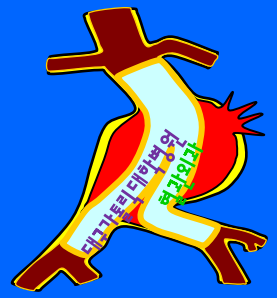
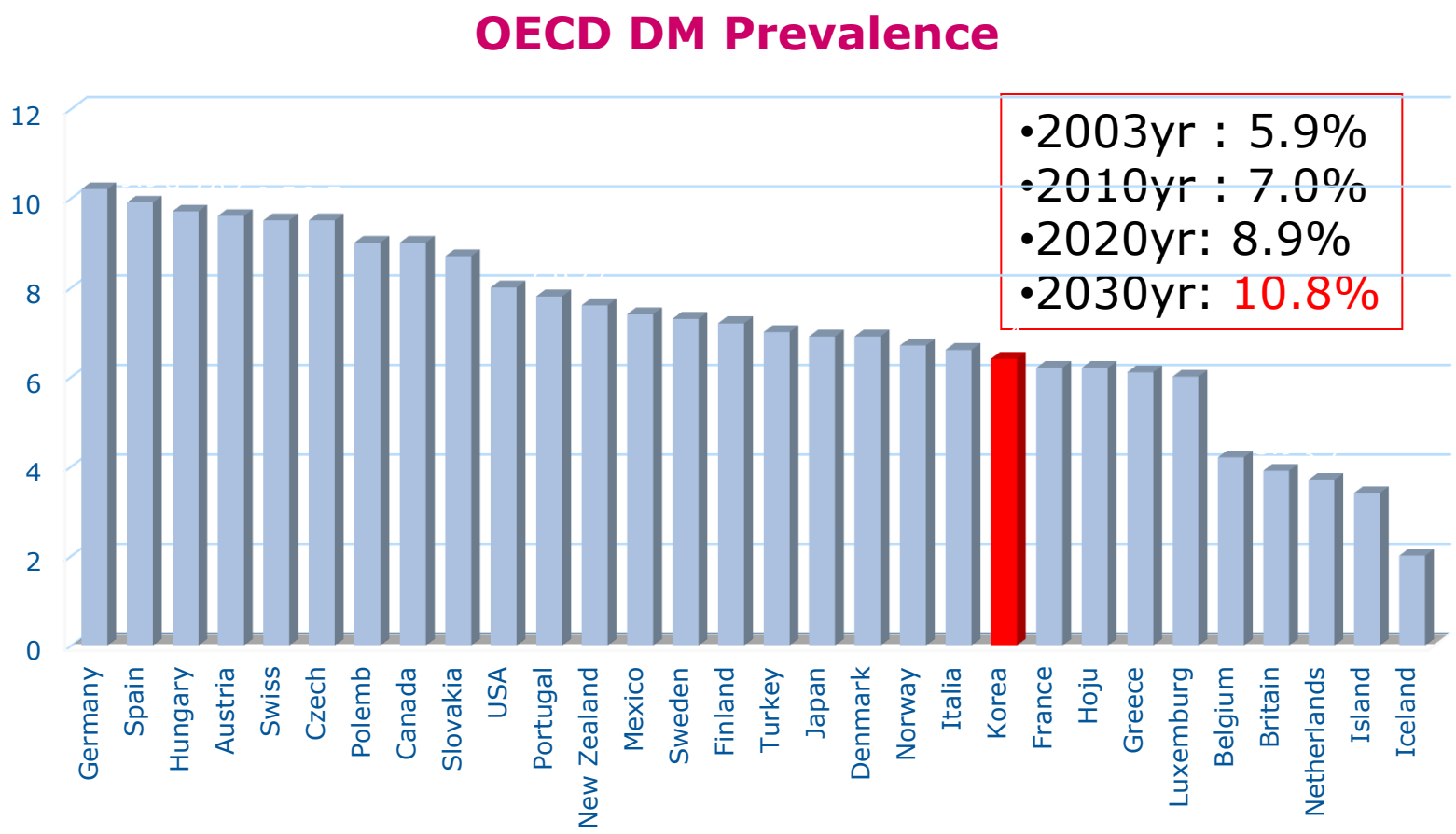
Diagnosis of Diabetic Vasculopathy

박기혁

대구가톨릭대학교 병원 혈관외과/외과



Diabetes prevalence in Korea

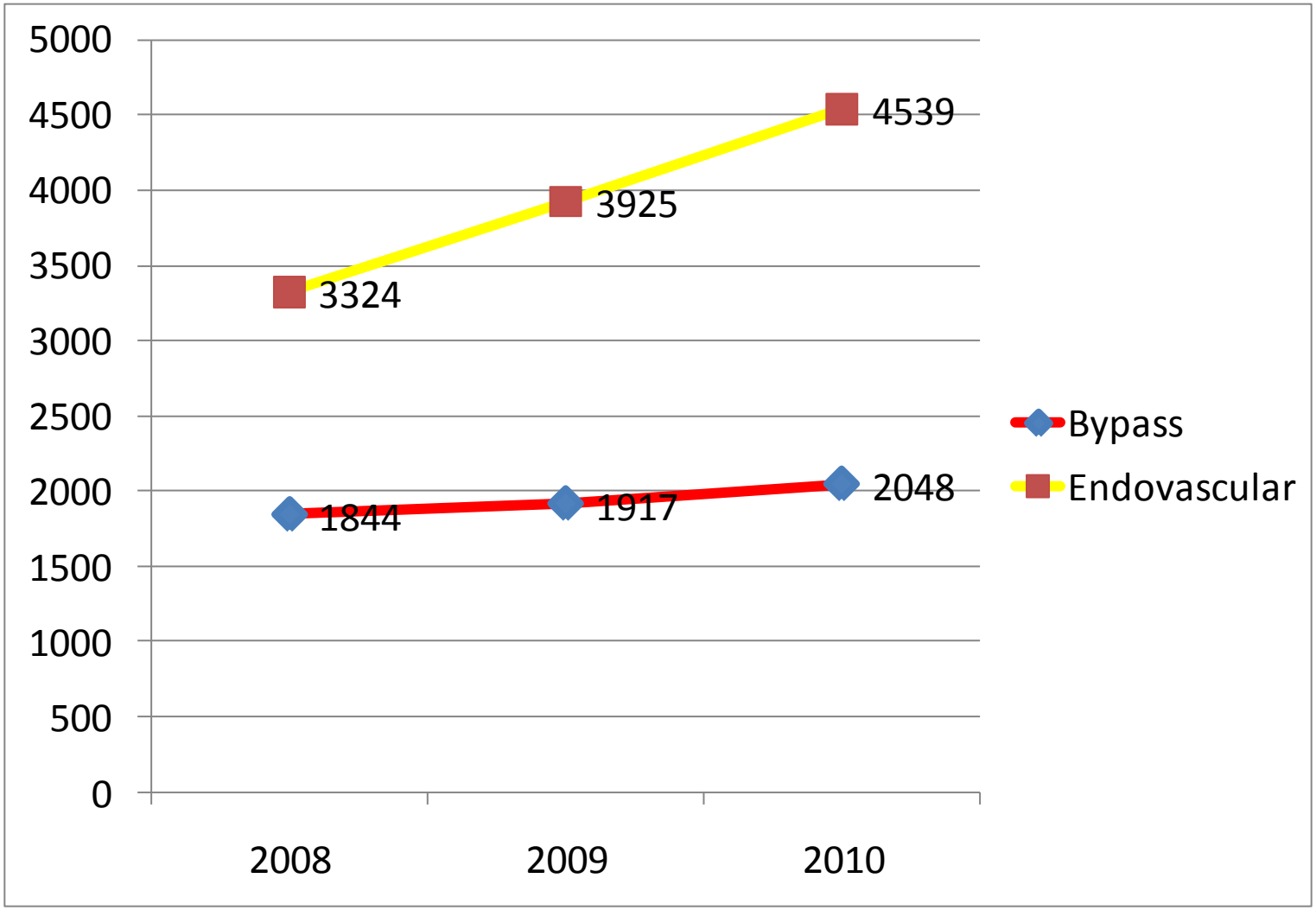


Korea Diabetes Association

Peripheral Arterial Occlusive Disease in DM

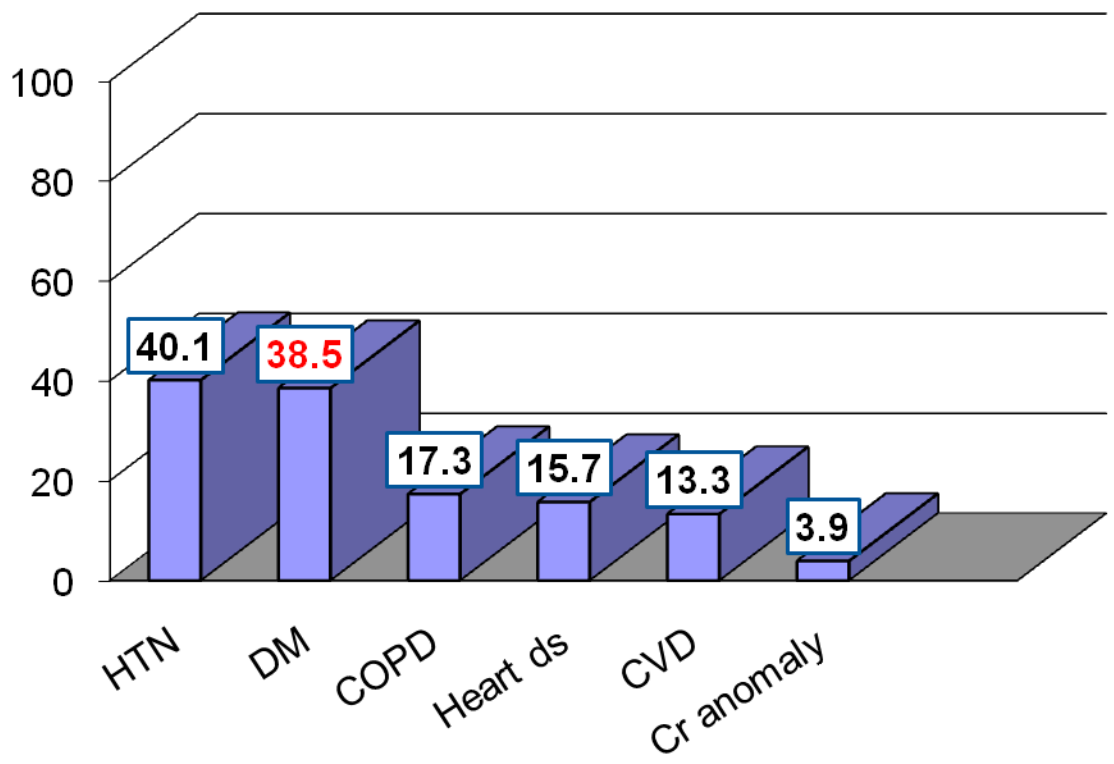
1. "Framingham Heart study" 20% of PAD had diabetes
2. Diabetes > 50yrs prevalence of PAOD 29% with ABI test (JAMA 2001) : higher than previously estimated
3. Natural history of PAOD in diabetes may worse than non-diabetes (more cardiovascular events)
4. In critical limb ischemia outcomes are worse, 30% amputations and 20% mortality within 6Mo

Peripheral arterial disease Tx in Korea



Korea National Health Insurance corp.

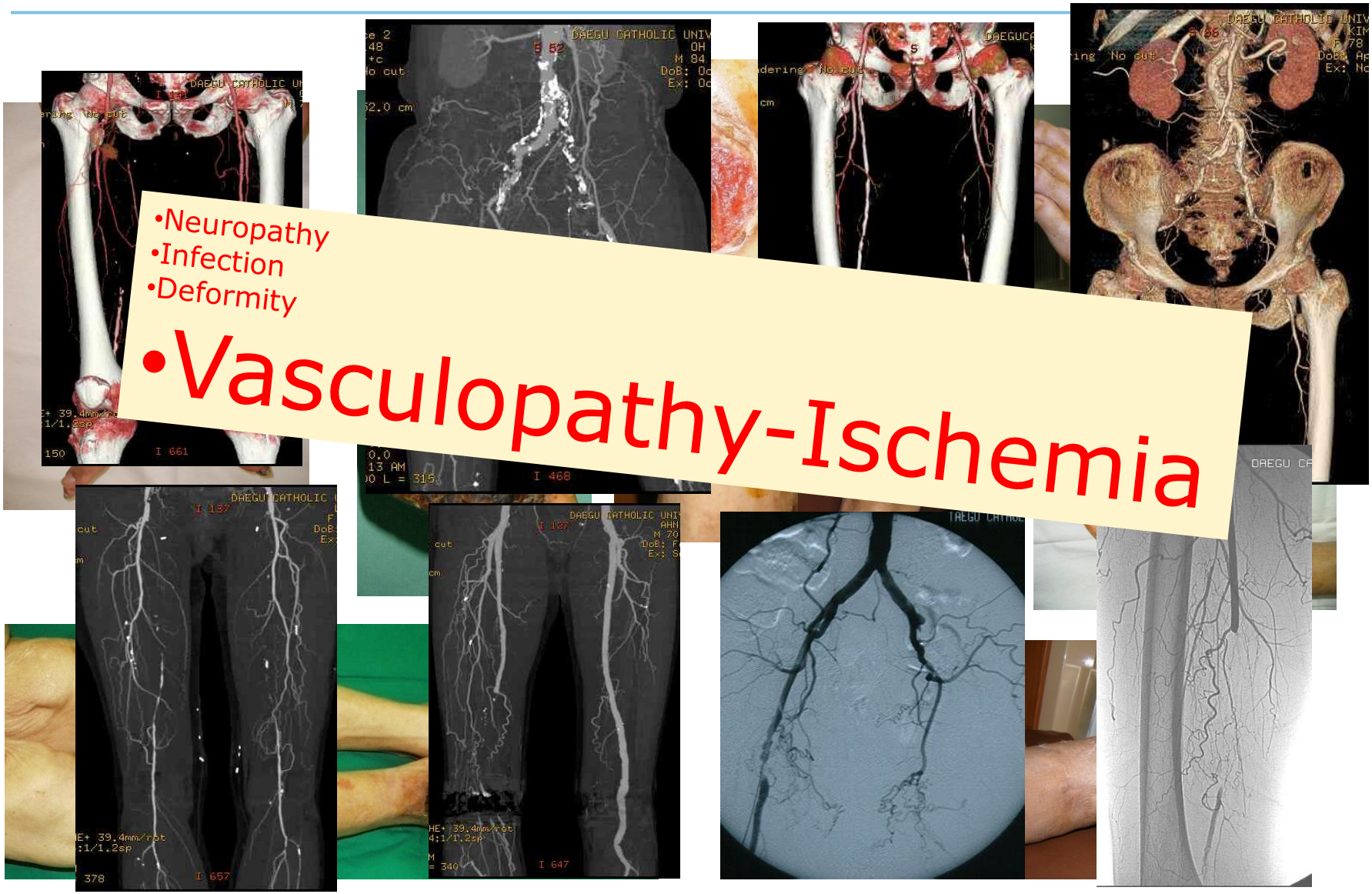
PAOD & DM-대구가톨릭대학교병원



Comparison between Perioperative Risks between Claudication & Critical Limb Ischemia
Journal of Korean Vascular & Endovascular Surgery: 2002 kh Park et al.

Critical Ischemic foot

Critical Ischemic foot



DM foot

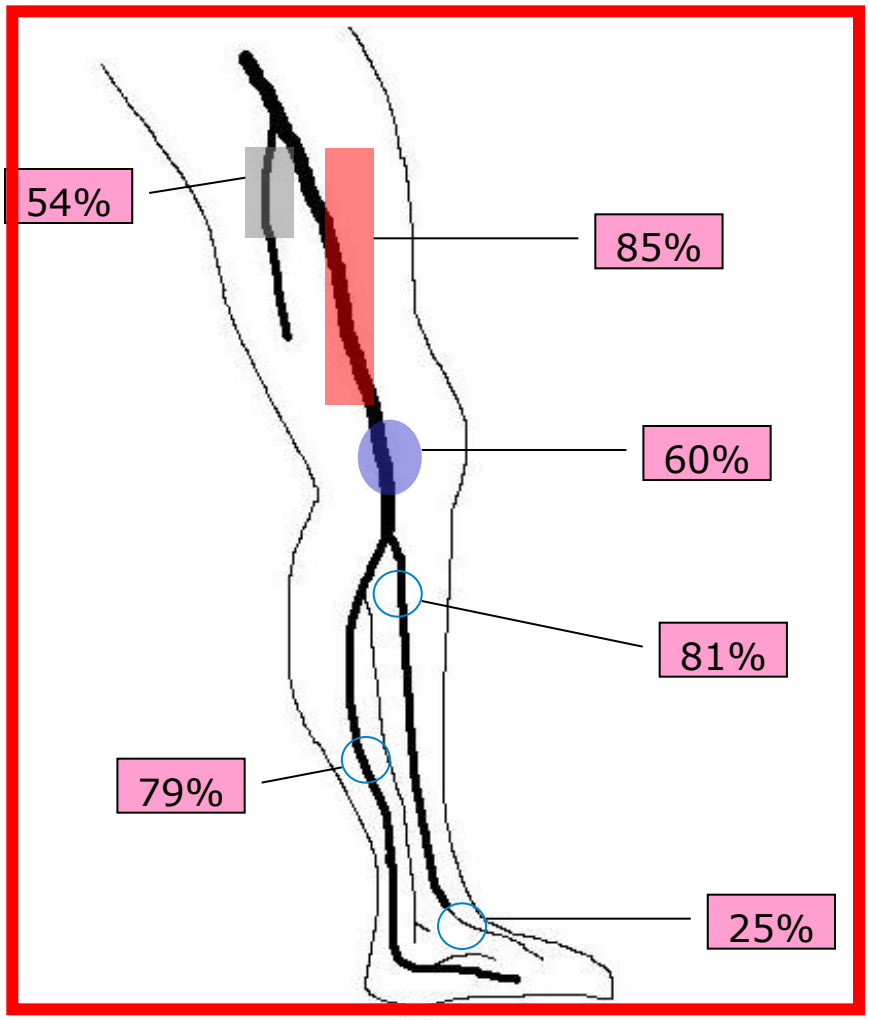
Difference of PAOD location with DM

- Aortoiliac segments are frequently free of disease
- Some arterial wall calcification in femoropopliteal system, but patent lumen
- Most severely affected in distal popliteal arteries

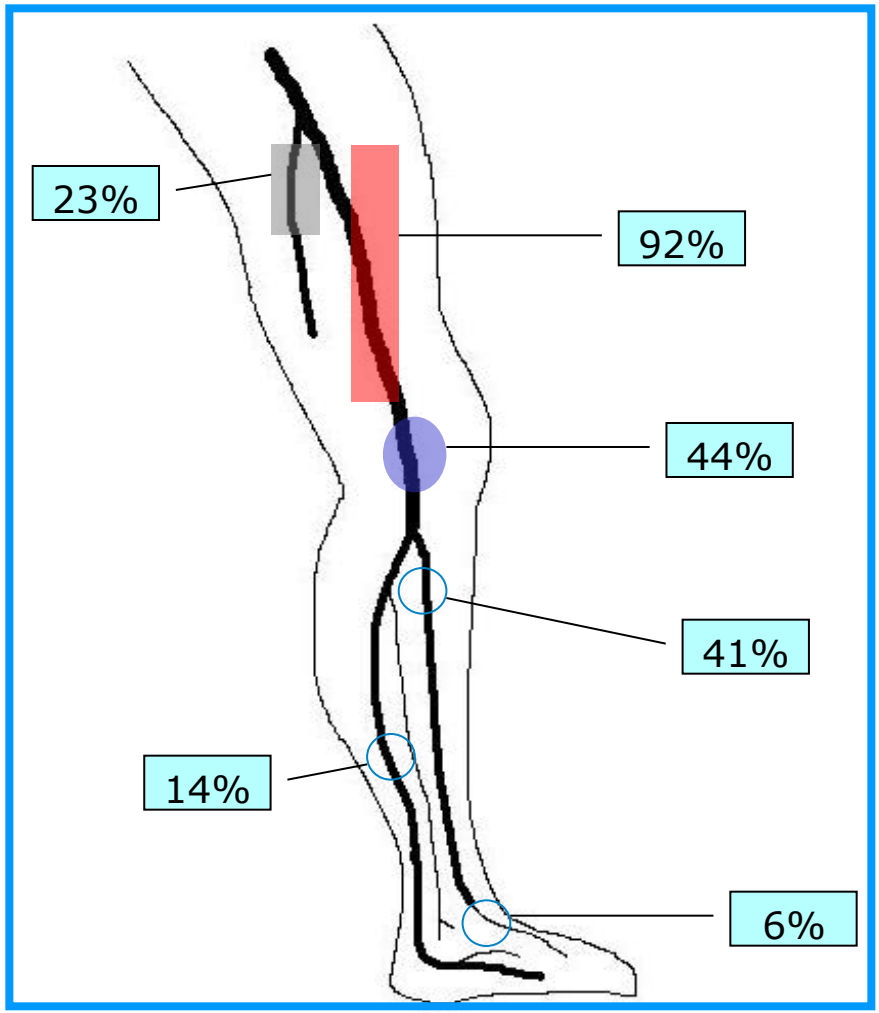
Difference of PAOD location with/without DM

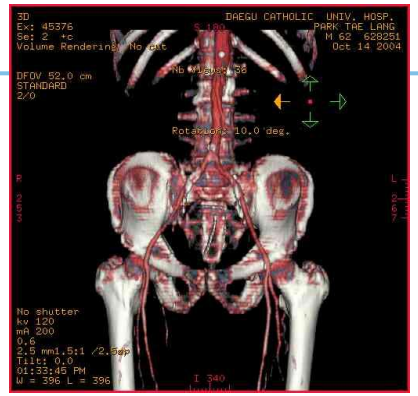
(*Alexander 1994*)

DM patient



Non-DM patient

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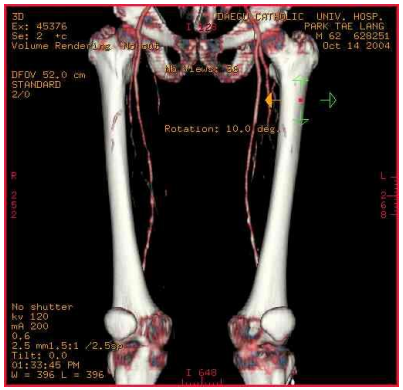
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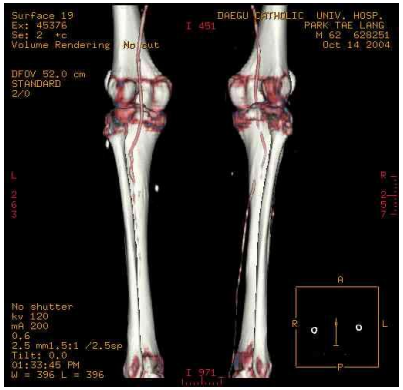
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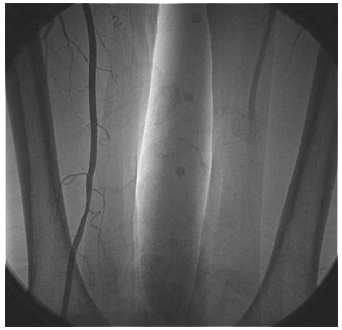

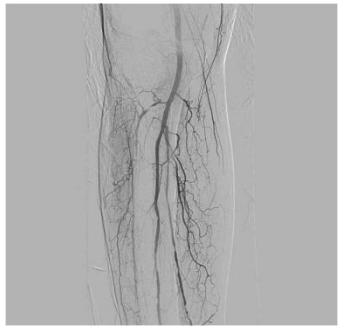

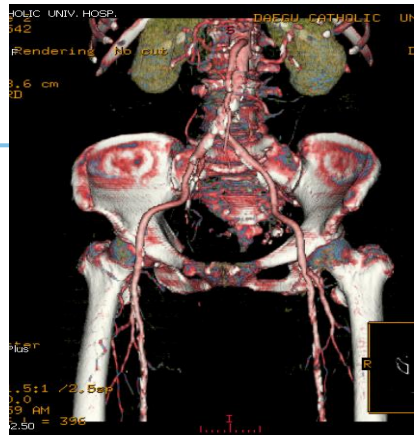
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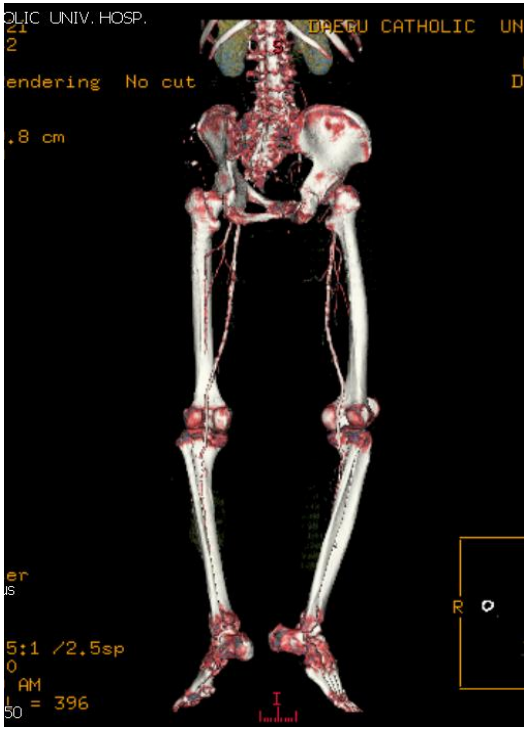
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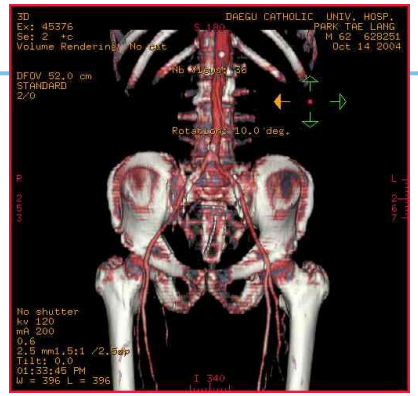
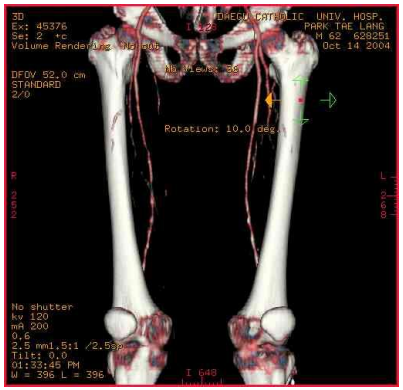
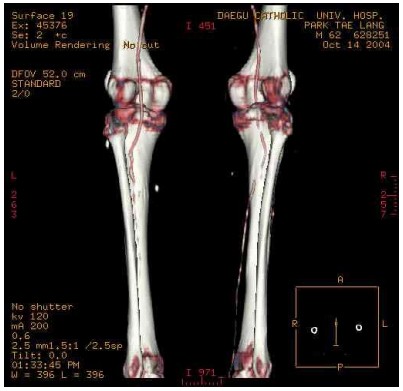
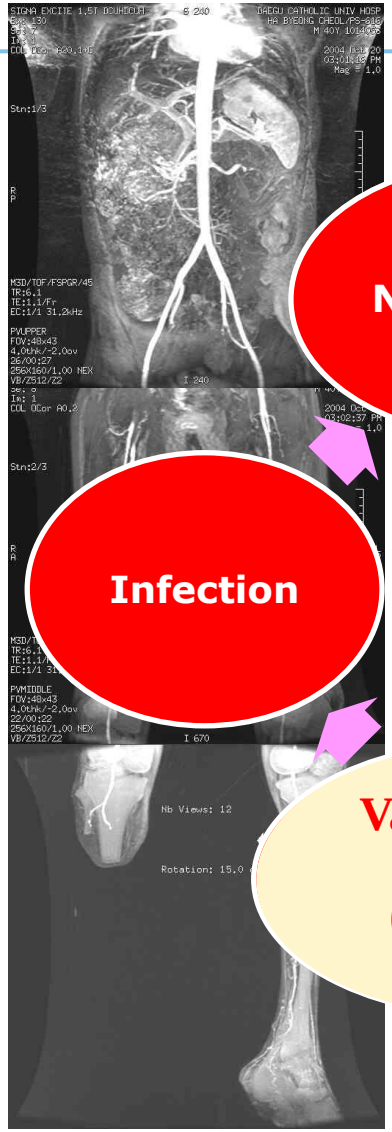
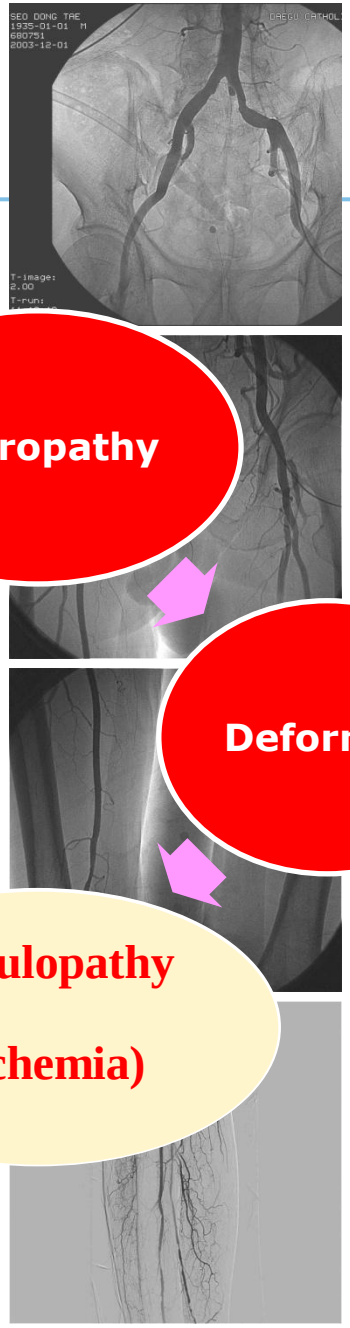
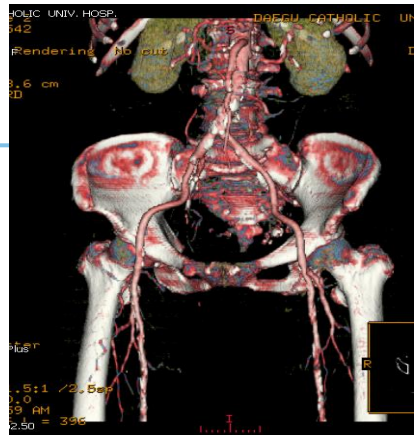


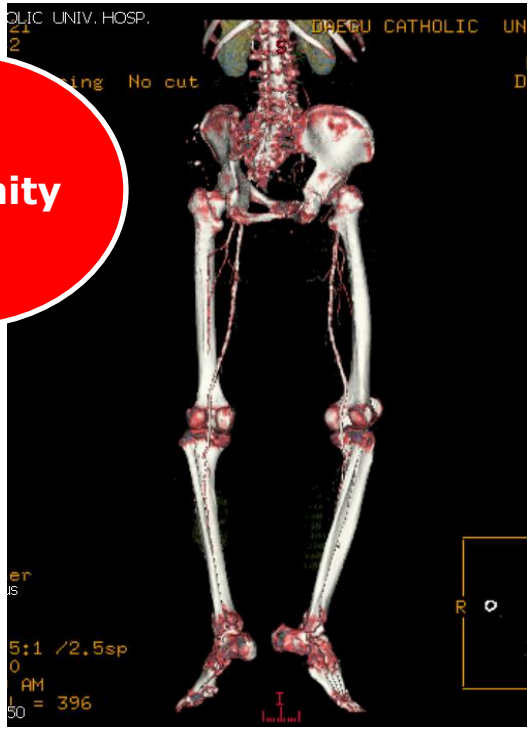












Neuropathy

Infection

Deformity

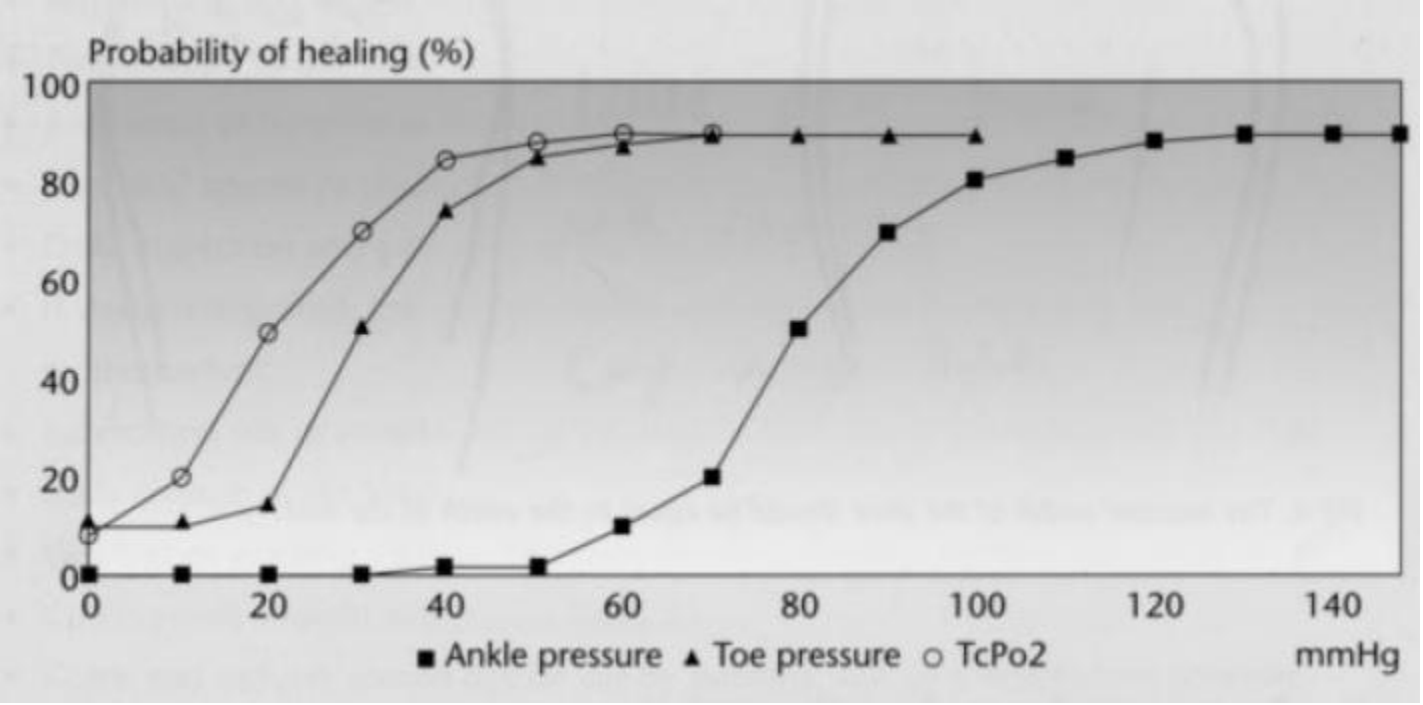
Vasculopathy

(Ischemia)

International Working Group on the Diabetic Foot

Every year, more than 1 million people with diabetes lose a leg as a consequence of this disease. This means that every 30 seconds a lower limb is lost to diabetes somewhere in the world. The vast majority of these amputations is preceded by a foot ulcer. The most important factors relating to the development of these ulcers are peripheral neuropathy, foot deformities, minor foot trauma, and peripheral arterial disease (PAD). Once an ulcer has developed infection and PAD are major causes for amputation.

International consensus and practical guidelines on the management and the prevention of the diabetic foot



- Schematic estimate of the probability of healing of foot ulcers and minor amputations in relation to ankle blood pressure, toe blood pressure and oxygen pressure(TcPo2) based on selected reports

Effectiveness of the Diabetic Foot Risk Classification System of the International Working Group on the Diabetic Foot

Diabetes Care 24:1442–1447, 2001

Table 4—*Distribution of adverse outcomes after 3 years among the groups of the consensus classification*

	Group 0 (no neuropathy)	OR (groups 1–3b)	Group 1 (neuropathy)	OR (groups 1–3b)	Group 2 (neuropathy, PVD and/or deformity)	OR (groups 2–3b)	Group 3a (previous ulcer, no amputation)	OR (groups 3a–3b)	Group 3b (previous amputation)	Total	*P*
n	79		21		51		43		19	213	
Follow-up ulcer	4 (5.1)	100.0 (20.4–491.0)	3 (14.3)	32.0 (5.6–181.6)	7 (13.7)	33.5 (7.7–145.6)	24 (55.8)	4.2 (1.1–16.7)	16 (84.2)	54 (25.4)	<0.001
Follow-up amputation	0	7.6 (4.5–12.8)	0	1.6 (1.1–2.2)	1 (2.0)	29.2 (3.3–260.1)	9 (20.9)	NS	7 (36.8)	17 (18.1)	<0.001
Toe/ray	0	—	0	—	1 (2.0)	—	6 (14.0)	—	1 (5.3)	8 (3.8)	
Midfoot/TMA	0	—	0	—	0	—	2 (4.7)	—	3 (15.8)	5 (2.3)	<0.001
BKA or AKA	0	—	0	—	0	—	1 (2.3)	—	3 (15.8)	4 (1.9)	
Reamputations	0	—	0	—	0	4.2 (2.7–6.4)	4 (9.3)	NS	3 (15.8)	7 (41.1)	<0.001
Follow-up bypass	0	6.0 (3.8–9.3)	0	2.3 (1.6–3.3)	1 (2.0)	NS	2 (4.7)	NS	3 (15.8)	6 (2.8)	0.001

Data are n (%) or OR (95% CI) unless otherwise indicated. For follow-up ulcer, follow-up amputation, toe/ray, midfoot/transmetatarsal amputation (TMA), below-the-knee amputation (BKA), or above-the-knee amputation (AKA), and reamputations, $P < 0.001$; for follow-up bypass, $P = 0.001$.

Group	Criteria	Ulceration rate (%)	Amputation rate (%)
0	no neuropathy	5	0
1	neuropathy, no deformity or vascular disease	14	0
2	neuropathy and deformity or vascular disease	19	3
3	previous ulcer or amputation	55	21

International Working Group on the Diabetic Foot

Risk Category	Definition	Treatment recommendations	Suggested follow-up
0	No LOPS, no PAD, no deformity	• Patient education including advise on appropriate footwear	Annually (by generalist and/or specialist)
1	LOPS ± deformity	• Consider prescriptive or accommodative footwear. • Consider prophylactic surgery if deformity is not able to be safely accommodated in shoes. Continue patient education.	Every 3-6 months (by generalist and/or specialist)
2	PAD ± LOPS	• Consider prescriptive or accommodative footwear. • Consider vascular consultation for combined follow-up.	Every 2-3 months (by specialist)
3	History of ulcer or amputation	• Same as category 1 • Consider vascular consultation for combined follow-up if PAD present.	Every 1-2 months (by specialist)

* LOPS(loss of protective sense: Neuropathy), PAD(peripheral arterial disease)

DDx foot wound with DM patient

Neuropathic ulcer

Ischemic wound

Diagnosis of Ischemia

- Status of Ischemia ?
- What condition of femoral, crural artery?

Symptom of Chronic Ischemia

- Claudication
- Coldness
- Atrophy
- Paresthesia
- Gangrene
- Ulceration
- Cyanosis

Clinical categories of chronic limb ischemia

Reporting standards in Lower leg ischemia

Scale for gauging changes in clinical status

Category	*Clinical description*	*Objective criteria*
0	Asymptomatic—no hemodynamically significant occlusive disease	Normal treadmill or reactive hyperemia test
1	Mild claudication	Completes treadmill exercise†; AP after exercise >50 mm Hg but at least 20 mm Hg lower than resting value
2	Moderate claudication	Between categories 1 and 3
3	Severe claudication	Cannot complete standard treadmill exercise† *and* AP after exercise <50 mm Hg
4	Ischemic rest pain	Resting AP <40 mm Hg, flat or barely pulsatile ankle or metatarsal PVR; TP <30 mm Hg
5	Minor tissue loss—nonhealing ulcer, focal gangrene with diffuse pedal ischemia	Resting AP <60 mm Hg, ankle or metatarsal PVR flat or barely pulsatile; TP <40 mm Hg
6	Major tissue loss—extending above foot no longer salvageable	Same as category 5

Clinical categories of chronic limb ischemia

Reporting standards in Lower leg ischemia

Scale for gauging changes in clinical status

Category	*Clinical description*
0	Asymptomatic—no hemodynamically significant occlusive dise
1	Mild claudication
2	Moderate claudication
3	Severe claudication
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6	Major tissue loss—extending above foot no longer salvageable

remia test

P after

t 20 mm Hg lower

ill exercise†

m Hg

arely pulsatile

0 mm Hg

r metatarsal

<40 mm Hg

Clinical categories of chronic limb ischemia

Reporting standards in Lower leg ischemia

Scale for gauging c tus

Category	*Clinical description*	
0	Asymptomatic—no hemodynamicall	mia test
	significant occlusive dis	
1	Mild claudication	after
		20 mm Hg lower
2	Moderate claudication	
3	Severe claudication	l exercise†
		Hg
4	Ischemic rest pain	rely pulsatile
		mm Hg
5	Minor tissue loss—nonhealing ulce	metatarsal
	, focal gangrene with diffuse	40 mm Hg
	pedal ischemia	
6	Major tissue loss—extending above	
	foot no longer salvageable	

Clinical categories of chronic limb ischemia

Reporting standards in Lower leg ischemia

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American Diabetes Association

-Consensus Conference about PAD in People with Diabetes -

- Vascular lab evaluation
  1. Segmental pressure
  2. Pulse volume recorder
- Imaging studies
  1. Duplex scan
  2. Contrast angiography
  3. MRA

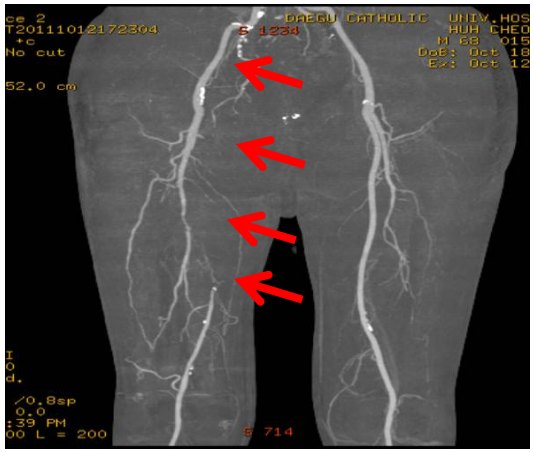
Vascular Laboratoy study
: 혈관기능검사/혈류검사

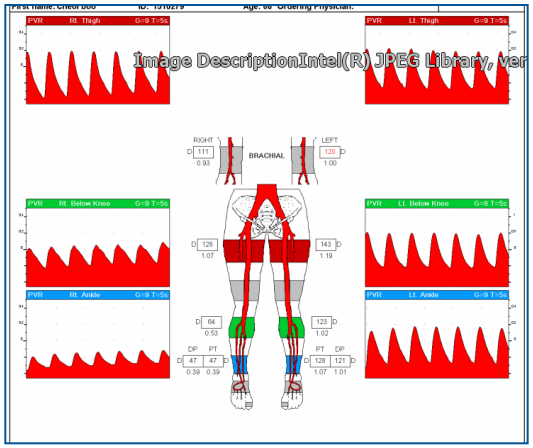
- **PAOD is hemodynamic rather than anatomic defect !**
- **Noninvasive, easily repeat, screening method**

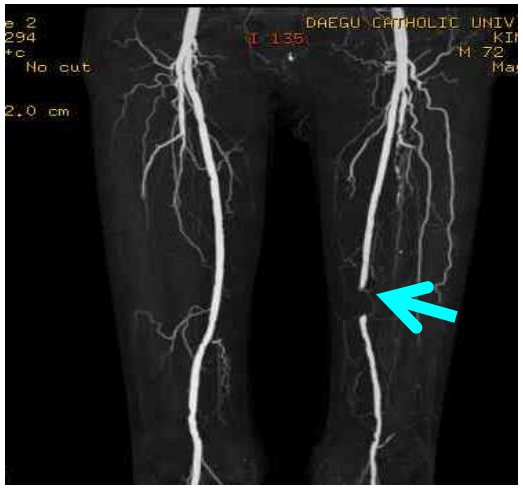
혈관기능검사 (Noninvasive Vascular Laboratory)

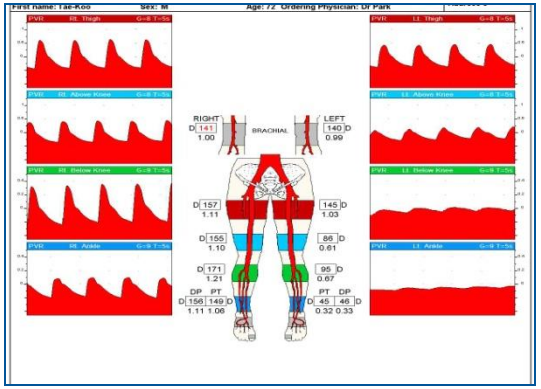
- Segmental Pressure (ABI)
- PVR (Pulse Volume Recorder)
- PPG (photoplethysmography)

PAOD is hemodynamic rather than anatomic defect !

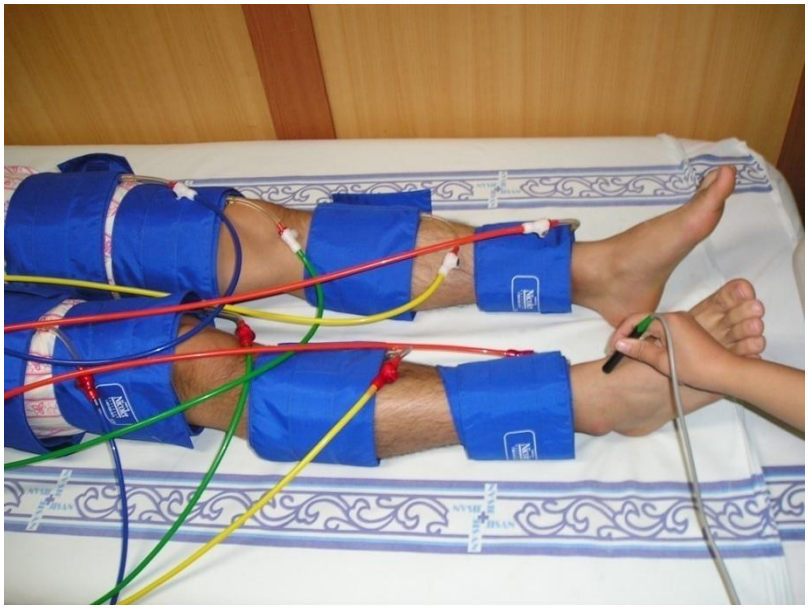








Vascular Lab



- **Segmental arterial pressure**

- **Four cuff method**
- **Thigh at groin / above knee / Calf / Ankle**
- **normal gradient : less than 20-30mmHg**

Vascular Lab

- **ABI** (Ankle/Brachial systolic Index)

1. Simple, reproducible, common noninvasive method
2. Screening ABI should be performed >50yrs of diabetes
3. But falsely high due to mediasclerosis :15%-40%(*Lehto. 1996*)

Vascular Lab

- Pulse volume recorder

1. Strain gauge(mercury) method
2. Air-plethysmography : easy, standard

Vascular Lab

▶ Pulse volume recorder

1. Apply pneumatic cuff

   Thigh – 18 * 36cm

   Calf - 12 * 23cm

2. Cuffs are inflated 65mmHg

   Thigh - 400±75ml

   Calf - 75 ± 10ml

3. Recordings are made successively

Vascular Lab

Pulse contour of PVR

normal

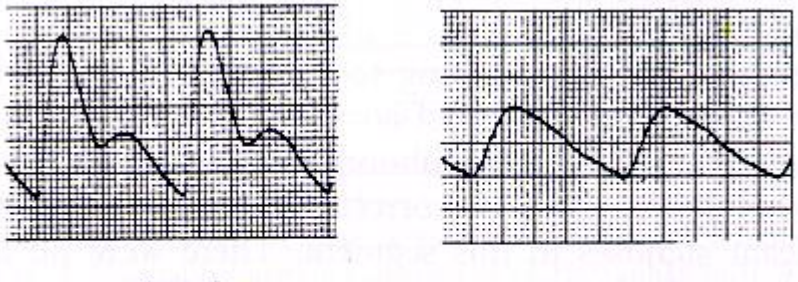
steep upstroke, downslope, prominent dicrotic wave

occlusive

1. absence of dicrotic wave
2. peak becomes delayed and rounded

Severe occlusive

1. rise and fall nearly equal, amplitude decrease



Normal and abnormal pulse volume contours recorded at ankle level. Normal form shows a prominent dicrotic wave on the downslope. Cuff pressure, 65 mmHg; cuff volume, 75 ml.

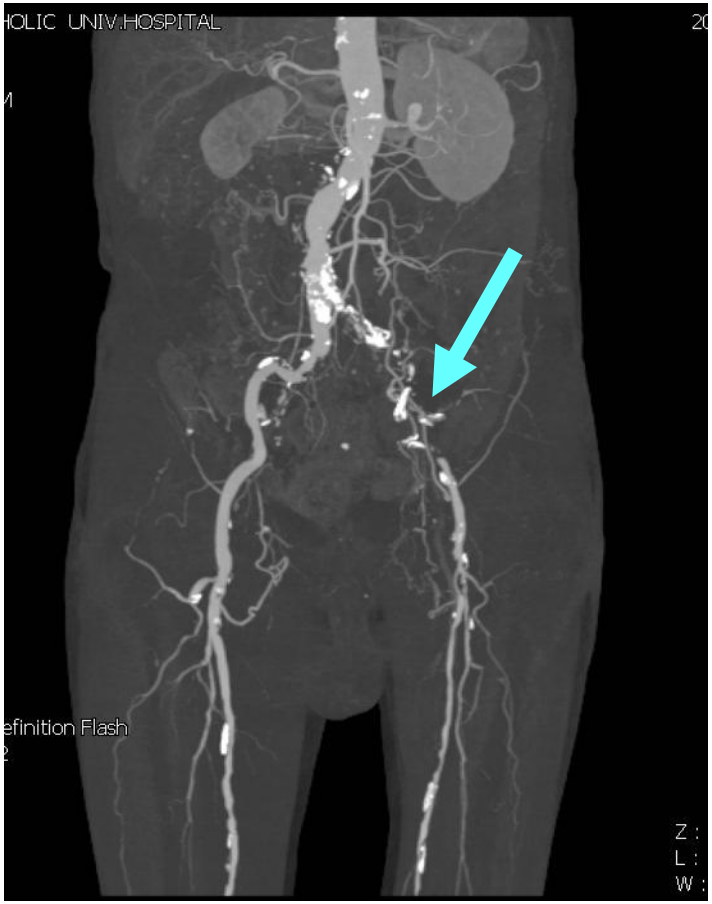
Vascular Lab

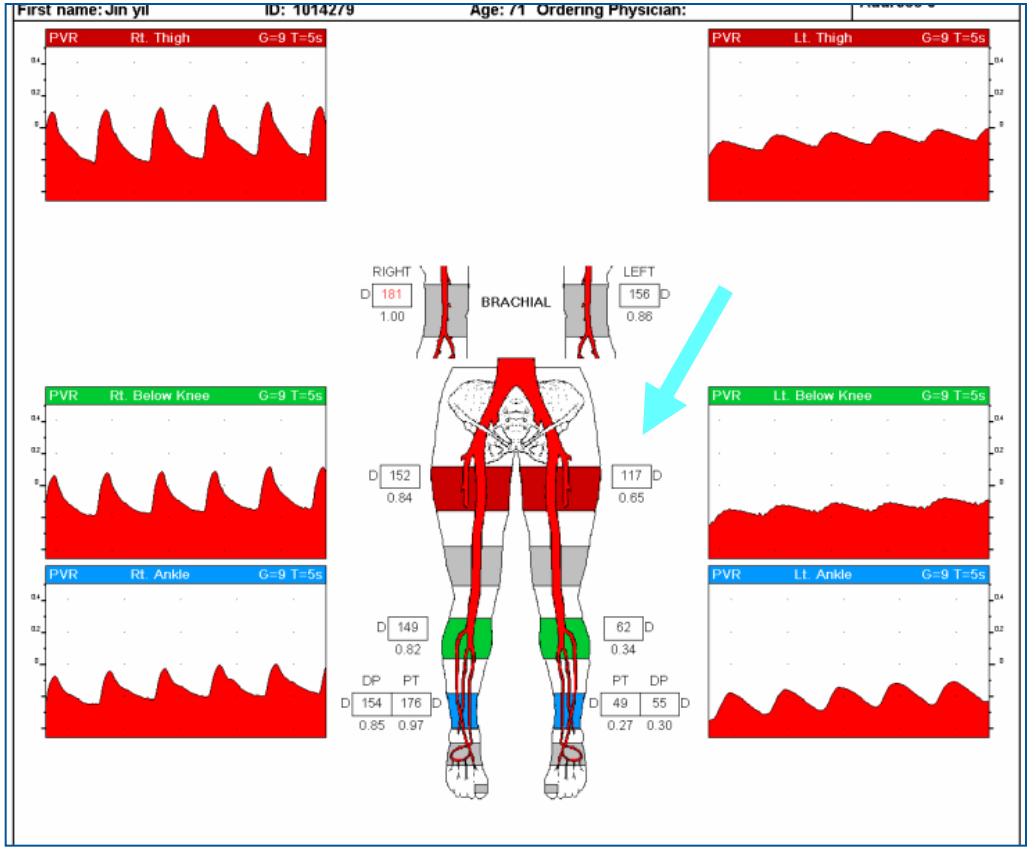
- PVR correctly assess patency of femoral artery in 97% (*kempczinski et al*.)
- Positive & negative predictive value in aortoiliac disease 64%, 87%, and in femoropopliteal disease 91%, 85%
- Accuracy of combined test

  : simultaneous use of PVR and segmental pressure

  : 86 – 100%

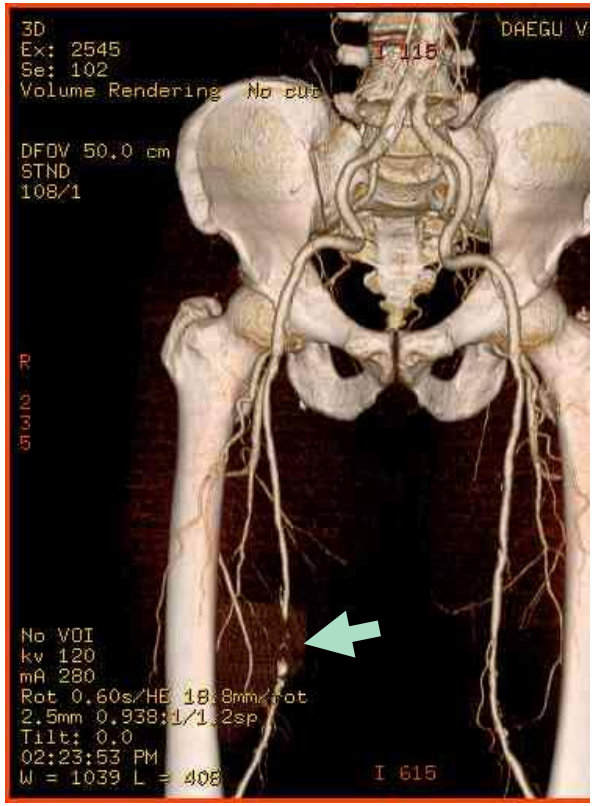
Localization of occlusive lesion with PVR results

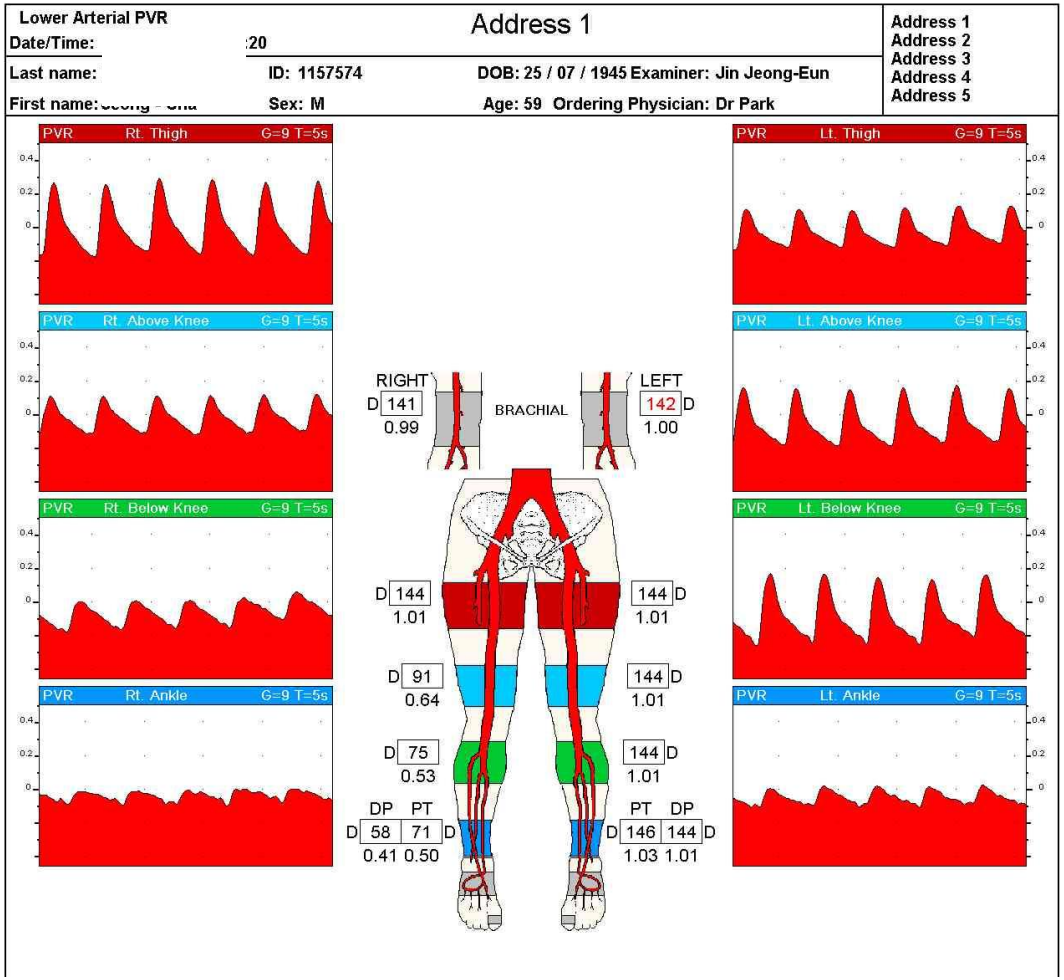




Lt. iliac artery occlusion

Localization of occlusive lesion with PVR results





Right femoral artery occlusion

Vascular Lab

- Toe pressure

Because calcification of the digital vessels is less pronounced than in proximal metatarsal, plantar, tibial vessels, it can be measured accurately than ABI

Vascular Lab

Toe pressure with Photoplethysmography

- Toe pressure is useful in DM
- Normal toe index is 0.75, less than 0.25 in severe occlusive disease
- *Carter*. Foot ulcer heals toe pr > 30mmHg in non DM, 55MHg in DM
- *Bone and Pomajzl*. Failure of toe amputations in all patients with <45mmHg

Vascular Lab

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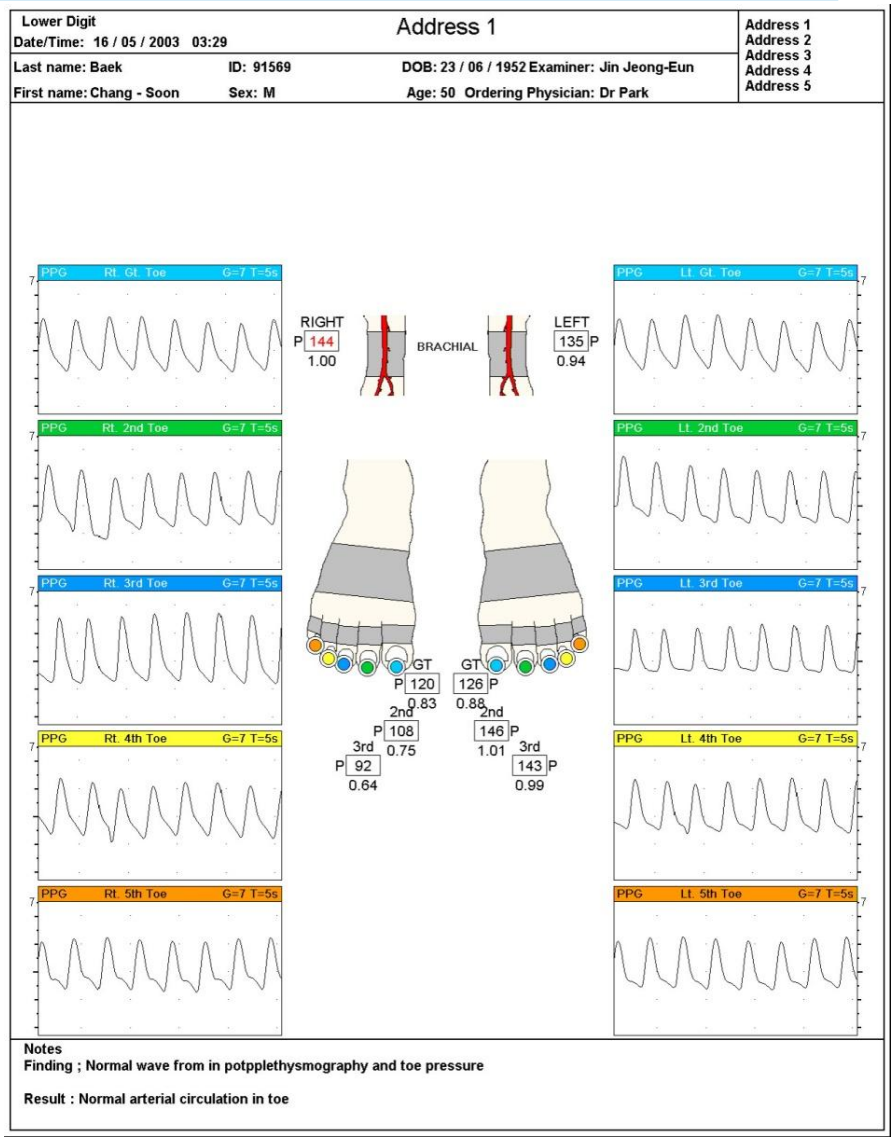
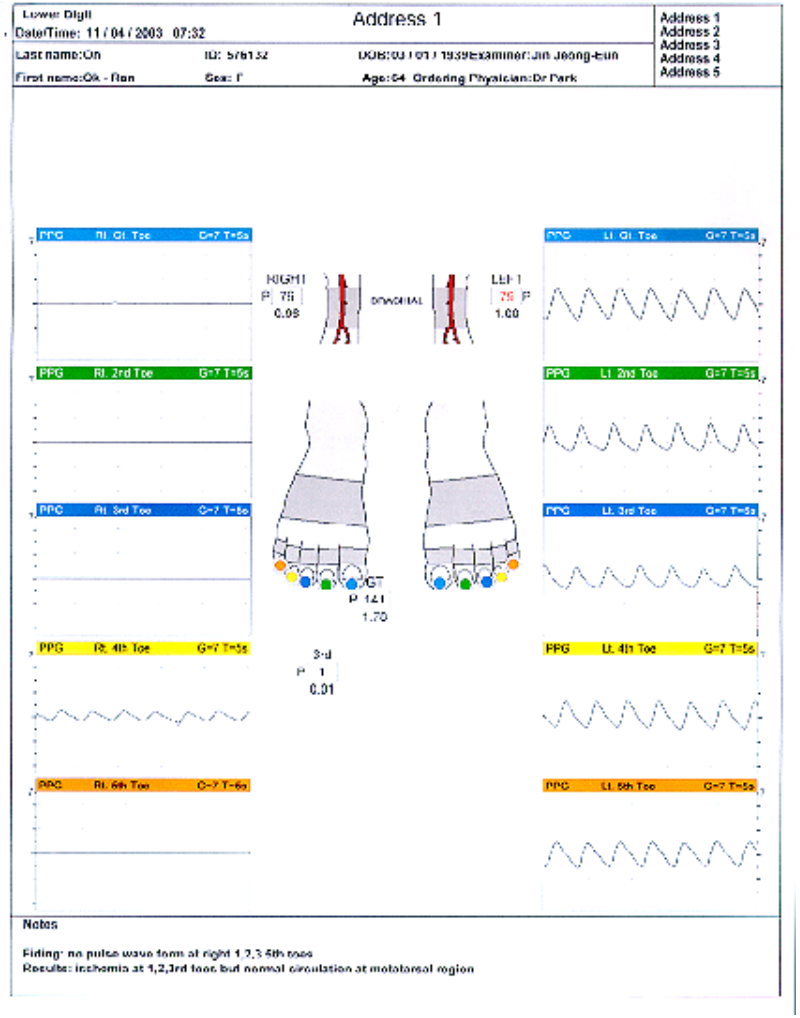


Photoplethysmography



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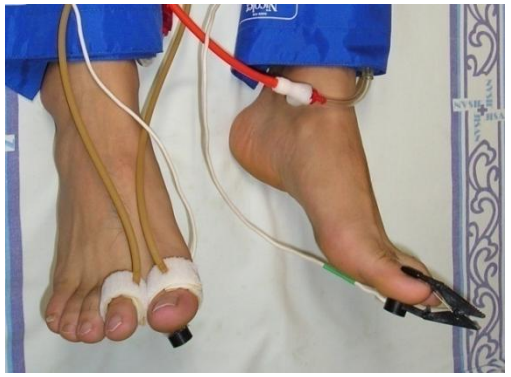
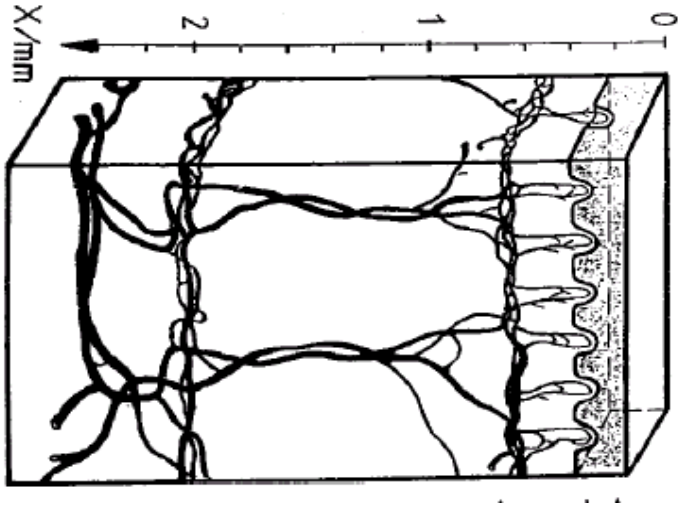
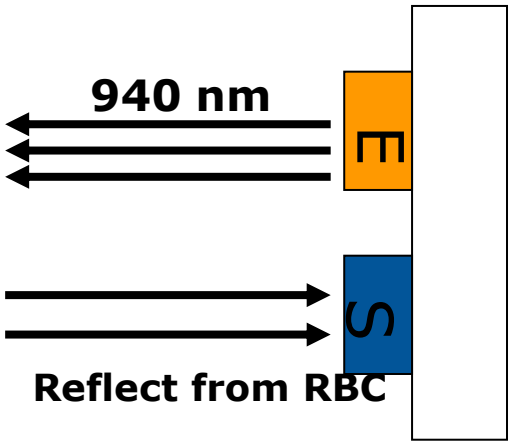
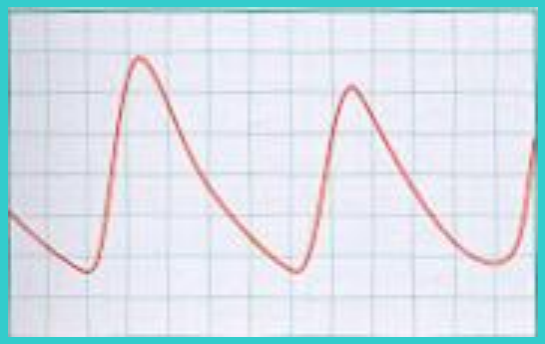




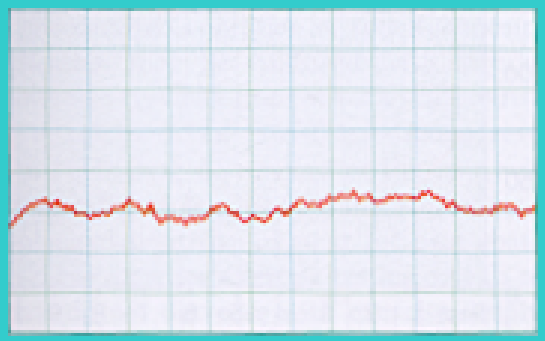


Toe photo-plethysmographic waveforms

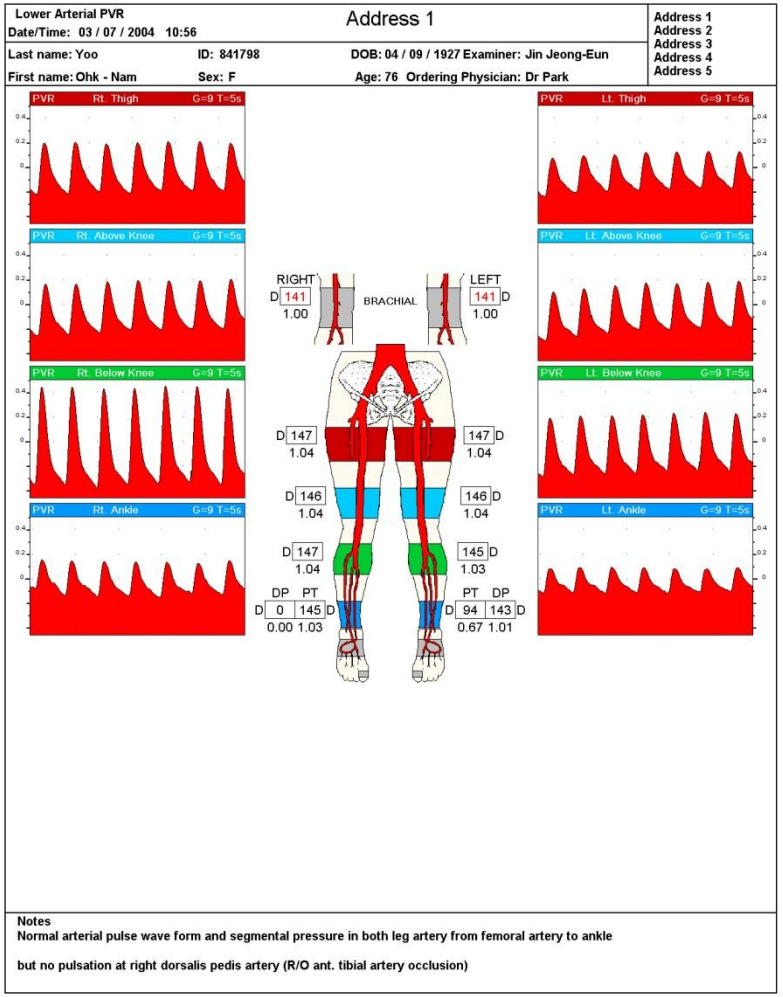
Normal digital artery waveform



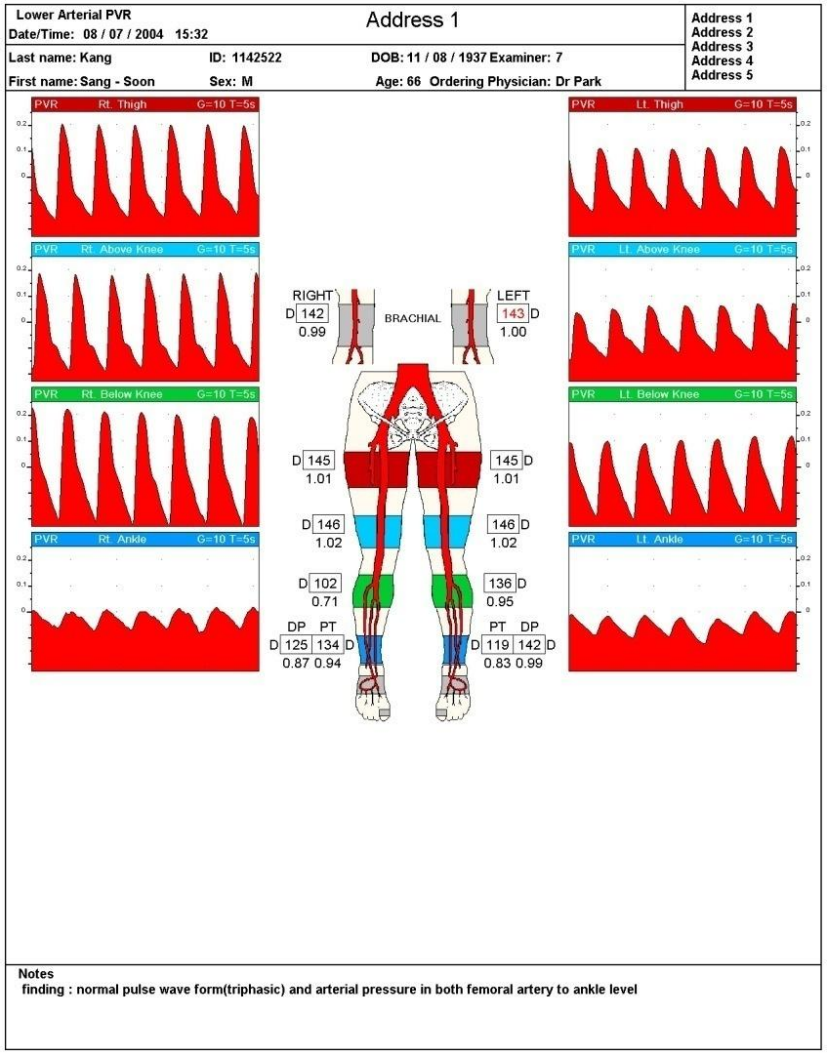
Obstructed digital artery waveform



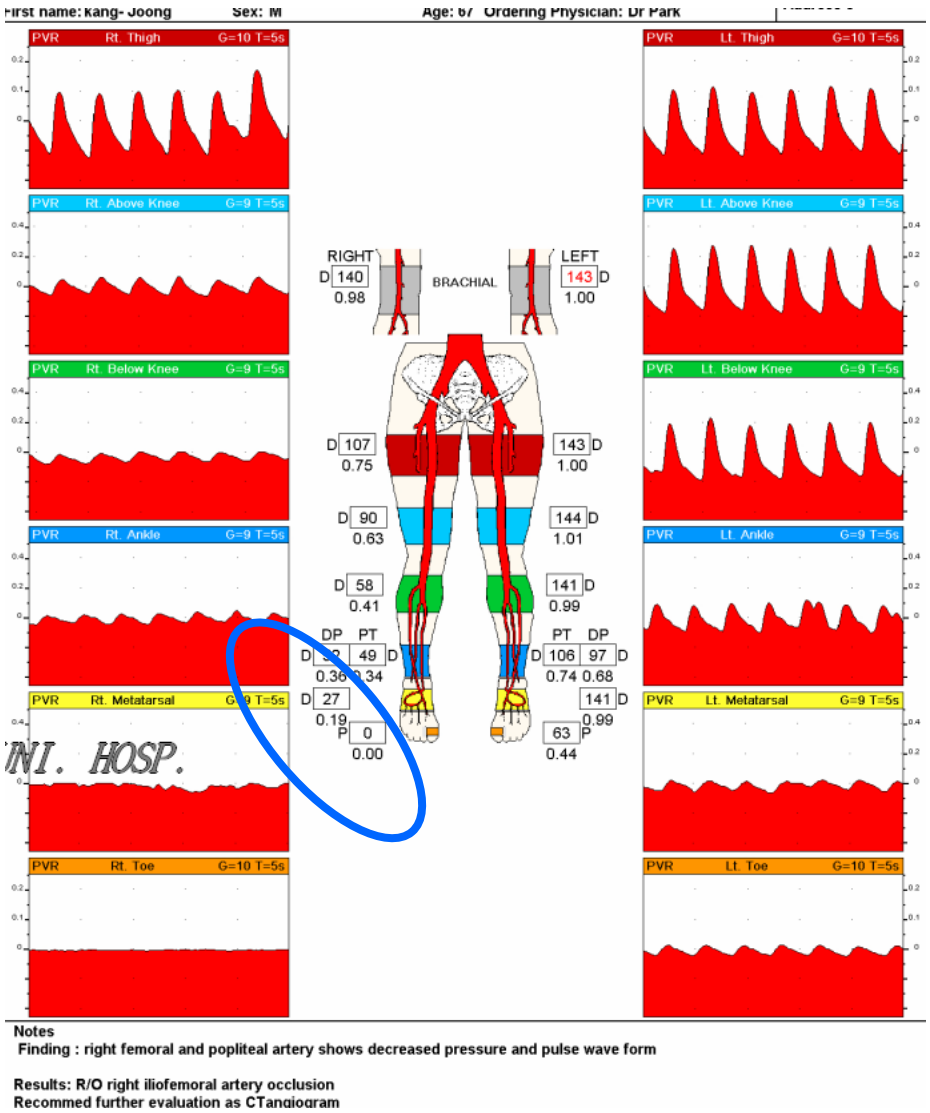
Case. No macro-angiopathy in DM foot ulcer



Case. No macro-angiopathy in DM foot ulcer



Case. Toe pressure in DM foot ulcer



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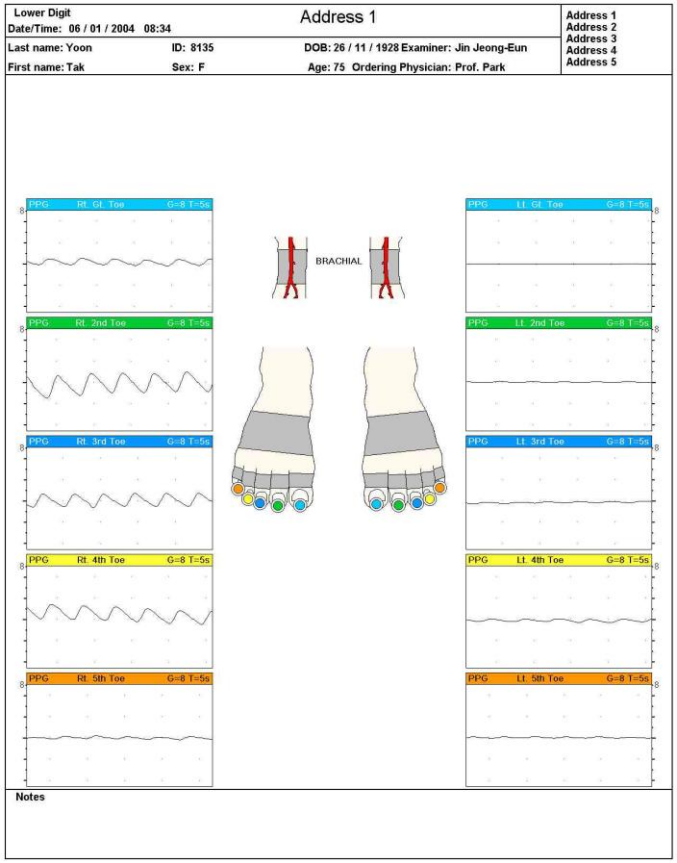
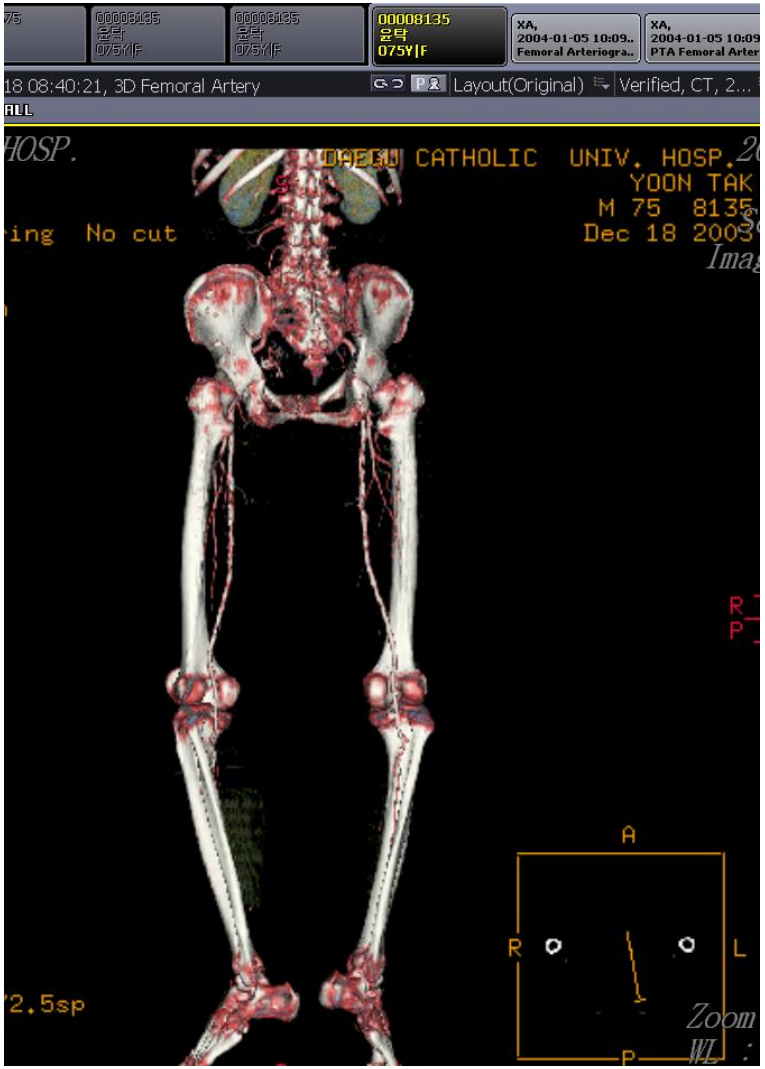
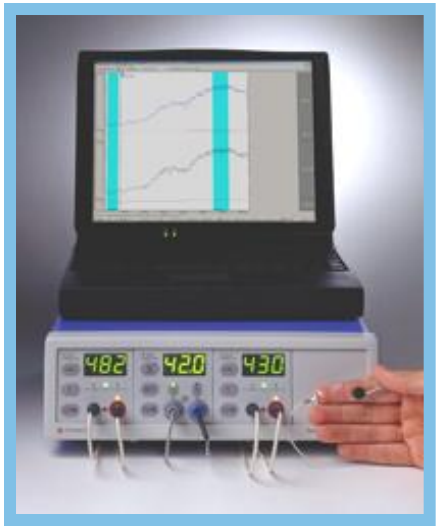


Photo-plethysmography



Transcutaneous oxygen tension

- Quantitative estimation of cutaneous oxygen delivery
- Reflect metabolic state of the target tissue, rather hemodynamic changes
- Not detect moderate arterial occlusion, only severe occlusion
- Limit accuracy, hyperkeratosis, edema, cellulitis
- Useful in predicting amputation, wound healing
- Wound heal > $TCPO_2$ 30mmHg, fail < $TCPO_2$ 20mmHg



Imaging studies in DM foot

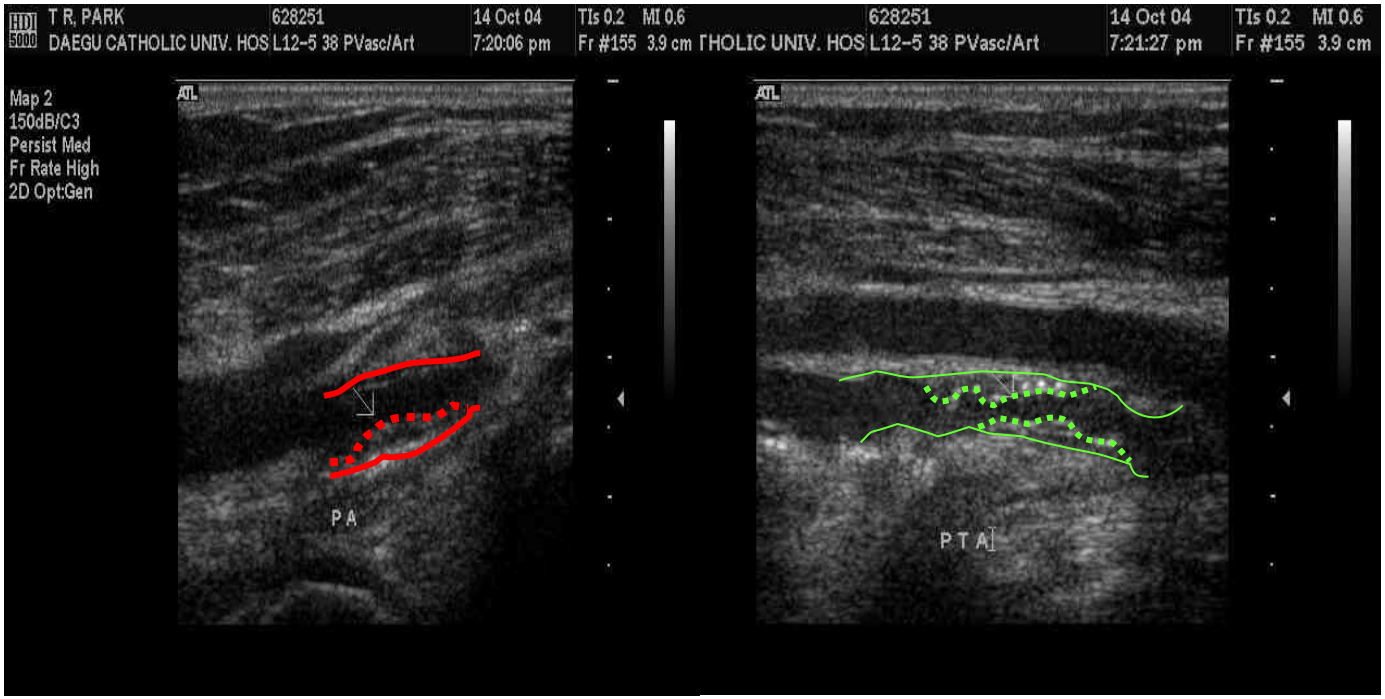
Imaging studies in DM foot

- Duplex scan
- CT-angiogram
- MR-angiogram
- Conventional angiogram

Duplex scan

- Gray scale B-mode image
- Color flow image
- Pulsed doppler spectral waveform analysis

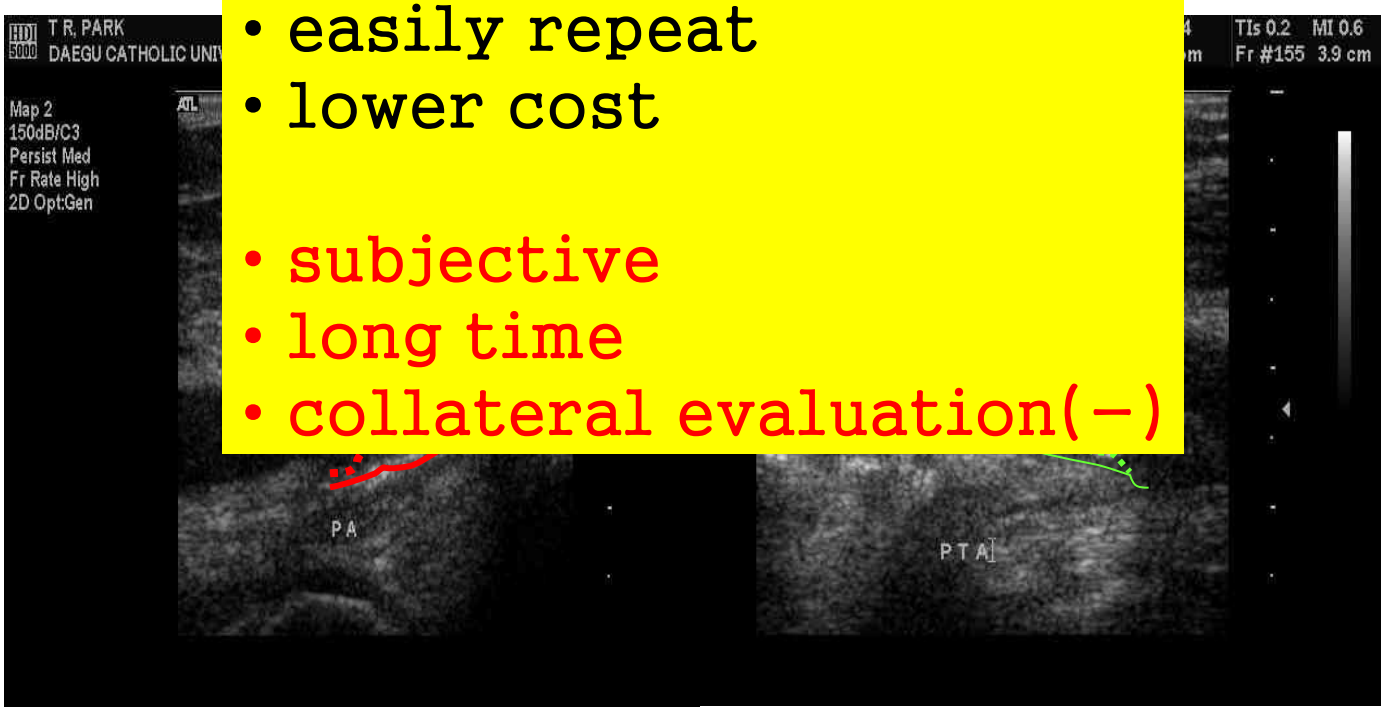
DM with CRF


T R, PARK
628251
14 Oct 04
TIs 0.2 MI 0.6
DAEGU CATHOLIC UNIV. HOS L12-5 38 PVasc/Art
7:20:06 pm
Fr #155 3.9 cm
Map 2
150dB/C3
Persist Med
Fr Rate High
2D Opt:Gen
PA
628251
14 Oct 04
TIs 0.2 MI 0.6
CATHOLIC UNIV. HOS L12-5 38 PVasc/Art
7:21:27 pm
Fr #155 3.9 cm
PTA

DM with CRF

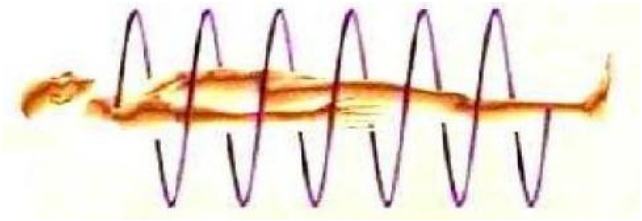
- Non invasive
- easily repeat
- lower cost

- subjective
- long time
- collateral evaluation(−)

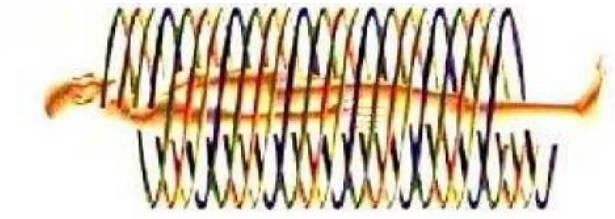


MD(multi detector row)-CT Angiogram

- Breakthrough in CT technology 1998
- Thinner reconstruction
- Improved longitudinal resolution – 3D
- Various arterial system (Cerebral, Coronary, peripheral) were in studying



Sprial CT



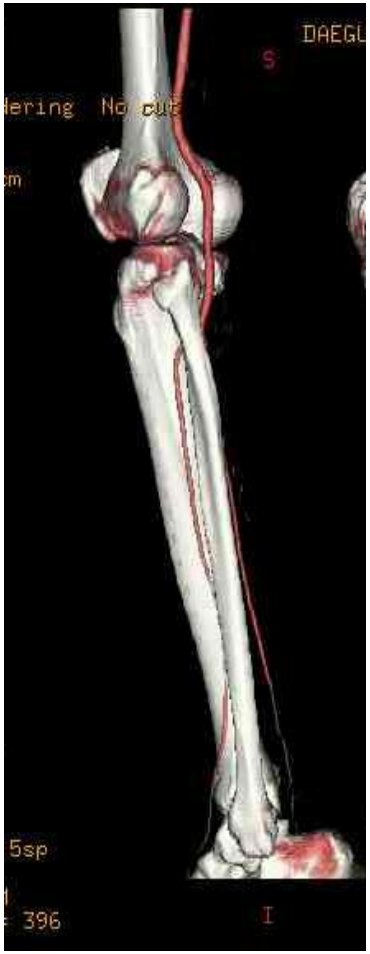
MD CT

MD-CT Angiogram

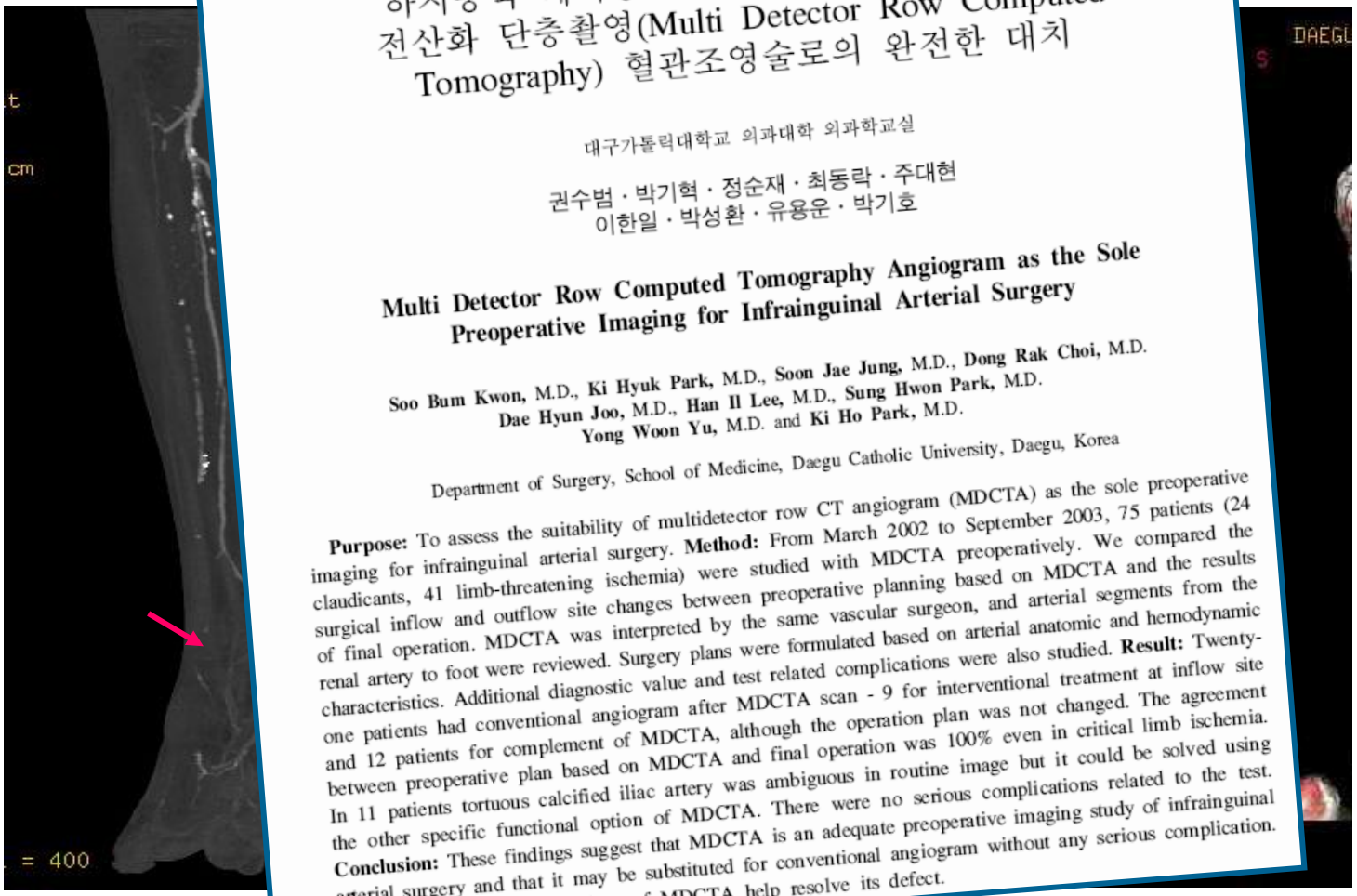
- OPD base perform
- No pain, No fear
- Low cost
- Easily done in emergecy
- Avoid puncture related Cx

Pseudoaneurys
Hematoma
Infection

Tibioperoneal artery in MDCTA



Tibioperoneal artery in MDCTA



대한혈관외과학회지 : 제 20 권 제 1 호
Vol. 20, No. 1, May, 2004

하지동맥 폐색증의 수술 전 진단에서 다측정 전산화 단층촬영(Multi Detector Row Computed Tomography) 혈관조영술로의 완전한 대치

대구가톨릭대학교 의과대학 외과학교실

권수범 · 박기혁 · 정순재 · 최동락 · 주대현
이한일 · 박성환 · 유용운 · 박기호

Multi Detector Row Computed Tomography Angiogram as the Sole Preoperative Imaging for Infrainguinal Arterial Surgery

Soo Bum Kwon, M.D., **Ki Hyuk Park**, M.D., **Soon Jae Jung**, M.D., **Dong Rak Choi**, M.D.
Dae Hyun Joo, M.D., **Han Il Lee**, M.D., **Sung Hwon Park**, M.D.
Yong Woon Yu, M.D. and **Ki Ho Park**, M.D.

Department of Surgery, School of Medicine, Daegu Catholic University, Daegu, Korea

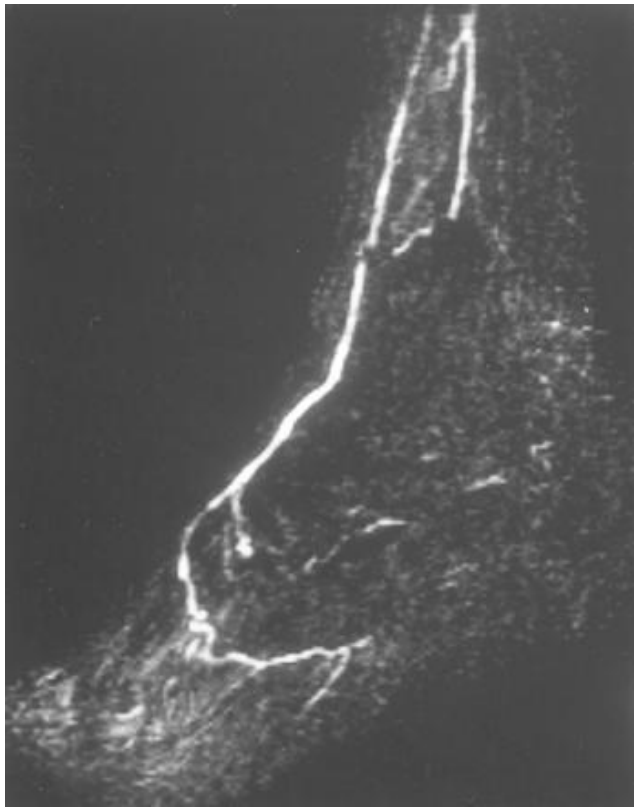
Purpose: To assess the suitability of multidetector row CT angiogram (MDCTA) as the sole preoperative imaging for infrainguinal arterial surgery. **Method:** From March 2002 to September 2003, 75 patients (24 claudicants, 41 limb-threatening ischemia) were studied with MDCTA preoperatively. We compared the surgical inflow and outflow site changes between preoperative planning based on MDCTA and the results of final operation. MDCTA was interpreted by the same vascular surgeon, and arterial segments from the renal artery to foot were reviewed. Surgery plans were formulated based on arterial anatomic and hemodynamic characteristics. Additional diagnostic value and test related complications were also studied. **Result:** Twenty-one patients had conventional angiogram after MDCTA scan - 9 for interventional treatment at inflow site and 12 patients for complement of MDCTA, although the operation plan was not changed. The agreement between preoperative plan based on MDCTA and final operation was 100% even in critical limb ischemia. In 11 patients tortuous calcified iliac artery was ambiguous in routine image but it could be solved using the other specific functional option of MDCTA. There were no serious complications related to the test. **Conclusion:** These findings suggest that MDCTA is an adequate preoperative imaging study of infrainguinal arterial surgery and that it may be substituted for conventional angiogram without any serious complication. The particular functional options of MDCTA help resolve its defect.

MR angiography

- Contrast(gadolinium)-enhanced MRA
- Minimal risk of nephropathy
- Some reports MRA is superior to DSA for distal artery imaging (image blood flow as slow as 2cm/sec)
- Tends overestimate stenosis

MR angiography

No visible in DSA



DPA with MRA

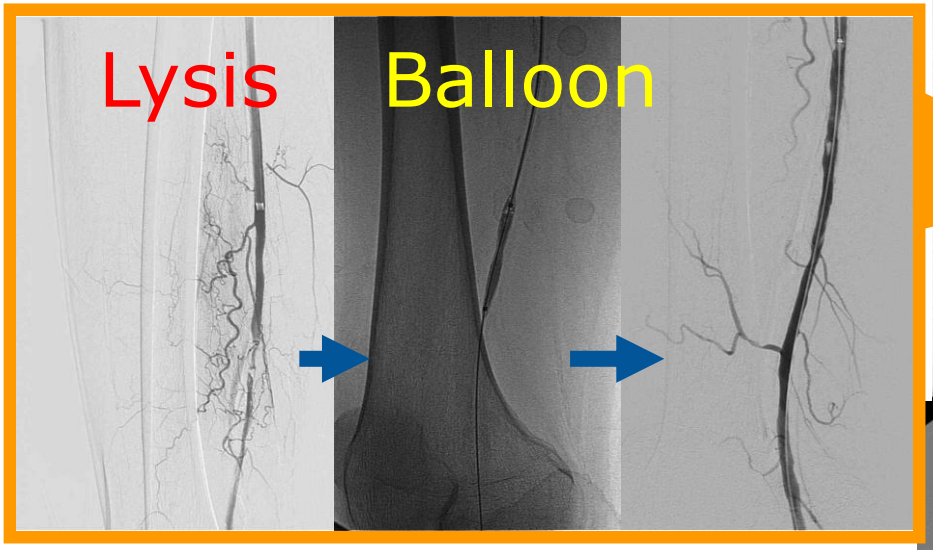
DM with 78yrs old with Nephropathy

Conventional angiography

- No more standard for vascular imaging
- Endovascular theraphy (balloon angioplasty, thrombolysis) at same time
- Intra-arterial digital subtraction angiography(DSA) scan especially for digital artery in foot
- Contrast-induced nephropathy higher in DM(13%) (*Gomes. AJR. 1985*) but only small fraction require long term dialysis

Conventional angiography

Conventional Angiogram during Endovascular Theraphy



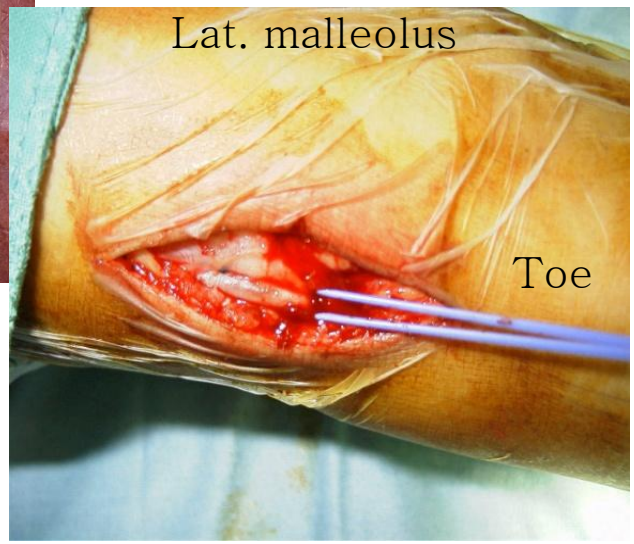
Paramalleolar artery in Angiogram

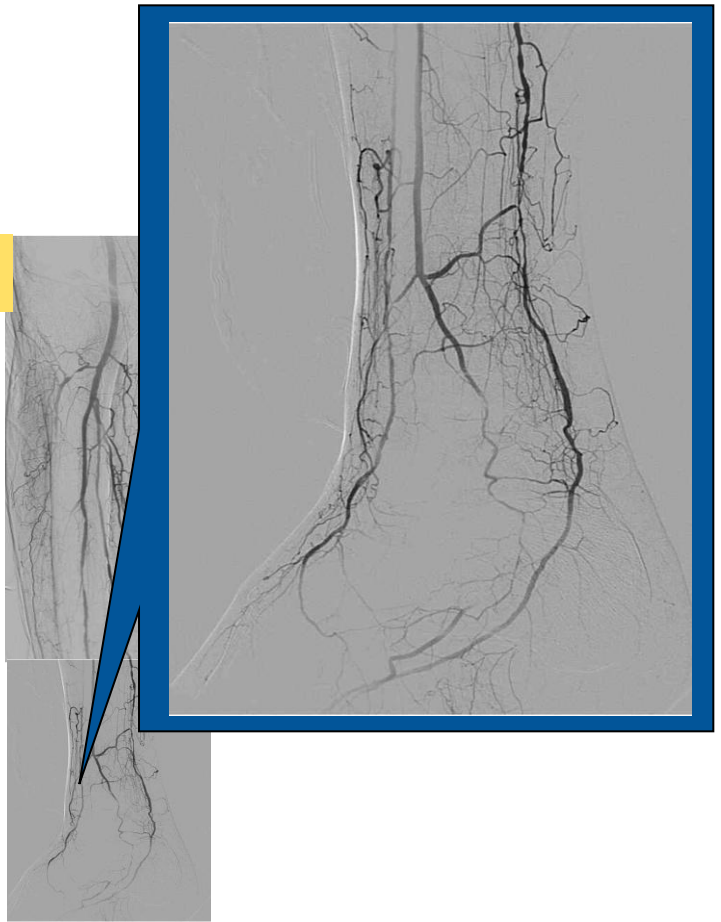
- Dorsalis pedis artery is the most common distal outflow in DM spared in 70% of DM(*Menzoian 1989*)
- Never terminate at the midtibia level

Paramalleolar artery in Angiogram

- Dorsalis pedis artery is the most common distal outflow in DM spared in 70% of DM(*Menzoian 1989*)

Bypass with saphenous vein





Summary

- Comprehensive approach with noninvasive hemodynamic & imaging study for diagnosis ischemia in DM foot wound management
- Noninvasive hemodynamic study for screening method, selective imaging evaluation for anatomic study

62/M, DM for 10yrs, Hx: Lt 3rd toe amputation due to infection

CONSULTATION REPORT

Name _____ Sex/Age M / 68 Status 보행가능 Room No. 0742 Hospital No. 00931029

HOSPITAL REGULATIONS : Complete and Report Consultations Within 24 Hours of Receipt Request.

REQUEST FOR CONSULTATION TO 외과 박기혁 [2108]
PHYSICIAN OR SERVICE

Summary of Present Findings.

안녕하십니까? 교수님

상기환자 known DM pt.로 내원 일주일전 Rt. 2nd distal phalanx에 wound 생겨

self dressing 하였으나 호전 없어 2/9일경 LMC 방문하여 conservative Tx. 하였으나

necrotic change 보여 큰병원 권유받고 본과 외래 통해 입원하신 분으로

상기 증상에 관하여 귀과적 management 고견 문의드리고자 consult 드립니다.

부디 고진선처 바랍니다. 감사합니다.

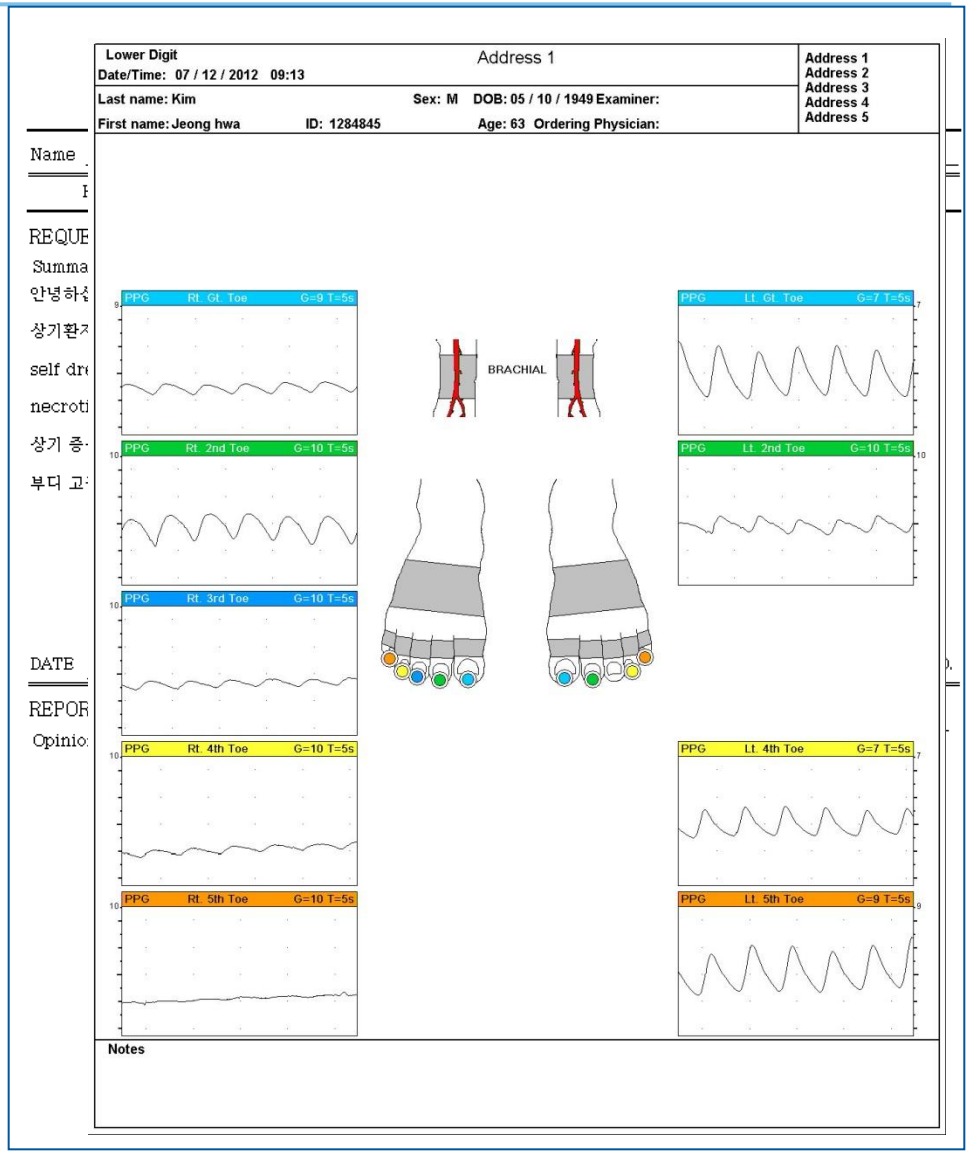
DATE 2013-02-12 오후 4:41:29 SIGNATURE OF PHYSICIAN 정형외과 [2289] M. D.

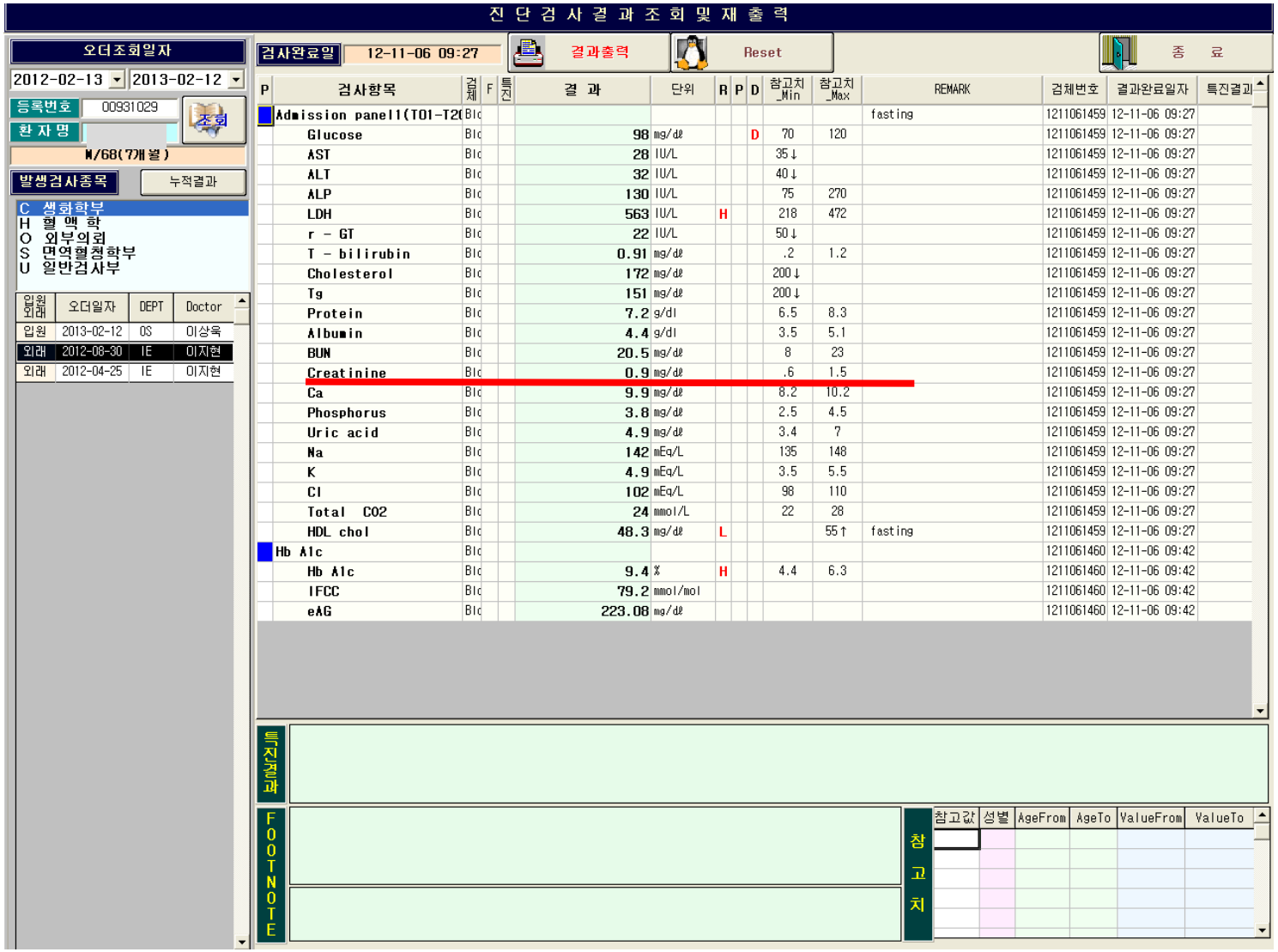
REPORT OF CONSULTATION

Opinion and Recommendation; Impression; Comment

Request Received _____
DATE

62/M, DM for 10yrs, Hx: Lt 3rd toe amputation due to infection

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2012-02-13
2013-02-12
등록번호
00931029
조회
환 자 명
M/68(7개월)
발생검사종목
누적결과
C 생화학부
H 혈 액 학
O 외부의뢰
S 면역혈청학부
U 일반검사부
입원 외래
오더일자
DEPT
Doctor
입원 2013-02-12 OS 이상욱
외래 2012-08-30 IE 이지현
외래 2012-04-25 IE 이지현
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Protein Blc 7.2 g/dl 6.5 8.3 1211061459 12-11-06 09:27
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Hb A1c Blc 1211061460 12-11-06 09:42
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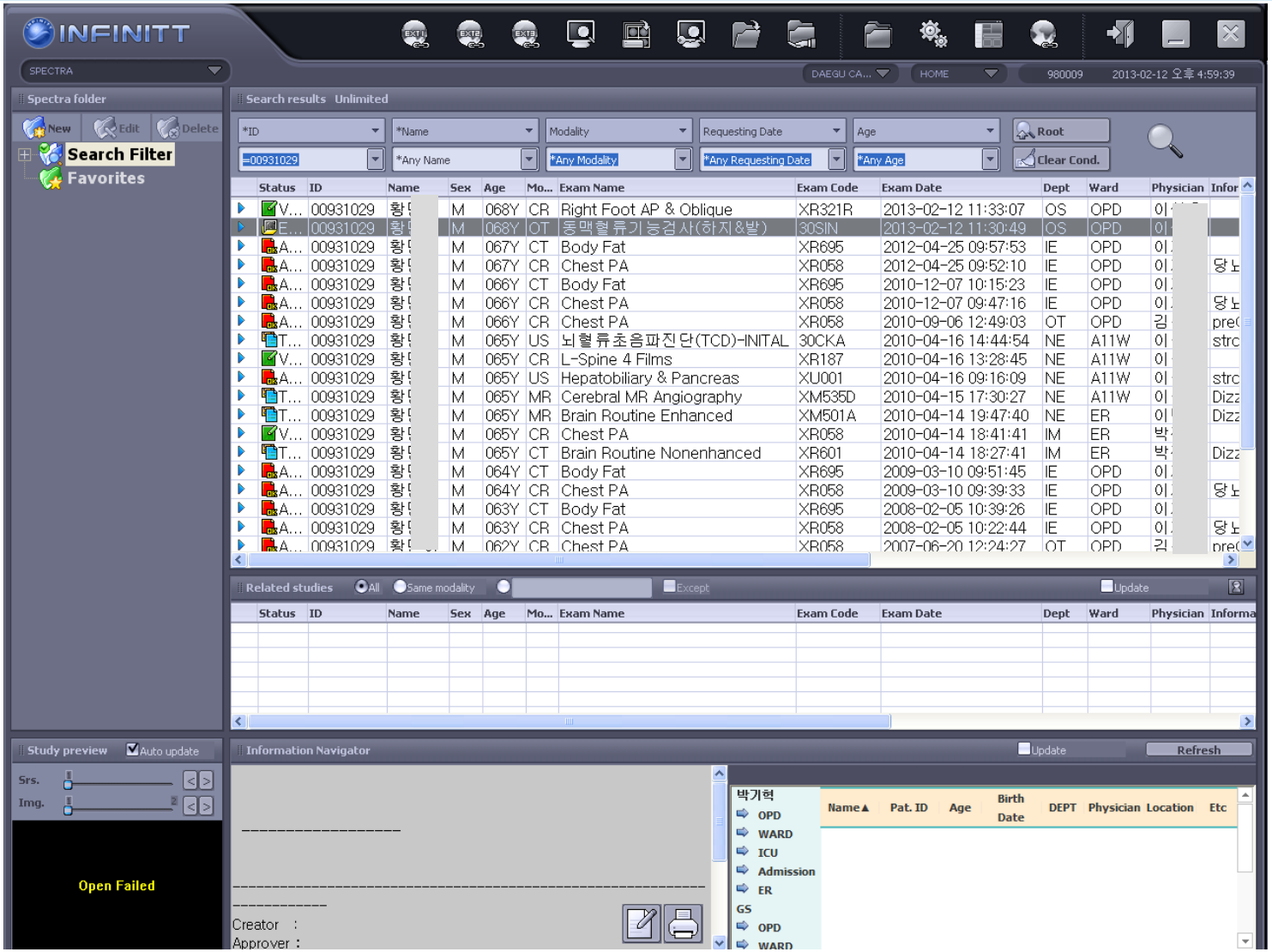
참고치
참고값 성별 AgeFrom AgeTo ValueFrom ValueTo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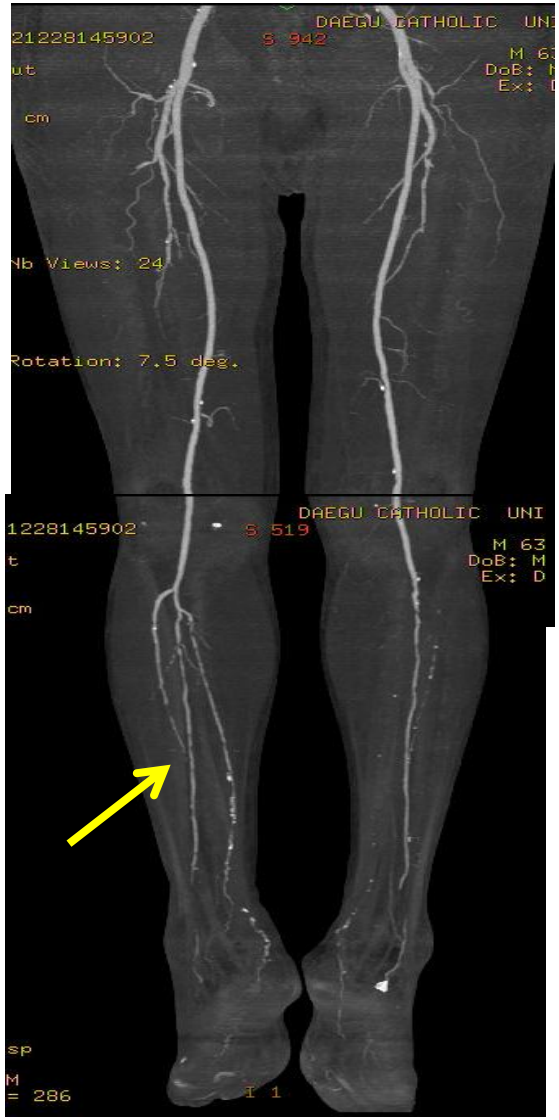
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After tibial artery balloon angioplasty 14days : aggravated

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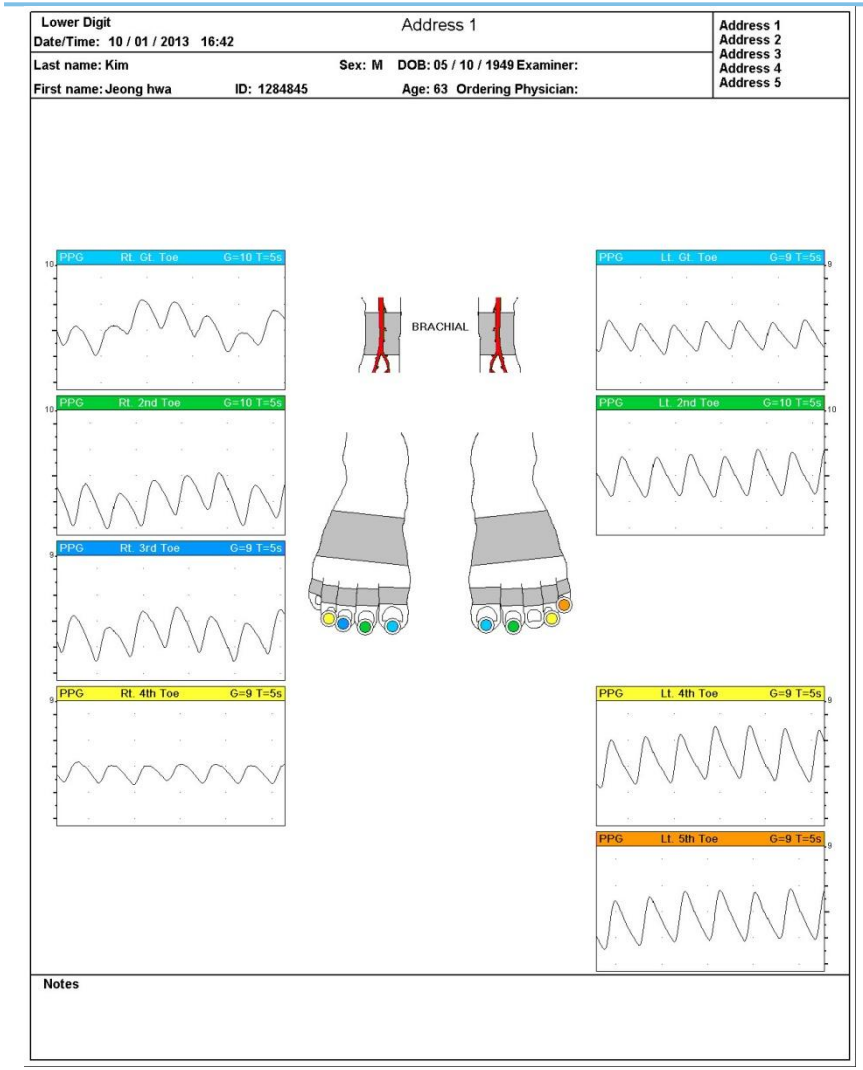
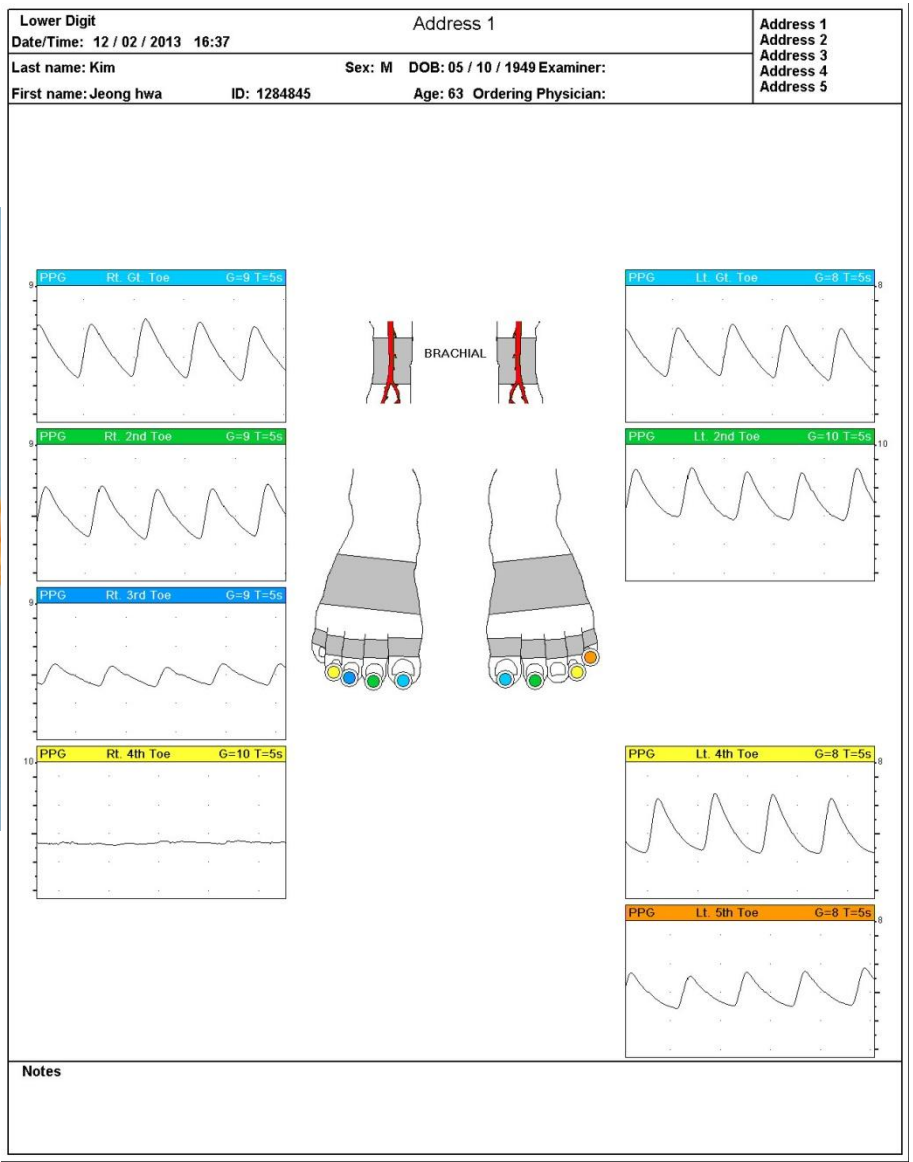


Revascularization + Amputation



감사합니다.