Abdominal Aortic Aneurysms

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Nursing & Cath Lab Symposium

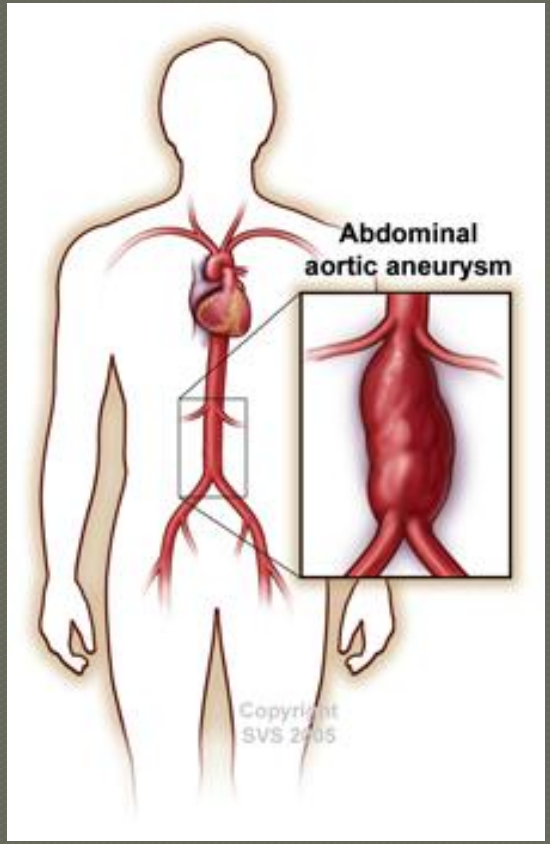
August 26, 2011

Abdominal Aortic Aneurysms

- Definition
- History
- Epidemiology
- Pathophysiology
- Signs and Symptoms
- Evaluation
- Management
- Complications
- Outcomes

Definition

- Aneurysm
  - Focal dilatation of an artery at least 50% greater than its normal diameter
  - Abdominal aortic aneurysms typically are at least 3 cm in size



History

- First described in 16th century by Vesalius
- Initial attempts at repair were ligation, first successfully done by Matas in1923
- 1948 – Rea wrapped aneurysm in cellophane
- 1949 – Nissen treated Einstein with wrapping of aneurysm
  - Einstein died 6 years later of ruptured AAA

History

- 1951 – Resection and graft replacement
  - Dubost and coworkers first reported it
  - Shaffer and Hardin actually did it first
- Current open repair with endoaneurysmorrhaphy and graft placement popularized by Creech, DeBakey, and their colleagues
- 1991 – Endovascular stent grafting successfully performed by Parodi

Epidemiology

- Generally affect elderly white men
  - Increase in frequency after age 50
  - Five times more common in men
  - 3.5 times more common in white men
- Usually begin developing in men at age 50 and in women about age 60
- AAA ≥ 3 cm prevalence of 3-10%
- 15-25% of patients undergoing AAA repair have 1st degree relative with AAA
- May be present in up to 85% of patients with femoral aneurysms and up to 62% in patients with popliteal aneurysms

Epidemiology

Risk Factor	Odds Ratio
Smoking history	5.6
Family history of AAA	2.0
Older age (per 7-year interval)	1.7
Coronary artery disease	1.6
Hypercholesterolemia	1.5
COPD	1.3
Height (per 7-cm interval)	1.2

From Lederle, *et al*. Prevalence and associations of abdominal aortic aneurysm detected through screening: Aneurysm Detection and Management (ADAM) Veterans Affairs Cooperative Study Group. Ann Intern Med 126(6): 441, 1997.

Epidemiology

Risk factors for aneurysm development, expansion, and rupture

Symptom	Risk Factors
AAA Development	Tobacco use
	Hypercholesterolemia
	Hypertension
	Male gender
	Family history (male predominance)
AAA Expansion	Advanced age
	Severe cardiac disease
	Previous stroke
	Tobacco use
	Cardiac or renal transplant
AAA Rupture	Female gender
	Decreased FEV1
	Larger initial AAA diameter
	Higher mean blood pressure
	Current tobacco use (length of time smoking >> amount)
	Cardiac or renal transplant
	Critical wall stress – wall strength relationship

Pathophysiology

- Degenerative process
  - Often attributed to atherosclerosis
- Significant decrease in elastin content in aortic wall at infrarenal level
  - Elastin not synthesized in adult aorta
    - Half-life of 40-70 years, accounts for reduction with age
- Other potential causes include hemodynamic, structural, autoimmune factors

Pathophysiology

- Increased expression and activity of matrix metalloproteinases (MMPs) in wall of aortic aneurysms
- Infectious organisms found in aneurysm wall, specifically *Chlamydia pneumoniae*

*No isolated factor yet identified as single cause of degenerative AAA

Pathophysiology

- Other less frequent causes
  - Infection
  - Cystic medial necrosis
  - Arteritis
  - Trauma
  - Inherited connective tissue disorders
  - Pseudoaneurysms from anastamotic disruption

Signs and Symptoms

- Usually asymptomatic
- Pulsatile mass on physical exam
- Incidental finding on imaging
- Back or abdominal pain*
  - If tenderness is elicited with palpation of aneurysm, suggests symptomatic aneurysm
- Acute thrombosis with ischemic legs*
  - Possible associated paraplegia from spinal cord ischemia
- Ischemic toes with embolism*
- Rupture†
  - More than half of ruptures die prior to hospitalization
  - Of those that reach OR, mortality with open repair is ~50%

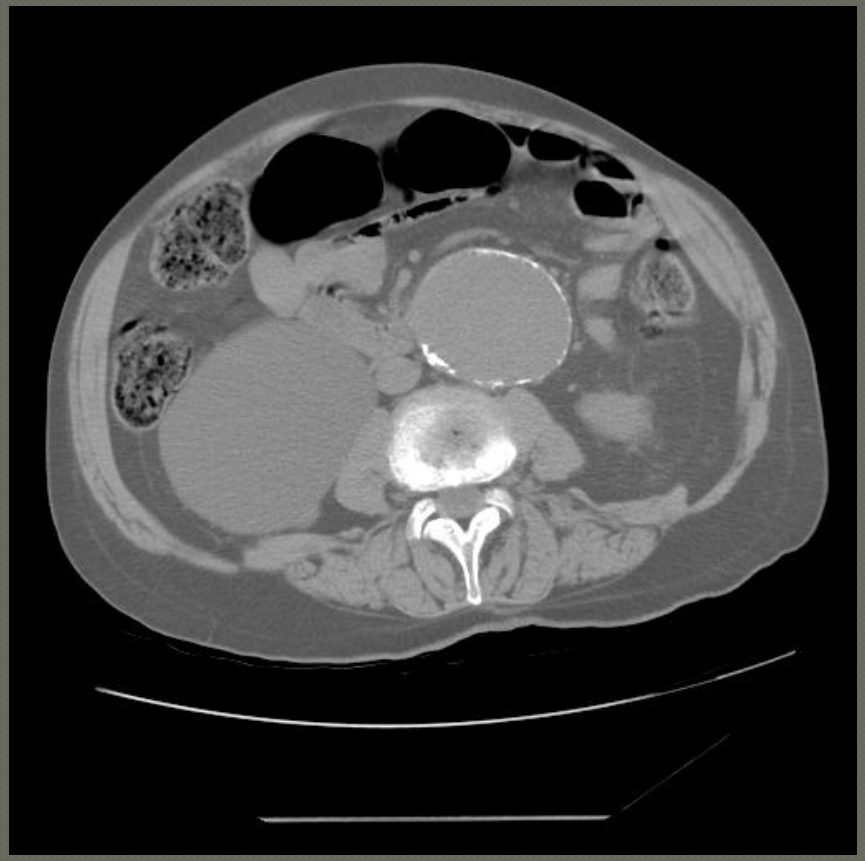
Require *urgent or †emergent repair

Signs and Symptoms

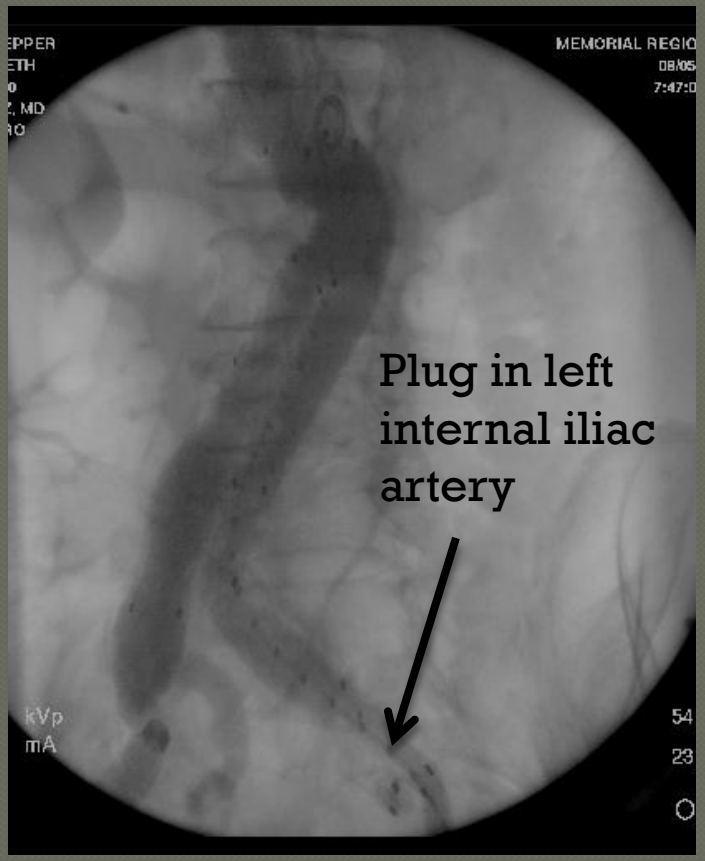
- Thin patient with large pulsatile mass

Signs and Symptoms

- Patient without knowledge of aneurysm
- Presented to ER with back and abdominal pain
- Tender over aneurysm
- Suggestive of symptomatic aneurysm



Signs and Symptoms



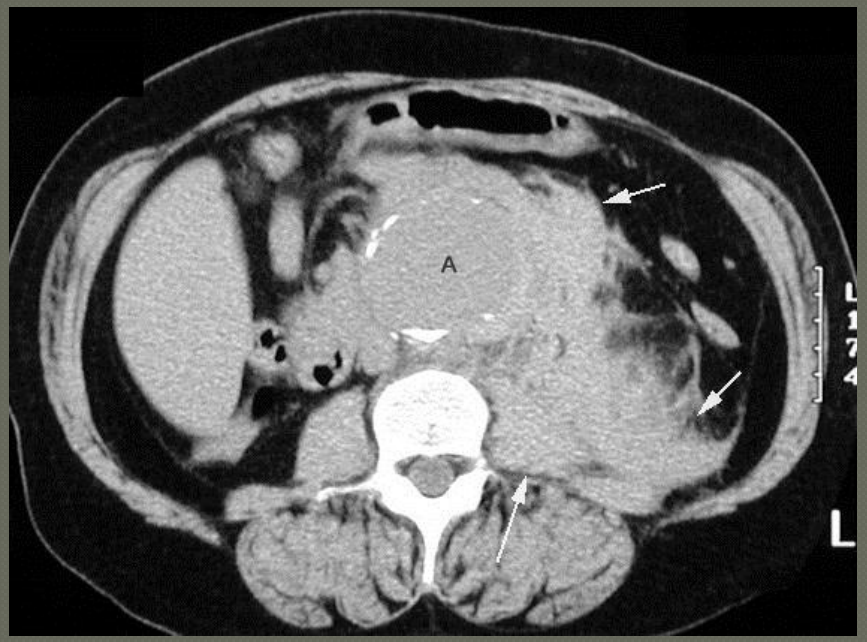
- Underwent urgent endovascular repair within 24 hours
- Required exclusion of left hypogastric artery

Signs and Symptoms

- Aneurysm with distal emboli
- "Trash foot"
- Cholesterol emboli (atheroemboli) to toes and feet
- Livedo reticularis

Signs and Symptoms

- Presented to ER with back pain and hypotension
- Ruptured aneurysm until proven otherwise
- CT Scan confirmed suspicion



Evaluation

- Physical exam
  - Pulsatile mass
    - Size
    - Tenderness
      - Back or abdomen
  - Always check peripheral pulses
- Ultrasound
- CT Scan
- MRA
  - Least used imaging modality for AAA

Evaluation

- Pulsatile mass
  - Focused exam detects about 50% of AAA 3.5 – 6 cm in diameter
  - Positive predictive value of physical exam for identifying AAA larger than 3.5 cm only 15%
  - Chervu*
    - 38% of 243 patients undergoing elective AAA repair were initially detected by physical exam
    - 62% detected by incidental radiologic studies
      - 43% of these were palpable on subsequent exam
    - 23% of all clinically significant AAA not palpable even when diagnosis was known
    - 2/3 of AAA in obese patients not palpable

*Chervu, A, *et al*. Role of physical examination in detection of abdominal aortic aneurysms. Surgery 117:454,1995.

Evaluation

- Ultrasound
  - Sensitivity and specificity approach 100%
  - Aorta cannot be visualized in 1-3% of patients due to bowel gas or obesity
  - Ideal for screening, but can be imprecise in measuring aneurysm size
    - Technologist dependent
  - Aneurysm growth rate of > 0.7 cm per 6 months or 1 cm per year suggested as threshold for proceeding to surgery

Evaluation

- CT Scan
  - Primary imaging modality for surgical planning
  - IV contrast is preferred to better delineate anatomy
- CT-Angiography
  - Best imaging modality to plan procedure
  - Stent graft protocol
    - Specific imaging protocol to plan endovascular repair
    - Slice thickness and contrast dose/timing considerations
  - Can also image legs simultaneously if lower extremity occlusive disease is concern on physical exam

Evaluation

Evaluation

- Aneurysm Screening Recommendations
  - One time ultrasound for:
    - All men older than 65
    - Men 55 years old with family history
    - Women 65 or older who have smoked or have family history

Management

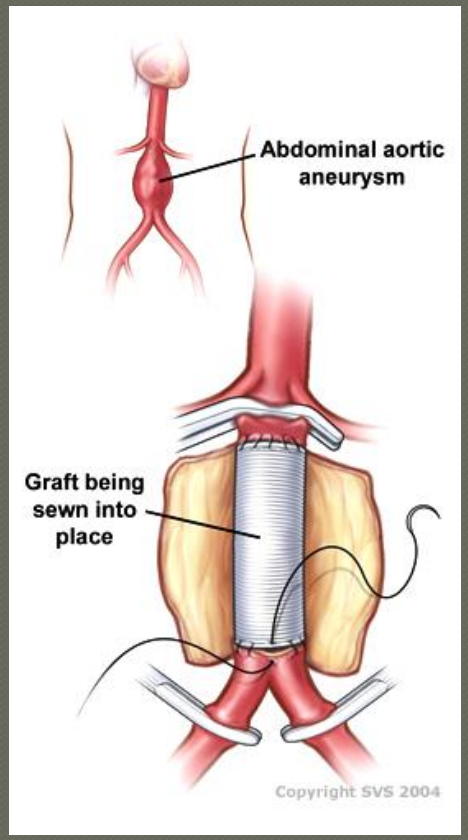
- Aneurysm Surveillance
  - Imaging at 12-month intervals for 3.5 to 4.4 cm
  - Imaging at 6-month intervals for 4.5 to 5.4 cm
  - 3-year intervals for 3.0-3.4 cm and 5-year intervals for 2.6-2.9 cm
- Recommendations for repair
  - Elective repair if ≥ 5.5 cm, in absence of significant co-morbidities
  - Elective repair if saccular aneurysm
  - Urgent repair if symptomatic
  - Emergent repair if ruptured

Management

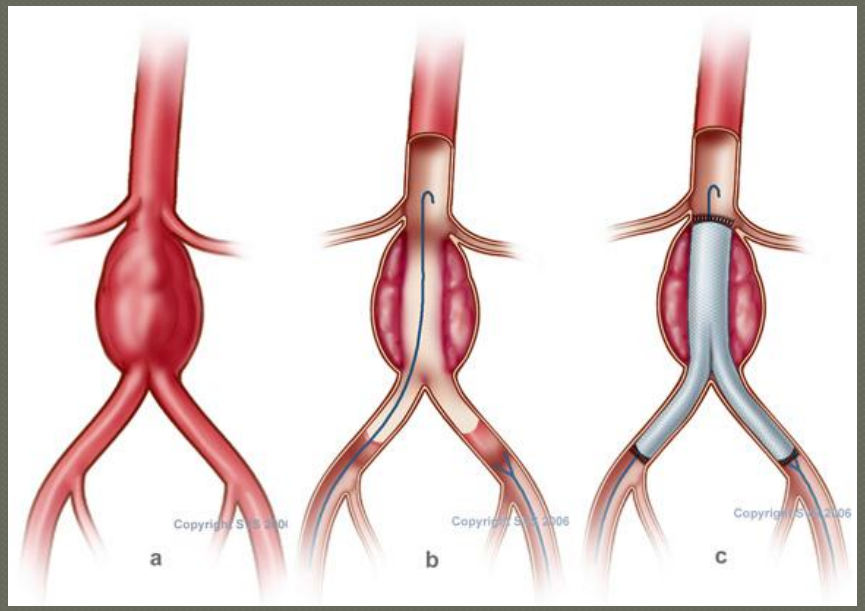
- Open versus endovascular repair
  - Open repair is traditional approach
  - Endovascular repair now commonplace
    - Accounts for over 50% of all AAA repairs
    - Has supplanted open repair as procedure of choice in most cases
    - Newer technology and refinements in devices
    - Better understanding of hemodynamic and biomechanical factors affecting use and durability
    - Will be applied to more complex anatomies
      - Branched and fenestrated endografts for visceral and iliac involvement

Management

OPEN REPAIR

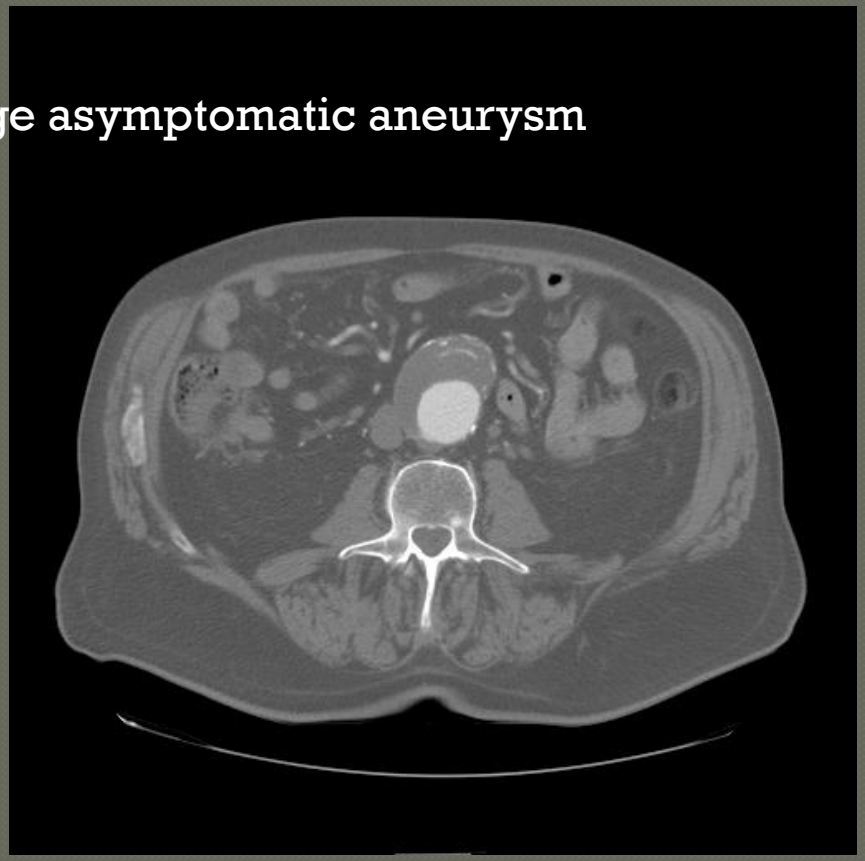


ENDOVASCULAR REPAIR

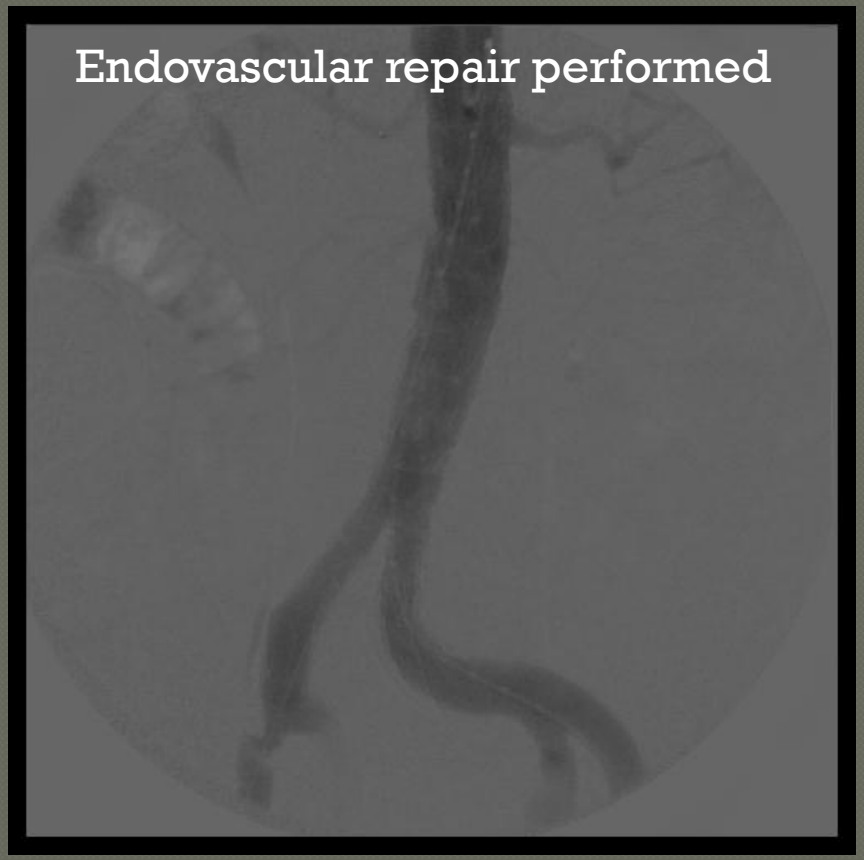


Management

83 year old man with large asymptomatic aneurysm



Management


Endovascular repair performed


Successful aneurysm exclusion
3D
DFOV 21.1 cm
SOFT
No VOI
1.2mm 1.375:1/1.2sp

Management

- Factors favoring open repair
  - Younger patient
  - Hostile proximal infrarenal aorta
  - Renal artery or visceral involvement
    - Juxtarenal or thoracoabdominal aneurysm
  - Extensive iliac occlusive disease
- Factors favoring endovascular repair
  - Medical co-morbidities
  - Hostile abdomen
  - Less surgical stress and easier recovery

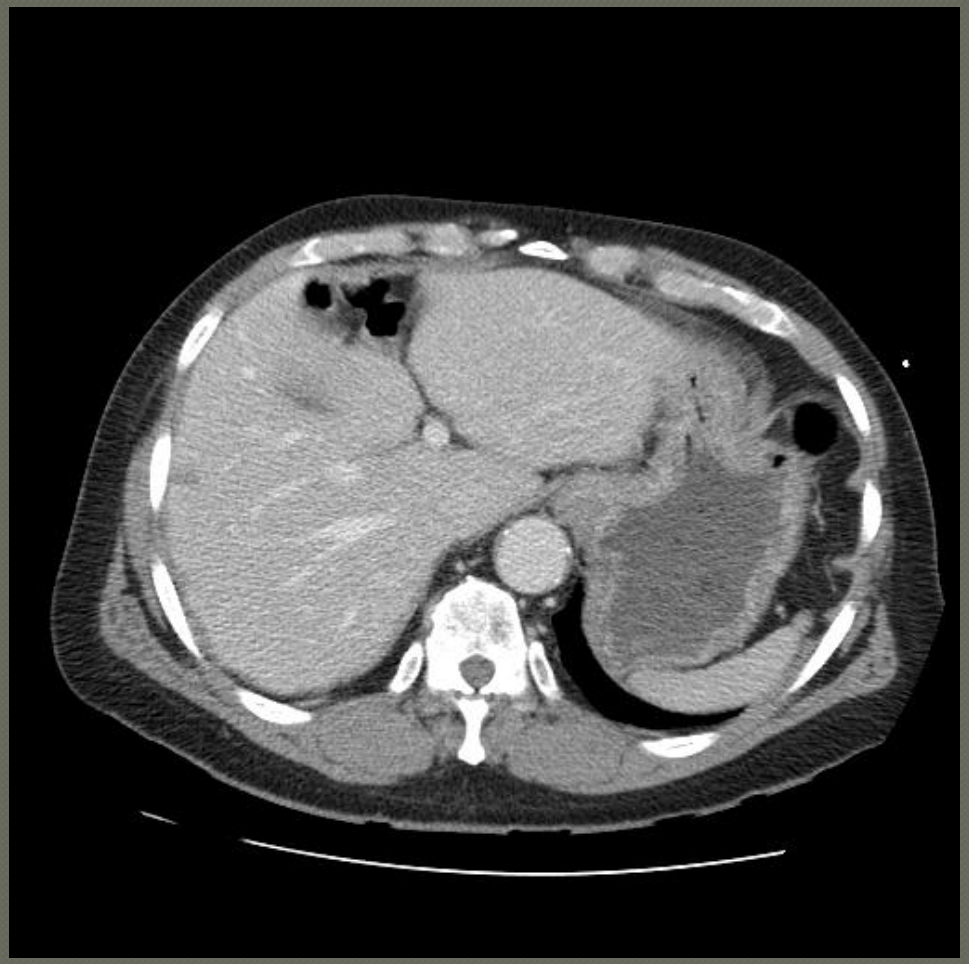
Management

- 67 year old hypertensive male
- Colon resection for carcinoma one year ago
- Known AAA with suprarenal and infrarenal component
- Underwent ultrasound a few days prior to presentation with apparently stable aneurysm

Management

- Presented to emergency room with new onset back pain
- Normotensive
- Underwent CT scan

Management



Supraceliac aorta normal

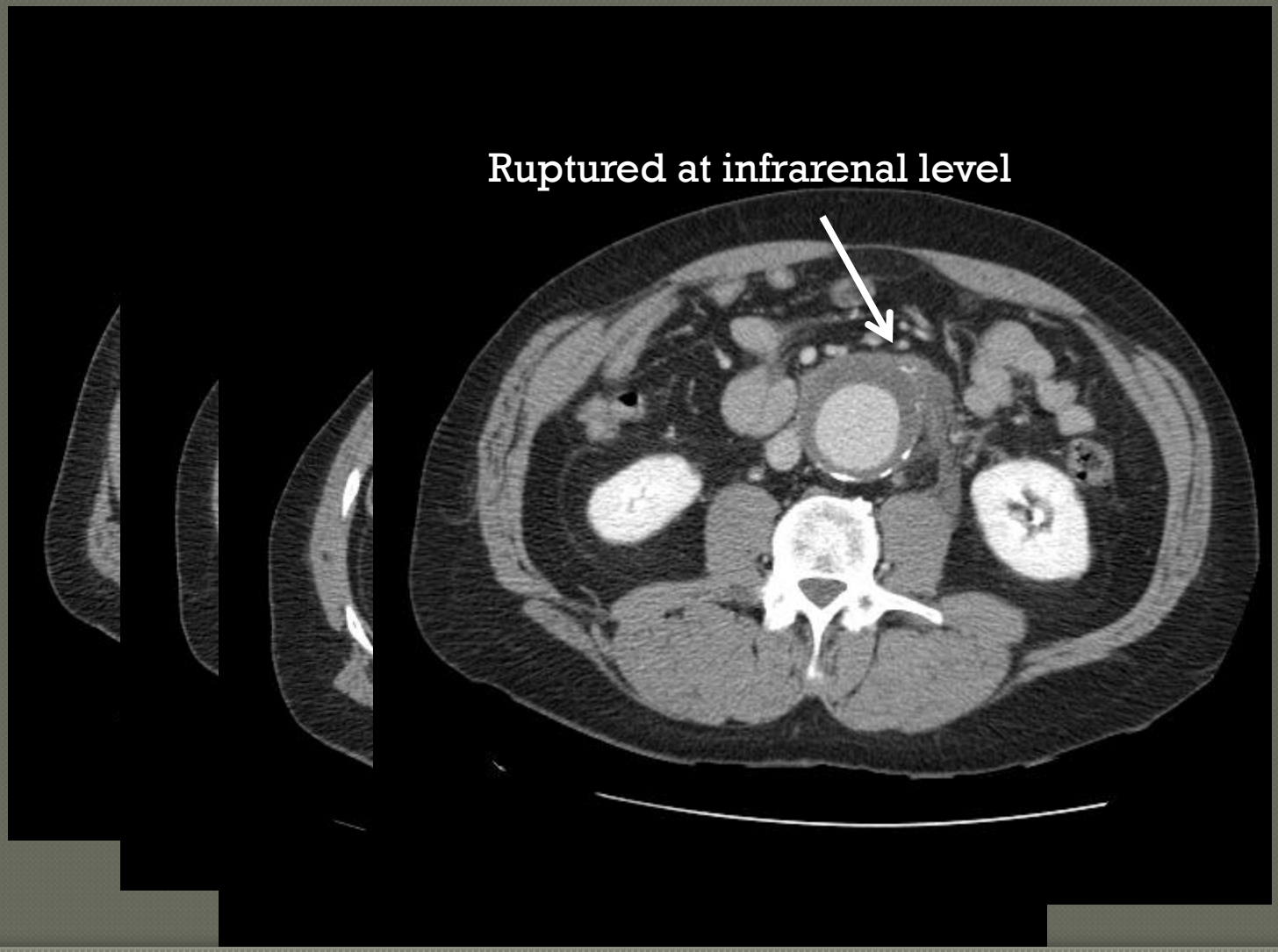
Management

Suprarenal involvement

Management

Aneurysmal at level of renal arteries

Management



Management

- Patient was taken to OR for emergent repair
- Not candidate for endovascular approach
- Retroperitoneal approach with exposure of distal thoracic aorta for proximal control
- Beveled repair of visceral/infrarenal aorta with bifurcated graft to common iliac arteries
- Unable to obtain pulses in left leg after closure, prior to leaving OR
- Performed right to left femoral-femoral bypass, with return of pulses

Management

- Prolonged ICU course with difficulty weaning from ventilator
- Failed extubation on multiple attempts
- Required tracheostomy and then rapidly improved
- Also developed wound hematoma, requiring wound care and VAC device placement
- Transferred to rehab unit soon after and then discharged home

Management

- Patient readmitted about one month later with bowel obstruction (from previous colon resection)
- CT scan obtained

Management

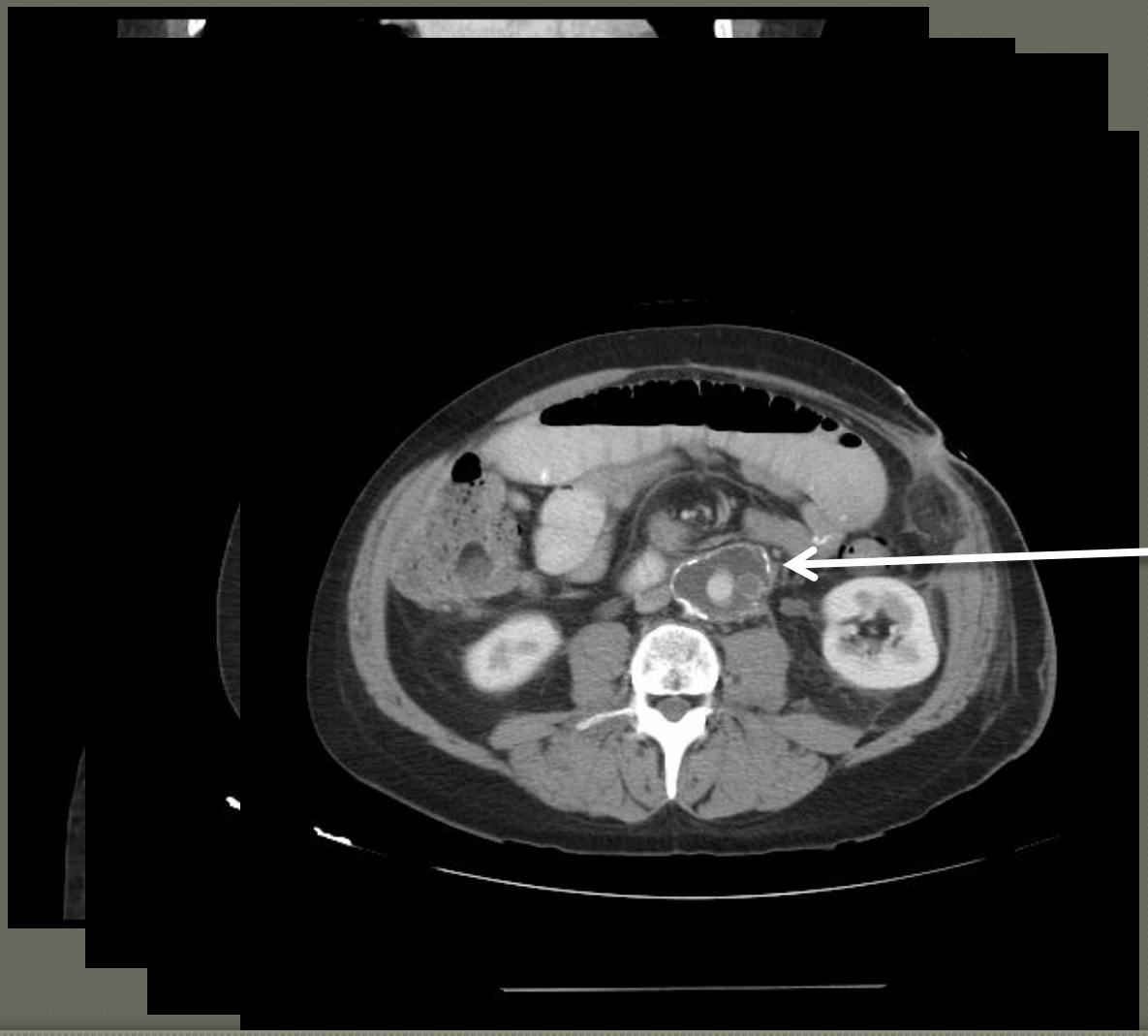
Management

Aneurysm improved at level of SMA without mural thrombus

Management

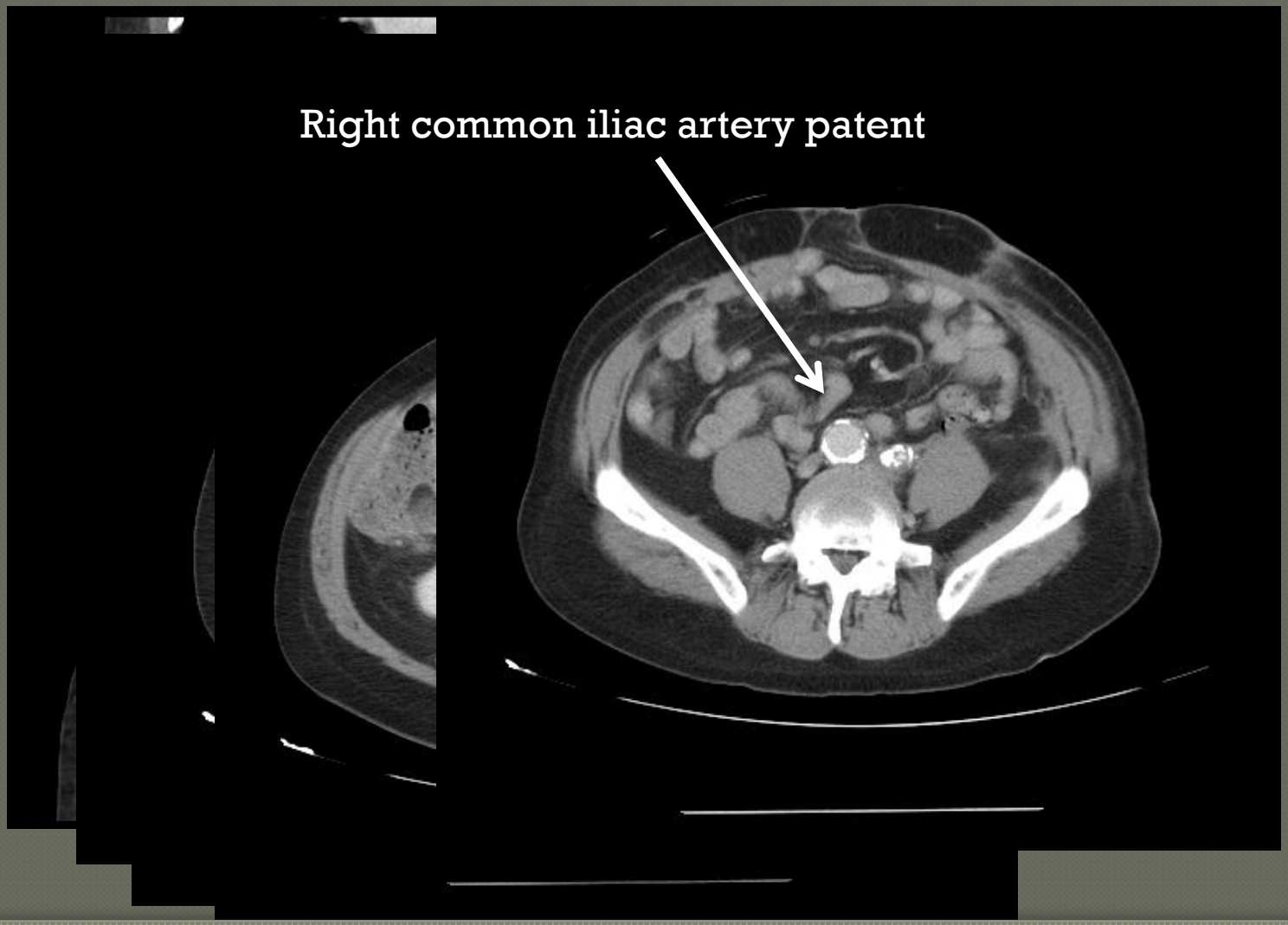
Good flow within graft below renal arteries

Management



Left limb of bifurcated graft occluded

Management



Management

Management

- 67 year old woman presented to ER with 8-12 hour history of back and abdominal pain
- Mild hypotension
- Extensive smoking history
- On exam, tender abdomen, normal right leg pulses, absent left leg pulses
- CT scan performed in ER

Management

- CT scan showed ruptured AAA and left external iliac artery occlusion
- Based on these findings, taken to OR for endovascular repair

Large retroperitoneal hematoma

Management

- Underwent aorto-uni-iliac graft placement, exclusion of left common iliac artery and femoral-femoral bypass
- Successful exclusion of aneurysm
- Required left brachial thrombectomy on postoperative day one
- Discharged home on postoperative day 4

Management


Volume Rendering No cut
DFOV 16.2 cm
SOFT
No VOI
1.2mm 1.375:1/1.2sp
W = 700 L = 200


Volume Rendering No cut
DFOV 23.0 cm
SOFT
No VOI
W = 700 L = 200

Management

- Perioperative considerations in open repair
  - Cardiac Disease
    - Coronary revascularization if:
      - Acute STEMI, unstable angina, stable angina with left main or 3-vessel disease
      - Stable angina with 2-vessel disease that includes LAD and either ischemia on noninvasive testing or EF < 0.5
    - Preferable to wait 4-6 weeks after bare metal stent or CABG or 12 months after DES
    - Continue β-blockers if used for angina, arrhythmias, or hypertension

Management

- Pulmonary Disease
  - Smoking cessation is recommended for at least two weeks prior to aneurysm repair
  - Bronchodilators recommended for at least two weeks prior to repair for symptomatic COPD or abnormal PFTs
- Renal Impairment
  - Hold ACE-inhibitors and ARBs the morning of surgery and restart when patient is euvolemic
  - Preoperative hydration
  - Intraoperative diuresis with furosemide or mannitol probably does not reduce risk of postoperative renal insufficiency

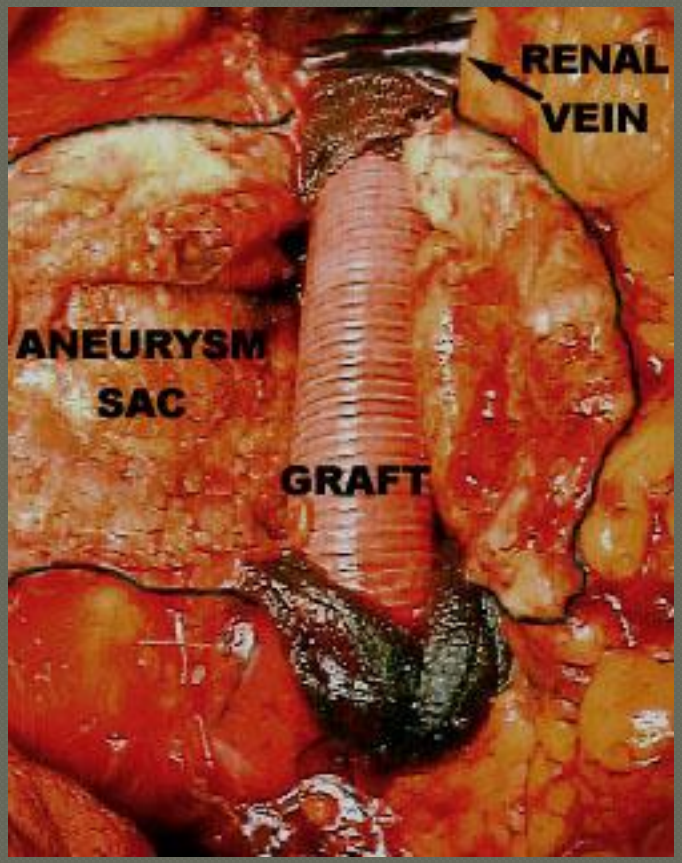
Management

- Diabetes
  - Maintain blood glucose below 180 mg/dL
- Hematologic disorders
  - Should transfuse if preoperative hematocrit less than 28%
    - Decreases risk of postoperative MI
  - Further assessment is recommended if preoperative platelet count less than 130,000/μL

Management

Mobilization of aneurysm

Open repair requires full laparotomy



Tube graft replacement

Management

- Anesthetic
  - General anesthesia for open repair
  - Select cases can be done with epidural agents
    - Retroperitoneal approach or "mini-laparotomy"
  - General or locoregional anesthesia for endovascular repair
- Antibiotics
  - First generation cephalosporin, or if allergic, vancomycin within 30 minutes of skin incision
  - Should be discontinued within 24 hours

Management

- Intraoperative blood conservation
  - Cell saver recommended for all cases
  - Transfusion recommended for hematocrit < 30% in presence of ongoing blood loss
  - If intraoperative hematocrit < 30% and blood loss is ongoing, use of FFP and platelets in a ratio of 1:1:1 should be considered

Management

- Intra- and postoperative cardiovascular monitoring
  - PA catheters should not be routinely used
  - Central venous catheters should be routinely used
  - ST segment monitoring in all cases of open repair and select cases of endovascular repair
  - Monitor troponins postoperatively in cases of EKG changes or chest pain after repair

Management

- Body temperature
  - Core body temperature should be maintained at or above $36^{0}C$ throughout repair
- ICU Care
  - Most open repair patients should be monitored in ICU following open repair
  - Select patients should be monitored in ICU after endovascular repair

Management

- Nasogastric decompression
  - Intraoperative use in all patients undergoing open repair and in select (most) patients postoperatively
- Nutrition
  - Elective repair should not be performed unless nutritional status is optimized
  - Parenteral nutrition recommended in patients unable to tolerate enteral support seven days after open or endovascular repair

Management

- Postoperative pain management
  - Epidural anesthetic or IV PCA for open repair
  - Oral or IV analgesics usually adequate following endovascular repair
  - Intramuscular opiates not recommended
- DVT prophylaxis
  - SCDs and early ambulation for all patients undergoing AAA repair
  - Low-dose (subcutaneous) heparin prophylaxis for patients at high risk for DVT

Complications

Complication	Frequency (%)
All cardiac	15
Myocardial infarction	2-8
All pulmonary	8-12
Pneumonia	5
Renal insufficiency	5-12
Dialysis	1-6
Bleeding	2-5
Wound infection	<5
Leg ischemia	1-4
Deep venous thrombosis	5-8
Colon ischemia	1-2
Stroke	1-2
Graft thrombosis	<1
Graft infection	<1
Ureteral injury	<1

From Schermerhorn ML, Cronenwent JL. Abdominal aortic and iliac aneurysms. In: Rutherford RB, editor. Vascular surgery, 6th ed. Philadelphia: Elsevier Saunders, 2005. p. 1431

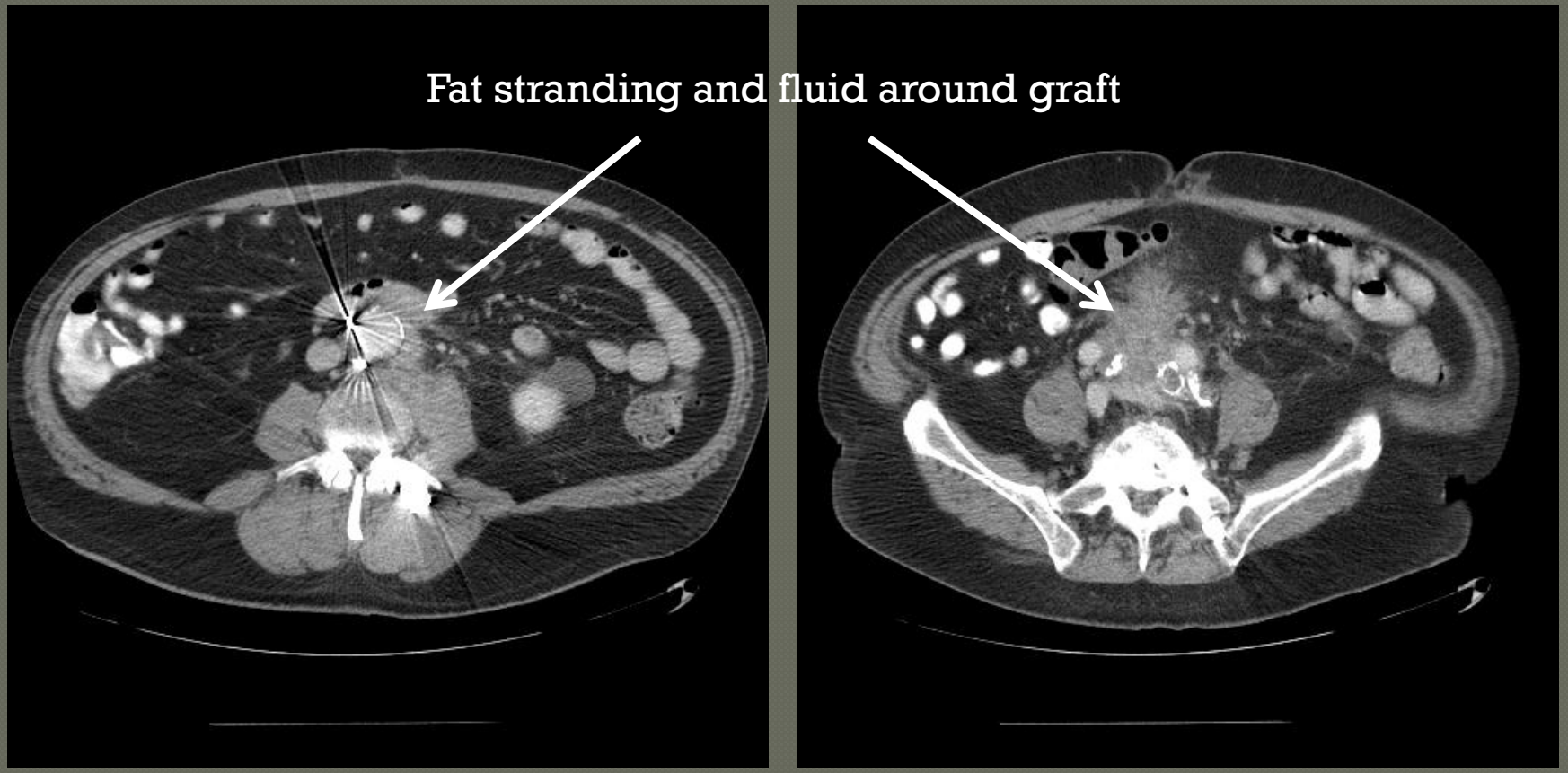
Complications

- Mortality
  - Selected centers of excellence report 1-4% for elective infrarenal AAA repair
  - Population-based series report 4-8%
  - Higher-volume centers have lower AAA mortality rate than lower volume centers
  - Surgeon volume impacts mortality rate
  - Vascular surgeons (4.4%) have lower mortality rate than cardiothoracic surgeons (5.4%) and general surgeons (7.3%)

Complications

- Graft infection
  - Patient underwent AAA repair with aortobifemoral bypass graft several months earlier at another institution
  - Persistent low-grade leukocytosis and malaise
  - Treated with steroids for polymalgia rheumatica by PCP
  - Admitted via ER and CT Scan obtained

Complications



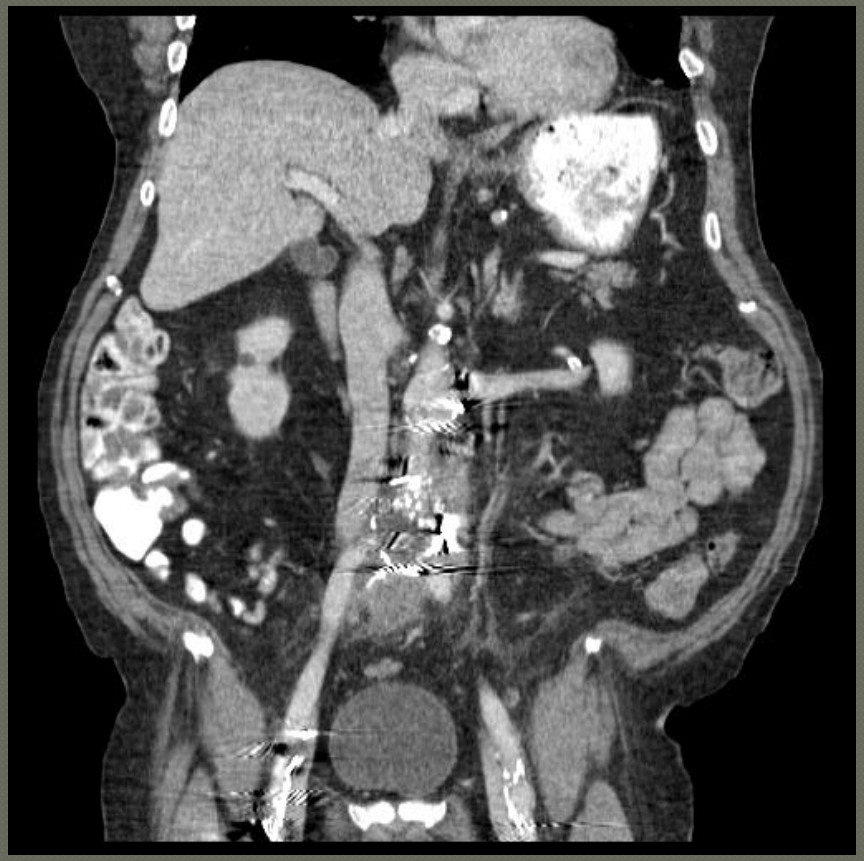
Complications

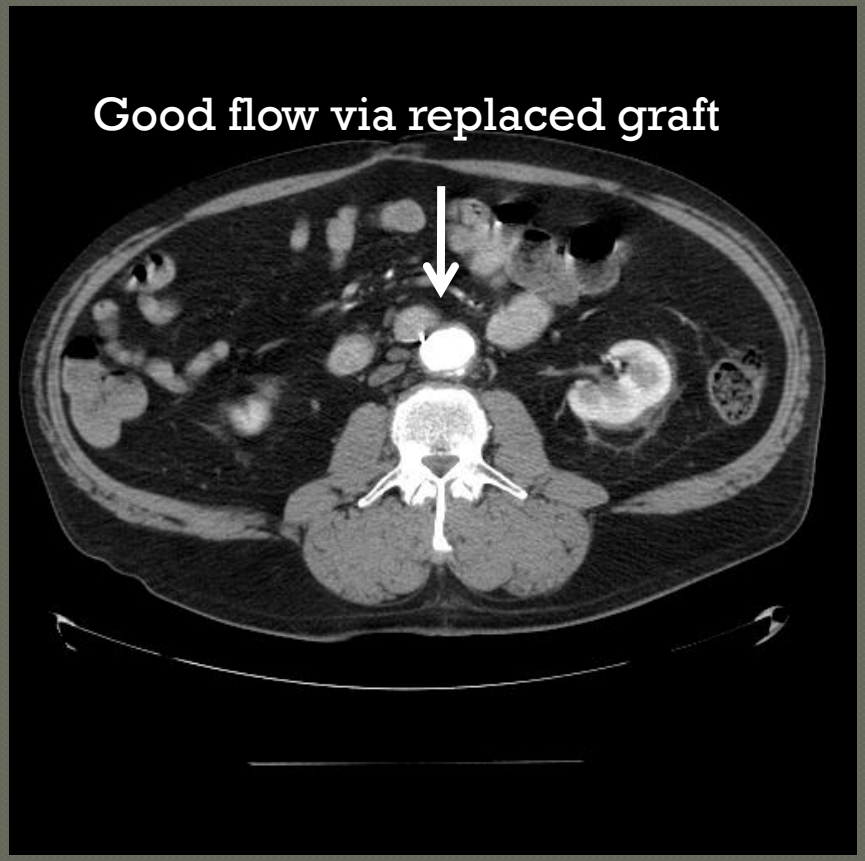
- Repair Options
  - Removal of infected graft and extra-anatomic bypass
    - Axillofemoral bypass
    - Oversewing of aortic stump
  - Removal of infected graft and direct repair
    - Cryopreserved tissue graft
    - Antibiotic soaked prosthetic graft
    - Autologous femoral-popliteal vein reconstruction

Complications

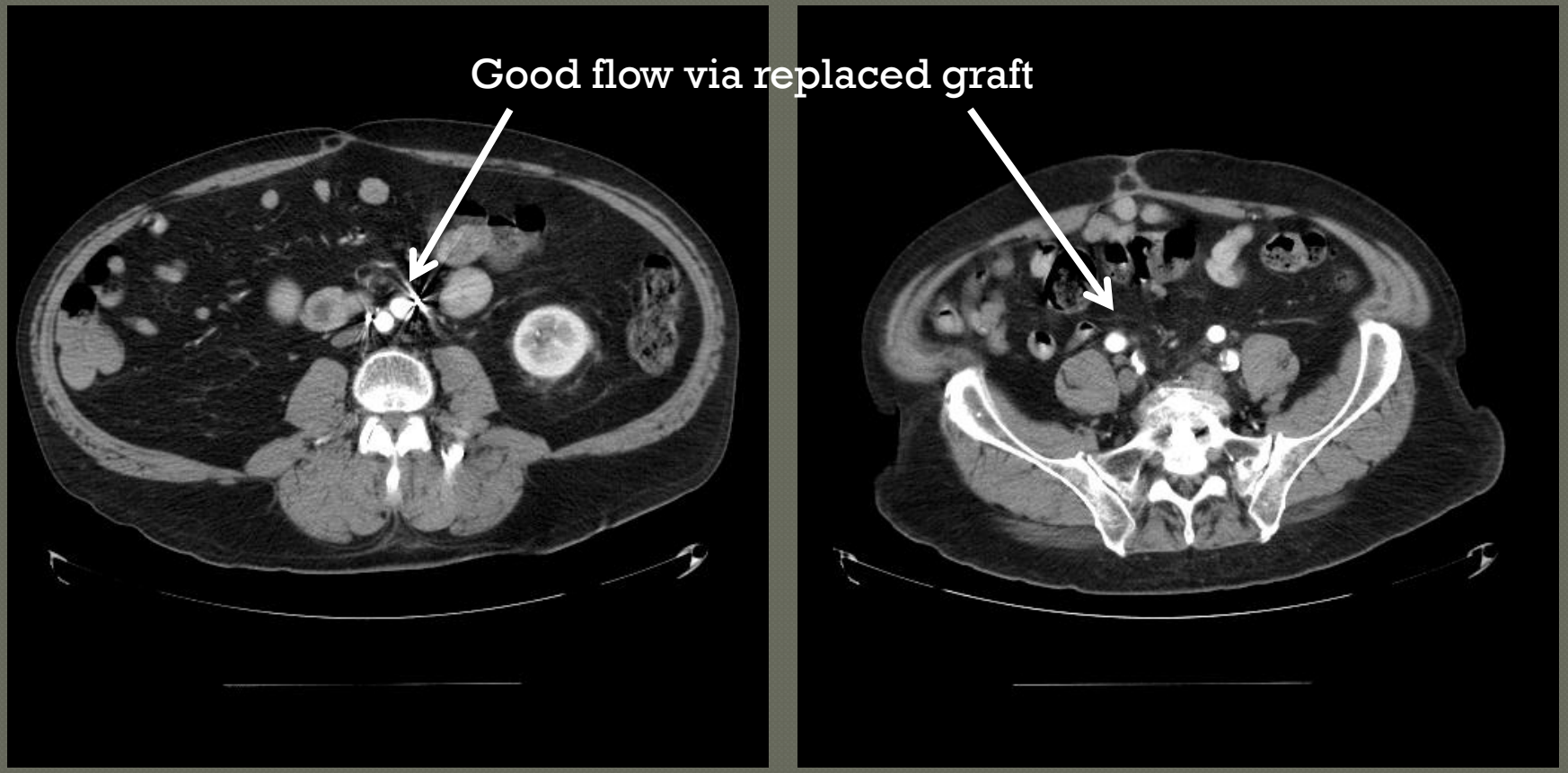
- Taken to OR for bilateral femoral-popliteal vein harvest and graft excision
- Aortoiliac reconstruction with aortobifemoral bypass graft composed of bilateral femoral veins
- Remained hospitalized for approximately ten days post-operatively
- No significant lower extremity edema and normal pedal pulses at follow-up

Complications





Complications



Complications

- Endovascular Repair
  - Most acute complications are due to groin wound issues
  - Mortality should be less than 3%
  - Endoleaks remain problematic
    - Type I – proximal or distal graft-vessel interface
    - Type II – collateral branches feed into sac
    - Type III – graft component separation or tears
    - Type IV – graft permeability
    - Type V – sac expansion without identified leak (Endotension, not seen with current devices)

Complications

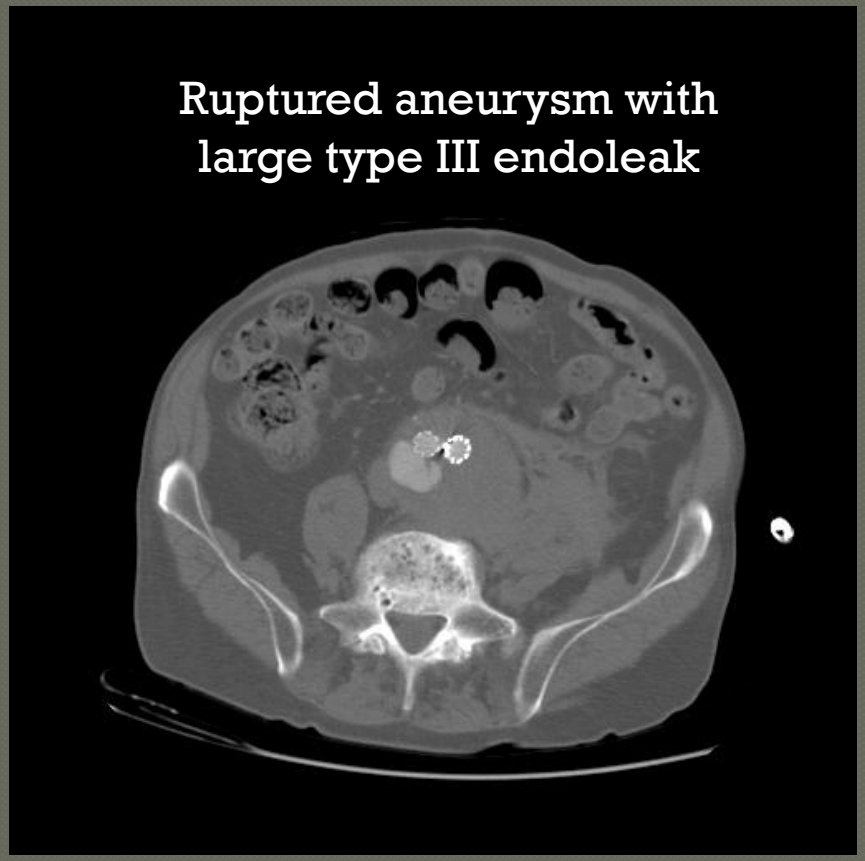
- Endovascular Repair
  - Type I
    - Should be treated when identified
      - Proximal stent or balloon often seals leak
      - If leak persists, will require conversion to open repair
  - Type II
    - Most common type of endoleak
    - Should be treated if aneurysm sac expansion is identified
    - If sac regression occurs, do not need treatment
    - Controversy remains regarding stable sac size

Complications

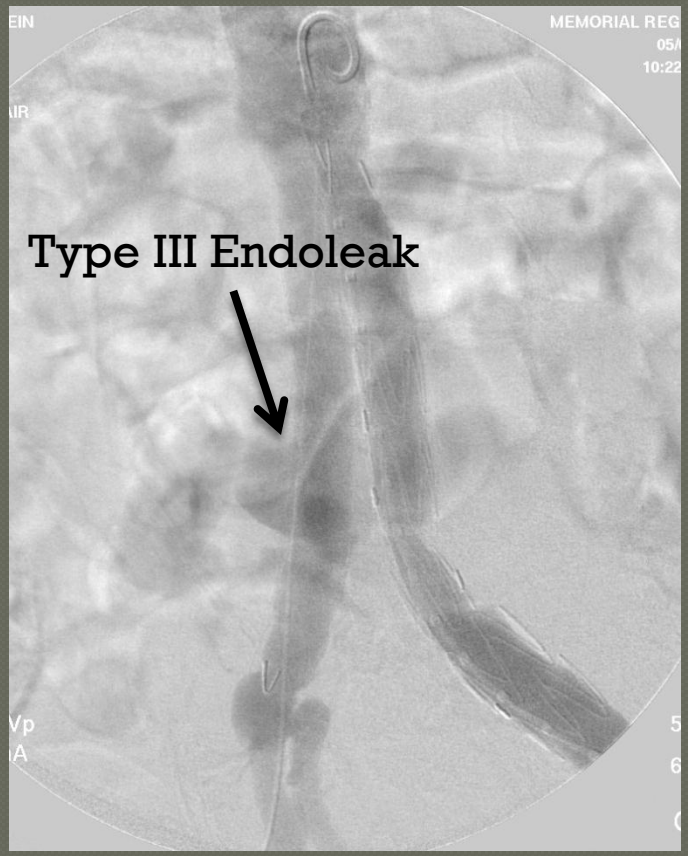
- Endovascular Repair
  - Type III
    - Should be treated
  - Type IV
    - Typically resolve after discontinuation of intraoperative heparin
    - Do not require treatment
  - Secondary interventions range from 9% to 35% over 1-3 years
    - To some degree, represents a moving target of indications for interventions as technology and understanding evolve

Complications

- 85 year old man underwent endovascular aneurysm repair several years earlier in New York
- Presented to ER with abdominal pain and hypotension
- CT scan obtained



Complications

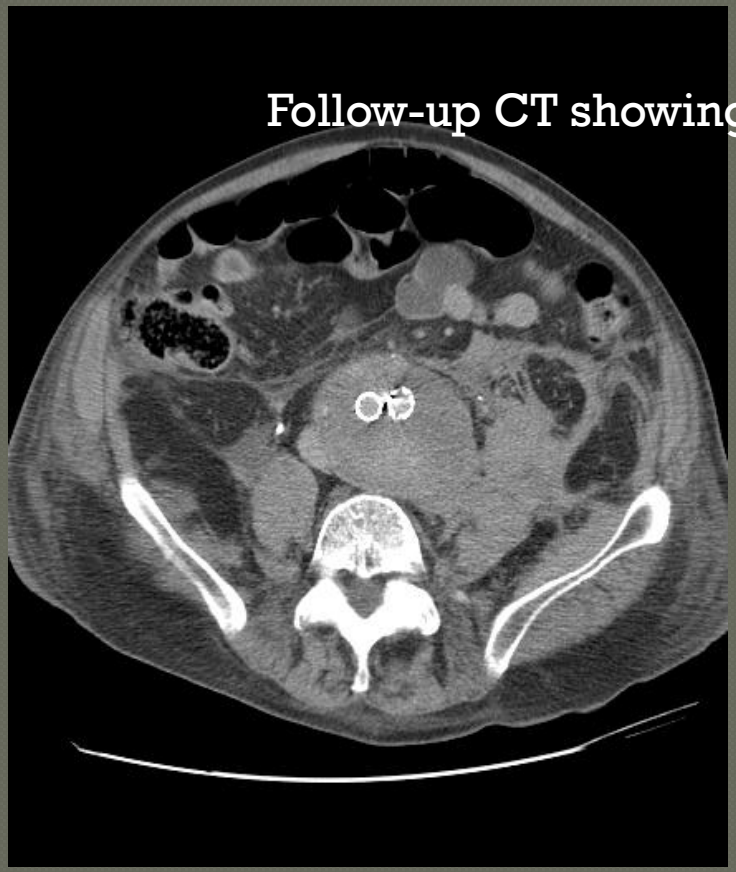


- Taken to OR
- Right femoral cutdown
- Angiogram via left femoral sheath
- Endoleak at right limb overlap identified

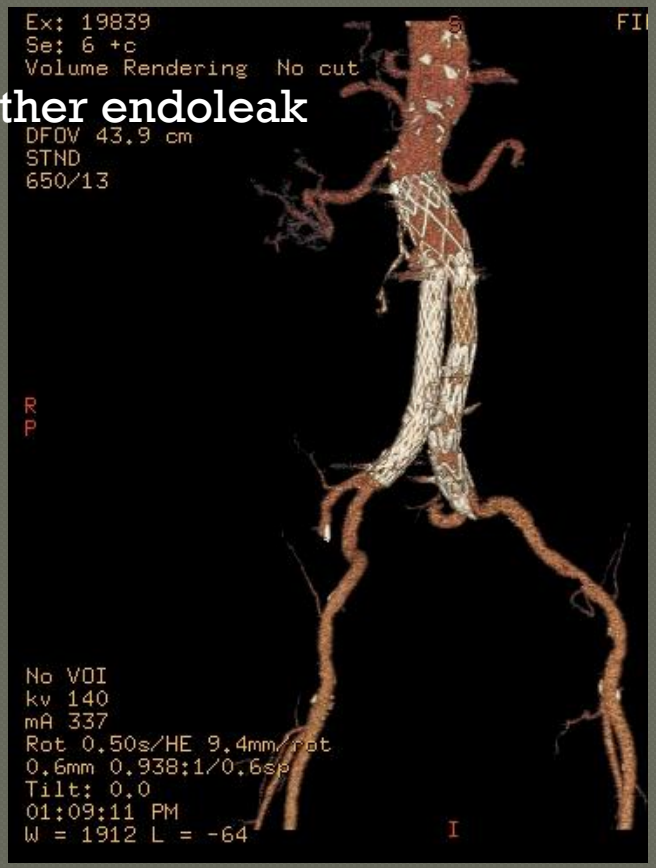
Complications

- Placement of new graft limb
- Successful exclusion of endoleak

Complications

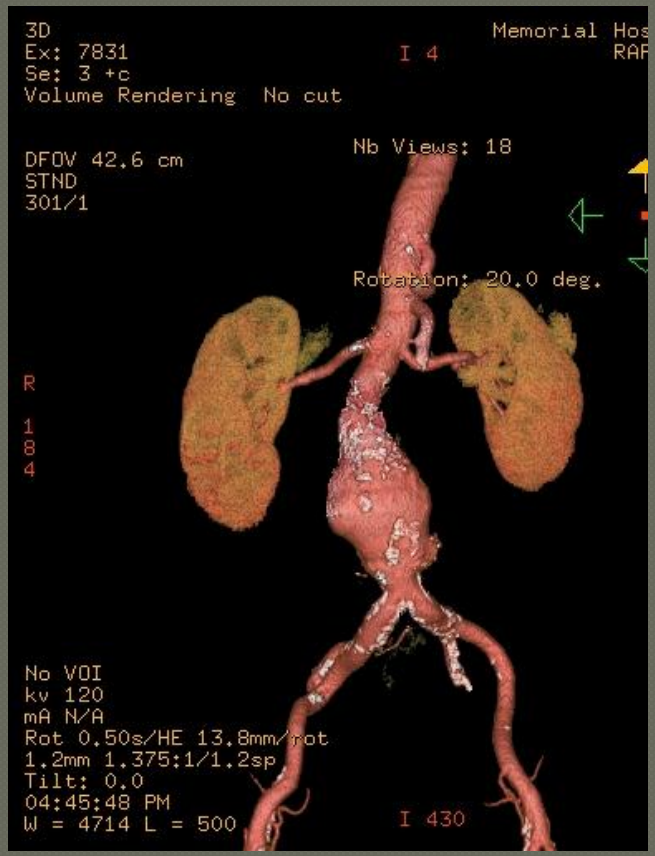


Follow-up CT showing no further endoleak

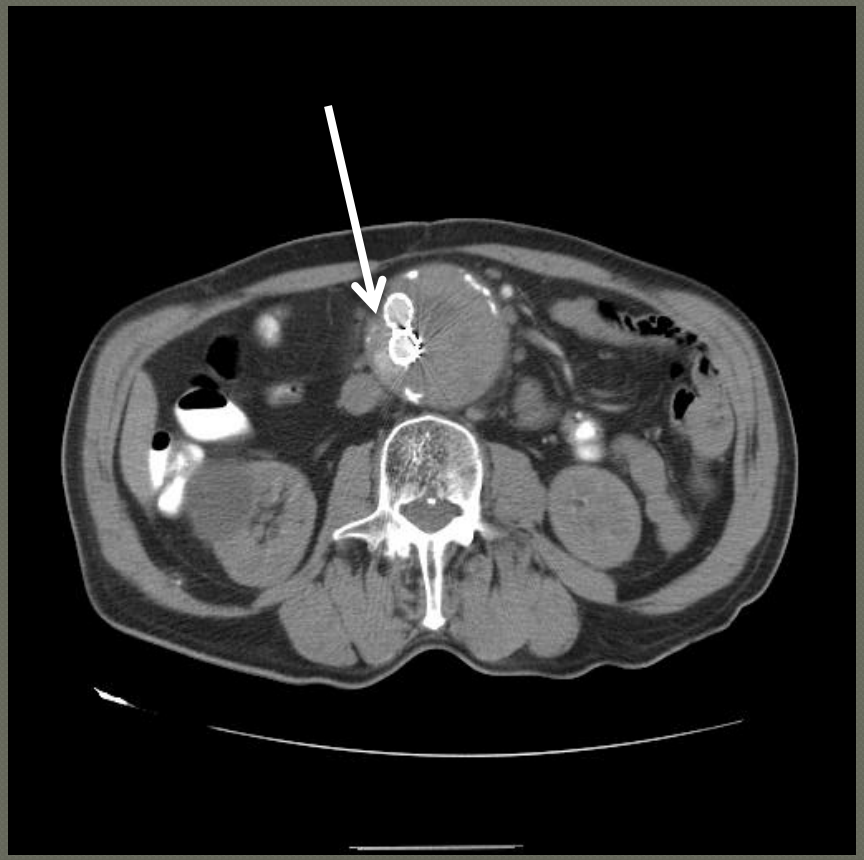


Complications

- 77 year old underwent endovascular aneurysm repair six years ago
- Lost to follow-up
- CT scan performed for abdominal pain



Complications



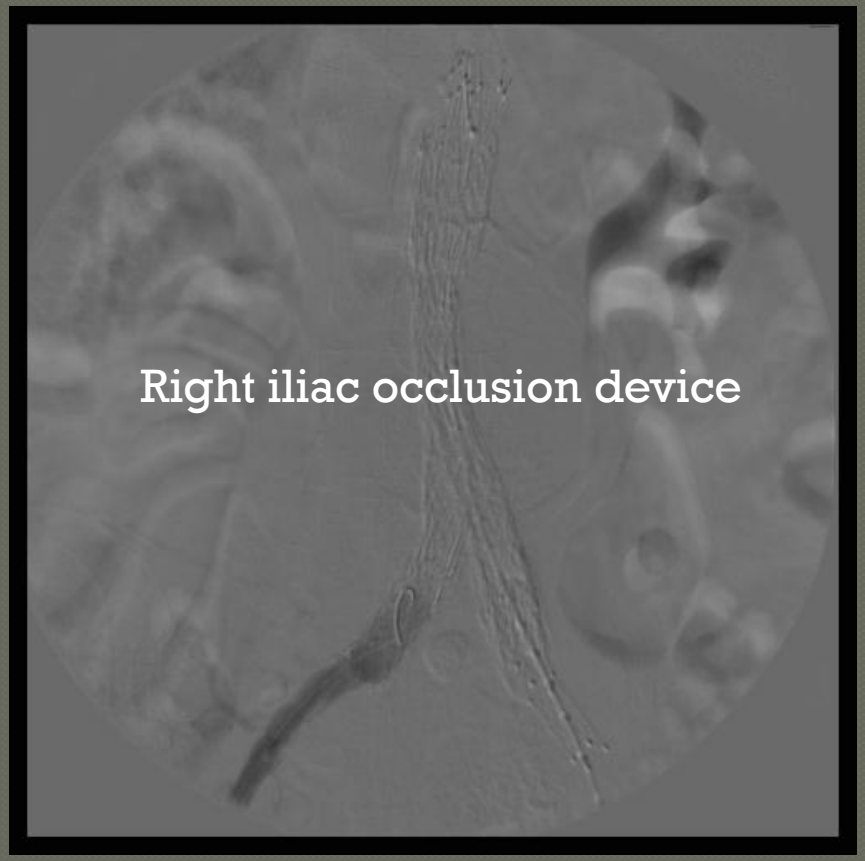
- CT scan revealed contrast extravasation into sac
- Underwent angiogram to identify source of endoleak

Complications

- Multiple images obtained
- Type III endoleak at bifurcation (flow-divider)
- Options
  - Endovascular conversion and femoral-femoral bypass
  - Conversion to open repair with graft explantation

Complications

Aorto-uni-iliac device into left limb



Right iliac occlusion device

Complications

- Aorto-uni-iliac endovascular conversion
- Endoleak resolved
- Femoral-femoral bypass graft to restore flow to right leg
- Discharged home on post-operative day two

Complications

- Additional endovascular issues
  - Device migration, graft limb occlusion
  - Post-operative fever not uncommon
    - Due to sac thrombosis
  - Need for long-term surveillance
    - Currently requires serial CT scans
      - 1 month, (6 months), annually
      - May be followed by ultrasound under specific circumstances (severe renal dysfunction)

Outcomes

- Long-term outcome of open repair better than endovascular repair
  - Need for reintervention higher in endovascular group
  - Mortality curves cross at about 5-6 years

The future

- Initial report by Parodi recommended stent grafts be used for patients unfit for open repair
  - Was he right?
  - Have we gone to far?
  - Should repair be offered to everyone?
  - What's next?

The future

- Endovascular technologies advancing
  - Branch grafts and fenestrated grafts for visceral aorta
  - Ascending aorta and aortic arch stent grafts
  - Endovascular "glue" to fill sac
  - Smaller introducer sheaths allow for fully percutaneous delivery

Questions