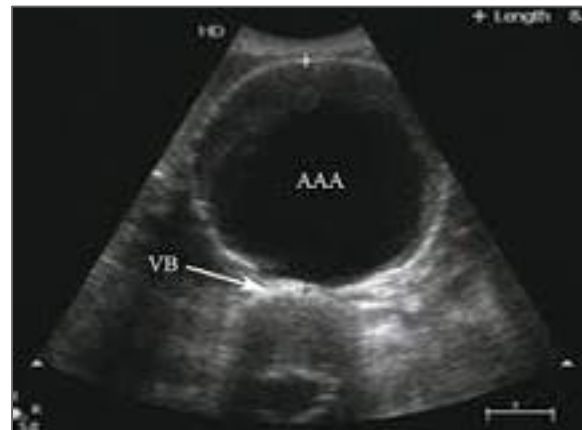
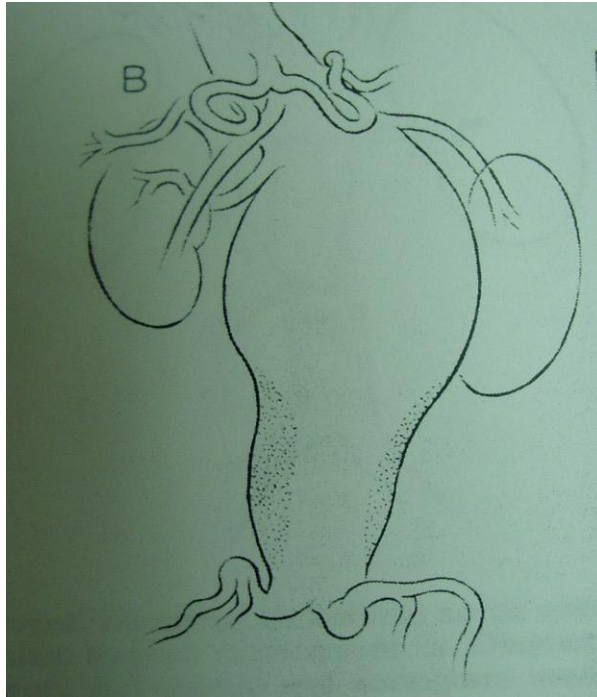




ReAcquaintance with Today's Abdominal Aortic Aneurysm

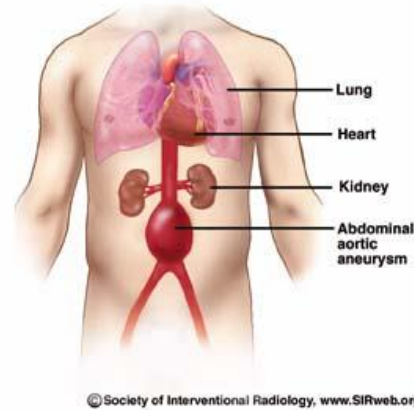
*Kristine C. Orion, M.D.
Associate Professor of Clinical Surgery
Section of Vascular Surgery
Director Quality and Patient Safety
The Ohio State University School of Medicine*

-
- No disclosures



Agenda

- History
- Demographics and Risk Factors
- Diagnosis
- Screening
- Treatment
 - Open
 - EVAR
 - Comparisons
 - Complications (Renal insufficiency and Endoleaks)
- Post surgical surveillance and management



History

- 1888 – Matas – first successful treated AAA with ligation
- 1951 – Dubost – first repair with a homograft
- 1952 - Voohres - he treated the first ruptured AAA in a human with Vinyon cloth
- 1953 – Sir Charles Rob reported doing the same in a injured soldier
- 1954 Debaquey and his group developed the the knitted Dacron



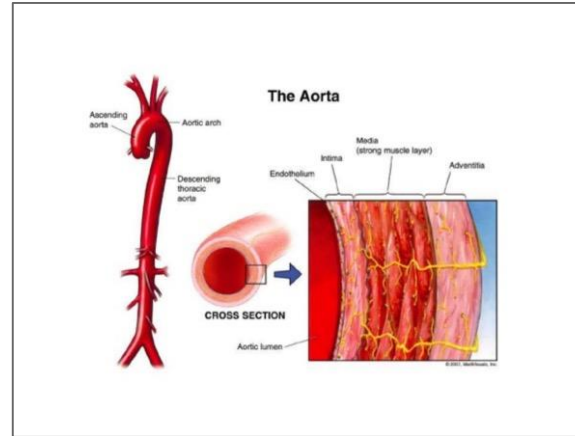
Juan Parodi, MD - EVAR

- Developed the concept as a junior resident at Cleveland Clinic
- Initial project done on stray dogs in Argentina
- September 7, 1990, Dr. Parodi implanted the first endograft in Buenos Aires
- Approved for use in US 1999
- Today most common method for AAA repair



What is a AAA?

- Dilation of all three wall layers of the aorta
- Grow 2-3 mm/year



Abdominal Aorta	Greatest diameter measurement
Normal	<2.0 cm
Ectasia	2.0-2.9 cm
Aneurysm	>3.0 cm

Demographics Facts

- 1.7% of women and 5% of men have AAA after the age 60
 - prevalence increases 6% per decade thereafter
- Rupture accounts for 15,000 deaths/yr
 - 15th leading cause of death in US
 - 80% overall mortality
 - 50% in the field
- Remain asymptomatic till rupture



AAA Risk Factors



age.

1. Age
2. Family History
3. Male Sex
4. Tobacco
5. Hypertension
6. Connective Tissue Disorders
7. Obesity

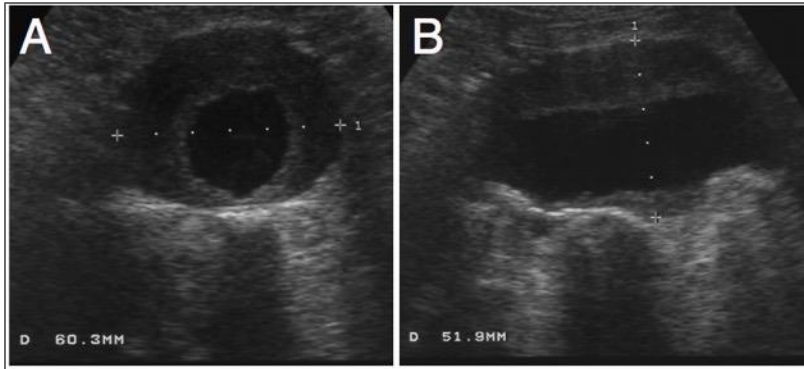


Aneurysm in Detection and Management (ADAM)
VA Cooperative Study (Annals 1997;126:441-449)

Diagnosis



- Physical Exam?**
- Pulsatile mass
 - Abdominal bruit



AAA Screening



- Ultrasound is preferred method
 - Sensitivity and specificity nearly 100%
 - Low cost
 - Patient accepted
 - Lack of radiation exposure
 - Widely available



Case



HPI: 58 yom steel worker presents to local hospital with 6 days of progressive back pain.

PMH: HTN, HLP

PSH: none

Family: not significant

Social: 50 pack year smoking history

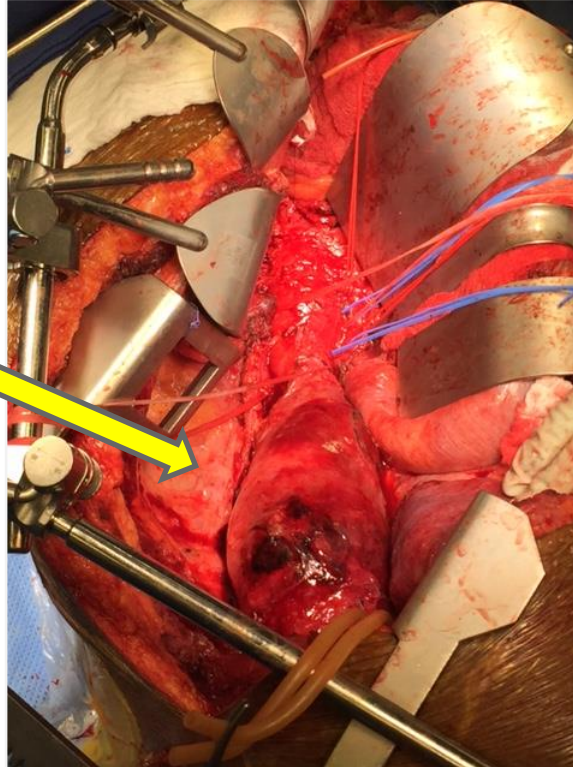
CTA





Emergent Open repair

Contained rupture



Screening studies

- Four randomized trials of AAA screening
 - Lindholdt JS et al. (Eur J Vasc Endovasc Surg 2002)
 - Scott RA et al. Br J Surg 1995
 - Vardulaki et al. (Br J Surg 2002)
 - Norman et al. (Br J Surg 2003)
 - Ashton HA et al. (MASS). (Lancet 2002)

AAA Screening

The Multicenter Aneurysm Screening Study Group. The Multicenter Aneurysm Screening Study (MASS) into the effect of abdominal aortic aneurysm screening in men: a randomized controlled trial. Lancet 2002;360:1531-9

AAA Screening

- Purpose:
 - To assess whether or not ultrasound (US) screening is beneficial
 - Screening does not adversely affect quality of life
- Design/method:
 - Randomized, blinded (data collectors and outcome assessors) controlled trial
 - Mean follow-up of 4.1 years at 4 screening and 4 academic centers in England, UK

AAA Screening

- Patients:
 - 67,800 men, age 65 to 74 (mean 69.2 yrs.)
 - Exclusion:
 - men with serious illness,
 - history of AAA repair

AAA Screening

- Intervention: Half (33,839) were invited for ultrasound (US) screening. US results were sent to family physicians
- Primary Outcome: Death from AAA
- Secondary outcome: all-cause mortality, ruptured AAA, and quality of life

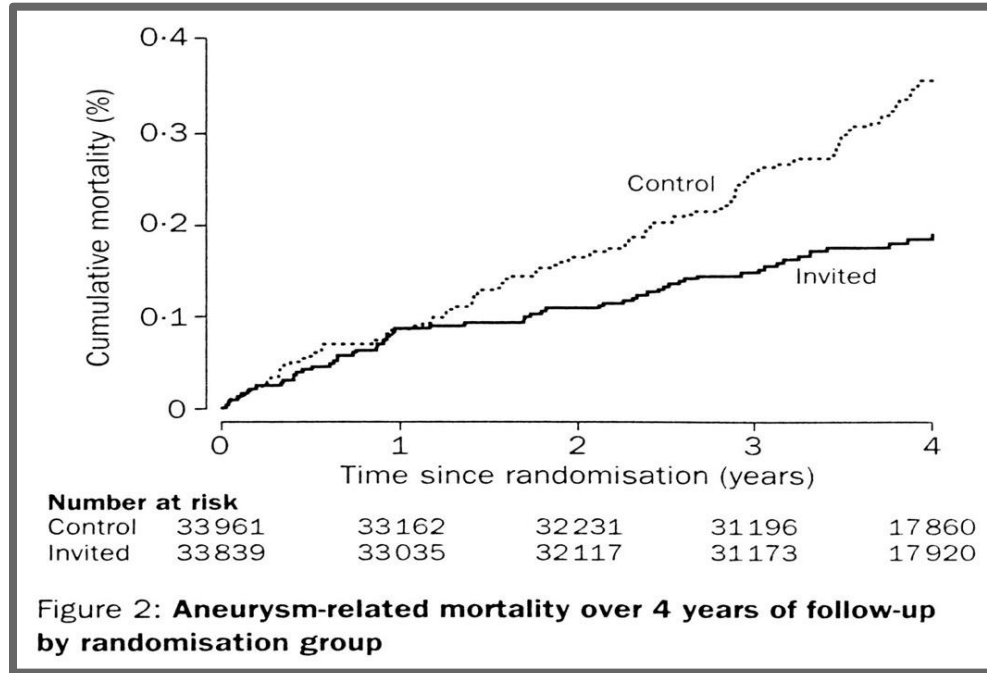
AAA Screening

- < 3.0 cm: not rescanned
 - 3.0-4.4 cm: scanned yearly
 - 4.5-5.5 cm: scanned q 3 months
 - > 5.5 cm: referred to vascular surgery
-
- 80% of men invited agreed to US
 - 1,333 AAA detected (4.9% scanned)

AAA Screening

- Results:
 - Deaths from AAA and ruptured AAA were lower in the invited group
 - More elective surgery and less emergent surgery in invited group
 - No difference in 30 day mortality, all-cause mortality, anxiety, depression, or health status measure

AAA Screening



MASS. Lancet 2002;360:1531-9.

AAA Screening

- Conclusion:
 - In older men, US screening for AAA reduced death from AAA without any detectable reduction in quality of life
 - 712 NNS to prevent one aneurysm-related death
 - Not applicable to women and men age 65-74
- Are we ready to screen all men older than age 65?

SAAVE Act

Screen for Abdominal Aortic Aneurysms

- Under the law, Medicare covers a one-time ultrasound scan screening of men aged 65 to 75 years of age who ever smoked in their lifetime or men and women who have a family history of AAA disease as part of a “Welcome to Medicare” package.
- 2007, this led to only a fraction (1%) of eligible beneficiaries actually receiving screening ultrasound
- SVS recommends:
 - in men aged 55 years or older with a family history
 - all men aged >65 years
 - women aged > 65 years who have smoked or have a family history

Treatment

- Risk factor modification
- Surveillance
- Surgery!
 - >5.5 cm for men
 - >5.0 cm for women

Size of Aneurysm	Risk of Rupture per year
< 4.0 cm	0.5%
4-4.9 cm	1-5%
5.0-5.9 cm	3-15%
6.0-6.9 cm	20%
7.0-7.9 cm	40%
>8.0 cm	50%

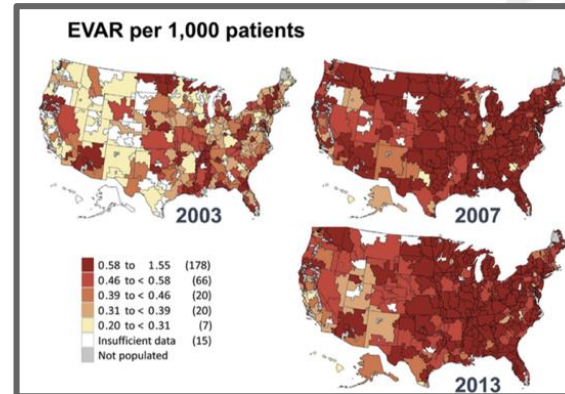
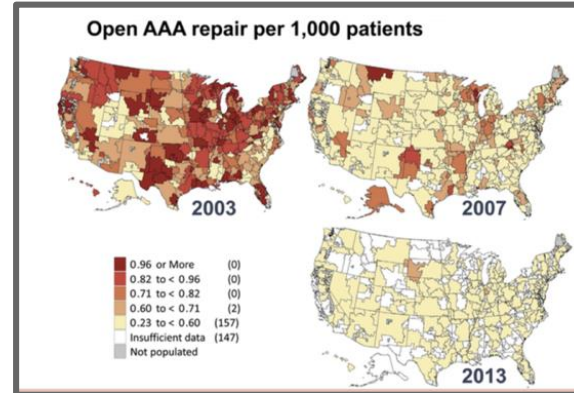
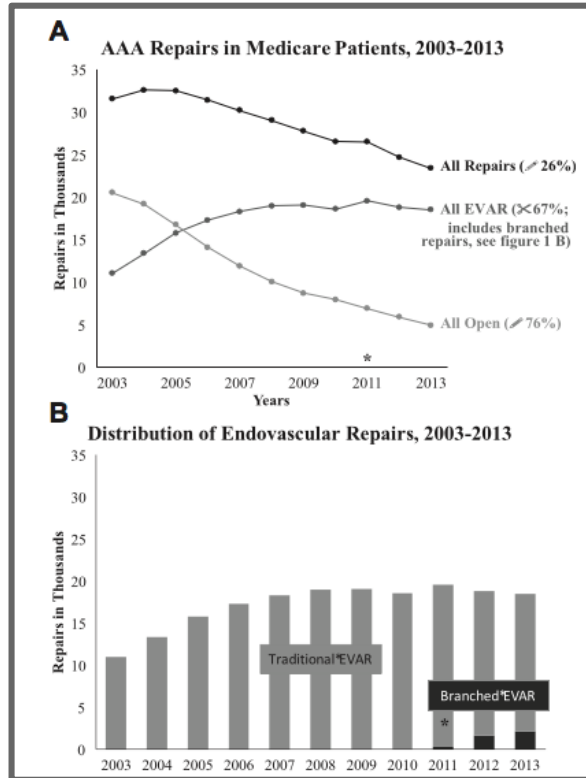


When to refer to Vascular Surgery?

- Aneurysm approaching 5 cm for men, 4 for women
- Fast growing aneurysms: >0.5 cm / year
- Any size AAA in the setting of PVD
- Anytime!



Surgical Repair of AAA: OPEN vs EVAR



Surgical Repair of AAA

- 150,000 abdominal aortic aneurysms repaired/year
- ~70% amenable to simple endovascular repair
- Cost of devices about \$9K (endografts) and open graft \$800
- Currently 6 commercially available endografts





Open vs Endovascular

Estimate Peri-Operative Risk Around the Time of Vascular Surgery using Vascular Quality Initiative Risk Calculators

Asymptomatic
ICA (Internal
Carotid Artery)
Stenosis Surgical
Risk
Stratification

Infra-inguinal
Bypass Cardiac
Risk Index

Ruptured
Abdominal
Aortic Aneurysm
(RAAA) Risk
Score

Open AAA
Repair Cardiac
Risk Index

Carotid
Endarterectomy
Cardiac Risk
Index

Respiratory
Adverse Event
Risk Post
Vascular Surgery

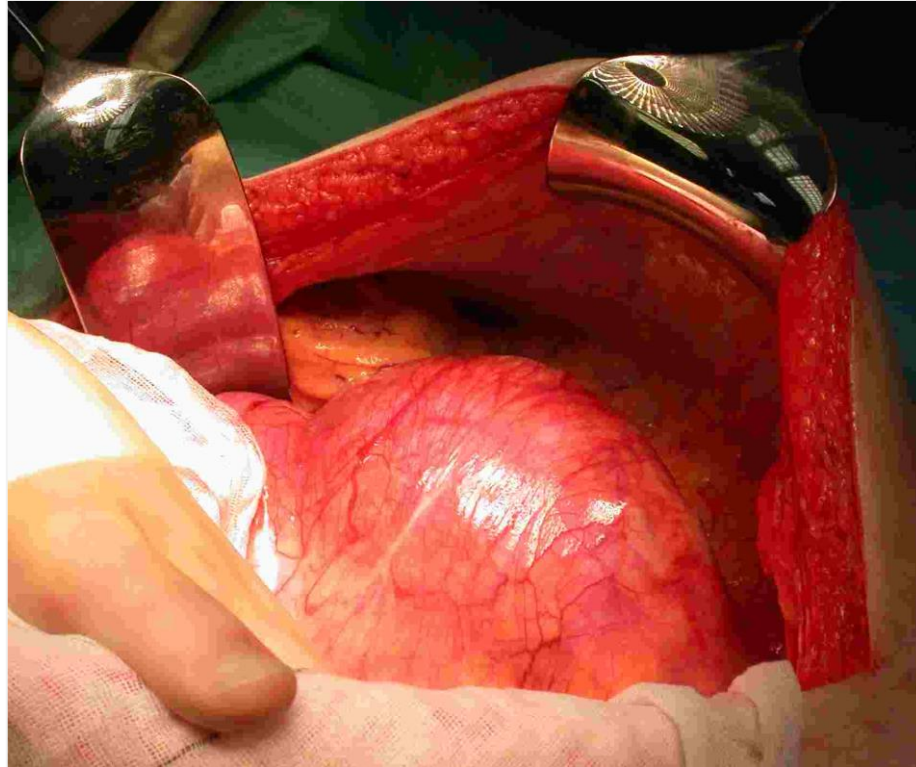
Suprainguinal
Bypass Cardiac
Risk Index

EVAR Cardiac
Risk Index (CRI)

30-Day Stroke
Risk Index for
Carotid
Endarterectomy

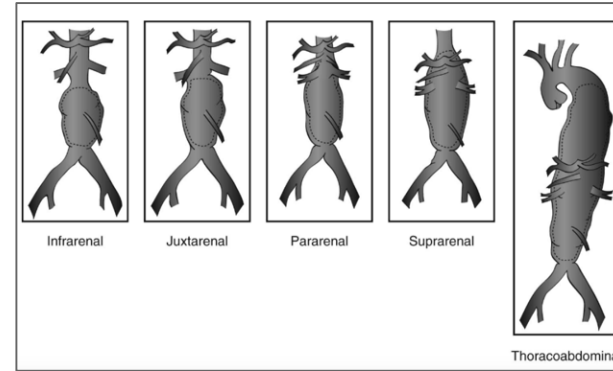
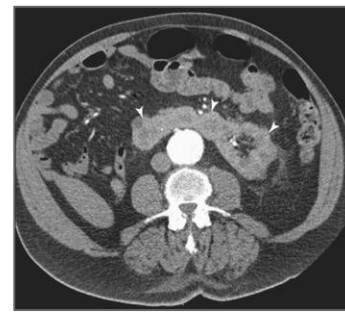
1-Year Mortality
Risk Index for
Carotid
Endarterectomy

Open Repair



Pre-op planning

- Imaging
 - Classification
- Anatomic anomalies
 - Left sided/duplicated IVC
 - Retroaortic left renal vein
 - Horseshoe kidney
 - Inflammatory aneurysm
 - Aortocaval fistula
 - Heavy calcification



Transabdominal/Transperitoneal (TA/TP)

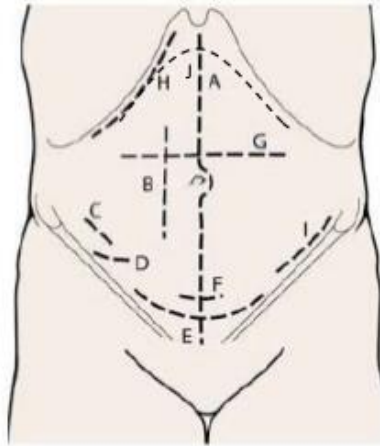
GOOD

- Right renal artery
- Right internal/external iliac arteries
- Co-existent intra-abdominal pathology
- Left sided vena cava

BAD

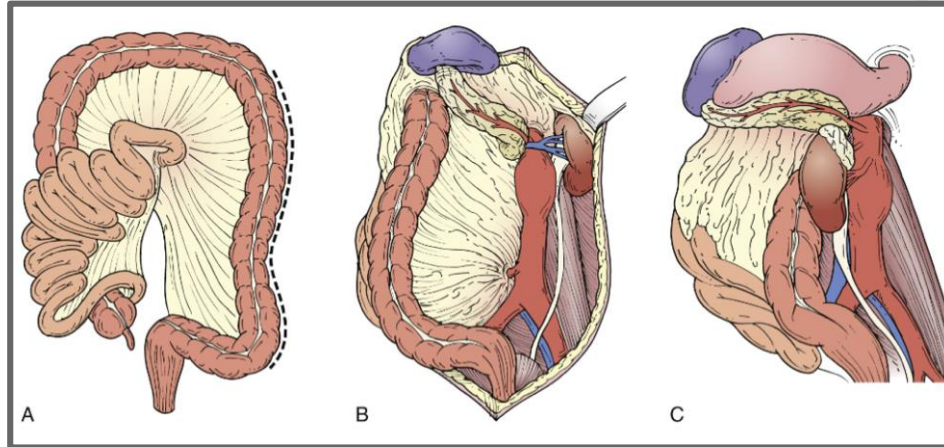
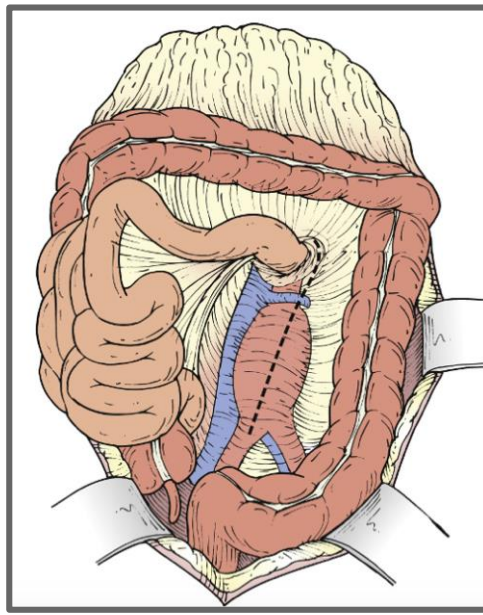
- Juxta renal exposure

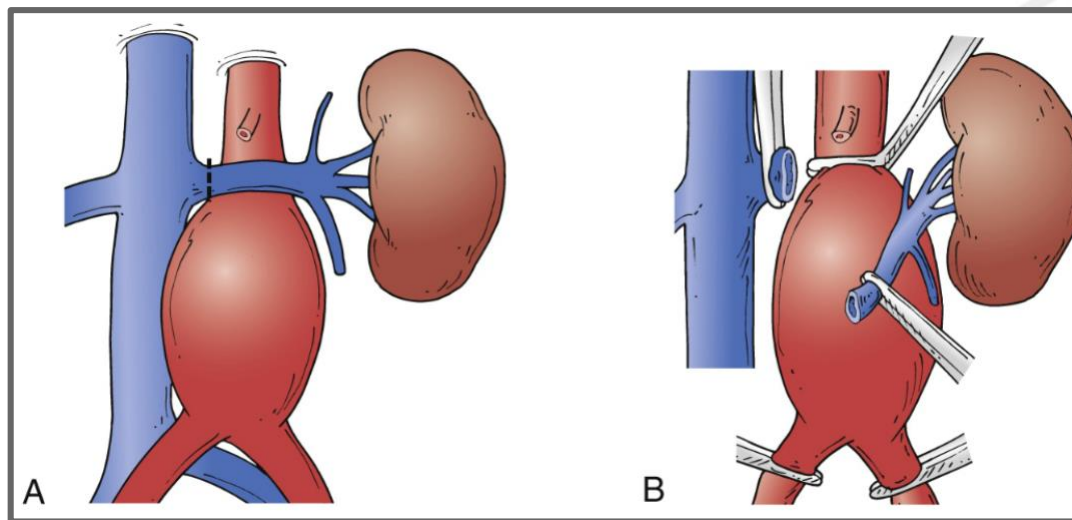
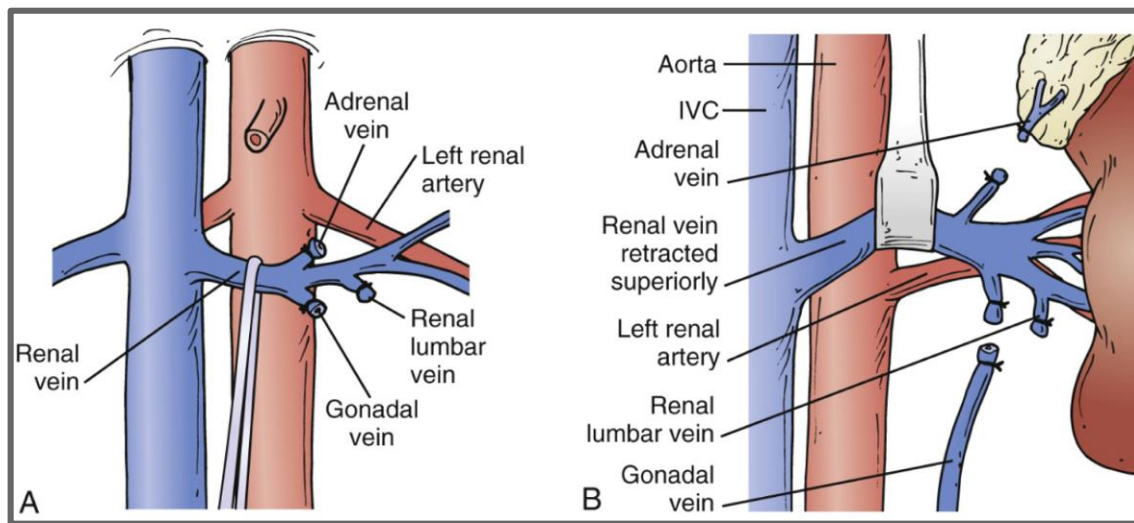
How many different laparotomy incisions are there?

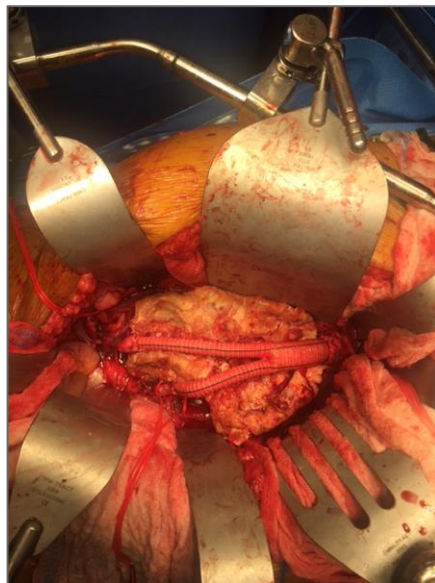
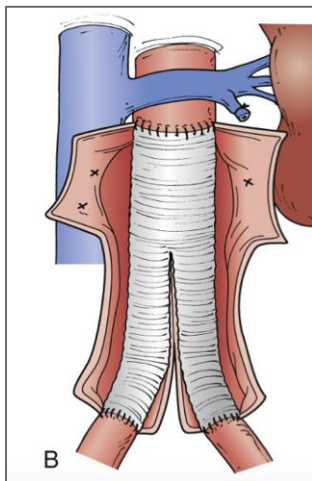
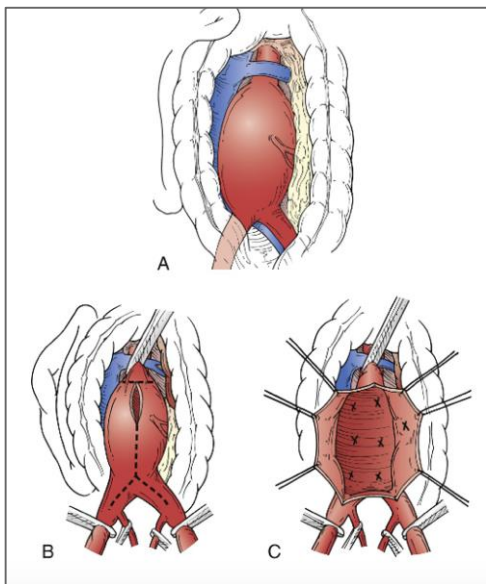
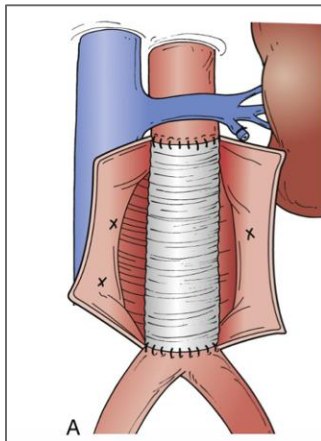
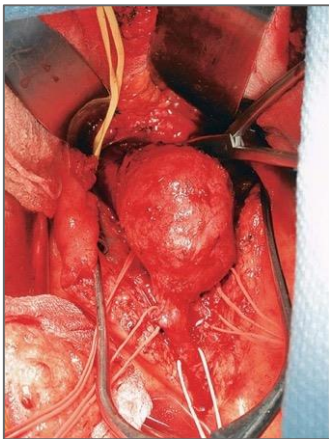


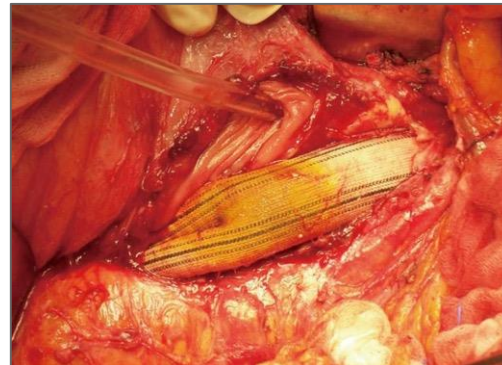
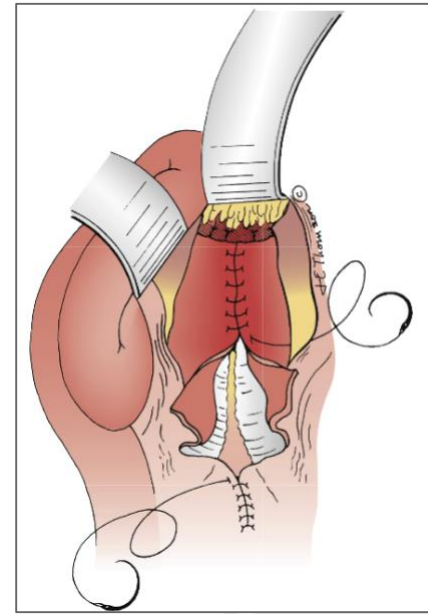
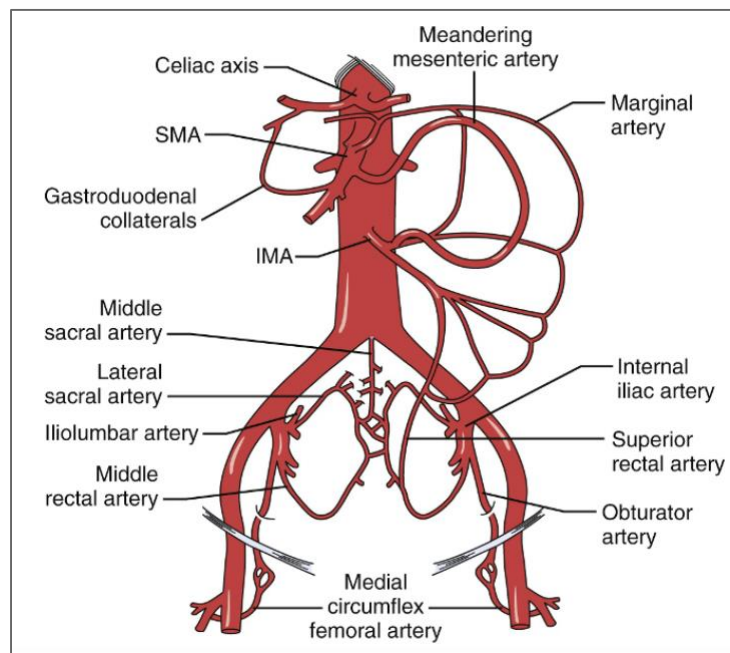
- A= Vertical midline
- B= ~~paramedian~~
- C= gridiron
- D= Lanz / Rockey Davis
- E= Pfannenstiel
- F= Suprapubic
- G= Transverse upper abdominal
- H= Subcostal (Kocher incision)
- I= Oblique iliac muscle cutting incision
- J= Chevron / Rooftop/ bilateral subcostal incision

LAPAROTOMY IS A MISNOMER.
Correct technical term is a celiotomy.

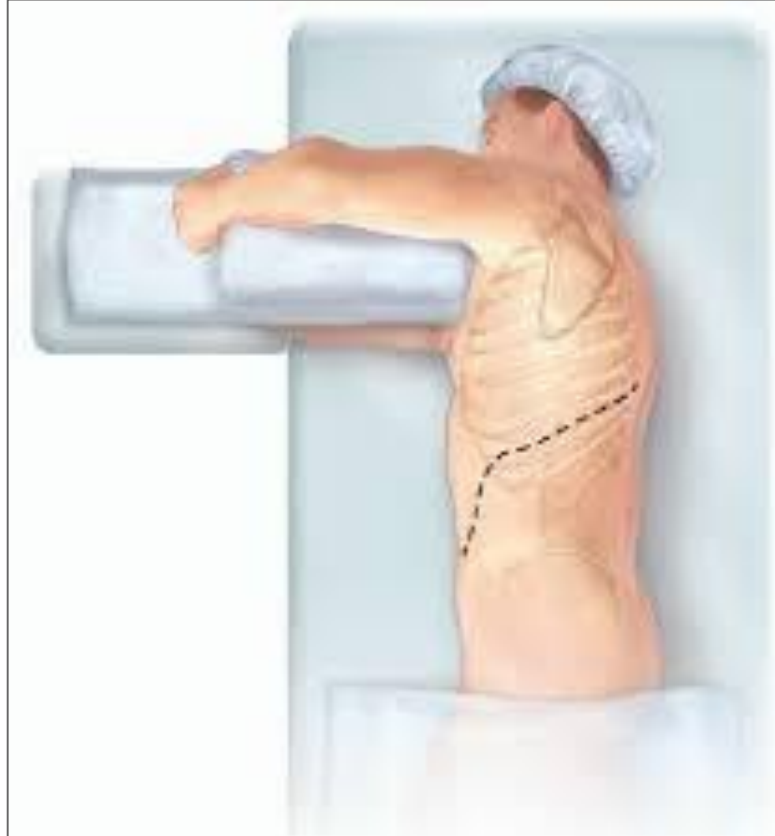


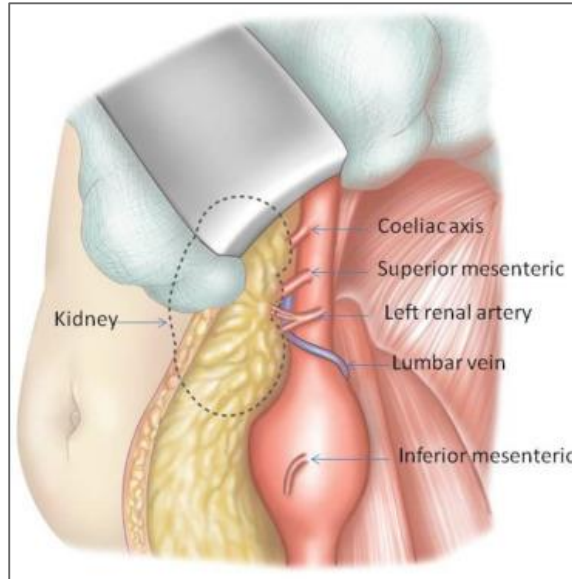
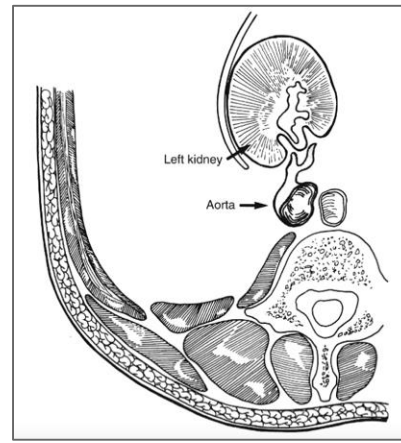
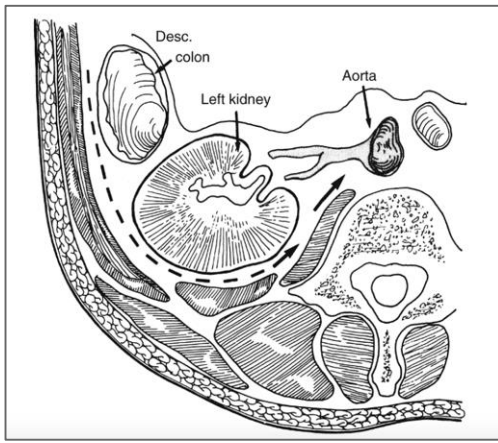






Retroperitoneal Approach (RP)





Retroperitoneal Approach (RP)

Box 23-2

Retroperitoneal Approach to Aneurysm Repair

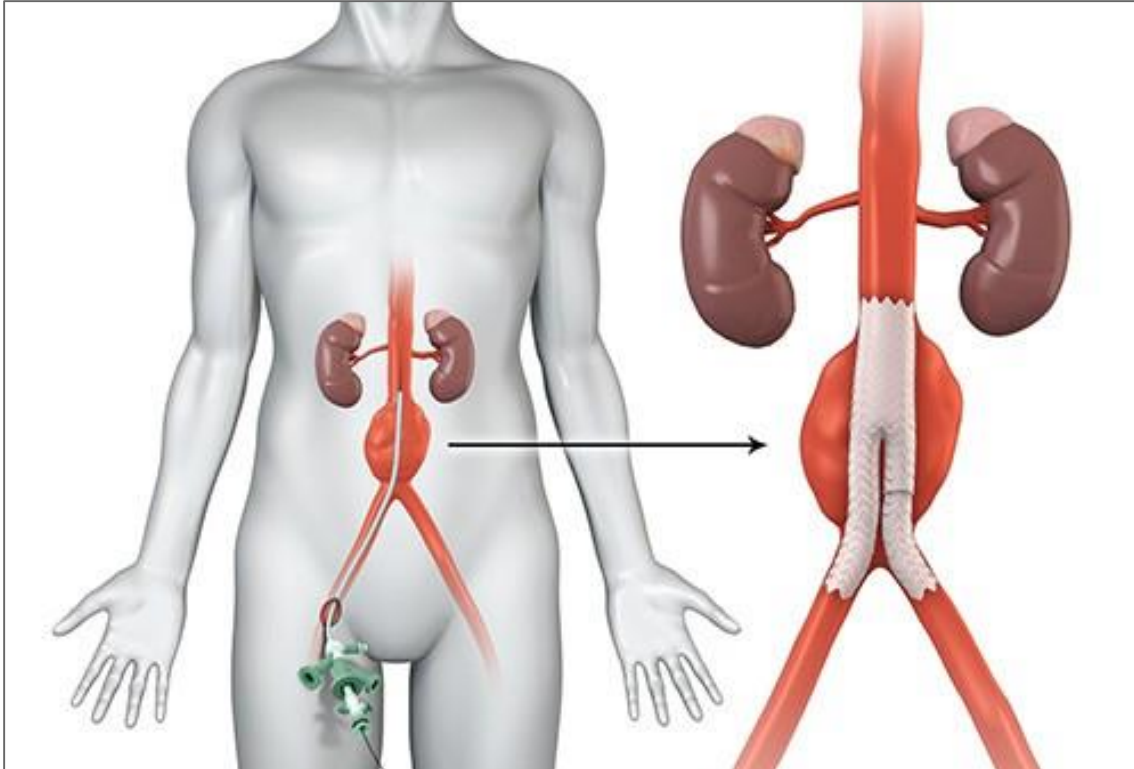
Advantages

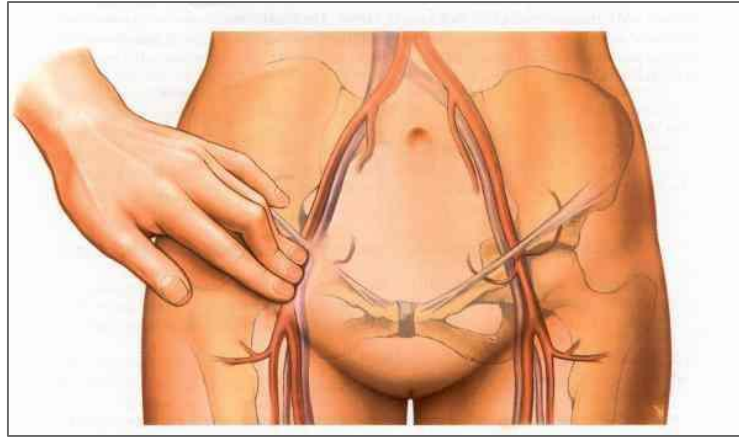
1. Improved exposure to the suprarenal aorta and visceral segment
2. Improved exposure of complex aortic aneurysms: suprarenal aneurysm, recurrent aneurysm, inflammatory aneurysm, and horseshoe kidney
3. Avoidance of hostile abdomen and abdominal wall ostomies
4. Balance of literature suggesting fewer gastrointestinal complications: ileus or small bowel obstruction

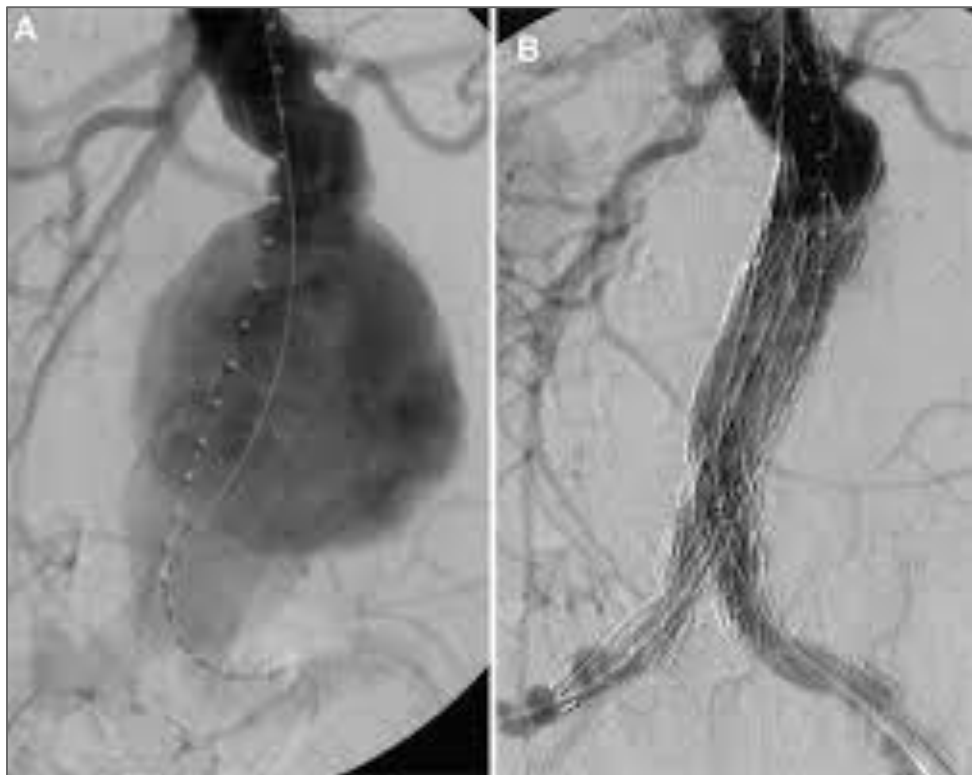
Disadvantages

1. Limited familiarity of many surgeons with anatomy
2. Limited visualization of abdominal contents
3. Difficult or limited exposure of right femoral, iliac, and renal arteries
4. Increased incisional pain and long-term wound problems

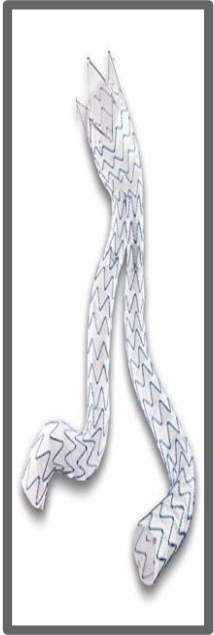
Endovascular Repair



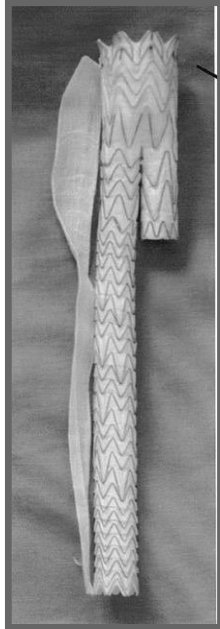




Endurant
Medtronic



Excluder
Gore



AFX
Endologix



Zenith
Cook



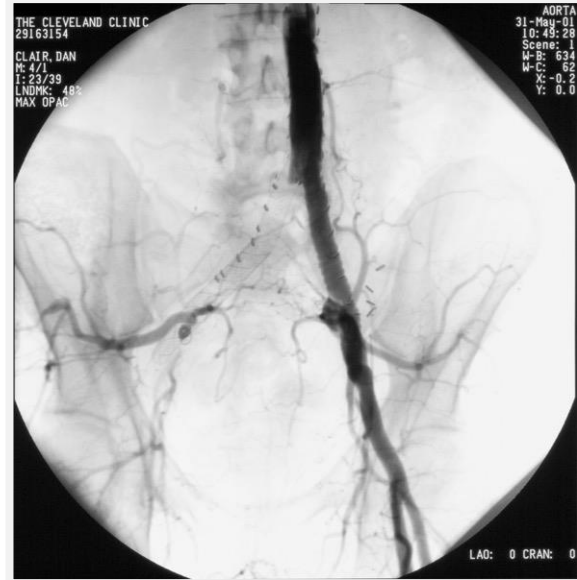
Nellix
Endologix



Early Technology Issue

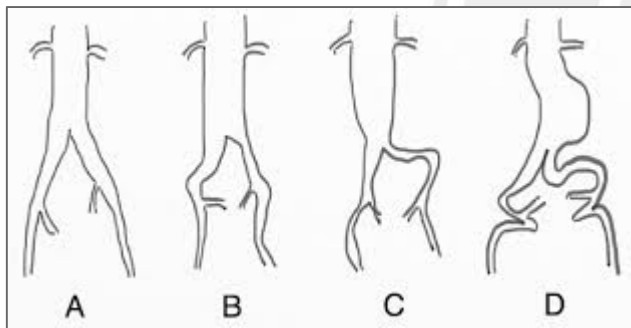
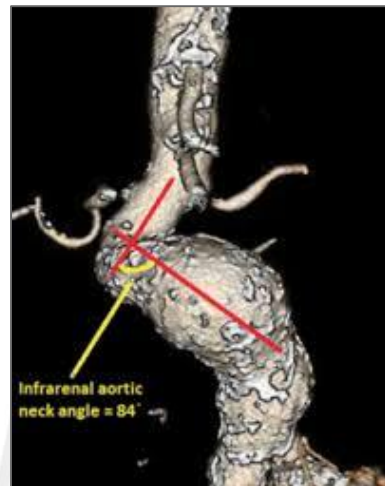
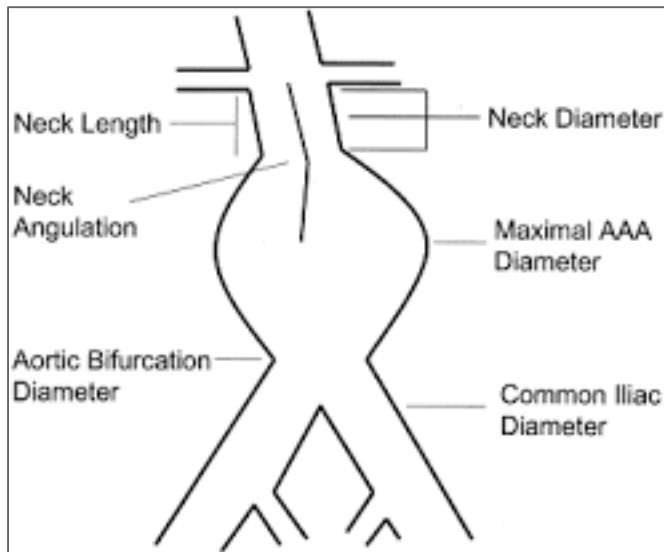
Ouriel et al J Vasc Surg. 2003 Jun;37(6):1206-12

- 703 repairs
- Rupture - 0.5-1%
- Endoleaks - 10-20%
- Migration – 3-6%
- Limb Compression and occlusion 2-10%
- Stent Fractures
- Mortality rates equivalent to open repair



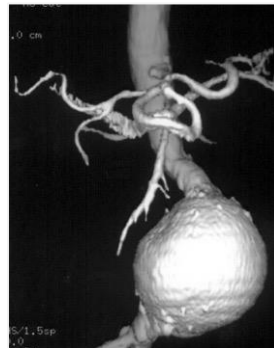
Candidates for EVAR

- Adequate “neck”
 - Length ~1.5 cm
 - $< 60^\circ$ angulation
- Access vessels
 - Calcification
 - Tortuosity





OPEN VS ENDO



Trial	Year	N	Follow Up	30 Day Mortality (%)		Survival (%)		Reintervention (%)	
				EVAR	Open	EVAR	Open	EVAR	Open
EVAR -1	1999-2003	1252	8	1.8	4.3	54	54	20	6
DREAM	2000-2003	351	6	1.2	4.6	69	70	30	18
OVER	2002-2008	881	2	0.5	3.0	93	90	14	13
MEDICARE	2001-2004	45660	4	1.2	4.8	65	65	13	11



OPEN VS ENDO

- Improved overall post-operative survival in US compared to Europe
- Early benefit of EVAR (30 day mortality)
- EVAR and OPEN equal at 2-3 years
- Shorter LOS and lower cost for EVAR
- Re-intervention rate higher in EVAR
 - Less invasive re-interventions in EVAR



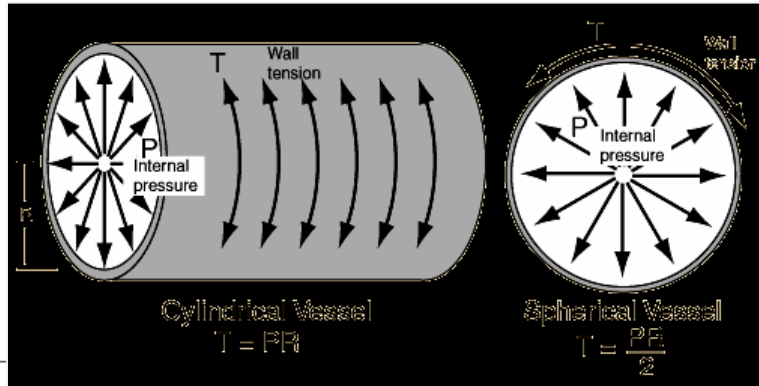
Ruptured AAA



Risk of Aneurysm Rupture

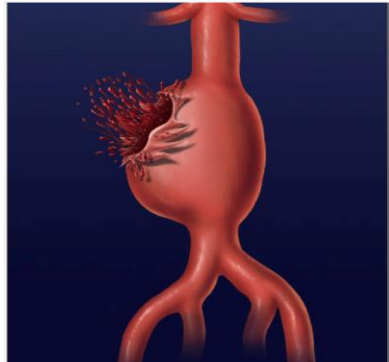
LaPlace's Law $T=PR$

The larger the vessel radius, the larger the wall tension required to withstand a given internal fluid pressure.

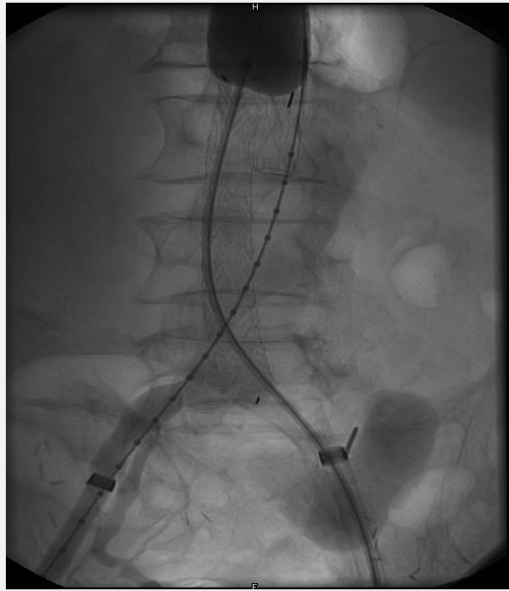


EVAR for ruptured AAA

- Despite improvements in technology, screening programs and early intervention, mortality of ruptured infrarenal AAA remains high.
- The first reported case of EVAR for ruptured AAA was by Dr. Parodi in Buenos Aires, and Frank Veith in the US.

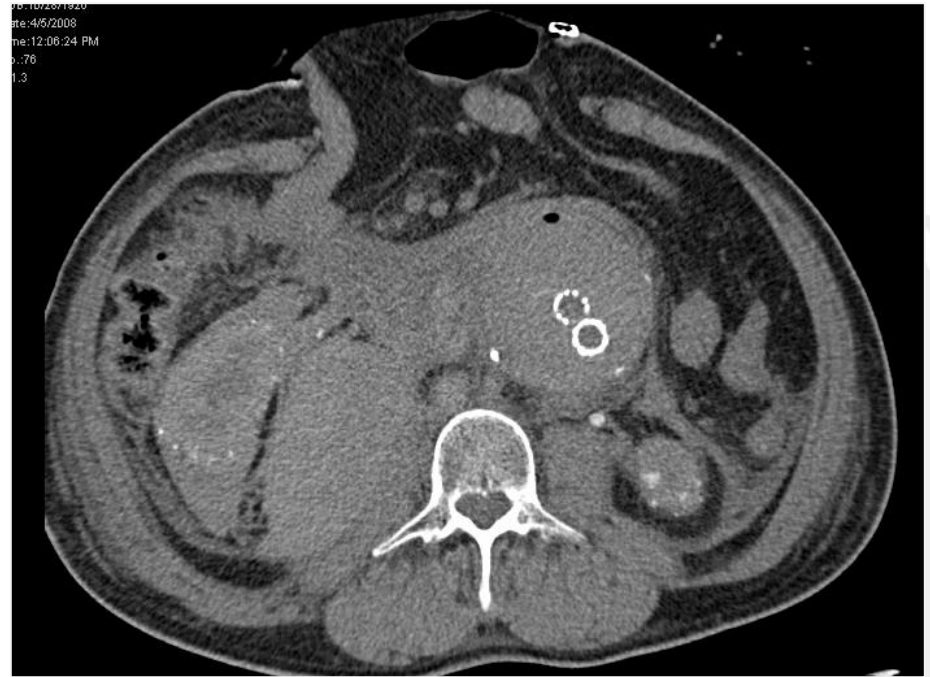
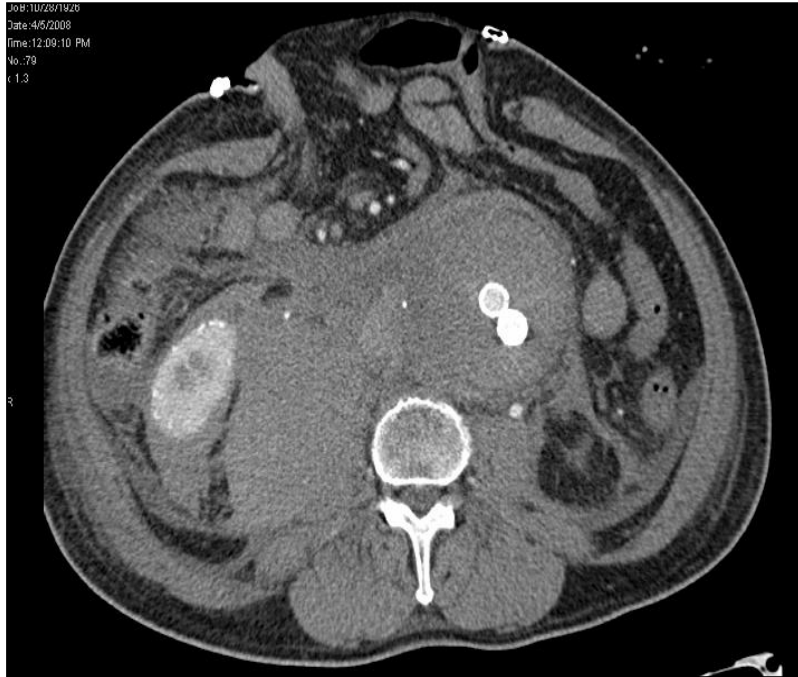


Proximal Control Needs Quality Imaging and a Great Team



Fast deployment and inflation of a balloon

Post Procedure Compartment Syndrome



Improve Trial

BMJ 2014

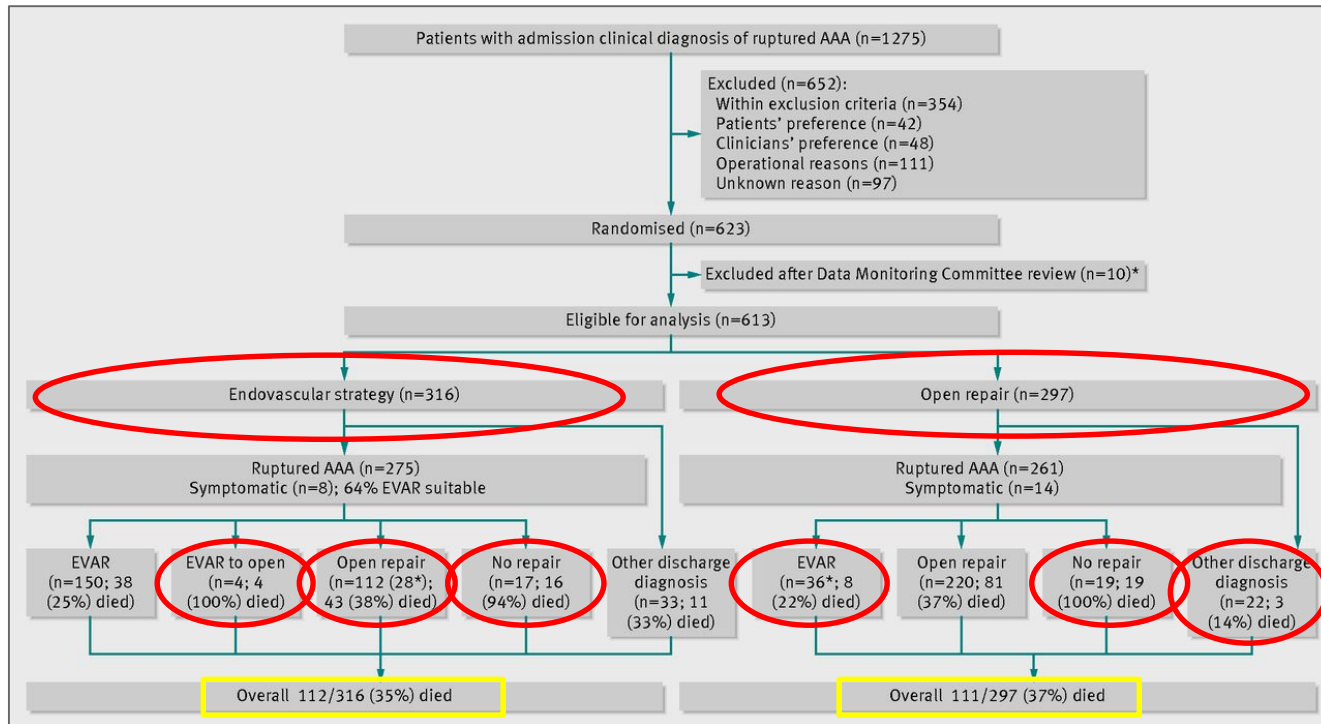
- 613 patients randomized to EVAR vs OPEN
- EVAR patients discharged home more (94% vs 77%)
- EVAR with shorter LOS (17 vs 26 days)
- 30 day mortality was 35.4% (EVAR) and 37.4% (OPEN)

No difference in mortality??



Improve Trial

BMJ 2014



Improve Trial

BMJ 2017

- Three year follow-up
- True survival benefit for EVAR
- Higher quality of life among survivors undergoing EVAR

SOCIETY FOR VASCULAR SURGERY® DOCUMENT

The Society for Vascular Surgery practice guidelines on the care of patients with an abdominal aortic aneurysm



If it is anatomically feasible, we recommend EVAR over open repair for treatment of a ruptured AAA.

Level of recommendation 1 (Strong)

Quality of evidence C (Low)



THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER

Suspected Ruptured Abdominal Aortic Aneurysm (rAAA) Algorithm

Recommended Time Goals

Emergency Department Door to Intervention = Less than 90 Minutes

30
Minutes

30
Minutes

30
Minutes

Evaluation by an Emergency Physician of Any Patient Suspected of Having a Ruptured AAA

- Airway, Breathing, Circulation (ABC) protocol
- General assessment
- Vital sign monitoring

Diagnosis

- Clinical diagnosis of a rAAA in patients:
 - Age > 50 with abdominal or back pain AND hypotension
 - Known AAA and symptoms of abdominal or back pain, hypotension, or impending cardiovascular collapse
- Radiologic confirmation (ultrasound or CT) only required when:
 - Alternative diagnosis is more likely on clinical grounds

Immediate Management

- Intravenous access with two large bore peripheral IVs (central and/or arterial not immediately necessary)
- Permissive hypotension (to maintain a mental status and target systolic pressure 70-90 mmHg)
- Lab work or x-rays should only be obtained to confirm the diagnosis of rAAA

Consideration of Transfer to Regional Center

- If appropriate vascular services cannot be provided:
 - Patients with good functional status and without severe co-morbidity should be transferred without delay
 - Patients previously declined elective surgery should still be considered for transfer and subsequent treatment
 - Patient should be discussed with a receiving vascular surgeon:
 - Goals of care
 - Medical comorbidities
 - Hemodynamics
- Contraindication for transfer:
 - Patients suffering from ongoing cardiac arrest

Yes

No

Rapid Transfer

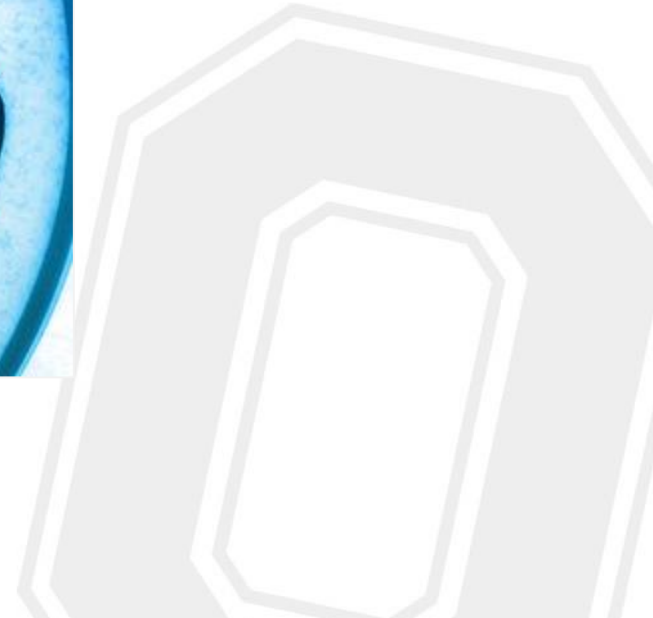
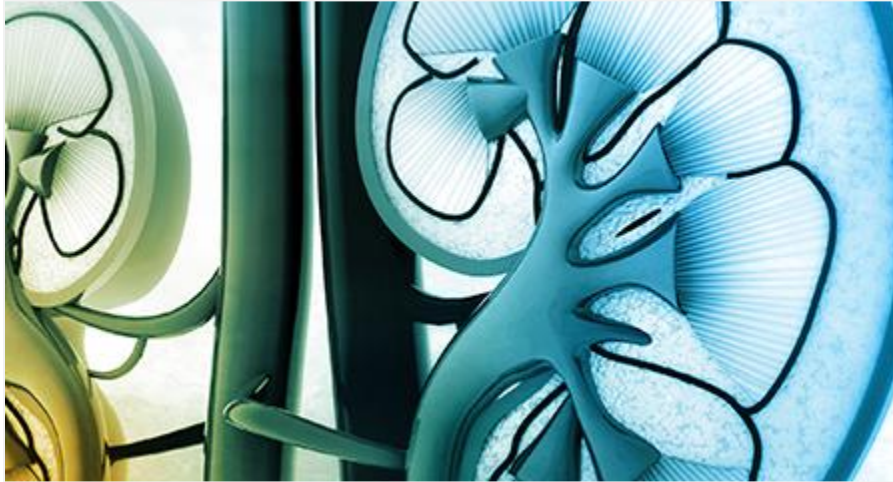
- Physician-to-physician phone hand-off
- If images are obtained at referring hospital, they must be transferred with patient
- In-transit care: vital sign monitoring and permissive hypotension

Emergent Evaluation by Receiving Vascular Surgery Team

Emergent In-house Vascular Surgery Evaluation

Intervention by Vascular Surgery Team

Renal Dysfunction and AAA



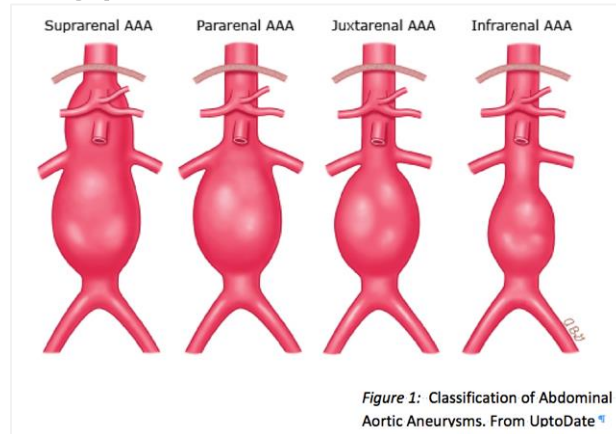
Open vs Endo??



- Rumors about renal insufficiency and AAA:
 - Patients with CKD should **NOT** undergo EVAR because of post-op CT scans
 - Patients with CKD should undergo EVAR because of decreased kidney injury

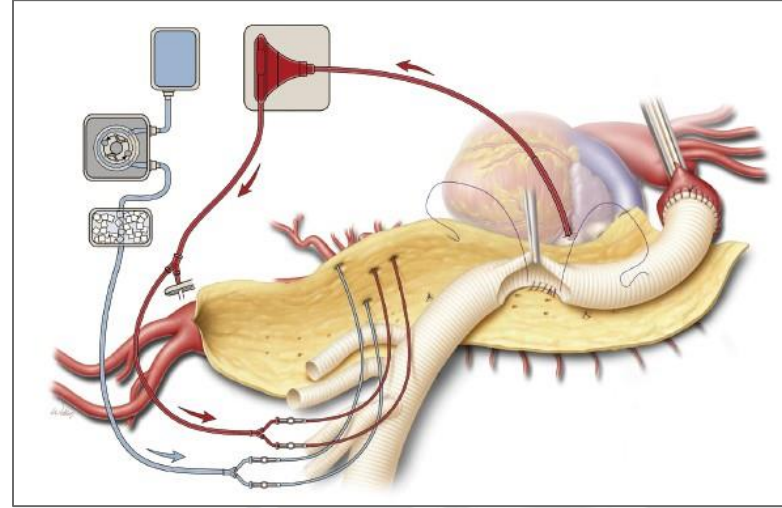
Renal protection in oAAA

- Intravascular volume expansion
- Location and duration of clamp
- Avoid excessive blood loss
- Avoid prolonged hypotension



Renal protection in oAAA

- Cold perfusate
- Warm oxygenated perfusate
- Treat renal artery stenosis simultaneously



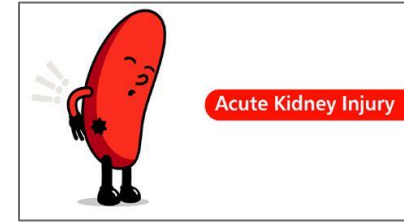
Renal protection in EVAR

- Pre-hydration
- N-acetylcysteine
- Judicious use of contrast volume
- Avoid prolonged hypotension
- Consider pre-stenting of renal arteries



Does renal disease worsen with specific surgical approach?

- Incidence of AKI is lower after EVAR
- Most AKI ~70% recover in both oAAA and EVAR



Acute kidney injury after open and endovascular elective repair for infrarenal abdominal aortic aneurysms

Claudio Castagno, MD,^a Gianfranco Varetto, MD,^a Simone Quaglini, MD,^a Edoardo Frola, MD,^a Gitana Scozzari, MD, PhD,^b Fabrizio Bert, MD,^b and Pietro Rispoli, MD, PhD,^a *Turin, Italy*

Acute renal failure after endovascular vs open repair of abdominal aortic aneurysm

Ron Wald, MDCM, MPH,^{a,b} Sushrut S. Waikar, MD,^c Orfeas Liangos, MD,^{a,d} Brian J. G. Pereira, MD,^a Glenn M. Chertow, MD, MPH,^e and Bertrand L. Jaber, MD,^{a,d} *Boston, Mass; Toronto, Ontario, Canada; San Francisco, Calif*

Does renal disease worsen with specific surgical approach?

From the Vascular and Endovascular Surgery Society

Long-term decline in renal function is more significant after endovascular repair of infrarenal abdominal aortic aneurysms



Ziad Al Adas, MD,^a Alexander D. Shepard, MD,^a Timothy J. Nypaver, MD,^a Mitchell R. Weaver, MD,^a Thomas Maatman, MD,^b Lenar T. Yessayan, MD,^c Praveen Balraj, MD,^a and Loay S. Kabbani, MD,^a Detroit, Mich

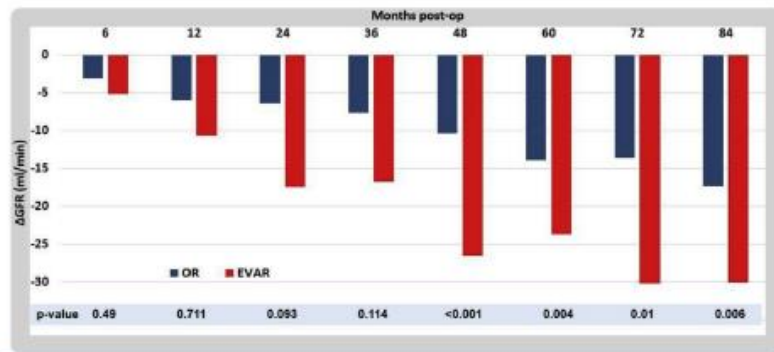


Fig 2. Change in glomerular filtration rate (Δ GFR) over time, open repair (OR) vs endovascular aneurysm repair (EVAR). GFR decline or Δ GFR is greater for EVAR than for OR at every year postoperatively. However, by looking at the *P* values at every year, we can see that the difference between the two groups becomes significant starting at 4 years postoperatively and thereafter.

Does renal injury effect outcomes after surgery?

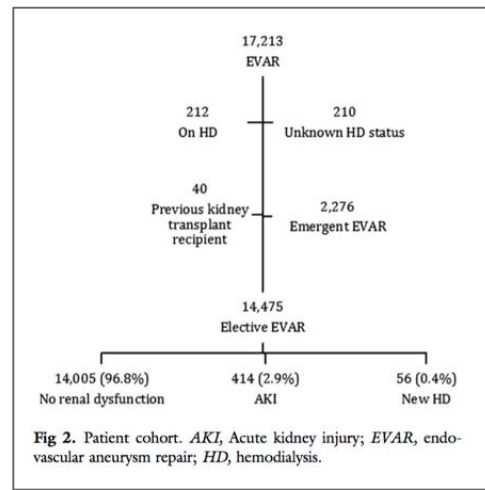
- 14,000 patients studied through VQI
- Only 3% undergoing EVAR had AKI but those who did had significantly decreased 5 year survival

Vascular Quality Initiative®

From the Vascular and Endovascular Surgery Society

Renal dysfunction and the associated decrease in survival after elective endovascular aneurysm repair

Devin S. Zarkowsky, MD,^a Caitlin W. Hicks, MD, MS,^b Ian C. Bostock, MD, MS,^a David H. Stone, MD,^a Mohammad Eslami, MD,^c and Philip P. Goodney, MD, MS,^a *Lebanon, NH; Baltimore, Md; and Boston, Mass*



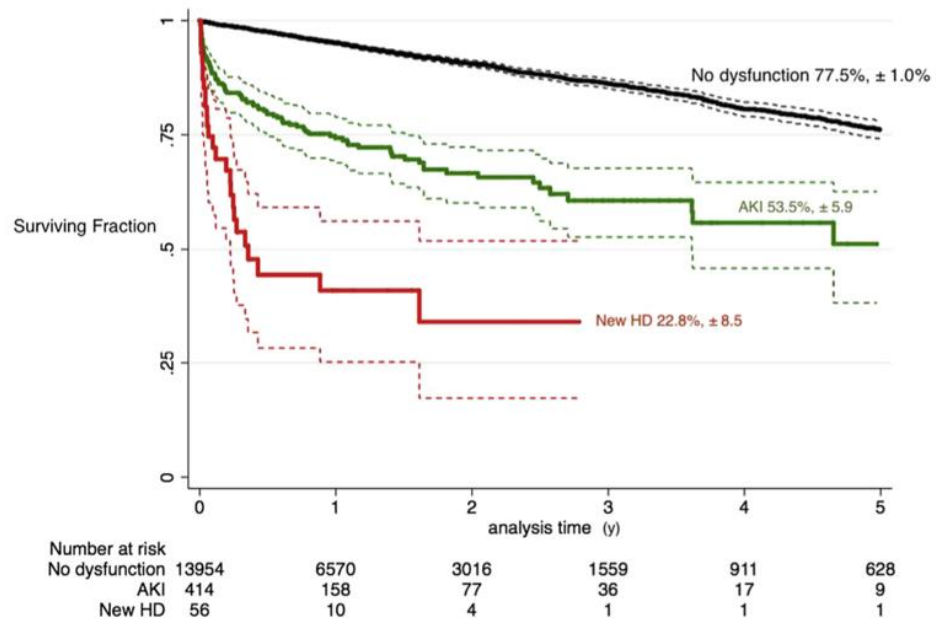


Fig 3. Actuarial survival stratified by renal outcome. Reported as a 5-year estimate $\pm$ standard error of the mean with 95% confidence interval (CI) bounds. *AKI*, Acute kidney injury; *HD*, hemodialysis.

Endoleaks



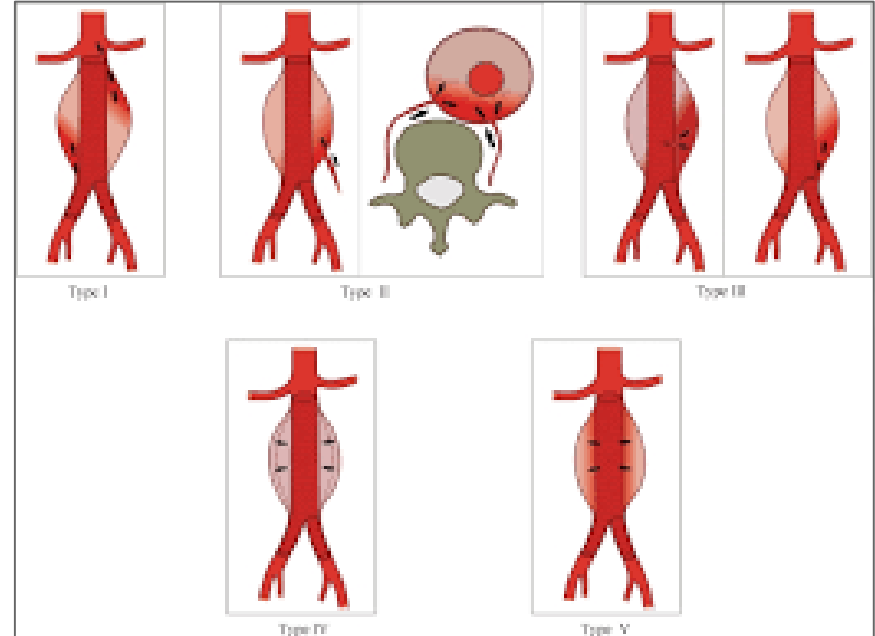
Long-term outcomes of secondary procedures after endovascular aneurysm repair

Manish Mehta, MD, Yaron Sternbach, MD, John B. Taggart, MD, Paul B. Kreienberg, MD, Sean P. Roddy, MD, Philip S.K. Paty, MD, Kathleen J. Ozsvath, MD, and R. Clement Darling III, MD, *Albany, NY* J Vasc Surg 2010;52: 8

Number of Patients	1,768
Mean Follow-up [SD]	34 Months [30]
% with Secondary Intervention	19.2%
Type II Endoleak	40.1%
Type I/III Endoleak	16.5%
Migration	13.6%
Limb Occlusion	7.4%
Rupture, Device Defect, etc.	8.6%

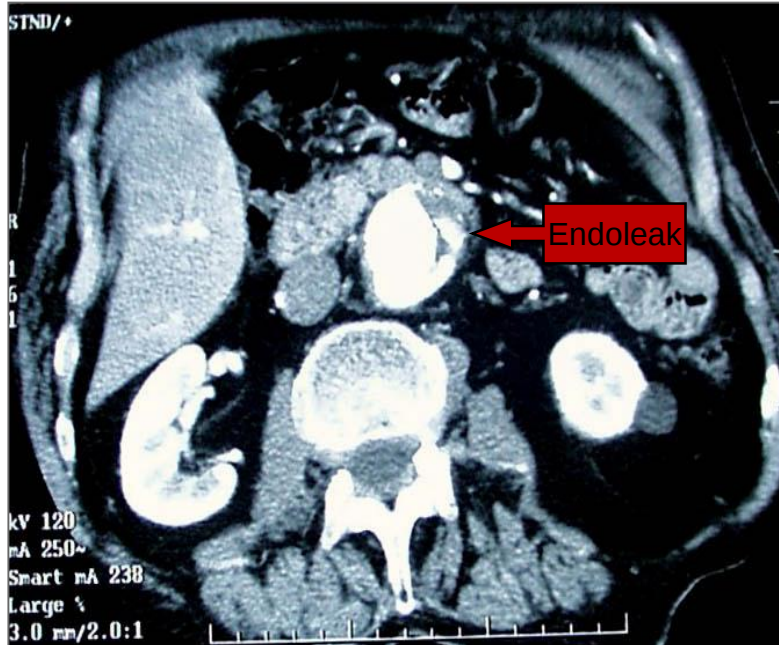
Endoleak : persistent flow into aneurysm sac

- Type I
 - Proximal or distal seal
- Type II
 - Branch vessel flow
- Type III
 - Graft or component junction
 - Fabric failure
- Type IV
 - Transgraft flow due to porosity
- Type V
 - Increase in diameter with no endoleak ? endotension



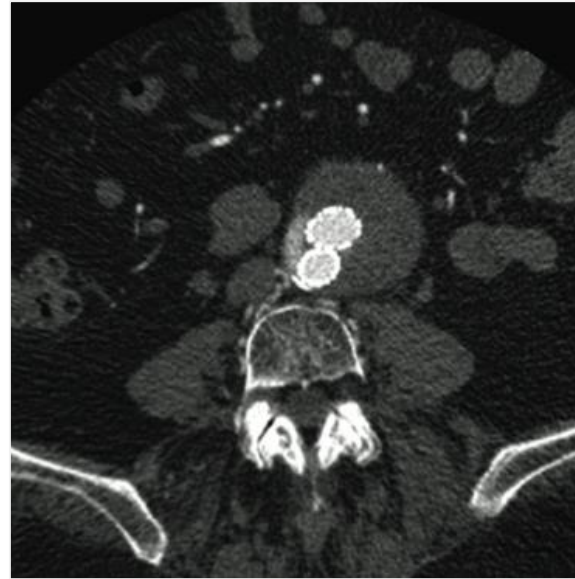
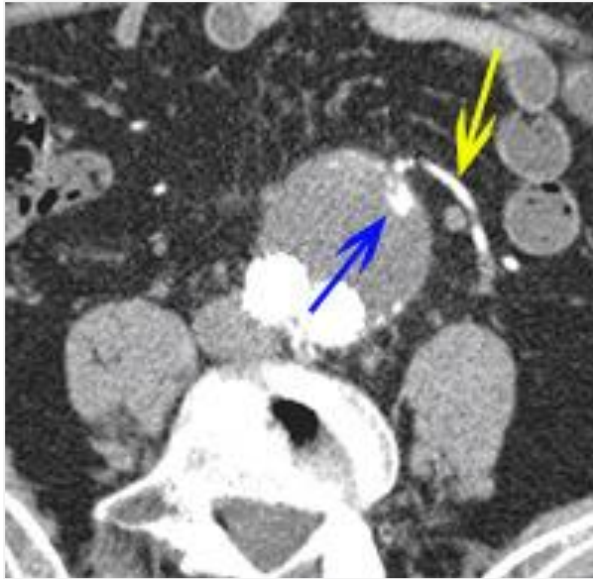
Type I Endoleak

- Large blush in either proximal or distal seal zones
- Requires urgent treatment



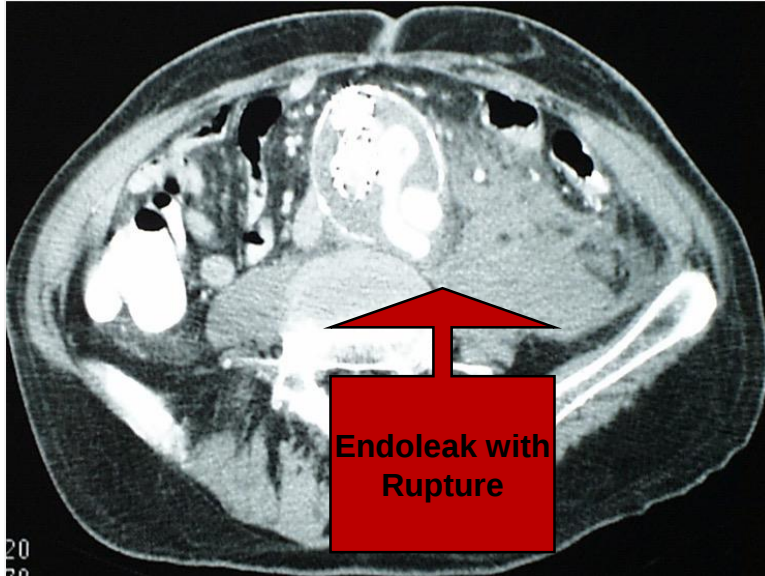
Type II Endoleak

- Branch vessel flow

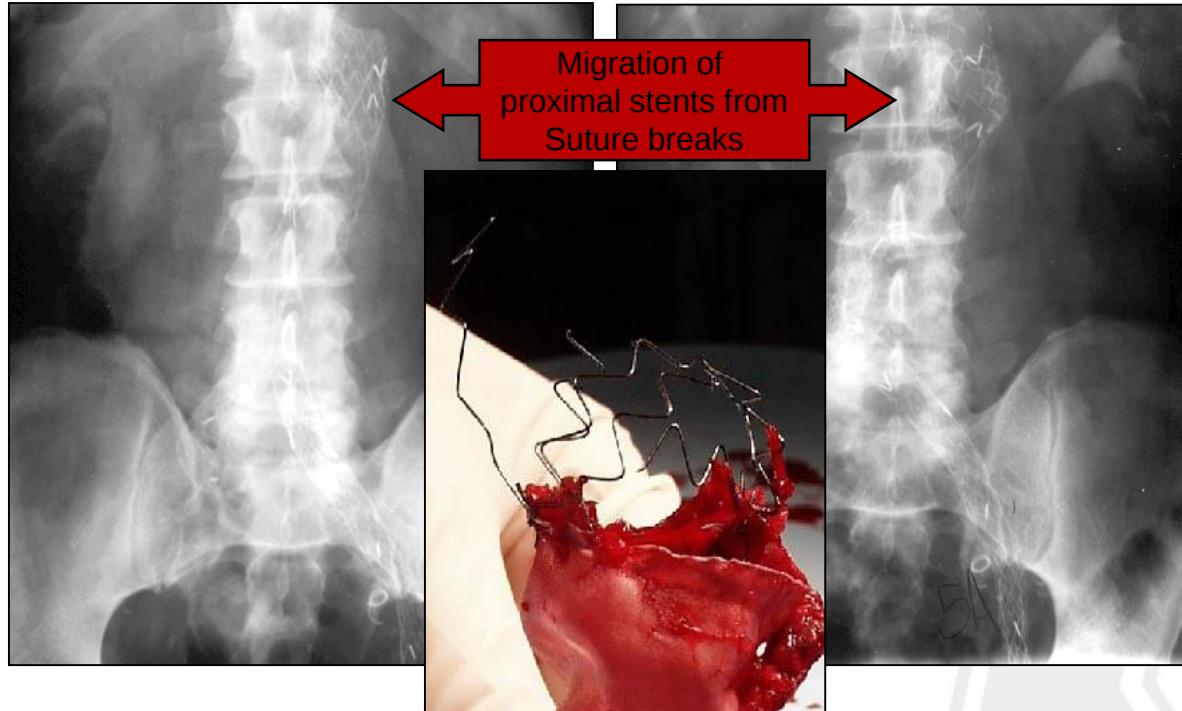


Type III Endoleak

- Component Separation

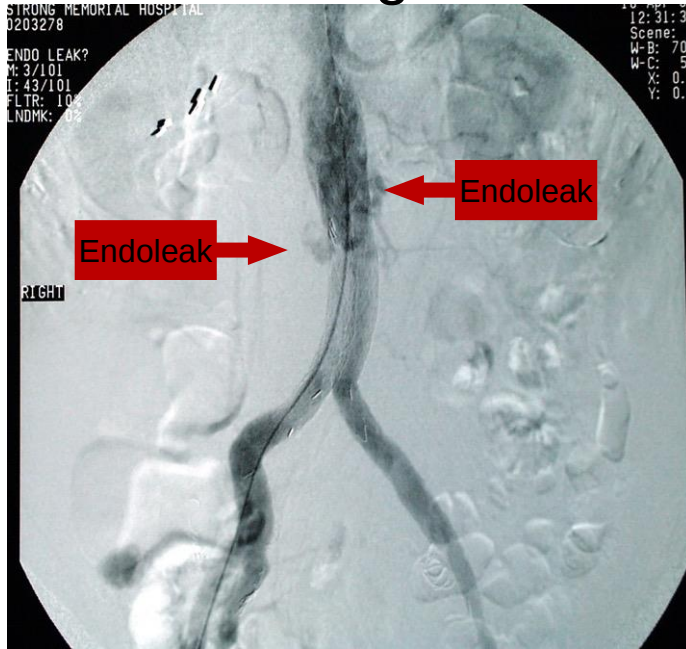


Type III Endoleak

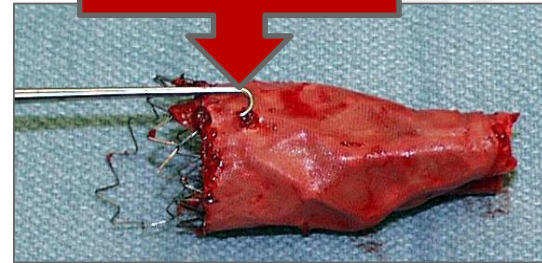


Type III Endoleak

Angio



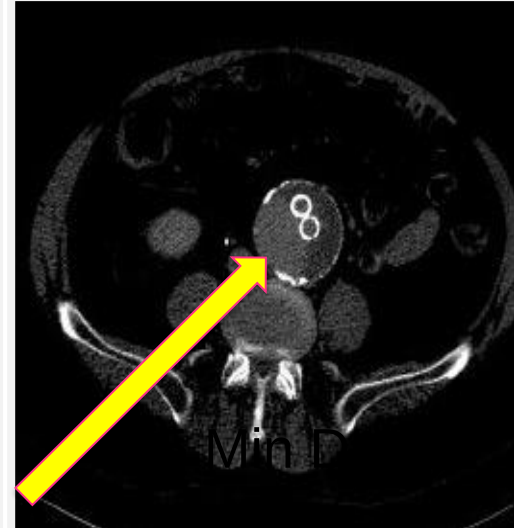
Probe engaged
In hole in fabric



Fabric tear due to stent motion after suture breaks

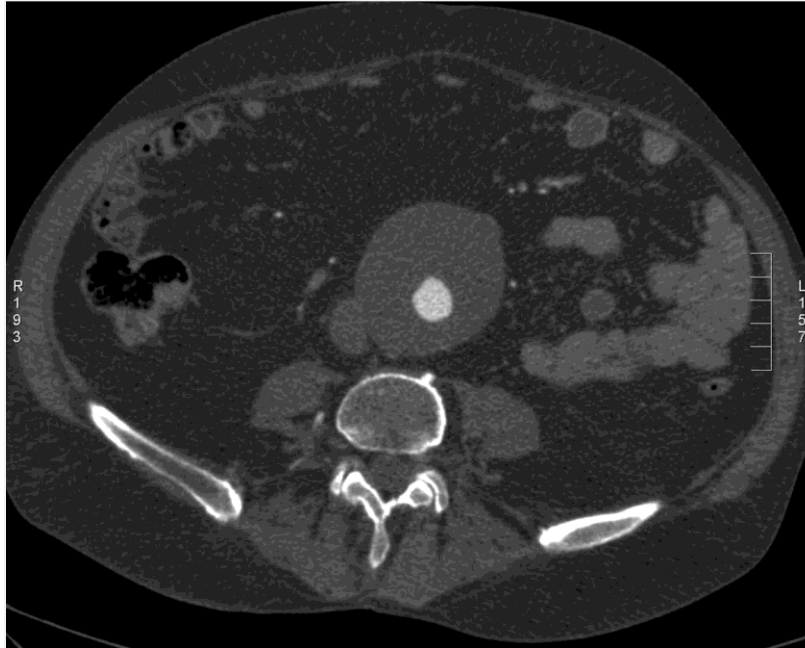
Type IV Endoleak

- Graft porosity
 - Problem with first generation endografts



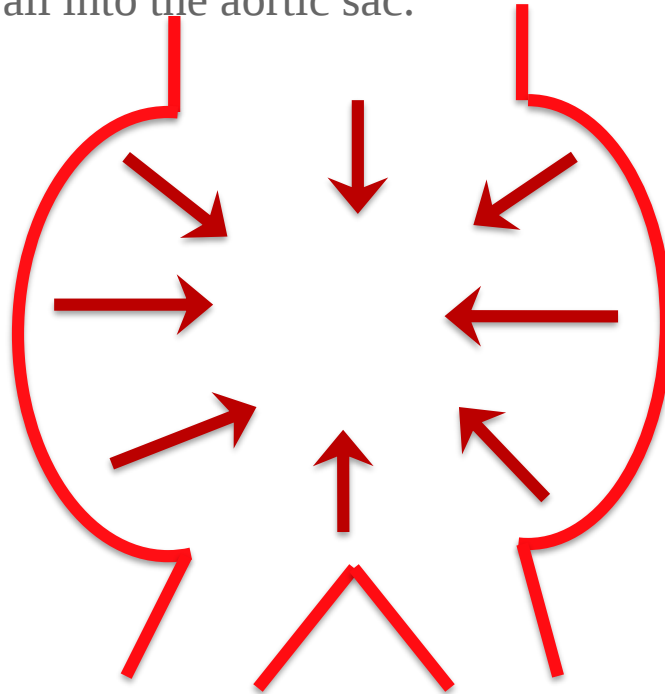
Type V endoleak

- Endotension

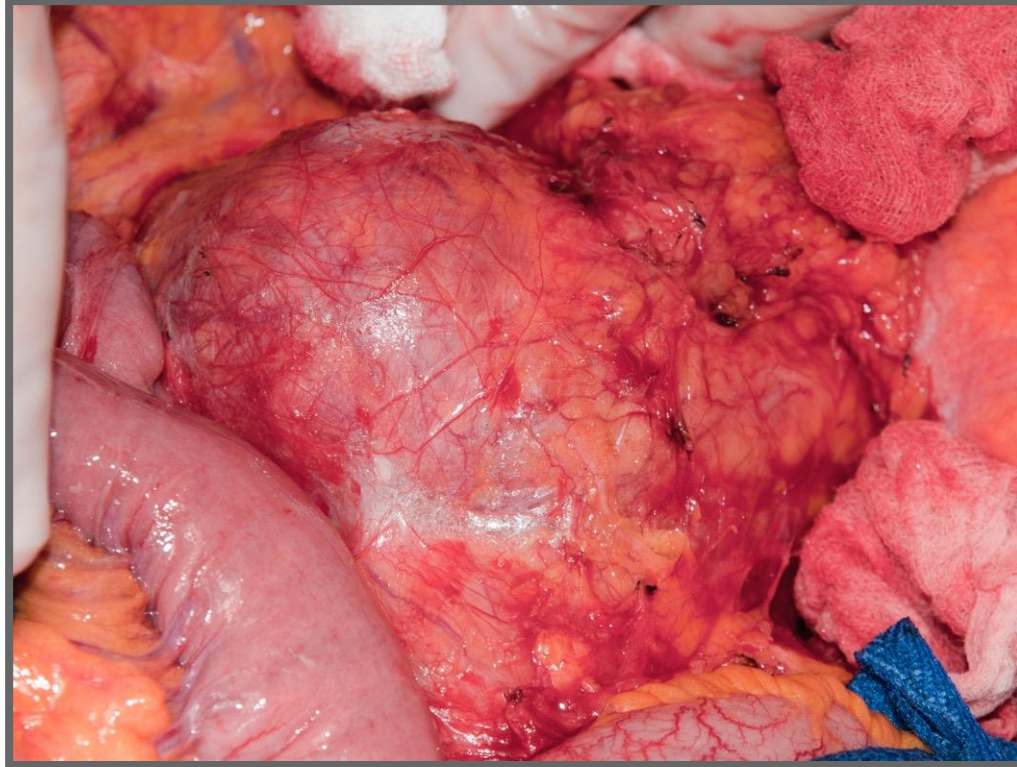


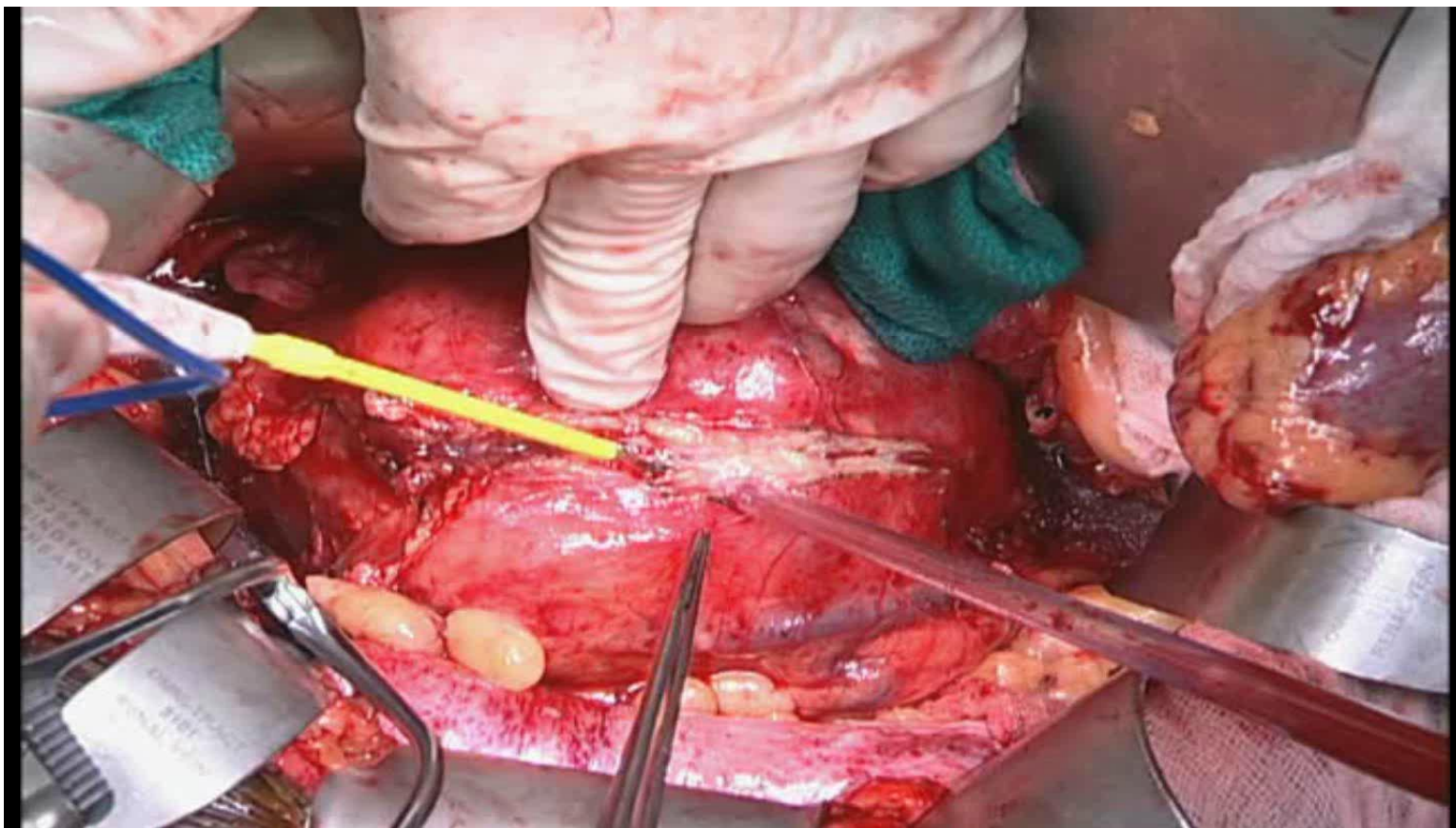
Theory on the Etiology of Type 5 Endoleaks *Observations From Explant Experience*

- Endotension or type 5 endoleaks results from aortic wall adventitial vascularity and leak from the aortic wall into the aortic sac.



At Explant – Aortic Wall Adventitial Vascularization





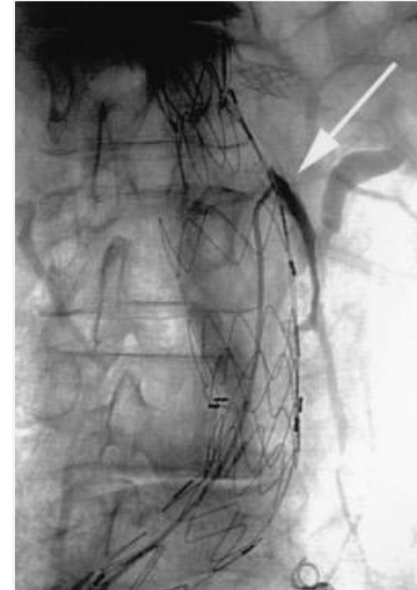
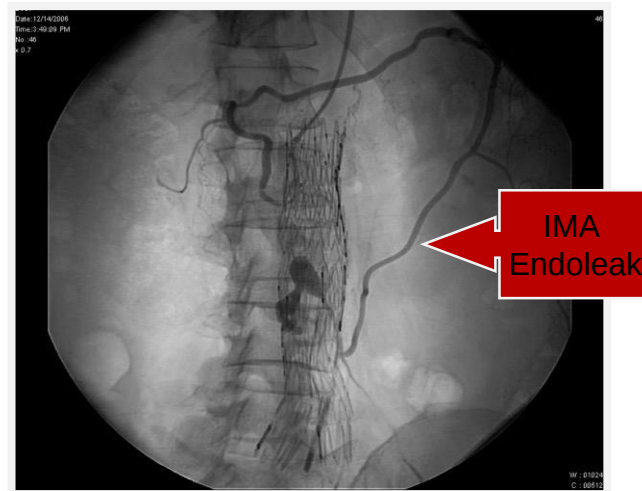
Which need treatment?

- Type I- needs URGENT repair
- Type II- only if sac grows $> 5\text{mm}$
- Type III- needs repair
- Type IV- only if sac grows $> 5\text{mm}$
- Type V- only if sac grows $> 5\text{mm}$



Treatment Options

1. Branch vessel embolization of inferior mesenteric artery or lumbar artery
2. Direct sac embolization
3. Reline
4. Explant



Post-operative Management



Medical Management



Journal of Vascular Surgery
Volume 59, Issue 6, June 2014, Pages 1615-1621.e1



Clinical research study

From the Society for Vascular Surgery

Perioperative management with antiplatelet and statin medication is associated with reduced mortality following vascular surgery

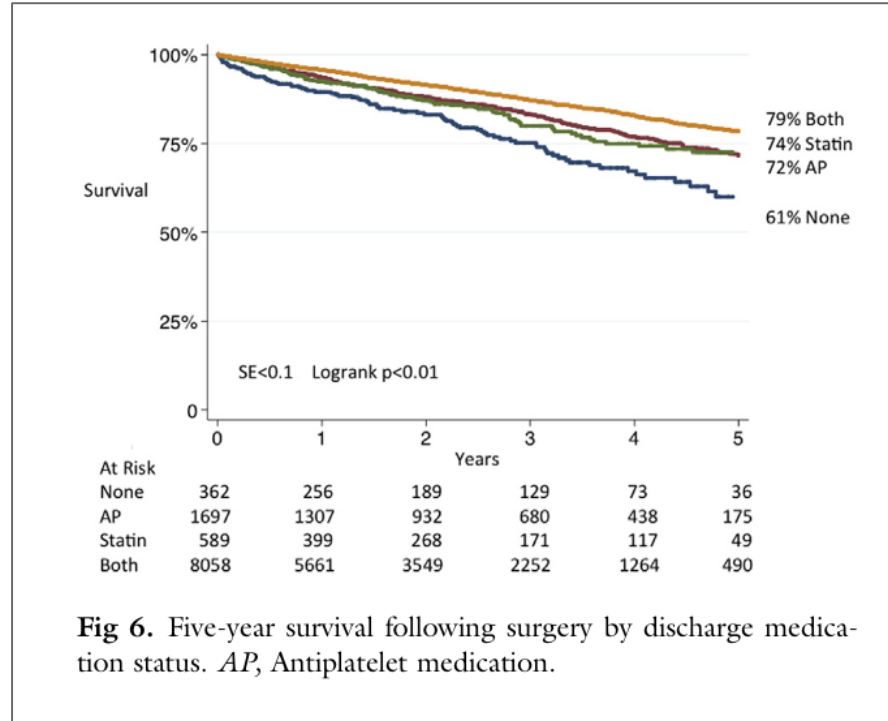
Presented at the 2013 Vascular Annual Meeting of the Society for Vascular Surgery, San Francisco, Calif, May 30-June 1, 2013.

Randall R. De Martino MD, MS^{a, b} ✉, Jens Eldrup-Jorgensen MD^c, Brian W. Nolan MD, MS^a, David H. Stone MD^a, Julie Adams MD^d, Daniel J. Bertges MD^d, Jack L. Cronenwett MD^a, Philip P. Goodney MD, MS^a, Vascular Study Group of New England



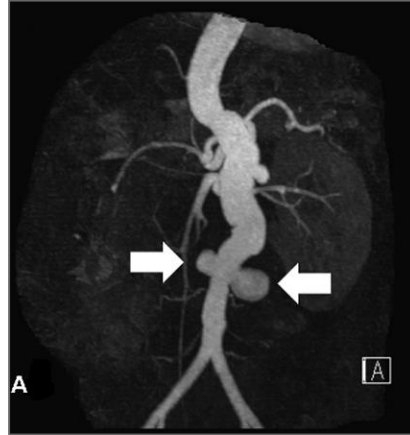
THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER

Improved 5 year survival



Post-Open Surveillance

- Recommend NON-CONTRAST ENHANCED CT imaging of entire aorta at 5 year intervals
 - Anastomotic pseudoaneurysms
 - Pelvic or thoracic aneurysms



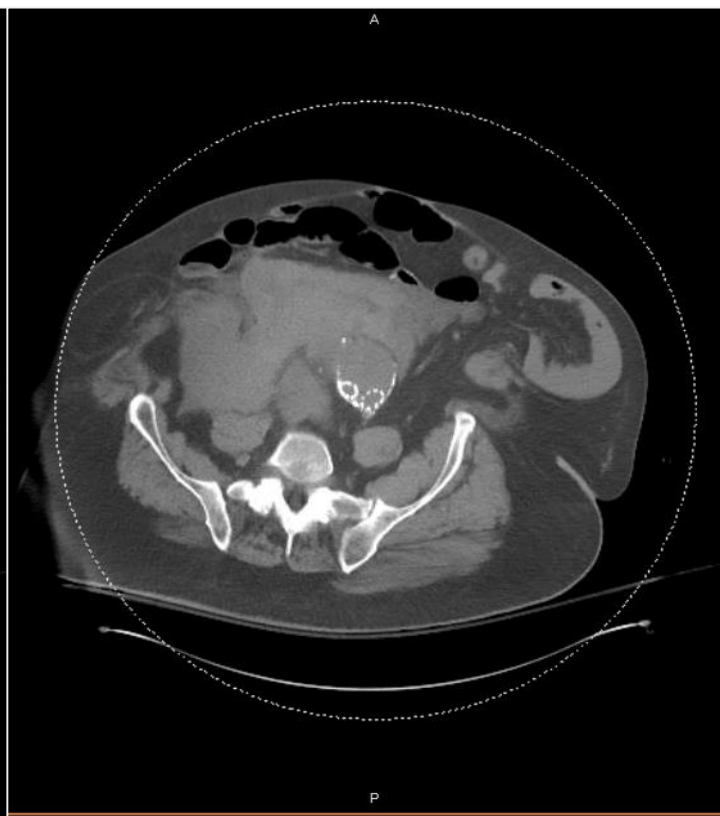
Post-EVAR Surveillance

- Recommend CONTRAST ENHANCED CT Imaging at 1 and 12 months
 - Patients with renal insufficiency may undergo color duplex ultrasound AND non-contrast CT
- If no evidence of endoleak is documented, may transition to yearly color enhanced duplex ultrasound
- If aneurysm sac does not shrink or endoleak is identified on ultrasound, return to CT imaging is recommended
- **LIFELONG SURVEILLANCE**

Case

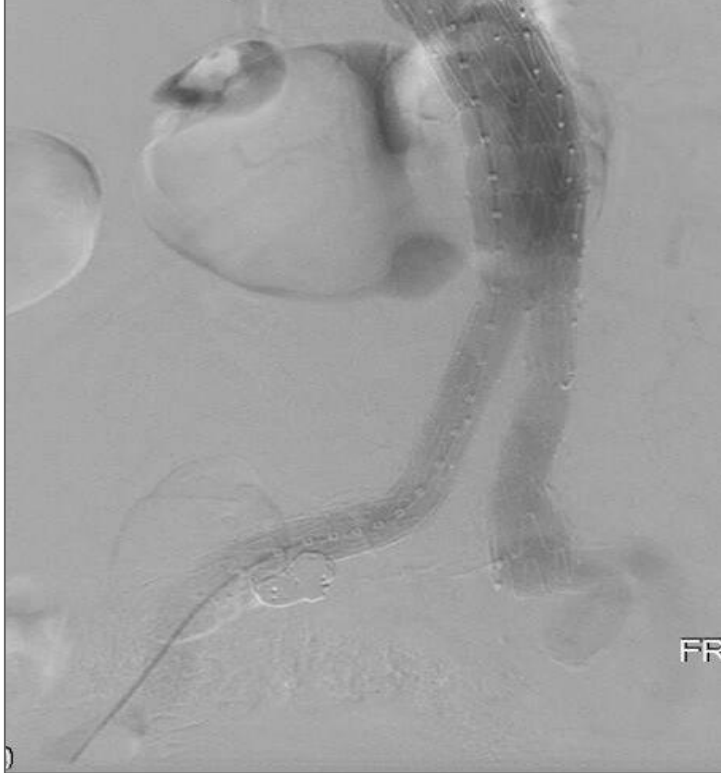


- 76M h/o AAA s/p EVAR at OSUMC in 2006, lost to follow up (last CT in our system from 2007 – AAA 5.5cm), presented to OSH on 1/26/19 with abdominal and back pain.
- PMH: CAD, CKD, AAA, HTN, DM, hypothyroidism
- PSH: EVAR, colon resection, colostomy reversal, ventral hernia repair
- Flown directly OSU Ross OR
- ABG: pH 7.15, pCO2 58, PO2 436, BE -8.5
- K 5.1, Hgb 8.5, Lactate 3.2

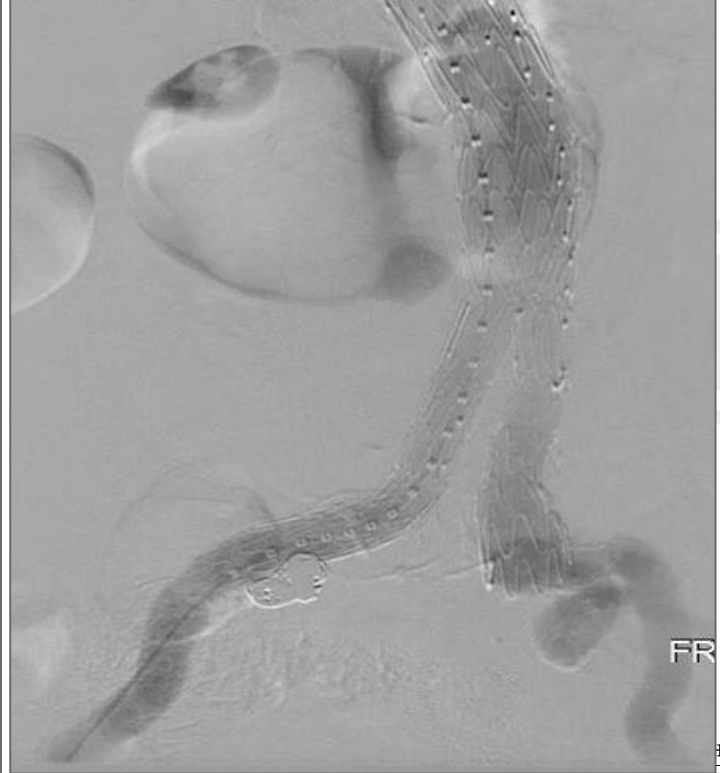


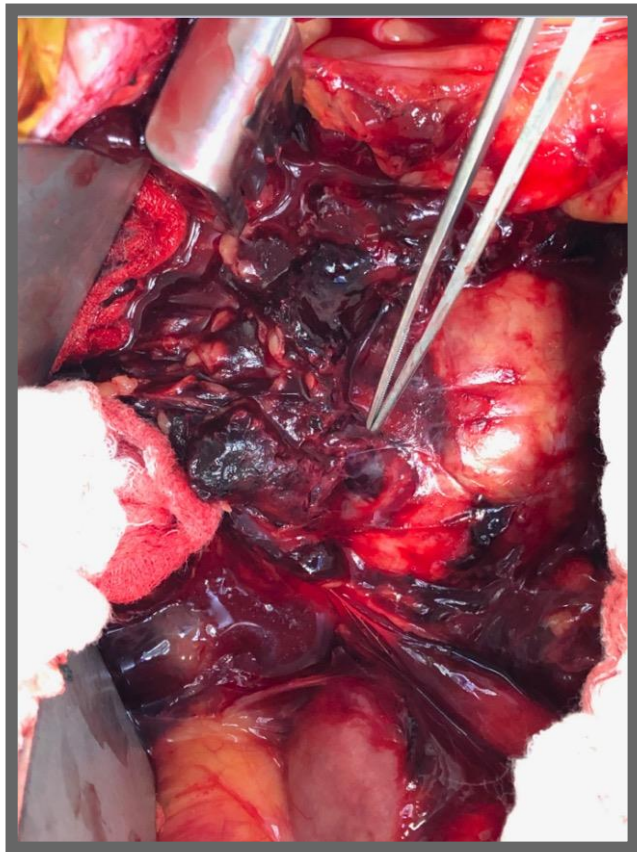
Aortogram

ate University Ross Heart Hospital



ate University Ross Heart Hospital







End of case:

ABG: pH 7.31, pCO2 51.4, PO2 113.8, BE -1.4

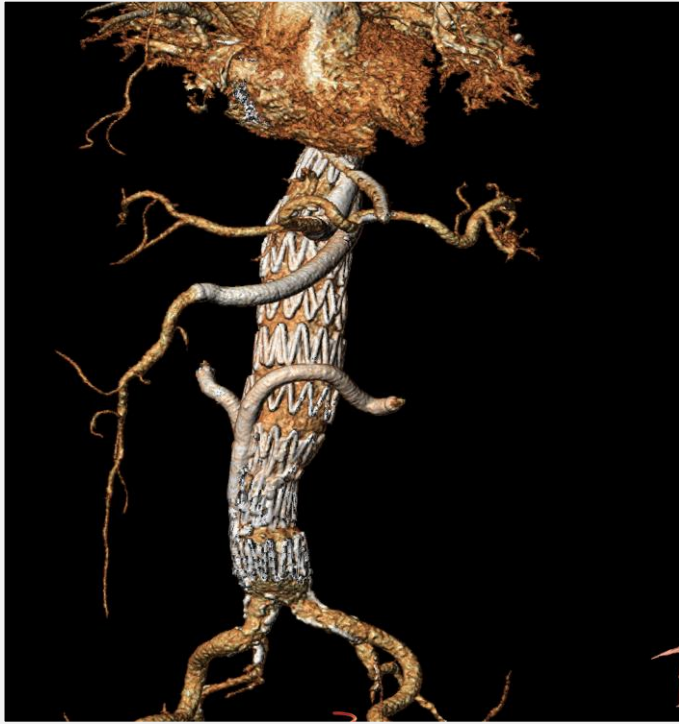
Lactate 1.91

Hgb 10.9

Review

- Ultrasound screening approved by Medicare for men
- 30 day benefit for EVAR but equal at 2 years
- EVARs performed 4 times more often
- EVAR first choice for ruptured AAAs
- Patients with renal insufficiency may undergo both open or EVAR
- Type I and Type III endoleaks must be repaired
- Improved 5 year survival with antiplatelet and statin
- Patients need LIFELONG SURVEILLANCE

What about para/suprarenal AAA's?





Thank you

kristine.orion@osumc.edu