taylor SM, Snyder BA, et al. Is surgical thrombectomy to salvage failed autogenous arteriovenous fistulae worthwhile? *Am Surg* 2006;72:1231-3.