

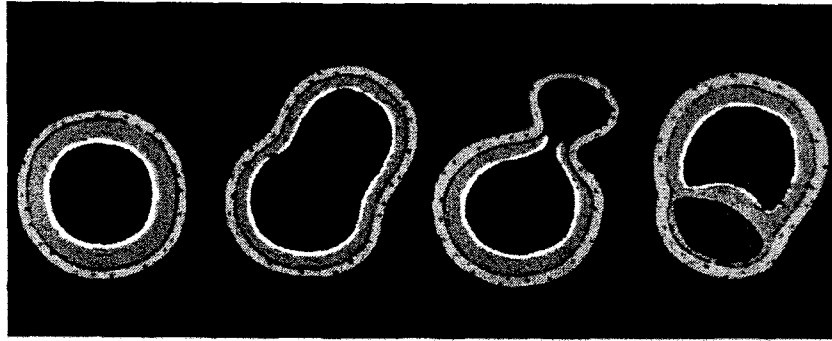
Endoleak & Hemodynamics in the EV Repair of Aortic An.

Jae Hyung Park, M.D.
Department of Radiology
Seoul National University
College of Medicine

Endoleak & Hemodynamics in the EV Repair of Aortic An.

- Introduction: Aortic Aneurysm
- Introduction: EVR with Stent-graft
- Technique
- Results: Case presentation
- Endoleak
- Hemodynamics related to Stent-graft
- Summary

Types of Aortic Aneurysm



Normal

True an.

False an.

Dissection

Clinical epidemiology: AAA

- AAA; 10th Cause of death (>65yo) in USA
- Spontaneous rupture; 90% death
- Risk of rupture 5-15%/yr of 5-7cm ϕ
- An >6cm, 5-yr survival: 6%
- Rupture risk factors : COPD, Hypertension, family history, rate of increase

*NEJM 1989;321:1009
J Vasc Surg 1994; 19:727*

Definition of AAA

- Infrarenal Abd Ao.:
1.2-2.0cm in normal
- Aneurysm:
50% dilation of normal
size, greater than 3cm



Management for Aortic An.

- Open surgical technique
 - A summary of 15 series of 21,000 pts:
30-day mortality (intact an.) 6.0%
- Sutureless graft
- Induced thrombosis
- Endovascular grafting

Endoleak & Hemodynamics

- Introduction: Aortic Aneurysm
- Introduction: EVR with Stent-graft
- Technique
- Results: Case presentation
- Endoleak
- Hemodynamics related to Stent-graft
- Summary

Stent graft placement for AAA



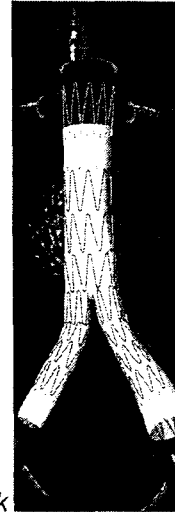
AAA

Stent-graft

An. exclusion

Stent-graft

- Vascular graft + metallic stent
- Indications
 - Aneurysm exclusion (surgically not indicated)
 - Blockage of AVF
- Contraindications
 - Anatomy: neck and cuff of An.
 - Tortuosity of iliac arteries



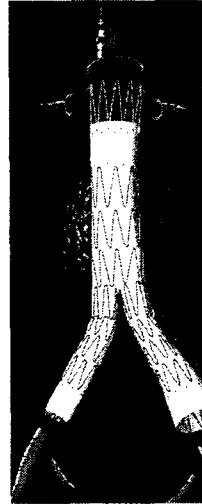
Zenith Cook

Exclusion of An.

- Graft anchoring at non-an. part, proximal & distal
- Graft exclude an.
- Barrier preventing contact of blood at systemic pressure
- Preventing continued an. expansion & rupture

Goal of Endograft

- Fixation
- Sealing
- Durability
- Patency



Fixation

- Ability of endograft to maintain its position over time without migration
- Three fundamental components
 - Radial force within the prox/dist neck
 - Columnar support
 - Penetrating component(hooks, barbs, tissue ingrowth)

$$(\Sigma f = \Sigma r + \Sigma c + \Sigma p + \Sigma g)$$

Fixation

- Dependent upon anatomy
 - Quantity & quality of proximal neck
- Tortuosity of aorta & iliac artery
 - Change of vectors of columnar support

Sealing

- Circumferential apposition of graft material to the arterial neck prox/distal
- Radial force within prox/distal stent
- Dependent on fixation

Durability

- Dependent upon interaction of the materials
- To outlast the patient's life
- Fit to the patient's anatomy
- Understanding of manufacturing imperfection

Patency

- A major problem with early unsupported prostheses
- Morphologic changes of aneurysm sac
- Flexibly conform to the morphology

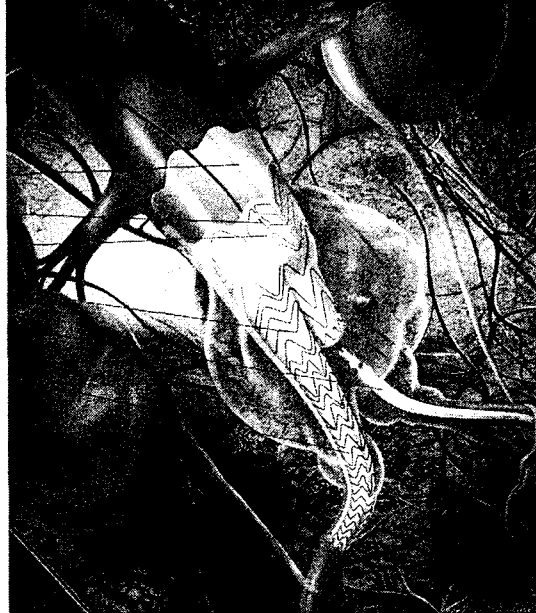
Excluder

Bifurcated
endoprosthesis

*ePTFE
Proximal anchors*

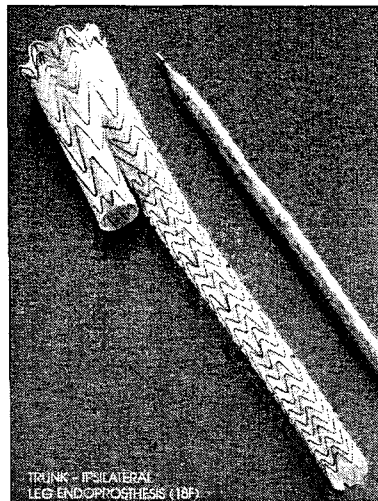
*External nitinol
support
18 & 12F*

*Conformable &
Kink-resistant*

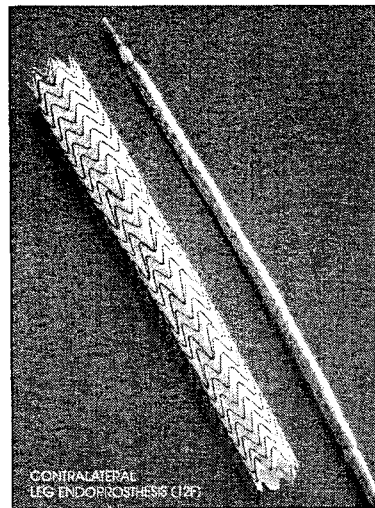


GORE

Excluder



Ipsilateral

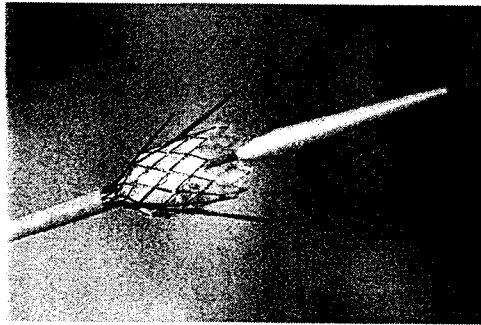


Contralateral

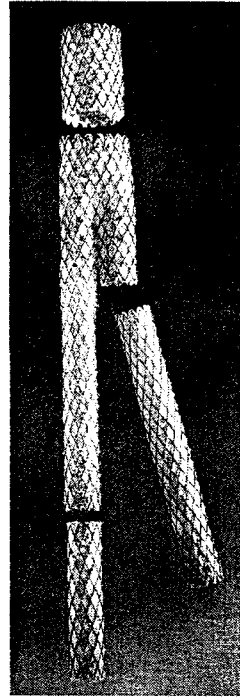
GORE

AneuRx

Fully supported exoskeleton



Meditronic



Ancure

Unibody design

Endo-Hooks provide pressure independent, positive fixation to the arterial wall:

- Patented Eigloy Endo-Hooks replicate surgical anastomoses and withstand significant longitudinal forces in the aorta.
- 0% (0/75) attachment site leak rate at 12 months in Bicuspid patient cohort.



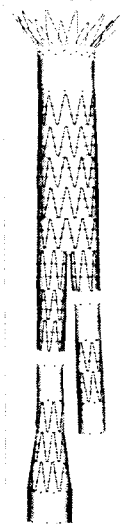
Unibody design adapts to changing morphology and difficult AAA anatomy:

- Unibody design eliminates need for modular component joints, reducing the potential of component separation, migration, and endoleaks.

- Designed to conform to changing morphology and to adapt to difficult and tortuous vessel anatomy.

Guidant

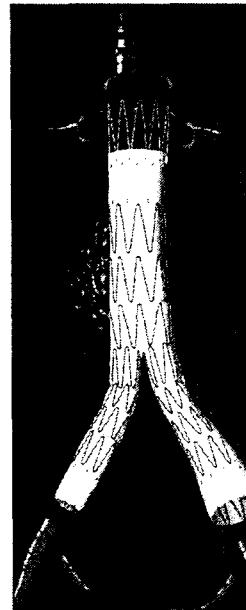
Zenith



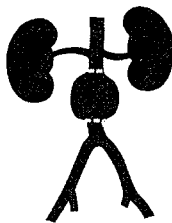
Cook



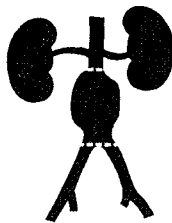
Introducer



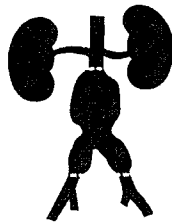
Morphology of AAA



A



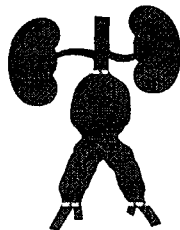
B



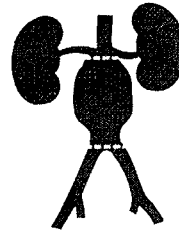
C

Endoluminal

Surgical



D

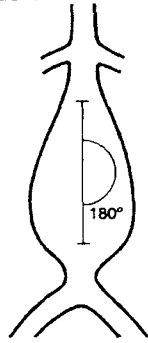


E

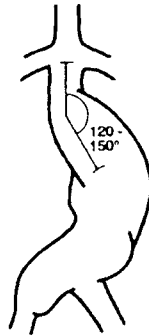
Blum U, et al. Endoluminal Tx of IR AA with stent-grafts. NEJM 1997; 336:13

Angulation of prox. neck of AAA

Grade I:



Grade II:



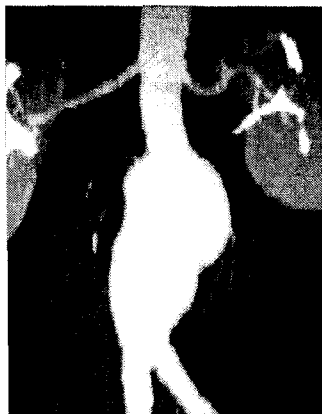
Grade III:



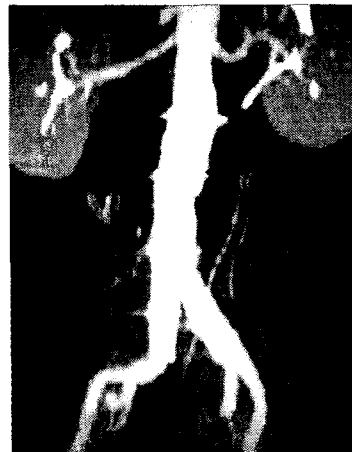
Reporting standards for IR endovascular AAA repair. J Vasc Surg 1997; 25:405-410

Stent-graft for AAA

Shin JK, M/64



Pre



Post

Anatomic evaluation of AAA

- Aneurysm size, renal art. Iliac art involve, peripheral art.
- IR aortic neck angulation & length
- Axis, major branch involve.
- Common & internal iliac involve.
- Calcified plaque and/or thrombus at proposed attachment

Ideal Anatomic Candidates(1)

- Ao. neck at least 15 mm
- Reverse taper ≤ 2 mm
- A diameter of 26 mm or less
- No mural thrombus
- Aortic angle of 60 degree or less

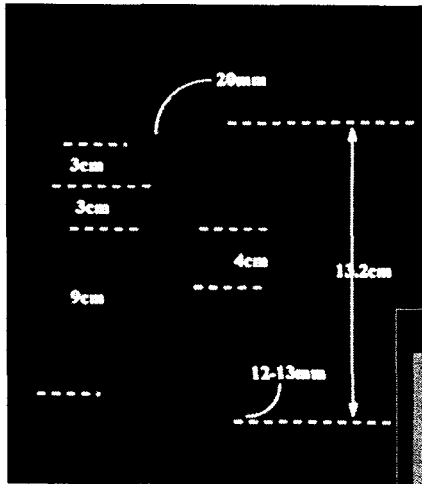
Ideal Anatomic Candidates(2)

- No severe tortuosity of iliac artery
- External iliac artery diameter \geq 8 mm or 6-8 mm without significant calcification or irregularity
- CIA without An. or ectasia (8-12 mm) & clean landing zone of 10 mm
- Absence of indispensable branches from An.

Endoleak & Hemodynamics

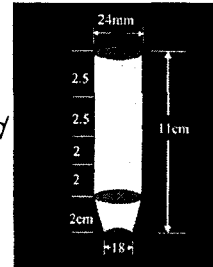
- Introduction: Aortic Aneurysm
- Introduction: EVR with Stent-graft
- Technique
- Results: Case presentation
- Endoleak
- Hemodynamics related to Stent-graft
- Summary

Stent-graft: Designs

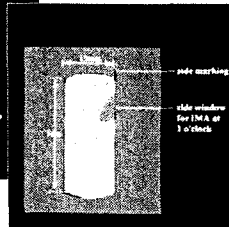


AAA F/63

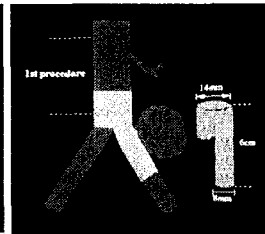
*Tubular
Tapered
M/64*



Behcet's M/41

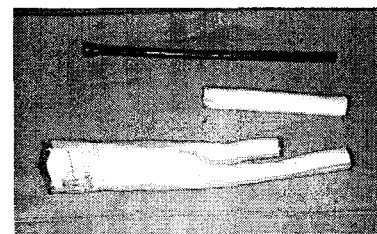
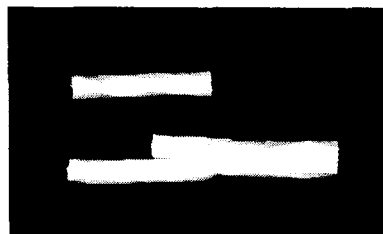
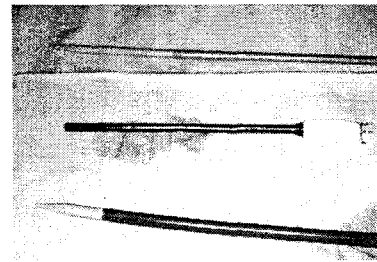
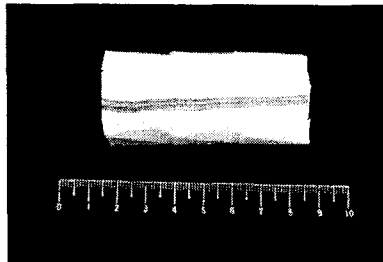


1st

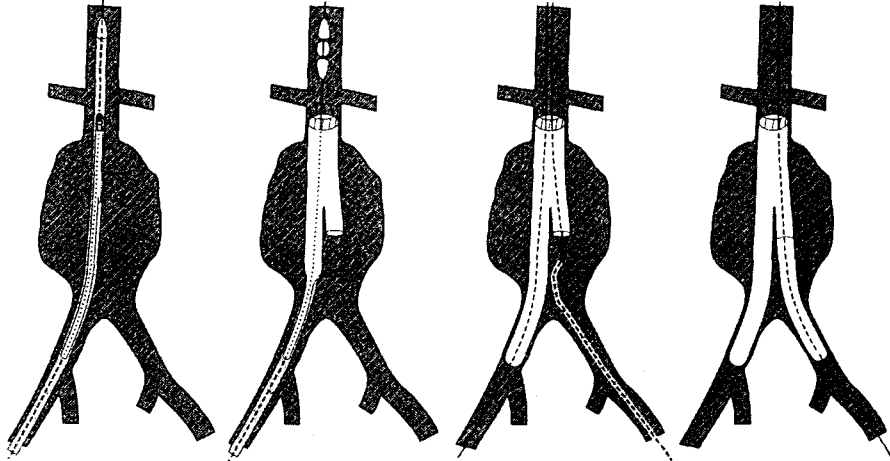


2nd

Stent-graft: Type & Materials

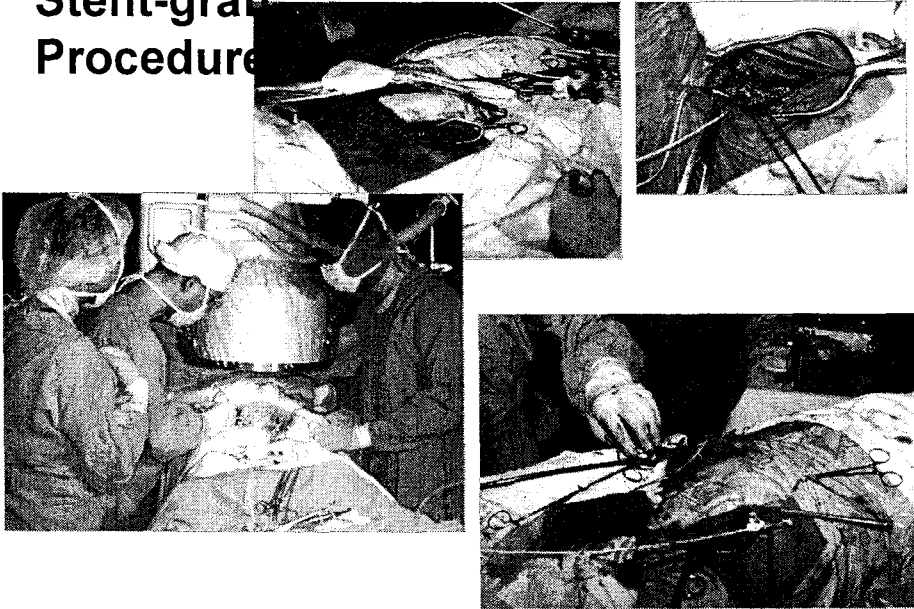


Technique of implantation



Bifurcated type

Stent-graft Procedure



Migration during deployment

- Aortic flow volume & pressure
 - Plug flow in as. Aorta & aortic arch
- Temporary obstruction
- Different order of expansion to prevent migration
 - Last expansion of proximal end: Zenith (Cook)
 - Last expansion of proximal & distal ends: Excluder (Gore)
 - Separate type; graft insertion first, stent deployment secondly

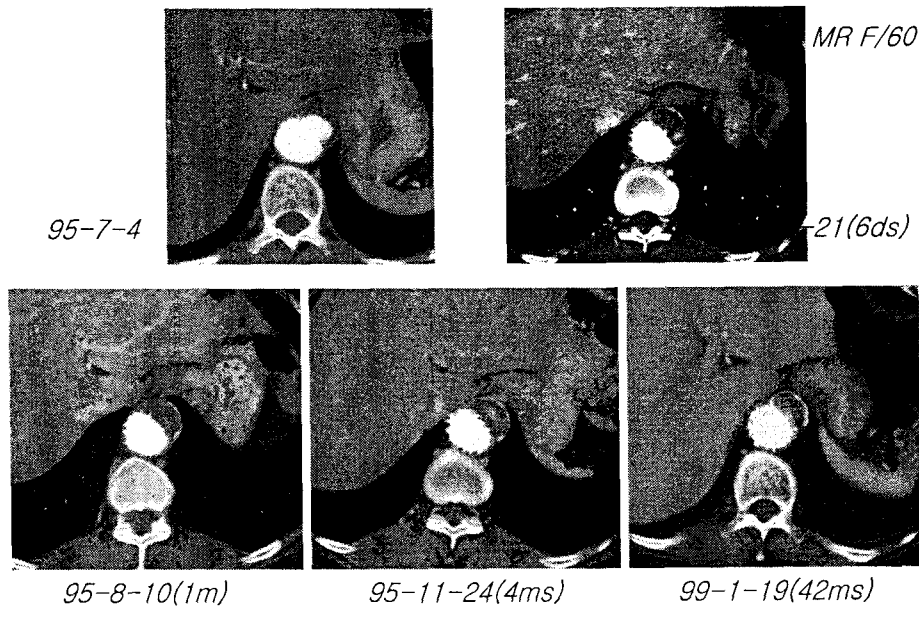
Endoleak & Hemodynamics

- Introduction: Aortic Aneurysm
- Introduction: EVR with Stent-graft
- Technique
- Results: Case presentation
- Endoleak
- Hemodynamics related to Stent-graft
- Summary

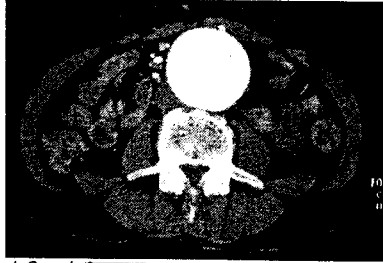
Penet. ulcer of TA: Stent-graft



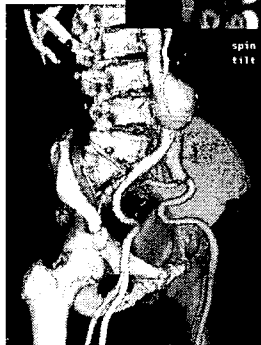
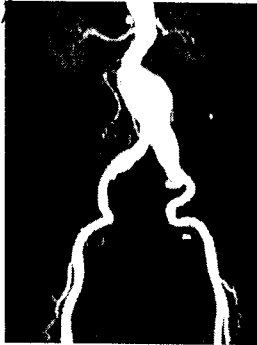
Penet. ulcer of TA: Stent-graft



AAA: Stent-graft *Sim JS M/81*

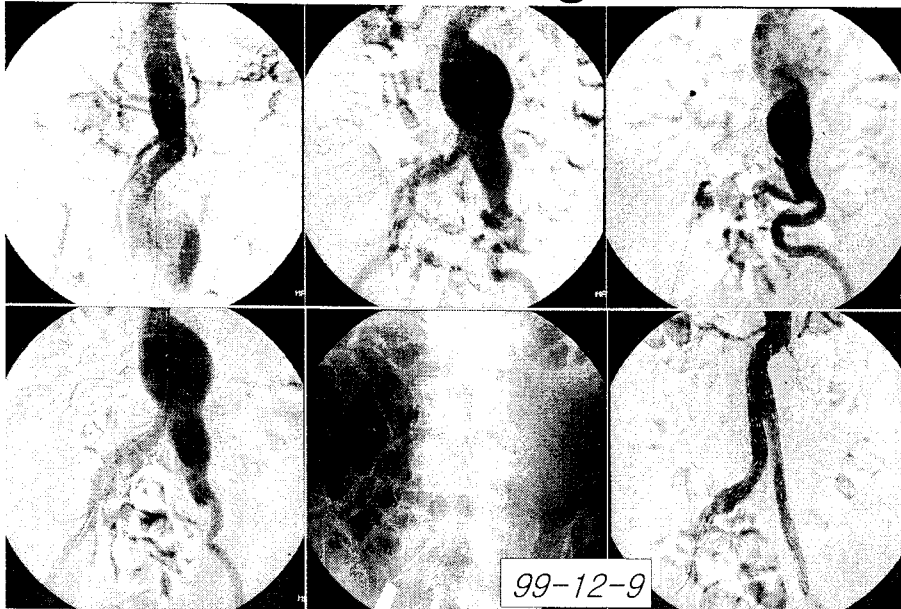


99-10-1



*Iliac
aneurysm
tortuosity*

AAA: Stent-graft *Sim JS M/81*



99-12-9

AAA: Stent-graft *Sim JS M/81*



00-1-3



00-9-2(9ms)

Definition of Results

- Primary technical success-complete
 - No endoleak, no increase of size
- Failure
 - Endoleak, size increase during F/U
- Secondary technical success

Materials & Methods

Patients with aortic aneurysm

- SNUH, 1995. 7-2003. 3
- 33 patients (M: F=15: 8)
- Age: 40-81yrs (mean 63yrs)
- Locations
 - Thoracic 11
 - Arch 4 DA 5
 - Abdominal 22

Results

Overall Results

- **Delivery Success 97% (32/33)**
- **Primary Success 84% (28/33)**
 - 1° Endoleak 5
 - Surgical conversion 1
 - Second st-g 1
 - Coil embolization 1
 - Observation 2
- **Secondary Success 90% (30/33)**

Cx. of endovascular repair

- Mortality
 - Around 4%, similar to open repair
- Technical complications
 - Learning curve(?), Inherent risks(!) of passing firm and large sheath or delivery system
 - Post-implantation syndrome upto 56%
- Endoleak
- Device failure
 - Kinking distortion, structural deterioration

Endoleak & Hemodynamics

- Introduction: Aortic Aneurysm
- Introduction: EVR with Stent-graft
- Technique
- Results: Case presentation
- Endoleak
- Hemodynamics related to Stent-graft
- Summary

Classification of endoleak

- Type I: Attachment leaks
- Type II: Collateral vessel leak
- Type III: Device failure leak
- Type IV: Porosity of graft material leak
- Endoleak undefined/ Endotension
 - ✓ Primary: immediate or <30days
 - ✓ Secondary: \geq 30days post-procedure

Endoleak type I

- Attachment site leaks
 - IA: Proximal
 - IB: Distal
 - IC: Iliac occluder

Endoleak type II

- Collateral vessel leaks
- IIA: Simple or to and fro (from single vs)
- IIB: Complex (flow through 2 or more vs)

Endoleak type III

- Graft failure
- IIIA: Mid-graft hole
- IIIB: Junctional leak or disconnect
- IIIC: Other causes of failure (suture holes, etc)

Endotension Type V

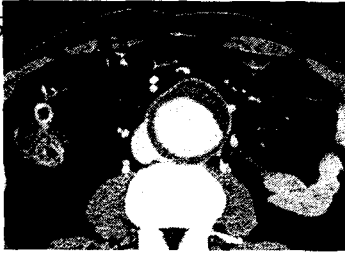
- Tension on an. wall without (with) the presence of and endoleak
- 20% pts-no shrinkage after Tx. success
- VA: Without endoleak
- VB: With sealed endoleak
- VC: With type I or III endoleak
- VD: With type II endoleak

Endoleak treatment

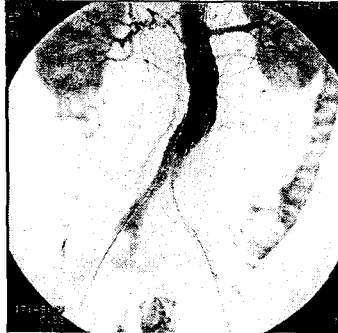
- Type I: angioplasty balloons, stents, or stent-graft extension
- Type II: Follow-up for spont. Thrombosis
 - Transarterial approach: microcatheter & coil embolization
 - Translumbar puncture: liquid embolic agents(NBCA: Trufill, Cordis)
- Type III: Stent-graft extension

AAA: Stent-graft

95



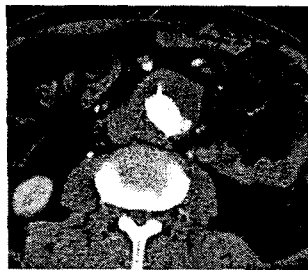
*Lee YJ, M/58
Bifurcated type*



*Endoleak
(+)
Type I*

95-7-31

AAA: Stent-graft



95-8-14

*Lee YJ, M/58
Bifurcated type*



*Endoleak(+)
Type I*

AAA: Stent-graft

Endoleak(-)



96-6-17

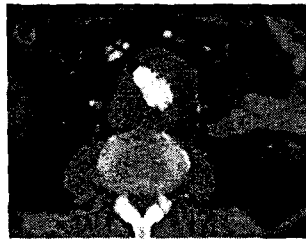


98-2-11

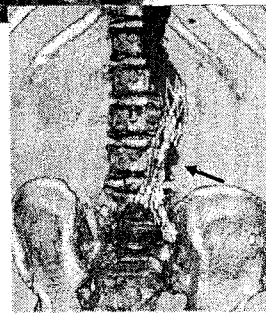
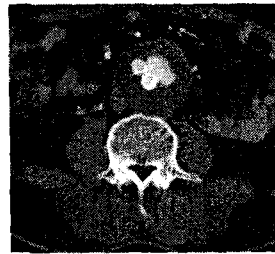
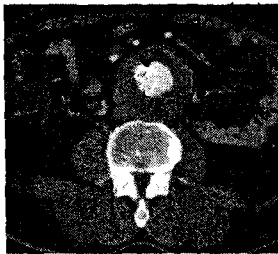
Lee YJ, M/58
Bifurcated type

AAA: Stent-graft

Lee YJ, M/58
Bifurcated type



99-7-6



00-6-19

Expired in Aug, 2000

Results

Follow-up results

• Follow-up period: 3m- 7y6ms	26
• Secondary endoleak	5
• Complete regression or decrease of aneurysm size	15
– Behcet's ds.	4/4
– Penetrating ulcer	4/4
– Abdominal aortic aneurysm	5/14
– Trauma	1/2
– Saccular an	1/2

Results

Complications

(N=33)

• Post-implantation syndrome	17 (51%)
• Endoleak	
Primary	5 (15%)
Secondary	5 (15%)
• New an. formation	1
• 30-d mortality (trauma 1, infection 1)	2
• Right EIA thrombosis	1

**Endoleak
Primary, type I
Secondary, type II**

F/71

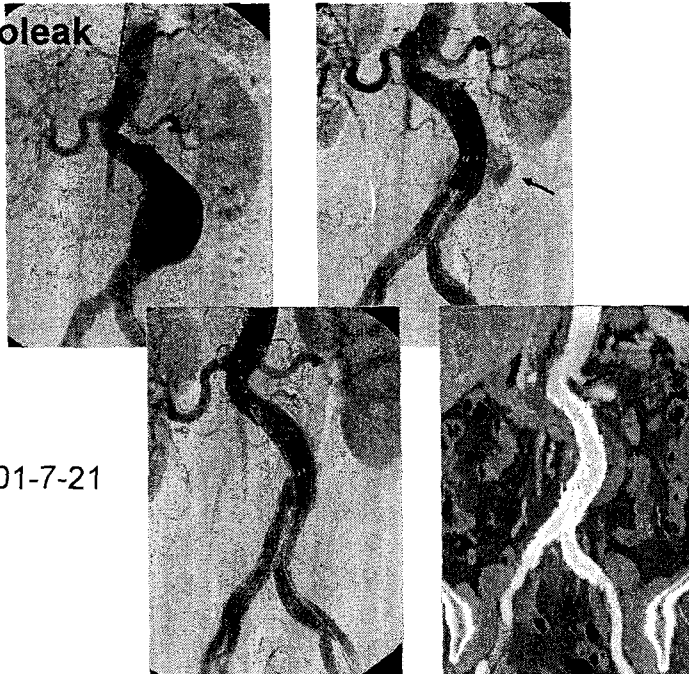
AAA

**Primary Endoleak
Type I
Second St-g**

2001-7-16

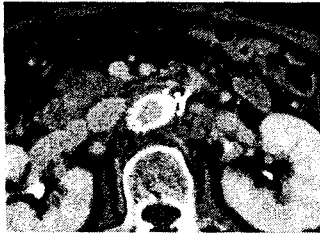
2001-7-21

*Lee SY
F/71*

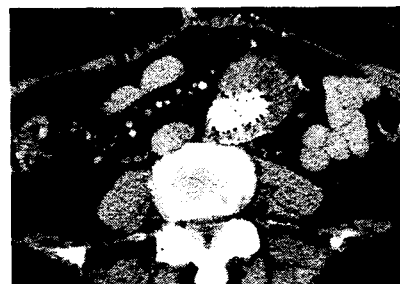


Lee SY

**Secondary Endoleak
Type II
Embolization**

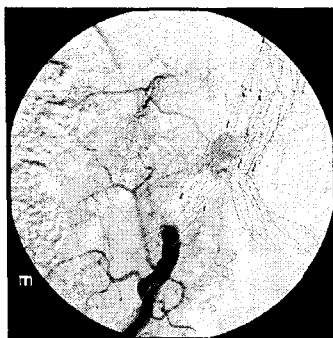


2001-7-26
Type I primary leak
controlled

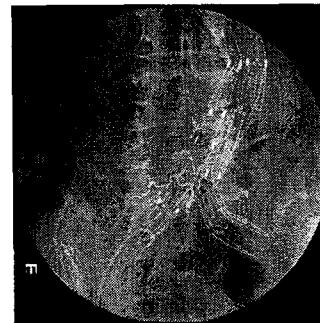
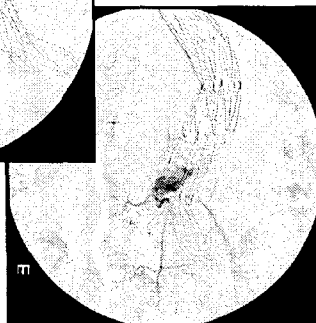
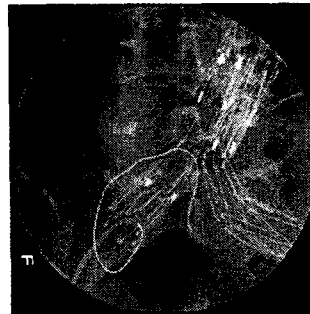


Post-embol.

**Secondary Endoleak
Type II
Embolization**



2001-11-20



Lee SY
F/71

Endoleak type I or Endotension?

M/63

Saccular an. of TA aorta

Park SB M/59

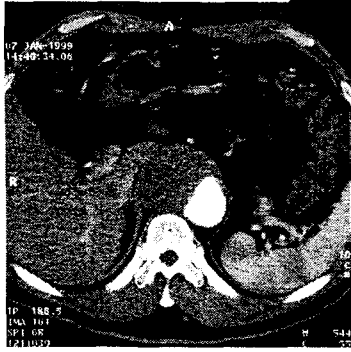
Management summary

- Dx: Saccular an. of thoraco-abd. aorta (97.3 routine check)
- Surgical op. rejection
- 1999-2-24 Stent-graft & CT f/u
- 2001-10-11 Coil embolization
- 2002-6-25 Pc. Glue injection
- 2003-1-13 Pc. Glue injection
- 2003-4-21 BM biopsy, RAEB-t
- 2003-5-23 Open surgery: vascular graft interposition

Eccent. An. of TA: Stent-graft

Park SB M/59

1999.1.7
69mm

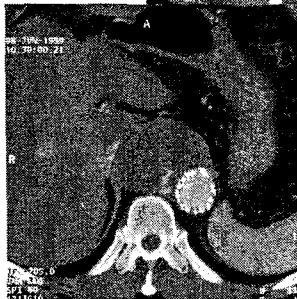
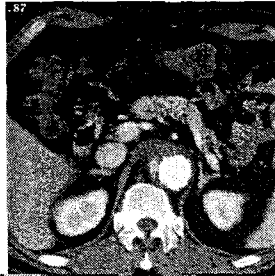
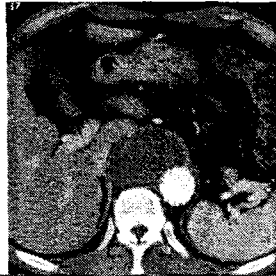


1999.2.24

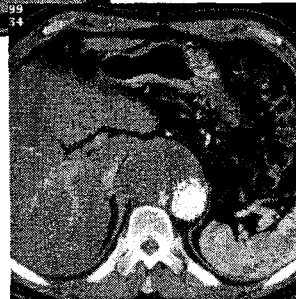
Eccent. An. of TA: Stent-graft

Park SB M/59

99-3-2
68mm



99-6-8



99-8-25

Eccent. An. of TA: Stent-graft

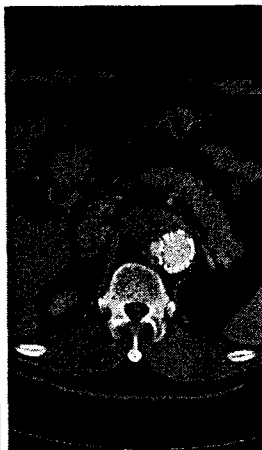
Park SB M/59



00-6-1



01-1-15



Eccent. An. of TA: Stent-graft



2001. 10. 11
Type I endoleak
Coil embolization



2002.10.6

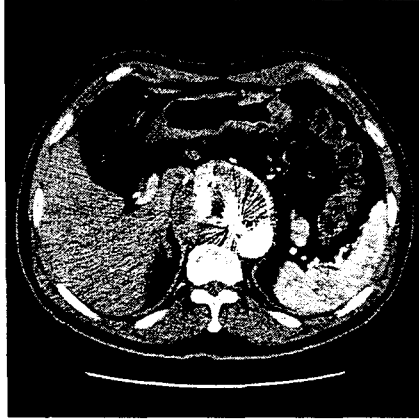
2003.1.13
Glue injection



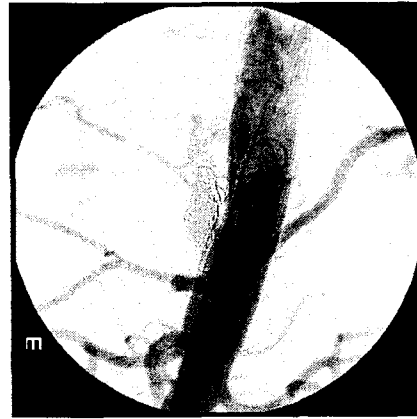
Park SB M/62

Endotension(?) Eccent. An. of TA

Park SB M/63



2003.4.10 (89mm)

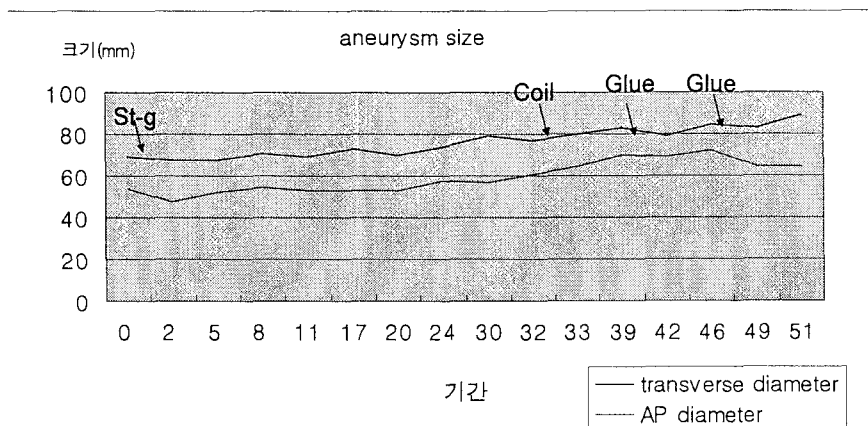


2003-5-7

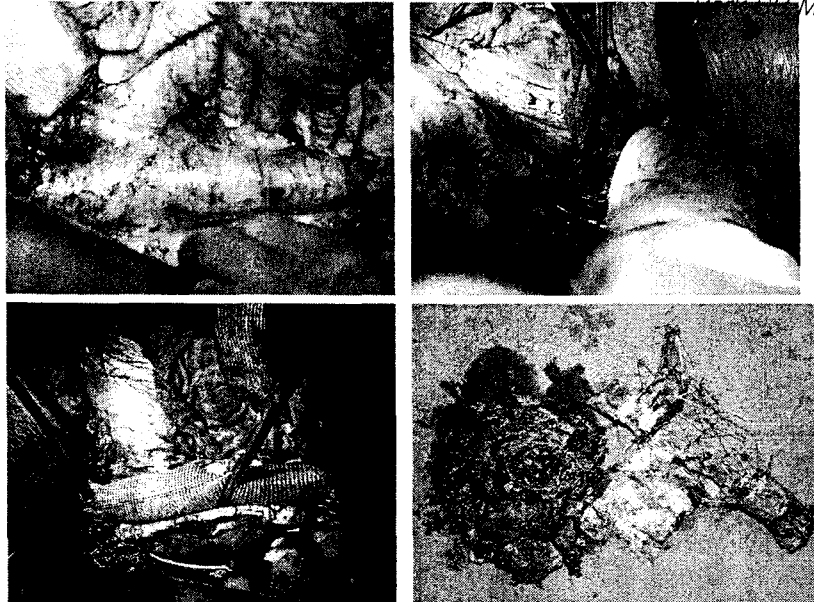
Eccent. An. of TA: Stent-graft

Park SB M/63

1999.1.7 - 2003.5.7 (4ys 4ms)



Eccent. An. of TA: Op. Findings



PPM/63

Endotension

- Increase of aneurysm without evidence of endoleak or stent-graft abnormality
- Leak <1 ml/min, not detected thrombus may transmit pressure
- Rigorous search for any endoleak and treatment
- If no endoleak - open conversion

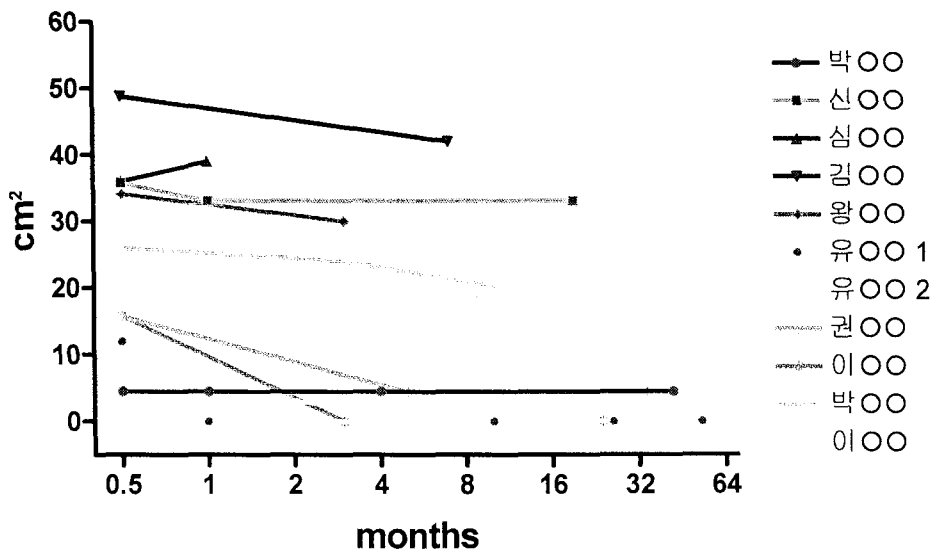
Size Change in AAA after St-G

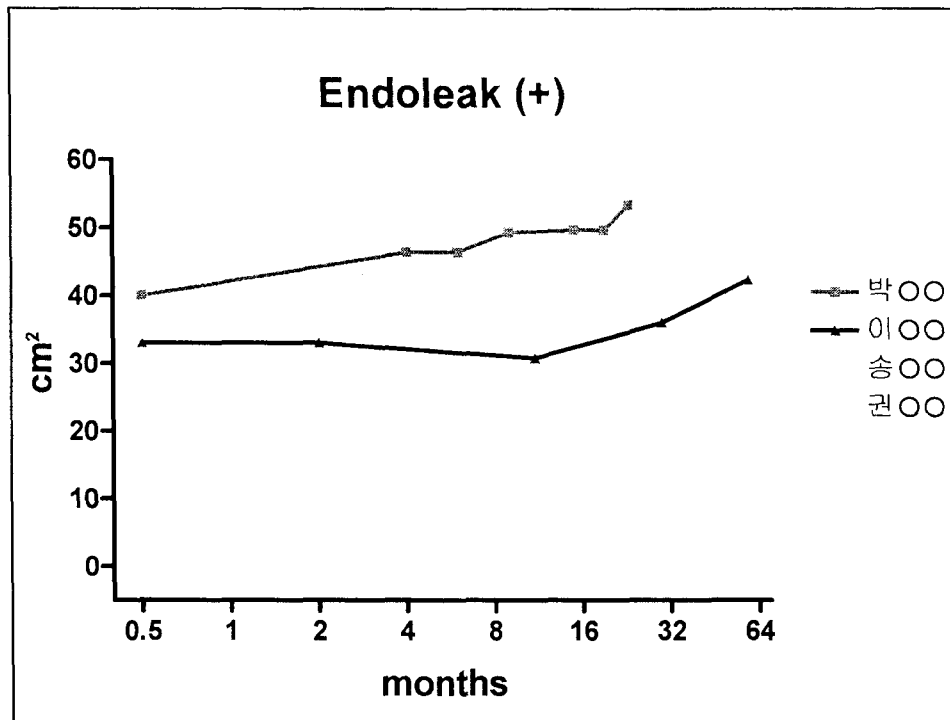
- Untreated AAA: inc.(mm/yr) 3.9 (0-10)
- Endograft of AAA in 73pts with F/U 3-30mos
- Dec. rate: 0.34mm/mo (0.50; EL-)

Change	EL +	EL -
Inc \geq 5mm	4.5%(1)	0
No change	91%(20)	63%(32)
Dec \geq 5mm	4.5%(1)	37%(19)
Total	22	51

Wolf YG, et al. J Vasc Surg 2000;32:108-115

Endoleak (-)





Endoleak & Hemodynamics

- Introduction: Aortic Aneurysm
- Introduction: EVR with Stent-graft
- Technique
- Results: Case presentation
- Endoleak
- Hemodynamics related to Stent-graft
- Summary

Endoleak size & an. pressure

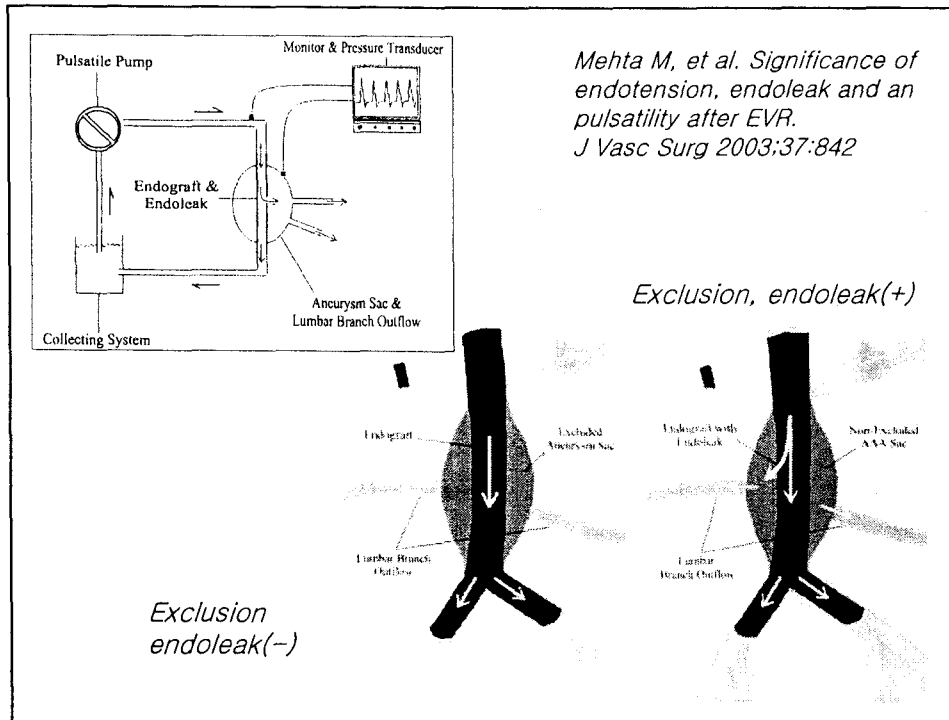
- Experiment on 3 pigs, 16 saccular an.
- Mean an. pressure
 - lower in a thrombosed endoleak
 - Related to the diameter of the endoleak
- Pulse pressure
 - Thrombosed endoleak-no pulse pressure

Schurink GW, et al. Experimental study of the influence of endoleak size on pressure-- Br J Surg 200;87:71

An. Pulsatility

- Lack of an. pulsatility after effective exclusion by Endovascular repair(EVR)
- Sac pressure directly related to the endoleak
- Sac pulsatility present with patent outflow
- No influence of thrombosis or type of stent on sac pressure & pulsatility
- Pulsatility is an unreliable guide for endoleak

Mehta M, et al. Significance of endotension, endoleak and an pulsatility after EVR. J Vasc Surg 2003;37:842



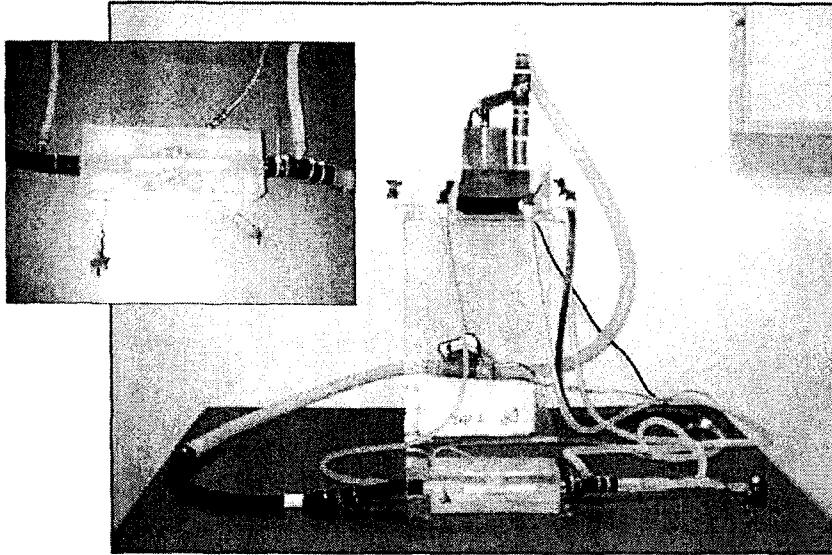
Endotension in An. Model

- Canine an. model
- An. sac pressure(ASP)
- ASP/BP measurement
 - Gr. I with exclusion 0.39 ± 0.02
 - Gr. II with failure 1.01 ± 0.02
- 2nd exclusion of attachment site failure
 - ASP/BP 0.98 to 0.46

Group I Group II

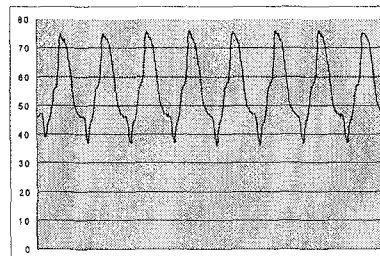
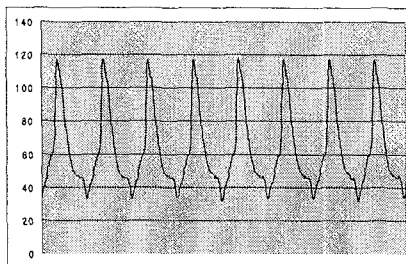
Skillem CS, et al. Endotension in an experimental an. model. J Vasc Surg 2002;36:814

An. Model with Pulsatile Flow

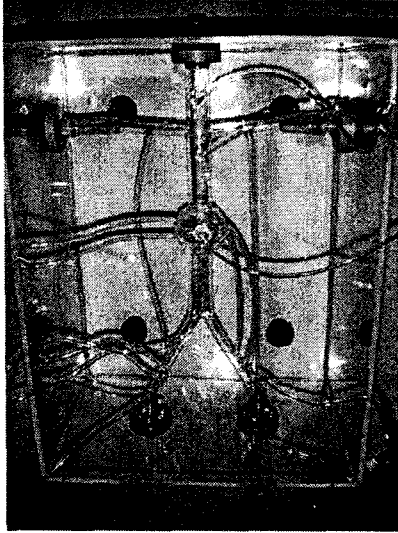


Results

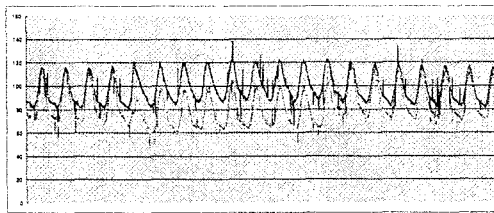
- Stent graft (14cm x 20mm)
 - Balloon dilatation in both ends of stent graft: *removal of type 1 endoleak*
 - No difference between collateral channel open or close



New An. Model



24mm x 10cm:
Type 1 endoleak (+)
26mm x 10cm:
Type 1 endoleak (-)



Endoleak & Hemodynamics

- Introduction: Aortic Aneurysm
- Introduction: EVR with Stent-graft
- Technique
- Results: Case presentation
- Endoleak
- Hemodynamics related to Stent-graft
- Summary

Current status: TL endografting

- Perioperative mortality ~ open repair
- Endoleaks ~ 1/6, secondary procedure
- Changes of neck & size of An.
- Not equivalent to conventional repair
- Needs close surveillance with CTA

Conclusion

- **Stent graft for aortic aneurysm**
 - Decrease or total regression of aneurysm with endoleak (-)
- **An. increase or rupture in cases with endoleak (+) or endotension**
 - Close F/U evaluation (CT) needed
- **Further hemodynamic evaluation for endoleak & endotension**