

## Repair of Arteriotomy after Removal of Infected Hemodialysis Access by Venous Graft

Mon-Yue Wu, MD; Po-Jen Ko, MD; Hung-Chang Hsieh, MD; Jaw-Ji Chu, MD;  
Pyng Jing Lin, MD; Yun-Hen Liu, MD

**Background:** Traditionally, extensive prosthetic arteriovenous (AV) graft infection is treated with graft removal and the arteriotomy or the graft stumps were simply sutured following the removal of the graft. However, postoperative bleeding may occur which requires emergent intervention. We report the results achieved at our clinic after arteriotomy repair with venous graft interposition in re-bleeding conditions.

**Methods:** From January 2000 through February 2001, 31 patients with extensive graft infections underwent graft removal with direct closure of the arteriotomy or graft stumps at our clinic. Seven of these patients experienced re-bleeding from the repaired brachial artery. Six of them received repair of the brachial artery with venous graft interposition and one received brachial artery ligation.

**Results:** Surgery of the infected dialysis graft removal was associated with a high re-bleeding rate (22.6%) in our group. In this study, we analyzed the preoperative data, including age, gender, incidence of diabetes mellitus, incidence of peripheral artery occlusive disease, and preoperative blood culture. Both univariate and multivariate analyses showed that the positive preoperative blood cultures were the only factors related to postoperative bleeding (Odds Ratio 22.8,  $p=0.009 < 0.05$ ). All of the patients that received brachial artery repair with venous graft interposition recovered well.

**Conclusion:** In the patients with positive blood cultures, we recommended brachial artery repair with venous graft interposition rather than simple closure of the arteriotomy or graft stump after removal of the infected graft. This may prevent re-bleeding due to inadequate debridement and eliminate the possibility of ipsilateral hand ischemia due to brachial artery stenosis following simple closure of the arteriotomy.

(*Chang Gung Med J* 2003;26:911-8)

**Key words:** arteriovenous shunt, blood vessel prosthesis, renal dialysis, postoperative complications.

Infection at the vascular access site is one of the major complications of hemodialysis access.<sup>(1-6)</sup> Among the various types of vascular access, pros-

thetic arteriovenous (AV) graft infection is one of the most complex problems involved in hemodialysis access surgery. Graft infection may result in morbid-

From the Division of Thoracic & Cardiovascular Surgery, Department of Surgery, Chang Gung Memorial Hospital, Taipei; Chang Gung University, Taoyuan.

Received: Dec. 24, 2002; Accepted: Jul. 11, 2003

Address for reprints: Dr. Yun-Hen Liu, Division of Thoracic & Cardiovascular Surgery, Chang Gung Memorial Hospital, 5, Fushing Street, Gueishan Shiang, Taoyuan, Taiwan 333, R.O.C. Tel.: 886-3-3281200 ext. 2118; Fax: 886-3-3285818; E-mail: i5710111@cgmh.org.tw

ity, prolonged dependence on dialysis central venous catheters, or the need for multiple vascular access surgery.<sup>(7)</sup> Several options exist for the surgical management of the infected graft, depending on the areas of the graft involved.<sup>(8)</sup> If the infection is localized and does not involve the anastomosis, it can generally be salvaged using the segmental bypass procedure by resection of the infected area of the graft using a new polytetrafluoroethylene graft interposition.<sup>(9)</sup> However, if the anastomosis is involved or multiple abscess formation is noted then total removal of the graft is preferred.<sup>(10)</sup>

After graft removal, the arteriotomy can be managed in many different ways which are divided into three major options: (1) the graft can be excised subtotaly with an oversewn stump left in the anastomosis, (2) the arteriotomy can be closed directly, or (3) the artery can be augmented using patch angioplasty. Although ligation of the artery is acceptable in the emergent condition when the arteriotomy is difficult to control, ischemia of the ipsilateral hand might occur after brachial artery ligation, especially in patients with diabetes or severe peripheral vascular disease.<sup>(11)</sup>

Sometimes, bleeding from the repaired arteriotomy after graft removal is encountered and requires emergent intervention.<sup>(5)</sup> Repeated bleeding may occur when definite repair of the arteriotomy and extensive debridement are not achieved. In this study, we reviewed our experience with re-bleeding from the simply repaired arteriotomy, and analyzed the risks of re-bleeding in these patients.

## METHODS

### Patients

From January 2000 through February 2001, 31 patients with severe hemodialysis graft infections (mean age,  $63.6 \pm 11.7$  years; 16 men and 15 women; 3 with forearm loop graft and 5 with upper arm straight graft) underwent AV graft removal with direct closure of the artery or oversewing of the graft stump at Chang Gung Memorial Hospital. All of the patients were clinically diagnosed with extensive graft infection for abscess formation with arterial anastomosis involvement. Seven patients (22.6%) experienced early postoperative bleeding from the repaired brachial artery, which occurred within 1 week after graft removal, and underwent emergent

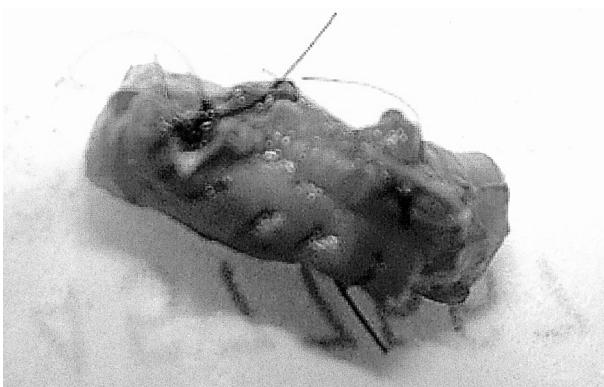
surgical intervention. Detailed data of those patients are provided in Table 1. Among those patients, six patients underwent repair of the brachial artery with venous graft interposition (5 great saphenous vein, 1 basilic vein). One patient received brachial artery ligation because of unstable hemodynamic condition during surgery.

### Operative Procedures

The patients were given general anesthesia, and proximal arterial control using a tourniquet (150 mmHg above the systolic blood pressure) was applied when necessary. For each patient, the blood clots were evacuated and the brachial artery was isolated. The ruptured brachial artery was then carefully dissected to allow vascular clamps to be applied at both ends (Fig. 1).



**Fig. 1** Isolation of the brachial artery containing the ruptured arteriotomy

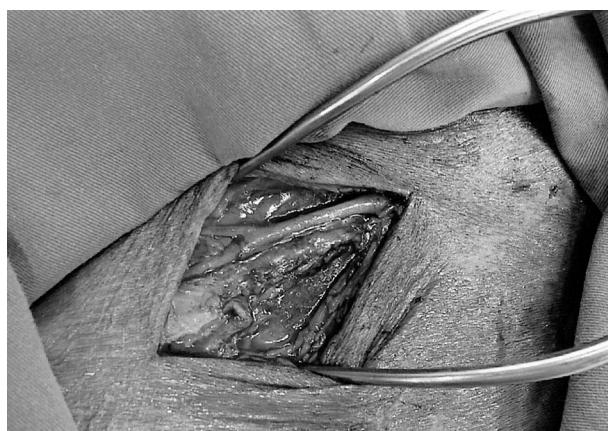


**Fig. 2** Removal of the segment of the brachial artery containing the ruptured arteriotomy

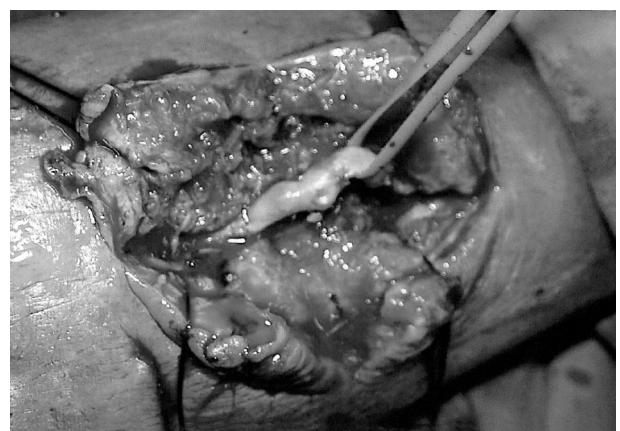
Under adequate control of the brachial artery, the arterial bed was debrided extensively with aggressive isotonic sodium chloride solution irrigation. The segment of the brachial artery that included the ruptured arteriotomy was excised, and the flow at both ends of the brachial artery was checked (Fig. 2). The vascular lumen was irrigated with 3-5

ml diluted heparin solution (1:100).

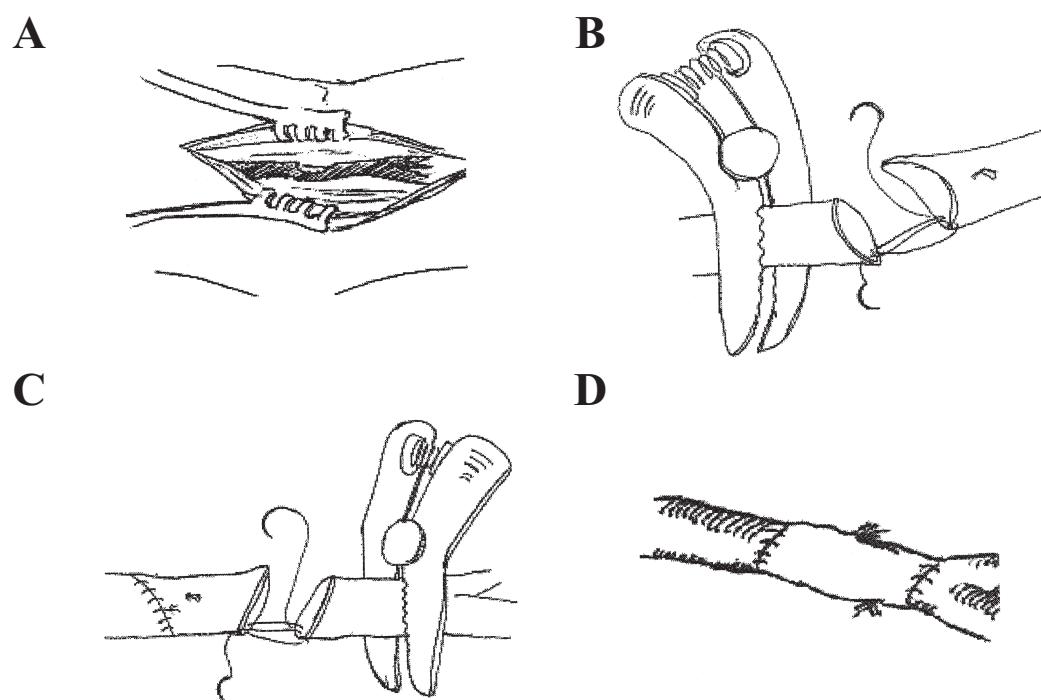
A venous graft (mostly left great saphenous vein) of the appropriate length was harvested (Fig. 3) and interposed between both ends of the cut brachial artery (Fig. 4). We used 7-0 Polypropylene sutures for vascular anastomosis. The procedures of venous graft interposition are depicted in Figure 5.



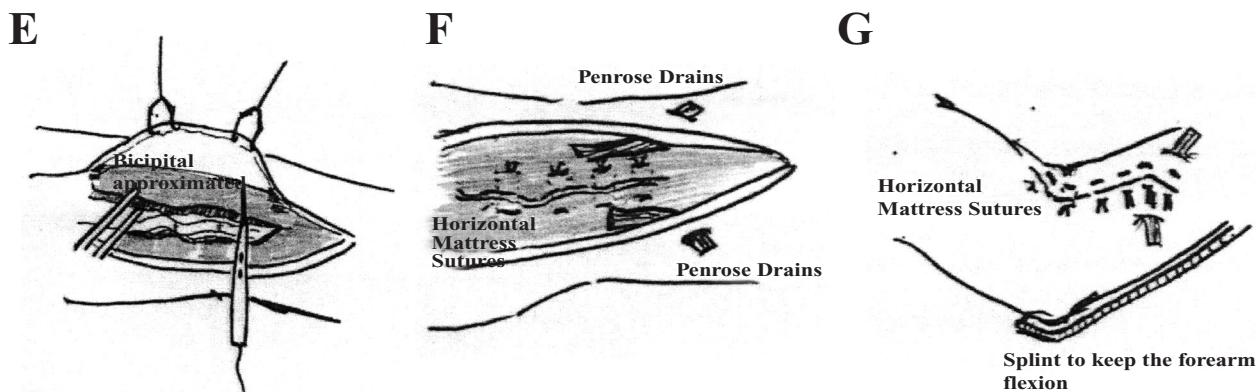
**Fig. 3** Harvest of the great saphenous vein for further use.



**Fig. 4** Vein graft interposition for brachial artery repair.



**Fig. 5** Brachial artery with the ruptured arteriotomy was isolated (A) followed by completion of proximal and distal anastomosis of the venous graft interposition by Prolene suture (B, C and D).



**Fig. 6** Wound closure. (E) Undermine the skin and soft tissue above the bicipital fascia. The repaired artery lies in the intermuscular groove. (F) The bicipital fascia was approximated as much as possible using several horizontal mattress sutures (using 4-0 prolene). One or two 6 mm Penrose drains were put in dependent pockets above the fascia. (G) The skin was closed directly using 2-0 Prolene and a splint was given to keep the forearm in flexion posture.

Finally, we undermined the subcutaneous soft tissue above the bicipital aponeurosis, and used three or four intermittent horizontal mattress sutures to approximate the bicipital aponeurosis as much as possible but not to compress the repaired artery. We put two or three open drain tubes (6 mm Penrose tube) in the dependent pockets above the bicipital aponeurosis for drainage. Skin then was closed directly using intermittent horizontal mattress sutures. Sometimes, a Z-plasty was performed when there was great tension in the skin closure. A forearm splint was made to keep the forearm in flexion posture to reduce the tension of the repaired artery. We removed the drainage tubes after minimal discharge and good wound healing. The procedure of wound closure is described in Fig. 6.

#### Statistics

Comparison between the re-bleeding and non-re-bleeding groups was performed using the SPSS statistical software package (SPSS Inc, Chicago, Ill). Independent *t* test and Fisher's exact tests were used for univariate analysis. The logistic regression method was also used for multivariate analysis.

## RESULTS

In the present series there was a high re-bleeding rate (22.6%) for those who underwent infected graft removal surgery. Some preoperative data were

analyzed, including age, gender, incidence of diabetes mellitus, incidence of peripheral vascular occlusion disease (defined as ischemic ulcers over extremities or any amputation due to ischemic limbs) and preoperative blood culture. The data was gathered during retrospective chart reviews.

All of the 31 patients had positive wound culture with *Staphylococcus* (*Staphylococcus aureus* and coagulase negative *Staphylococcus*) growth. Notably, the blood culture also showed *Staphylococcus* growth in 11 patients. We analyzed the preoperative data, including age, gender, incidence of diabetes mellitus, incidence of peripheral artery occlusive disease, and preoperative blood culture between the non-bleeding and re-bleeding group using the *t* test and Fisher exact test. The logistic regression method was also performed for multivariate analysis. In both univariate and multivariate analyses, positive preoperative blood culture was found to be the only factor that related to re-bleeding following primary closure of the arteriotomy or graft stump (Odds Ratio, 22.8; *p* = 0.009 < 0.05; Hosmer-Lemeshow (2 test, 0.105; *p* = 0.949). The detailed results of univariate and multivariate analysis are listed in Table 2 and Table 3.

All of the patients who received brachial artery repair with venous grafts during the second operation recovered smoothly. Moreover, the patient who underwent emergent brachial artery ligation recovered without evidence of distal gangrene. However,

**Table 1.** Data of the Re-bleeding Group

Age (years)	Gender	Graft position	Initial repair	Re-bleeding time (day) (after first operation)
68	F	Upper arm straight graft	Stump oversewn	7
75	F	Upper arm straight graft	Direct closure	5
47	M	Forearm loop graft	Direct closure	7
73	M	Upper arm straight graft	Stump oversewn	6
76	M	Upper arm straight graft	Direct closure	5
75	M	Upper arm straight graft	Direct closure	2
51	M	Forearm loop graft	Stump oversewn	7
Average : $5.3 \pm 0.7$ day				

Abbreviations: M: male; F: female.

**Table 2.** Comparison of the Re-bleeding and Non re-bleeding Groups Matched by Age, Gender, DM, PAOD and Positive Preoperative Blood Culture

	No re-bleeding group N = 24	Re-bleeding group N = 7	p
Age (years)	$62.83 \pm 11.68$	$66.43 \pm 12.25$	0.506
Gender	11M 13F	5M 2F	0.394
DM	16 (66.7%)	3 (57%)	0.384
PAOD	7 (30%)	2 (28.6%)	1.000
Positive Blood Culture	5 (21%)	6 (85.7 %)	0.004

\*p value calculated by independent t test in Age and Fisher exact test in Gender, DM, PAOD, and Positive Preoperative Blood Culture.

\*Abbreviation: M: male; F: female; DM: Diabetes Mellitus; PAOD: peripheral artery occlusive disease

**Table 3.** Logistic Regression Analysis of Risk of Re-bleeding after Infected Hemodialysis Graft Removal with Primary Repair or Stump Over-sewn.

	Coeff.	p	Odds ratio	CI lower limit	CI upper limit
Positive B/C	3.127	0.009	22.800	2.207	235.509
Constant	-2.944	0.004			

\*Positive B/C: Positive preoperative blood culture; Coeff.: Coefficient expressed in logits; CI: 95% confidence interval for the odds ratio, Hosmer-Lemeshow (2 test: 0.105, p=0.949

the functional status of the limb was impossible to evaluate because the patient had ipsilateral hemiparesis due to a previous stroke.

## DISCUSSION

Prosthesis infection is one of the leading causes of hemodialysis grafts loss.<sup>(5,12,13)</sup> Many patients die because of exhausted hemodialysis sites. Graft salvage with preservation of the native vessels is the goal of management of graft dysfunction.<sup>(14)</sup> The risk of graft infection increases after graft intervention, and as Miller et al. reported, a mean of 1.22 interventions per graft per year were required to maintain

graft patency.<sup>(15)</sup> Using cryopreserved human vein allografts to replace an infected graft is an alternative to graft salvage in managing infected grafts.<sup>(16)</sup> However, it is impractical at this stage of development.

Postoperative bleeding after graft removal surgery is common, especially when the arteriotomy or the graft stump is simply oversewn. Some reports in the literatures have mentioned the use of a segmental bypass of the infection zone to salvage the dialysis grafts.<sup>(5,9,12)</sup> However, for patients with extensive graft infections in which the whole dialysis grafts are involved, especially when the arterial anastomosis is involved, segmental bypass of the infected

zone cannot be performed. To treat an extensive graft infection, the dialysis graft must be entirely removed.<sup>(17)</sup> Few reports in the literature contain discussions on the management of the arterial end of the infected graft. Padberg et al. summarized the most commonly used methods. They suggested that stump oversewing was more reliable than direct arteriorrhaphy or venous patch angioplasty when the arterial anastomosis was not infected, and that brachial artery ligation was safe in most patients for established collaterals after long-term hemodialysis.<sup>(8)</sup> However, the possibility of distal ischemia in patients with brachial artery ligation cannot be ignored. Padberg et al. encountered two episodes of postoperative bleeding in 13 patients who underwent complete removal of infected grafts. One patient had simple arteriorrhaphy during his first operation, while the other underwent patch angioplasty. They treated the ruptured arteriotomy with simple re-suturing in one case and brachial artery ligation in the other case. Moreover, Taylor et al. reported two cases of post-graft removal bleeding among a sample of 19 patients (5 femoral artery, 14 brachial artery), and both occurred within 2 weeks of the graft removal surgery. They resolved the problem successfully using re-suturing in one case, and patch angioplasty in the other case.<sup>(5)</sup>

In our series, the rate for postoperative arterial bleeding was as high as 22.6% after graft removal surgery when the arteriotomy or the graft stump was simply oversewn. Apparently, simple closure of the arterial anastomosis does not eliminate the infection completely in all cases. Definite repair after extensive debridement must be done in certain cases. The question arose as to which cases need graft bypass rather than the simple repair for the arteriotomy. In this study, we found a close relationship between preoperative positive blood culture and re-bleeding after the initial repair of arteriotomy. Tabbara et al. reported a close relationship between sepsis and early death in patients after hemodialysis graft infection.<sup>(18)</sup> It may be that for the patients who have extensive graft infection with preoperative positive blood culture results, we should perform extensive trimming of the infected vessel wall and venous graft bypass after complete synthetic graft removal to eliminate the ongoing sepsis. Repair of the arteriotomy through simple arteriorrhaphy or patch angioplasty may limit the extent of the debridement of the

vessel wall. The infected vessel wall may not have been trimmed adequately because of concern about vessel lumen stenosis and excessive tension on the arteriorrhaphy suture. Incomplete debridement often leads to disruption of the repaired arteriotomy with massive bleeding that always requires emergent surgical management.

The results of this study suggest that definite brachial artery repair with vein graft interposition as well as extensive wound debridement should be performed in patients with forearm graft infection. The infected graft must be removed entirely and the vessel wall adjacent to the anastomosis must be trimmed until the relatively healthy vessel wall is met. After copious irrigation with isotonic sodium chloride solution, a segment of the venous graft can be implanted to restore the arterial blood flow and prevent distal ischemia. In contrast to the artificial graft, autologous venous grafts are more resistant to infection. This method can also prevent stenosis of the repaired brachial artery and reduce the occurrence of ischemia in the hand. In addition, upper arm brachial-axillary bridge grafts can be planned in the future without worrying about impaired brachial artery flow. Nicholas et al. found that patients with diabetes mellitus or previous amputation because of peripheral vascular occlusion disease carried a higher risk of developing ischemia in the hand following AV access operation.<sup>(11)</sup> To reduce the risk of distal ischemia, the brachial artery should be preserved as much as possible. Ligation of the brachial artery should be avoided. In addition, silent graft and subcutaneous abscess near the infected focus should be explored and excised to prevent further infection.<sup>(19)</sup> Thus, we suggest that extensive debridement of the vessel wall and surrounding soft tissue are important in patients with surgeries for infected AV prosthesis removal.

Sometimes, the wound closure after definite arterial repair is really a problem because of severe tissue edema and excessive soft tissue loss after debridement. In our cases, the adequate short length of the venous graft, bicipital aponeurosis undermining, and initial S-shape wound incision were enough for adequate wound closure. Local flap from the lateral part of the arm or skin graft may be helpful if there is great tension in the primary wound closure, however, we did not have the experience in our cases. The method of definite repair of brachial

artery comes from the experiences of repairing injured brachial arteries. Adequate debridement of wounds and vessel walls are also the points in management of patients with vascular trauma because dirty wounds and extensive soft tissue loss are common in these cases.

Postoperative bleeding after infected dialysis graft removal is a devastating and troublesome complication. We think that any infected prosthesis or unhealthy vessel tissue should not be left in place after graft removal due to the risk of persistent infection. *Staphylococcus aureus* is by far the most common organism implicated in dialysis graft infections.<sup>(20)</sup> Based on the experience presented here, we conclude that patients with extensive hemodialysis graft infection, especially those with positive blood culture results, should be treated with total graft excision plus definite artery repair by venous graft interposition after graft removal. These patients tend to have a higher risk of postoperative bleeding if the arteriotomy or the graft stump were simply repaired. This method can reliably eliminate the infected materials and prevent further arteriotomy bleeding. However, further prospective, randomized studies may be needed to support our conclusion.

## REFERENCES

1. Dobkin JF, Miller MH, Steigbigel NH. Septicemia in patients on chronic hemodialysis. *Ann Intern Med* 1978; 88:28-33.
2. Tokars JI, Light P, Anderson J, Miller ER, Parrish J, Armistead N, Jarvis WR, Gehr T. A prospective study of vascular access infections at seven outpatient hemodialysis centers. *Am J Kidney Dis* 2001;37:1232-40.
3. Claeys LG, Matamoros R. Anaerobic cellulitis as the result of *Clostridium perfringens*: a rare cause of vascular access graft infection. *J Vasc Surg* 2002;35:1287-8.
4. Albers FJ. Clinical considerations in hemodialysis access infection. *Adv Ren Replace Ther* 1996;3:208-17.
5. Taylor B, Sigley RD, May KJ. Fate of infected and eroded hemodialysis grafts and autogenous fistulas. *Am J Surg* 1993;165:632-6.
6. Tokars JI, Miller ER, Stein G. New national surveillance system for hemodialysis-associated infections: initial results. *Am J Infect Control* 2002;30:288-95.
7. Minga TE, Flanagan KH, Allon M. Clinical consequences of infected arteriovenous grafts in hemodialysis patients. *Am J Kidney Dis* 2001;38:975-8.
8. Padberg FT, Jr., Lee BC, Curl GR. Hemoaccess site infection. *Surg Gynecol Obstet* 1992;174:103-8.
9. Schwab DP, Taylor SM, Cull DL, Langan EM, 3rd, Snyder BA, Sullivan TM, Youkey JR. Isolated arteriovenous dialysis access graft segment infection: the results of segmental bypass and partial graft excision. *Ann Vasc Surg* 2000;14:63-6.
10. Anderson JE, Chang AS, Anstadt MP. Polytetrafluoroethylene hemoaccess site infections. *Asaio J* 2000;46:S18-21.
11. Nicholas JJ, Khanna P, Baldwin D, Jr., Merkel F, Rodby R, Jensik S. Amputations associated with arteriovenous access. *Am J Phys Med Rehabil* 2000;79:180-3.
12. Raju S. PTFE grafts for hemodialysis access. Techniques for insertion and management of complications. *Ann Surg* 1987;206:666-73.
13. Vanholder R. Vascular access. *Int J Artif Organs* 2002; 25:347-53.
14. McKenna PJ, Leadbetter MG. Salvage of chronically exposed Gore-Tex vascular access grafts in the hemodialysis patient. *Plast Reconstr Surg* 1988;82:1046-51.
15. Miller PE, Carlton D, Deierhoi MH, Redden DT, Allon M. Natural history of arteriovenous grafts in hemodialysis patients. *Am J Kidney Dis* 2000;36:68-74.
16. Lin PH, Brinkman WT, Terramani TT, Lumsden AB. Management of infected hemodialysis access grafts using cryopreserved human vein allografts. *Am J Surg* 2002; 184:31-6.
17. Nguyen MH, Yu VL, Morris AJ. Candida infection of the arteriovenous fistula used for hemodialysis. *Am J Kidney Dis* 1996;27:596-8.
18. Tabbara MR, O'Hara PJ, Hertzler NR, Krajewski LP, Beven EG. Surgical management of infected PTFE hemodialysis grafts: analysis of a 15-year experience. *Ann Vasc Surg* 1995;9:378-84.
19. Nassar GM, Ayus JC. Infectious complications of the hemodialysis access. *Kidney Int* 2001;60:1-13.
20. Mohamed M, Habte-Gabre E, Mueller W. Infected arteriovenous hemodialysis graft presenting as left and right infective endocarditis. *Am J Nephrol* 1995;15:521-3.
21. Thal ER, Weight JA, Carrico CJ. Operative trauma Management: An Atlas, 2nd ed, New York: McGraw-Hill Companies.

# 洗腎用人工血管感染摘除手術後動脈出血的外科處理： 以靜脈作徹底修補

武孟餘 柯博仁 謝宏昌 朱肇基 林萍章 劉永恆

**背景：**洗腎用人工血管感染是洗腎通路術後的嚴重的併發症之一，通常須要以外科手術將人工血管摘除。而在人工血管摘除之後的動脈端修補處，有時會有手術後持續感染動脈破裂造成大出血。本研究回顧了本院對於此種動脈出血狀況以大隱靜脈作動脈修補的手術經驗及分析相關的危險因子。

**方法：**在2000年1月到2001年2月間，一共有31例的嚴重洗腎用人工血管感染接受人工血管的摘除手術，而動脈端是以直接縫合動脈切口或人工血管殘留端作為處理方式。（平均年齡63.6歲；16男15女）其中有7人發生術後動脈破裂出血而行緊急手術。（5男2女）其中6人我們以靜脈繞道手術作為破裂動脈的徹底修補，1人則進行了肱動脈結紮手術。

**結果：**本報告描述了感染性洗腎用人工血管摘除後，動脈端若是僅作簡單縫合則可能有高達22.6%的術後出血可能。而術前血液細菌培養陽性則為術後動脈出血的危險因子。所有的病人在以靜脈繞道手術作徹底修補後都能後康復。

**結論：**洗腎用人工血管感染，若病人術前的血液培養是陽性，則建議在人工血管摘除手術時徹底清創後以靜脈血管繞道術作動脈之徹底修補，而不是僅作動脈切口或人工血管殘留端之簡單縫合，以避免術後動脈持續感染出血以及充份保持遠端肢體的血流供應。

(長庚醫誌 2003;26:911-8)

**關鍵字：**動靜脈瘻管，人工血管，腎臟透析，術後併發症。