Aortic Prosthetic Graft Infections: Radiologic Manifestations and Implications for Management[1]

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LEARNING OBJECTIVES

After reading this article and taking the test, the reader will be able to:

- Recognize the varied clinical presentation associated with perigraft infection.
- Develop an imaging algorithm in the evaluation of patients with suspected perigraft infection.
- Identify the radiologic findings that suggest perigraft infection with various imaging modalities.

Prosthetic graft infections are an uncommon complication of aortic bypass. These infections may have serious sequelae such as limb loss and can be lethal. They are hard to eradicate and, under certain circumstances, difficult to diagnose. Usually, computed tomography (CT) is the most efficacious imaging method for diagnosis of graft infections due to its quick availability. The sensitivity of magnetic resonance imaging in detection of perigraft infection has not been thoroughly investigated but is probably similar to that of CT. After the early postoperative period, persistent or expanding perigraft soft tissue, fluid, and gas are the CT findings of graft infection. Aortoenteric fistula should be considered a subset of aortic graft infection; however, perigraft air is more likely to be seen with an aortoenteric fistula. Other conditions associated with graft infection include pseudoaneurysm, hydronephrosis, and osteomyelitis. Adjunctive studies such as sinography, ultrasonography, gallium scanning, and labeled white blood cell scanning can be quite useful in diagnosis, determination of the extent of disease, and selection of the treatment modality. White blood cell scanning is an important complementary test to CT in ambiguous cases, such as in the early postoperative period, and may be more sensitive in detection of early graft infection.

Abbreviation: WBC = white blood cell

Index terms: Aorta, grafts and prostheses, 89.457, 943.4522, 981.4522 • Aorta, surgery, 89.457, 943.4522, 981.4522 • Grafts, infection, 89.458, 943.458, 981.4522

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Introduction

Approximately 2.3 million patients per year in the United States undergo bypass procedures, many with prosthetic grafts (1). Prosthetic graft infections are uncommon complications of vascular procedures (1.3%–6% of cases) (2,3) but are devastating, with mortality rates of 25%–75% (3). Reinfection of a repeat abdominal aortic graft remains a risk, particularly during treatment of an established extraanatomic bypass graft infection (4). Aortic prosthetic graft infections that require emergent treatment are associated with high rates of early and late mortality and limb loss despite aggressive intervention and limb salvage procedures (5). A recent study found that percutaneous drainage of perigraft infected fluid can be used as an initial form of treatment and that surgery after percutaneous drainage appears to be safer than surgery alone (6).

The clinical presentation may be straightforward, especially with infections of the femoral component, where swelling, heat, tenderness, a pulsatile mass, or possibly a draining sinus tract may be noted. However, the clinical presentation of an intracavitary graft infection may be nonspecific and temporally remote (up to 10 years after surgery). Such nonspecific presentations as malaise, back pain, fever, gastrointestinal bleeding, elevated sedimentation rate, hydronephrosis, or ischemia from a clotted graft should also be considered potential manifestations of a graft infection and warrant further diagnostic evaluation. Aortoenteric fistula should be considered a subset of aortic graft infection, as can aortic–right ureteral fistula, which is rare (5). The radiologic signs of aortoenteric fistula and graft infection overlap, although there is a greater likelihood that perigraft or intraluminal air will be seen with an aortoenteric fistula.

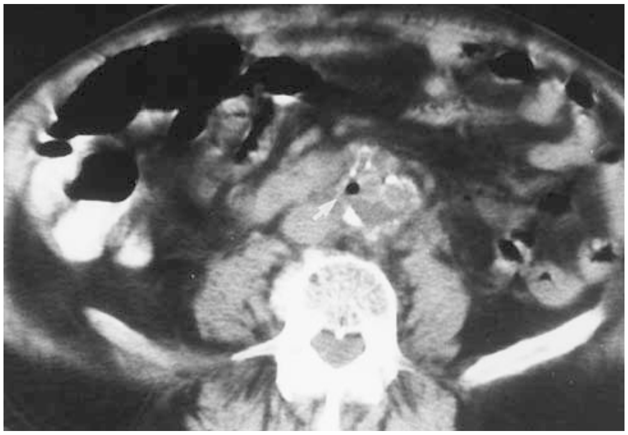
In this article, we discuss computed tomography (CT) and magnetic resonance (MR) imaging of aortic prosthetic graft infections and review the radiologic findings, adjunctive studies, and associated conditions.

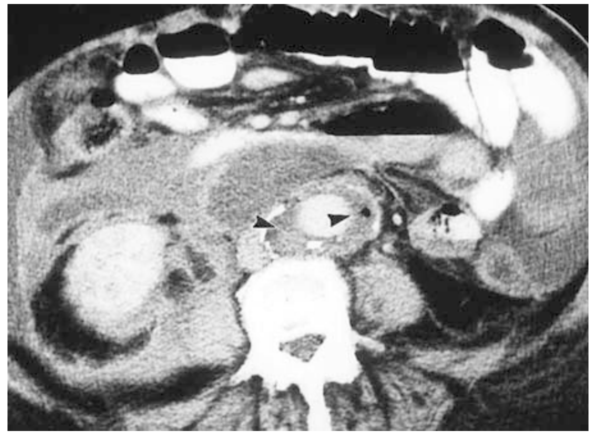
CT and MR Imaging

CT is the standard against which other radiologic diagnostic methods are compared, with the caveat that culturing, if performed properly, is the ultimate method of establishing the diagnosis and is therefore the reference against which all imaging studies are ultimately compared. Recently, technetium-99m hexametazime has been used to label leukocytes, with excellent results; although this method is superior to CT (7) and likely to supplant it, the method still has drawbacks in that it is not performed quickly and is associated with hepatobiliary excretion. CT has a sensitivity of 94% and a specificity of 85% when the criteria of perigraft fluid, perigraft soft-tissue attenuation, ectopic gas, pseudoaneurysm, or focal bowel wall thickening are used (8). In studies from the first half of the 1980s, CT had a specificity and sensitivity of approximately 100% (9–11), but studies from the late 1980s suggest that CT is accurate in diagnosis of advanced graft infection (eg, periprosthetic abscess, aortoenteric fistula) but not low-grade infection, with overall specificity of 100% and overall sensitivity of 55.5% (7).

In the early postoperative period, signs of graft infection can be difficult to differentiate from normal postoperative changes and adjunctive tests may be necessary. Perigraft air is rare beyond 1 week after surgery but is not pathognomonic of graft infection until 4–7 weeks after surgery (12,13). Similarly, perigraft fluid that persists beyond 3 months should be considered highly suspicious for infection (12). CT is the modality of choice for detection of perigraft fluid or air; because the median time to manifestation of a graft infection is 3 years (70% of cases manifest after the 1st year), the vast majority of aortic graft infections can be diagnosed with CT without difficulty. All persistent perigraft fluid collections that manifest beyond 3 months should be presumed to be from infected graft material and should be cultured. If the culture is negative, close clinical and CT or nuclear medicine follow-up of the fluid for up to 1 year may be considered because noninfected fluid will rarely persist for this long. Fastidious and therefore hard-to-culture organisms may be the explanation for such cases.

Because of its high sensitivity and specificity and the rapidity with which it can be performed, CT should be the first examination ordered in cases of suspected aortic graft infection or aortoenteric fistula. CT has an advantage over MR imaging in that intervention, such as needle aspiration, can be performed at the same time (14). The sensitivity of MR imaging in detection of perigraft infection has not been thoroughly investigated and remains unknown. MR imaging should be quite sensitive in demonstrating small amounts of perigraft fluid but would be limited because of motion artifact from the great vessels and insensitivity in differentiation of gas from remnant native vessel calcified plaque. Owing to the characteristic signal intensities on T1- and T2-weighted images, MR imaging often allows





1. 2.

Figures 1, 2. **(1)** Normal findings in a patient with abdominal pain 1 week after elective aneurysm repair. CT scan shows air around the aortic graft (arrow). The abdominal pain subsided, with an otherwise uneventful postoperative course. **(2)** Normal findings in an 87-year-old woman with spiking fevers 1 week after repair of a ruptured aortic aneurysm. CT scan shows perigraft fluid and air (arrowheads), which are within normal limits for this early postoperative period. The ascites was transudative, and the culture was negative. The fevers were due to a lung abscess (not shown).

differentiation of perigraft fluid and inflammatory changes in surrounding structures from subacute or chronic hematoma. Differentiation between fluid surrounding the graft and soft-tissue masses (viz, infection vs hematoma) is difficult with ultrasonography (US) or CT; however, MR imaging does not allow distinction between various types of nonhemorrhagic fluid (ie, infected vs sterile fluid) (15).

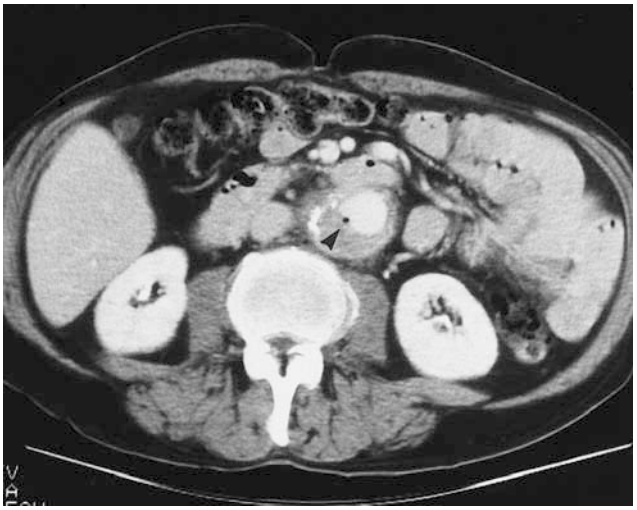
In 1994, Spartera et al (16) followed up 36 cases of aortic or aortoiliac reconstructions with MR imaging to check for "postoperative periprosthetic collections," which caused changes in signal intensity on T1- and T2-weighted images. Two concentric rings, the external ring corresponding to the wall of the aneurysm and the internal ring corresponding to the graft, were nearly always separated by a periprosthetic collection. The diameter of the collection varied significantly when correlated with the type of initial disease being treated, the type of proximal anastomosis used (end-to-end vs end-to-side), and even whether drainage and postoperative transfusions were performed. The periprosthetic collections usually disappeared 3–6 months after surgery, with the changes in signal intensity on T1- and T2-weighted images diminishing after about the same length of time. There was only one case of graft infection, which was characterized by persistence of the periprosthetic collection and high signal intensity on T2-weighted images 6 months after surgery; the latter corresponded to incomplete or delayed healing due to infection.

In cases of graft infection manifesting in the groin, CT should be used to stage the extent of the infection (10). In cases of localized infection (or in high-risk surgical candidates or those with grafts located in positions that preclude removal), local excision of one limb of a bifurcation graft with extraanatomic bypass or replacement with in situ autologous bypass tissue may be performed, as well as less aggressive alternatives such as topical antibiotic irrigation (3,17). (When and if prosthetic grafts that are less susceptible to infection due to incorporation of antibiotics into the graft are developed, in situ replacement may become the treatment of choice.)

Radiologic Findings

Perigraft Air

Perigraft air can be seen in aortic graft infection with or without aortoenteric fistula. Nevertheless, this sign is more prevalent with aortoenteric fistula than with aortic graft infection alone. Perigraft air in the early postoperative period may be suspicious for graft infection but is not diagnostic (Figs 1, 2). In cases in which there is doubt,



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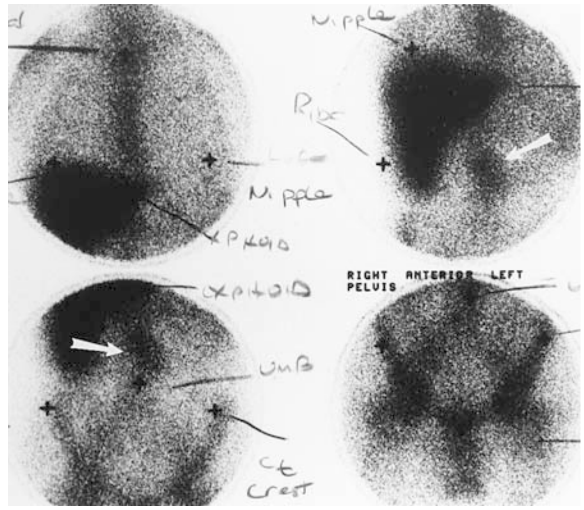

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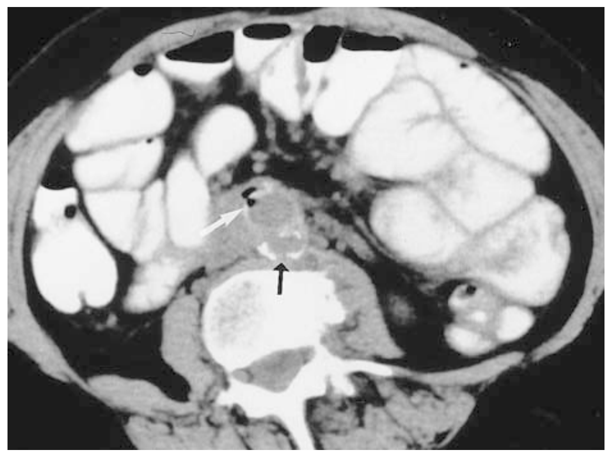
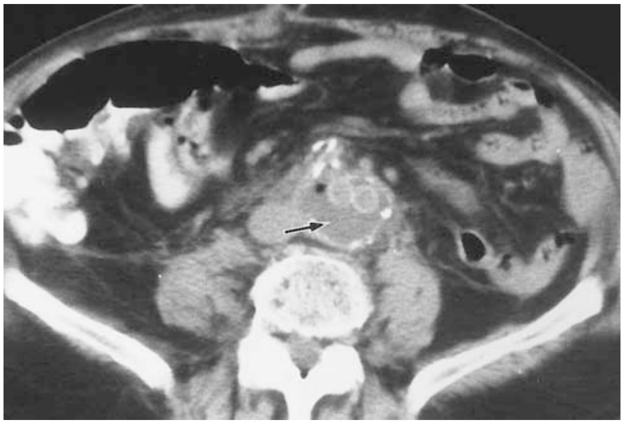
4a.



4b.

Figures 3, 4. **(3)** Perigraft air secondary to graft infection in an asymptomatic patient. The patient originally presented with anemia and a hemoglobin level of 7 g/dL (70 g/L). Because of the possibility of an aortoenteric fistula (the patient had a history of duodenal ulcer), endoscopy was performed but showed no evidence of an aortoenteric fistula. **(a)** CT scan shows perigraft air (arrowhead), which was an incidental finding. Because the patient had undergone surgery nearly 2 years earlier, the diagnosis of graft infection was almost certain; however, owing to the lack of symptoms, a gallium scan was obtained. **(b)** Gallium scan shows increased uptake at the mid–abdominal aorta (arrows), thus confirming the diagnosis of infection. Cultures of the graft showed growth of *Citrobacter diversus*. **(4)** Aortoenteric fistula in a patient with new-onset heme-positive stools and a history of aortic repair. **(a)** CT scan shows gas near the beginning of the graft (black arrowhead). The duodenum is closely adjacent (white arrowhead). **(b)** Contiguous CT scan obtained inferior to **a** shows perigraft air (white arrow) and the collapsed native aortic bed posterior to it (black arrow). Cultures of the graft were negative.

supplemental studies such as indium-111 white blood cell (WBC), gallium-67 citrate, or Tc-99m hexametazime scanning can be performed for further clarification (Fig 3). Superior graft anastomotic air at the crossing point of the transverse duodenum due to aortoenteric fistula (Fig 4) has an appearance not unlike that of air due to graft infection.



a.

b.

Figure 6. Normal early postoperative findings. **(a)** CT scan shows an area of attenuation around the graft (arrow), which represents residual fluid and hematoma. A small amount of air is also present. The patient had an uneventful postoperative course. **(b)** CT scan obtained 4 months later shows complete resolution of the perigraft fluid and hematoma.

Figure 5. Normal perigraft ring. CT scan shows perigraft tissues that are no more than 5 mm thick (arrows).

Figure 7. Perigraft fluid collection in the left groin in a patient with persistent fever and elevated WBC count 4 months after surgery. CT demonstrated a persistent fluid collection around the graft. Because an infection could not be ruled out, CT-guided aspiration was performed. CT scan shows aspiration of the fluid collection, which demonstrated no bacterial growth but abundant WBCs. The fluid collection eventually showed growth of *Campylobacter fetus*. The patient and surgeon opted for treatment with antibiotics and close follow-up, which proved successful in the long term.

Perigraft Fluid or Soft-Tissue Attenuation

After the early postoperative period, the normal graft has a ring of fat attenuation around it. There should be less than 5 mm of soft-tissue attenuation between the aneurysm wall and the graft (Fig 5). For up to 3 months after surgery, the patient may have a persistent fluid collection or soft-tissue attenuation around the graft (Fig 6). Rarely, fluid can be seen around a graft for up to 1 year without being infected (18). In such a case, when infection is suspected, needle aspiration for culture, sensitivity, and Gram stain of the fluid can be helpful (Fig 7). Some surgeons prefer to perform aspiration of perigraft fluid

a.

b.

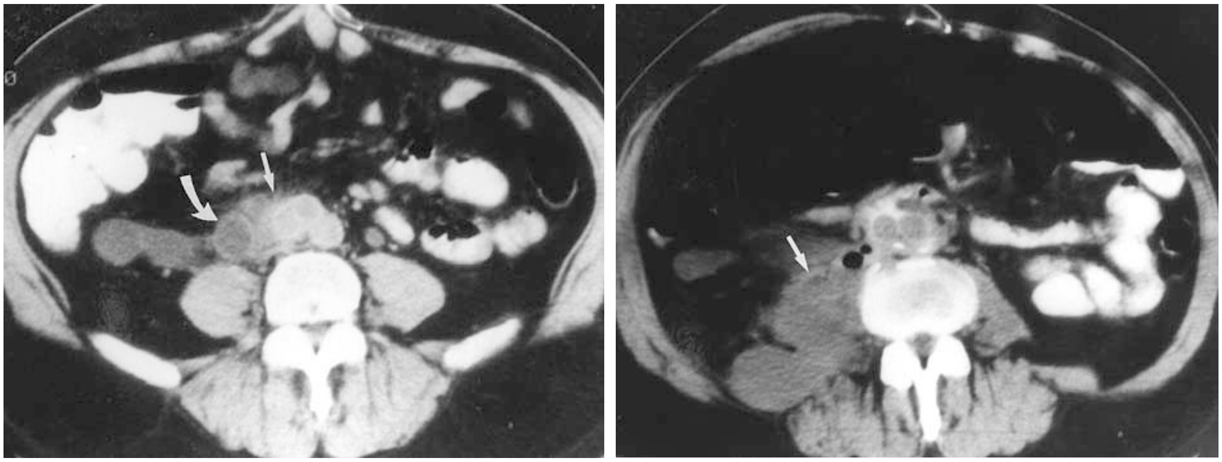
c.

d.

e.

f.

Figure 8. Persistently culture negative, slowly progressive graft infection in a patient with a draining left groin mass 1 year after placement of an aortobifemoral graft for peripheral vascular disease. Angiography demonstrated no pseudoaneurysm. **(a)** CT scan obtained March 23, 1987, shows perigraft soft-tissue attenuation extending to the skin (arrowhead). **(b)** CT scan obtained May 13, 1988 (one of a number of follow-up CT scans), shows a small perigraft fluid collection and enhancing soft-tissue attenuation around the graft (arrowhead), findings consistent with perigraft infection. Fluid aspiration was positive for WBCs, but the culture was negative. In July 1989, the left limb of the graft was removed because it was infected and unresponsive to conservative therapy. In August 1989, the patient was readmitted for elective left axillofemoral bypass. **(c)** Follow-up CT scan obtained November 14, 1989, shows a fluid collection around the axillofemoral graft, which was positive for WBCs but negative at culture. **(d)** CT scan obtained December 17, 1989, shows persistence of the fluid collection and extension to the left groin (arrowhead). **(e)** CT scan obtained August 13, 1991, shows fluid around the right limb of the aortic bifurcation graft (arrow). This finding prompted excision of the entire aortic graft and placement of a right axillofemoral graft. **(f)** CT scan obtained October 4, 1991, shows persistent fluid around the left axillofemoral graft (arrow), but the graft remained uninfected. Subsequently, the left axillofemoral graft was removed and a femoral-femoral graft was placed. The infection was presumed to be due to *S epidermidis* on the basis of the clinical course and the multiple negative cultures, which are characteristic of slime-producing organisms such as *S epidermidis*.



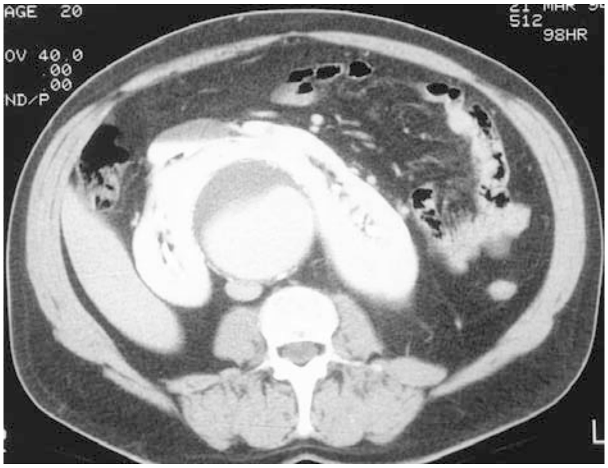
a. b.

Figure 9. Graft infection in a patient with an aortic bifurcation graft. **(a)** CT scan obtained several years after graft placement shows that the wall of the right limb of the graft is indistinct (straight arrow), merging with an area of soft-tissue attenuation and without a circular rim of fat. This appearance was not recognized at the time as a very suspicious finding for graft infection. A fluid-filled loop of ileum is present anterior to the right psoas muscle (curved arrow). The abnormality was not recognized until development of an obvious graft infection and psoas abscess 1 year later. **(b)** CT scan obtained approximately 1 year later shows a right psoas abscess in the same location, contiguous with the graft (arrow) (window width and level were changed to show the abscess better). At surgery, there was staining of the graft in this location, indicating an enteric fistula.

even when there is little doubt about the diagnosis to obtain accurate cultures before initiating antibiotic therapy and to facilitate selection of the perioperative antibiotics (19).

Many of the organisms are fastidious, and the microbiologist should be instructed to incubate specimens for up to 14 days rather than the typical 48–72 hours to allow growth of slow-growing and damaged organisms (20). The majority of fluid aspiration specimens that show WBCs but no organisms and result in negative cultures tend to contain *Staphylococcus epidermidis*, which produces a slime that adheres to the graft and not only prevents retrieval of the organism but also protects it from eradication by local host defenses or antibiotics (21). The natural history of such a case consists of a series of CT examinations over several years, ultimately resulting in graft removal (Fig 8). Recent laboratory work suggests that percutaneous drainage with instillation of urokinase into the cavity may help sterilize these resistant *S epidermidis* abscesses (22).

Perigraft soft-tissue attenuation can be a subtle finding, with indistinctness of the graft margins and absence of the normal perigraft ring of fat (Fig 9a). The take-home lesson about perigraft fluid is that there are no hard-and-fast rules. The duration of fluid in noninfected grafts is quite variable, and even focal infected fluid collections can sometimes be treated successfully



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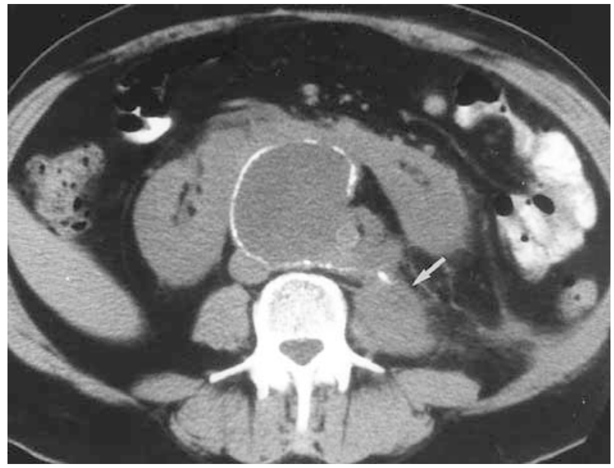

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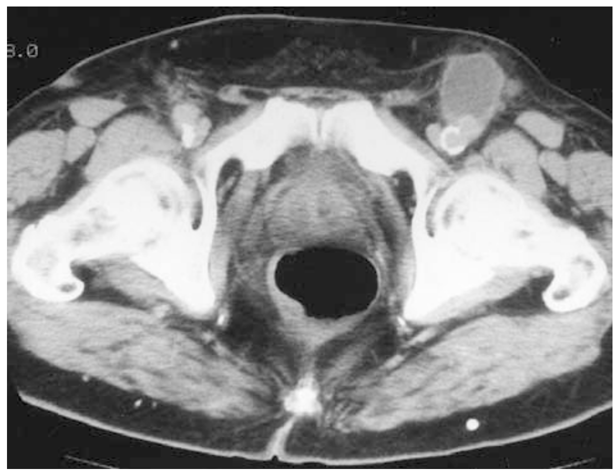


11.

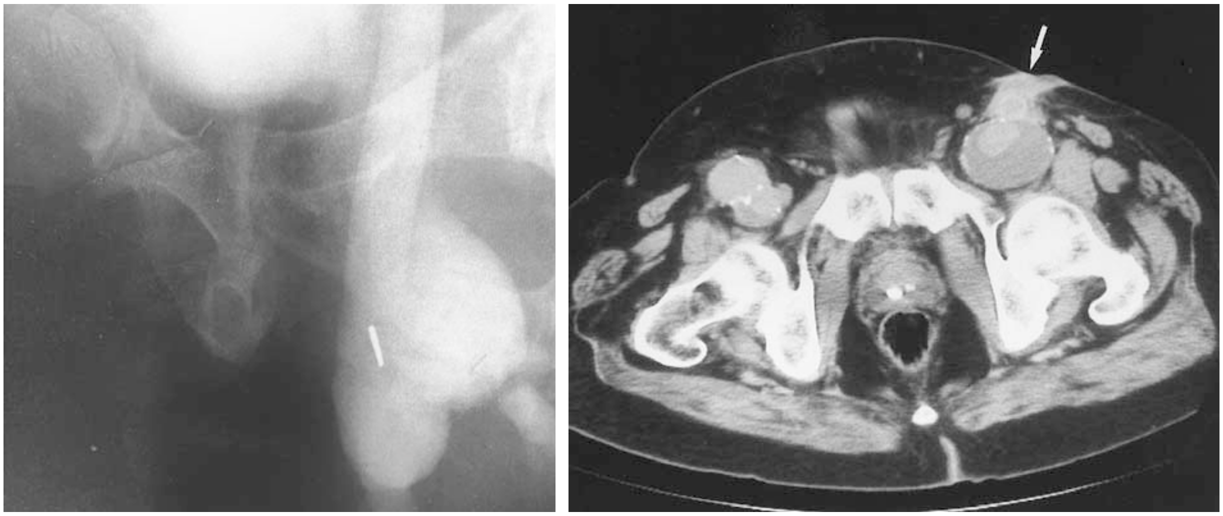
Figures 10, 11. **(10)** Psoas abscess in a symptomatic patient with a horseshoe kidney and an abdominal aortic aneurysm. **(a)** CT scan shows the early postoperative appearance. **(b)** CT scan shows that the left portion of the horseshoe kidney has become infarcted, with eventual gas in the graft (not shown) and concomitant abscess formation. The left psoas abscess (arrow) is contiguous with the graft; thus, the graft was removed. **(11)** Perigraft fluid collection. CT scan obtained about 5 months after surgery shows soft-tissue attenuation extending to the skin and the femoral component of the left limb of the graft. CT showed no proximal extension. The patient was successfully treated with intravenous antibiotics.

solely with antibiotics, but more often than not eventual graft removal is necessary (Figs 10, 11).

Pseudoaneurysm

Pseudoaneurysms occur in approximately one-fourth of graft infections, but the majority of patients with pseudoaneurysms have no graft infection. When graft infection is the cause, the interval from surgery to presentation is shorter than in noninfected cases (23). When graft infection is suspected, angiography should be supplemented with CT and US to demonstrate perigraft fluid collections (Fig 12).

After graft removal, one dreaded complication to be alert for is aortic stump blowout, which we believe is a form of pseudoaneurysm. Stump blowout is a result of residual contamination of the graft bed or low-grade infection that may reside in the arterial wall proximal to the area of aortic débridement, coupled with the continuous "water hammer" effect of the pumping action of the heart. To prevent this complication, surgeons débride the distal aorta generously and place well-vascularized omentum around the aortic stump. Stump blowout frequently manifests as a confined pseudoaneurysm immediately adjacent to the aortic stump (Figs 13, 14). Pseudoaneurysm secondary to



a. b.

Figure 12. Pseudoaneurysm. **(a)** Angiogram shows a left-sided pseudoaneurysm. **(b)** CT scan shows lower-attenuation perigraft fluid (arrow). The patient subsequently underwent pseudoaneurysm repair and creation of an extraanatomic bypass, which also became infected.

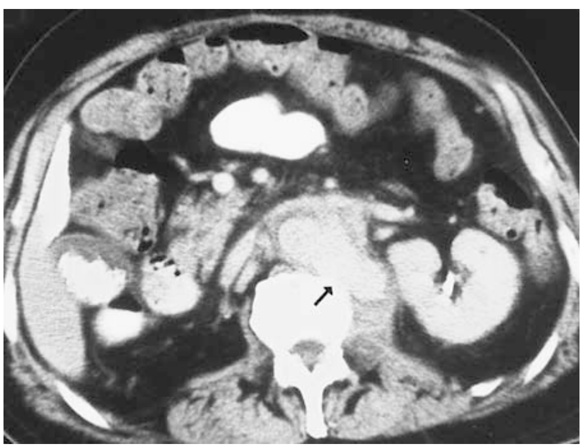
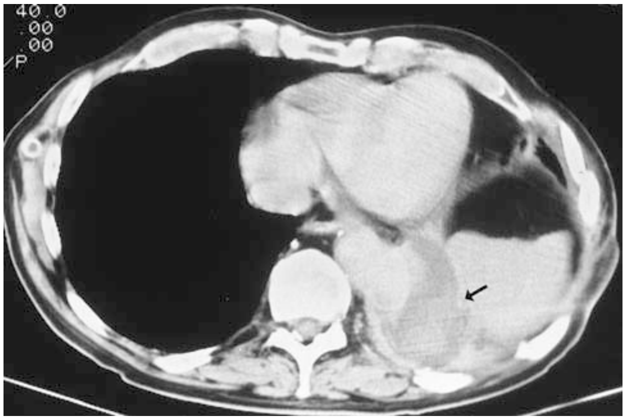


Figure 13. Aortic stump blowout in a patient with back pain and a drop in hematocrit level 6 months after aortic graft removal. CT scan shows a pool of contrast material extending from the aortic stump (arrow), with temporary tamponade of the collection by the left psoas muscle.

Figure 14. Aortic stump blowout. CT scan obtained 3 months after prior repair of an aortic stump blowout shows blood attenuation extending from the aortic stump (arrows).



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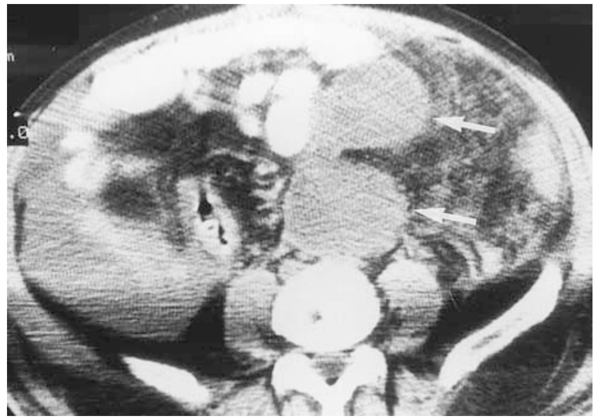


16a.

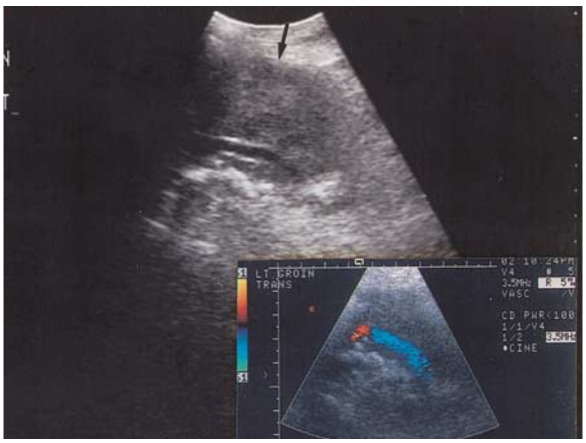
15b.

16b.

17.

Figures 15–17. **(15)** Pseudoaneurysm in a 61-year-old hypertensive patient with bilateral thoracic-aortic-femoral and axillary–profunda femoral bypass grafts. The patient developed a fistula from the graft to the left lower lobe of the lung, which was resected with muscle flap closure. Several weeks later, the patient developed hemoptysis and presented to the local emergency department. **(a)** CT scan of the lower chest shows the end-to-side anastomosis with a pseudoaneurysm on the left side (arrow). The pseudoaneurysm is partly occluded, but there is also some leakage with resultant loculated left lower lobe hemothorax. **(b)** Aortogram obtained with a brachial approach on the same day shows an irregular outpocketing of contrast material arising from the end-to-side anastomosis at approximately the level of T10, with some leakage into the left hemithorax (arrows). Immediate surgery was performed, which consisted of Dacron graft repair of the recurrent pseudoaneurysm with left lower lobe resection, as well as resection of the prior muscle flap closure in the left chest wall. Intraoperative cultures demonstrated infection with *Candida*. The postoperative course was otherwise uneventful with long-term antibiotic coverage. The final culture result was *Candida parapsilosis* of the anastomosis. (Courtesy of James Caridi, MD, Shands Hospital, Gainesville, Fla.) **(16)** Pseudoaneurysm. **(a)** CT scan shows a dumbbell-shaped fluid collection (arrows) immediately below the aortic stump (not shown), as well as signs of peritonitis. **(b)** Radiograph obtained after placement of a temporizing abscess drainage catheter shows a small-bowel communication, which was thought to be a forme fruste of aortoenteric fistula. **(17)** Pseudoaneurysm. Radiograph obtained after placement of a temporizing abscess drainage catheter shows a colon communication, which was thought to be a forme fruste of aortoenteric fistula.

a.



b.

Figure 18. Perigraft malignancy. **(a)** CT scan shows a likely graft abscess in the left groin, with apparent extensive fluid around the graft at the anastomosis. **(b)** Longitudinal US scan shows a mass that is echoic and probably solid (arrow), thus raising the possibility of a malignancy rather than an infection. US-guided needle aspiration demonstrated an unusual case of metastatic squamous cell carcinoma surrounding the graft.

graft infection can take various other forms (Figs 15–17).

Adjunctive Studies

Arteriography

Arteriography is useful for providing a preoperative road map of arteries in anticipation of graft excision and extraanatomic bypass grafting. It has a limited role, if any, in diagnosis of graft infection but is used in the work-up of pseudoaneurysms.

Ultrasonography

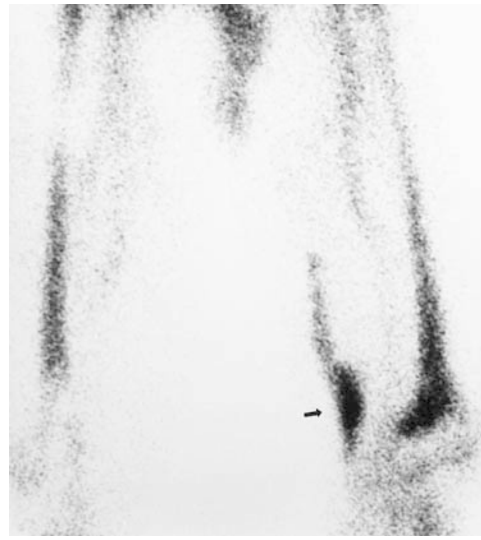
US is useful for evaluation of groin masses and correlation with other imaging studies, such as CT and angiography (Fig 18). US is thought to be useful as a primary imaging modality only for superficial grafts if complex or purely anechoic fluid or "dirty echoes" signifying gas are demonstrated around the graft in the appropriate time frame (viz, 3 months or longer for fluid and beyond 7 weeks for gas). US of aortic grafts could prove useful in the same manner but is obviously limited by overlying bowel gas and large body habitus.

Most surgeons would not operate solely on the basis of the US appearance at either graft locale because most would desire a detailed anatomic road map to check for subtle extension of graft gas or fluid up or down the graft bed or beyond, as well as unexpected, more remote abscess pockets and other complications of graft infection such as organ ischemia. Use of excessive probe pressure to obtain adequate US scans of an unexpected infected aortic pseudoaneurysm could prove disastrous, precipitating rupture. Once a graft infection is found and confirmed with CT, nuclear medicine, or another modality, US has only limited usefulness for fast bedside follow-up to check for a change in gross size of a perigraft fluid collection or pseudoaneurysm size in a patient being readied for surgery or other treatment.

MR Imaging

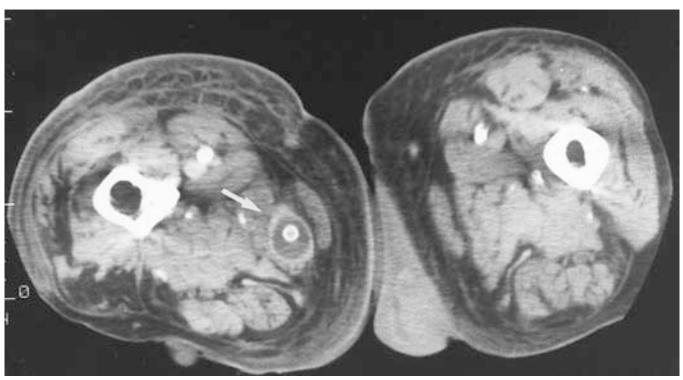
MR imaging has not been evaluated as extensively as CT for diagnosis of graft infections but probably has similar sensitivity and specificity. With MR imaging, it is similarly difficult to distinguish "normal" perigraft fluid in the early postoperative period from an infected perigraft fluid collection (24). MR imaging does not allow differentiation of the signal void produced by calcification from that of air. However, MR imaging may be more sensitive than CT in detection of inflammatory changes in the psoas muscles (15). After a postoperative period of up to 24 weeks, MR imaging shows low signal intensity on T1- and T2-weighted images, which suggests periprosthetic fibrosis (16,25). In cases of graft infection, MR imaging shows eccentric fluid collections with low to medium signal intensity on T1-weighted images and high signal intensity on T2-weighted images. Newer pulse sequences may improve diagnostic accuracy (26).

19.



20.

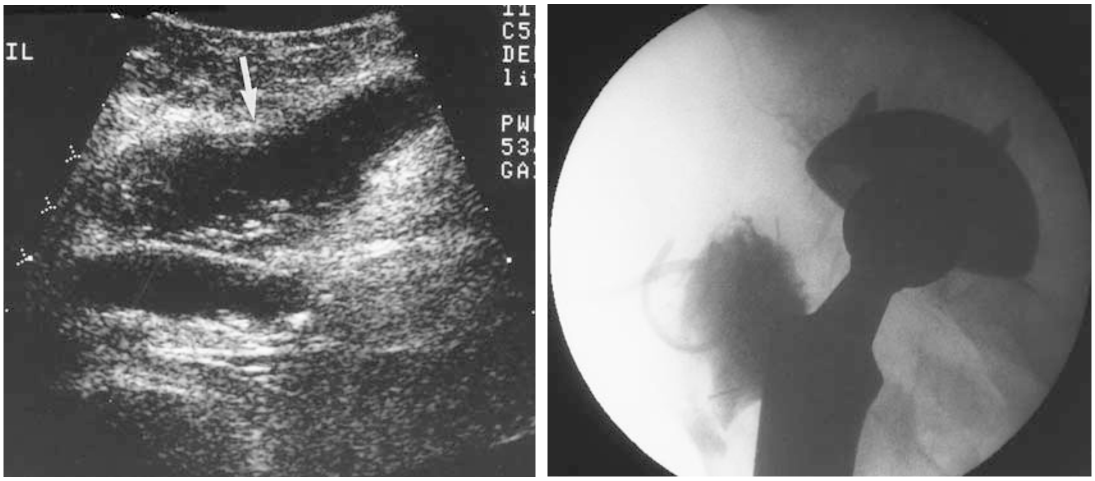
Figures 19, 20. **(19)** Graft infection. In-111–labeled WBC scan shows uptake in the right groin and to a lesser extent along the right iliac limb of the bifurcation graft (arrow). (Courtesy of Gary Purnell, MD, University of Arkansas, Little Rock.) **(20)** Graft infection. In-111–labeled WBC scan shows uptake in the distal portion of a left femoral-popliteal bypass graft (arrow). (Courtesy of Gary Purnell, MD, University of Arkansas, Little Rock.)



a.

b.

Figure 21. Graft infection. **(a)** CT scan shows an infected right obturator bypass graft (arrow) with fluid around it and further distally in the thigh. **(b)** Sinogram shows the extent of the infection, with contrast material tracking all the way to the obturator foramen.



a. b.

Figure 22. Groin abscess. **(a)** US scan shows a fluid collection (arrow) adjacent to the femoral limb of an aortic bifurcation graft, suggesting possible graft infection. **(b)** Sinogram shows that contrast material does not track along the graft, indicating that infection does not involve the graft or is very focal.

Gallium Scanning

Gallium scanning has been successfully used to identify graft infections. Gallium scans are less expensive than WBC scans, but delayed scanning is necessary and postoperative changes can produce false-positive results (27). A gallium scan can be useful in confirming an aortic graft infection in an asymptomatic patient with a suspicious CT scan (Fig 3b).

Labeled WBC Scanning

In-111–labeled WBCs have been used to detect graft infections (Figs 19, 20) with sensitivities variously reported as 60% (9), 80% (28), and 100% (7). More recently, Tc-99m hexametazime has been used to label leukocytes with excellent results—somewhat superior to those of CT—with a sensitivity of 100% in patients without overt clinical signs of graft infection (7). For appropriate accuracy, these techniques depend on minimal cross-labeling of platelets, which can produce false-positive results, especially in the early postoperative period. Other infections of adjacent tissues can also be mistaken for graft infections (19). White blood cell scanning is an important complementary test to CT in ambiguous cases, such as in the early postoperative period, and may be more sensitive than CT in detection of early graft infection. Some institutions use WBC scanning as the primary diagnostic modality.

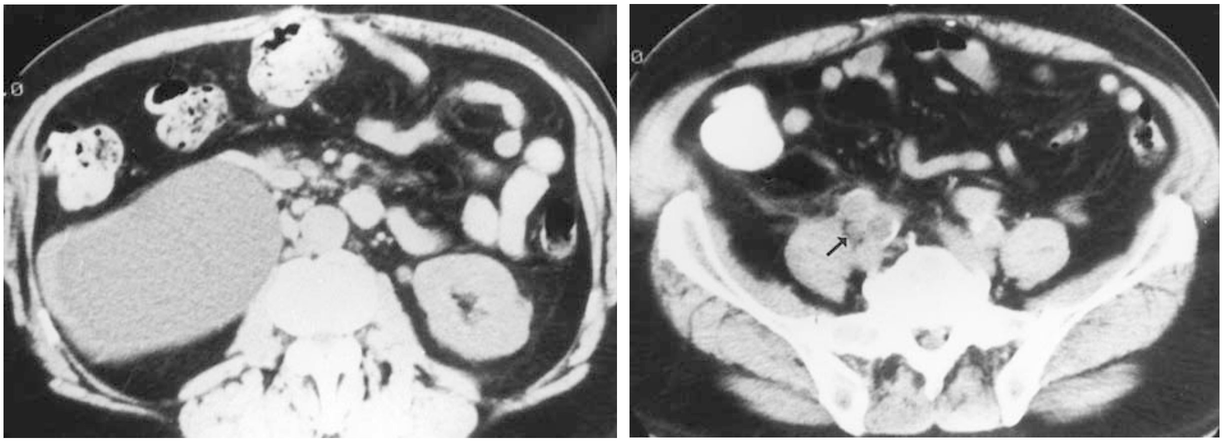
Sinography of Perigraft Fluid Collections

Sinography of a perigraft fluid collection is a useful way to stage the extent of infection and thus determine treatment (Fig 21). In noninfected areas, the graft is well incorporated into the surrounding tissue with no potential space available for contrast material (Fig 22). An infected graft is not incorporated, thus allowing contrast material to track adjacent to it.

Associated Conditions

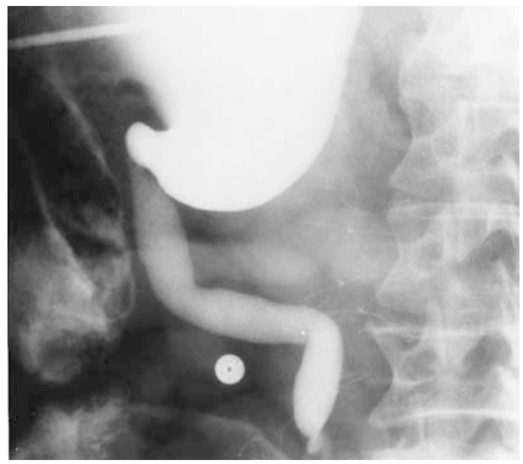
Hydronephrosis

Hydronephrosis is a significant finding after aortic bypass grafting, not only because of the underlying renal dysfunction but also because hydronephrosis is associated with a very high frequency of graft complications, including infection rates of 14%–47% (29,30). The ureteral obstruction can be due to retroperitoneal fibrosis or

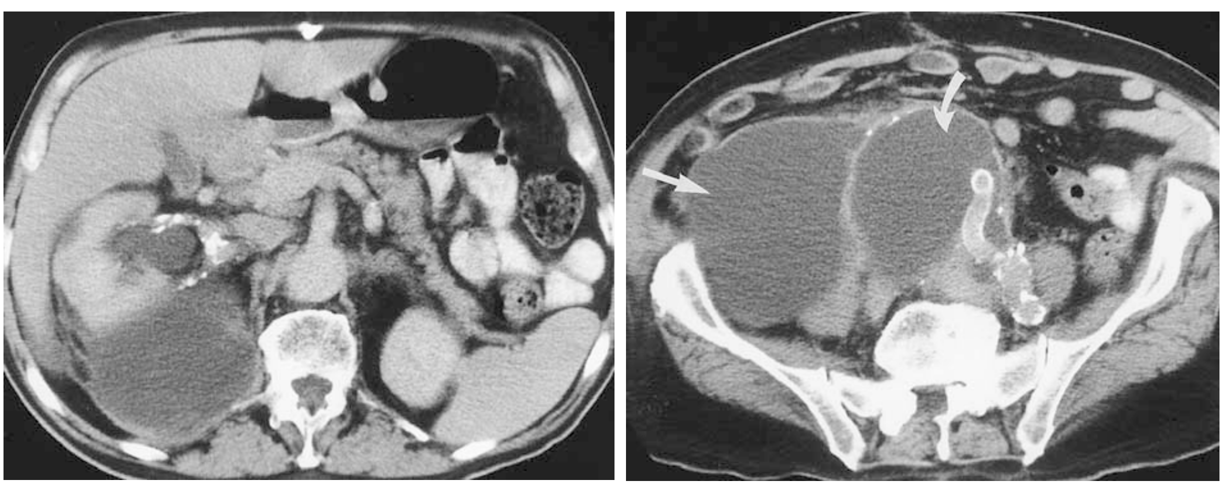


a. b.

Figure 23. Hydronephrosis secondary to ureteral entrapment. **(a)** CT scan shows marked right hydronephrosis. **(b)** CT scan shows entrapment of the right ureter between the right limb of an aortic bifurcation graft and the right native iliac artery. The margins of the right limb of the graft are indistinct and not surrounded by fat (arrow), unlike on the contralateral side. **(c)** Nephrostogram shows the same level of obstruction seen in **b**. The early indistinctness of the graft wall and the significance of the hydronephrosis were not recognized as foretelling a graft infection, which became clinically apparent 1 year later.



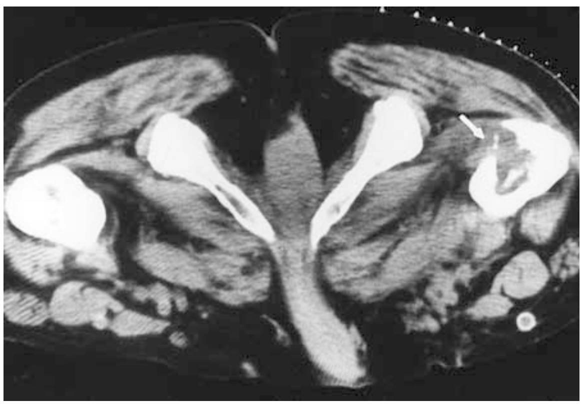
c.



a. b.

Figure 24. Hydronephrosis secondary to ureteral entrapment. Two CT scans from a series show a large amount of fluid tracking down the right limb of an aortic graft (curved arrow in **b**) and causing obstruction of the right kidney secondary to mass effect by the fluid. The fluid was eventually positive at culture. The lower image may also show a large urinoma (straight arrow in **b**) with marked ureteral dilatation.

a.



b.

Figure 25. Osteomyelitis secondary to graft infection. **(a)** Pelvic radiograph shows bilateral lytic lesions (arrowheads), which were initially thought to be metastatic. **(b)** CT scan shows a lytic lesion in the right lesser trochanter (arrow), which corresponds to an infection of the right psoas muscle and a fluid collection along the right limb of the aortofemoral graft (not shown). CT-guided bone biopsy performed at this level showed that the lesion was osteomyelitis. The infection probably tracked along the psoas muscle into its insertion on the femur.

entrapment of the ureter between the native iliac artery and the prosthetic graft (Figs 23, 24).

Osteomyelitis

An aortic graft infection occasionally manifests as osteomyelitis (Fig 25). The typical manifestation is vertebral osteomyelitis. Rarely, lower-extremity heterotopic osteoarthropathy is associated with aortic graft infection (31).

Conclusions

A high clinical index of suspicion is usually present in cases of graft infection in superficial locations. Unfortunately, these signs can be absent in cases of deeper grafts. Perigraft infections are notorious for manifesting late after surgery and are often indolent with subtle clinical presentations. As such, they may be incidental findings on CT scans obtained for other clinical reasons. Although graft infections, due to their persistence, can be deadly even when recognized and treated, prompt recognition and diagnosis still holds the best chance for cure. Recognition of the various manifestations of graft infection and their significance is key to management. CT performed in conjunction with interventional

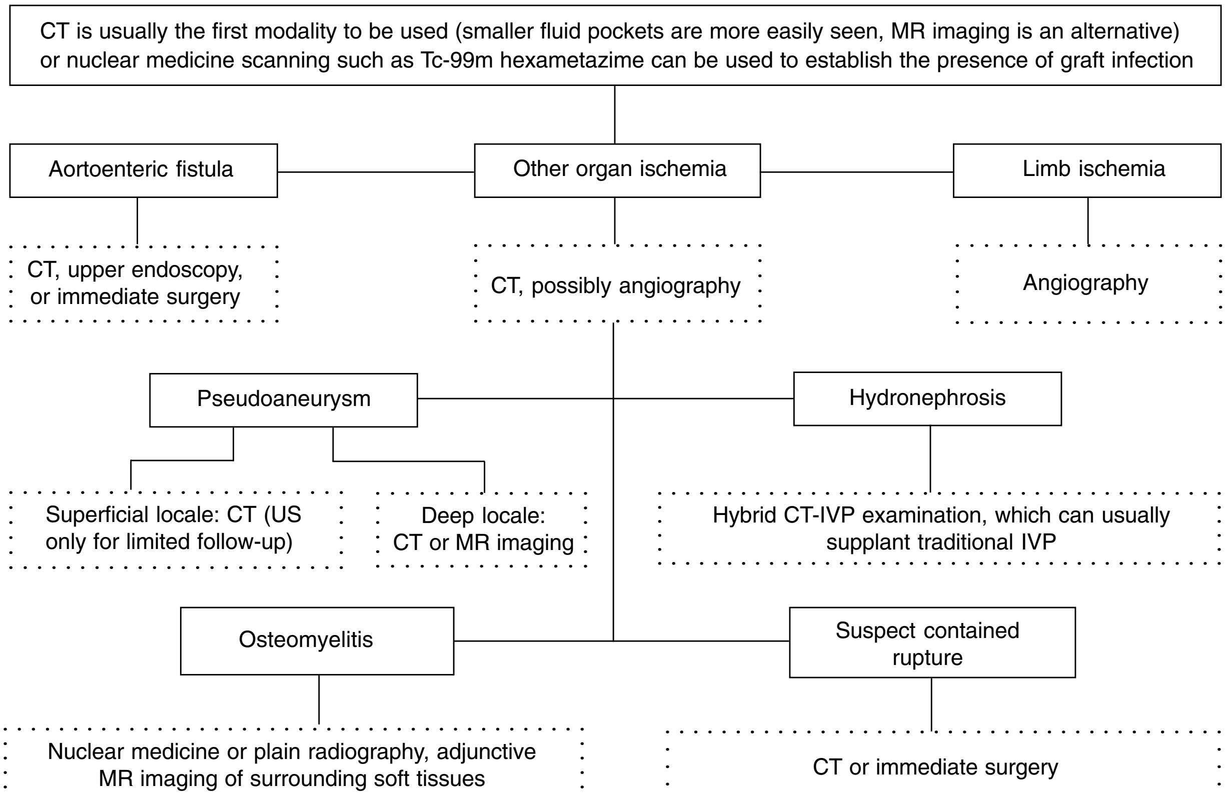


Figure 26. Algorithm for the work-up of various complications of graft infection. The algorithm is used in cases with a high clinical index of suspicion based on physical examination results, history, or laboratory values (viz, elevated WBC count and sedimentation rate). *IVP* = intravenous pyelography.

sinography, US, and nuclear medicine allows detection and staging of graft infections and is an integral part of the surgical management of this condition (Fig 26).

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