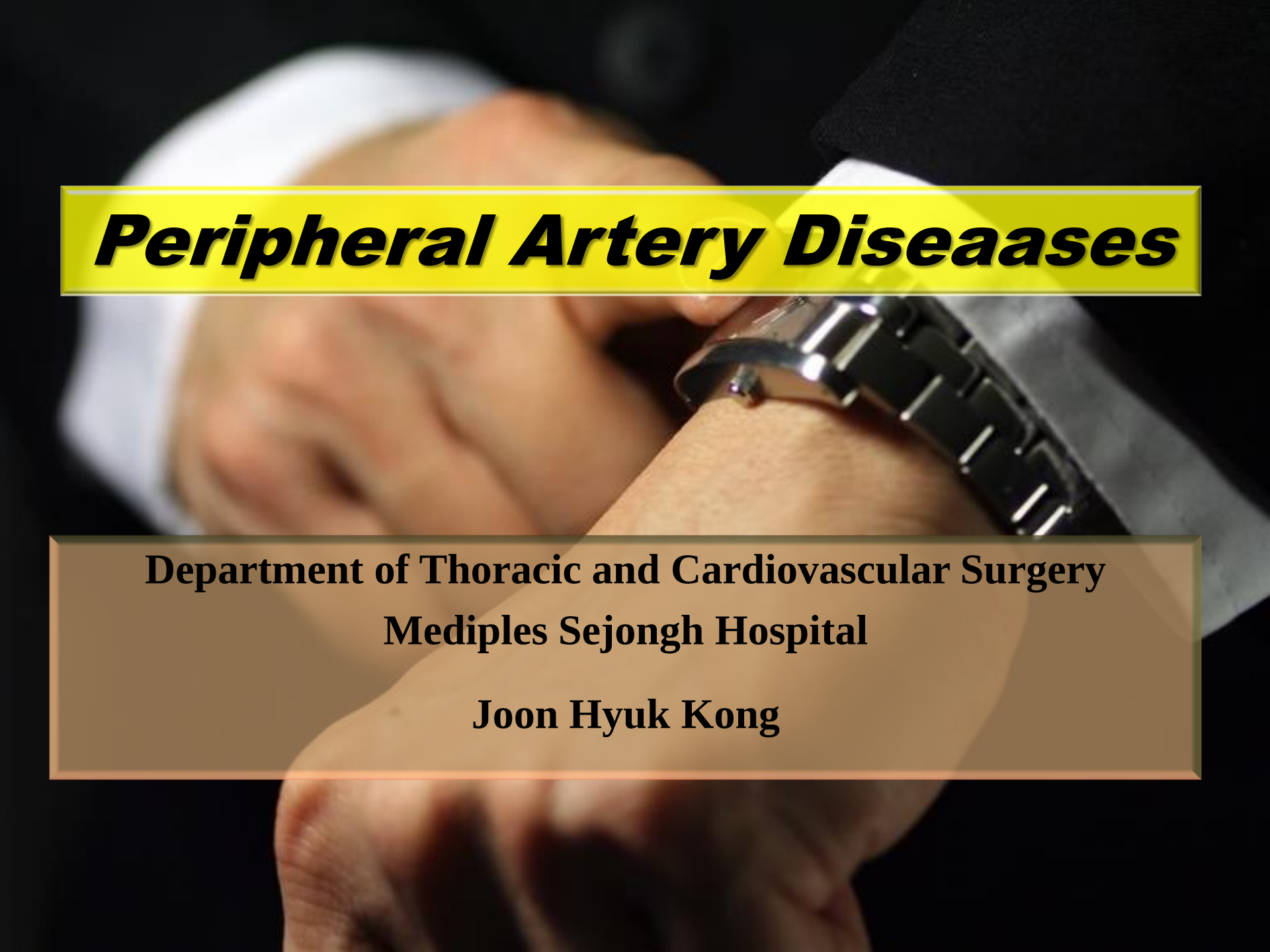


Peripheral Artery Diseaases

Department of Thoracic and Cardiovascular Surgery

Mediples Sejongh Hospital

Joon Hyuk Kong

0. Overview

Lower Extremity Disease

- Iliac artery disease
- SFA ds – long occlusion, femoropopliteal disease
- Below the Knee

Renal, Carotid, Subclavian Artery Stenosis

Venous disease – SVC, DVT, Vein occlusion

Aorta Disease – Aortic dissection, aneurysm, AAA

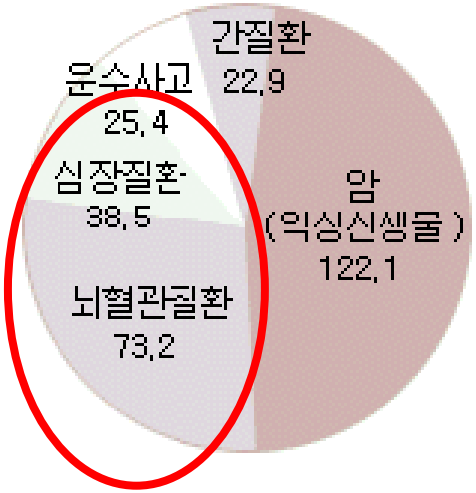
Adult congenital and structural heart disease (TAVI, ASD closure, percutaneous MVP)

1. Atherosclerosis

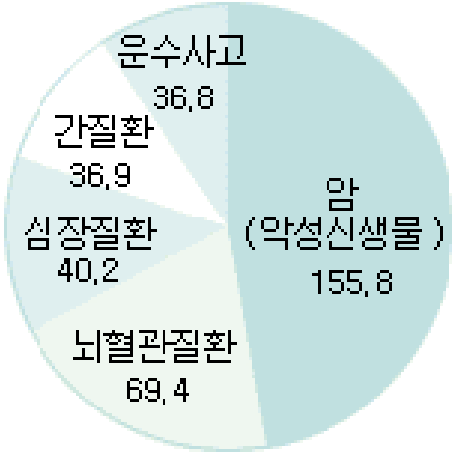
Cause of Moratlity in Korea

* 국내사망원인 (인구십만명당)

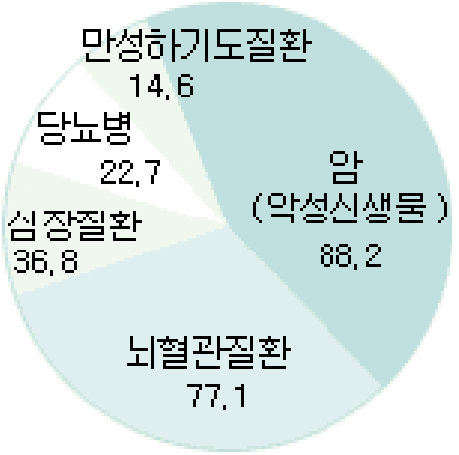
전체 사망원인 통계

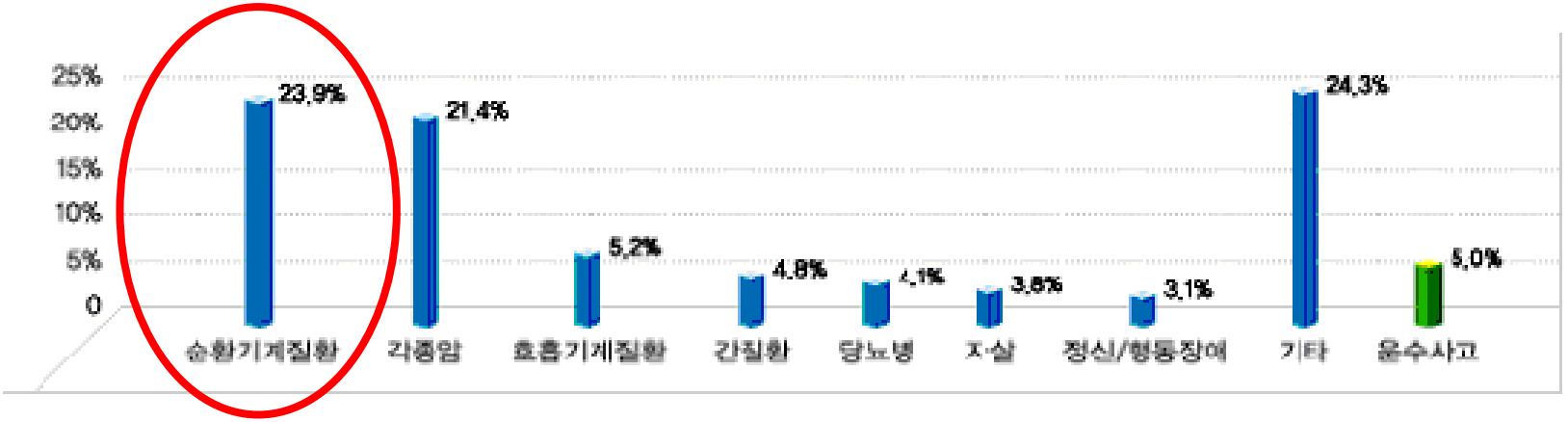


남자 사망원인 통계



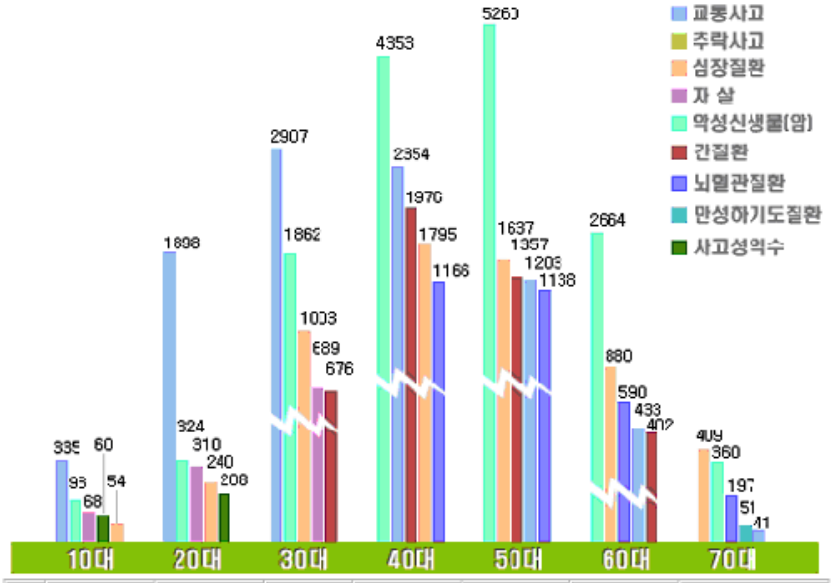
여자 사망원인 통계





Cause of Moratlity in Korea

▸ 연령별 사망원인 (남성)



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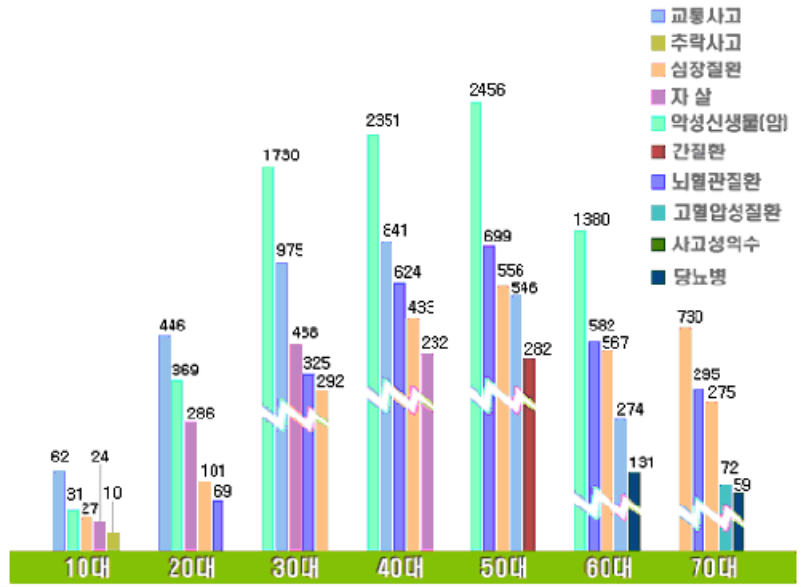
2위	암	암	암	교통사고	심장질환	심장질환	암
3위	자살	자살	심장질환	간질환	간질환	뇌혈관질환	뇌혈관질환
4위	사고성익수	심장질환	자살	심장질환	교통사고	교통사고	만성하기도질환
5위	심장질환	사고성익수	간질환	뇌혈관질환	뇌혈관질환	간질환	교통사고

자료 : 보험개발원 (1999~2000 생명보험가입자 사망원인)

* 연령별 사망원인 (여성)



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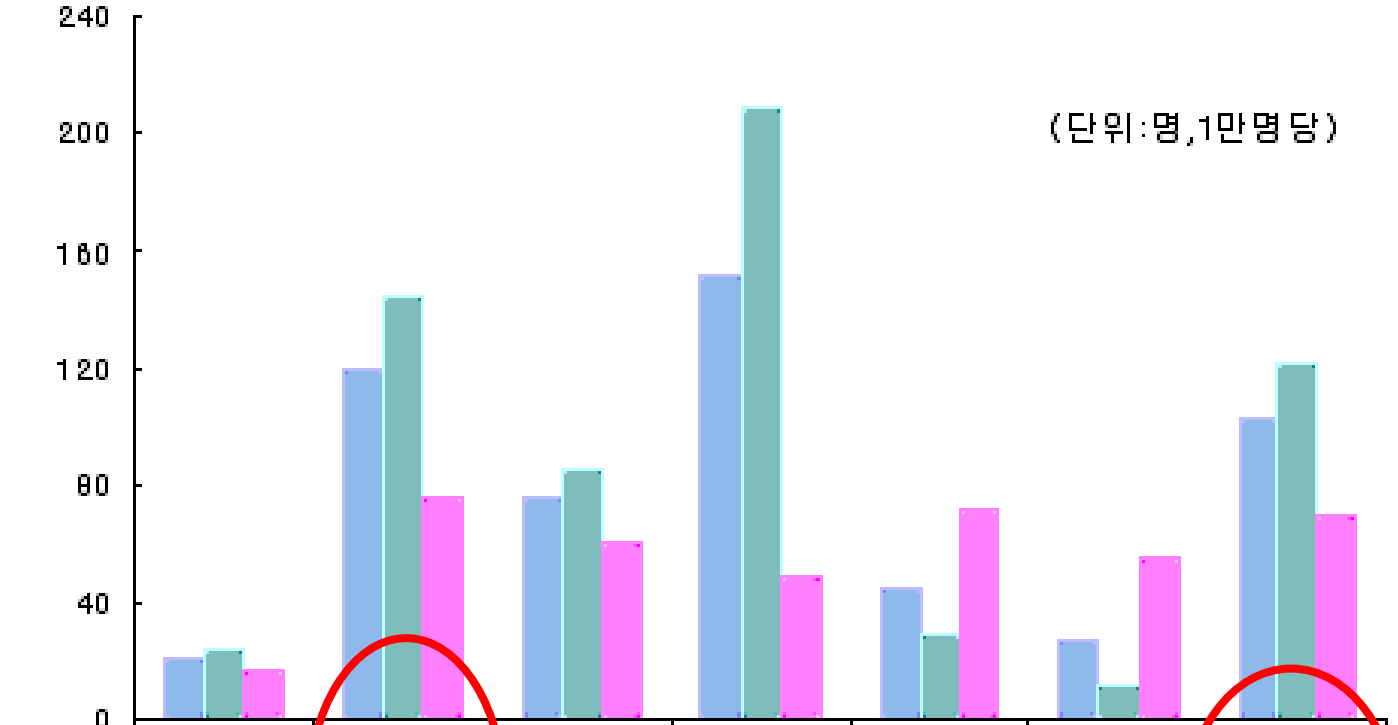
1위	교통사고	교통사고	암	암	암	암	심장질환
2위	암	암	교통사고	교통사고	뇌혈관질환	뇌혈관질환	암
3위	심장질환	자살	자살	뇌혈관질환	심장질환	심장질환	뇌혈관질환
4위	자살	심장질환	심장질환	심장질환	교통사고	교통사고	고혈압성질환
5위	추락사고	뇌혈관질환	뇌혈관질환	자살	간질환	당뇨병	당뇨병

자료 : 보험개발원 (1999~2000 생명보험가입자 사망원인)

Cause of Moratlity in Korea

* 건강검진 결과 질환별 유질환율 (국민건강보험공단 시행)



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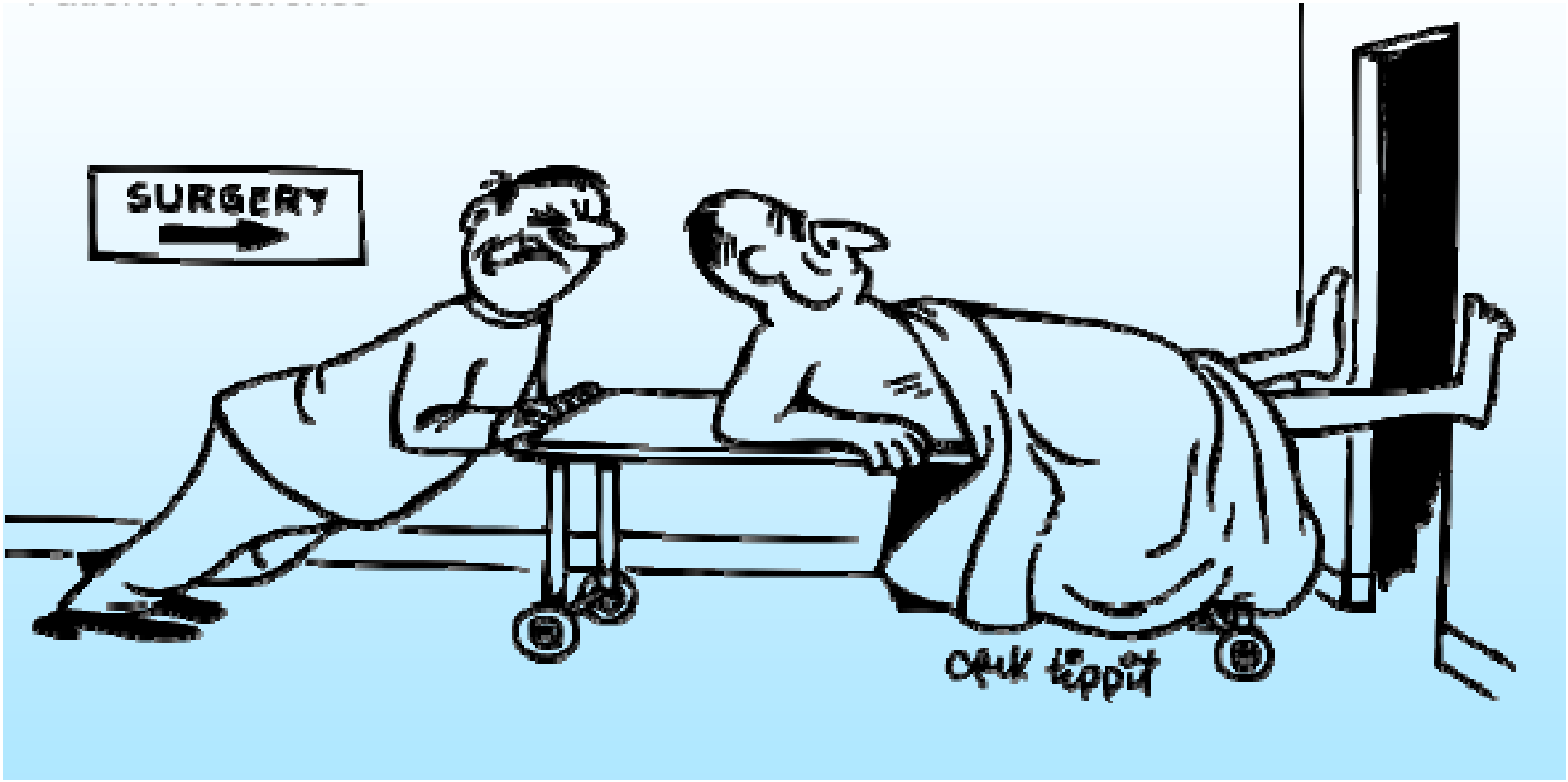
계	21.14	119.91	76.68	151.92	44.14	26.68	102.82
남자	23.44	144.97	85.68	209.74	28.79	10.45	121.61
여자	17.01	74.98	60.56	48.27	71.66	55.78	69.13

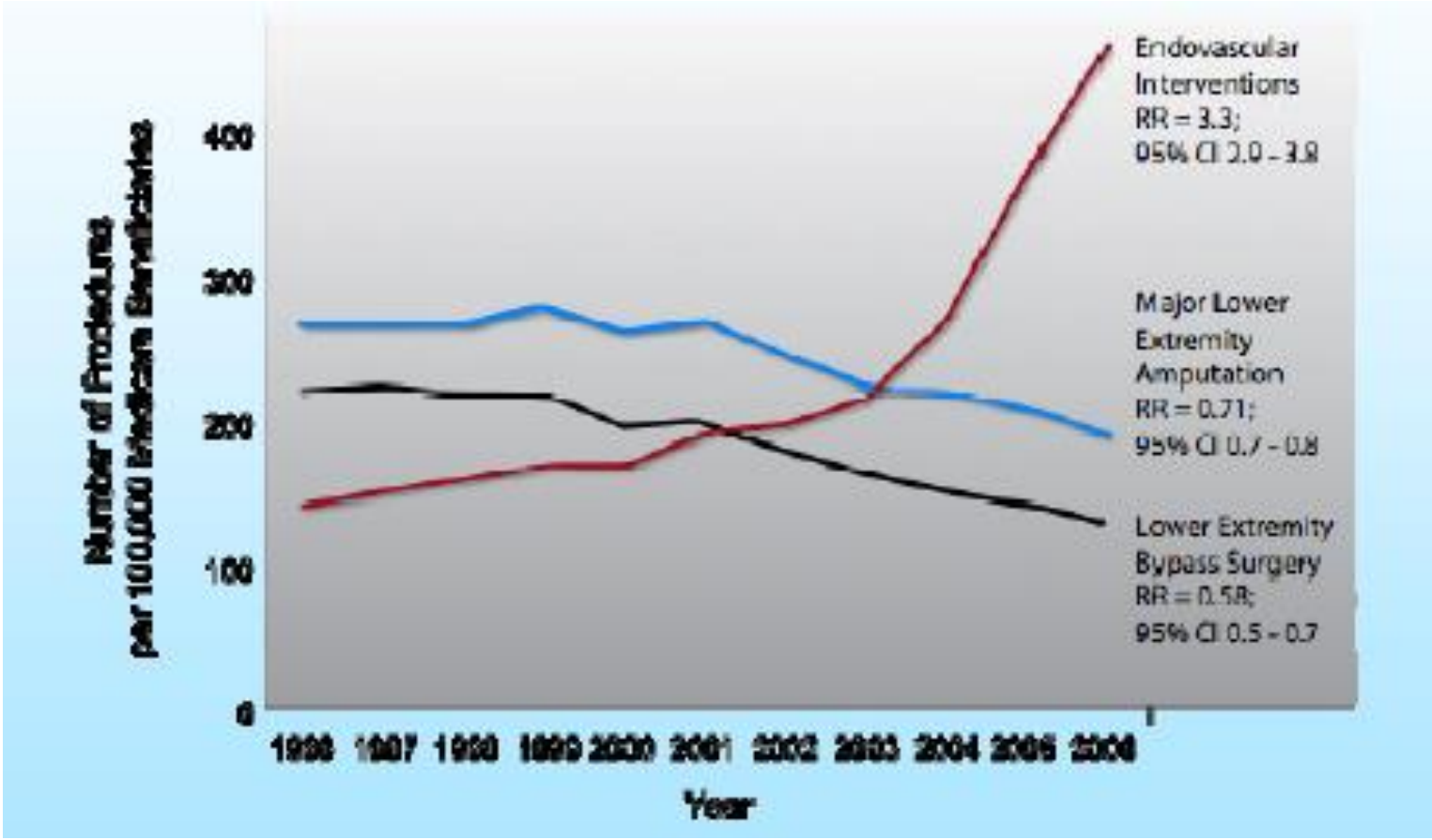
2. Trend of Endovascular Treatment

Patient Preference



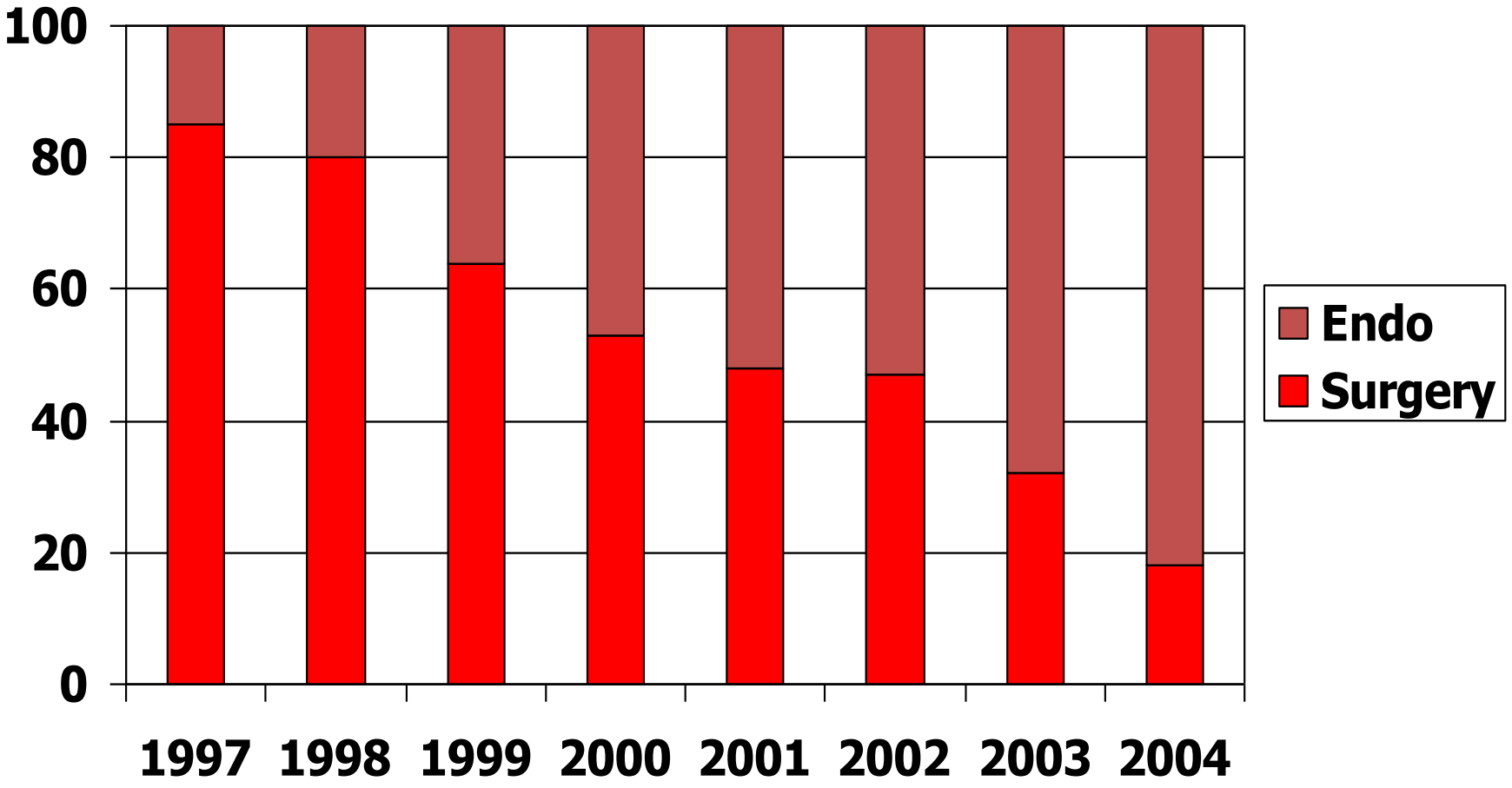
Trend in Lower Extremity Revascularization in USA

: Exponential Rise in Endovascular Intervention

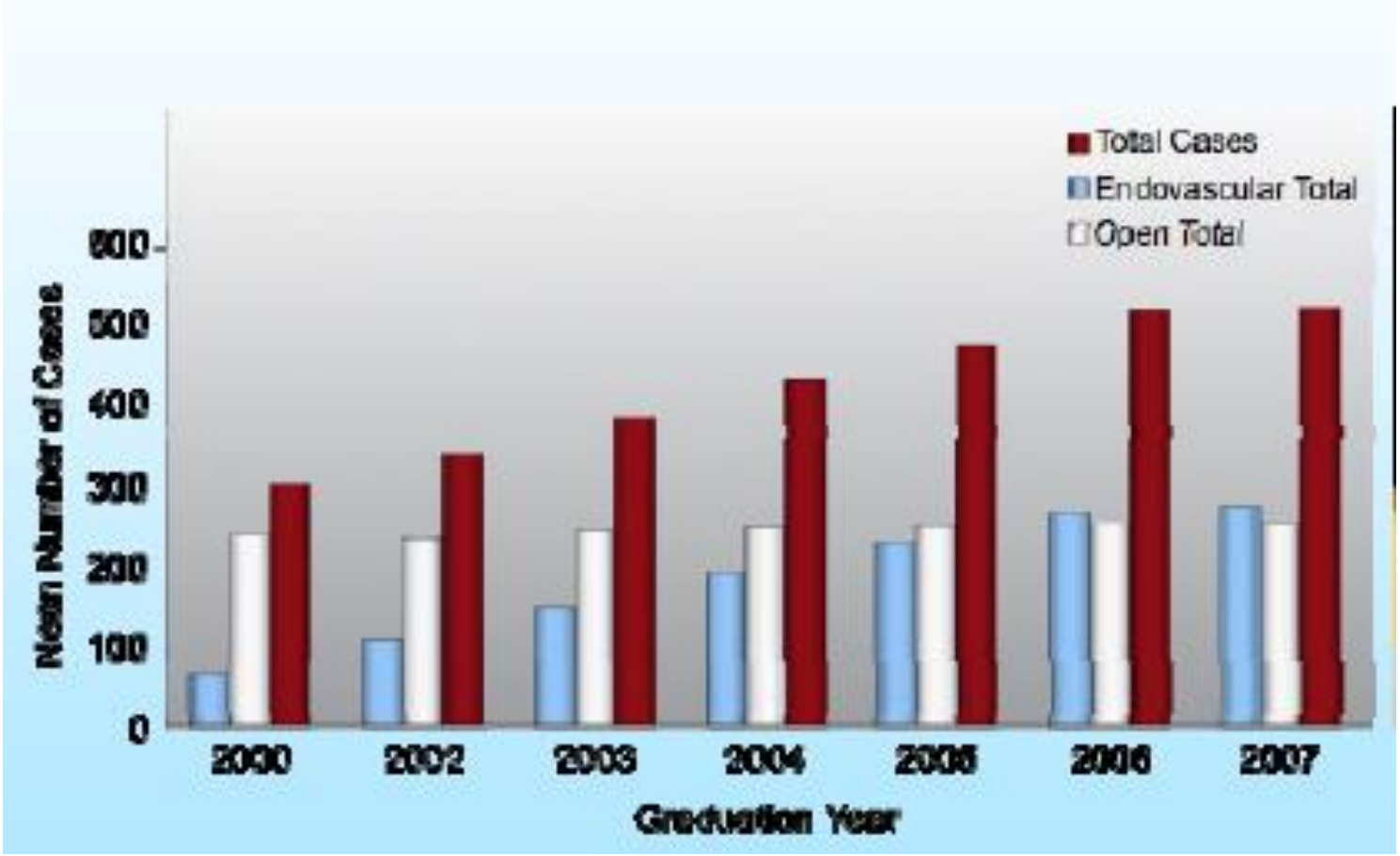


Goodney PP et al. J Vasc Surg 2009;50:54-60

Endo Vs Surgery POAD Volume (1997-2004) in the US



Rise of Endovascular Intervention



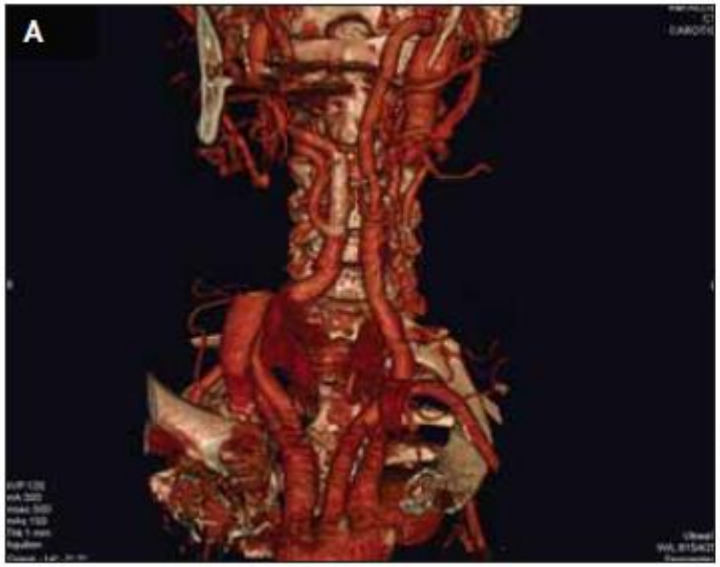
Shanzer A et al, J Vasc Surg 2008;49:1339-1344

3. Technical Issue

Technology Issues

- Be aware of the PVD
  - A *low thresthold* for **non-invasive evaluation,**
  - The *high incidence* of **asymptomatic cardiac and peripheral vascular disease**

Establishing aPeripheral VascularCenter of Excellence. DAVID E. ALLIE, MD; CHRIS J. HEBERT, RT, R-CIS; AND CRAIG M. WALKER, MD. FEBRUARY 2005 I ENDOVASCULAR TODAY I 41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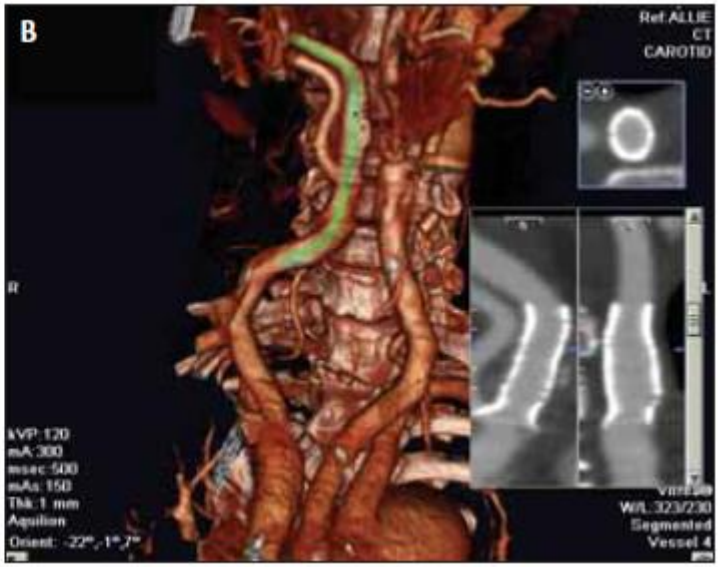
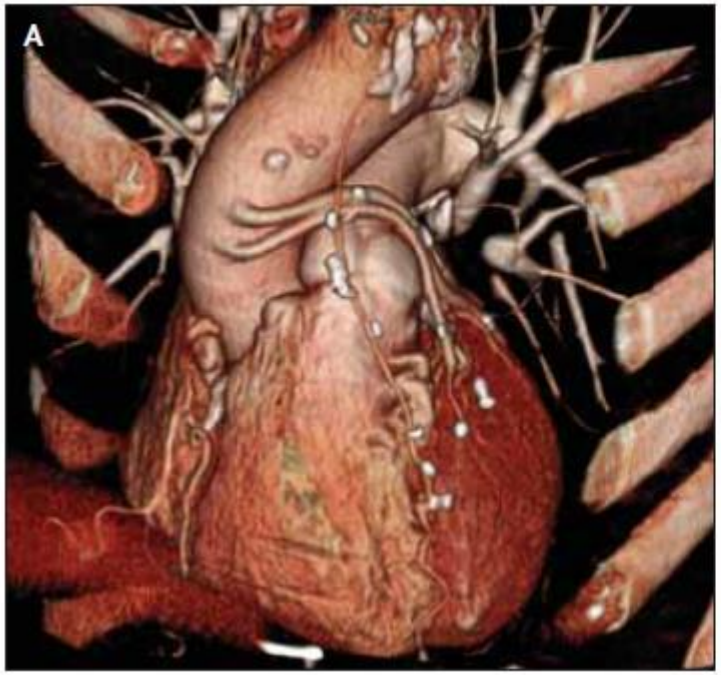

B
Ref:ALLIE
CT
CAROTID
kVP:120
mA:300
msec:500
mAs:150
Thk:1 mm
Aquilion
Orient: -22°,-1°,7°
WIL:323/230
Segmented
Vessel 4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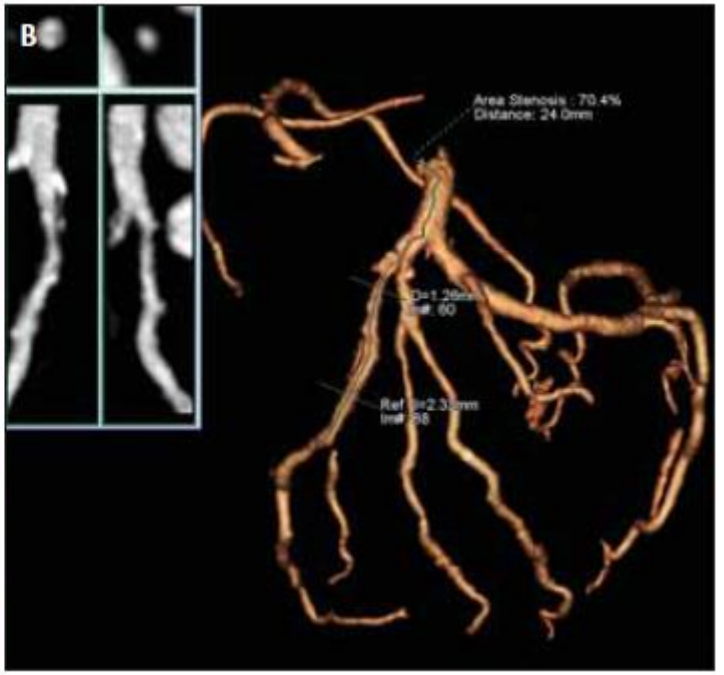
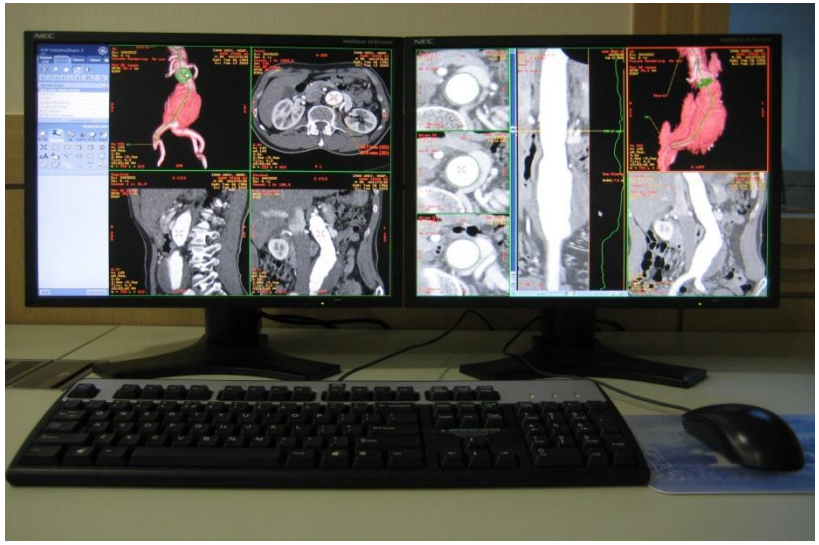
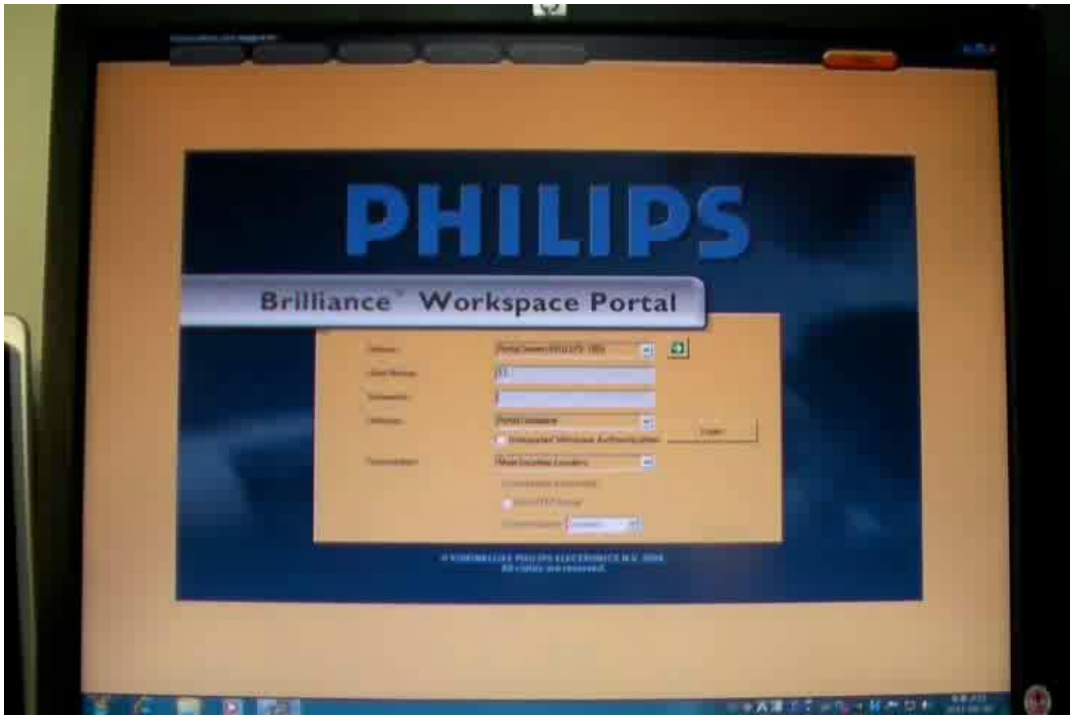
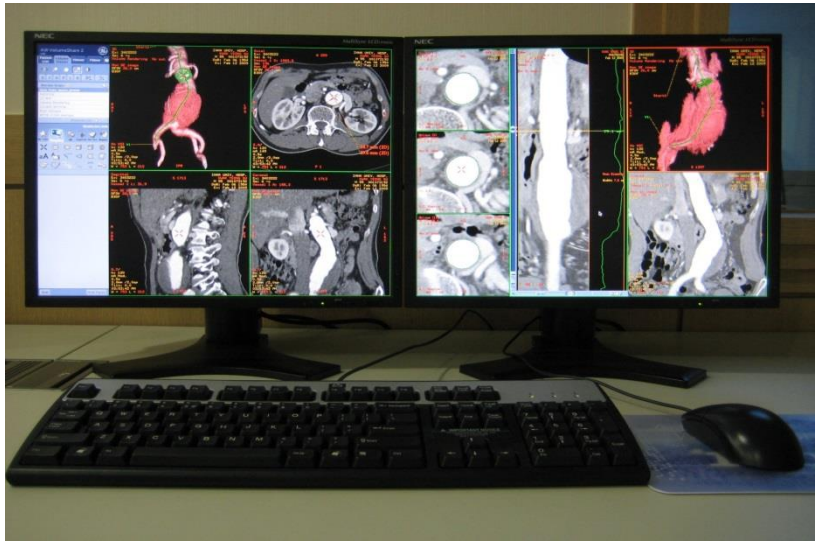

B
Area Stenosis : 70.4%
Distance: 24.0mm

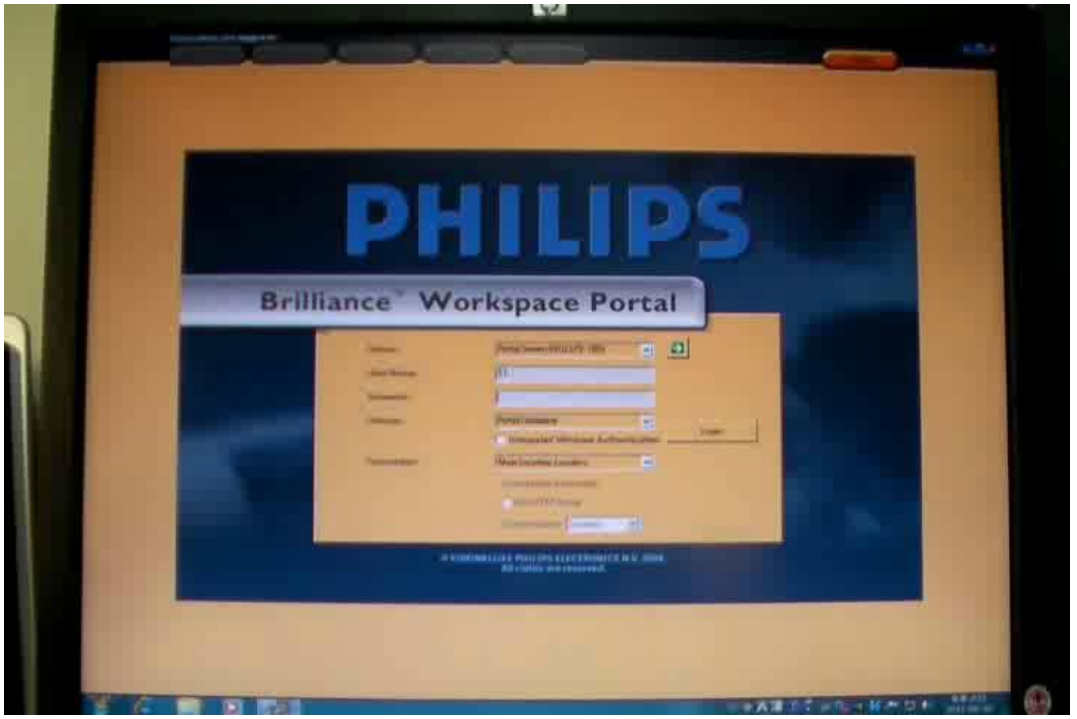
3D WorkStation:Detailed Case Planning





3D WorkStation:Detailed Case Planning





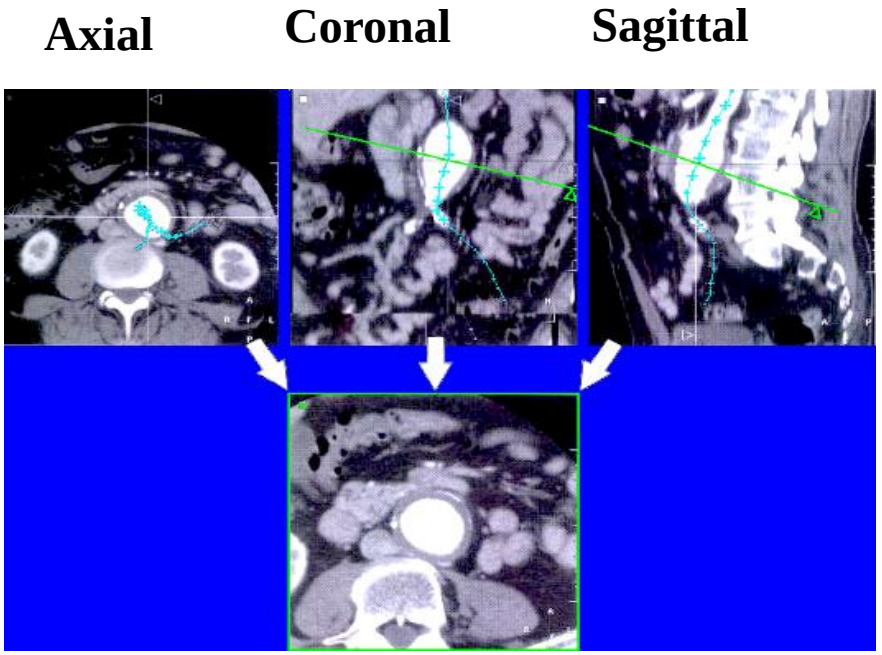
Central Lumen Line (CLL) reformatting

- **MPR loaded into workstation (Philips Easy Vision)**

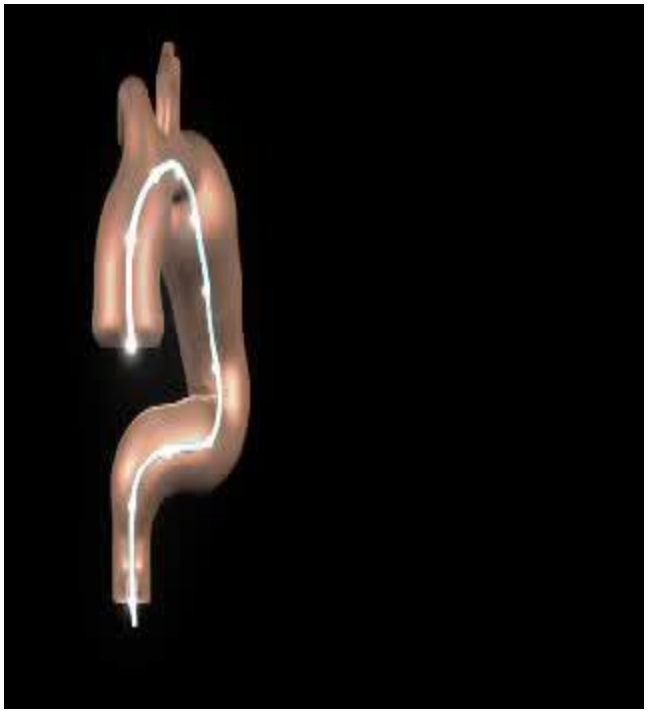
- **Manually placed markers (in 3 dimensions) to determine the central lumen line**

  (= proposed axis of how the prosthesis will eventually be placed)

- **Curved linear reformat is calibrated:**
  - **CLL continuously in centre of projection**
  - **cross-sections perpendicular to the axis of the CLL**



Central Lumen Line (CLL) Flow Analysis



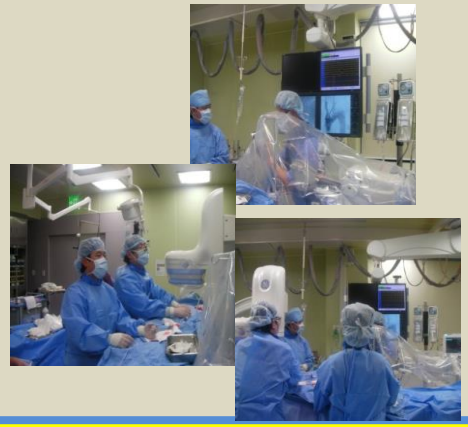
4. Endovascular Tool Introduction

- 2019년 강의록 참조

5. Endo vs OSR ?

Hybrid-room

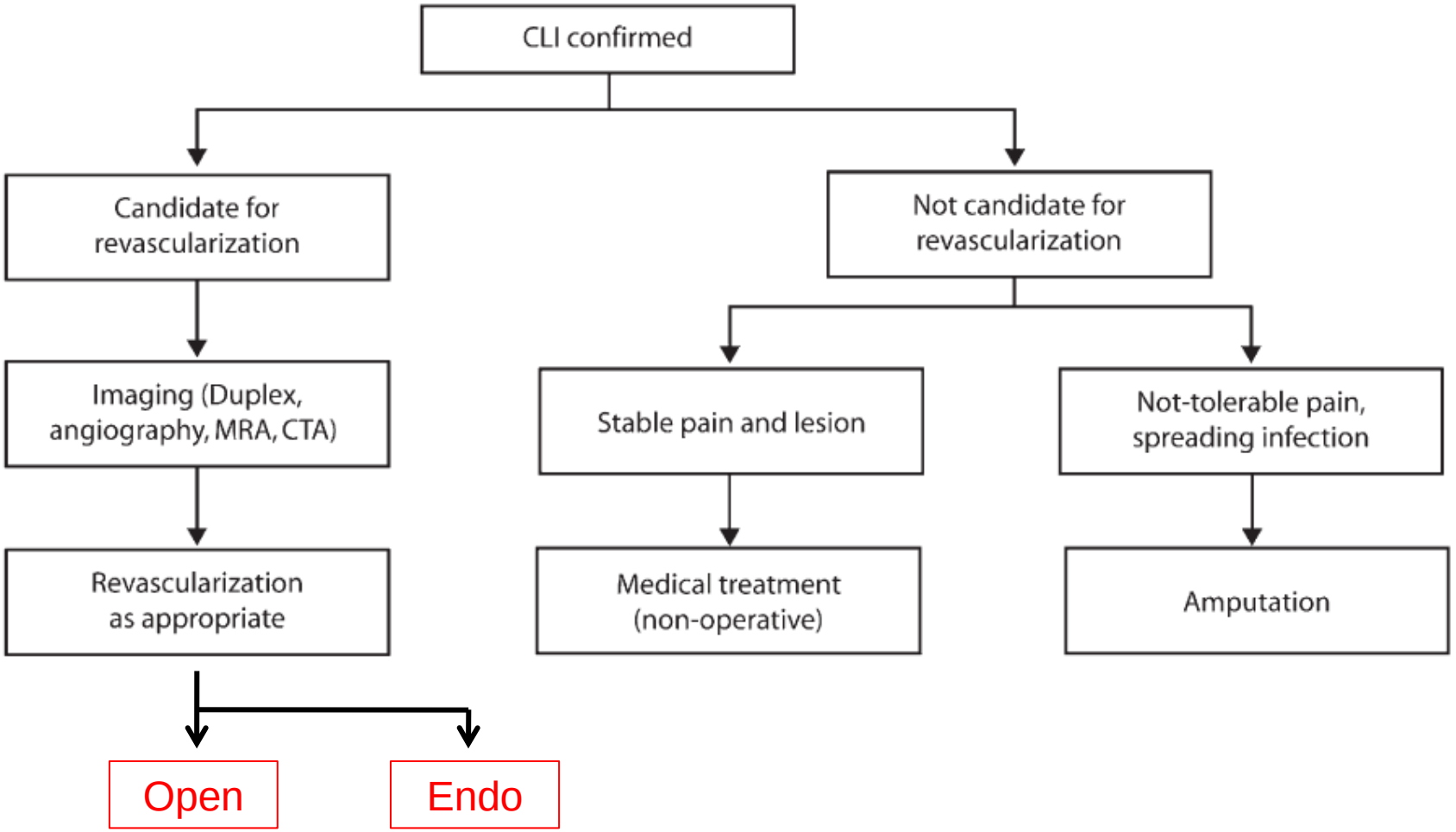
Cath-room



C-arm based

CLI is not a single group of patients

What is the Optimal Treatment for CLI?



First step for the treatment of CLI

- *Optimize modifiable risk factors*
  - *Education*
  - *Lifestyle modification*
  - *Pharmacotherapy*
  - *Smoking cessation*

- *Medical therapy alone*
  - *For stable, uncomplicated tissue loss AND*
  - *Poor surgical candidate (age > 75, significant CAD, CKD)*

- *Schanzer et al. JVS 2008;47:774*
  - *PREVENT III cohort*
  - *Statin 45%, B-blocker 59%, antiplatelet 80%*
  - *Only improved survival; statin use*
  - ***Suboptimal medical treatment** performed in patients with CLI than with CAD*

Amputation as a primary therapy

- ***How to interpretate the preexisting data***
  - ***Physician-oriented view of success***
    ; Graft patency, limb salvage, and survival
  - ***Patient-oriented outcomes***
    ; Quality of life
- ***Ischemia-reperfusion syndrome***
  - ***might jeopardize patient survival***

→ Limb amputation may actually improve QOL in select patient population

Revascularization in CLI

- ***Methods***
  - ***Open first***
  - ***Endo first***
  - ***Hybrid***

- ***How to select optimal treatment?***
  - ***Hospital resources***
  - ***Operator's preference (VS vs IR)***
  - ***Evidence-based practice, Treatment guideline***

Bypass vs Angioplasty

	Bypass Surgery	Balloon Angioplasty
Pros	Superior long-term anatomic patency and clinical durability	Low morbidity and mortality and requirement for urgent surgical intervention Low cost Quick to perform Shorter hospital stay Can be repeated Failed angioplasty has been said not to jeopardize subsequent surgery Preserves collaterals so that even if the angioplasty site occludes symptoms may not return and tissue loss may remain healed
Cons	Significant morbidity and mortality Significant resource utilization (theater time and personnel, prolonged hospital stay) Graft surveillance, often leading to repeated prophylactic reintervention, required to optimize patency Vein as a conduit often unavailable, inadequate in length or poor quality Use of prosthetic material associated with poorer patency and risk of graft infection	Limited anatomic and hemodynamic patency and clinical durability Only a minority of patients may be suitable, especially with the transluminal technique The technique, particularly using the sub-intimal approach, is technically demanding and satisfactory results may not be widely achievable

BASIL trial (Bypass versus Angioplasty for Severe Ischaemia of the Leg)

BASIL trial, Treatment recommendations

- *Patients expected to live less than 2 years should usually be offered 'BAP first'.*
  - *Because BAP is less expensive and morbid in the short term*
- *Patients expected to live beyond 2 years should usually be offered 'BSX first', especially where vein is available as a conduit.*
- *If no vein conduit is available, many would have been served by 'BAP first' than prosthetic bypass.*

- *Role of BAP in the management of SLI*
  - *The failure rate of angioplasty is as high as 25%*
  - *Patients who underwent bypass after failed angioplasty fared significantly worse than those who underwent 'BSX first'*

When should open surgery be the initial option for CLI ?

- *5 conditions for "open first" approach agreed by 'endo first' vascular surgeons*
  - *Common femoral artery pathology*
  - *Arterial occlusion by extrinsic compression pathology*
  - *Extensive foot gangrene / sepsis*
  - *Young patients and those requiring dependent-free soft tissue reconstructions where durability is paramount*
  - *Infrageniculate politeal and proximal tibial occlusion with single, distal tibial target vessel*

Lawrence & Chandra. EJVES 2010;39:S32

Field of Vascular Care !!

Lower Extremity Disease

- Iliac artery disease
- SFA ds – long occlusion, femoropopliteal disease
- Below the Knee

Renal, Carotid, Subclavian Artery Stenosis

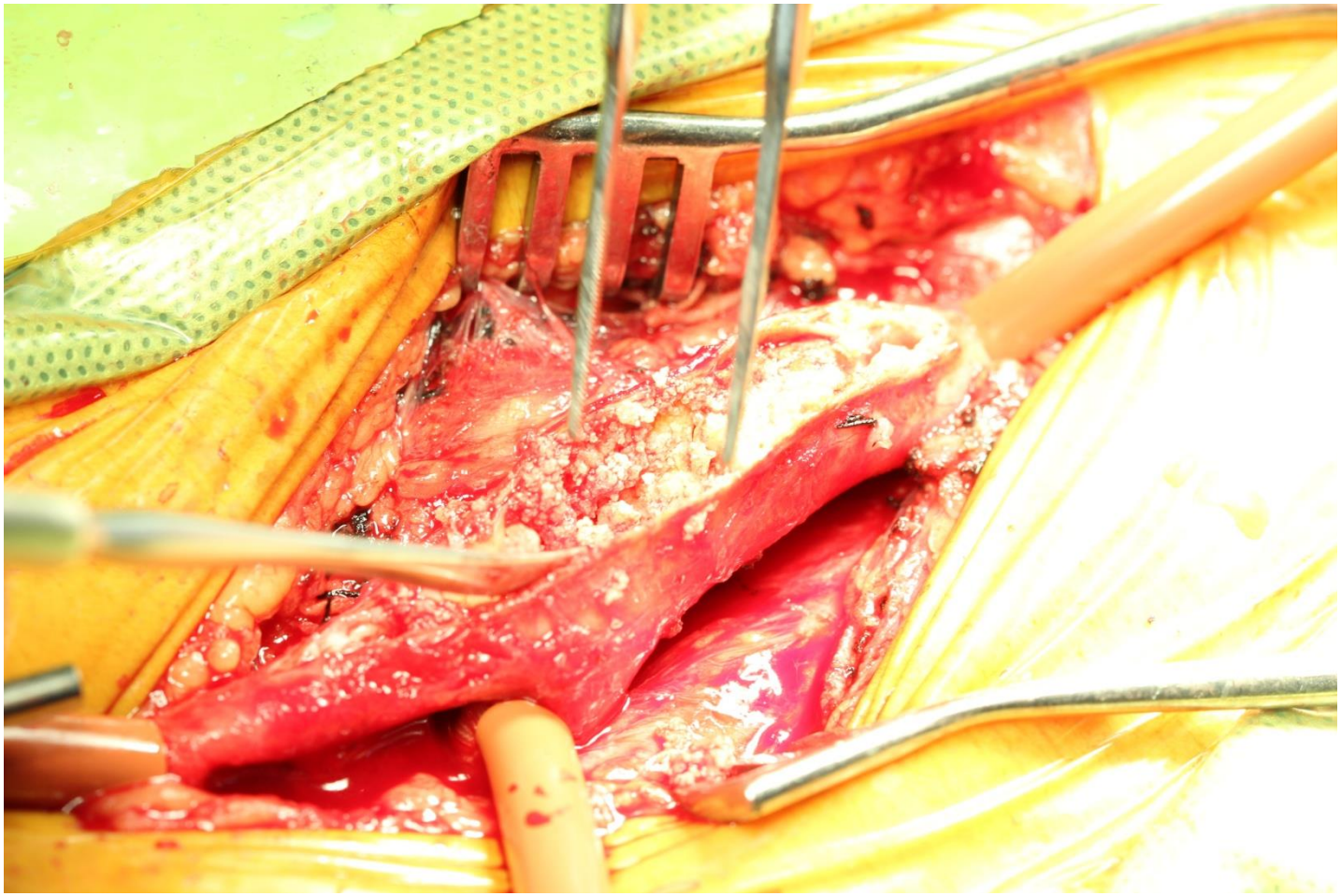
Venous disease – SVC, DVT, Vein occlusion

Aorta Disease – Aortic dissection, aneurysm, AAA

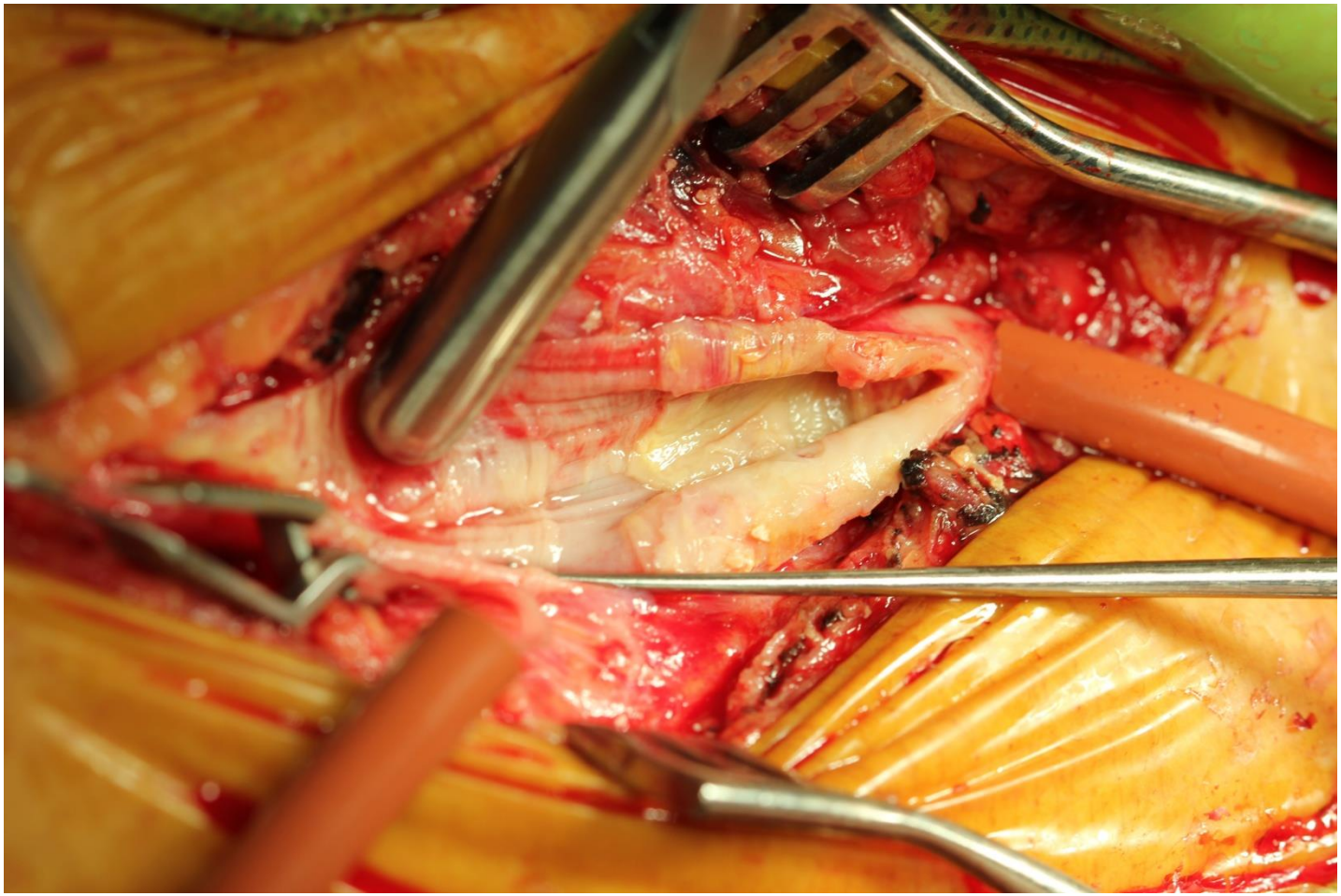
Adult congenital and structural heart disease (TAVI, ASD closure, percutaneous MVP)


R
30 cm

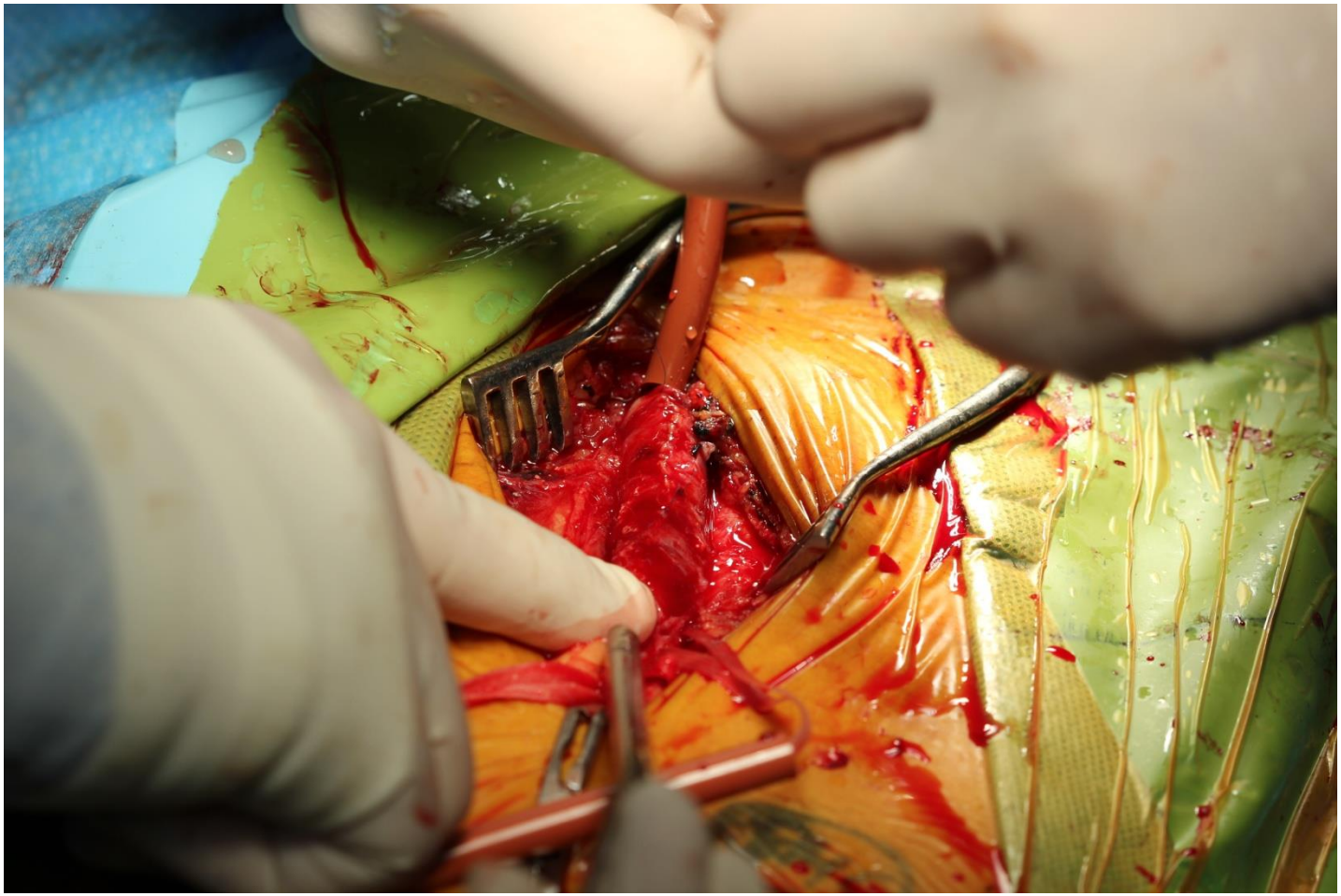
Op. Field



Op. Field

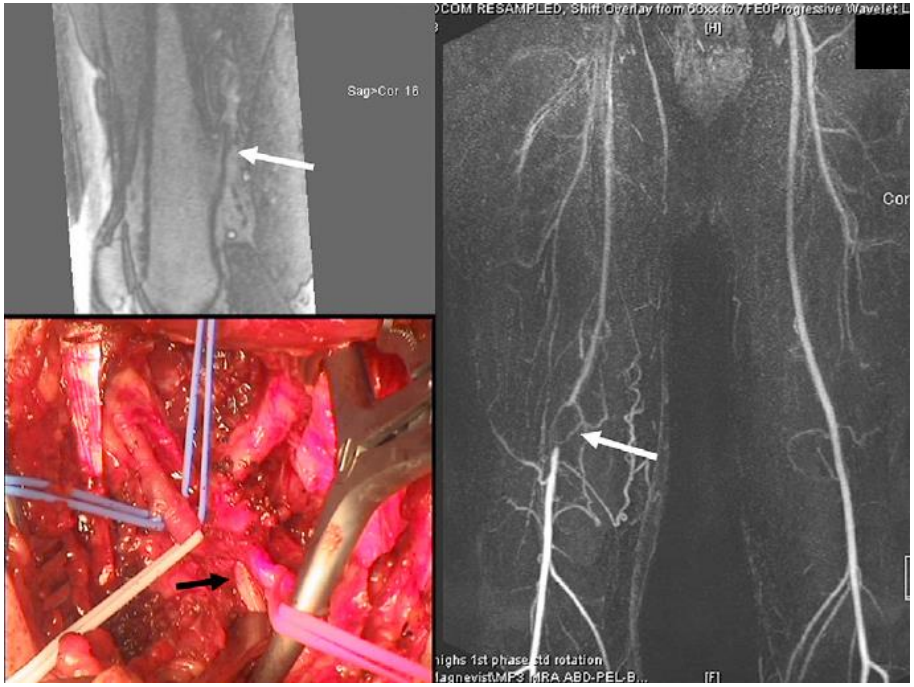


Op. Field



2. Pathology ; extrinsic compression

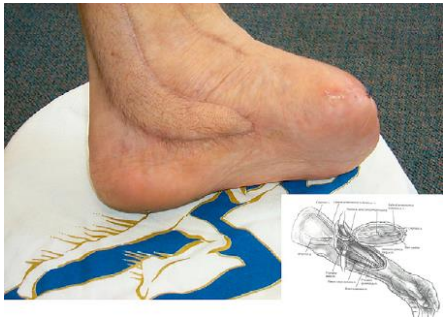
- Bony **exostosis**
- **Popliteal entrapment**, adventitial cystic dis



3. Physiology ; extensive foot sepsis or gangrene

- Maximum blood flow should be delivered.
- **Endovascular approach** ; risk of providing increased but **inadequate flow to the foot**, often mandating a higher level of amputation

4. Durability



- Who requires a durable procedure
  - **Young patient** for limb salvage
  - **For maintenance of a free flap or a distal procedure** that is dependent on the patency of the proximal procedure
  - Endovascular procedure ; shorter durability, needing repeated procedures for restenosis

5. Limited distal targets

- **Occlusion of below-knee popliteal artery** and the origins of all three tibial arteries

- Patients with **a good conduit and a single distal target vessel**
  - Endo; often loses that target during repeated endo procedure due to embolism or thrombosis.
  - Optimal situation for an Open procedure before that target is lost

Problems for bypass surgery on CLI

- *Tibial bypass is not perfect.*
  - *Diffuse disease with calcifications*
  - *Poor distal runoff*
  - *Appropriate 'vein' conduit*
- *Perioperative morbidity and mortality is not low.*
- *Functional outcome is **different** than patency.*
- *Lifelong F/U – the need for revision*

- *Recent trends*
  - *Conduit availability is decreasing*
  - *Population aging*
  - *Increasingly seeing patients following multiple failures with extensive wounds*

- *What do we do with all of these patients ?*

Angioplasty AND Surgery

- *Intervention works*
  - *Lowers morbidity*
  - *Faster recovery*
  - *Limits wound morbidity*
  - *Especially helpful in the elderly*

- *Surgery works*
  - *With good conduit and favorable target*
  - *Can be used for intervention failures early*
  - *In healthy individuals, it offers the best chance of long-term success*

I. Pathophysiology

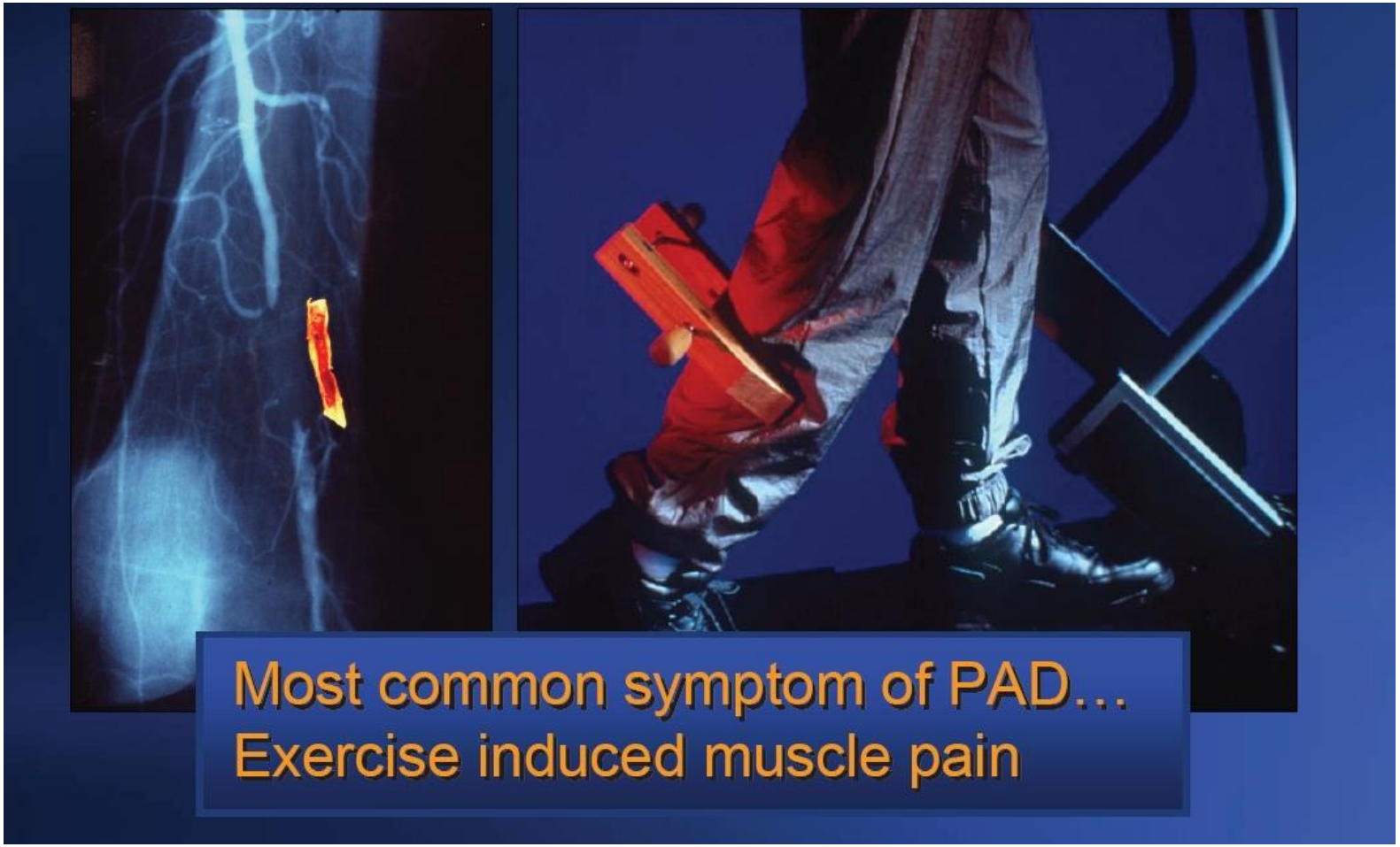
PAD: A Call to Action

Section 1	**What is peripheral arterial disease (PAD) and why is it so dangerous?**
Section 2	**Diagnosing PAD in the primary care setting**
Section 3	**The importance of aggressive risk management of PAD**

Section 1:

- **What is peripheral arterial disease (PAD) and why is it so dangerous?**

Man with calf cramping



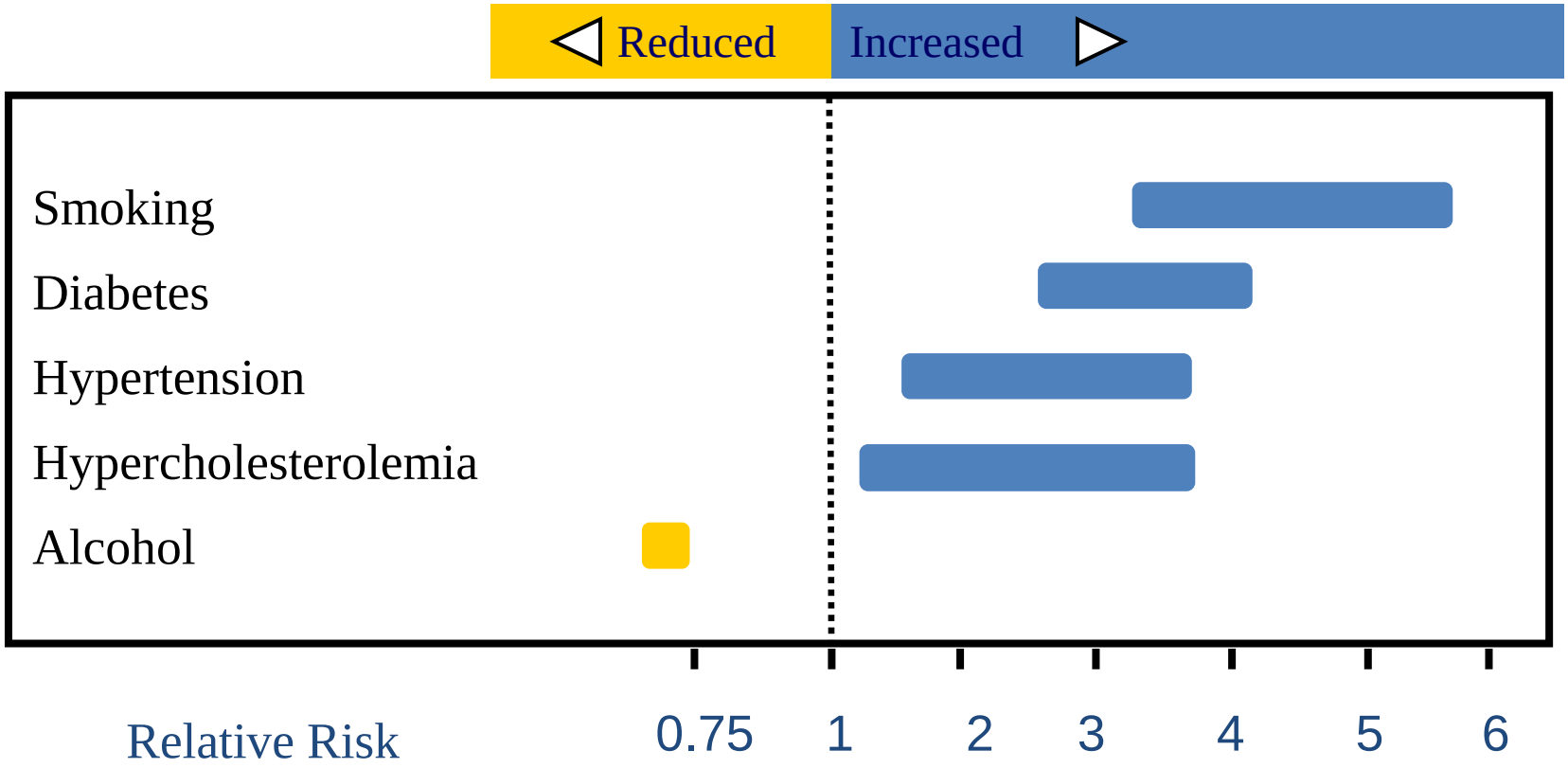
What is PAD?

- **PAD is an atherothrombotic disorder affecting the peripheral arteries and it is associated with a high risk of MI, stroke and vascular death[1]**

- **The major risk factors** for PAD are:2
  - **smoking**
  - **diabetes**
  - **age >55 years (men) or >65 years (women)**
  - **hyperlipidemia**
  - **hypertension**
  - **history of cardiovascular disease**

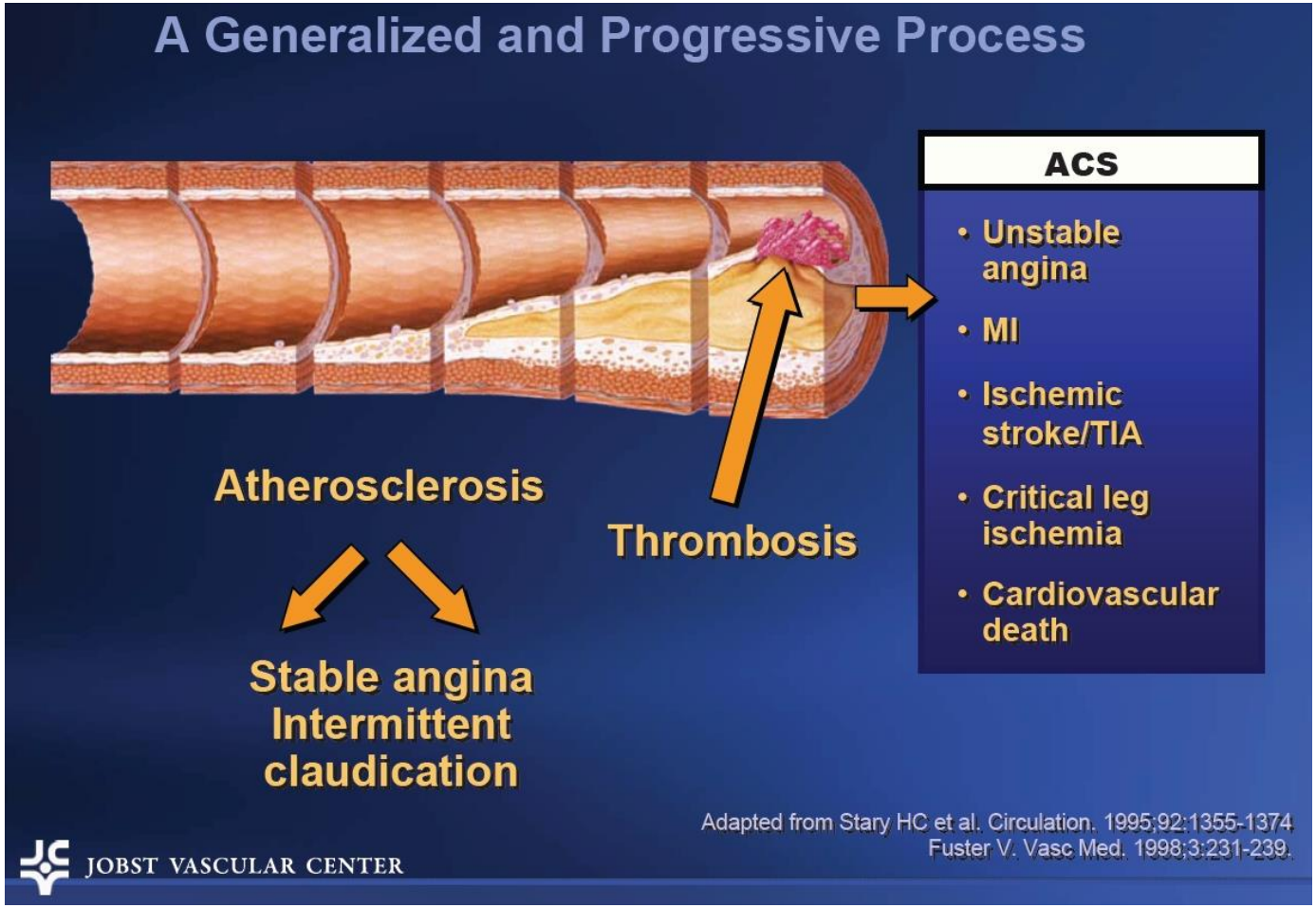
1. Hiatt WR. J Vasc Surg. 2002; 36:1283-1291.
2. Belch JJ et al. Arch Intern Med 2003; 163: 884- 892.

Risk Factors for PAD

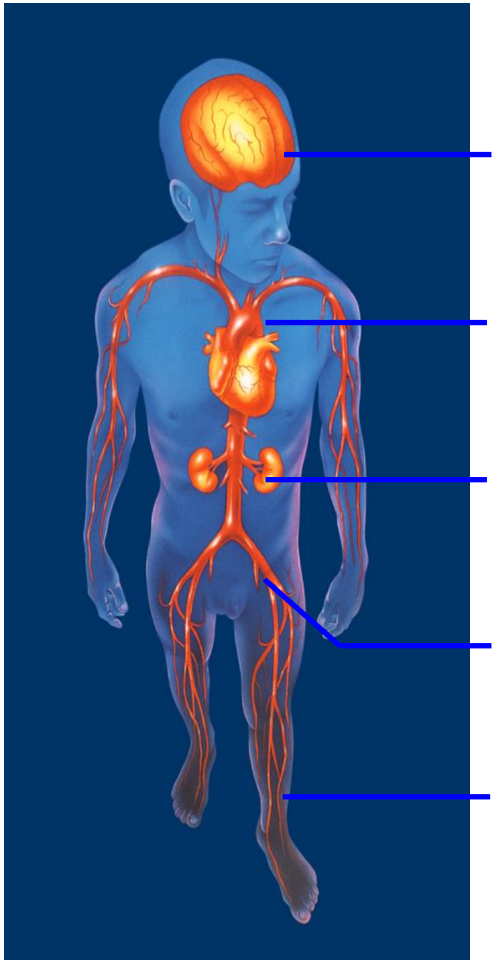


Newman AB et al. Circulation 1993; 88: 837-845.
TASC Working Group. J Vasc Surg 2000; 31 (1, pt 2): S1-S288.
Djousse PM et al. Circulation 2000; 102: 3092-3097.

Pathologic progression to atherothrombosis



Major manifestations of atherothrombosis



Cerebrovascular disease

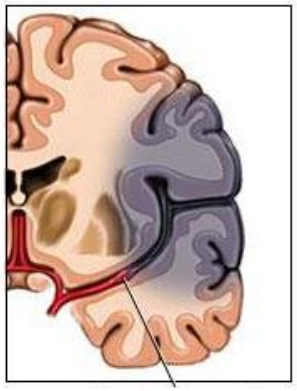
Coronary artery disease

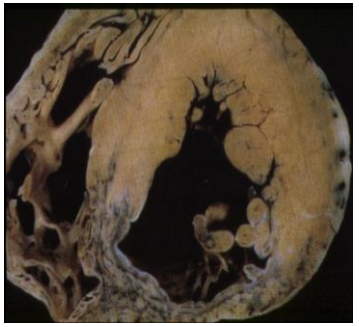
Renal artery stenosis

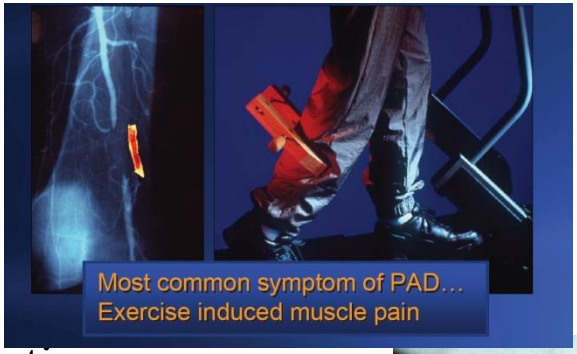
Visceral arterial disease

Peripheral arterial disease

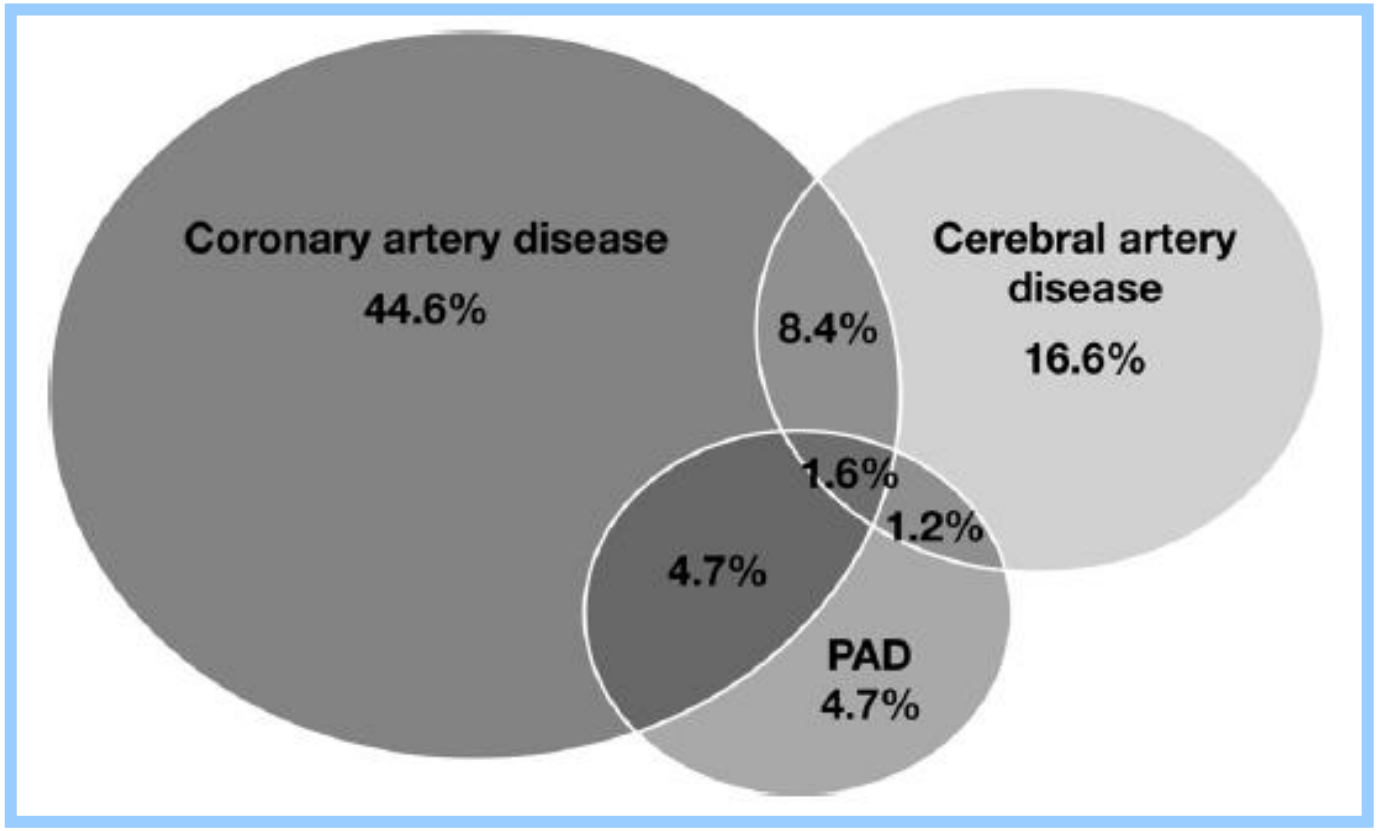
- Intermittent claudication
- Critical limb ischemia





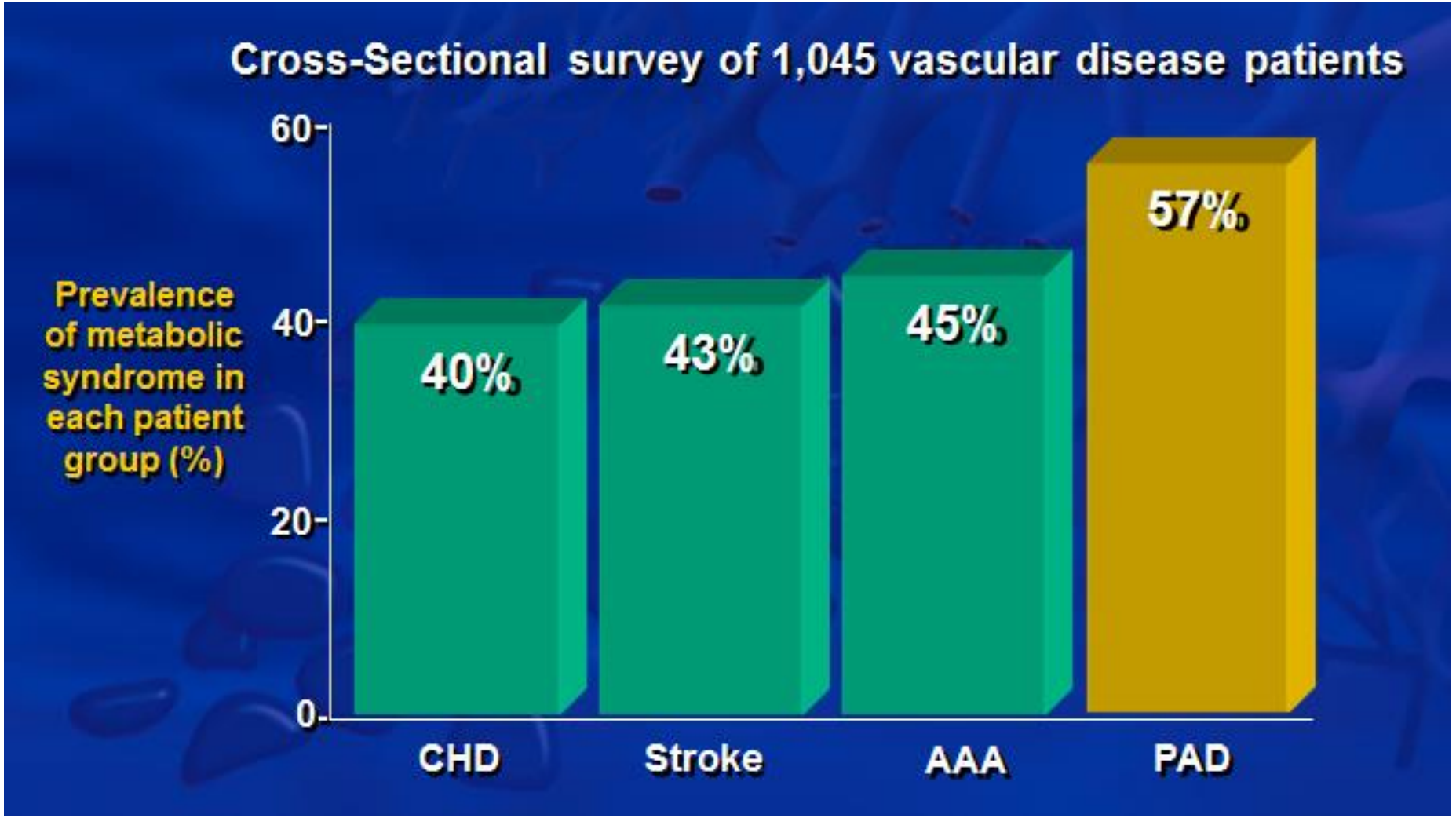


Systemic Atherosclerosis



JAMA 2006;295:180-189.

Metabolic syndrome is more common in PAD than in CHD or stroke



Olijhoek JK et al. Eur Heart J 2004; 25: 342-348.

Prevalence of PAD increases with age

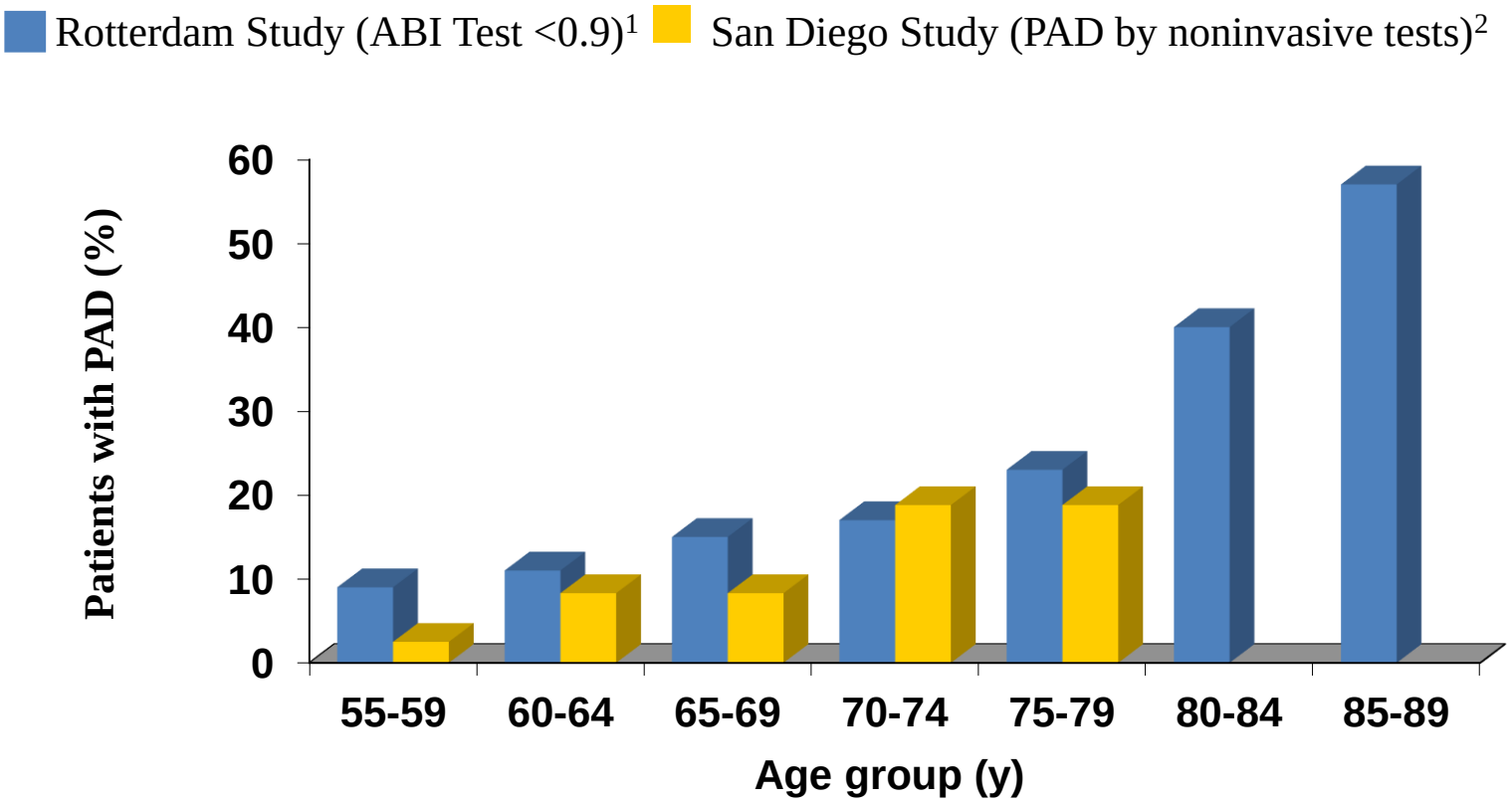
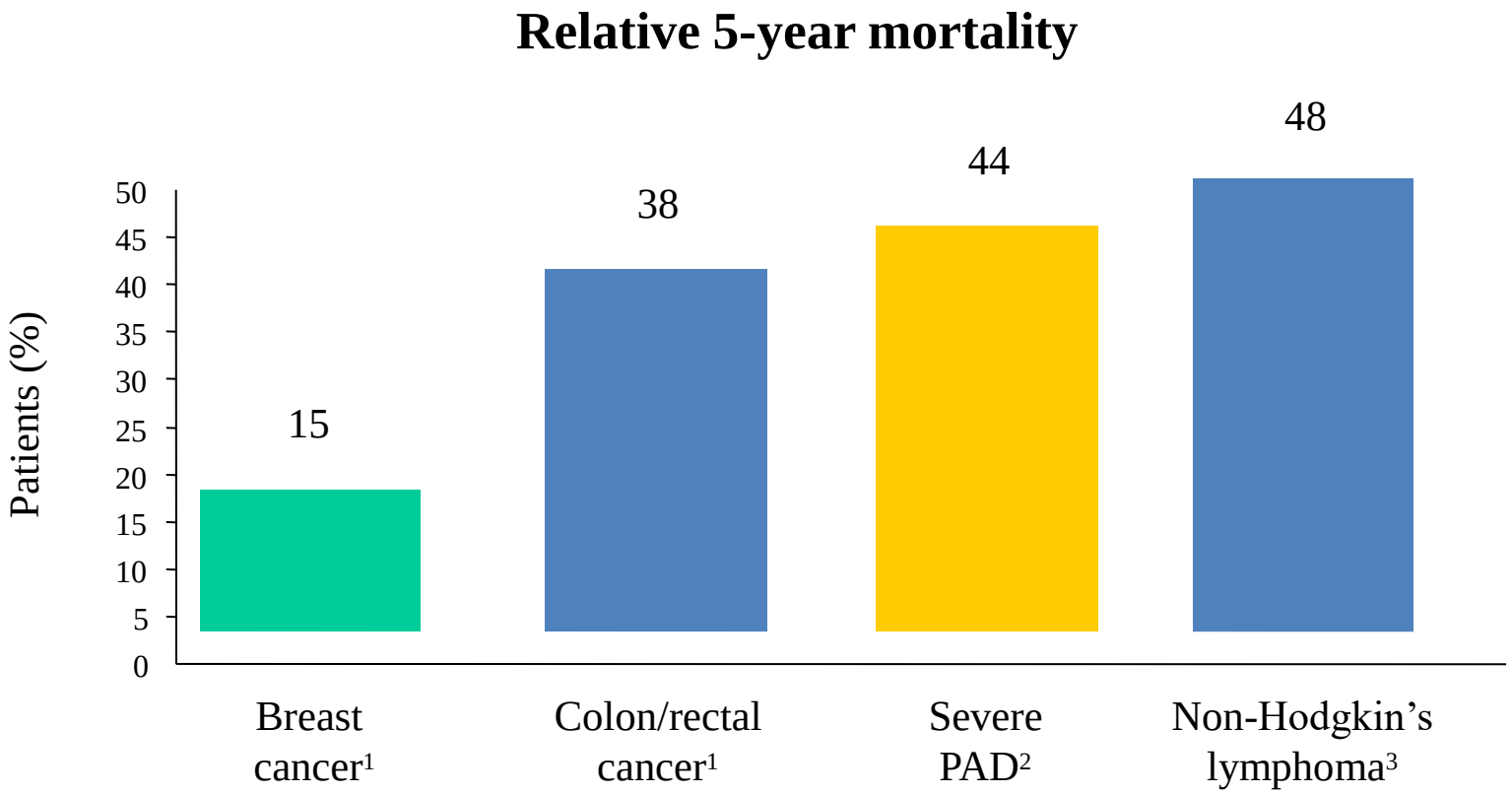


Figure adapted from Creager M, ed. Management of Peripheral Arterial Disease. Medical, Surgical and Interventional Aspects. 2000.

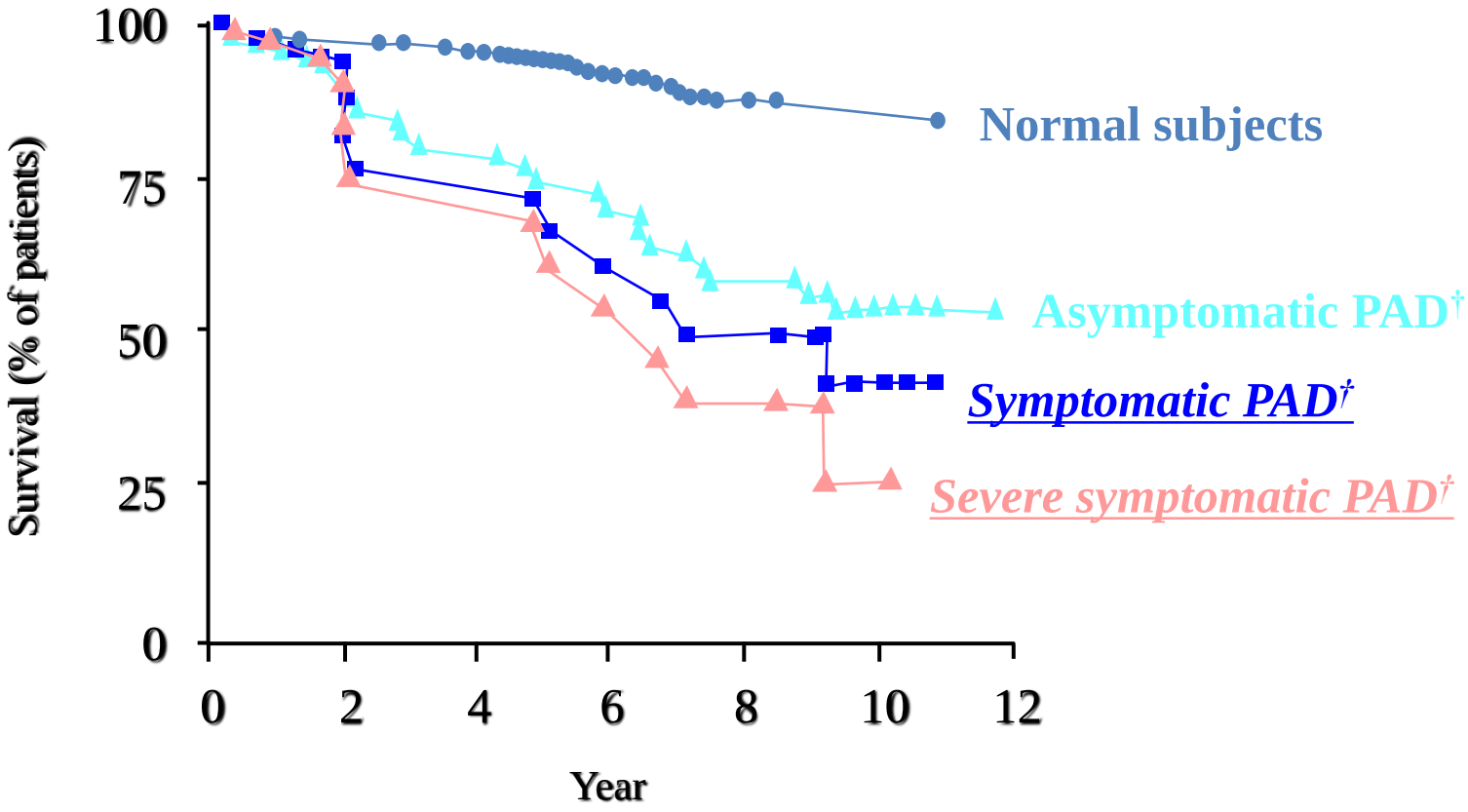
1 Meijer WT et al. Arterioscler Thromb Vasc Biol 1998; 18: 185-192.
2.Criqui MH et al. Circulation 1985; 71: 510-515.

Mortality is very high in patients with severe PAD



1. Criqui MH. Vasc Med 2001; 6 (suppl 1): 3–7.
2. McKenna M et al. Atherosclerosis 1991; 87: 119–28.
3. Ries LAG et al. (eds). SEER Cancer Statistics Review, 1973–1997. US: National Cancer Institute; 2000.

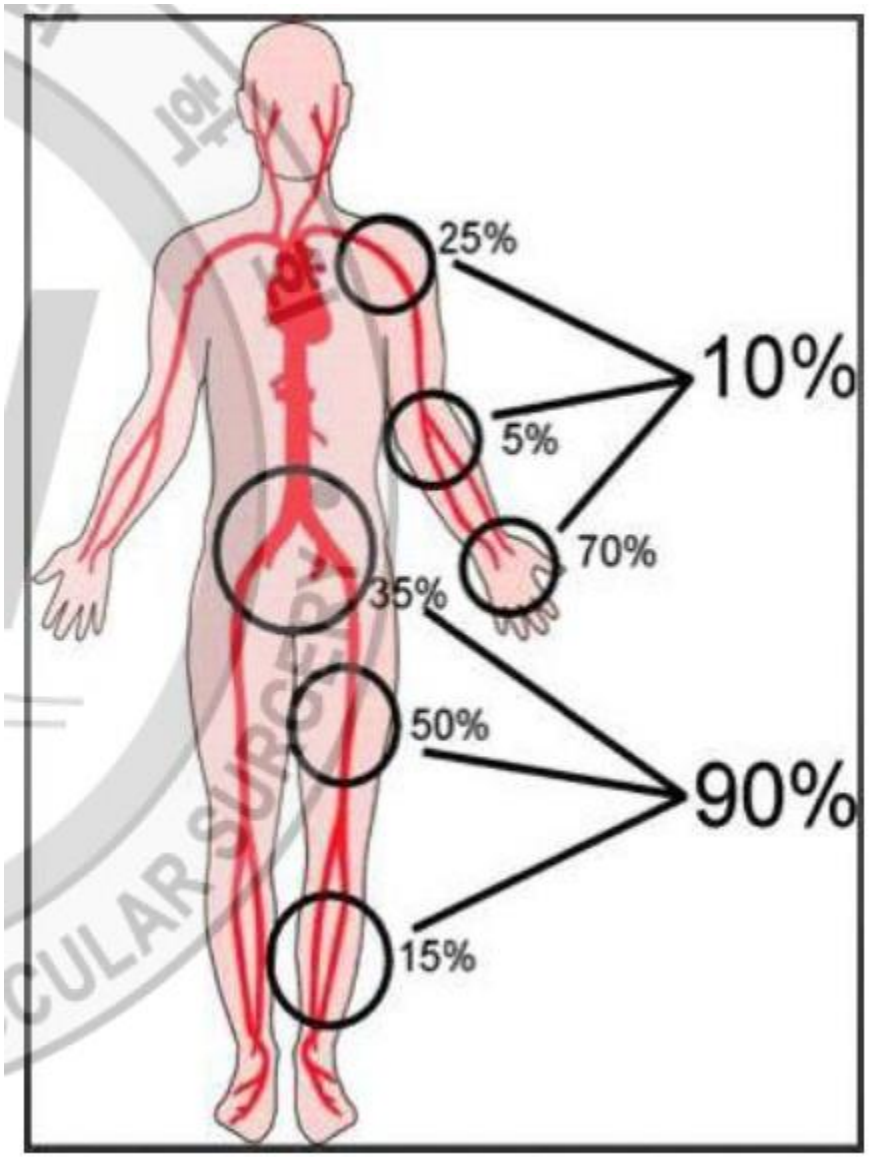
Risk of death is increased in patients with both *symptomatic* and asymptomatic PAD



*Kaplan-Meier survival curves based on mortality from all causes.
†Large-vessel PAD.

Criqui MH et al. N Engl J Med 1992; 326: 381-386.

Sites for PAD



Fate of patients with CLI

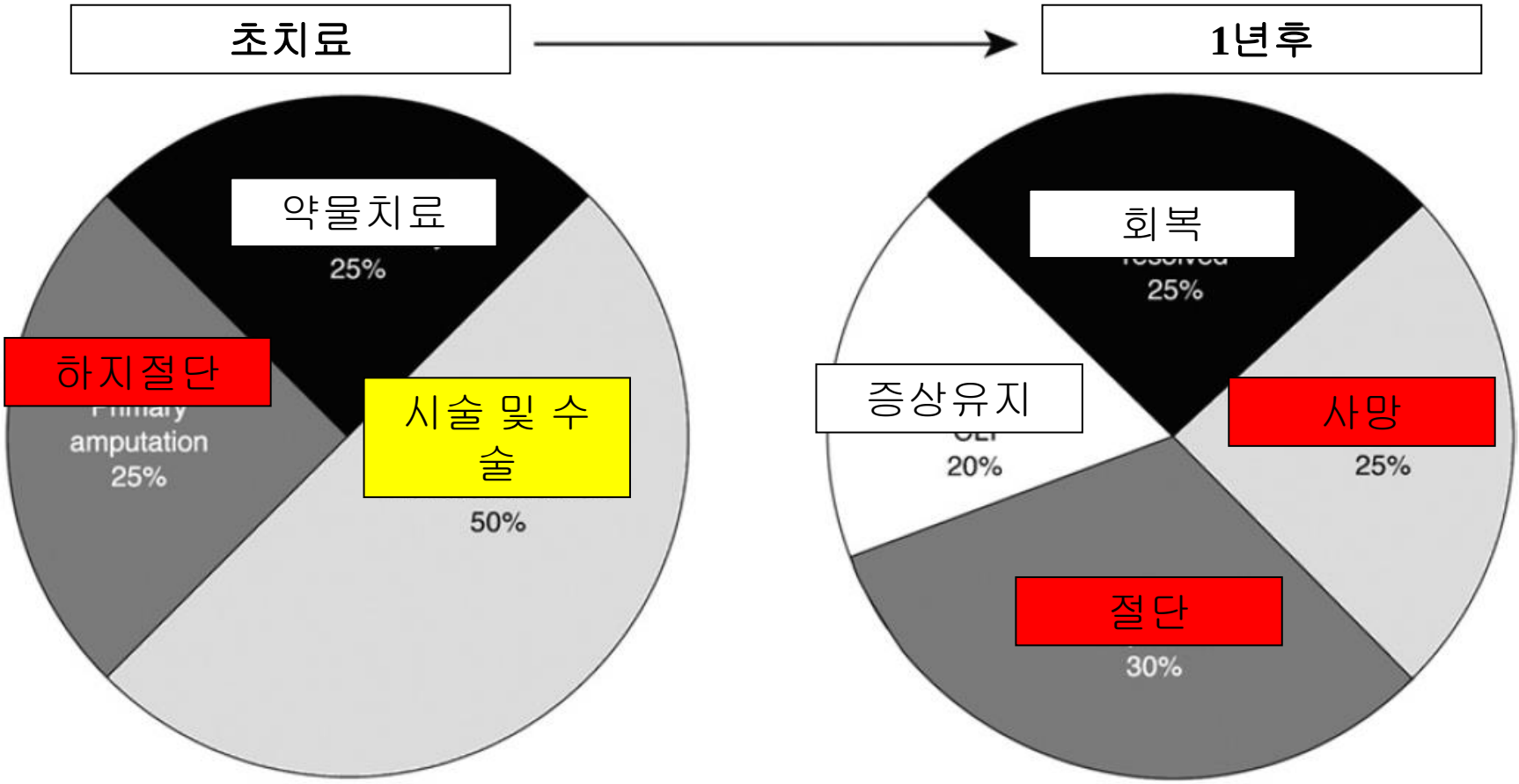
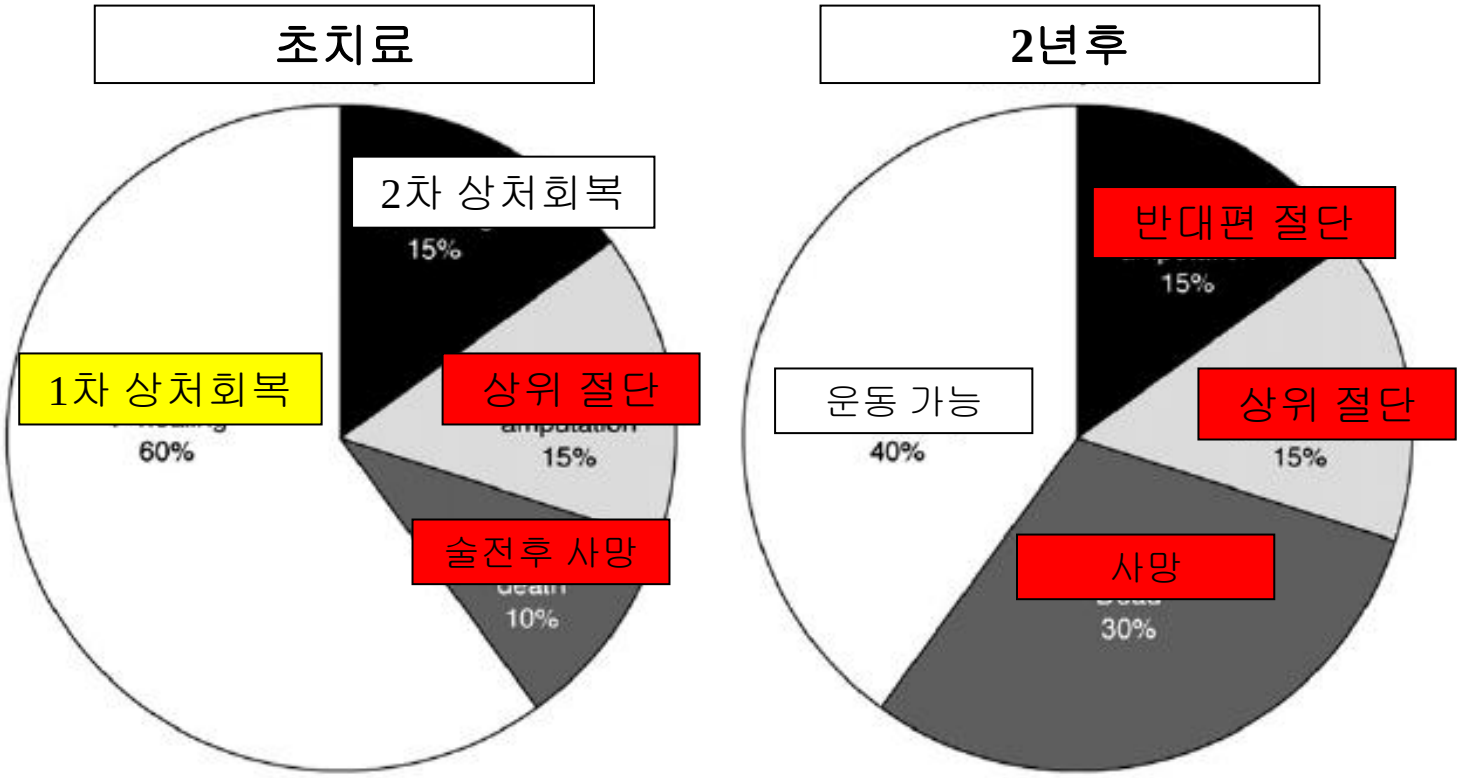


Fig. A5. Fate of the patients presenting with chronic critical leg ischemia. CLI – critical limb ischemia.

Norgren L, et al. TASCII, J Vasc Surg.2007

Fate of patients with CLI



Norgren L, et al. TASCII, J Vasc Surg.2007

PVD is not Benign!!!

- The diffuse nature and high association of PVD with **other medical conditions (ie, diabetes, renal disease, coronary disease, wound care)** demand **a multidisciplinary approach t**oward patient care at a PVD center of excellence.

- Every patient with PVD needs a multidisciplinary work-up and needs treatment.

- This treatment may be as simple as *risk factor modification* and *follow- up*, *medications*, or *complex treatments requiring interventional or surgical treatment.*

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Multidisciplinary Team

- A true PVD center of exellence cannot exist without close cooperation and input from a **true multidisciplinary "team" approach**,
  - surgeon,
  - cardiologist,
  - peripheral interventionalists,
  - podiatrists, and
  - specialists in vascular medicine, diabetes, nephrology, neurology, wound care, and vascular imaging,
  - along with well-trained registered nurses, nurse practitioners, and physician assistants.

Establishing aPeripheral VascularCenter of Excellence. DAVID E. ALLIE, MD; CHRIS J. HEBERT, RT, R-CIS; AND CRAIG M. WALKER, MD. FEBRUARY 2005 I ENDOVASCULAR TODAY I 41

Section 2:

- **Diagnosing PAD in the primary care setting**

PAD can be silent or cause symptoms ranging from exertional pain to critical limb ischemia

Typical[1]	Atypical[1]
Intermittent claudication: pain, ache, cramp, numbness, muscle fatigue in calves, thighs or buttocks; exacerbated by exercise and relieved by rest	**Decreased walking ability:** (speed or distance) for reasons other than classical symptoms of intermittent claudication
Critical limb ischemia: rest pain, ulcers, gangrene	**Pain in other areas:** e.g. general aching

Differentiating *True Claudication* from *Pseudoclaudication*

	Intermittent Claudication	Pseudoclaudication
Charcter of discomfort	Cramping, tigahtness, tiredness	Same or tingling, weakness, clumsiness
Location of discomfort	Buttock, hip, thigh, calf, foot	Same
Exercise induced	Yes	Yes or No
Distance to claudication	Same each time	Variable
Occurs with standing	No	Yes
Relief	Stop walking	Often muse sit or change body positions

Guidance for PAD diagnosis

- **STEP 1**
  - Assess patient for **risk factors**
    - smoking
    - diabetes
    - age: men >55 years and women >65 years
    - hypertension
    - hyperlipidemia
    - history of cardiovascular disease
  - Assess patient for **leg symptoms**
    - intermittent claudication
    - critical limb ischemia
  - Tools: PAD checklist, Rose questionnaire, Edinburgh questionnaire
- **STEP 2**
  - If suspicion of PAD, perform an **ABI** to confirm diagnosis
  - Tool: **Doppler, CT, DITI**

How is Ankle-Brachial Index (ABI) measured?

$$ABI = \frac{\text{Ankle systolic pressure}}{\text{Brachial systolic pressure}}$$

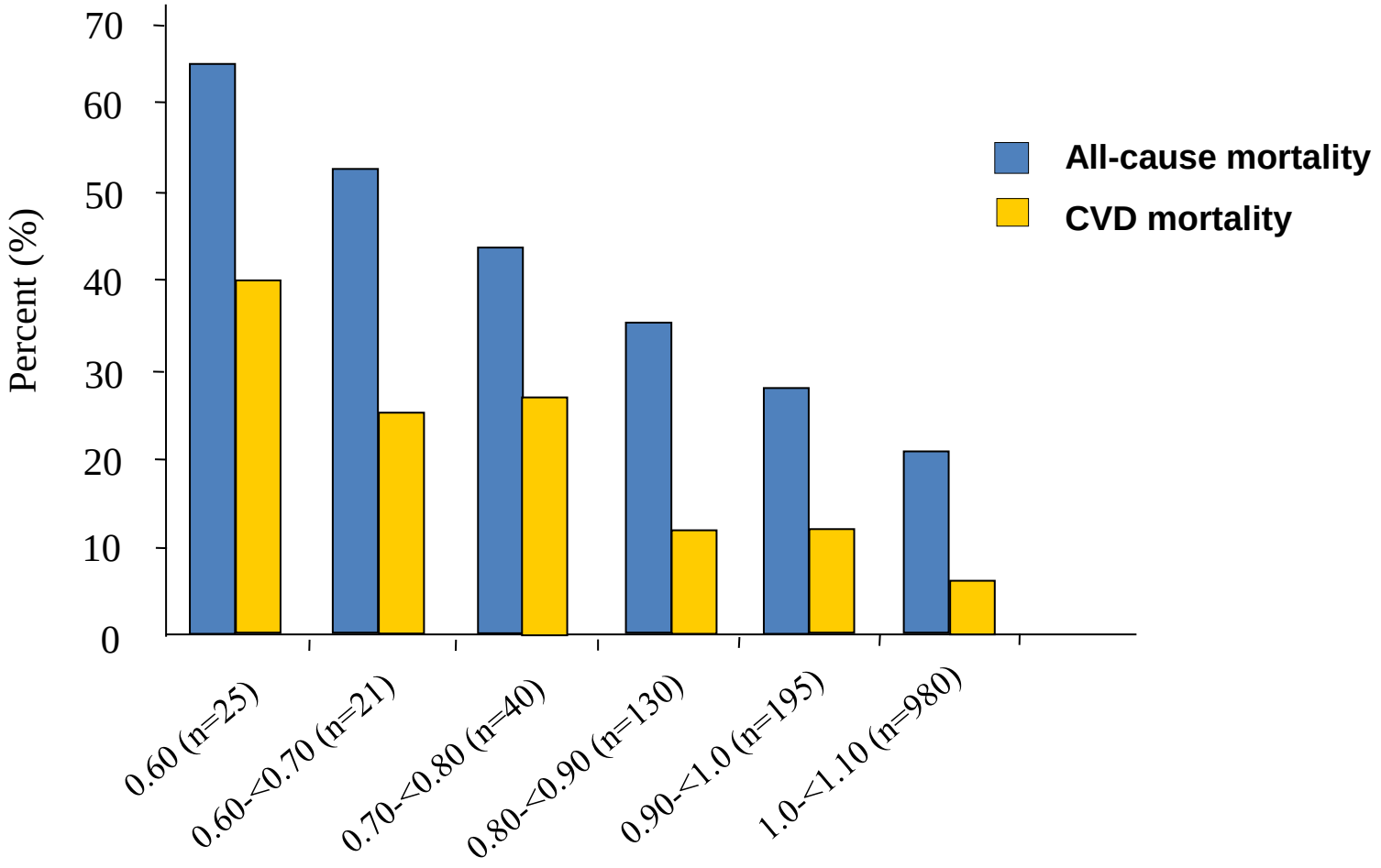
- Measure ankle and brachial systolic pressures with Doppler[1,2]
- Use highest arm and each ankle pressures[1,2]

ABI Interpretation[3]

> 0.90	**Normal**
0.41 – 0.90	**Mild-to-moderate peripheral arterial disease**
0.00 – 0.40	**Severe peripheral arterial disease**

1. TASC Working Group. Int Angiol 2000; 19 (suppl): 5-34.
2. Vascular Disease Foundation, 2003. Available at:http://www.vdf.org/ABI.htm.
3. Hiatt WR. N Engl J Med 2001; 344: 1608-1621.

There is a strong two way association between decreased ABI and increased risk for cardiovascular death[1]



Resnick HE et al. Circulation 2004; 109: 733-739.

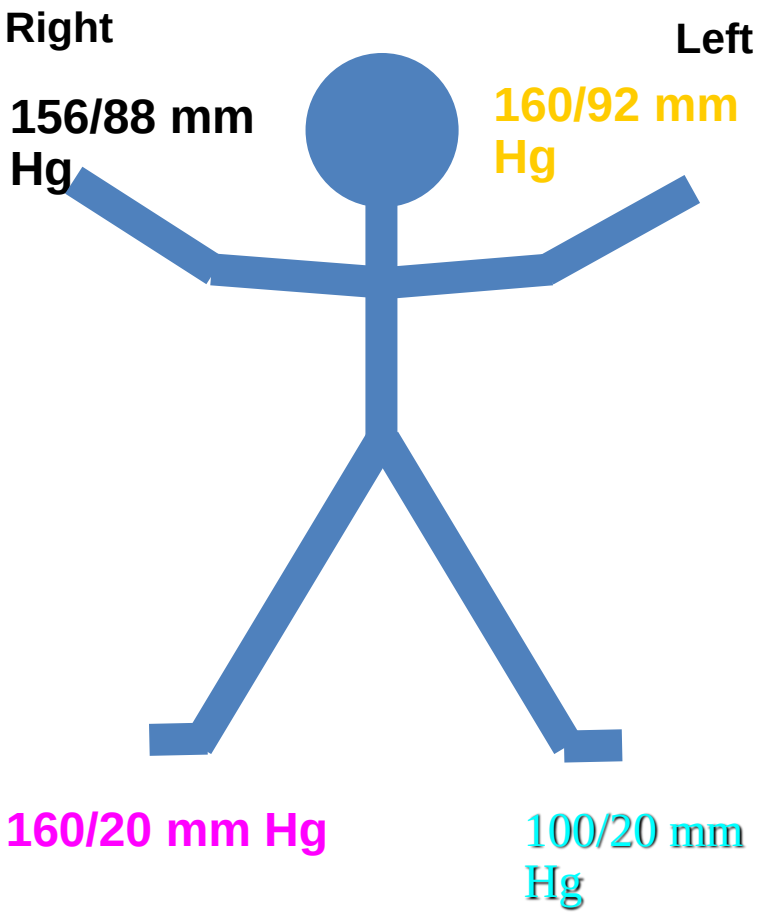
ABI Calculation

Physical Examination

- **Brachial blood pressure**
  - Right: 156/88 mm Hg
  - Left: 160/92 mm Hg

- **ABI performed in office**
  - Take the higher of the two arm pressures
  - Right:
    160/160 = 1.00
  - Left:
    100/160 = 0.63

Diagnosis:
moderate PAD in left leg



ABI Calculation

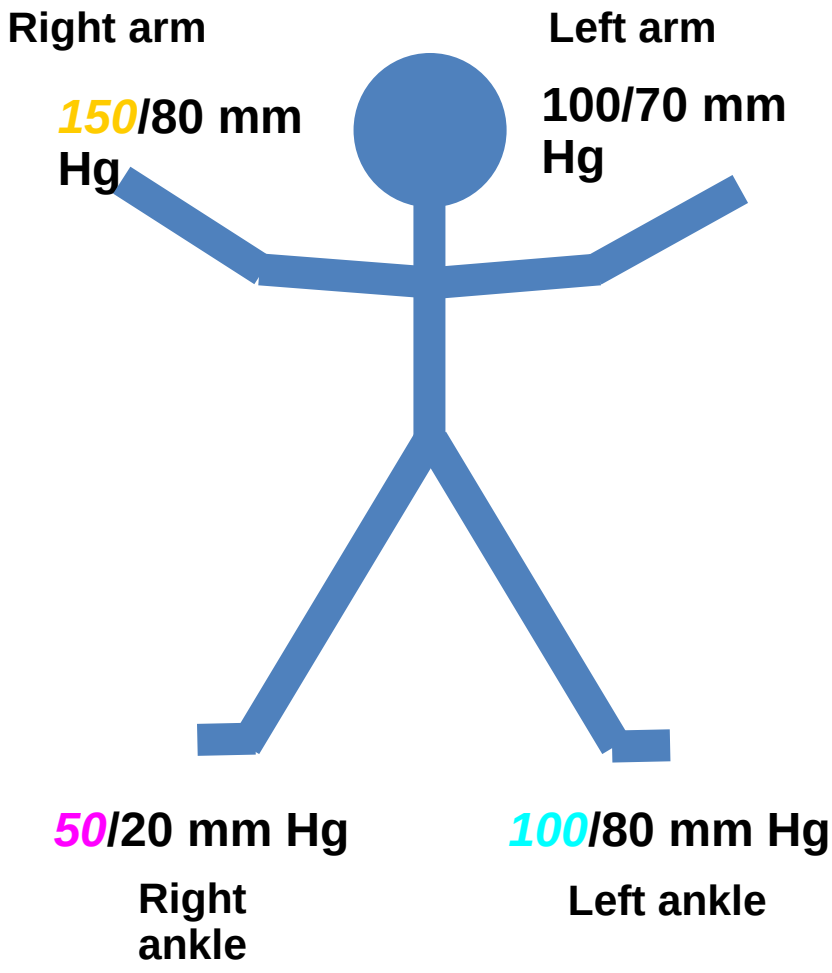
Physical Examination

- **Brachial blood pressure**
  - Right: 150/88 mm Hg
  - Left: 100/70 mm Hg

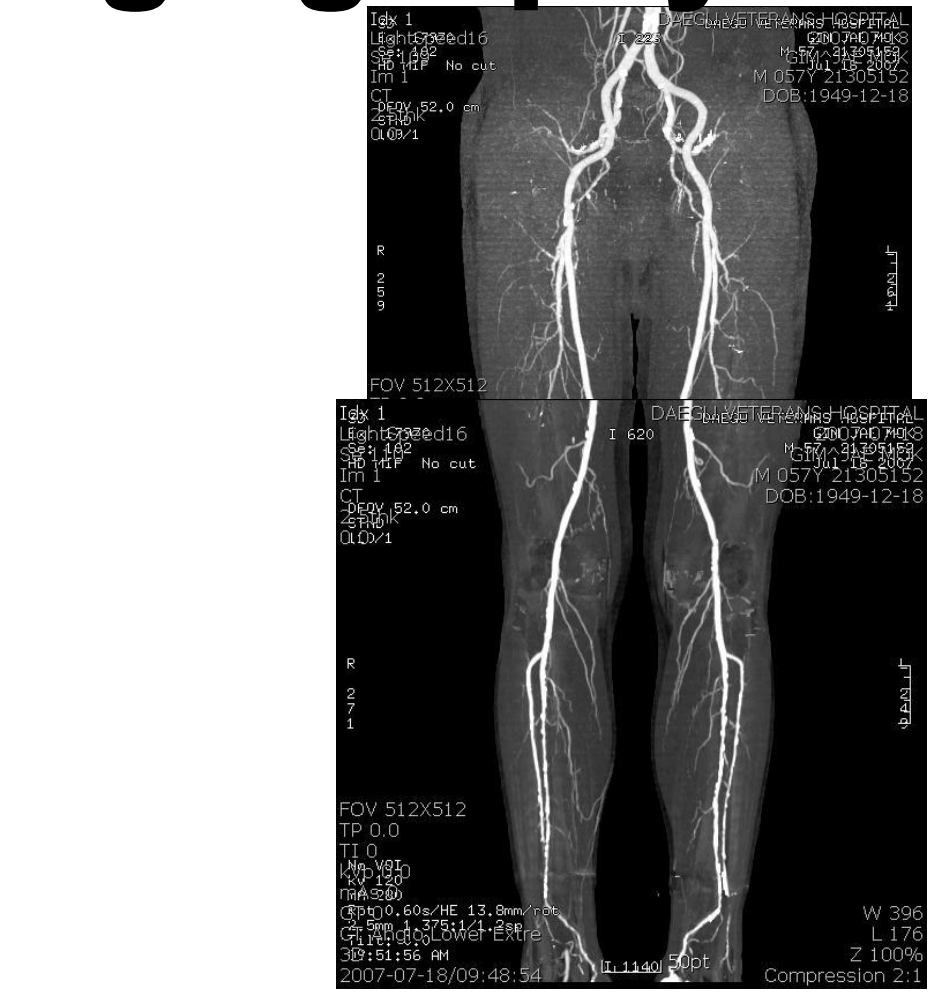
- **ABI performed in office**
  - Take the higher of the two arm pressures
  - Right:
    50/150 = 0.33
  - Left:
    100/150 = 0.66

Diagnosis:

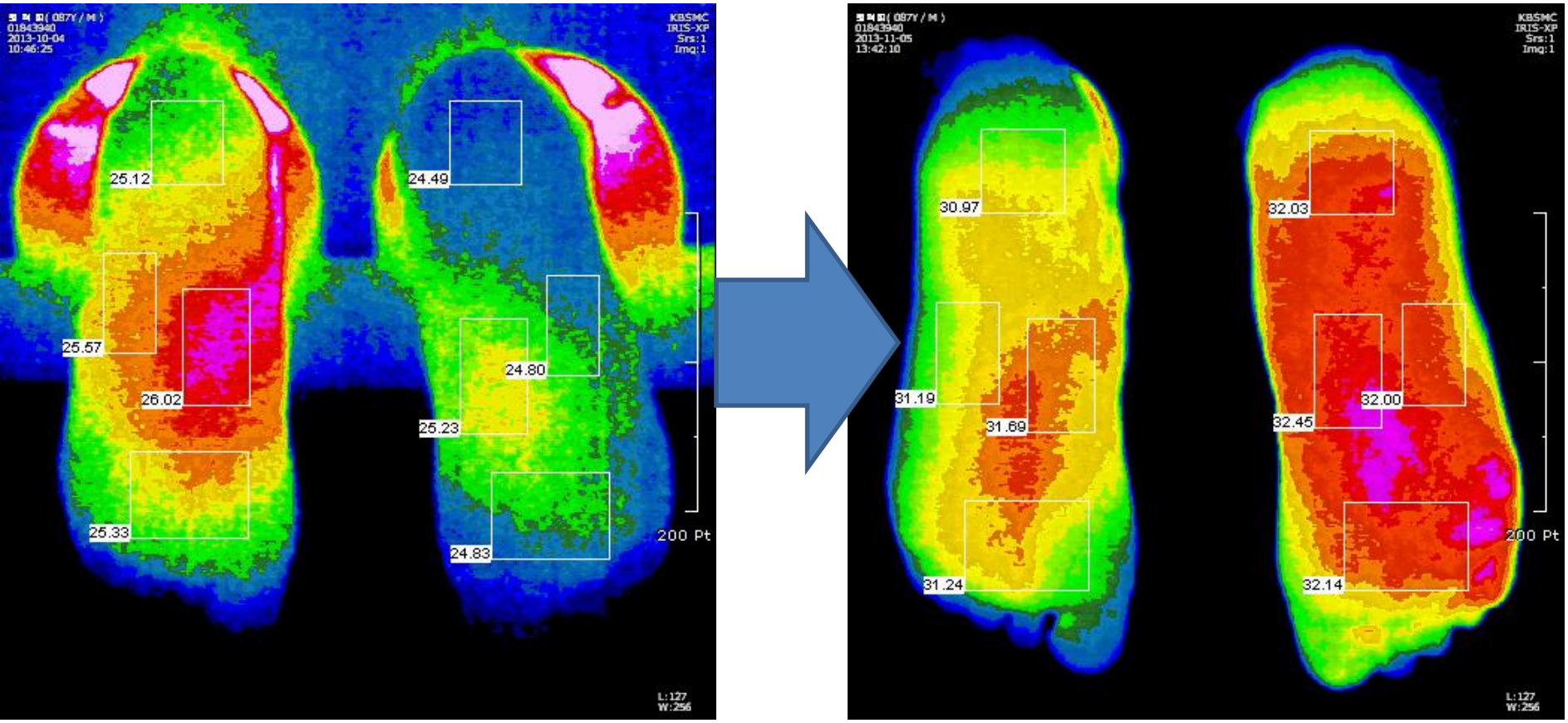
severe PAD in left leg



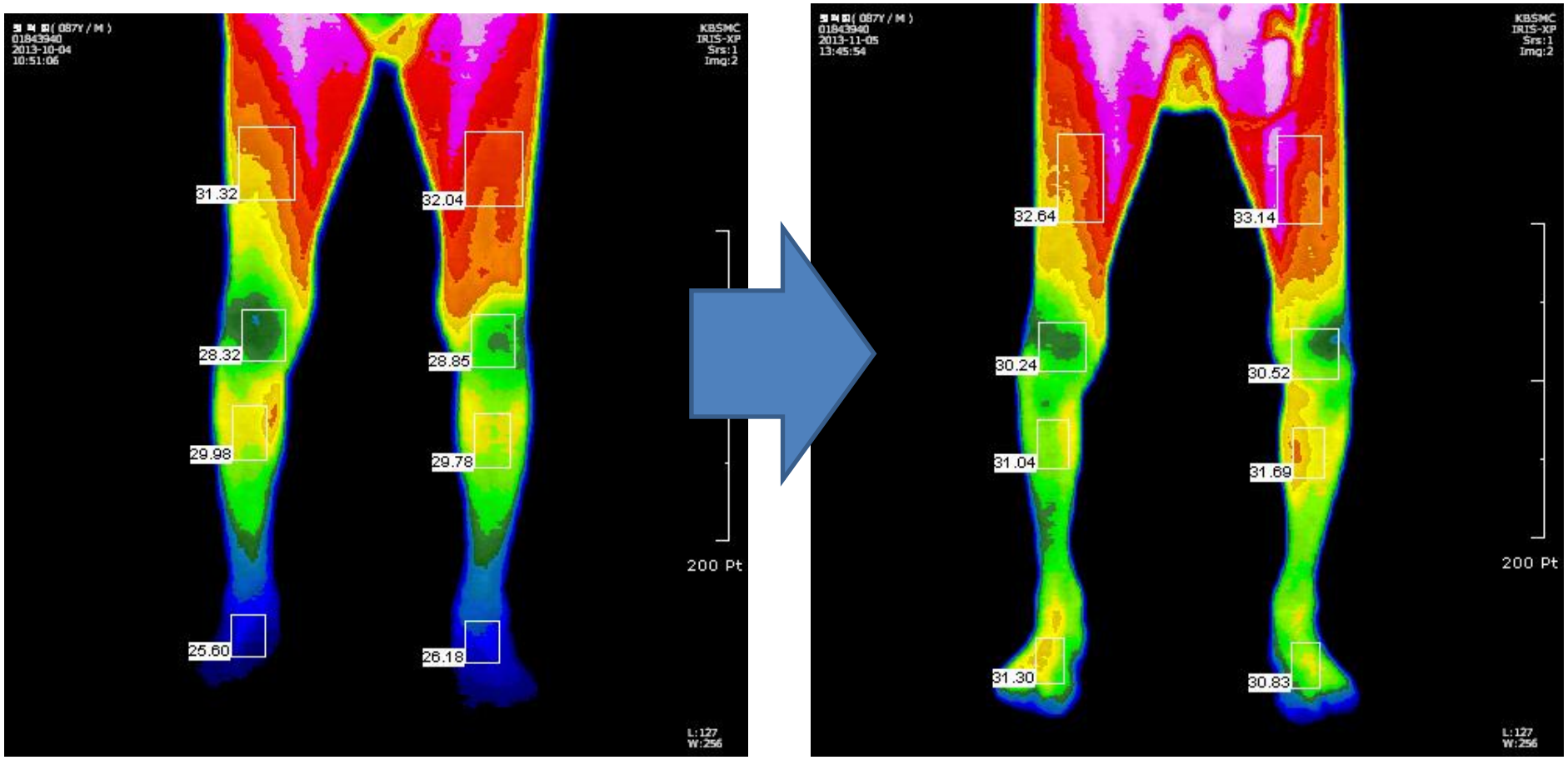
CT angiography



DITI: Digital Infrared Thermal Imaging



DITI: Digital Infrared Thermal Imaging



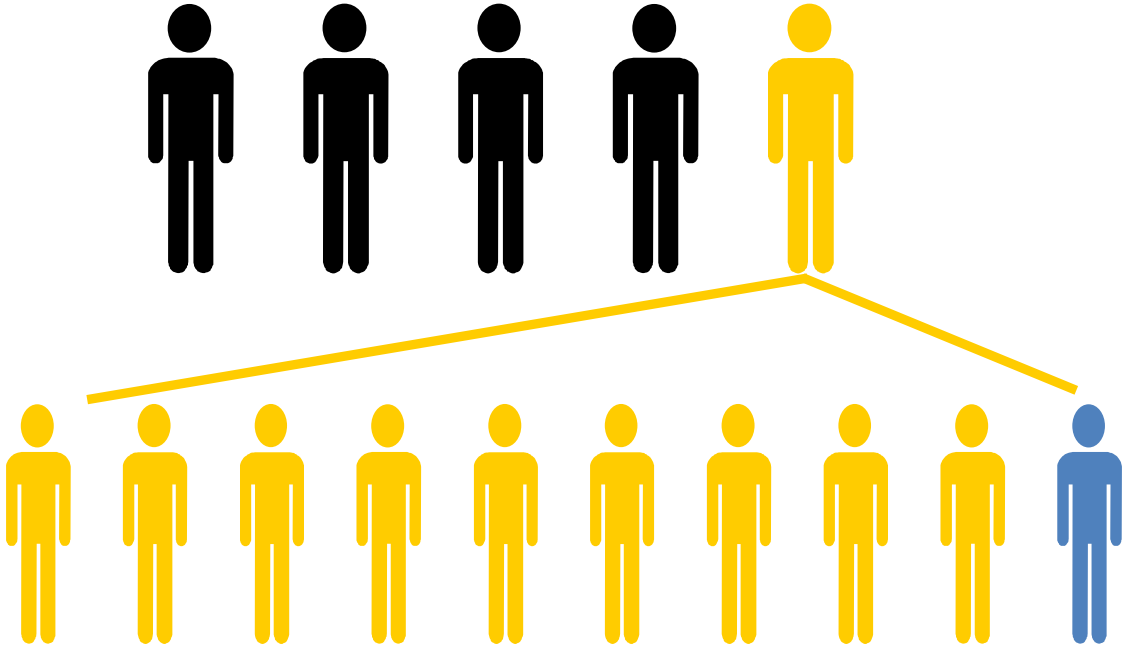
Section 3:

- **The importance of aggressive risk management of PAD**

Only 1 in 10 patients with PAD has classical symptoms of intermittent claudication

1 in 5 people over 65 has PAD†

Only 1 in 10 of these patients has classical symptoms of intermittent claudication (IC)



† ABI<0.9

Diehm C *et al*. *Atherosclerosis* 2004; **172**; 95-105.

The American Diabetes Association recommends screening for PAD in patients with diabetes

A screening ABI **should be** performed in patients **with diabetes**

Those >50 years of age	**Those <50 years of age who have other risk factors associated with PAD**
• If normal, an exercise test should be carried out • The ABI test should be repeated every 5 years	• Smoking • Hypertension • Hyperlipidemia • Duration of diabetes >10 years

- Foot care is also important in diabetic patients as PAD is a major contributor to diabetic foot problems[2]

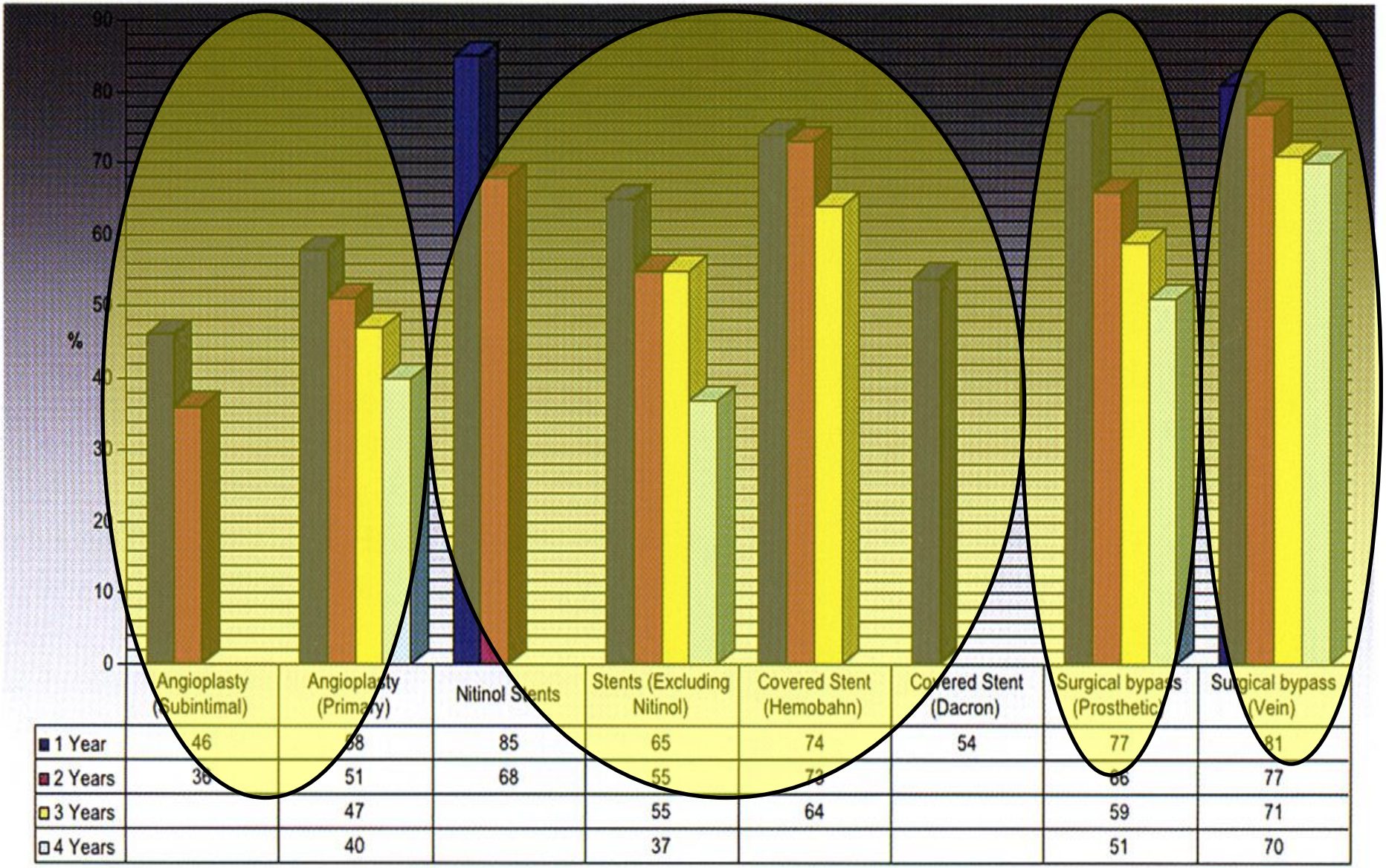
1. American Diabetes Association. *Diabetes Care* 2003; **26**: 3333–3341.
2. Estes JM, Pomposelli FB Jr. *Diabet Med* 1996: **13**: S43–S57.

Risk factor management approach

- Smoking cessation
- Weight reduction
- Total cholesterol <175 mg/dL / <4.5 mmol/L
- LDL cholesterol <100 mg/dL / <2.6 mmol/L
- Glycosylated hemoglobin <7.0%
- Blood pressure (BP) <140/90 mm Hg
- For patients with diabetes BP < 130/80mm Hg
- Platelet inhibition

Hiatt WR. *N Engl J Med* 2001; **344**: 1608-1621.

II. Treatment

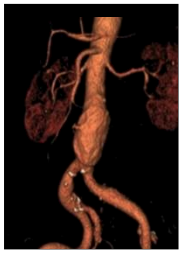


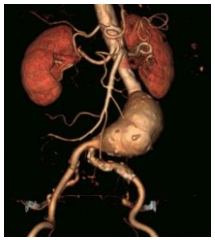
	Angioplasty (Subintimal)	Angioplasty (Primary)	Nitinol Stents	Stents (Excluding Nitinol)	Covered Stent (Hemobahn)	Covered Stent (Dacron)	Surgical bypass (Prosthetic)	Surgical bypass (Vein)
1 Year	46	58	85	65	74	54	77	81
2 Years	36	51	68	55	73		66	77
3 Years		47		55	64		59	71
4 Years		40		37			51	70

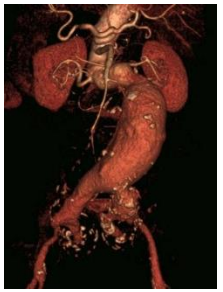
J Endovas Ther
2004;11(suppl II):II-107-II-127
Lower Extremity Endovascular Interventions
Bates and AbuRahma

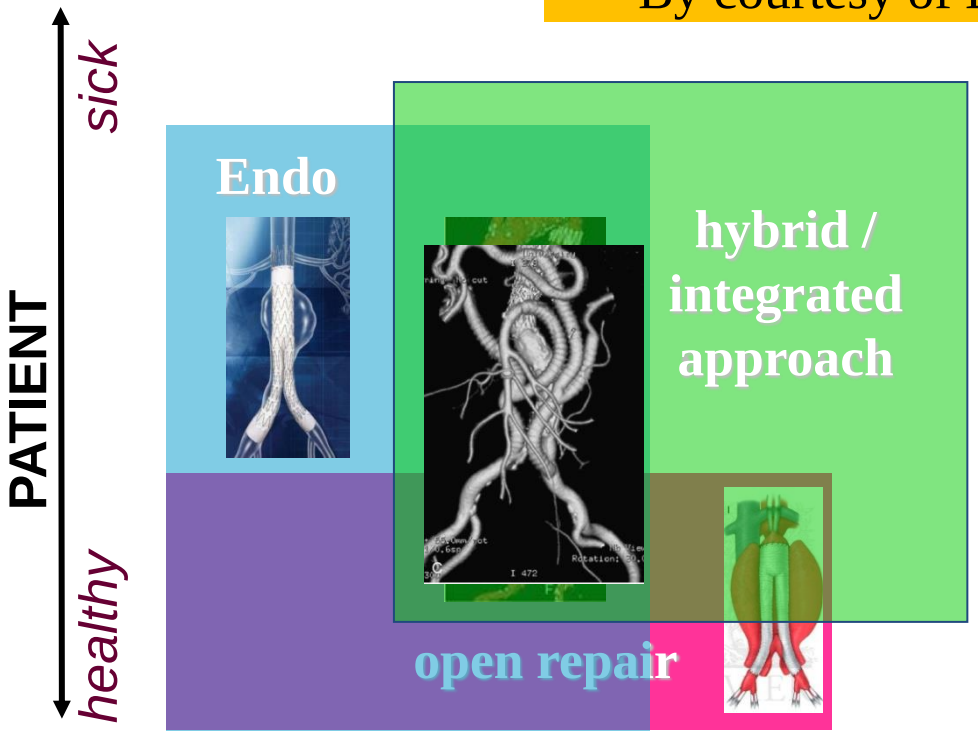
Endo. & OSR & Hybrid

By courtesy of Dr. Park (Kae Hyun)









Schema

- **Arterial occlusive disease**
  - Clinical:
    - **Acute arterial occlusion**
      - Acute embolism
      - Acute thrombosis
    - **Chronic arterial occlusion**

  - Cause:
    - Aatherosclerosis
    - Vasculitis, Arteritis
    - Takayasu's arteritis
    - Buerger's disease

- **Arterial aneurysm**

  - Anatomical: Aortic, other arterial
  - Cause:

    Nonspecific (degenerative),
    Connective tissue disease
    Mycotic,
    Others
  - Patologic : True vs. False aneurysm

Schema

- Acute limb ischemia

- Chronic limb ishemia

II-1. Acute Limb Ischemia

Definition

- Sudden occlusion of an artery is commonly due to either **emboli** or **trauma** & it may also happen when **thrombosis** occur *on plaque pre-existing atheroma.*

Cause - Emboli

Origin of Acute Arterial Embolism:

Cardiac		**80%**
	Af	50%
	MI	25%
	Valve and Others	5%
Non-Cardiac	10%	
	Aneurysm	6%
	Prox. Artery	3%
	Paradoxical	1%
Unknown	10%	

Occlusion Site - Emboli

Sites of occlusion embloi to the lower limb:

Abdominal bifurcation	10-15%
Iliac artery branch	15%
Femoral artery branch	**40%**
Popliteal artery	10%
Upper extremity	10%
Cerebral artery	10-15%
Mesenteric & Intraabdominal	5%

Cause - Trauma

- It is important to determine a history of arterial trauma, arterial catheterization, intra-arterial drug induced injection, aortic dissection, limb fractures.

Cause - Thromosis

- Thrombosis usually occur on a pre-existing atherosclerotic lesion.

- Occasionally thrombosis occur on relatively normal artery in patients with hypercoagulabale states
  - ex: Pt with malignancy, polycythemia or pt taking high doses of oestrogen.

Clinical Features

- The ***5 (6) P's***
  - **Pain.**
  - **Pallor.**
  - **Pulselessness.**
  - **Paraesthesia.**
  - **Paralysis.**
  - Perishing cold.

Embolism vs Thrombosis

	Acute arterial embolism	Acute arterial thrombosis
Cause	AF, MI, MS etc	Atherosclerotic lesion
Sx.	More sudden	Pre-existing claudication
Angio.	1. Clear cut off lesion 2. No or minimal collateral 3. No or minimal arterial calcification 4. Normal opposite leg artery	1. Irregular 2. Well developed collateral 3. Arterial calcification 4. Diseased opposite leg artery
Tx.	Embolectomy + Anticoagulation	Thrombolytic therapy + Bypass op (or endovascular intervention)
Prognosis ampu. mortality	 Lower Higher	 Higher (x 2) Lower

By Courtery of Prof. WY Kim

Management

Immediately

- **Anticoagulant with heparin** to prevent propagation of thrombus & distal thrombosis & this achieved by giving a bolus of 10,000 units of heparin intravenously & an infusion of about 1000 units of heparin per hour after that.

- In pt thrombosis is thought to be the dx arteriography should be considered to define the extant of problem before revascularization.

???????

- Is it possible to remove thrombus or emboli with Fograty Catheter?

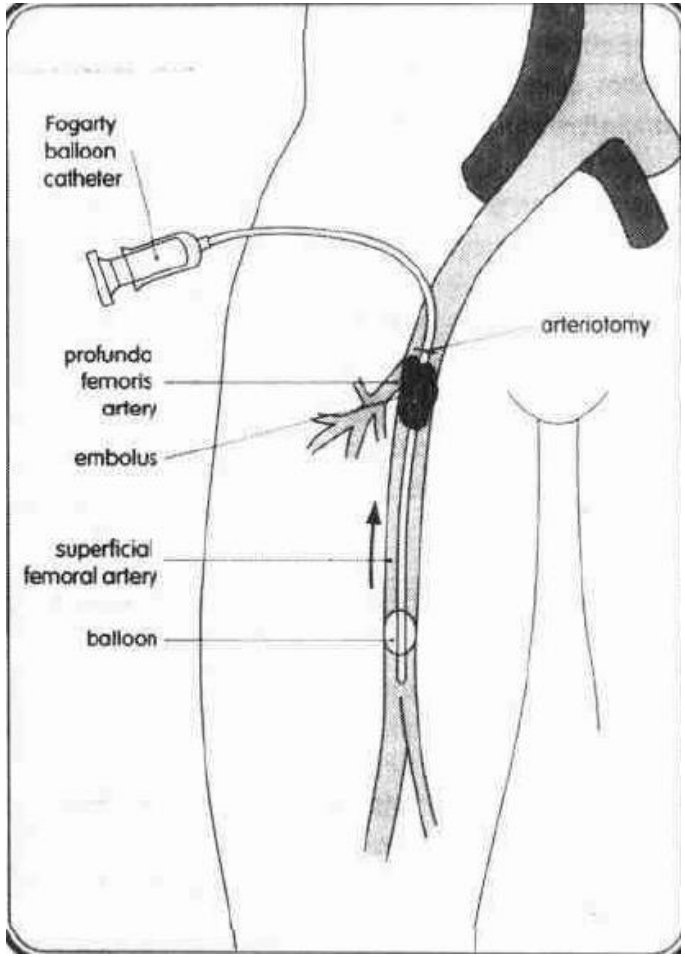
- Is it possible to treat underlying cause (origin of emboli or origin of thrombus)

- If not, what should we do?

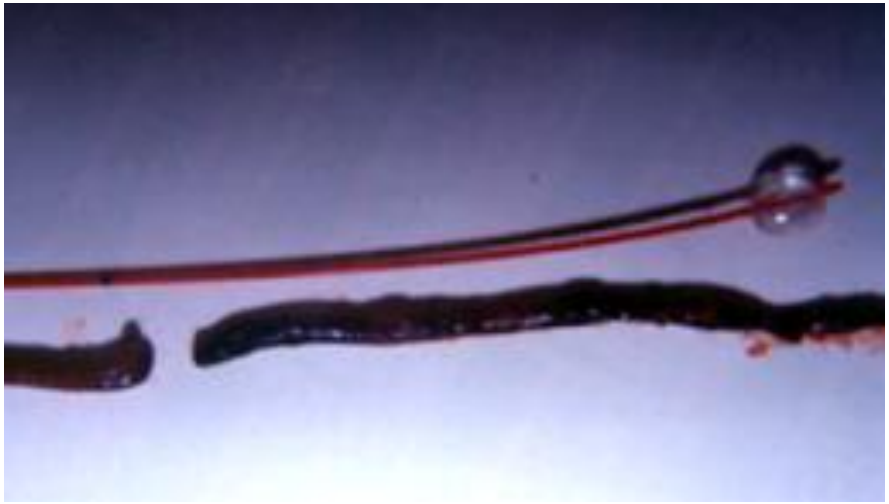
Embolectomy

- This operation usually performed under local anaesthesia.
- A groin incision is made **& the common femoral artery is opened**.
- often the clot is found in the artery a **Fogarty balloon catheter** is passed in turn into the proximal & distal arteries the balloon is inflated & the catheter withdrawn removing the clot.

Embolectomy



Fogarty's balloon catheter

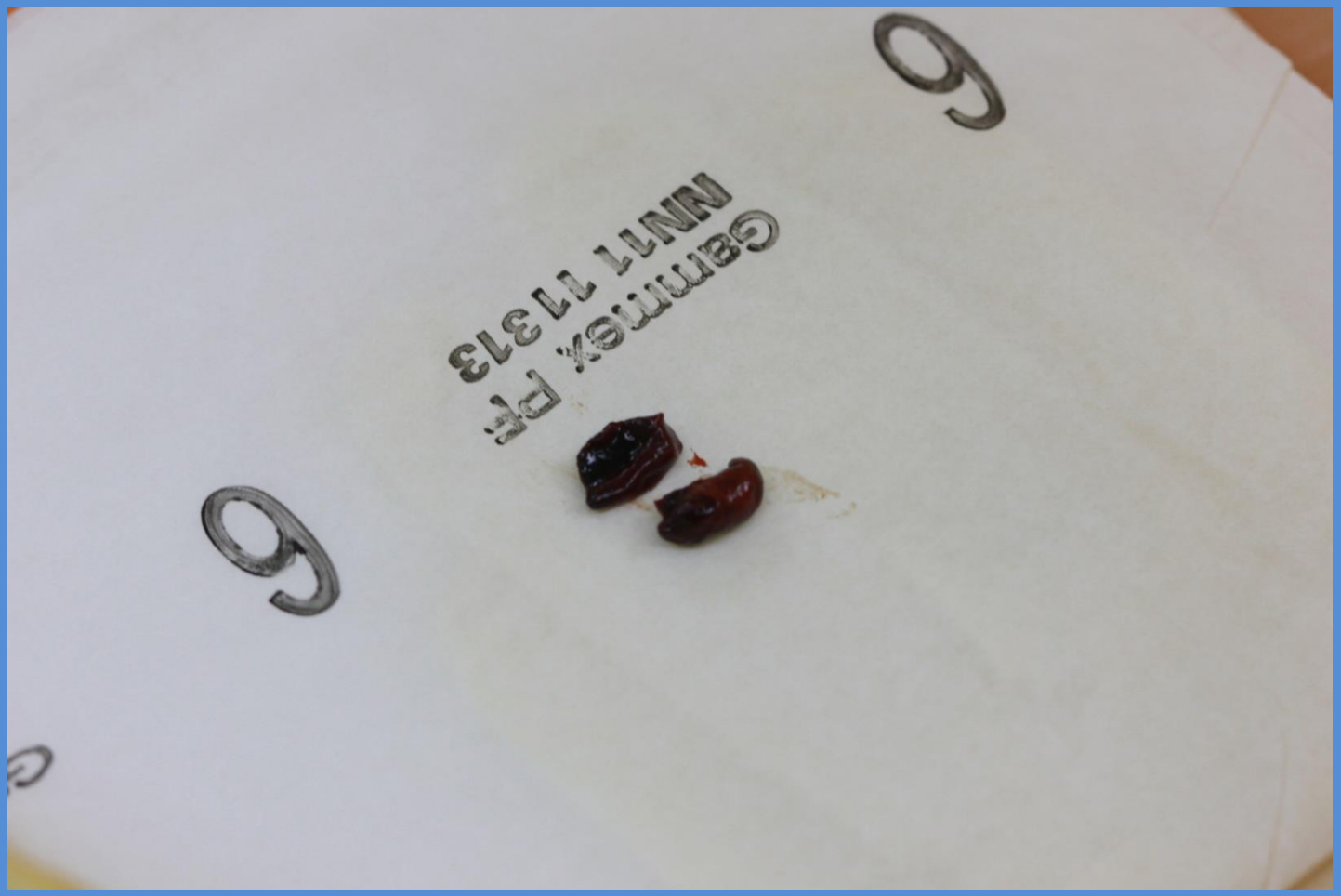


Thrombolytic Therapy

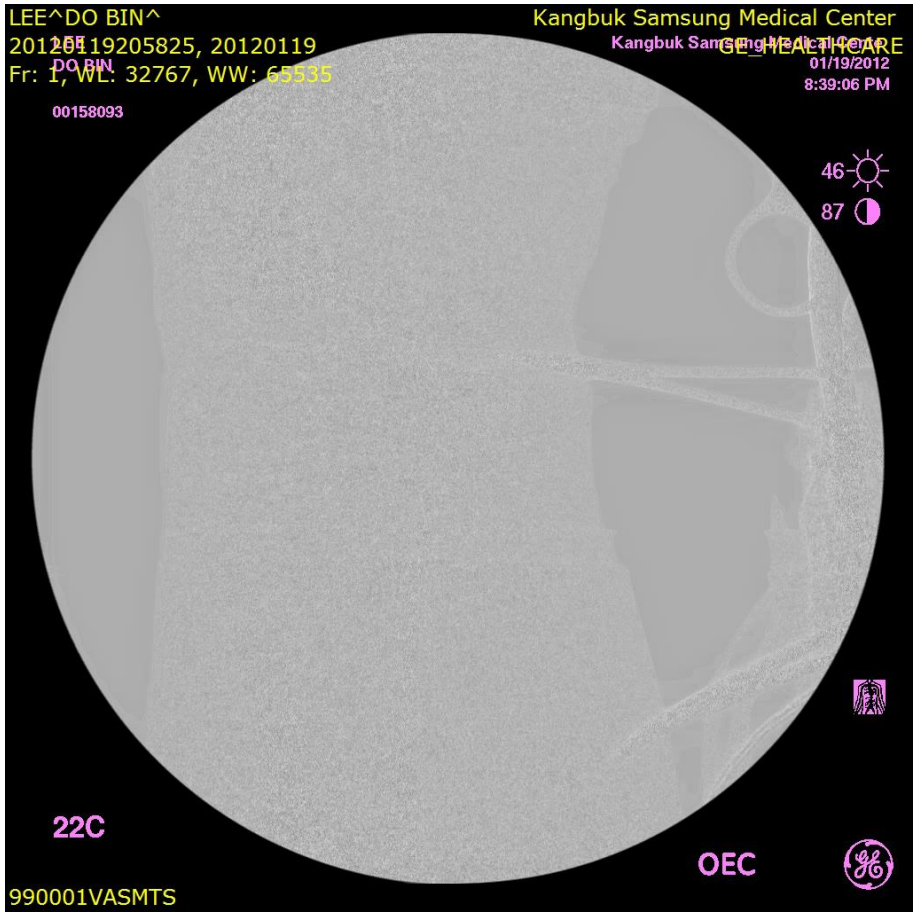
- Percutaneous intra-arterial thrombolytic therapy.
- Takes approximately 12-72 hours to dissolve the clot.
- Agents used: streptokinase, urokinase & tissue plasminogen activator.
- Mechanism: The convert plasminogen to plasmin which the active lytic agent.

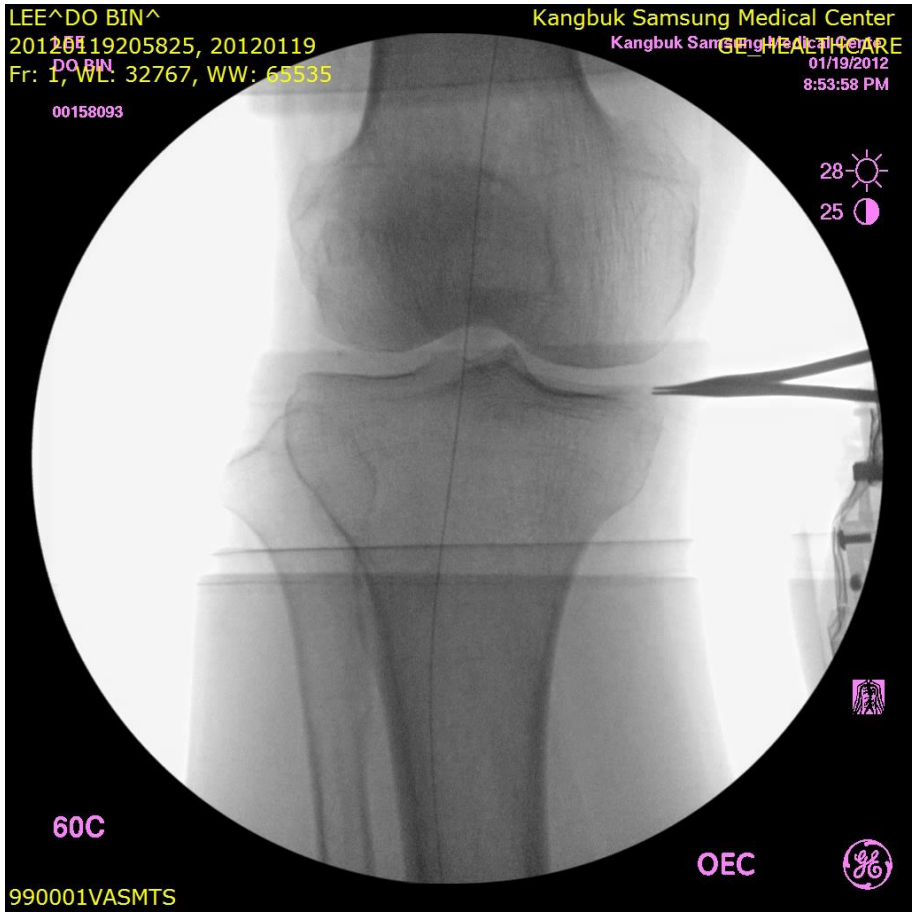
Case Presentation

- **Embolectomy:** antegrade approach at Rt CFA



Completion Angio





II-2. Chronic Limb Ischemia

Definition

- It is the decrease in arterial blood supply to the tissues **due to partial occlusion of arteries**.

- **Stenosis or occlusion** produces symptoms & signs that are related to the organ supplies by the artery.

- The severity of symptoms is related to **the size of the vessel occluded** & **alternative routes (collaterals) available for blood flow**.

Causes

- Atherosclerosis (ASO)
- Burger’s disease
- Raynaud’s disease
- Others

Definition of ASO

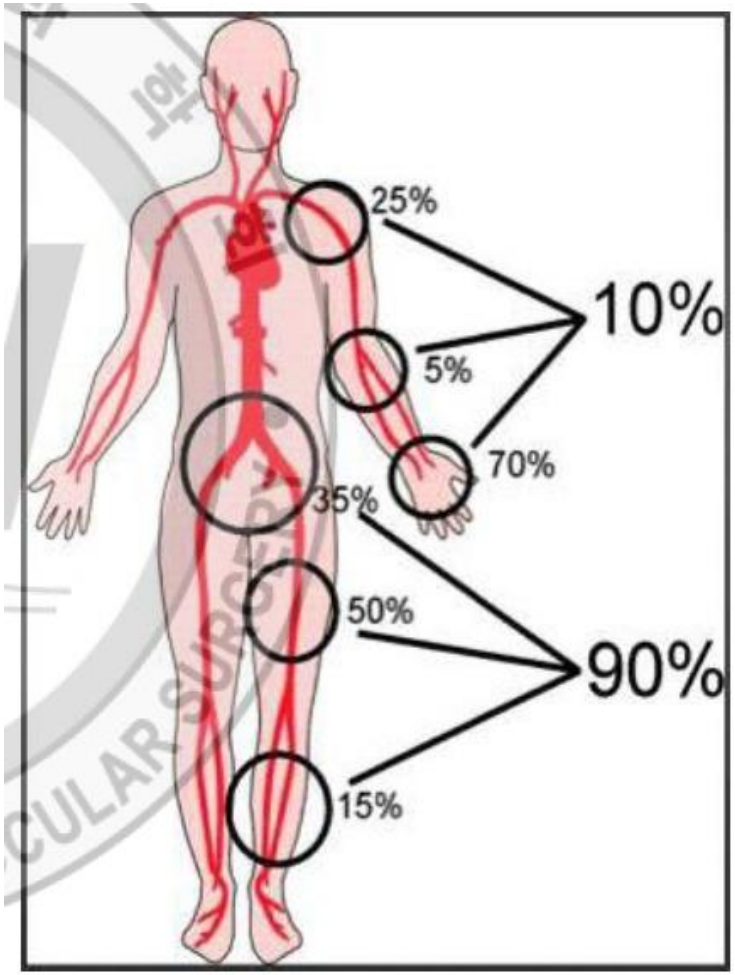
- It is the process underlying the formation of focal obstructions or plaques in large & medium sized arteries.

- It is characterised by the presence of **focal intimal thickening,** these intimal elevations being made up of **accumulations of cholesterol rich & a proliferation of connective tissue.**

- An essential component of atherogenesis is inflammation involving **monocytes / macrophages, T lymphocytes & mast cells.**

Common sites of plaque formation in arteries

- Branch points.
- Tethered sites like in superficial femoral artery in Hunter's canal in the leg.



Definition of Burger's Disease

- It is occlusive disease of **small & medium size arteries**, thrombophlebitis of superficial or deep veins & Raynaud's syndrome.

- It occurrs in male patients with **heavy smoking** & usually **under the age of 30 years**.

Characteristics of Burger's disease

Histology:

Localised **inflammatory changes** occur in walls of arteries and veins leading to thrombosis.

Clinical picture:

- **The usual symptoms** and signs of arterial occlusive disease are present.
- **Gangrene of the toes and fingers** is common and progressive.

Clinical Manifestation

- Non-Critical Limb Ischemia
- Cricial Limb Ischemia (CLI)

Non-Critical Limb Ischemia

- **Intermittent claudication:**
  - ABI: 0.5-0.9
  - Cludication distance
  - Calf is the most common

Critical Limb Ischemia

- **Rest Pain**
  - Worst at night,lying, relieved by putting the leg in dependent site
  - Coldness
  - Numbness
  - Parasthesia
  - Color change
  - Differentiated from night cramps
- **Ulcer**
- **Gangrene**

Definition of Critical Limb Ischemia

- **Hemodynamic parameters for CLI**

  ; no consensus yet.

- **TASC II**
  - **Ischemic rest pain**

    ; ankle systolic pressure < 50mmHg or

    ; toe systolic pressure < 30mmHg

  - **Ulceration or gangrene**

    ; ankle systolic pressure < 70mmHg or

    ; toe systolic pressure < 50 mmHg

Definitions of Critical Limb Ischemia

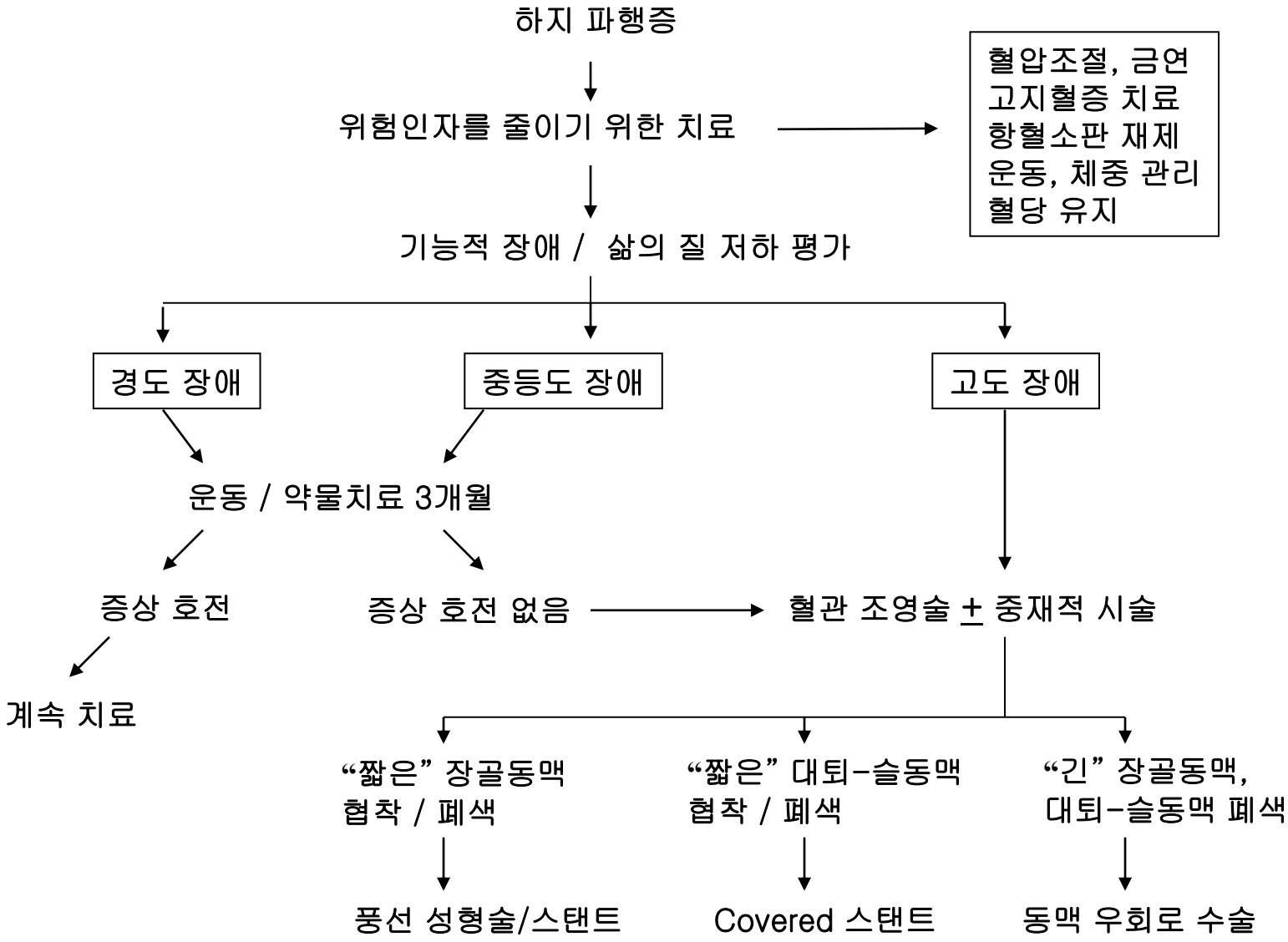
(TASC II Inter-Society Consensus)

Classification of PAD

Fontaine		Rutherford	
Stage	**Clinical**	**Category**	**Clinical**
I	Asymptomatic	0	Asymptomatic
IIa	Mild claudication	1	Mild claudication
IIb	Moderate to severe claudication	2	Moderate claudication
		3	Severe claudication
III	**Ischemic rest pain**	4	**Ischemic rest pain**
IV	**Ulceration or gangrene**	5	**Minor tissue loss**
		6	**Major tissue loss**

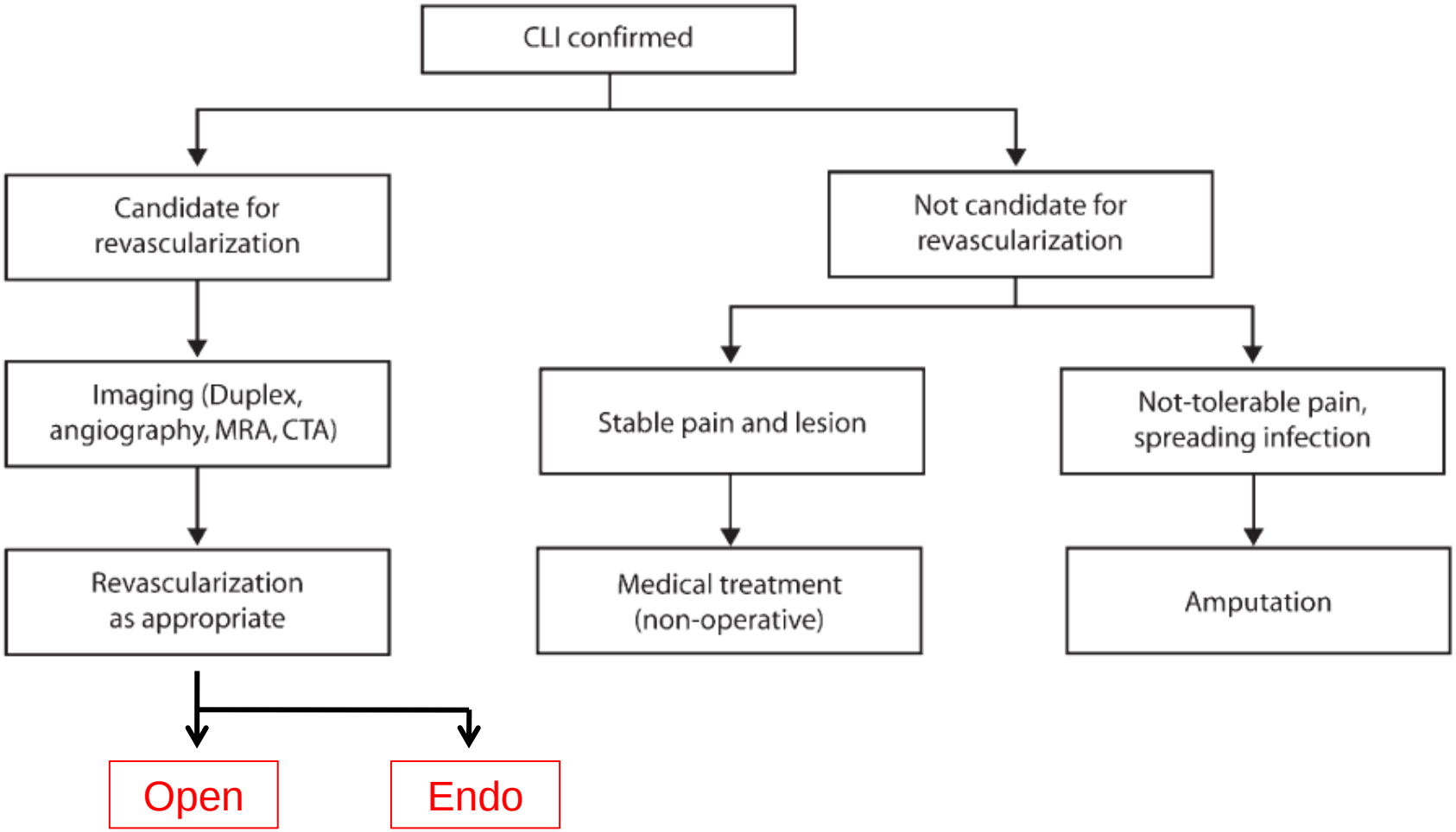
* CLI should only be used in the presence of symptoms for more than 2 weeks.

Algorithm for Non-CLI (claudication)



임상심장학 2nd edition

Algorithm for CLI



Amputation as a primary therapy

- **How to interpretate the preexisting data**
  - Physician-oriented view of success
    ; Graft patency, limb salvage, and survival
  - Patient-oriented outcomes
    ; Quality of life

- **Ischemia-reperfusion syndrome**
  - might jeopardize patient survival

→ Limb amputation may actually improve QOL in select patient population

Revascularization in CLI

- **Methods**
  - **Open first**
  - **Endo first**
  - **Hybrid**

- **How to select optimal treatment?**
  - **Hospital resources**
  - **Operator's preference (VS vs IR)**
  - **Evidence-based practice, Treatment guideline**

Management

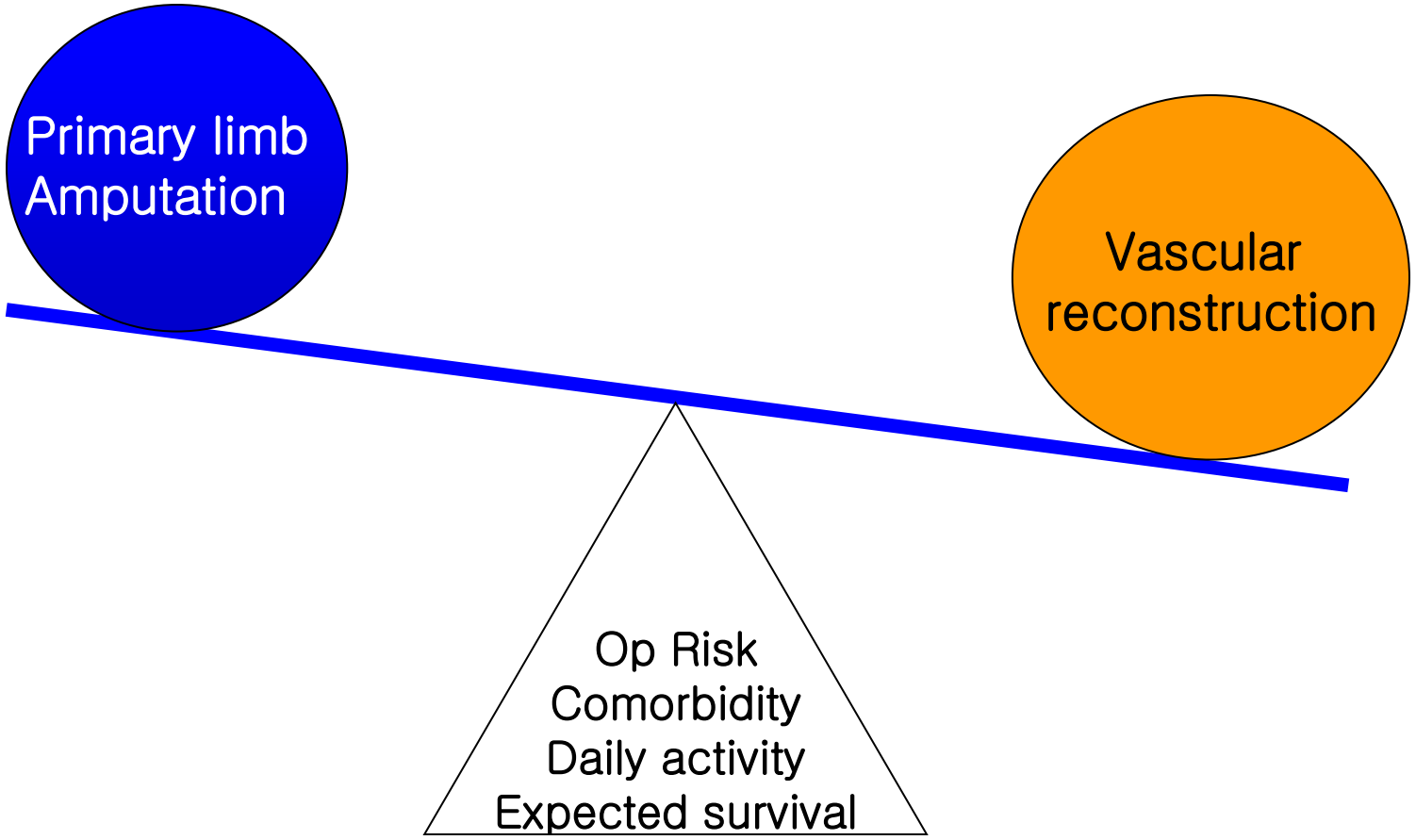
General Management - 01

- Explanation and advice
- Life style adjustment
- Smoking
- Exercise
- Diet
- Heal raise
- Analgesics and use of position

General Management - 02

- Sympathectomy
- Transluminal angioplasty: usually percutaneous
- Iliac success more than the leg arteries bypass
- Atherectomy

Preop. Risk-Benefit Analysis



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Major changes between TASC 2000 and II 2007

1. **Length of lesion:** simplified to below 3cm, 3-10cm

2. **TASC B**

   a. aortic stenosis without iliac lesion was added

   b. adding segmental obstructive lesion in TASC B

3. **TASC C:**

   a. heavily calcified obstruction of EIA were added

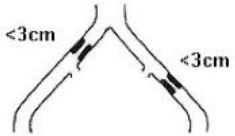
   b. EIA occlusion involving orifice of internal iliac artery orifice and/or CFA

4. **TASC D**: with the preexisting four types,

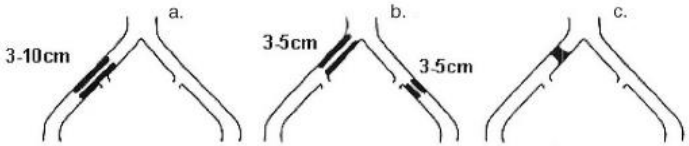
   a. Aortic lesions including Leriche ds. and triple A were added

TASC 2000 and TASC II 2007

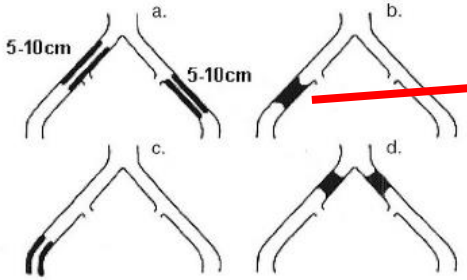
Type A lesions



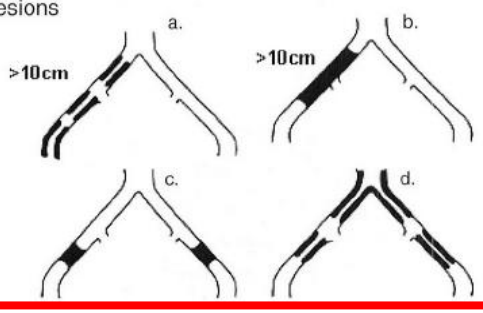
Type B lesions



Type C lesions



Type D lesions

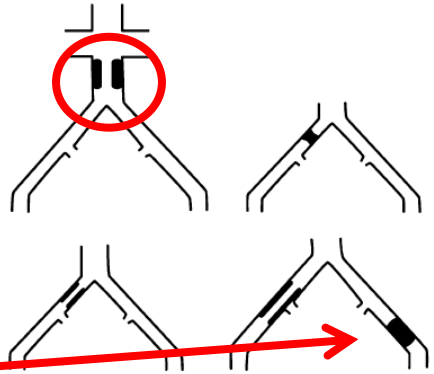


Type A lesions

- Unilateral or bilateral stenoses of CIA
- Unilateral or bilateral single short (≤3 cm) stenosis of EIA

Type B lesions:

- Short (≤3cm) stenosis of infrarenal aorta
- Unilateral CIA occlusion
- Single or multiple stenosis totaling 3–10 cm involving the EIA not extending into the CFA
- Unilateral EIA occlusion not involving the origins of internal iliac or CFA

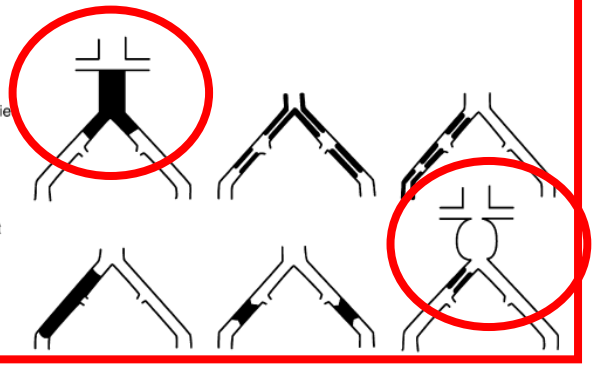


Type C lesions

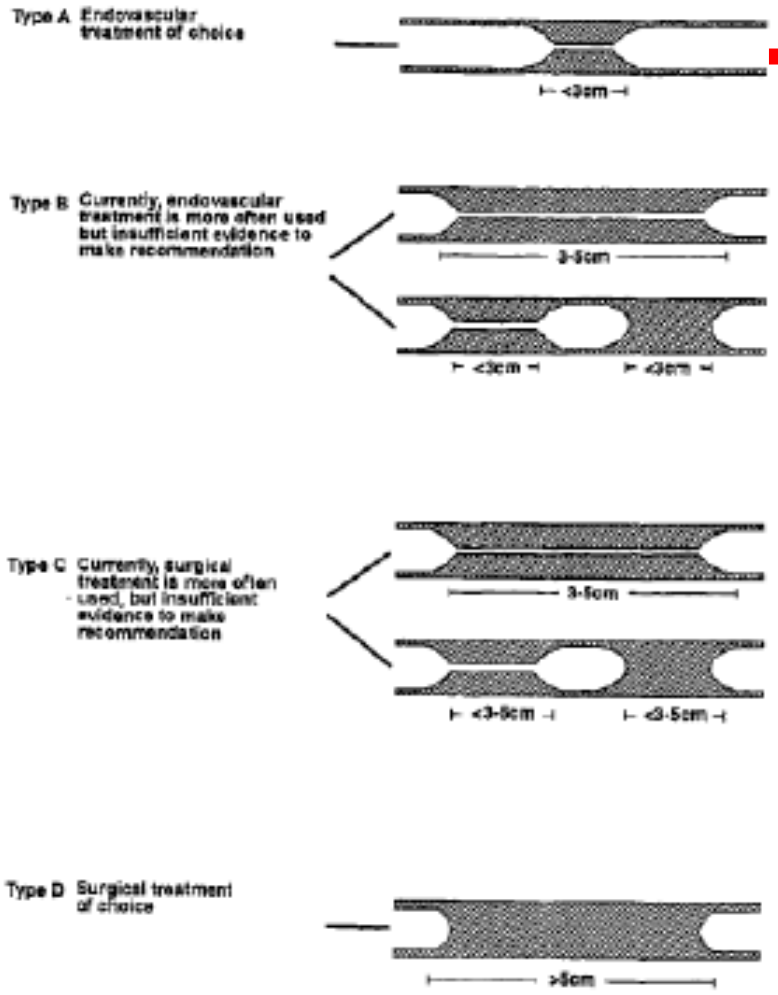
- Bilateral CIA occlusions
- Bilateral EIA stenoses 3–10 cm long not extending into the CFA
- Unilateral EIA stenosis extending into the CFA
- Unilateral EIA occlusion that involves the origins of internal iliac and/or CFA
- Heavily calcified unilateral EIA occlusion with or without involvement of origins of internal iliac and/or CFA

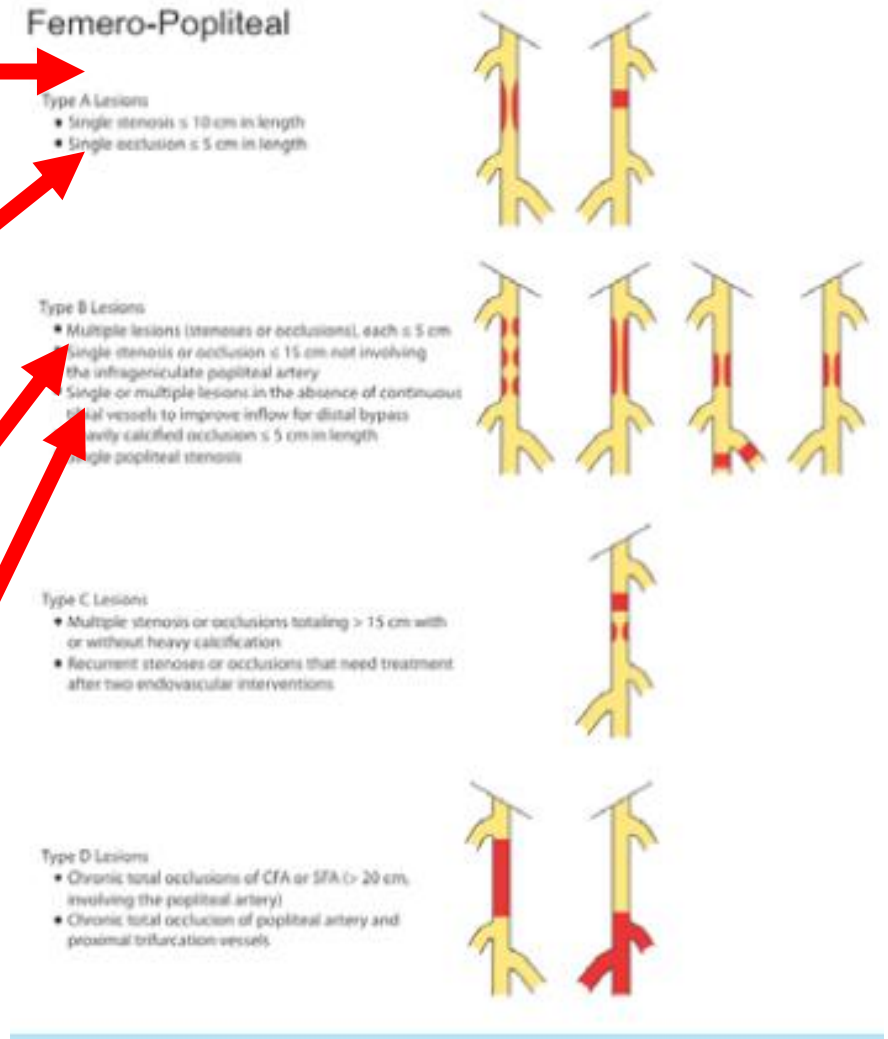
Type D lesions

- Infra-renal aortoiliac occlusion
- Diffuse disease involving the aorta and both iliac arteries requiring treatment
- Diffuse multiple stenoses involving the unilateral CIA, EIA, and CFA
- Unilateral occlusions of both CIA and EIA
- Bilateral occlusions of EIA
- Iliac stenoses in patients with AAA requiring treatment and not amenable to endograft placement or other lesions requiring open aortic or iliac surgery



TASC 2000 and TASC II 2007

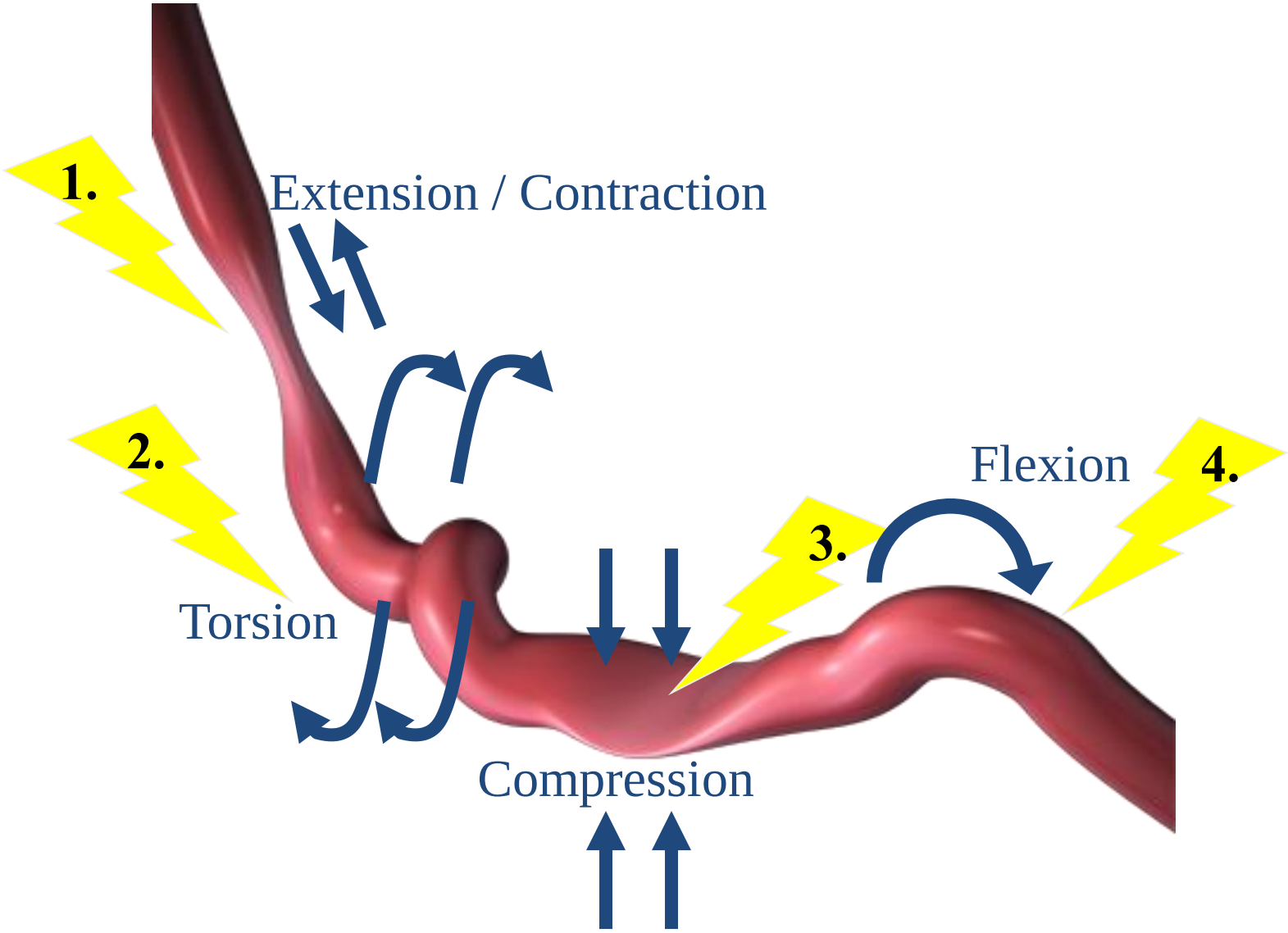




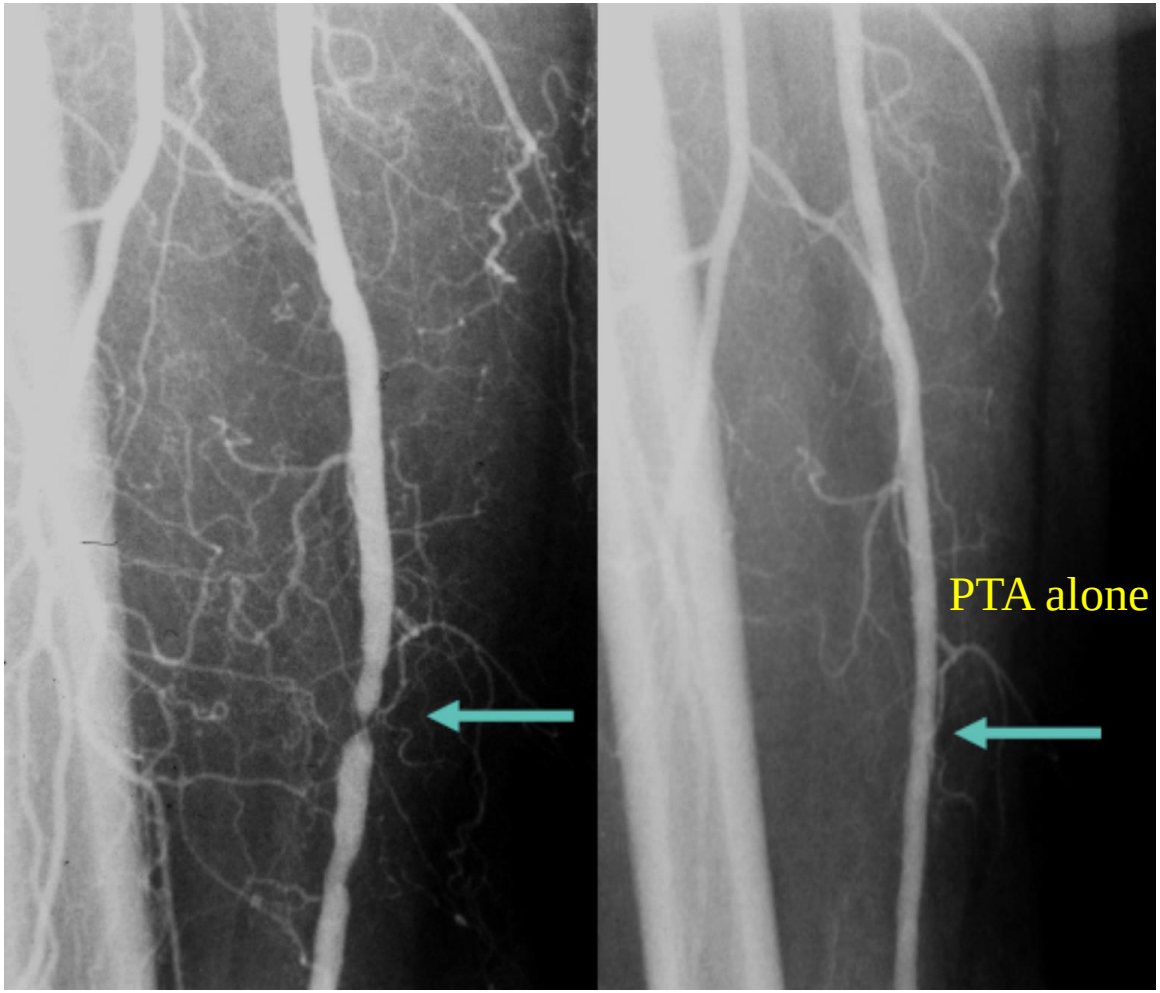
Treating more complex lesions

TASC 1 (2000)		TASC II (2007)
Stenosis <3cm	A	Stenosis ≤10cm Occlusion ≤5cm
Stenosis 3-5cm Occlusion <3cm	B	Stenosis/occlusion ≤15cm Calcified occlusion ≤5cm Single popliteal stenosis Multiple lesions, each ≤5cm
Stenosis/occlusion >5cm Multiple stenosis/occlusions 3-5cm	C	Stenosis/occlusion >15cm Recurrent restenosis
Occlusion >5cm	D	Occlusion >20cm involving Pop Popliteal occlusion

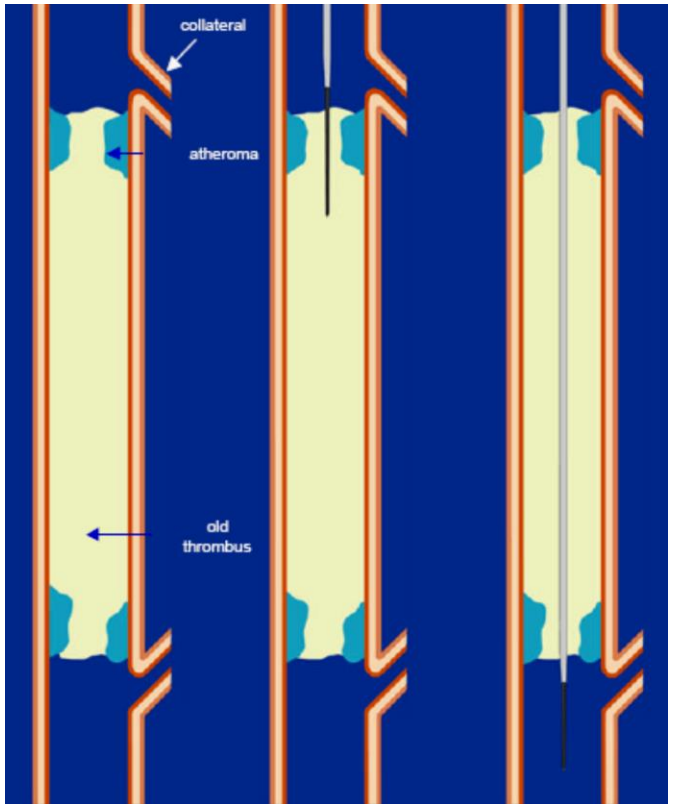
Forces Exerted On Stents In SFA

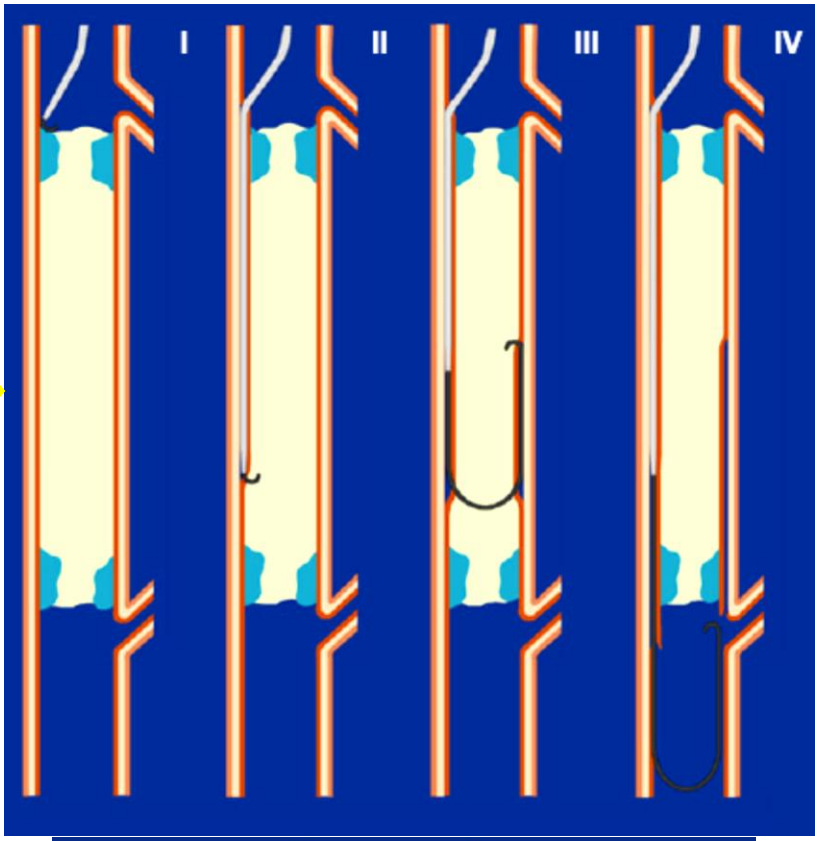


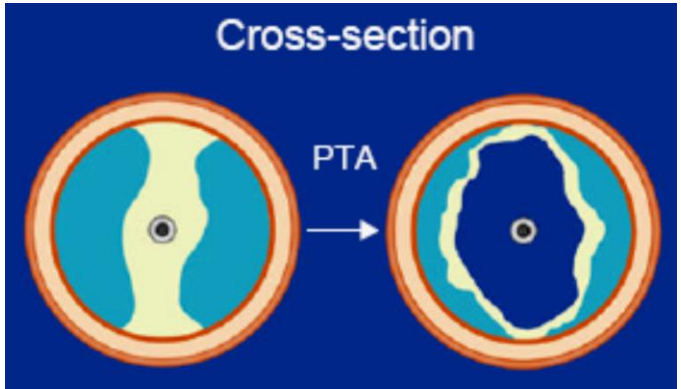
The Ideal SFA Lesion is Rare

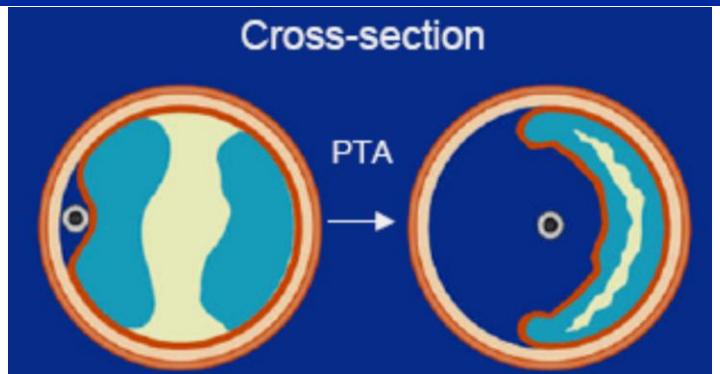


Intraluminal vs. Sub-intimal

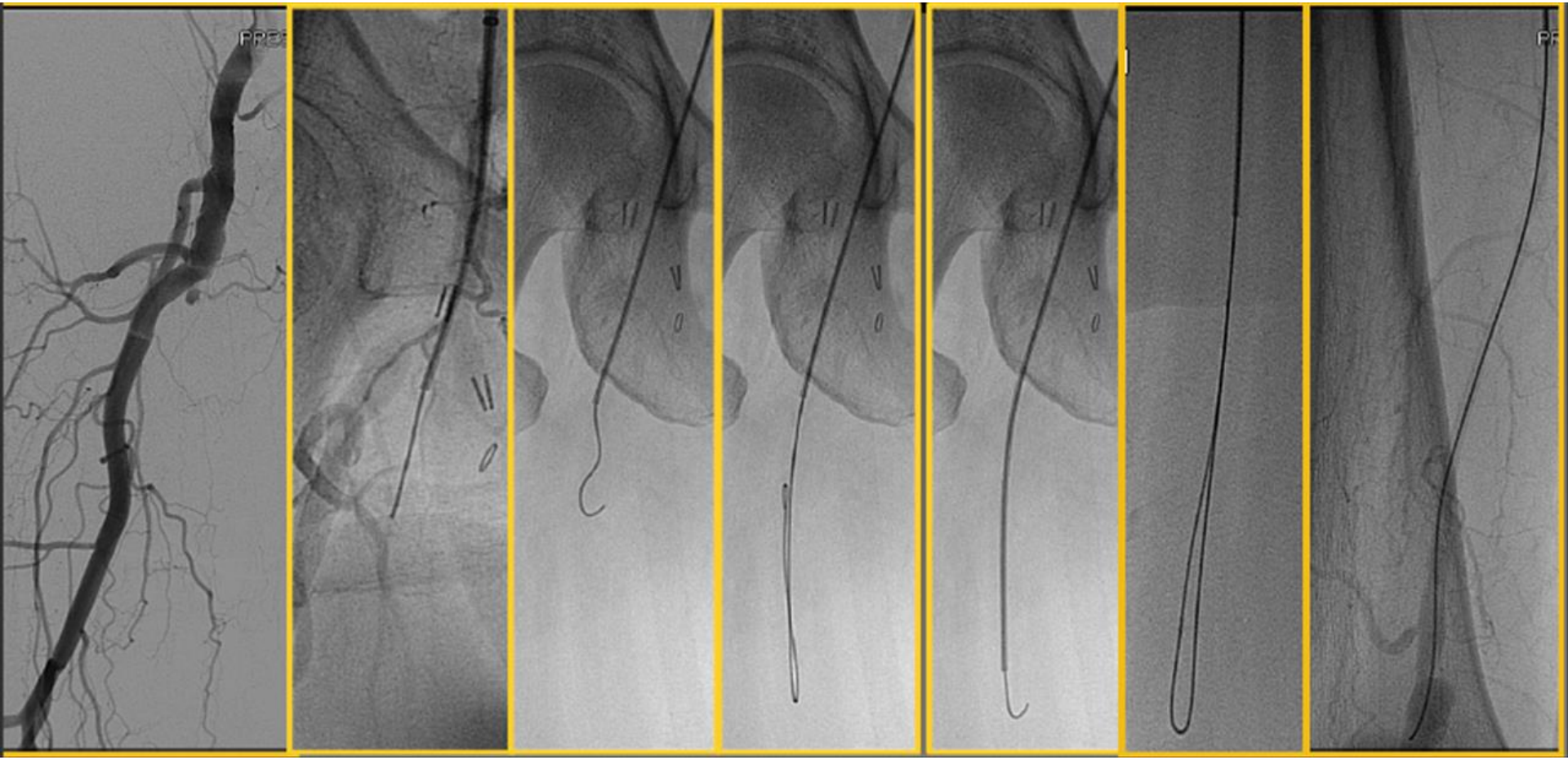






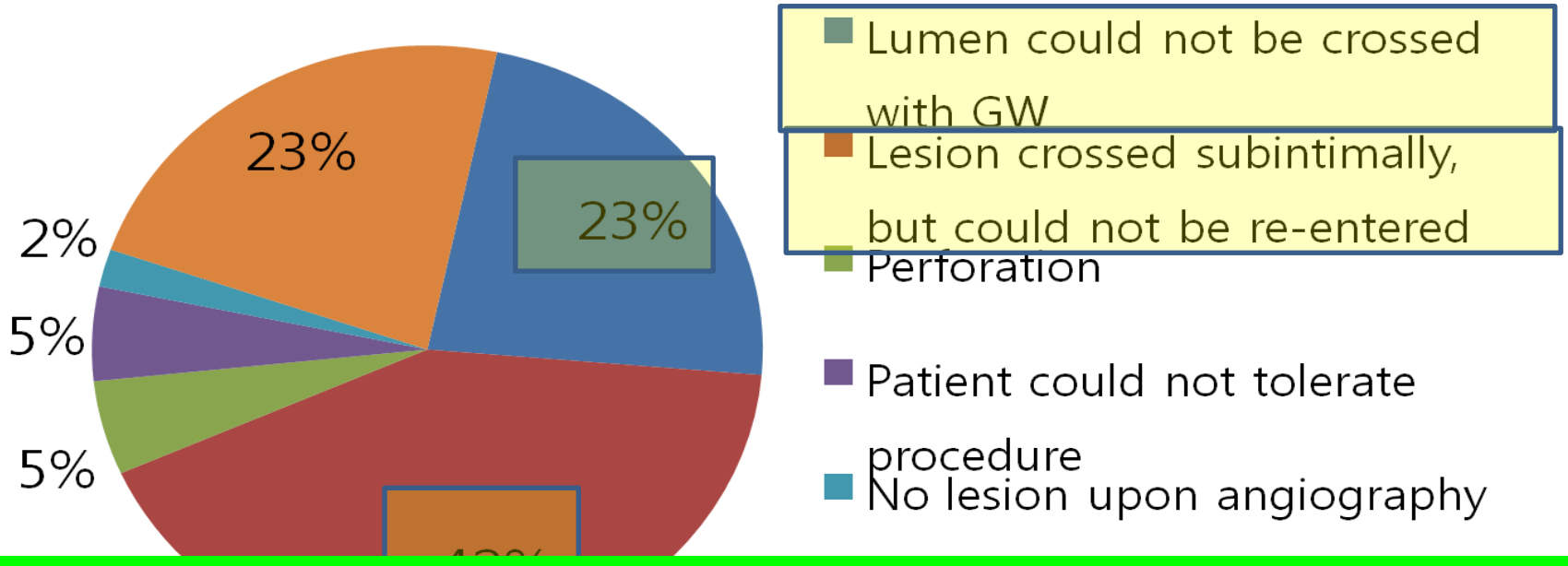


Standard SFA Subintimal Technique



Angioplasty Attempts and Immediate Failures

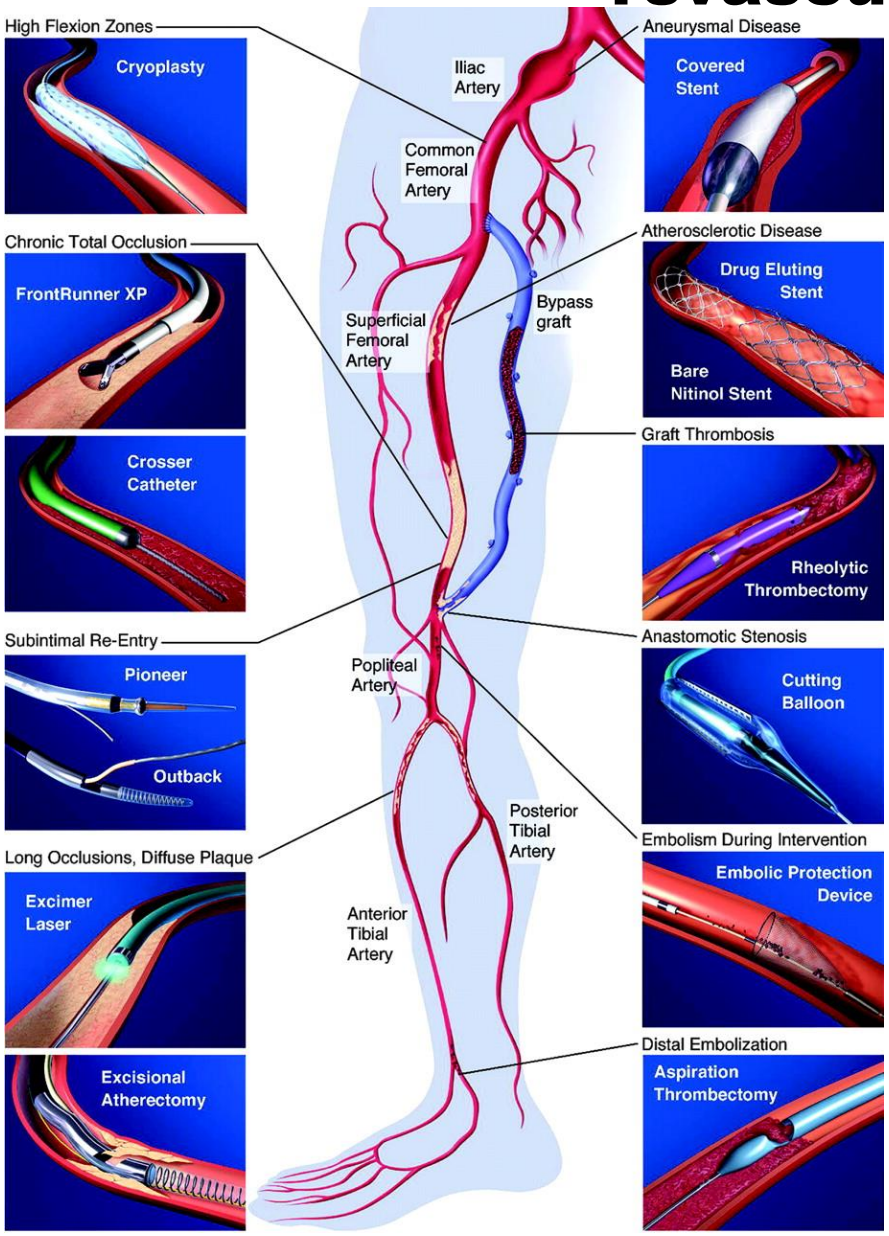
- Of the 224 patients allocated to angioplasty, 216 underwent attempted angioplasty
- Of these, 43 (20%) of attempted angioplaty patients were considered immediate failures



Nowdays, there have been a lot of improvements in techniques and devices.

However, the failure of re-entry has always been a problem.

New technologies for lower extremity revascularization



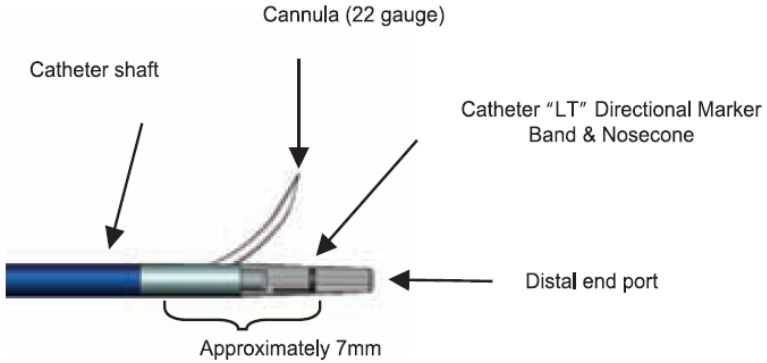
- Drugs
- Subintimal Angioplasty
- Bare Stents
- Covered stents
- Drug eluting Stents
- Drug eluting balloon
- Bioabsorbable Stents
- Brachytherapy
- Cryoplasty
- Cutting balloon
- Photodynamic therapy
- Debulking -artherectomy

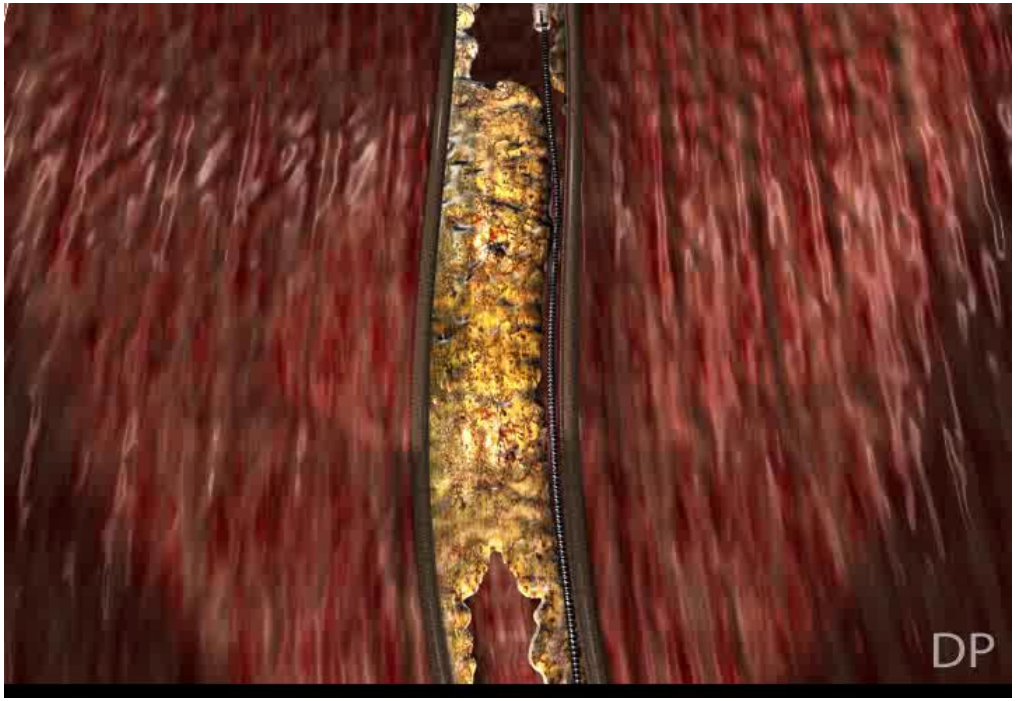
Rogers, J. H. et al. Circulation 2007;116:2072-2085

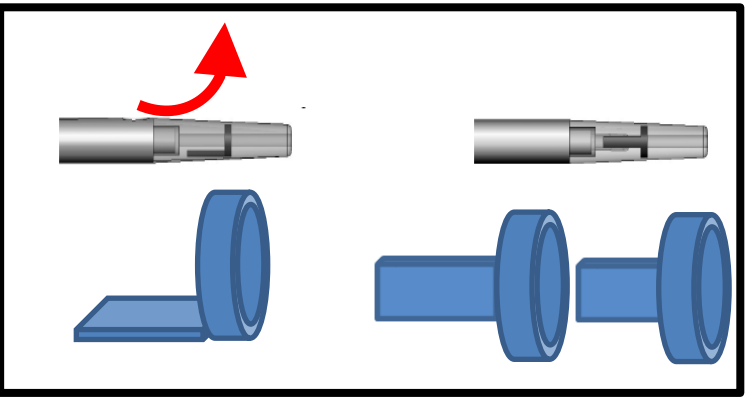
To solve passage or reentry problems

1. ***Reentry catheter***
2. **Retrograde approach**
3. **Bypass surgery**

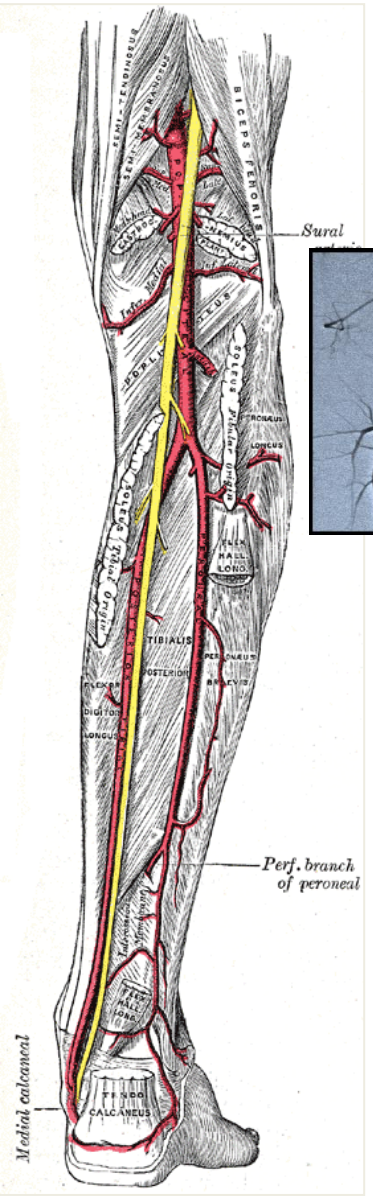
Distal Housing & Nosecone Assembly - Detail A







BTK / Infrapopliteal arteries



- Popliteal, and Trifurcation (tibial & peroneal): 2-4mm

Main issues

- Not Uncommon
- DM Occlusive Disease is more common in BTK
- Occlusion more common than stenoses: 2/3
- Critical Limb Ischemia > claudication
- Multilevel obstruction
- Need distal bypass surgery/major amputation
- Poor prognosis
- Low flow arteries
- Long segment disease: 50% >10cm

- Few randomized study
- Not good long term results
- No especially designed stent
  - 95% PTA,
  - 35% Stent,
  - 30% thrombolysis
- Savy balloon, long balloon

ASO vs DM

특징	신경병성 족부 궤양 (neuropathic ulcer)	허혈성-신경병성 족부궤양 (neuro-ischemic ulcer)
통증	없음	있음
동맥 맥박	정상	소실
궤양의 모양	"Punched-out lesion"	불규칙한 변연
궤양의 위치	발바닥 혹은 발의 가장자리	주로 발가락
피부 경결	있다	없다 혹은 흔치 않다
감각 소실	있다	다양함
혈류	증가	감소
발등의 정맥	확장	수축
발의 체온	따듯하다	차다
족부 변형	있다	없다
발의 피부 색깔	붉다	창백 혹은 청색증

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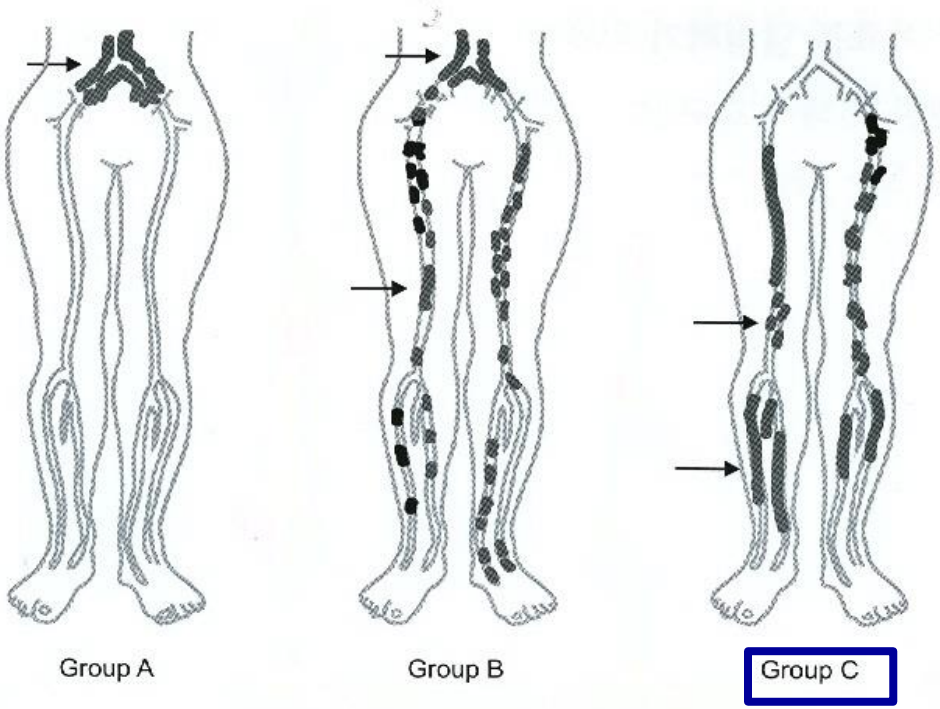
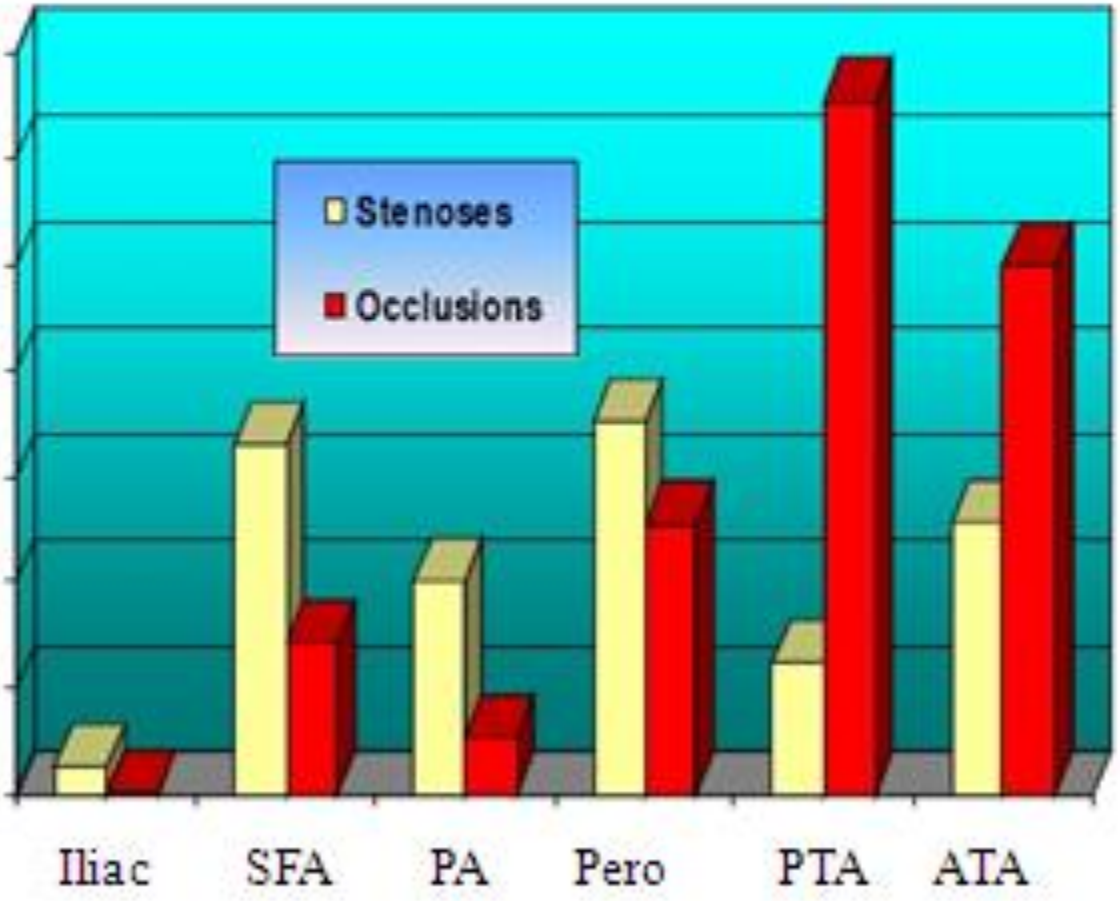


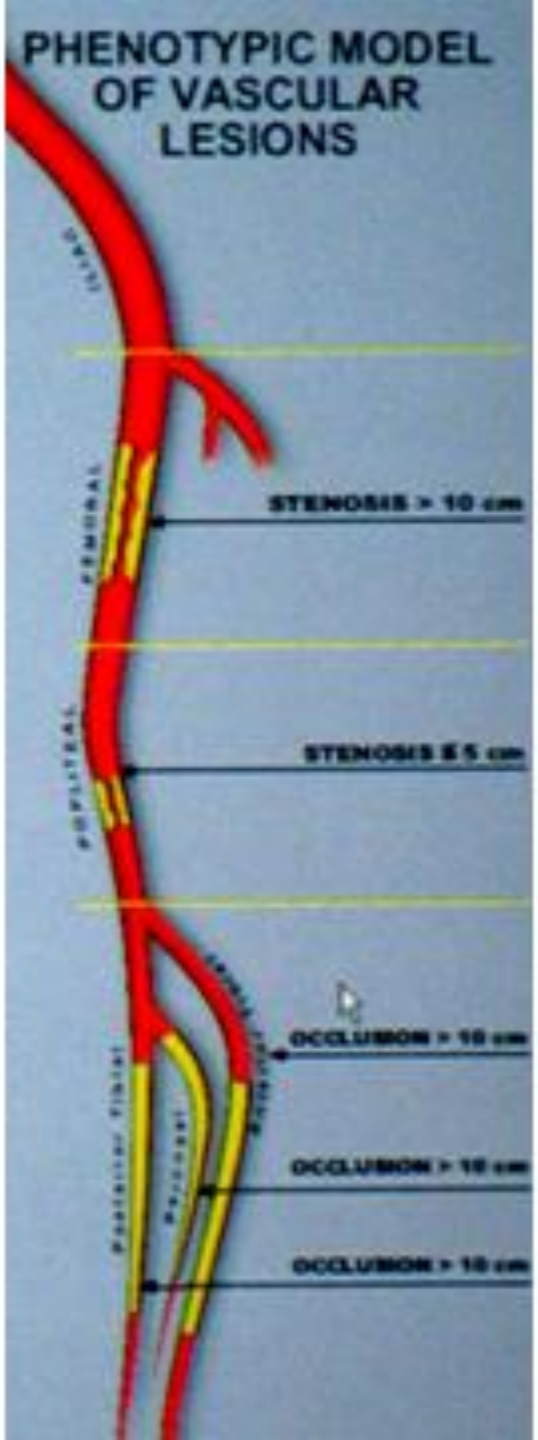
그림 2-2. 동맥경화증의 해부학적 위치. Group A: 대동맥 병변, Group B: 복합 병변, Group C: 하지 동맥 병변.

TYPE AND DISTRIBUTION OF **2,893** LESIONS in **417** Consecutive Diabetics with CLI and Ischemic Foot Ulcer:

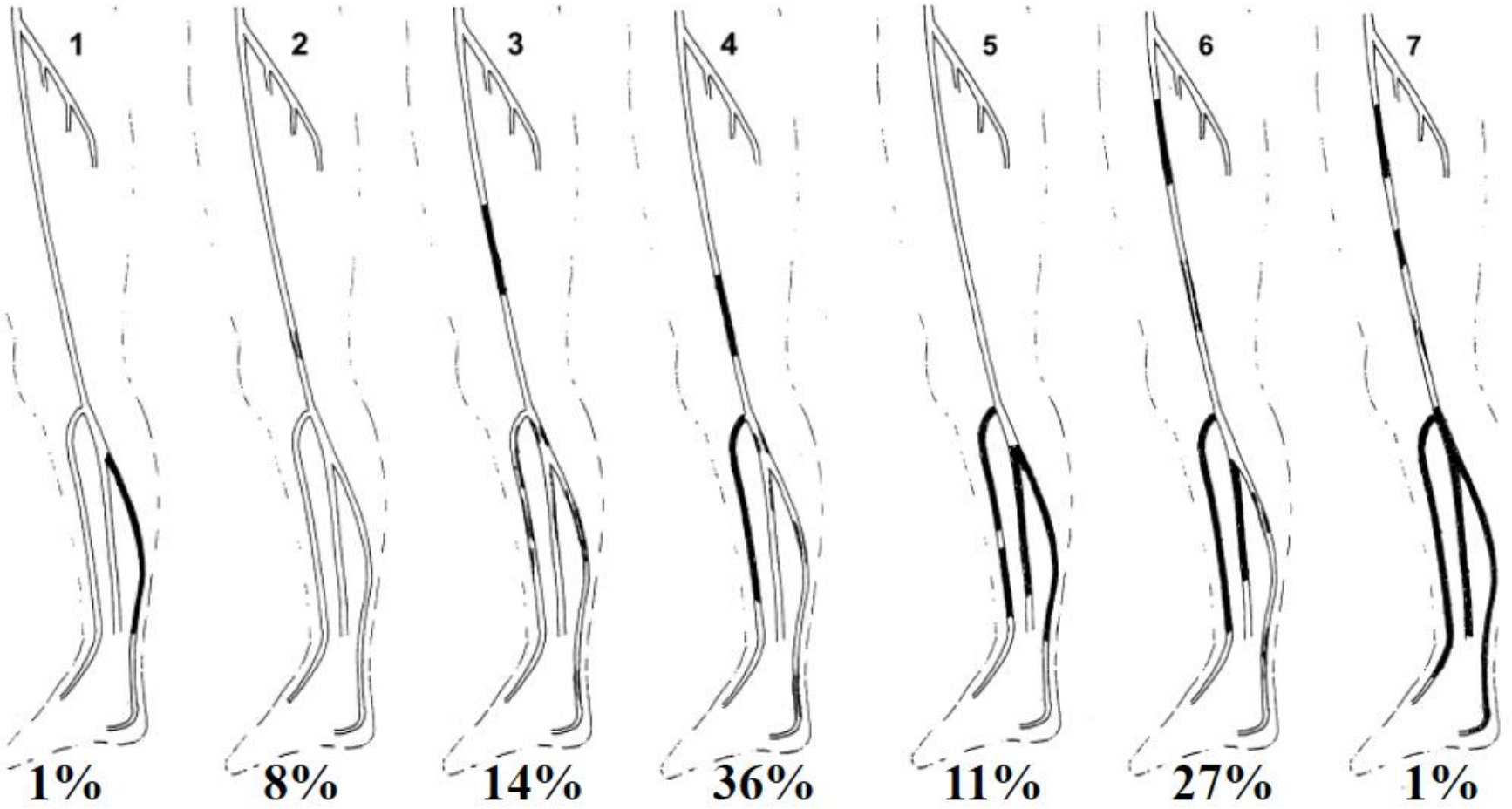
occlusions more common than stenoses !

Eur J Vasc Endovasc Surg 33, 453e460 (2007)





CLI : disease pattern



~ 50% : long occlusion (>10cm)
~ 30% : three-vessel occlusive lesions
~ 50% : at least one patent distal foot vessel

Graziani et al. Eur J Vasc Endovasc Surg 2007

Why PTA for Complex BTK lesions?

- Angiosome -

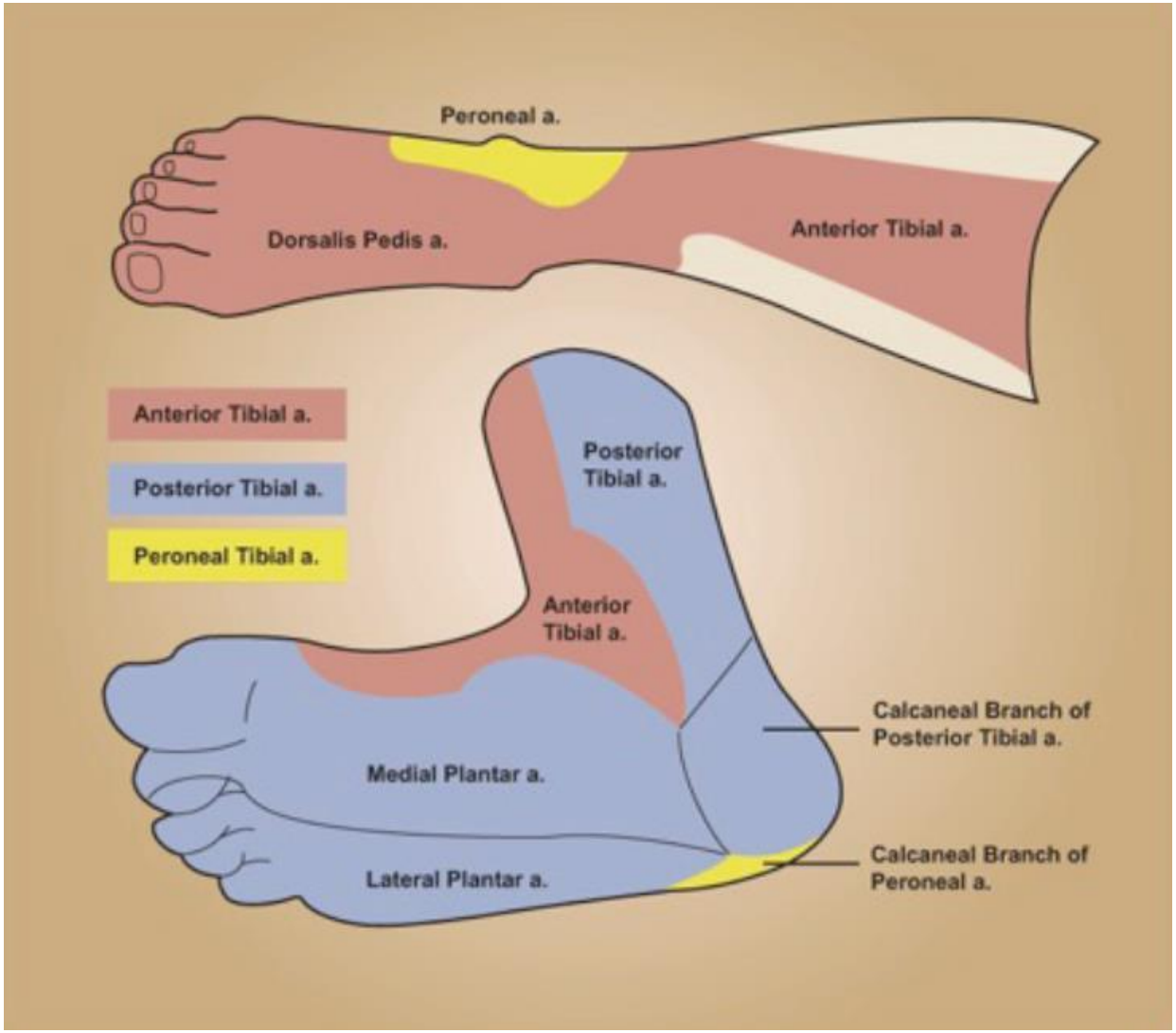
ATA

PA

PTA

Why PTA for Complex BTK lesions?

- Angiosome -

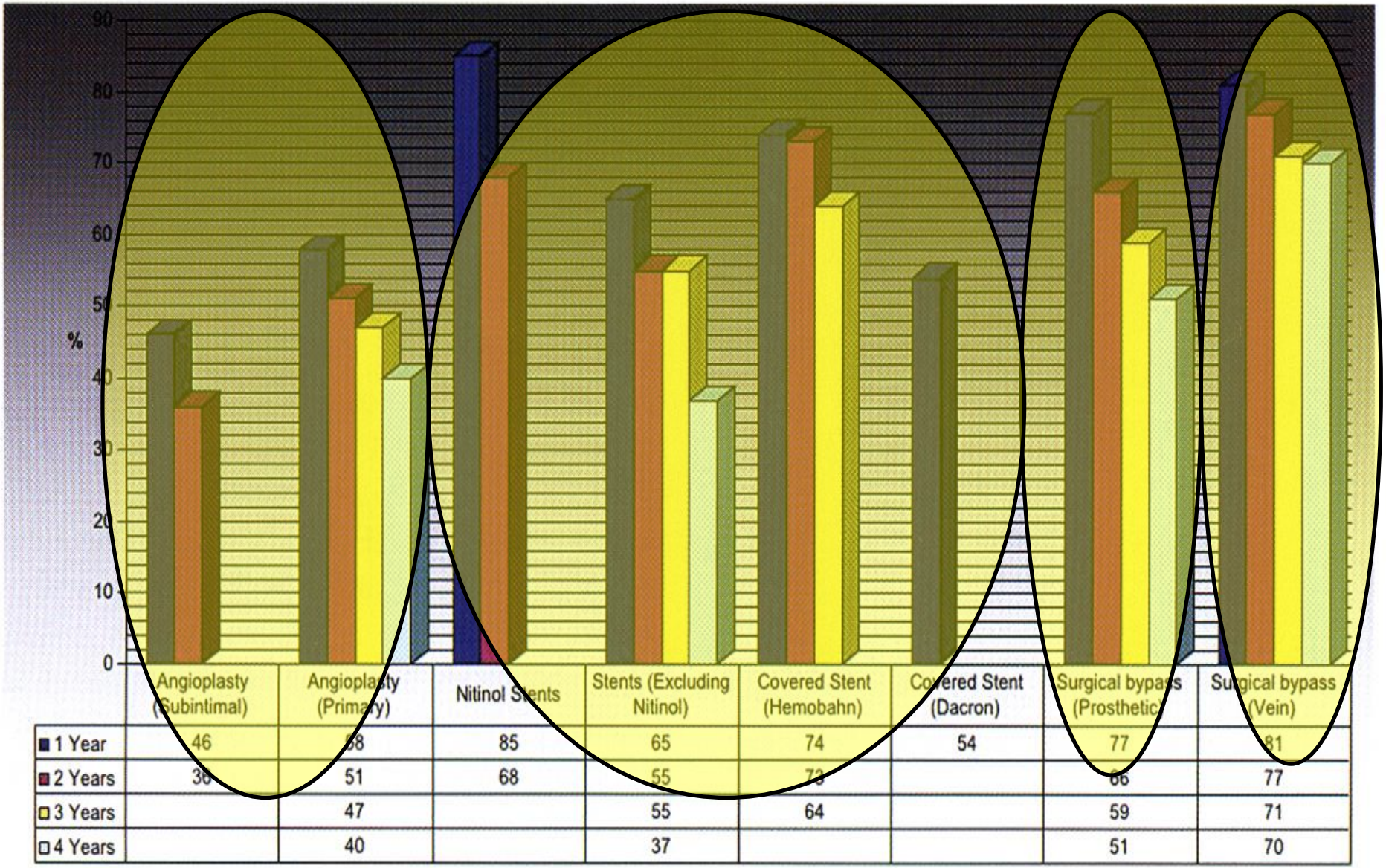


Use of diagnostic evaluation

First Key Procedure	No. of Pts with Lesion Assessment	Total No. of Pts in pathway group	%pts receiving Lesion assessment before 1st Key Procedure
Amputation	138	281	49%
Bypass	67	96	70%
PTA	33	40	83%
Total	238	417	57%

- Less than ½ of pts that received primary amputation had any diagnostic evaluation prior to amputation

Allie et al. Eurointervention 2005;1(1).75-84



	Angioplasty (Subintimal)	Angioplasty (Primary)	Nitinol Stents	Stents (Excluding Nitinol)	Covered Stent (Hemobahn)	Covered Stent (Dacron)	Surgical bypass (Prosthetic)	Surgical bypass (Vein)
1 Year	46	58	85	65	74	54	77	81
2 Years	36	51	68	55	73		66	77
3 Years		47		55	64		59	71
4 Years		40		37			51	70

J Endovas Ther
2004;11(suppl II):II-107-II-127
Lower Extremity Endovascular Interventions
Bates and AbuRahma

Comparison of arterial reconstructive techniques

	Angioplasty	Bypass	Endarterectomy	PTA/stenting
Stenosis *Vs.* Occlusion	Either	Either	Stenosis better	Stenosis better
Length of lesion	Short segment Better	Not a Factor	Short segment Better	Short segment Better
Vessel caliber	> 2 mm	> 2 mm	> 5-6 mm	**> 4 mm (?)**
Suitable site	Any site	Any site	Carotid, femoral bifurcations Aortic branching	Distal abd aorta Iliac, Renal, Carotid, **BTK, BTA(?)**

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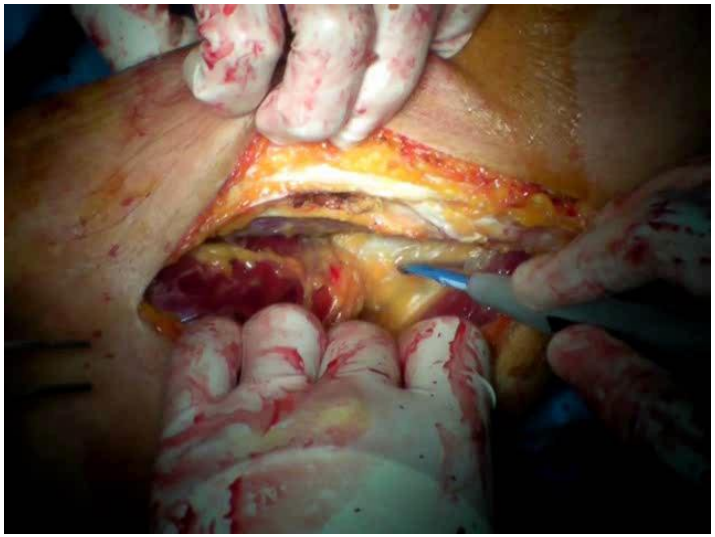
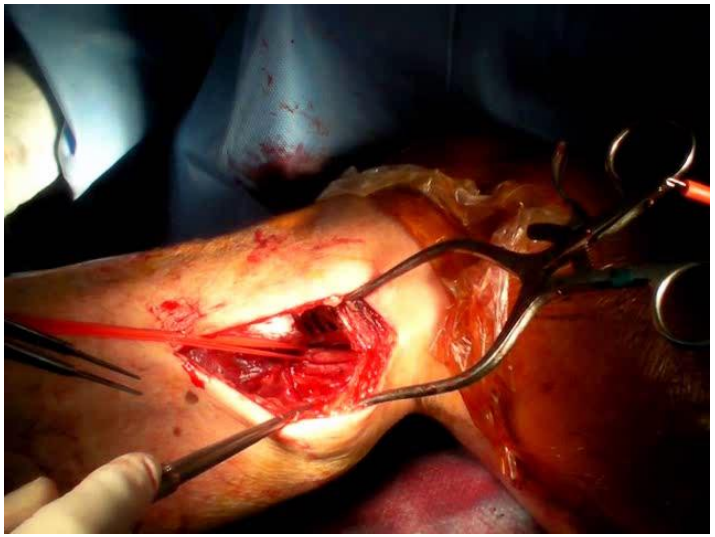
CFA Angioplasty

Exposure of Popliteal Artery

FP bypass

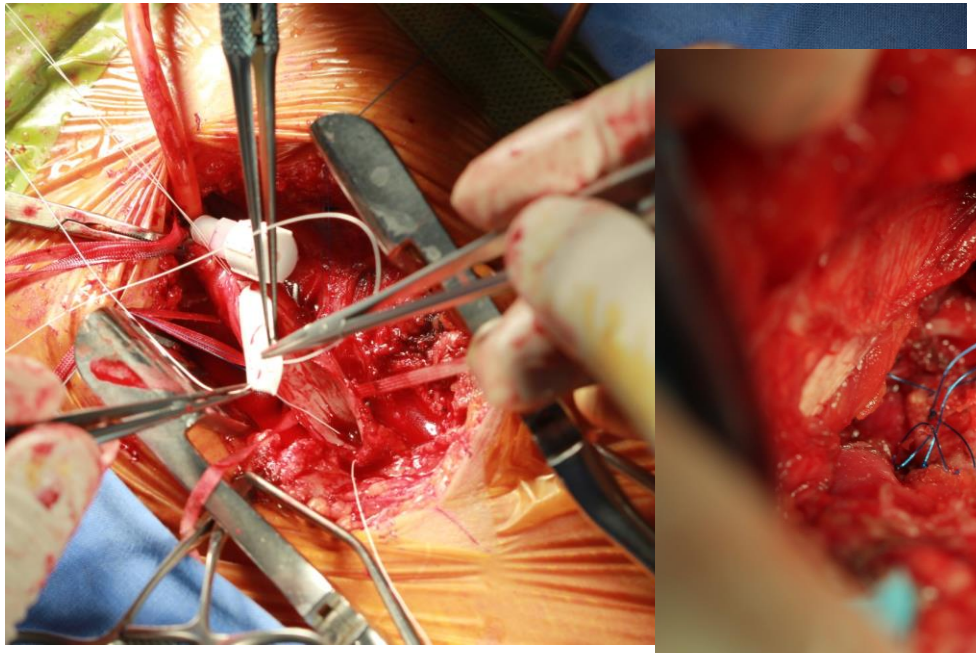


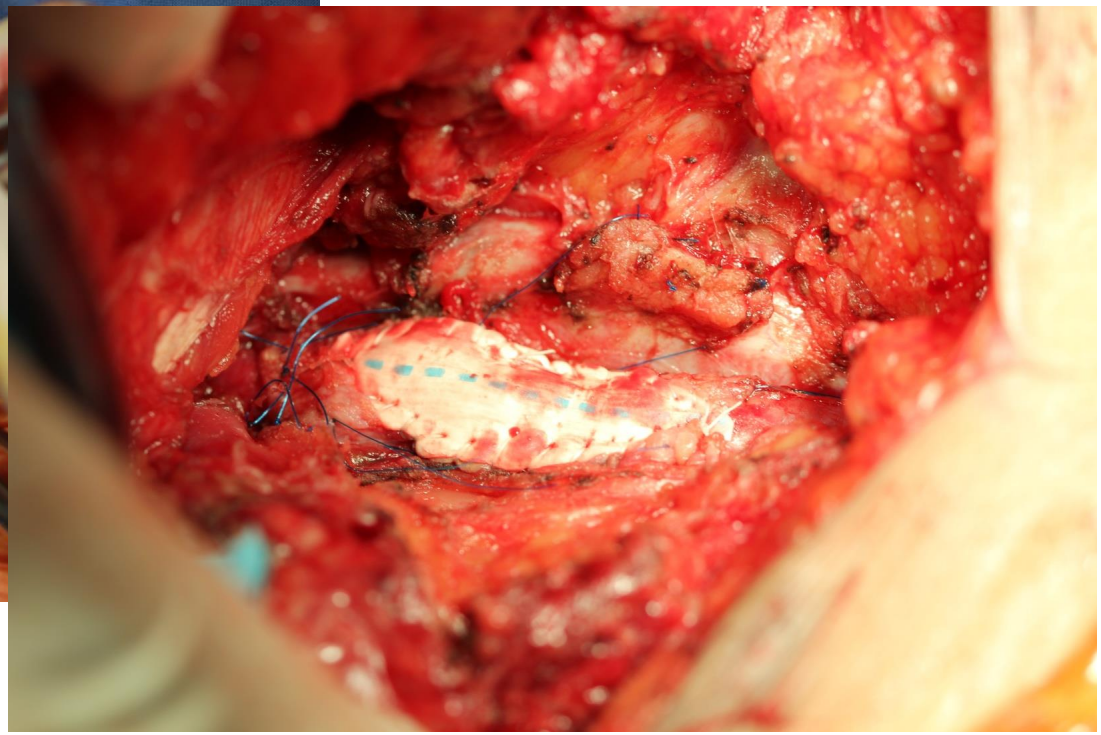
Retrograde approach



Angioplasty

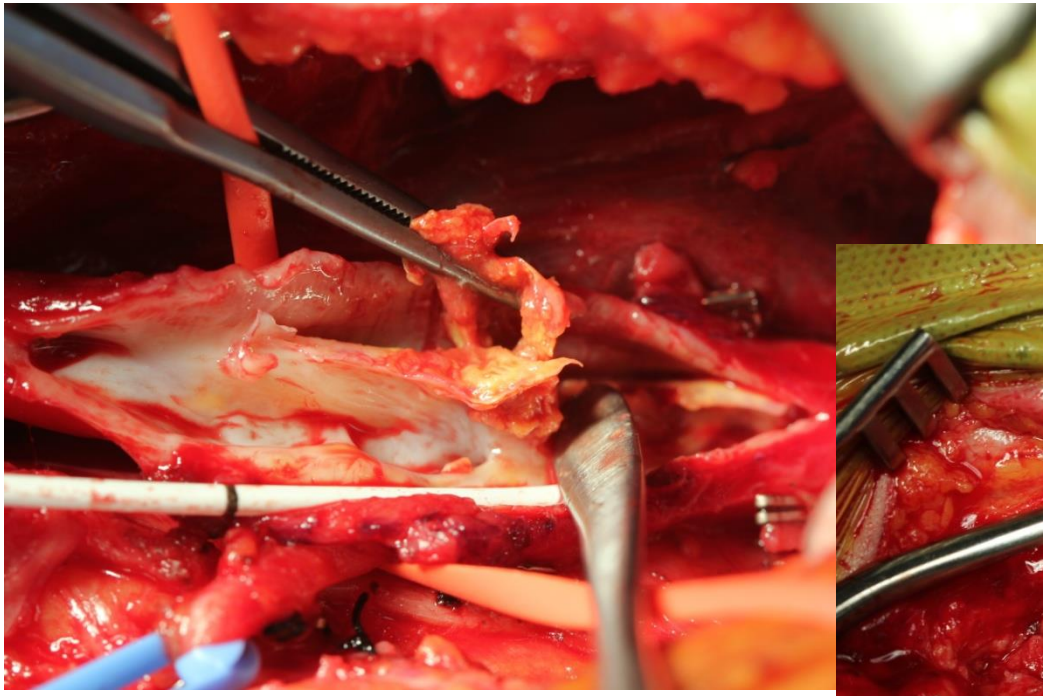
- Graft angioplasty

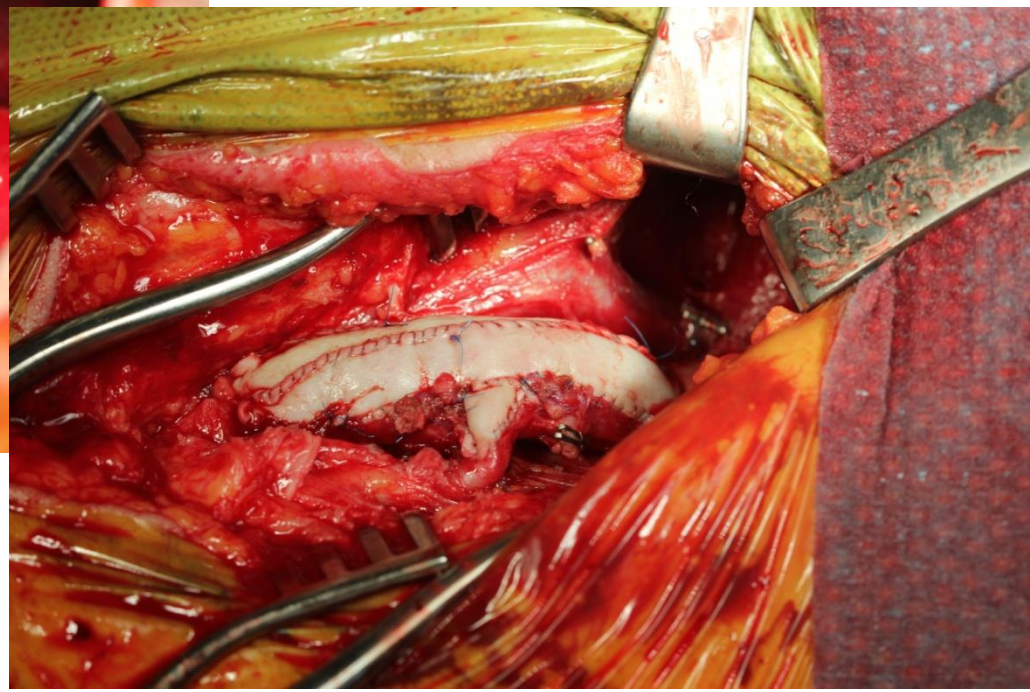




Angioplasty

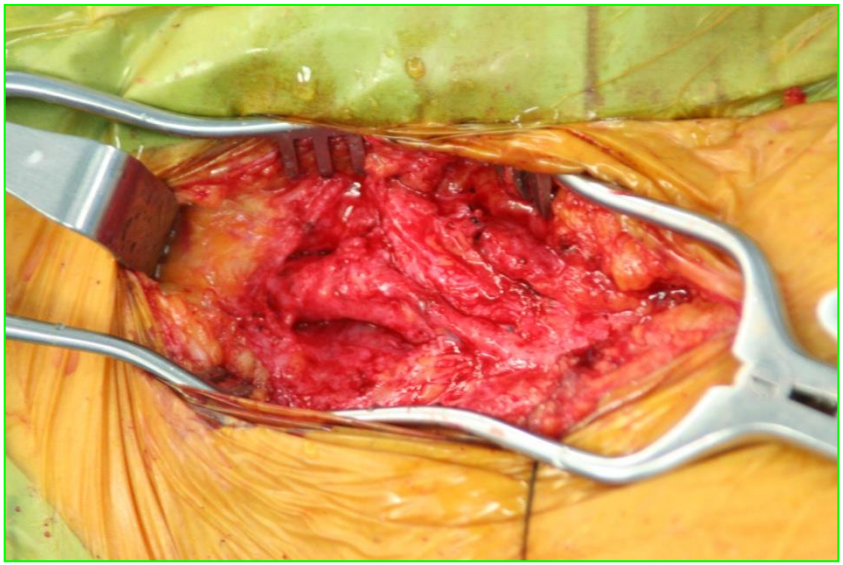
- Pericardial patch angioplasty

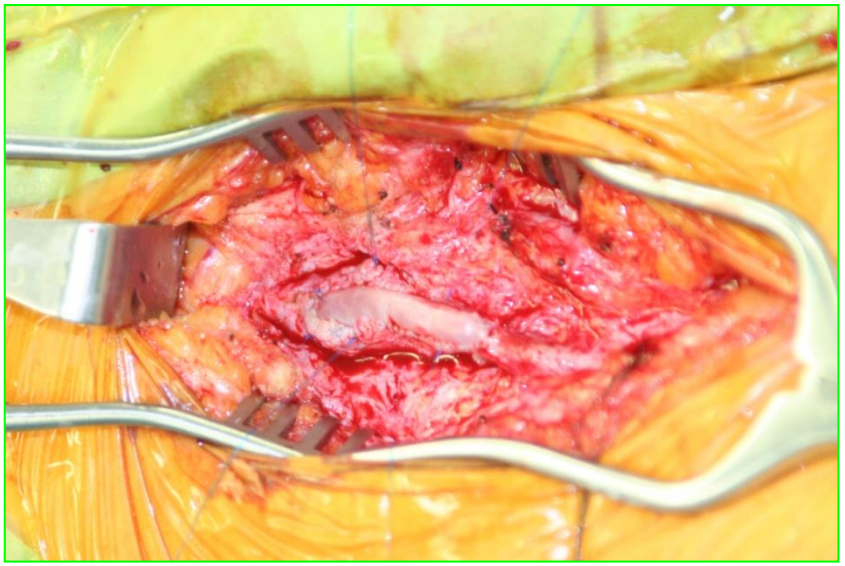




Angioplasty

- Vein patch angioplasty





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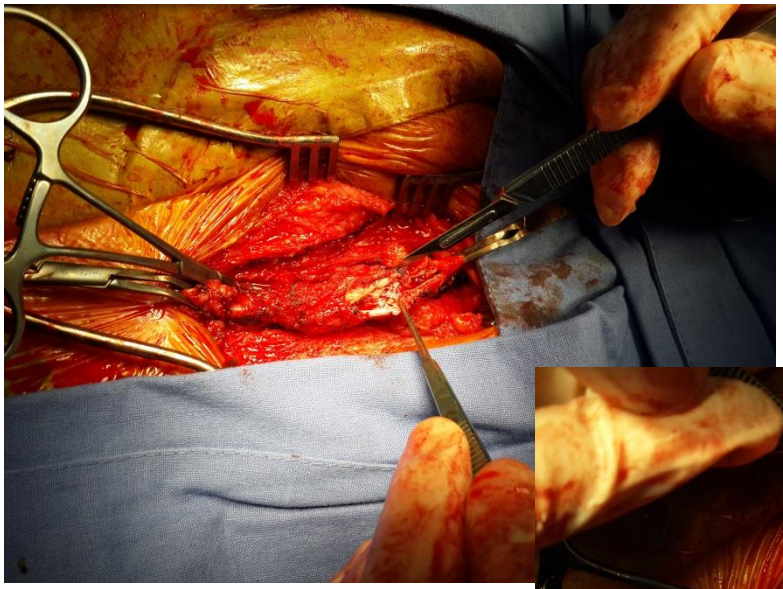
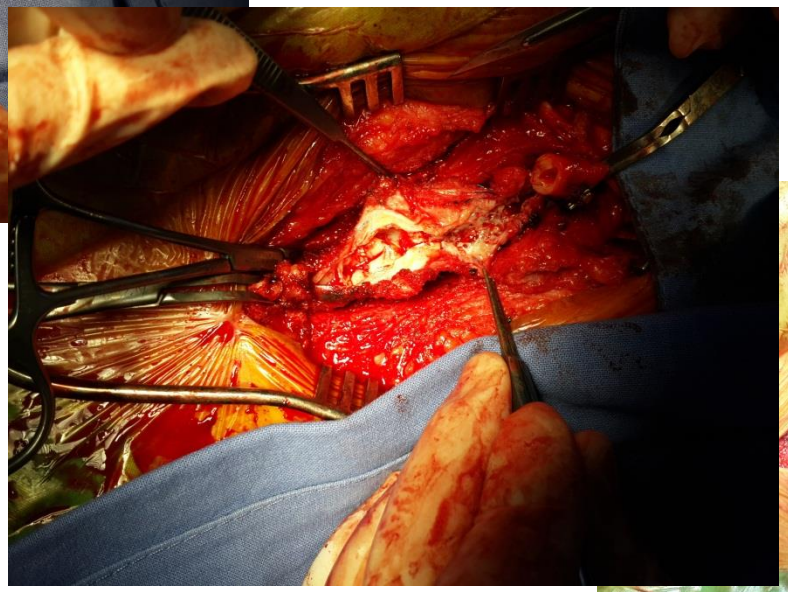
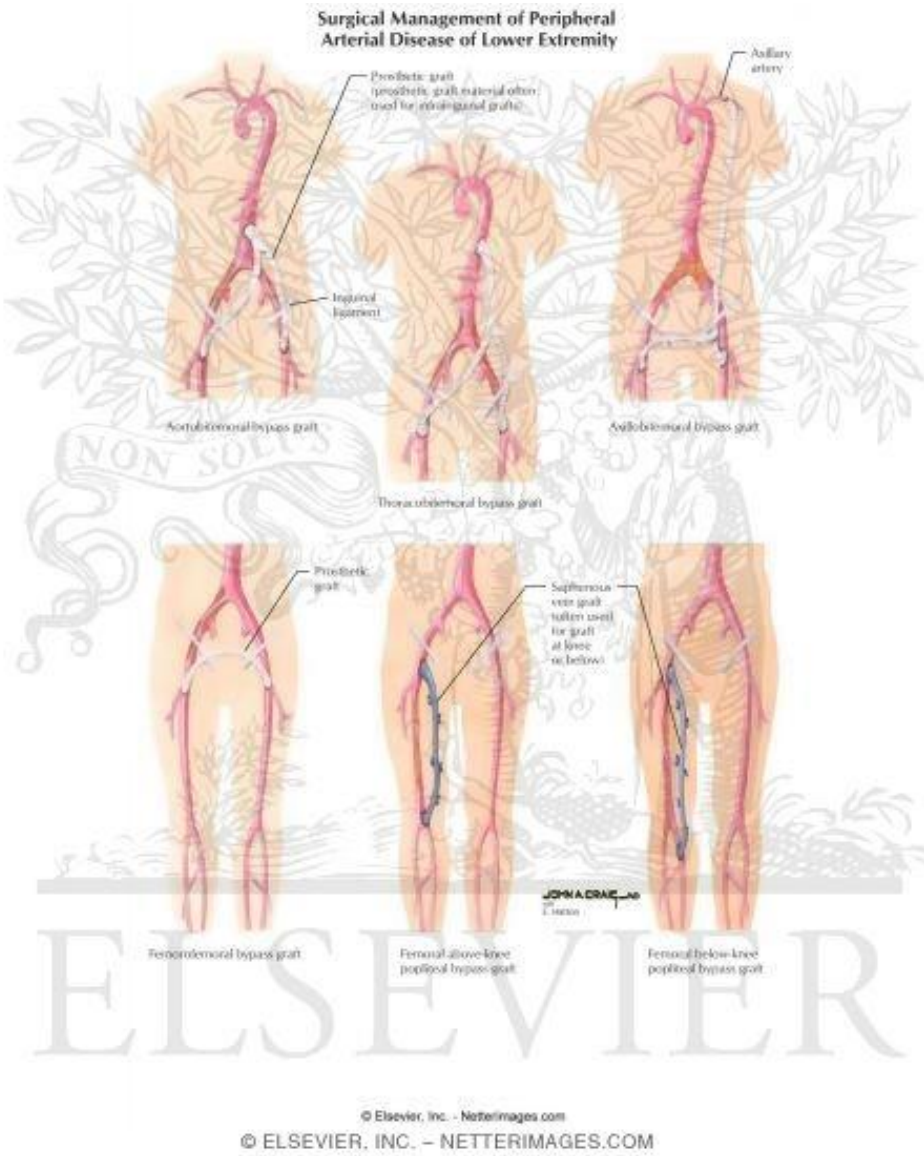
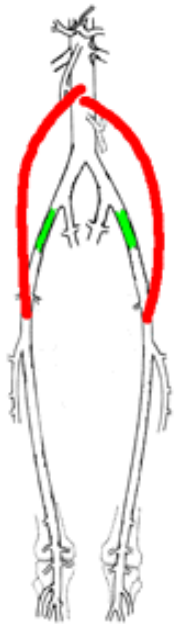
Graft Interposition



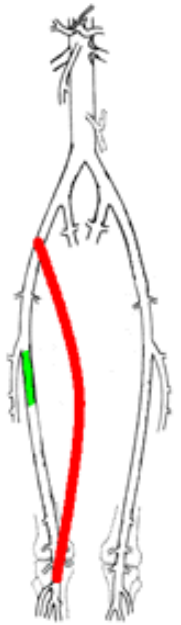


Bypass

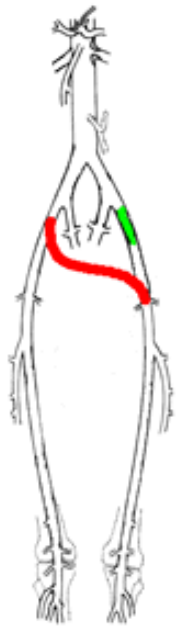




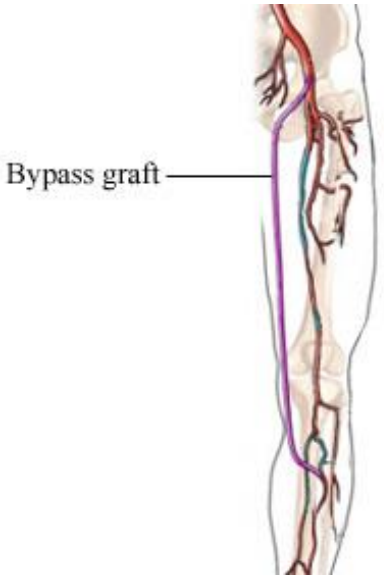
Aorto-Bifemoral Bypass



Femoral-Popliteal Bypass



Femoro-Fermoral Crossover



Bypass with Vein Graft

- Reversed vein
- In situ vein
- Non-reversed translocated vein
- Spliced vein

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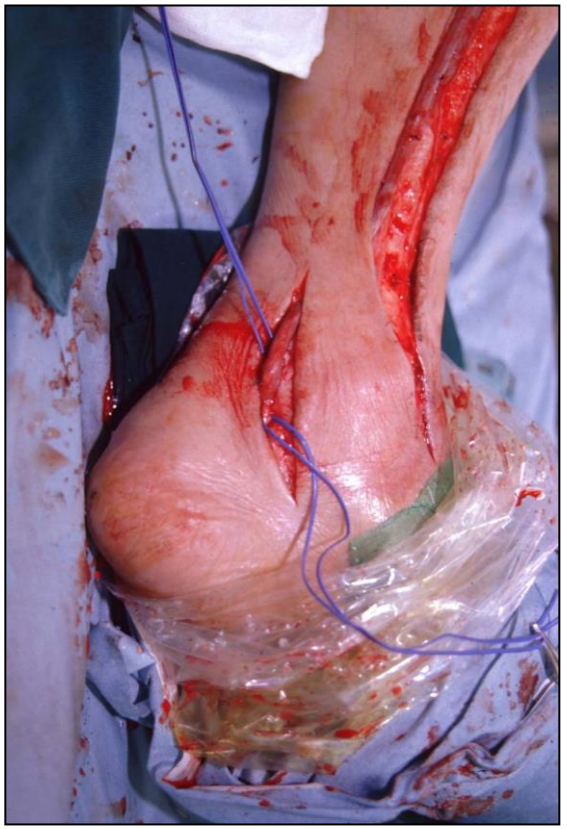
Bypass with Vein Graft

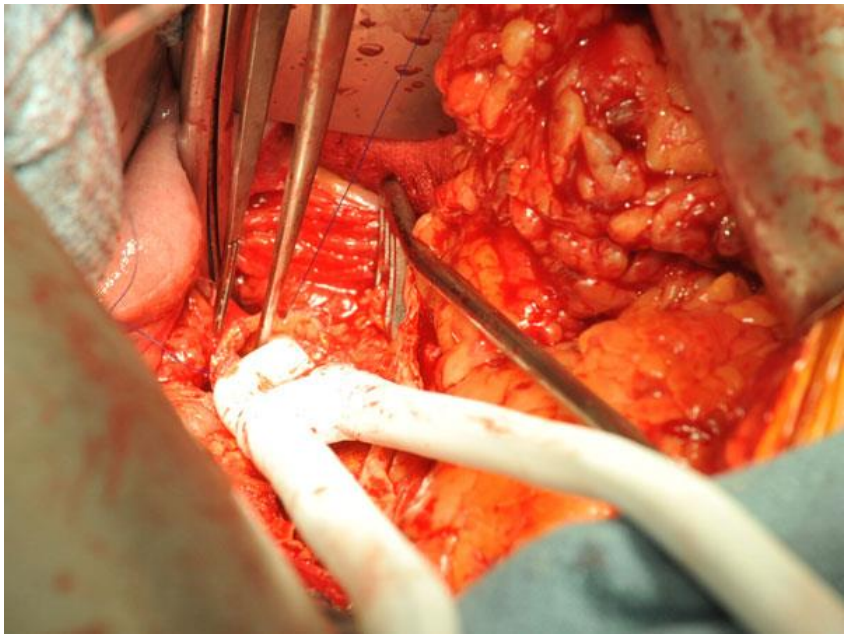
- Inframalleolar bypass



By Courtery of Prof. WY Kim

Graft

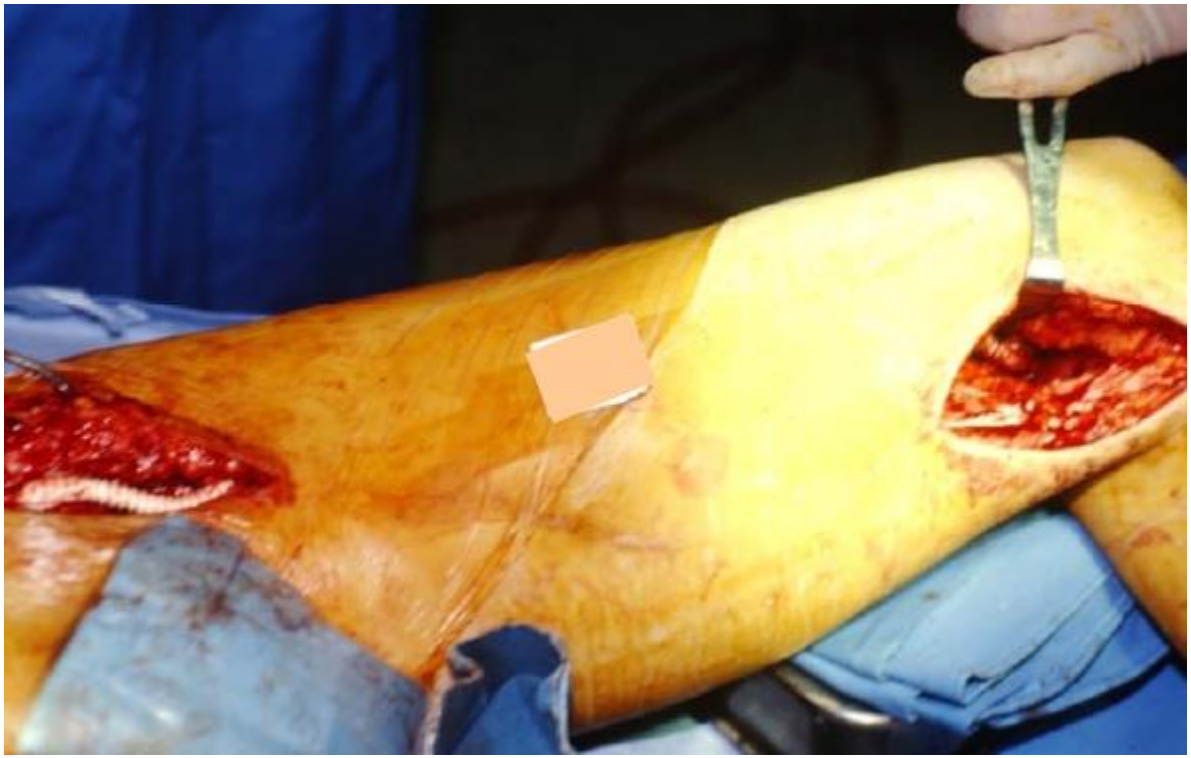
Dacron® graft



Goretex® graft

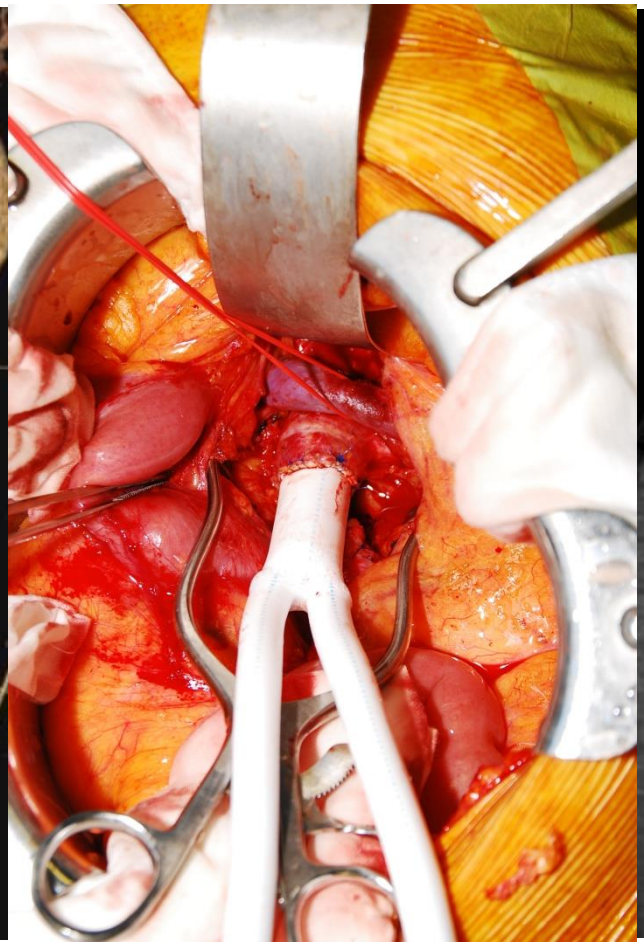
Bypass with Artificial Graft

- Femoropopliteal bypass



Bypass with Artificial Graft

- Aorto-Bi-Fermoal bypass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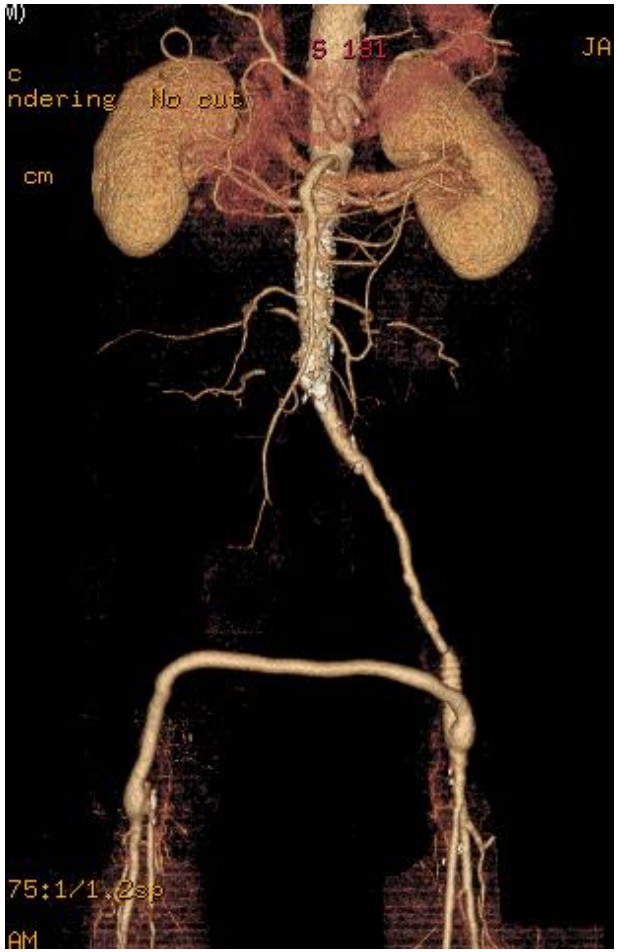
Bypass with Artificial Graft

- Extra-anatomical bypass

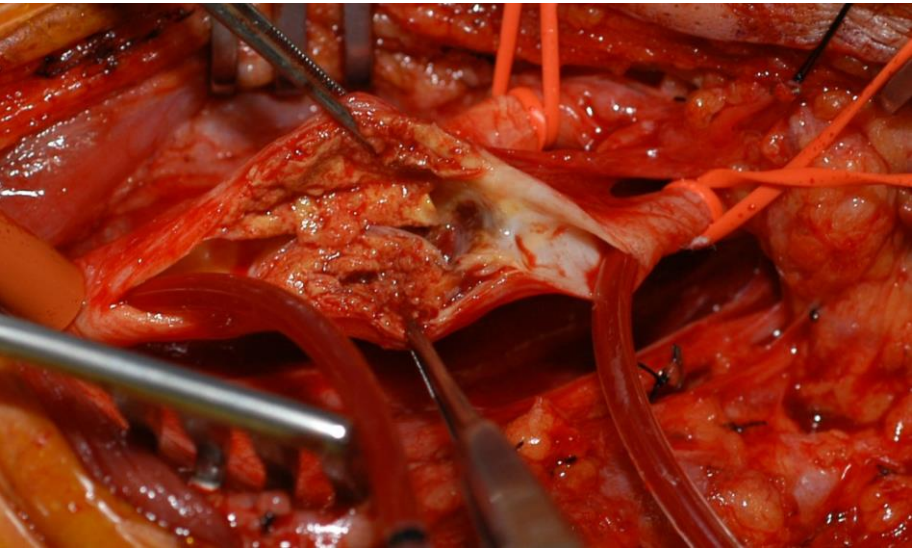


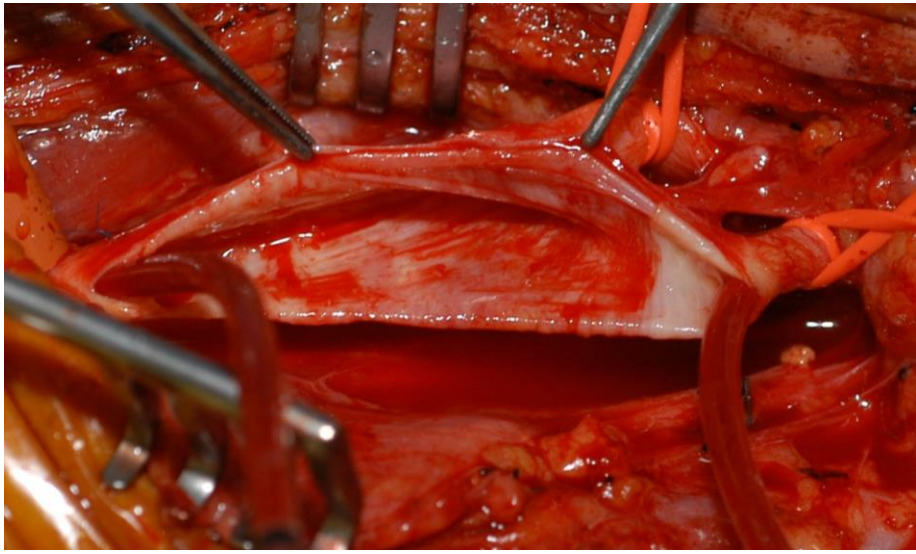
Fem-fem crossover bypass

Axillo-bifemoral bypass

Endarterectomy

- Carotid

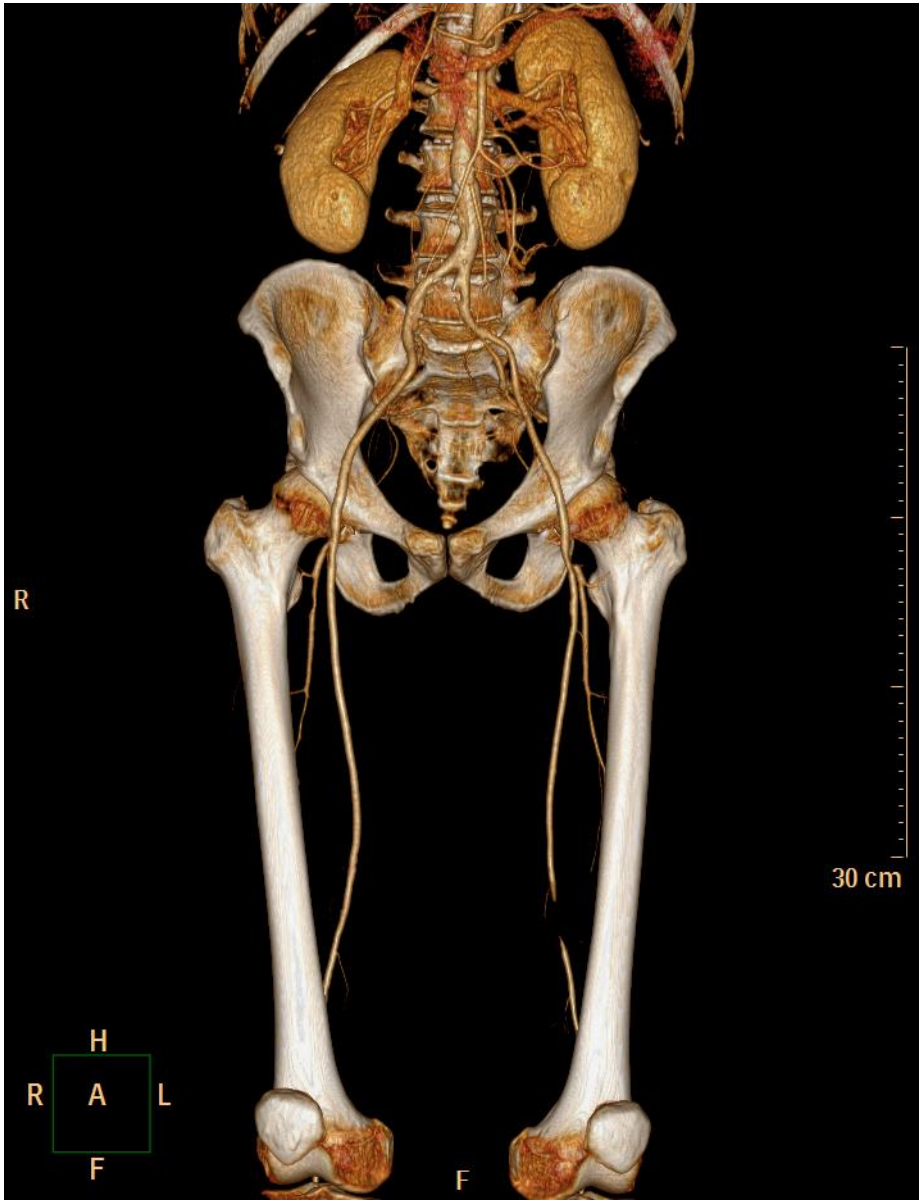


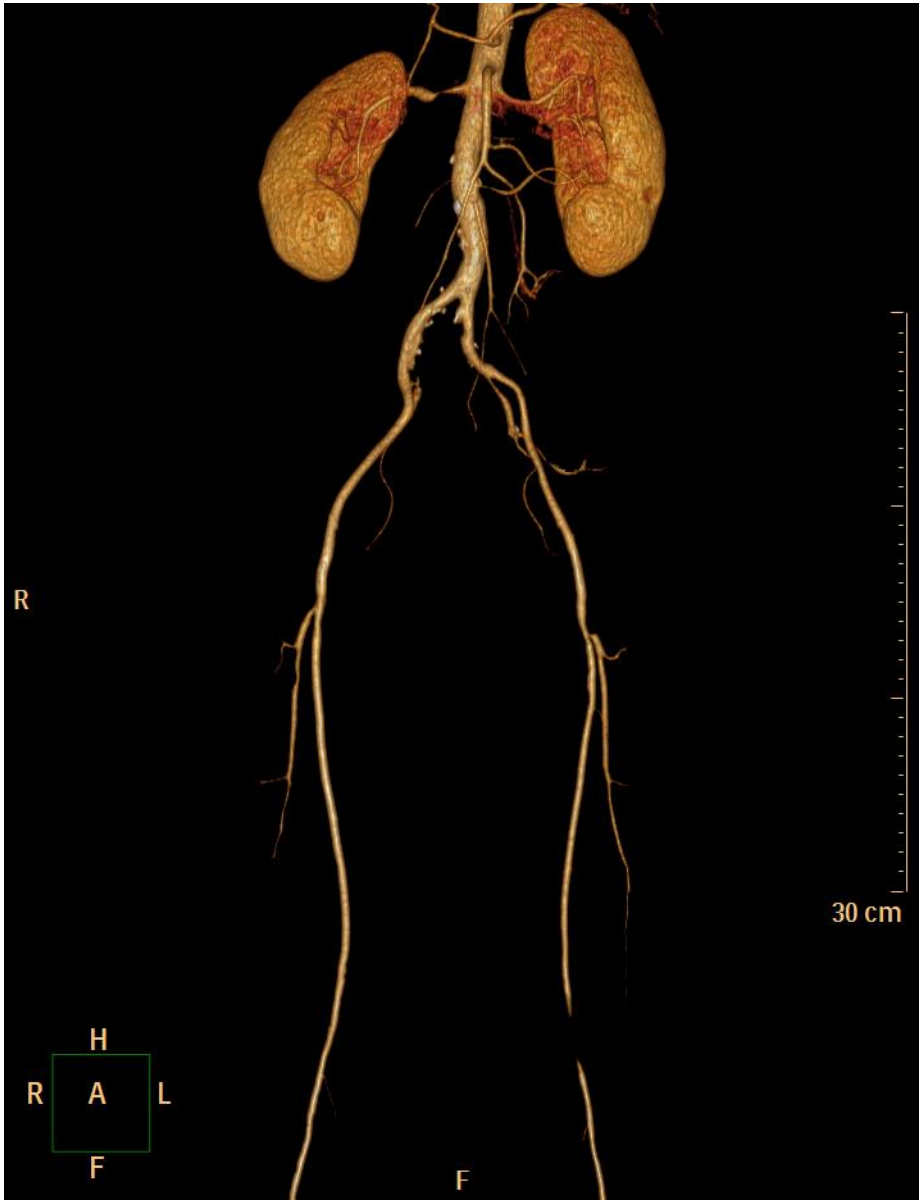


By Courtery of Prof. WY Kim

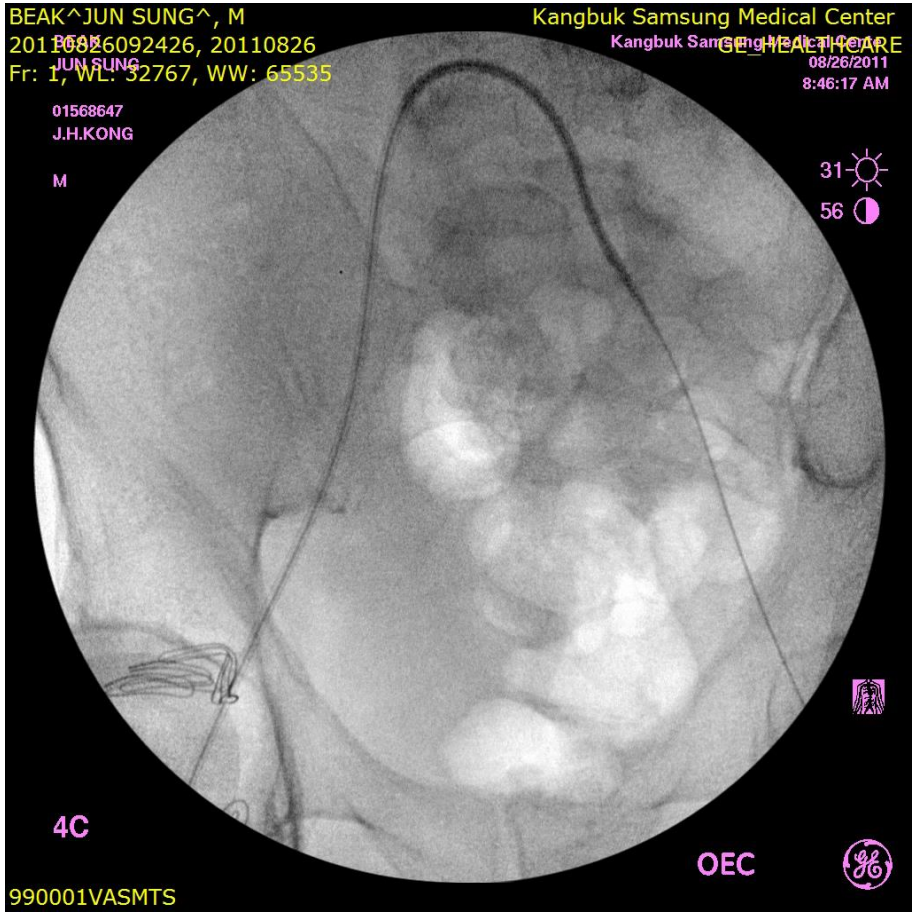
Case – SFA short CTO

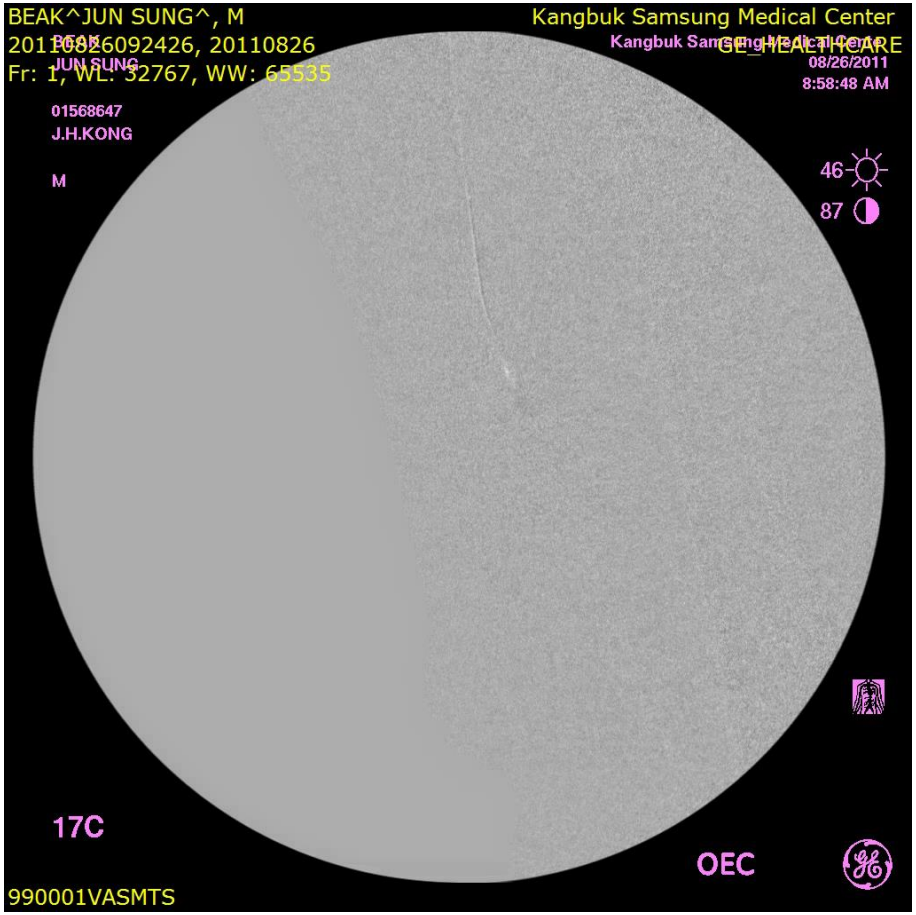
- Lt SFA Focal CTO: subintimal dissection


R
30 cm
H
R
A
L
F
F

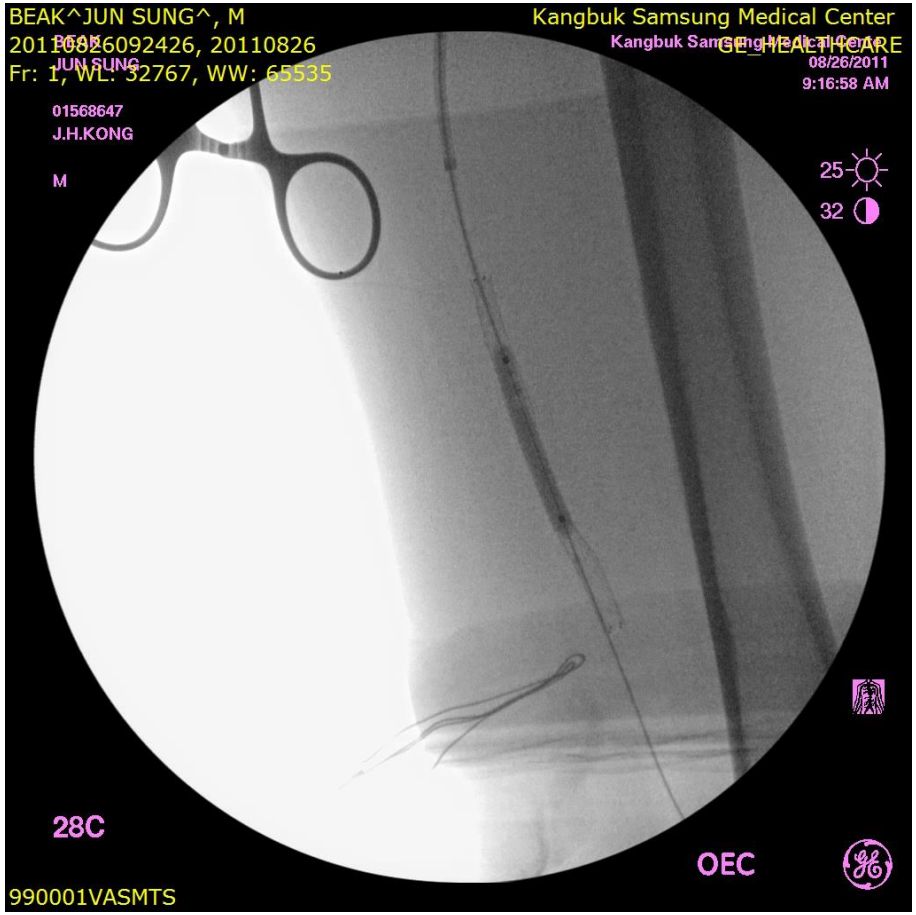

R
30 cm
H
R
A
L
F
F

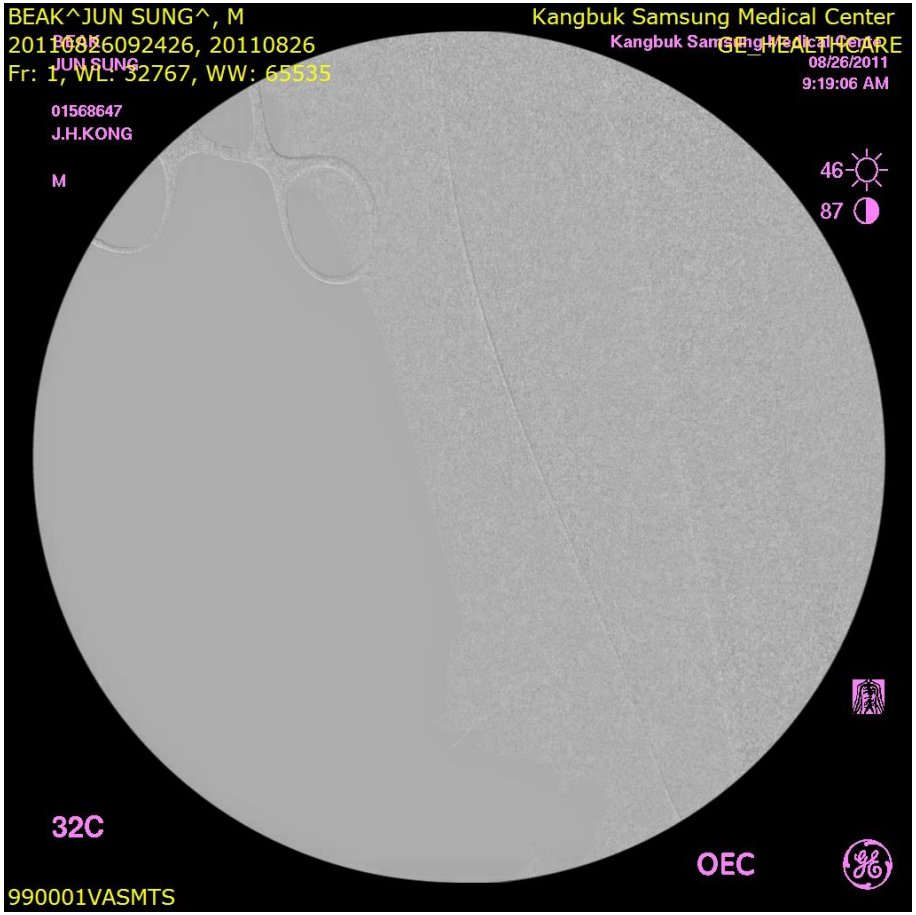
Simple PTA & Stent

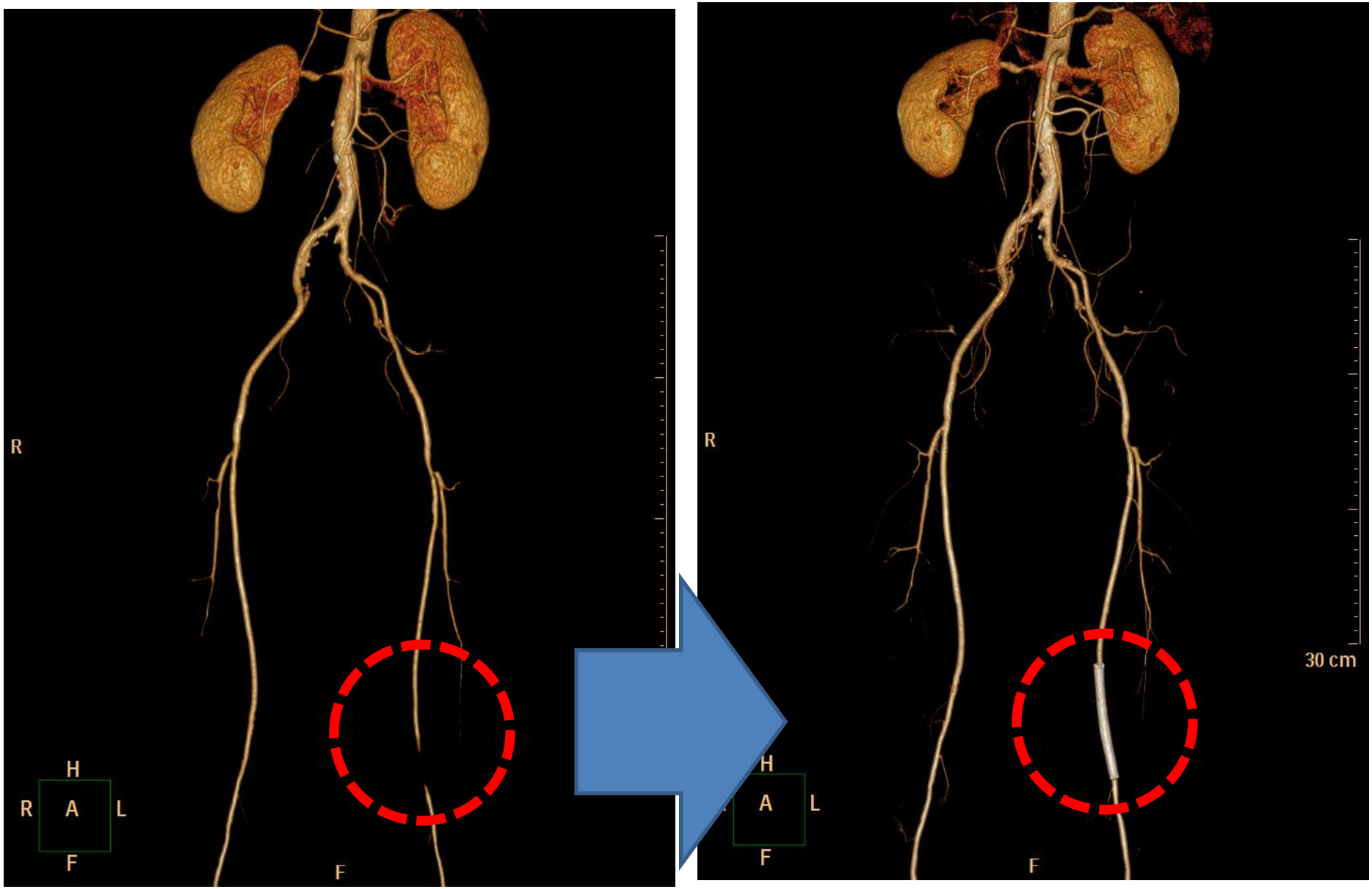




Simple PTA & Stent





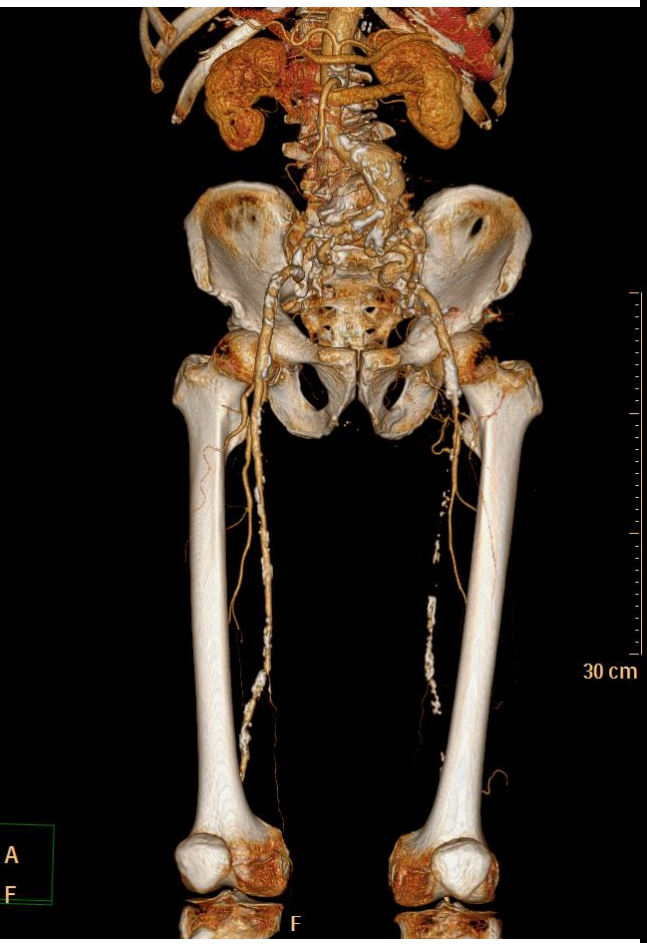

R
H
R
A
L
F
F
R
30 cm
H
A
L
F
F

Case Presentation

- Both **CFA angioplasty** (Rt: Goretex patcha angioplasty, Lt: Endoarterectomy)

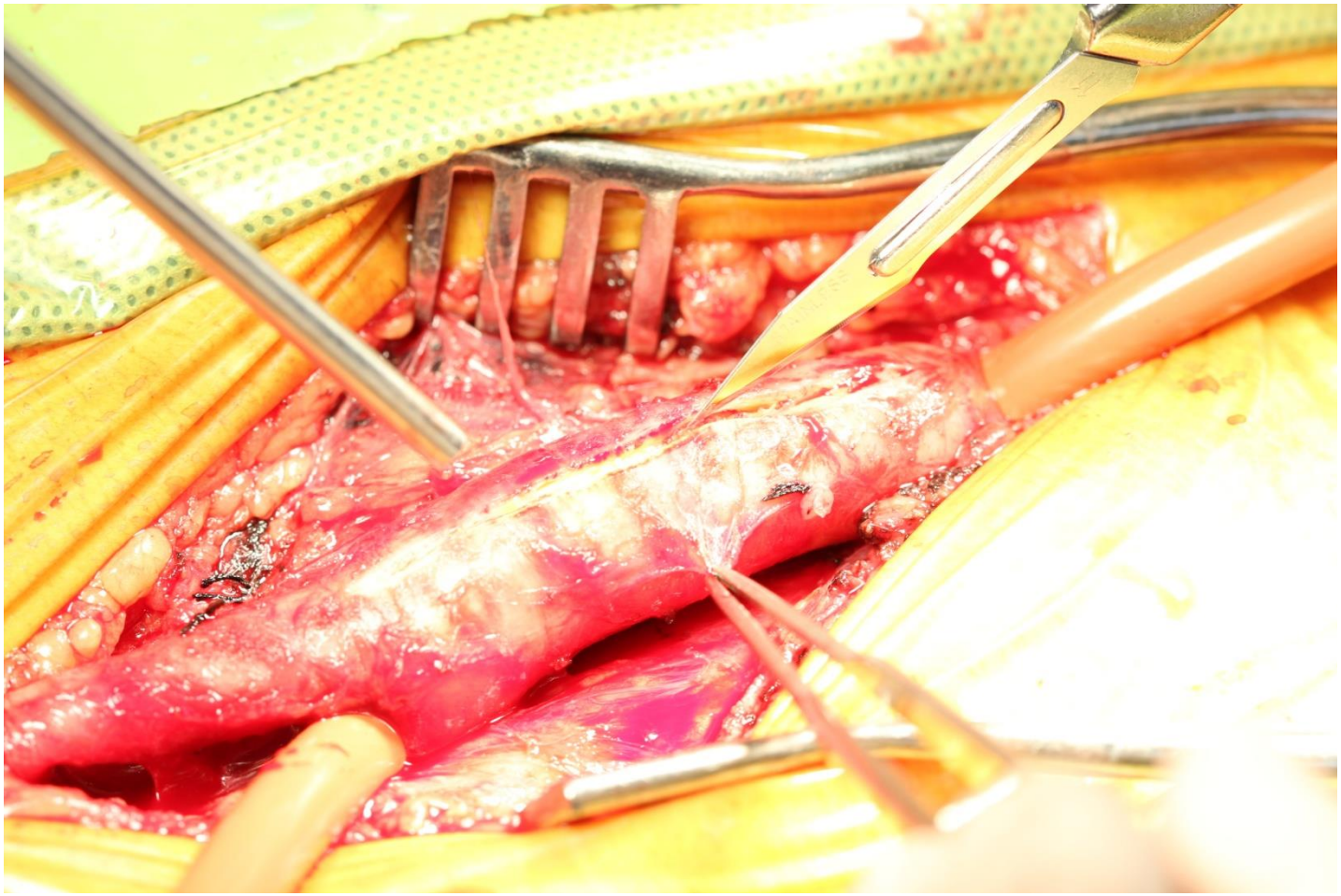
- Both **SFA PTA Stent**

Preop.

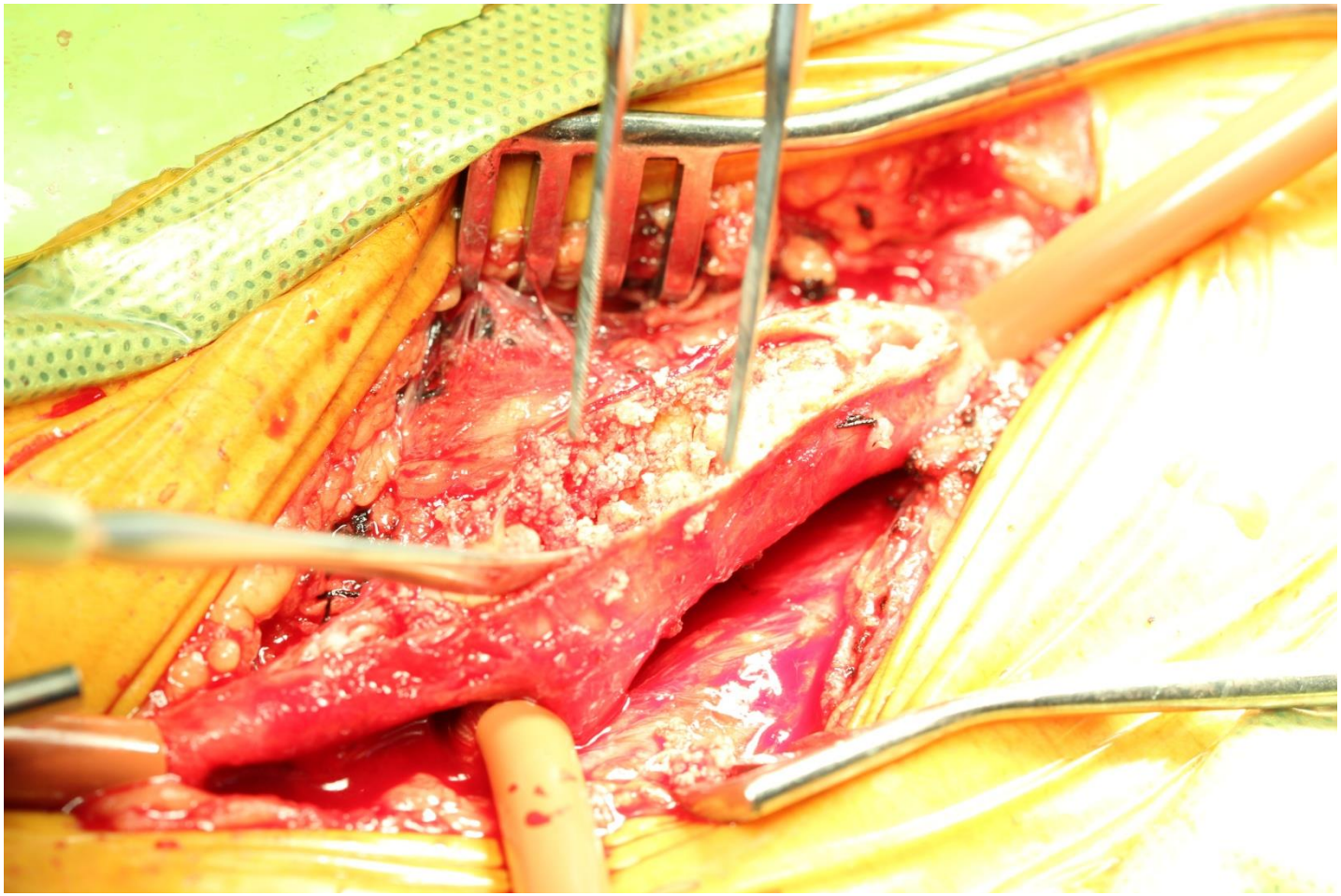



R
30 cm

Op. Field



Op. Field



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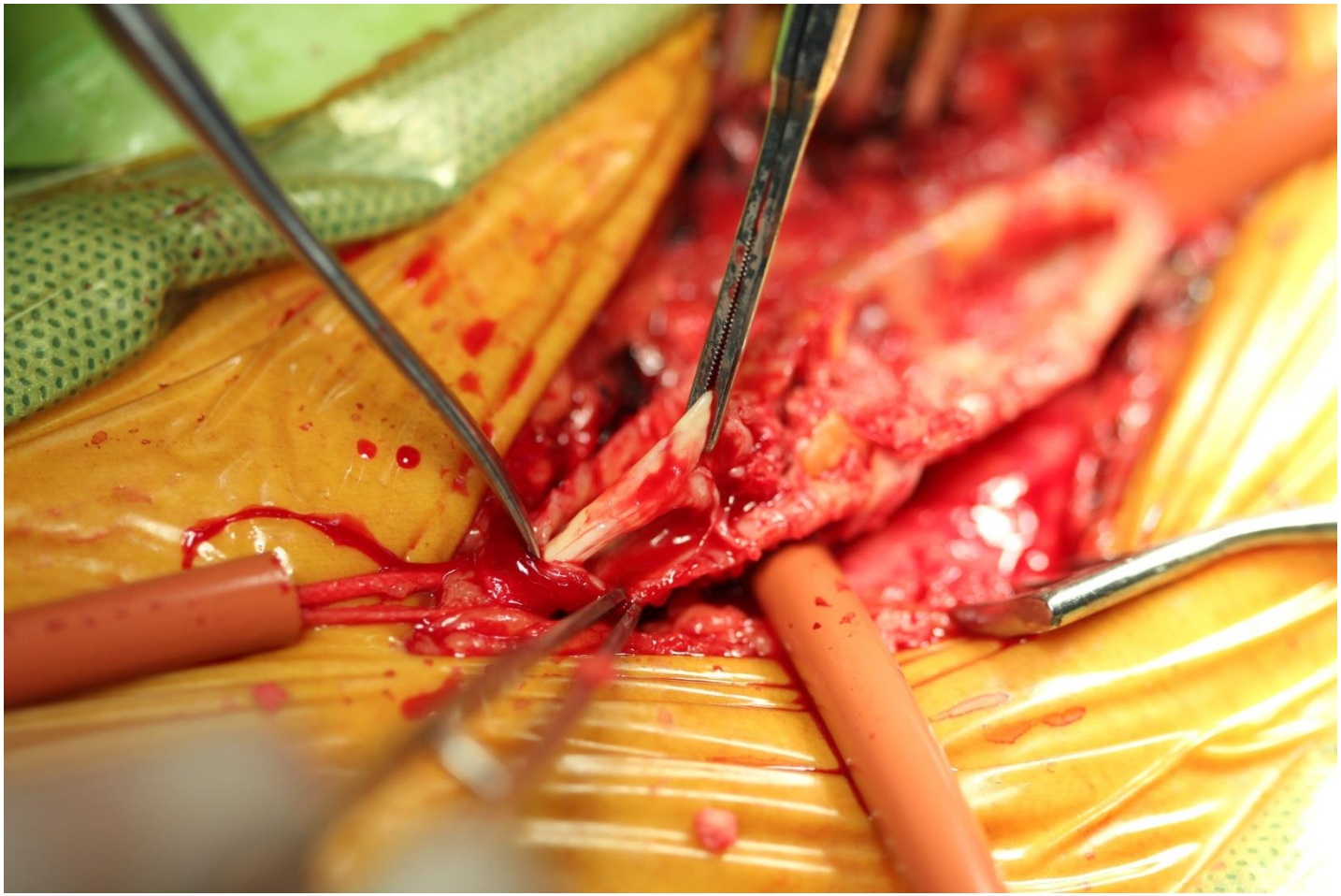

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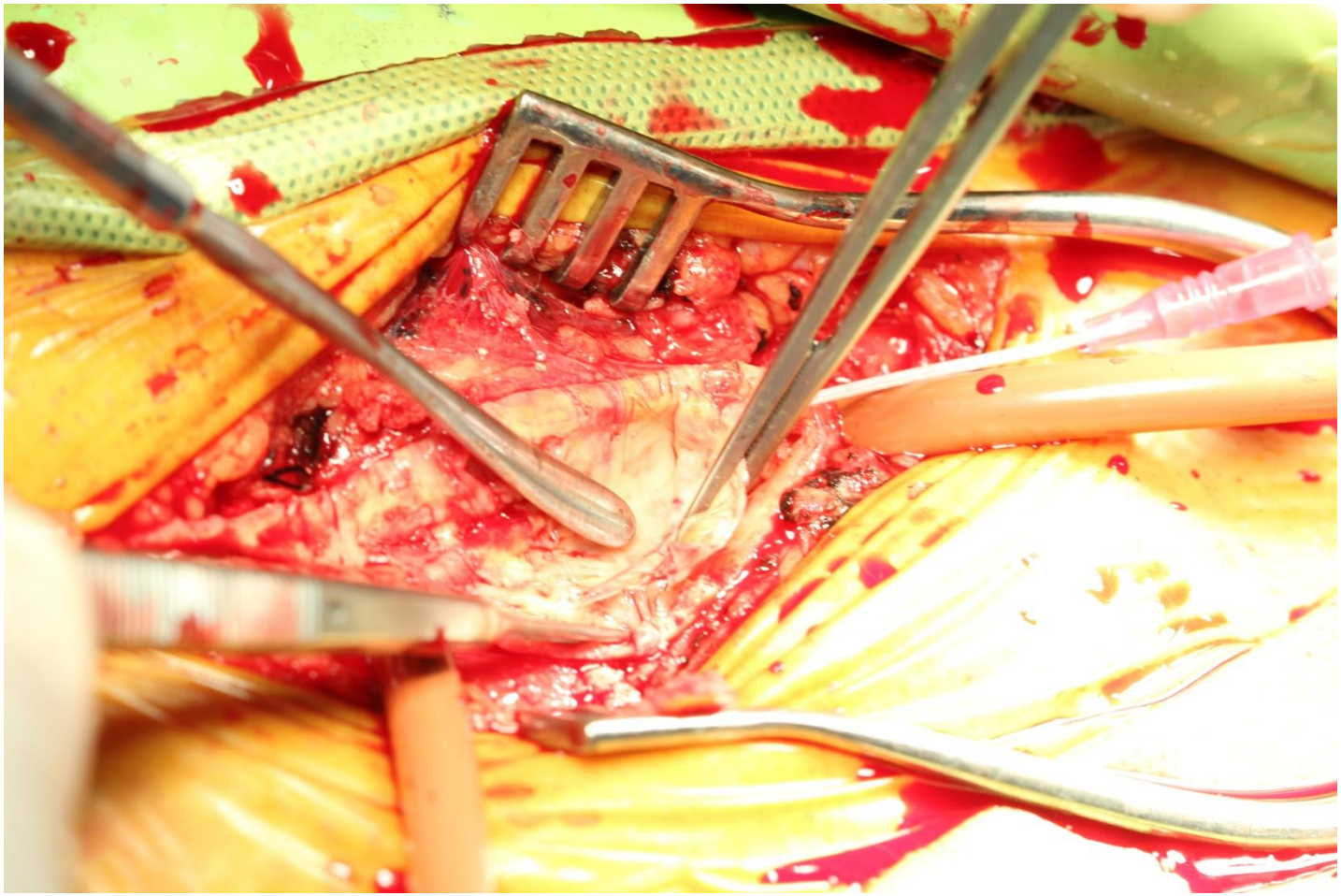

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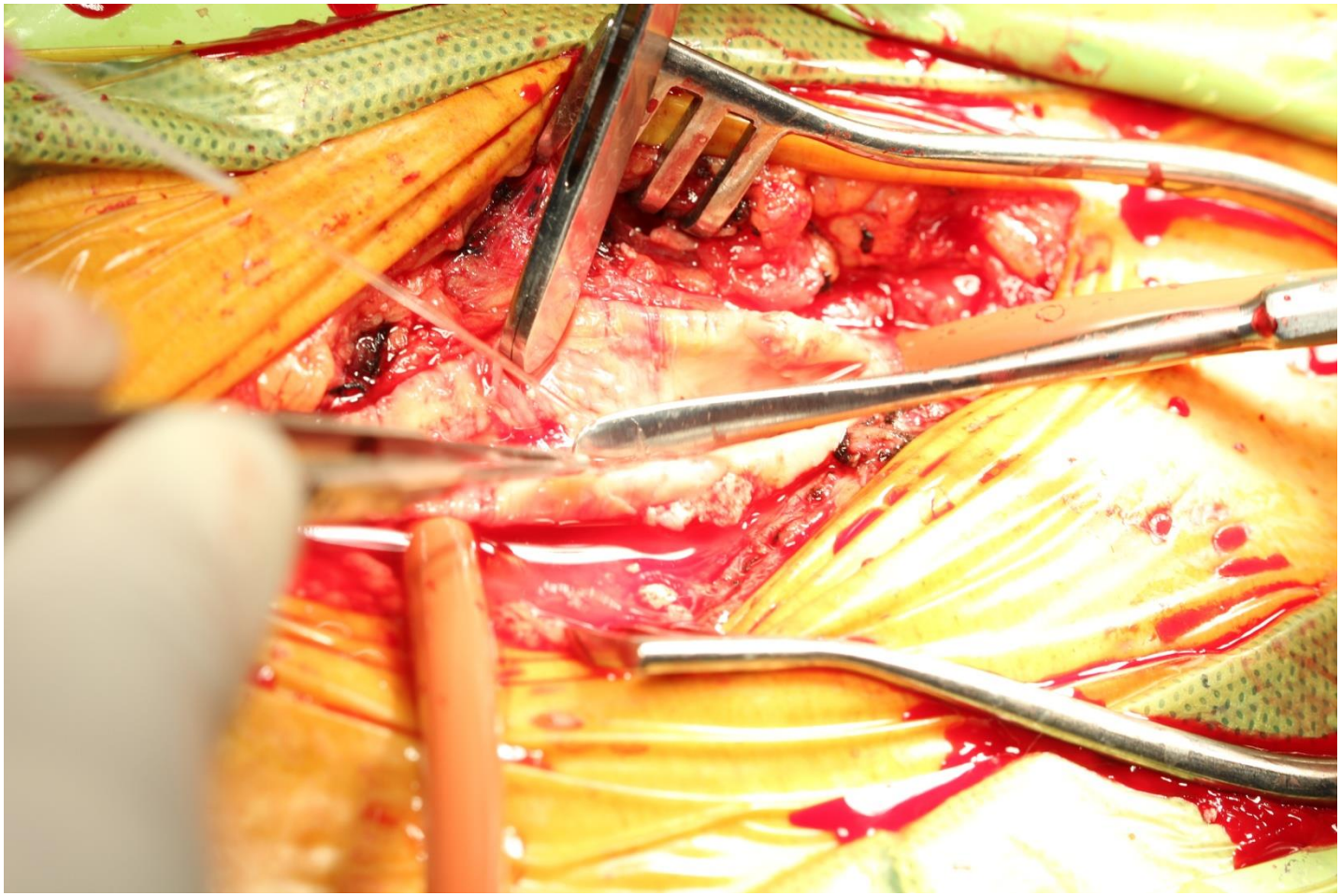

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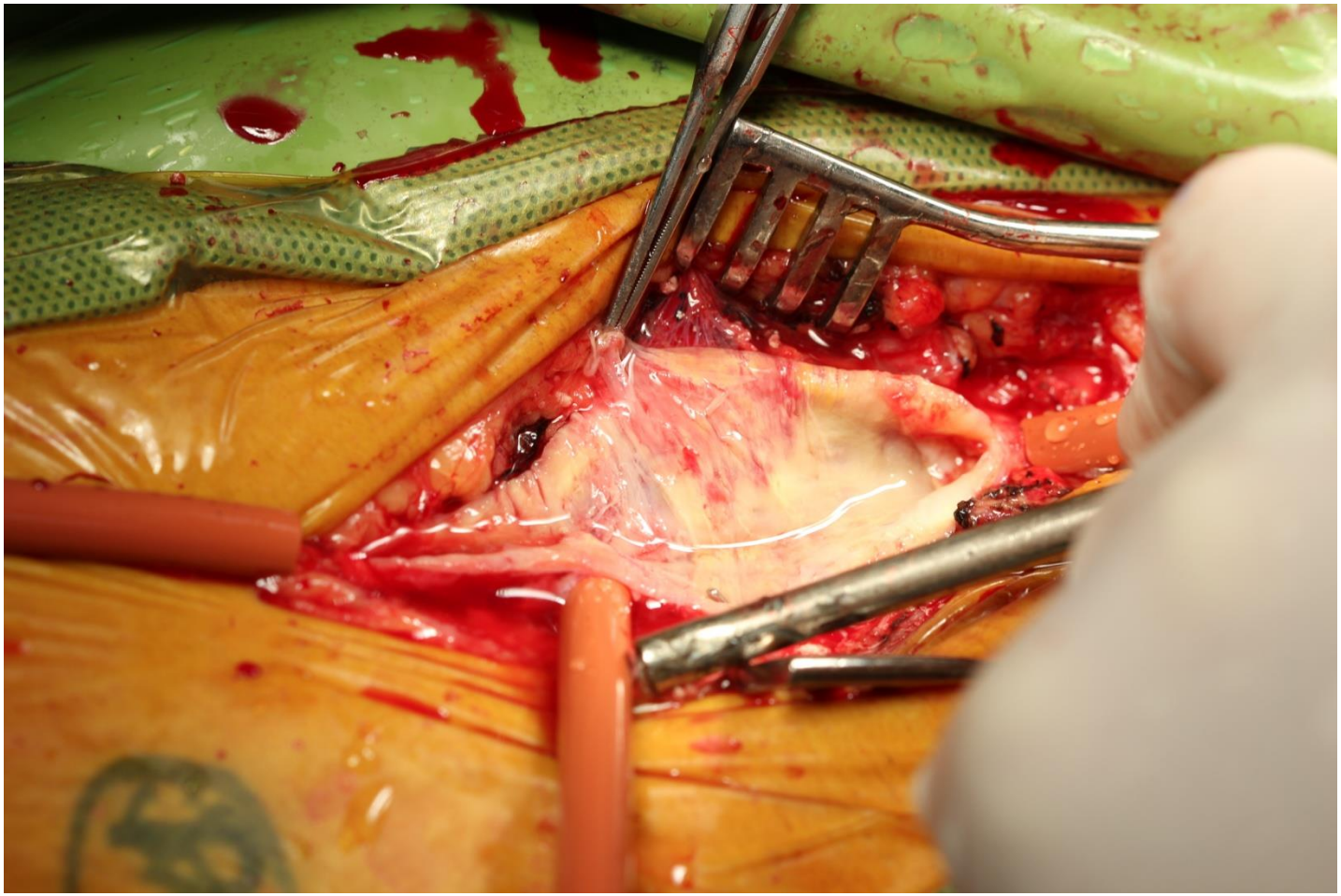

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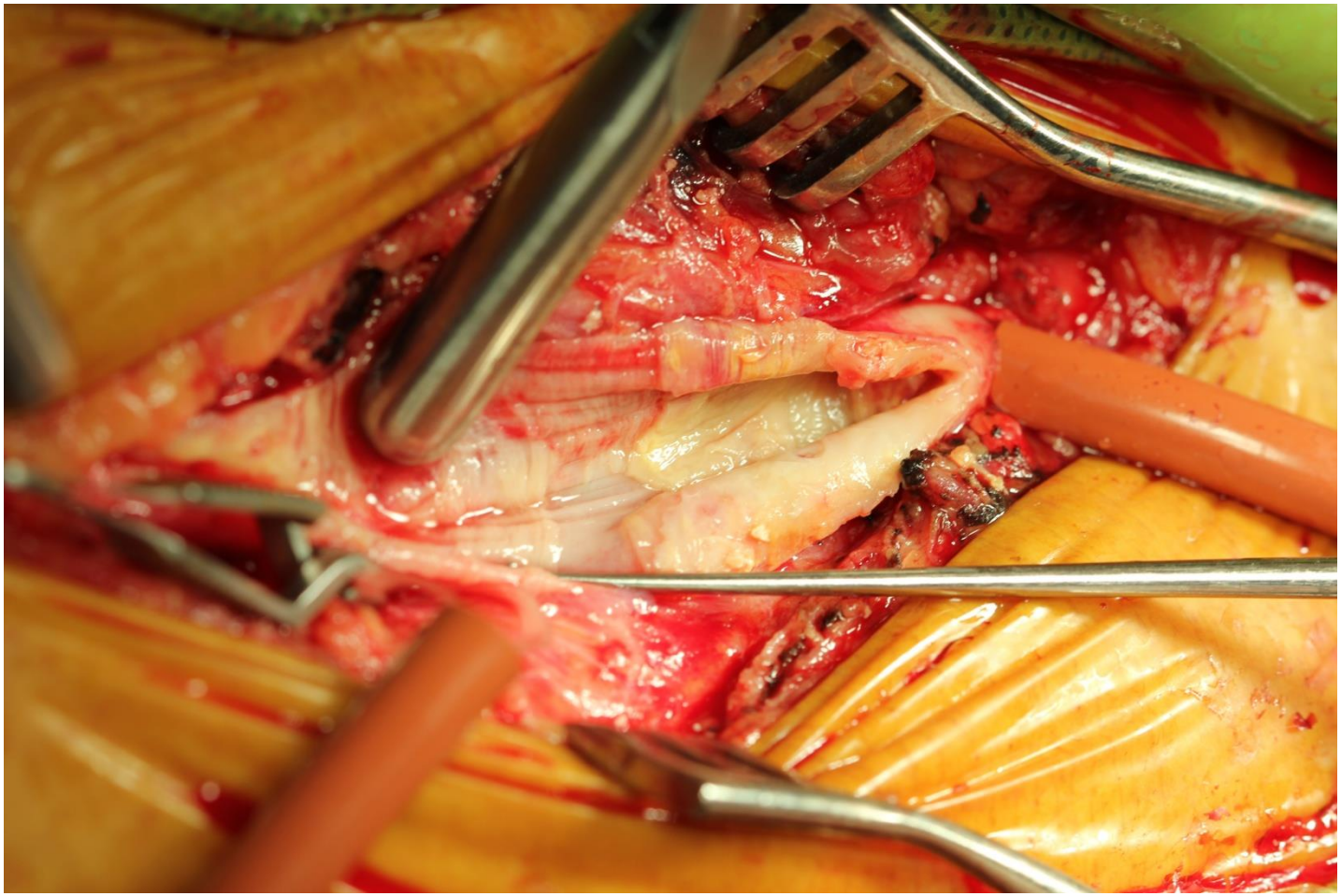

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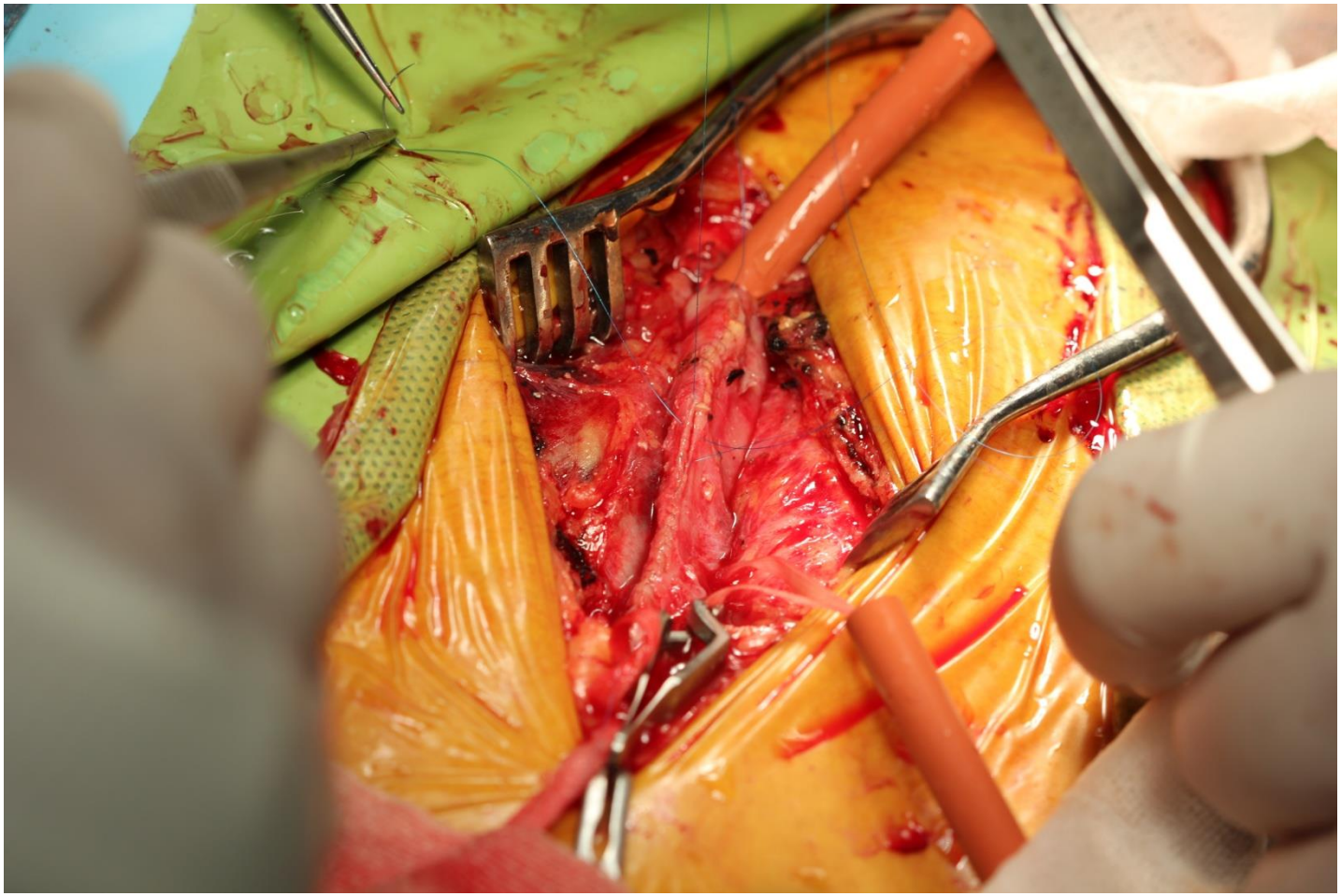

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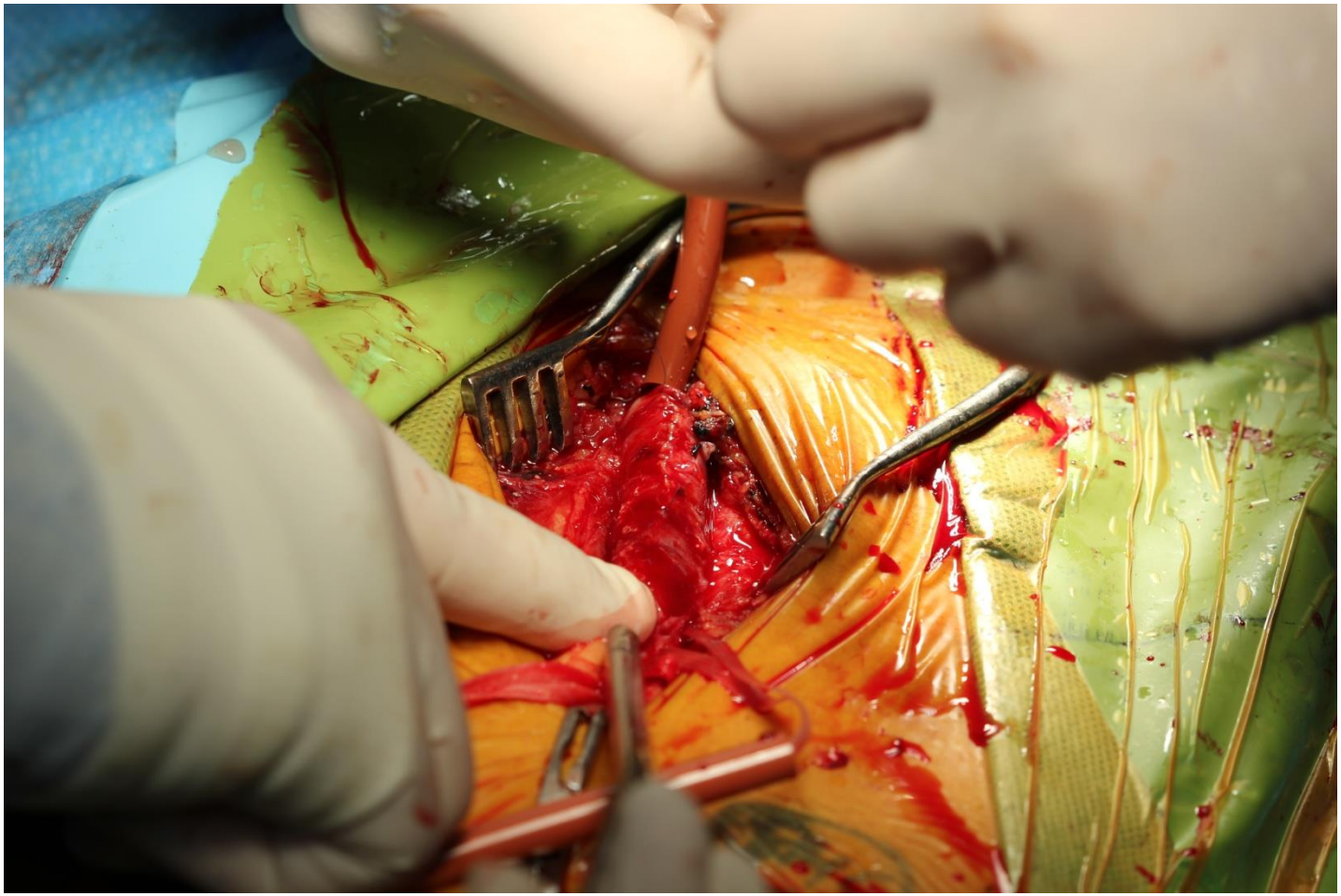
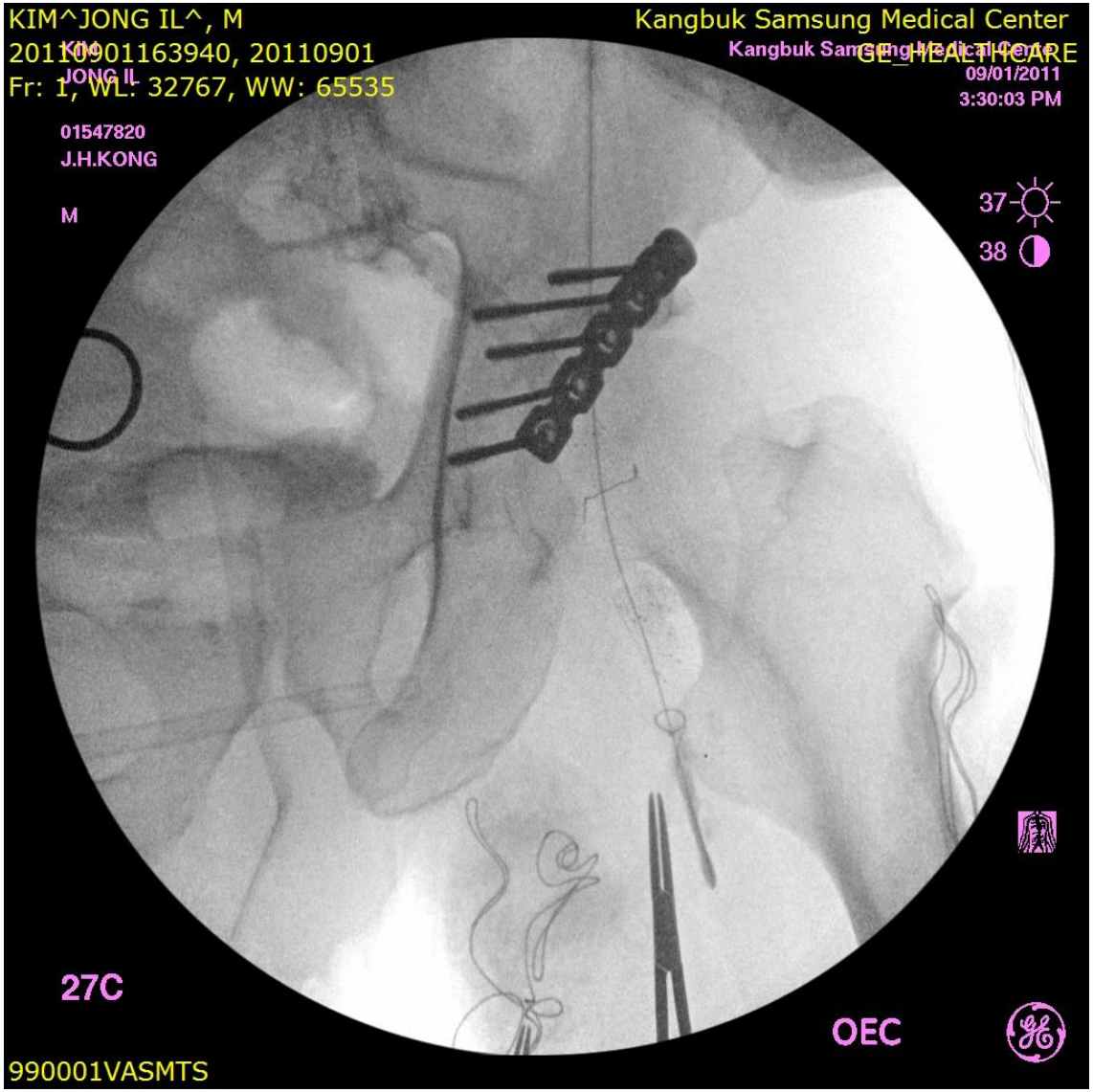
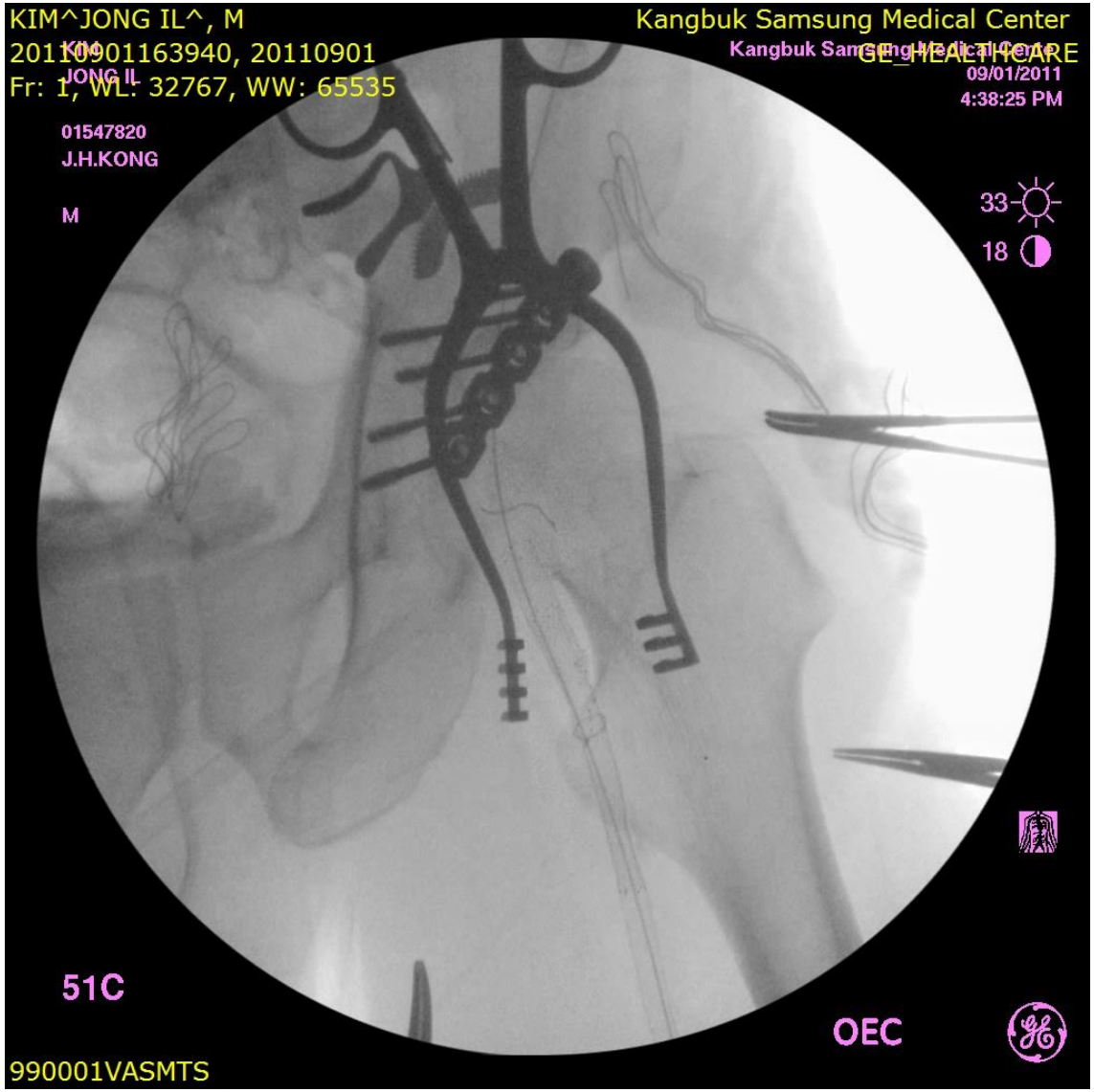


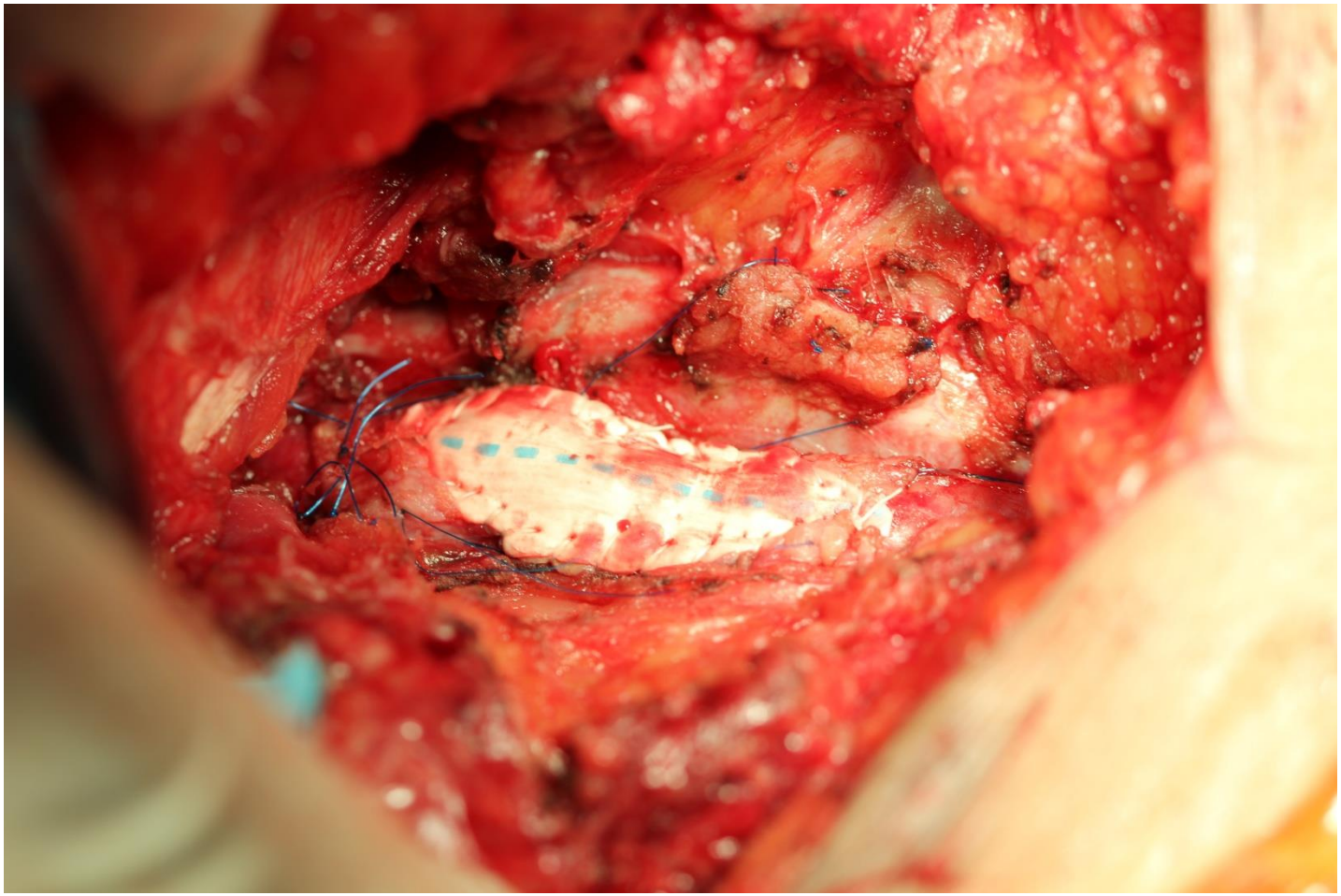
Endovascular Procedure



Endovascular Procedure

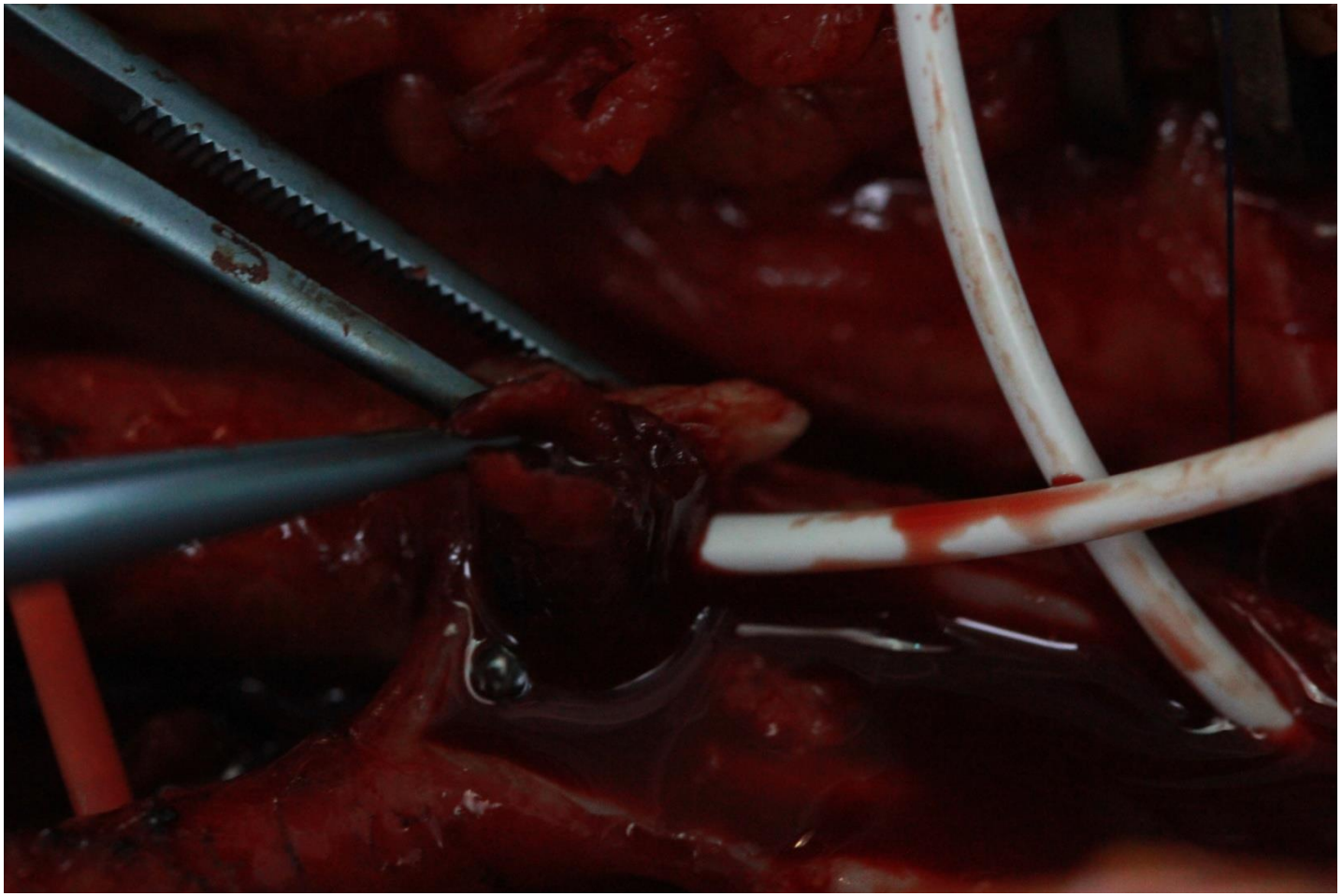


Op. Field at 2nd Op. (Right Side)



Postop.

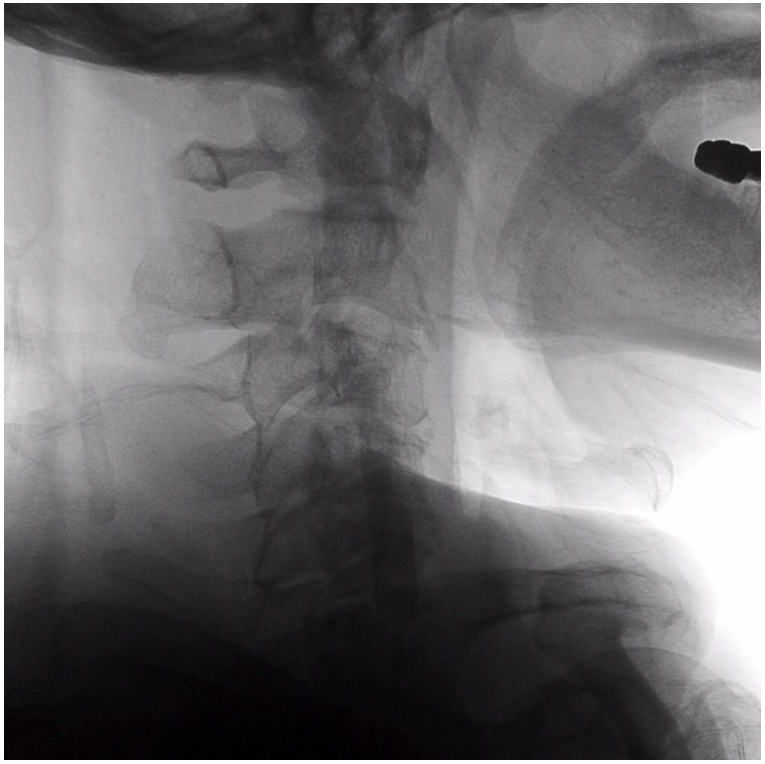
DFA: Embolus Removal

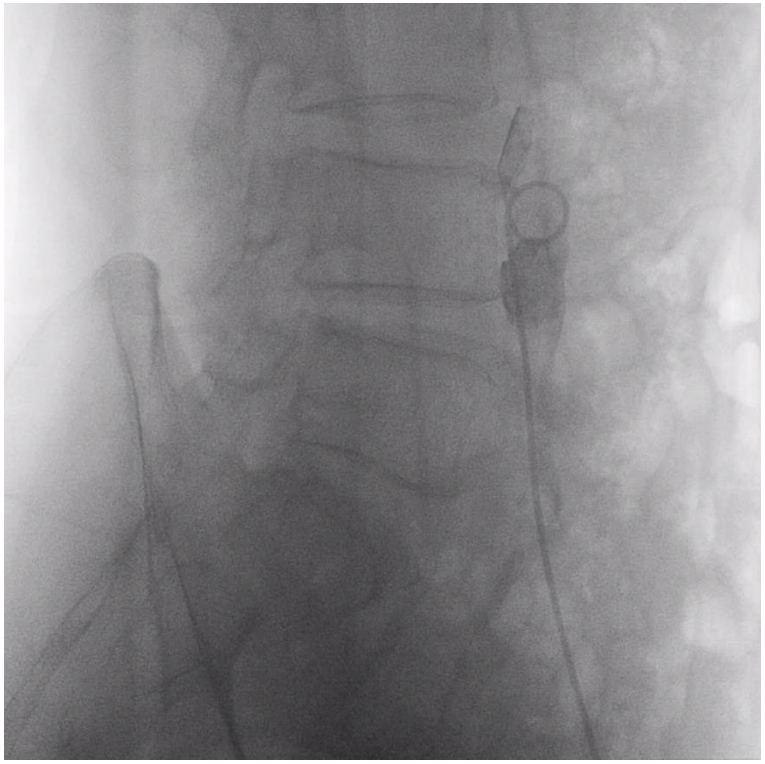


III. Future & Conclusion

- **New Devices & New Concepts**
- **Nano Technologies**

3D Angiogram





Translational Technologies in EVAR:Multimodality

Figure 1. Multimodality interventional translational suite: electromagnetic (EM) tracking, ultrasound, fluoroscopy, and computed tomography (CT) imaging during a preclinical nonsurvival procedure examining the accuracy of navigational paradigms using smart interventional devices enabled with the medical equivalent of GPS.

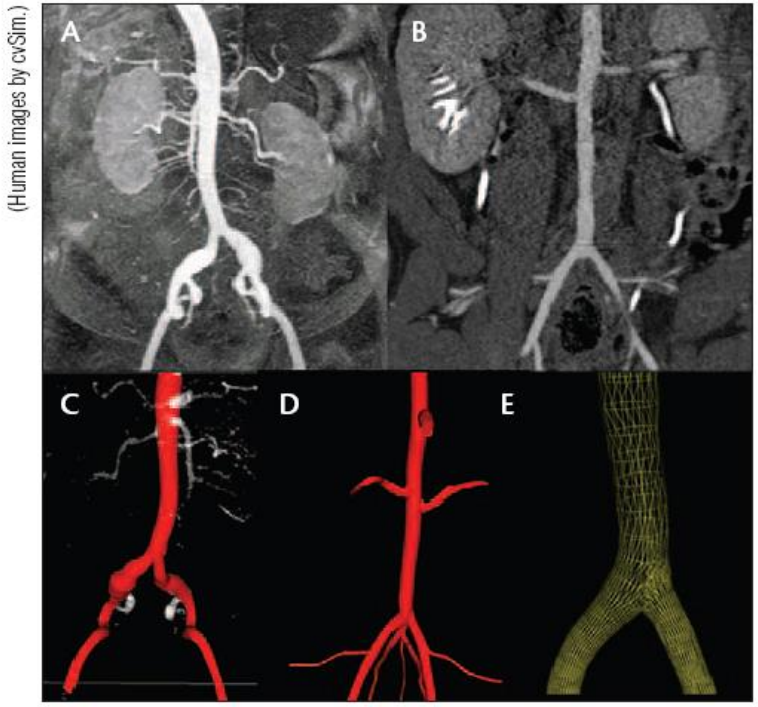


Figure 2. Human CT angiography (A), swine CT angiography (B), and 3D volume rendering of human (C) and swine (D) abdominal aortoiliac region. A simulation tool (cvSim, Cardiovascular Simulation, Inc., Stanford, CA) was used to generate 3D images (C,D) and computational grid for swine (E) that allows for flow and force evaluations.

JOHN W. KARANIAN, PHD; NADINE ABI-JAOUDEH, MD;
Translational Technologies in EVAR:Multimodality Interventions.
Endovascular toady 2009;March:15-18

Translational Technologies in EVAR:Multimodality

(Courtesy of Hansen Medical.)

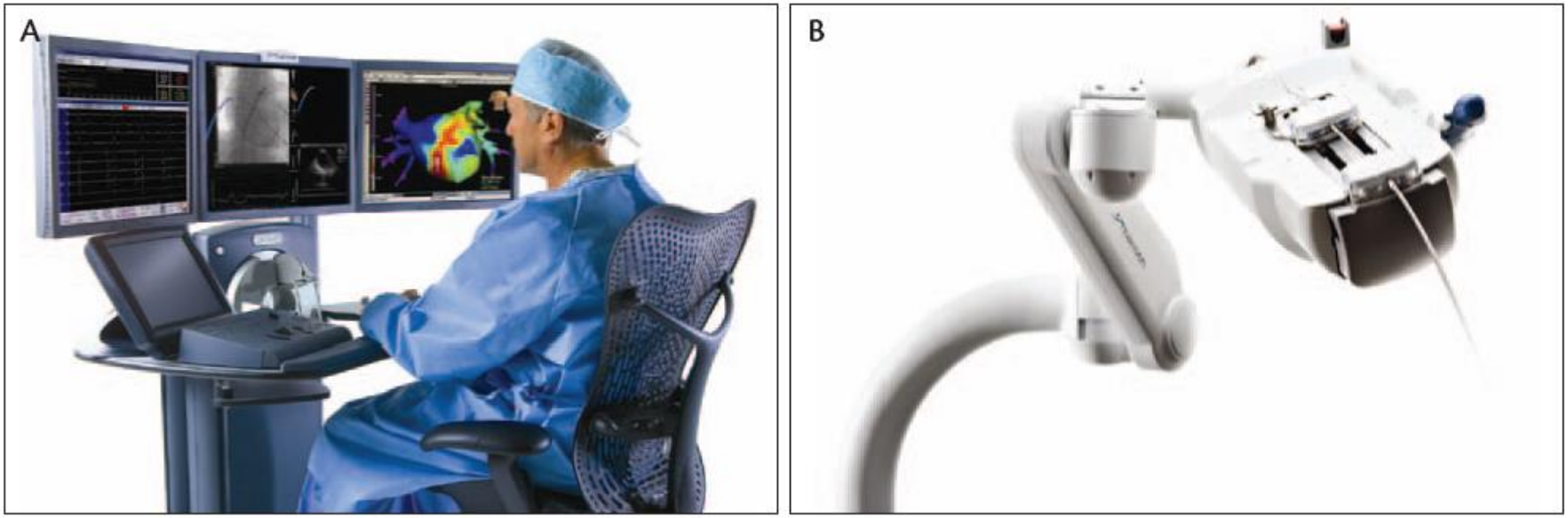


Figure 6. The Sensei control workstation (Hansen Medical, Mountain View, CA) allows the physician to control catheter positioning and provides force feedback (A). The mechanically positioned robotic drives the Artisan control catheter for manipulations within the vasculature (B).

JOHN W. KARANIAN, PHD; NADINE ABI-JAOUDEH, MD;
Translational Technologies in EVAR:Multimodality Interventions.
Endovascular toady 2009;March:15-18

Figure 1. The Sensei robotic system (Hansen Medical, Mountain View, CA) workstation is shown outside the angiography suite during cannulation of the short contralateral limb of an infrarenal Endurant stent graft (Medtronic, Inc., Minneapolis, MN).

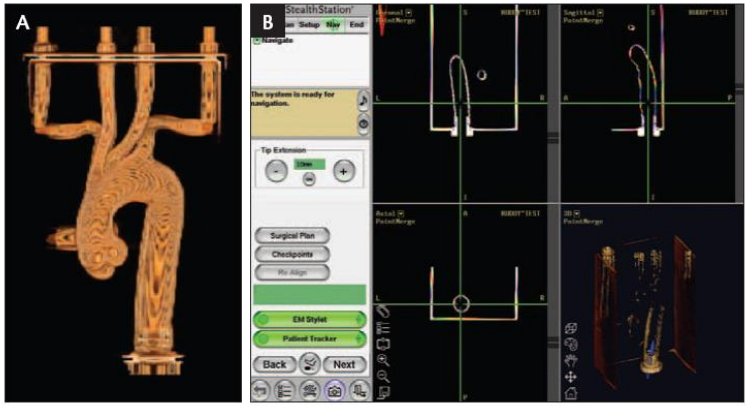


Figure 2. A pulsatile silicon arch model representing an angulated type III aortic arch (A). The Stealth electromagnetic navigation system (Medtronic, Inc.) combines cross-sectional ınetic tracking of microposition sensors located at the tip of an e operator can use the cross-sectional images to navigate through this pulsatile silicon model successfully and accurately with mini- ;el wall and without fluoroscopic guidance.

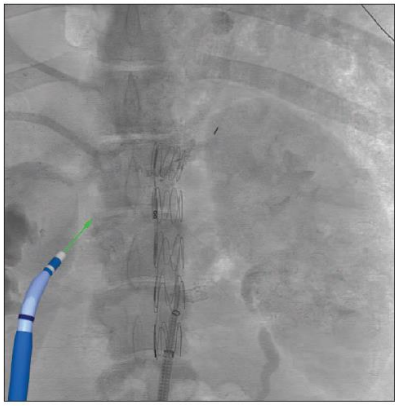


Figure 3. Successful antegrade in situ fenestration of an aortic stent graft (16-mm iliac extension covered stent; Endurant, Medtronic, Inc.) with subsequent stenting of the left renal artery in a porcine model. The robotic catheter can be seen in position, adjacent to the orifice of the left renal artery.

CELIA V. RIGA, BSC, MRCS; COLIN D. BICKNELL, MD, FRCS;
Navigation and Robotics for Endovascular Treatment of Aortic Disease
Endovascular toady 2009;March:19-23

Nano and the Future of Endovascular Medicine

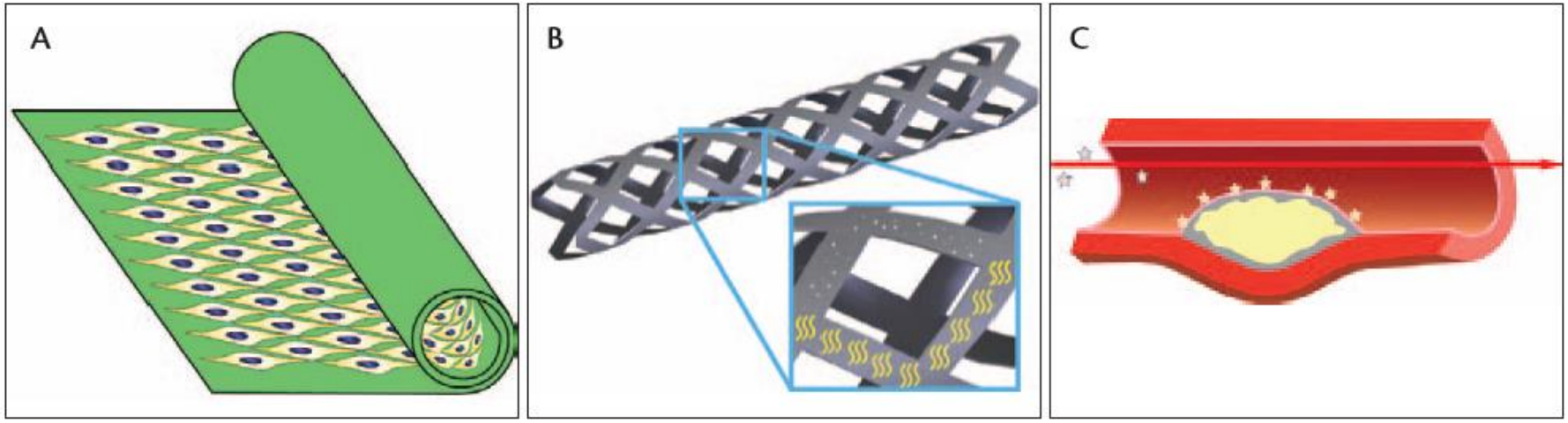
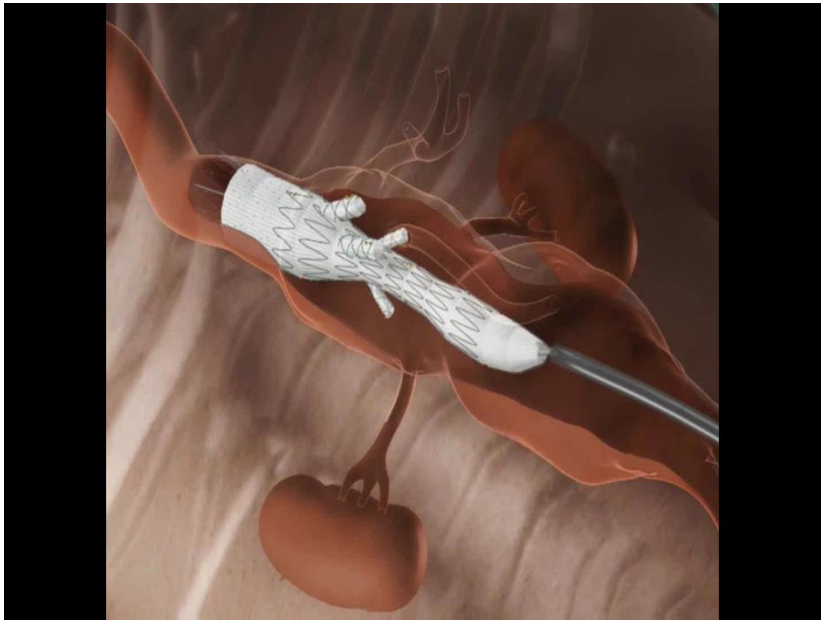
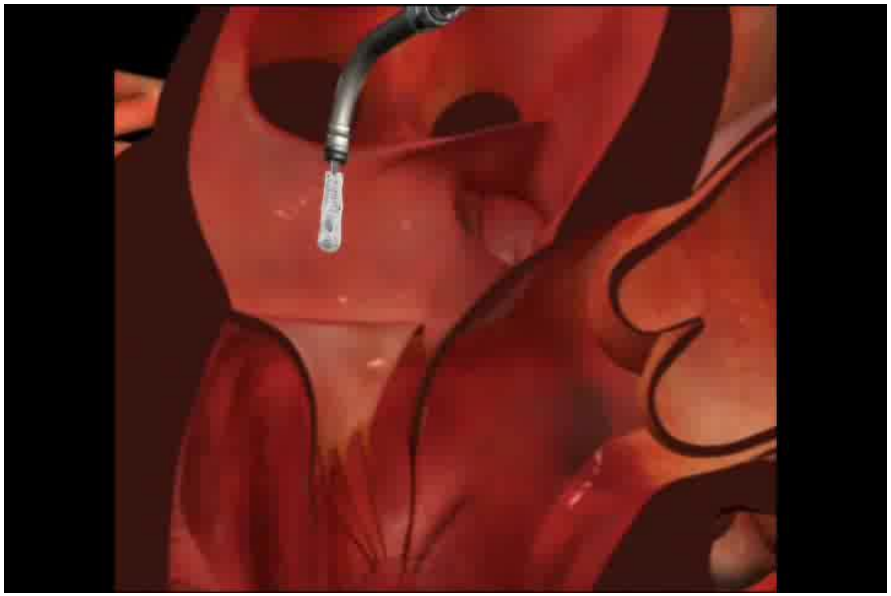


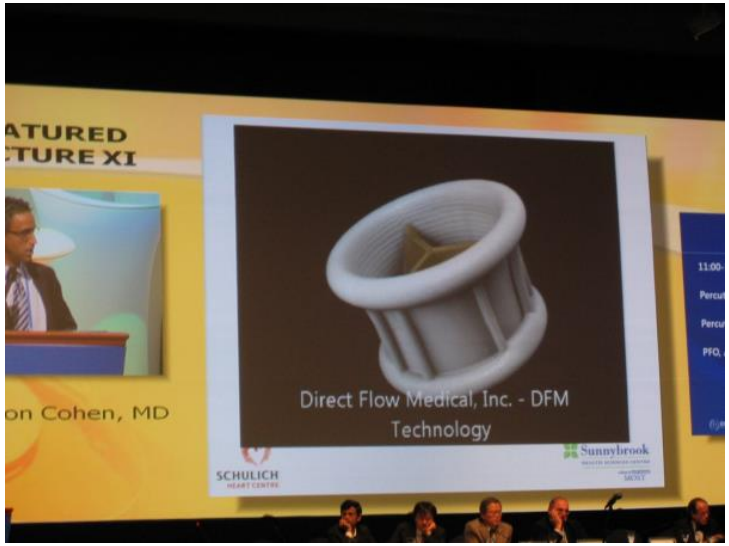
Figure 1. Technological innovations leveraging nanotechnology are expected in three categories with examples of anticipated or current technologies in engineered tissues assembling cells and proteins into physiologically correct microstructures (A). Hybrid stents combining nanotopography or functionalized surfaces to promote integration with native tissues and augmented for improved material properties (B). Medical tools that use nanostructures or devices for improved imaging and ablation of diseased tissues (C).

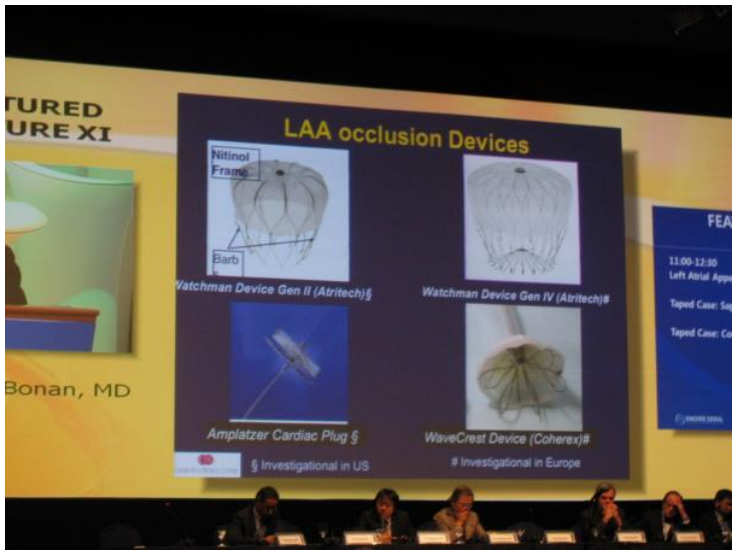
REBECCA TAYLOR, MS; JAMES J. NORMAN, PHD; CHELSEY SIMMONS, BS Nano and the Future of Endovascular Medicine
Endovascular toady 2009;March:27-

Near Future



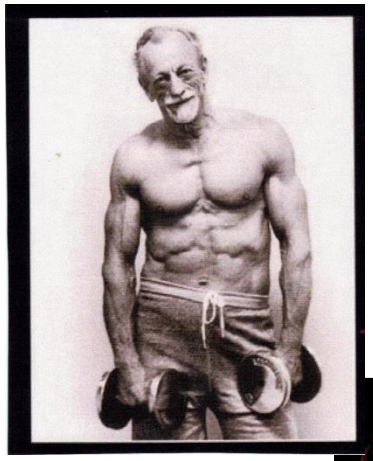


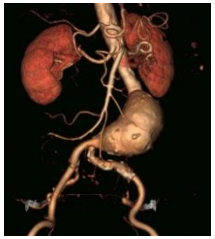

Direct Flow Medical, Inc. - DFM Technology
SCHULICH
Sunnybrook

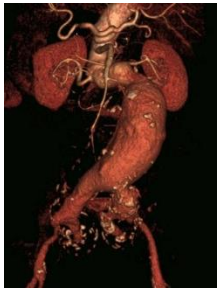

LAA occlusion Devices
Nitinol Frame
Barb
Watchman Device Gen II (Atritech)§
Watchman Device Gen IV (Atritech)#
Amplatzer Cardiac Plug §
WaveCrest Device (Coherex)#
§ Investigational in US
# Investigational in Europe

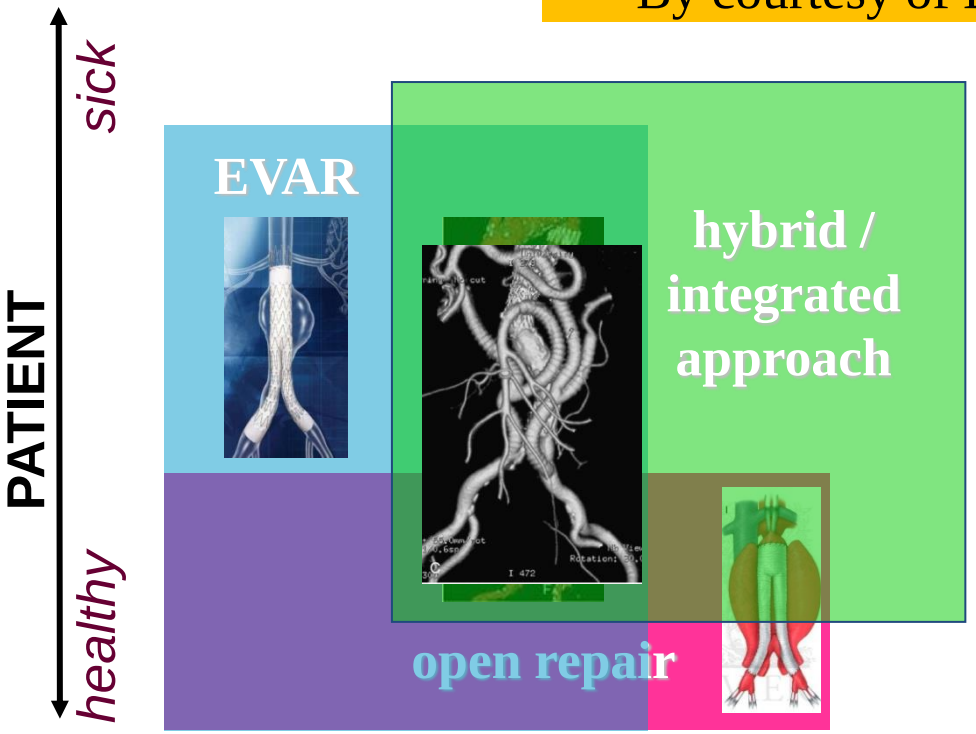
Endo. & OSR & Hybrid

By courtesy of Dr. Park (Kae Hyun)









Human Technology => Human Philosophy

- Certainly, our patients have benefited greatly from new technologies, devices, and cardiovascular treatment strategies, and these are integral to improving outcomes, but they do not ensure a successful cardiovascular center of excellence.

- The creation of a true multidisciplinary team approach is at the very core of the center of excellence concept.

- Perhaps when creating any center of excellence, the first technology to get right is the “human philosophy.”

Establishing aPeripheral VascularCenter of Excellence. DAVID E. ALLIE, MD; CHRIS J. HEBERT, RT, R-CIS; AND CRAIG M. WALKER, MD. FEBRUARY 2005 I ENDOVASCULAR TODAY I 41