

Management of Complications of Endovascular Dialysis Access Procedures

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ABSTRACT

Endovascular procedures are becoming the standard of care for the management of hemodialysis (HD) vascular access dysfunction. As with any type of medical procedure, these techniques result in procedure-related complications. The expected frequencies are low. The most frequent procedure-related complication seen in association with angioplasty that dictates the need for intervention is tearing of the vein or vein rupture. The clinical significance of this complication is variable, ranging from none to disaster for the access. The difference lies in the severity of the tear. Management depends on the clinical presentation, ranging from symptomatic meas-

ures alone to the need to occlude the graft. Since endovascular thrombectomy is a combined procedure including angioplasty, all of the complications of that procedure can occur with this procedure as well. The major unique procedure-related complication requiring interventional therapy is the occurrence of a symptomatic peripheral artery embolus. This complication can generally be managed successfully by mechanical endovascular means. It is essential that the interventionalist be prepared to manage these complications appropriately when they are encountered.

Venous stenosis and its end result, thrombosis, are common occurrences when synthetic grafts are used for hemodialysis (HD) access. Endovascular procedures are becoming the standard of care for the management of these problems. As with any type of medical procedure, these techniques result in procedure-related complications. In general, a procedure-related complication for any given procedure is an adverse event that is expected to occur. The rate at which it can be expected to occur varies with the individual procedure. The actual rate observed can be affected by external factors such as the manner in which the procedure is performed. A background occurrence rate is to be expected; however, the rate should not exceed an acceptable norm. An excessive complication rate suggests the need for critical evaluation of techniques and procedures. The interventionalist performing the basic procedure must be prepared to manage the complications as they occur. The purpose of this article is to discuss those complications that appear during the treatment of vascular access problems requiring additional endovascular therapy for management.

Complications of Angioplasty

The major complications that may be expected to occur in association with the performance of dialysis vascular access angioplasty along with the maximum acceptable frequencies for quality assurance purposes are shown in Table 1. The expected frequencies are low. The most frequent procedure-related complication seen in association with angioplasty that dictates the need for intervention is tearing of the vein or vein rupture (1). Although some investigators have reported an alarmingly high incidence of vein rupture in association with angioplasty treatment of autologous fistulas (2,3), in our experience the occurrence has been relatively low. In a series of 1796 angioplasty procedures, an overall complication rate of 2.4% (44 cases) was seen. This series was composed of 73% synthetic grafts (1311 cases with a 1.8% complication rate) and 27% autologous fistulas (485 cases with a 4.1% complication rate). Seventy percent of these complications were vein rupture of some degree (4).

The clinical significance of vein rupture is variable, ranging from none to disaster for the access. The difference lies in the severity of the tear. The presence of this complicating event is heralded by the extravasation of contrast, blood, or both. Small extravasations are of no clinical significance. It is not unusual to observe a small ecchymosis over the treated site the day following therapy. There may be tenderness at the site as well. It is obvious that a small, subclinical extravasation of blood has occurred. These are of no consequence. Most are totally missed except by the

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TABLE 1. Acceptable rates for adverse outcomes of venogram/angioplasty

Event	Threshold
Adverse reaction to medication	3%
Hemorrhage requiring transfusion	0%
Subclinical extravasation of contrast	2%
Class 1 hematoma	2%
Class 2 hematoma	1%
Class 3 hematoma	0%
Referrals to surgery:	
Complication of procedure	0%
Lesion not amenable to angioplasty ^a	10%

^aProcedure failure: not a procedure-related complication, but should be tracked.

patient, who may not mention it. Nothing need be done except to reassure the patient. They need not be listed as a complication, although it is obvious that a small break has occurred.

Vein rupture with extravasation becomes more obvious when there is either the extravasation of contrast creating an image on fluoroscopy or the formation of an obvious hematoma. These occurrences should be tabulated as procedure-related complications. Clinical problems occur when the extravasation is associated with the formation of a hematoma. This occurs when blood has extravasated and accumulated in a significant amount. A hematoma is always listed as a procedure-related complication, but its clinical consequence may range from minimal to major. The amount of extravasated contrast associated with the hematoma may be minimal or absent. We have found it useful to use a classification system for extravasation (Table 2) based on clinical significance (5).

Definitions

Subclinical Extravasation of Contrast (SEC)

Occasionally during the course of an angioplasty procedure, a blush of contrast adjacent to the vein at

the site of the dilatation is observed but there is no associated hematoma. As is the case with blood, this small extravasation is subclinical in that it is asymptomatic and only obvious on fluoroscopy (Fig. 1). It takes on significance because it is immediately obvious on the fluoroscopic image. An SEC should be listed as a minor complication.

Grade 1 Hematoma

When a hematoma is noted, one must make two determinations: is it stable or continuing to enlarge, and does it affect flow? A grade 1 hematoma is stable (not continuing to grow) and does not affect flow. If it is not stable, it will rapidly become a grade 2 or grade 3 hematoma. Although the grade 1 situation causes concern on the part of the operator and the patient, it is of no real consequence to the outcome of the procedure and requires no specific treatment. This is true regardless of its size. In general, a hematoma that remains stable over 30 minutes to 1 hour will continue to behave in this manner as long as the downstream vascular drainage is patent. It does not require further observation. A grade 1 hematoma is a minor complication. In the large angioplasty series mentioned previously (2), the incidence of grade 1 hematoma was 30 cases out of 1796, accounting for 68% of all complications.

Grade 2 Hematoma

If a hematoma is stable but affects flow it is classified as a grade 2 hematoma. This is not strictly dependent upon size. Most of these lesions stabilize very quickly after they form. If they do not, they will soon develop into a grade 3 extravasation. In these cases a tear has been created in the vein's wall that requires treatment. A grade 2 hematoma is classified as a minor complication if it is successfully treated. It is classified as a major complication if the access is lost. In the series mentioned previously (2), 1.9% of the total complications (2 cases out of 1796) fell within this category.

TABLE 2. Extravasation classification

Subclinical extravasation of contrast	
No associated hematoma ^a	
Only evident on fluoroscopy	
Grade 1 hematoma	
Does not interfere with flow ^a	
Size variable	
Requires no therapy	
Stable ^a	
Grade 2 hematoma	
Slows or stops flow ^a	
Size variable	
Therapy required	
Stable ^a	
Grade 3 hematoma (vein disruption)	
Large extravasation or hematoma	
Size variable, generally large	
Continues to expand and may be rapid ^a	
Pulsatile ^a	

^aDenotes a defining feature.

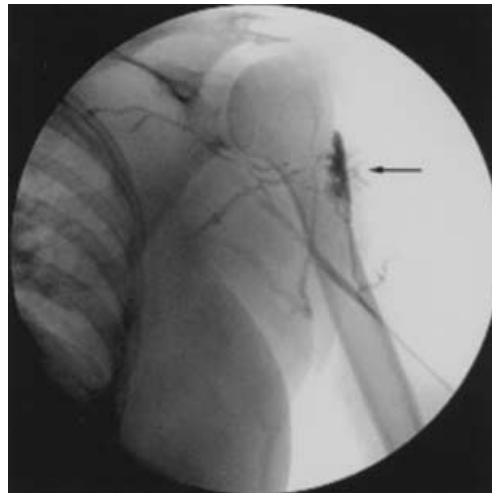


FIG. 1. Subclinical extravasation of contrast. The arrow indicates the extravasation, there is no associated hematoma.

Grade 3 Hematoma

This is a catastrophic event resulting from a complete or near-complete rupture (or dehiscence) of the vein. Hematoma formation generally occurs very rapidly. The size of the hematoma, however, is quite variable. It depends on how quickly the condition is recognized and controlled. When a grade 3 hematoma occurs, the access is lost. A grade 3 hematoma is always classified as a major complication. In the series mentioned previously (2), 0.1% of the total complications (2 cases out of 1796) fell within this category.

Management

SEC

Subclinical extravasation of contrast is listed as a complication because it is immediately obvious; however, it is of no clinical consequence. No treatment is required (Table 3).

Grade 1 Hematoma

The patient with a grade 1 hematoma will have an ecchymosis and will need reassurance and may require symptomatic treatment measures (Table 3). Localized patient discomfort may be significant and may last for several days. Mild analgesics and a heating pad may be helpful. The resulting ecchymosis may be quite large, depending on the size of the hematoma.

Grade 2 Hematoma

With this problem, it appears that the tear in the wall of the vessel is being displaced into the former lumen, resulting in its obstruction. The goal of treatment is to press the tear outward in order to open the lumen and restore flow (Table 3). If the lumen is opened with an angioplasty balloon, the pressure of the balloon will frequently stabilize the situation after a few minutes and allow for the restoration of flow.

This treatment requires that a guide wire be positioned across the lesion. Therefore it is recommended that the guide wire never be removed after an angioplasty until the treated lesion has been evaluated for complications. If the guide wire has not been retained, it is often difficult or impossible to replace it. A guide wire with a very floppy tip, such as a Roadrunner (Cook Inc., Bloomington, IN) is the best choice for this difficult situation. A straight guide wire or one whose tip is not so floppy can enter the tear and make matters worse. The Roadrunner is both steerable and hydrophilic. It has a long, curved, floppy tip. The floppy tip makes it atraumatic, while the curve allows it to be steered.

With a guide wire in position, the first step is to determine the site of the tear. The tear is not actually visible; its location has to be deduced. First, it is obviously in the region of the hematoma, and second, it is most likely located in the region covered by the angioplasty balloon when pressure was applied to the stenotic lesion. This is not invariably true; movement of a

TABLE 3. Managing extravasation

Subclinical extravasation of contrast	No treatment required
Grade 1 hematoma	Symptomatic management
Grade 2 hematoma	Restore lumen with prolonged balloon dilatation (primary) Endovascular stent (secondary)
Grade 3 hematoma (vein disruption)	Occlude access Refer to surgery (not an emergency)

guide wire or catheter can cause tears inadvertently during the procedure, but this is the place to start.

Once the location has been decided, the next step is to pass the angioplasty balloon over the guide wire and position it over the site of the tear. If there is doubt, err on the upstream side. Additional intraluminal obstruction downstream from the lesion can make it worse. Use the same balloon that created the tear, unless it was grossly oversized to begin with. Once in position, the balloon should then be inflated with a low pressure, only the amount necessary to fully expand the balloon should be applied. The use of higher pressures may make the tear worse. Leave the inflated balloon in place for 4–5 minutes. This is done to plaster the torn endothelial surfaces against the wall and to displace the compressing hematoma. After the required time, deflate the balloon and remove it gently. Check the site using a puff of radiocontrast to see if flow is now present. If flow appears normal or relatively so and the hematoma is stable, nothing further needs to be done. It is important at this time that you not do unnecessary manipulations in the area—accept a result that works, even if it is not perfect.

If flow continues to be significantly affected, consider inserting an endovascular stent (6–8). If the hematoma is continuing to enlarge, you are probably dealing with a grade 3 rupture.

Grade 3 Hematoma

The primary goal in the management of this complication is to arrest a progressing process. This is critical in order to limit the size of the hematoma. The hematoma begins, expands rapidly, and is pulsatile. Arterial blood is being pumped directly into the tissue surrounding the area. Early recognition is critical, but not always easy. When doing an angioplasty on a properly sedated patient, there is generally some response to the painful stimulus of the dilatation. However, this should go away immediately after the pressure is released. If the patient continues to behave in a manner suggesting that they are experiencing pain, a grade 3 hematoma should be suspected. It can be diagnosed by palpating the area just dilated. A rapidly expanding, pulsatile hematoma will be evident. As soon as the situation is recognized, the access should be occluded (Table 3).

Occluding the access will remove the pressure that is driving the growth of the hematoma and arrest the situation. Most grade 3 hematomas occur at the venous

anastomosis. To occlude the access, simply inflate the angioplasty balloon to a low pressure within the access below the site of rupture. If you cannot do this immediately, occlude the graft manually until the balloon can be applied. Once the graft has been occluded, close the valve attached to the catheter, remove the inflation device, tie a knot in the catheter, roll it up, tape it to the patient's arm, and leave it in place. The graft will thrombose over the next few hours. Then the catheter can be deflated and removed without difficulty. Although the patient will need a new access, this is not a surgical emergency. Once the graft is thrombosed, the problem is over except for the lack of a functioning access.

Complications of Endovascular Thrombectomy

The major complications that may be expected to occur in association with the performance of endovascular thrombectomy on a dialysis vascular access, along with expected frequencies, are shown in Table 4. As with angioplasty, the expected frequencies are low. Since this is a combined procedure including angioplasty, all of the complications of that procedure are included. The major unique procedure-related complication requiring interventional therapy is the occurrence of a peripheral artery embolus (9) (Fig. 2).

Residual thrombi are present following an endovascular thrombectomy, even after the graft is flowing (10). These can be washed or pushed back across the arterial anastomosis and into the artery. Overinjection (injection of saline or radiocontrast into the graft in an amount that exceeds the graft volume) will promote this occurrence, especially if there is a downstream obstruction. Just the passage of a catheter or guide wire across the arterial anastomosis can result in this complication.

Most arterial emboli are asymptomatic and are recognized only radiographically. These do not require treatment (11). Symptomatic emboli are not common, but must be treated in a timely fashion in order to prevent permanent sequelae. In a series of 1176 cases of thrombosed grafts treated by endovascular means, only 4 cases of symptomatic arterial emboli were seen (9). Most of these emboli represent fragments of the arterial plug which is composed of relatively old, laminated

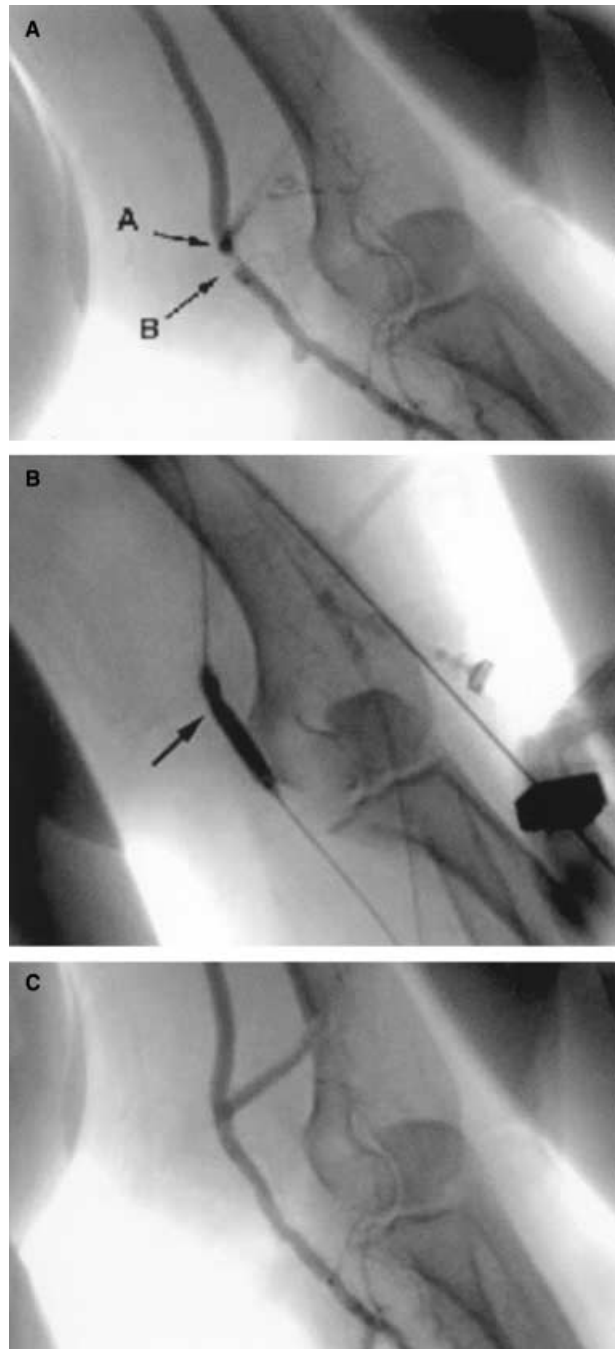


FIG. 2. (A) Embolus in the brachial artery. A, the arterial anastomosis; B, the embolus in the brachial artery just upstream from the anastomosis. (B) Angioplasty balloon (6 mm × 4 cm) being used as an embolectomy catheter. (C) Postembolectomy angiogram.

thrombus. They most frequently lodge within the brachial artery, generally just above its bifurcation. There are several approaches to the therapy of symptomatic peripheral artery emboli.

Embolectomy Catheter Technique

The clot can be retrieved using an embolectomy catheter (Fig. 2B). For this, a catheter that can be passed

TABLE 4. Complications of Percutaneous Thrombectomy

Events	Threshold
Adverse reaction to medication	3%
Hemorrhage requiring transfusion	0%
Subclinical extravasation of contrast	2%
Class 1 Hematoma	2%
Class 2 Hematoma	1%
Class 3 Hematoma	0%
Arterial embolism	0%
Clinical pulmonary embolism	0%
Referrals to surgery:	
Complication of procedure	0%
Not amenable to treatment*	10%

*Procedure failure – not a procedure related complication, but should be tracked.

over a guide wire must be used. There are several candidates for this purpose. It may be possible to use an angioplasty balloon catheter. For this purpose a 4 mm × 4 cm balloon or a 6 mm × 4 cm balloon should be used, depending on the size of the vessel. If the angioplasty balloon catheter that has been used in the thrombectomy procedure has a large profile, it would be advisable to use a new catheter. The profile of the unused balloon might be advantageous. An occlusion balloon catheter can also be used in this technique.

The following procedure should be used:

1. Perform an arteriogram to confirm the diagnosis and to accurately locate the position of the embolus. This should be done through a catheter so as to avoid additional embolization from any residual clot fragments that might be present.

2. Pass a guide wire across the arterial anastomosis. A straight Glidewire (Boston Scientific Corp., Med-Tech Division, Natick, MA) would be an appropriate choice for this purpose. Manipulate the guide wire down the artery so that its tip is well beyond the embolus. A guiding catheter may be necessary for this purpose.

3. Insert the catheter that is to be used as the embolectomy catheter over the guide wire and pass it down below the level of the embolus (Fig. 2B).

4. Inflate the balloon and withdraw the catheter back across the arterial anastomosis into the graft.

5. Remove the catheter and repeat the arteriogram to evaluate the result (Fig. 2C).

If this approach is not effective, it should be tried a second time. If it fails again, the patient should be treated with either infusion thrombolysis or surgery. Of these two, surgery is probably the most successful, since the type of thrombus involved (fragments of the arterial plug) can be expected to be relatively resistant to enzymatic lysis.

Back-Bleeding Technique (12)

For this to work, the graft must be patent. If the brachial artery is occluded above the level of the anastomosis, there is enough blood flow via collateral arteries to produce back-bleeding into the patent graft. This back-bleeding will dislodge the embolus from its location in the artery below the anastomosis and move it into the graft. The details are as follows:

1. Perform an arteriogram to confirm the diagnosis and to accurately locate the position of the embolus. This should be done through a catheter so as to avoid additional embolization from any residual clot fragments that might be present.
2. Insert a 4 Fr. Fogarty catheter through the sheath and pass it into the artery. The Fogarty catheter

should be maneuvered so that the tip lies just above the anastomosis on the upstream side.

3. Inflate the Fogarty balloon to occlude the arterial flow and have the patient exercise their hand for approximately 1 minute.
4. Deflate the balloon to restore flow through the artery and perform an arteriogram to evaluate the results.

If the back-bleeding technique is not effective, it should be tried a second time. If it fails again, the patient should be treated with another technique.

Conclusion

Procedure-related complications should not be common occurrences; their expected incidence is relatively low. However, they do occur and it is essential that the interventionalist be prepared to manage them appropriately when they are encountered. It is important that complication be monitored and tabulated on an ongoing basis. What is important is how often they occur for each individual operator and how well they are managed.

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