OPCAB:
Off-pump Coronary Artery Bypass

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SMC TS

OPCAB?

- Coronary artery bypass grafting without cardiopulmonary bypass.

- 인공심폐기를 사용하지 않는 관상동맥우회술
- 무펌프관상동맥 우회술?

Invasiveness of OHS

- CPB: hemodilution, stoke, renal insufficiency,
  coagulopathic bleeding,
  systemic inflammatory response

- Manipulation of aorta: neurologic sequelae

- Median sternotomy: pain, pulmonary dysfunction,
  sternal wound infection,
  brachial plexus injury

Terminology

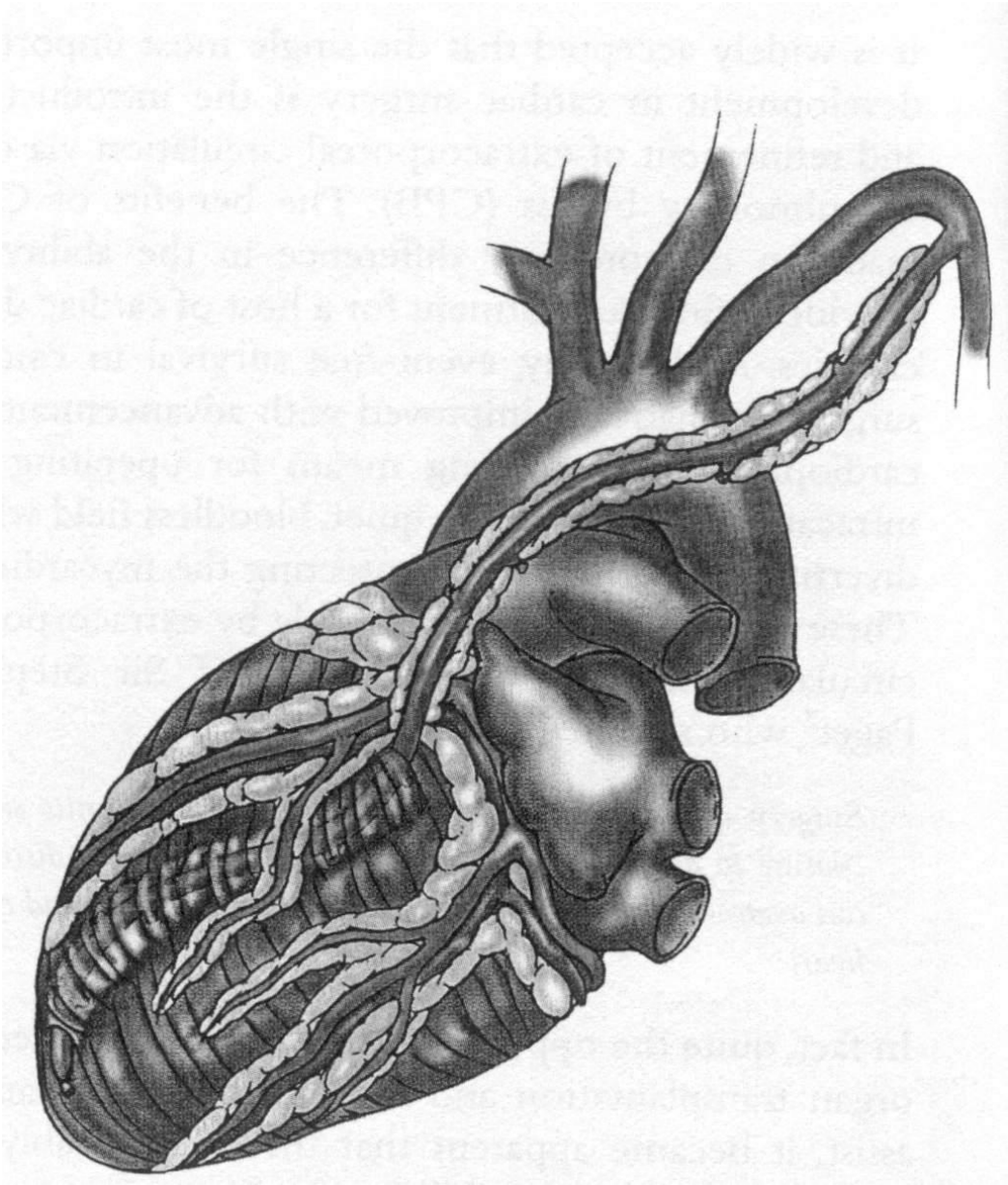
	CPB	ACC	full sternotomy
Conventional CABG	+	+	+
Off-pump CABG(OPCAB)	-	-	+
On-pump beating heart CABG	+	-	+
Minimally invasive direct CABG (MIDCAB)	-	-	-

*CPB: cardiopulmonary bypass, ACC: aortic cross clamping

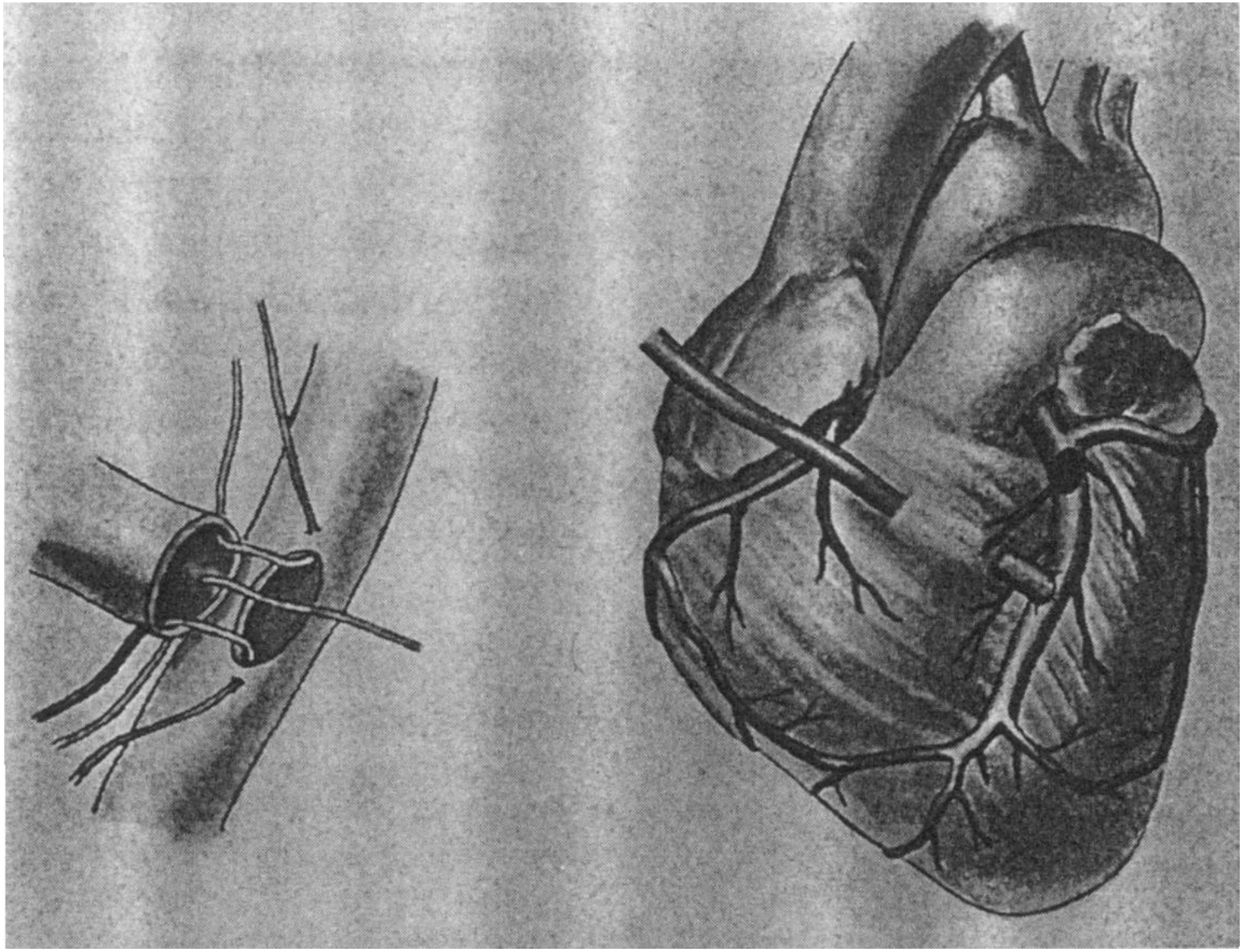
History of OPCAB (I)

- 1946 Vineberg: IMA into cardiac muscle
- 1954 Murray: Experimental anastomosis
- 1962 Sabiston: First CABG (SVG to RCA)
- 1964 Kolessov: LITA to LAD or LCx

  (thoracotomy)



제7차 전공의 학술세미나



History of OPCAB (II)

- ~ 1980: Conventional CABG
- 1980 Benetti: Initial experience of OPCAB
- 1985 Buffolo: large experience
- 1992 Pfister: USA, safety of OPCAB

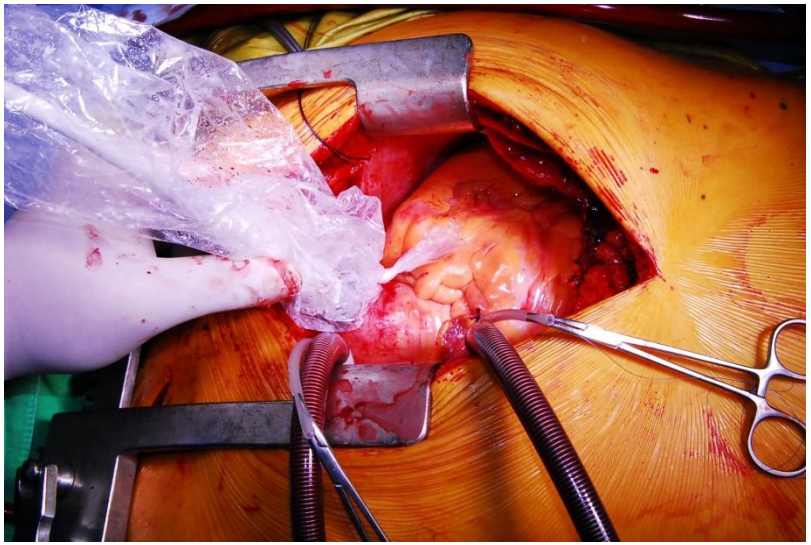
Indications ?

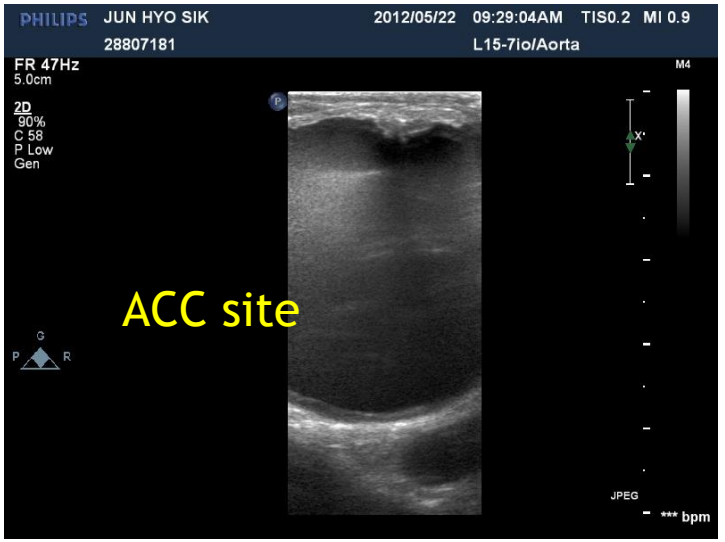
- With little experience
  - 1 ~ 3 bypasses
  - Anterior cardiac surface
  - Large target vessels
  - Minimal distal disease
  - Elective
  - Hemodynamically stable

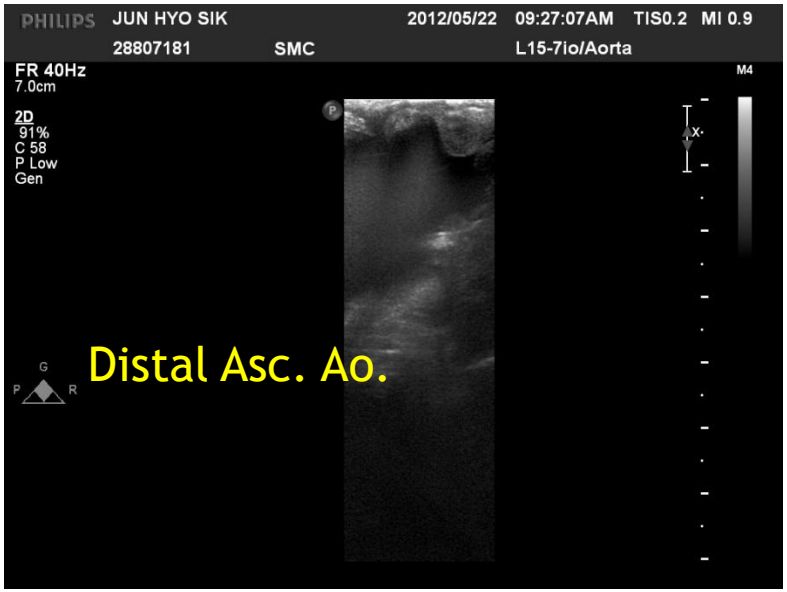
Indications ?

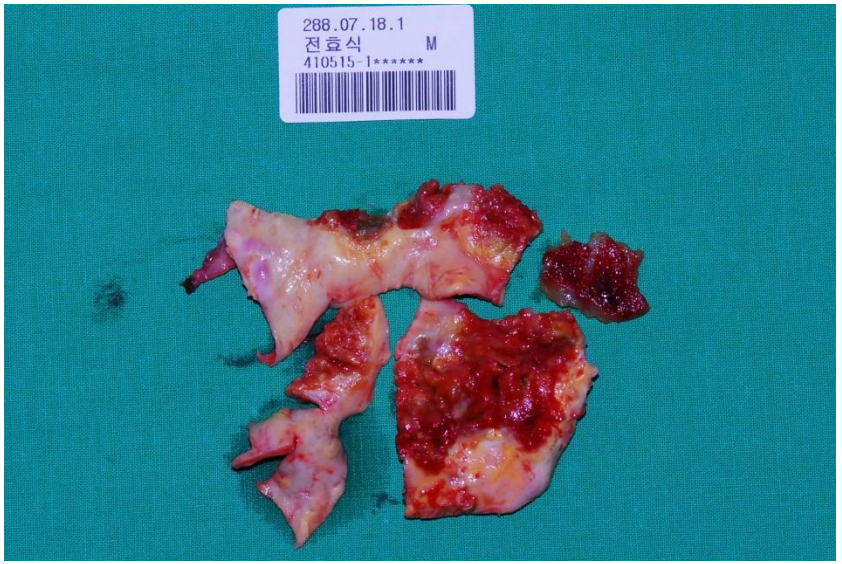
- When experienced
  - Elderly
  - Re-operative
  - Poor left ventricular function
  - Cerebral vascular disease
  - Peripheral vascular disease
  - Chronic lung disease
  - Chronic renal insufficiency
  - Significant co-morbidities

Atherosclerosis of Aorta









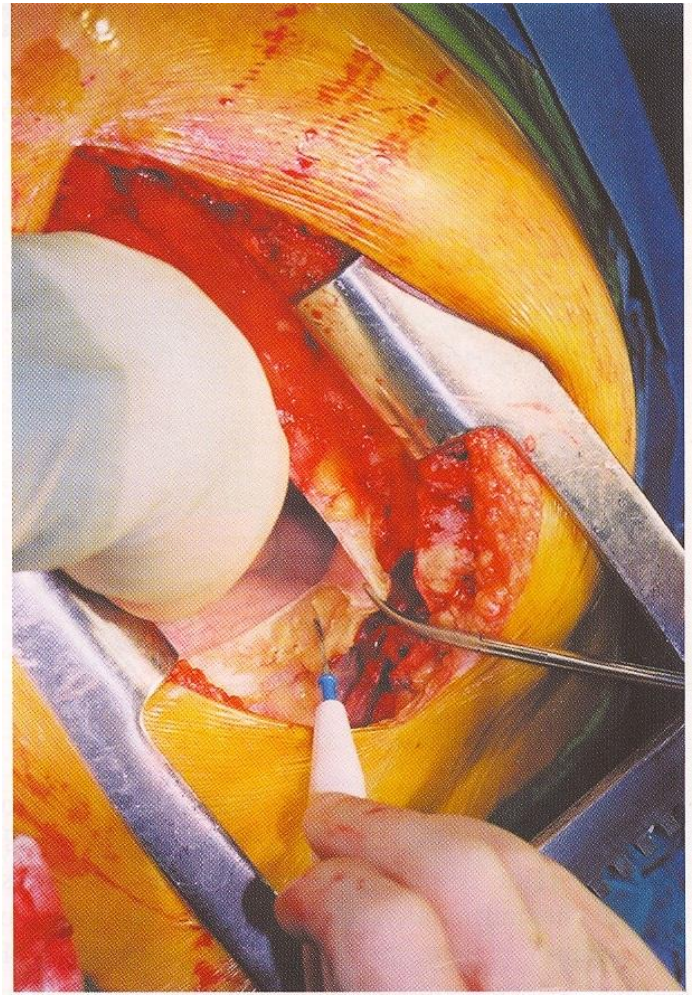
Anesthetic Preparation

- Use intermediate or short-acting agents
- Avoid hypothermia
  - Warming mattress, fluid & gas, room temperature
- Oxymetric pulmonary artery catheter
- TTE
- Adequate cardiac filling pressure
  - Volume loading
  - Trendelenberg position
- Intravenous NG
- Judicious use of positive inotropes
- Avoid negative inotropes

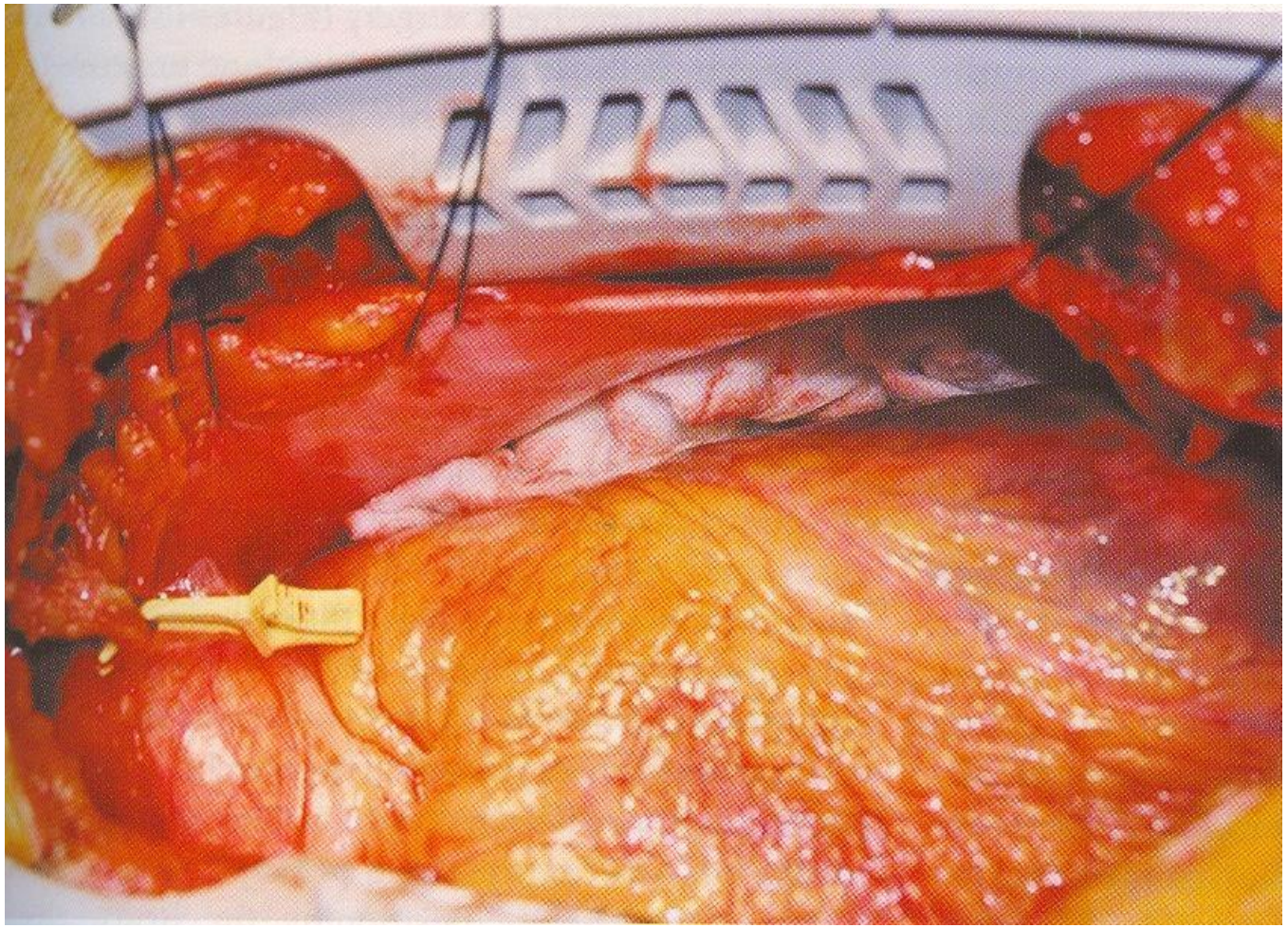
Preparations

- Extended pericardiotomy in inverted T-shape
- Right pleural usually opened
- Deep pericardial tenting suture
- Stabilizer & apical suction devices
- Reduce tide volume for ventilation
- Palpation of aorta for possible cannulation & proximal anastomosis
  - Aorta CT, TEE, epi-aortic scan

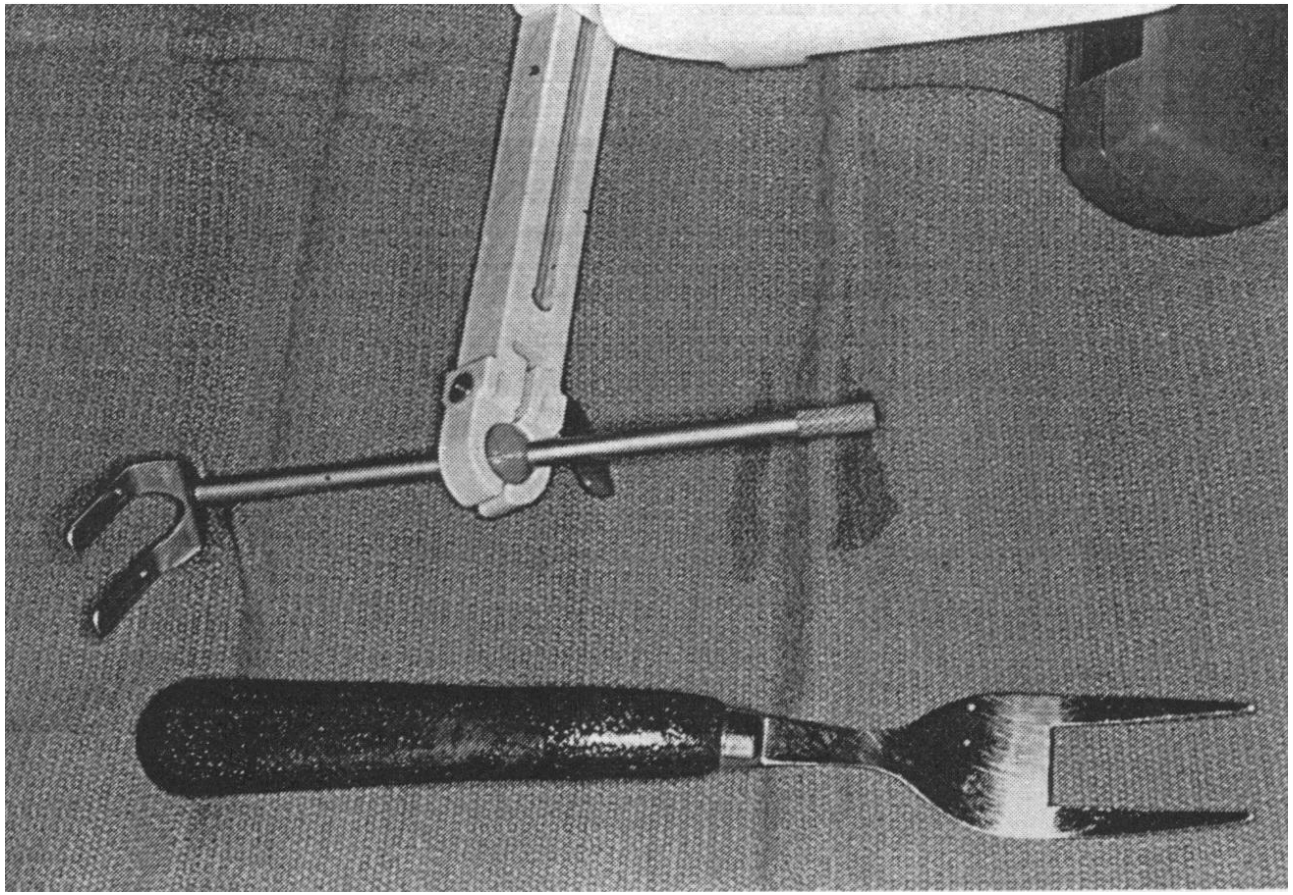
Extended Pericardiotomy



Deep Pericardial Tenting Suture



Mechanical Immobilization

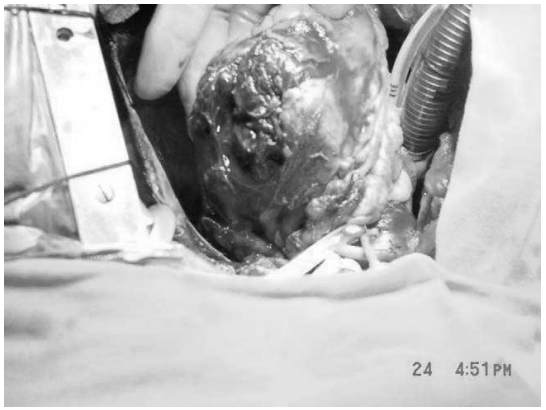


Stabilizer & Apical Suction Devices

- Medtronic
  - Octopus < - 400mmHg
  - Starfish < - 400mmHg
  - Urchin < - 250mmHg

- Marquet
  - Acrobat < - 400mmHg
  - Xpose < - 250mmHg

- Rosta < - 400mmHg



Stabilizer Effect

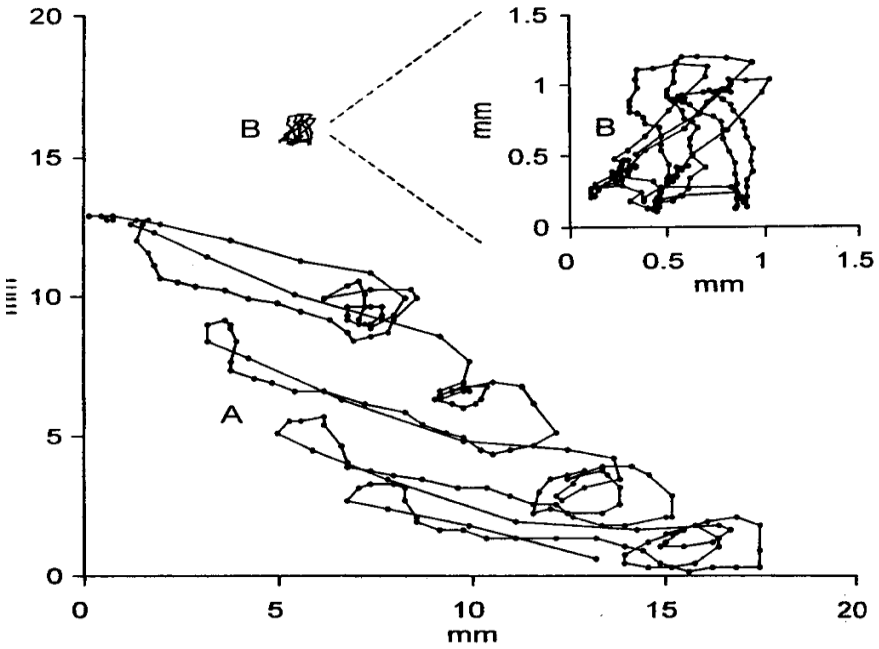
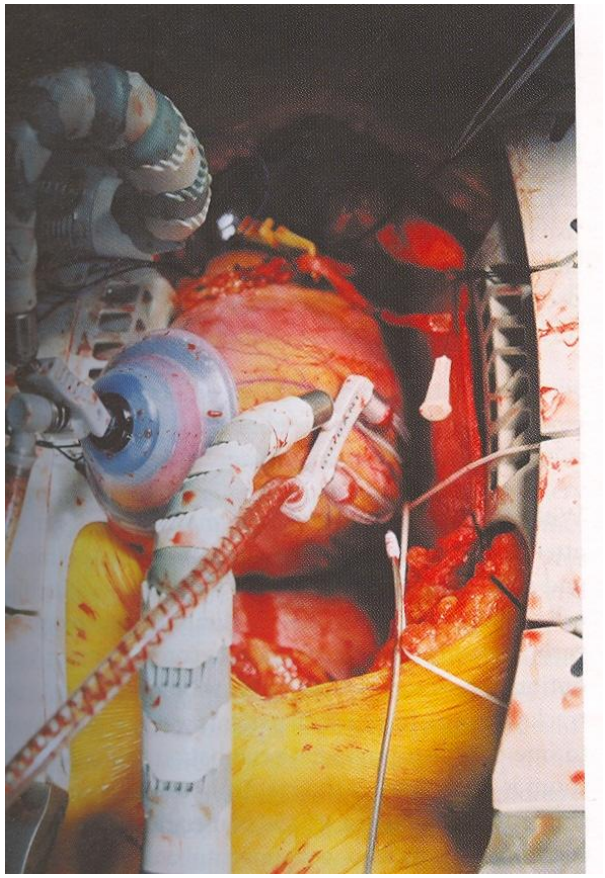


Fig. 15-1. Example of two-dimensional epicardial beacon (represented by a dot) motion in the obtuse marginal artery (OM) area during an open chest procedure in the pig: Unrestrained (Off) and restrained by the Octopus (On). The dotted line represents the motion during four heartbeats and one half respiratory cycle.

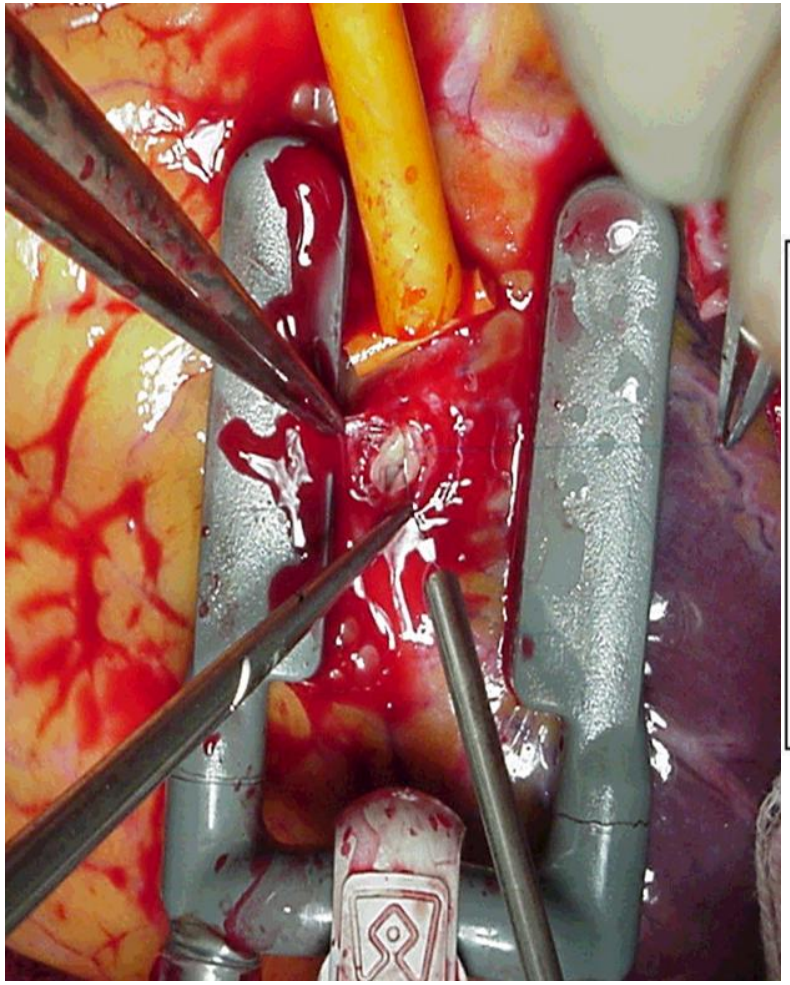


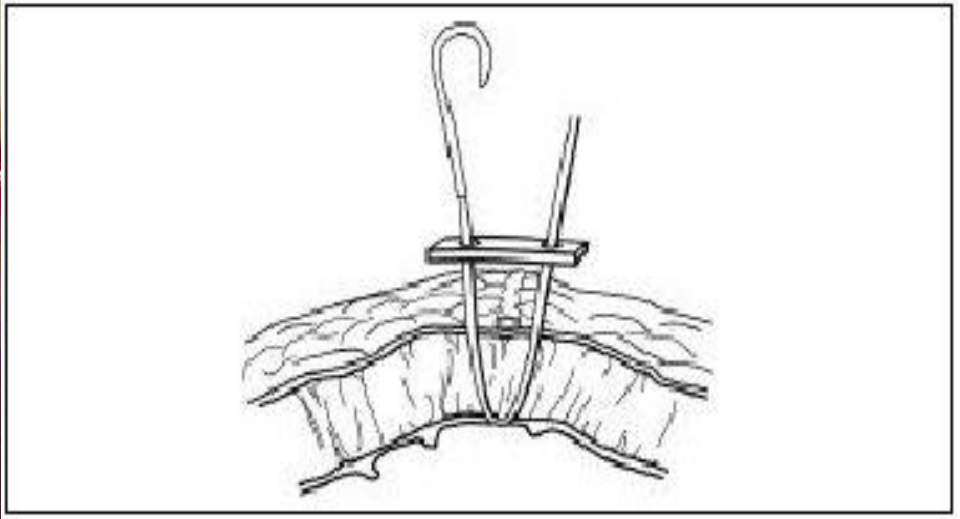
Sequence of Anastomosis

- From easiest to hardest
  - Collaterized vessels first
  - LAD with LITA
  - Proximal before distal
  - Diagonal
  - Main RCA
  - PDA
  - Distal circumflex, OM2, OM3
  - PL
  - Proximal OM
  - Ramus intermedius

External Occlusion

- Vessel loops





Ischemic Preconditioning

- 1986 Murry et al.
- Repeated short episodes of ischemia protect the myocardium against a subsequent ischemic insult
- Endothelium-dependent relaxation, endotherial viability, beta adrenergic regulation, post-ischemic myocardial blood flow, neutrophil accumulation

Pros

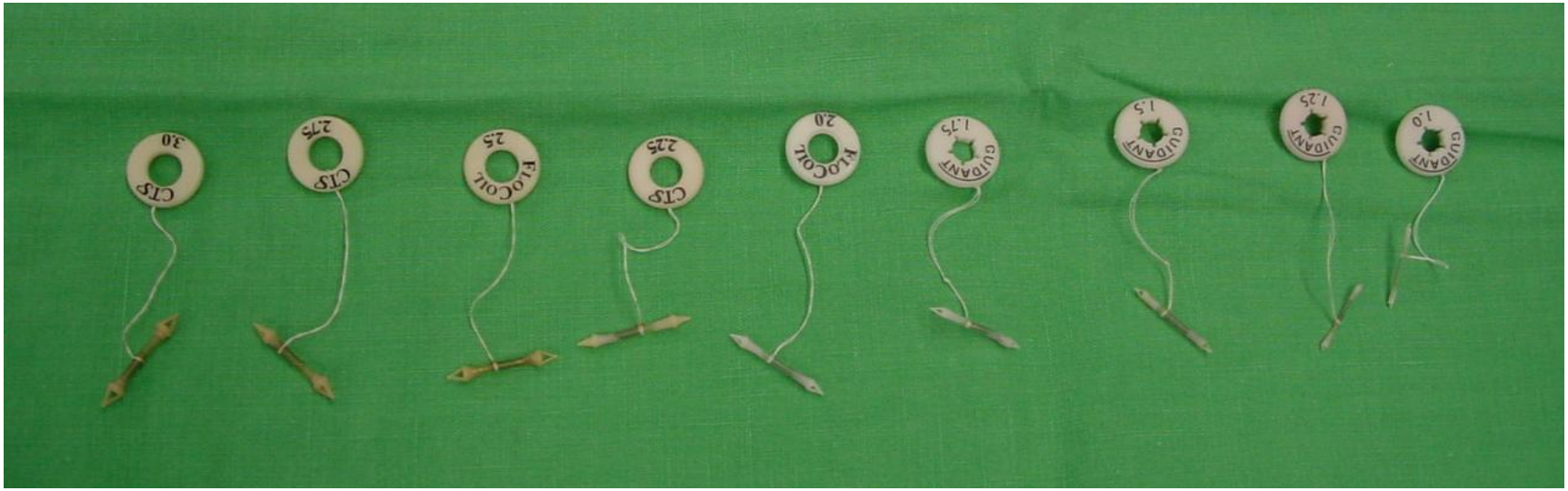
- Laurikka et al. Chest 2002
- Yellon et al. Lancet 1993
- Saeian et al. Echocardiography 1990
- Sabbah et al. Circulation 1986

Cons

- Luchetti et al. Eur J Cardiothora Surg 1998
- Malkowski et al. J Am Coll Cardio 1998
- Dupouy et al. J Am Coll Cardio 1996
- Tofukuji et al. Circulation 1998

Intraluminal Coronary Shunt

- 1.0 ~ 3.0 mm
- Increment by 0.25mm



Snaring vs Shunt

Snaring

- Induce ischemia
- Easy to perform anastomosis
- Long ateriotomy
- Possible damage to coronary vessel
- Stitch can catch post. wall of coronary a.
- Reperfusion can induce arrhythmia

Shunt

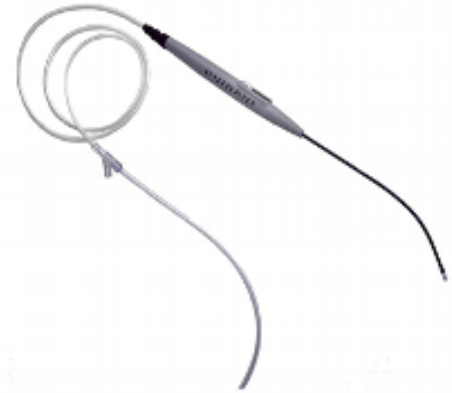
- Without ischemia
- Stabilize hemodynamics
- Use smaller one
- Possible damage to endothelium
- Stitch can catch shunt
- Be careful when you remove

Indications of Coronary Shunt

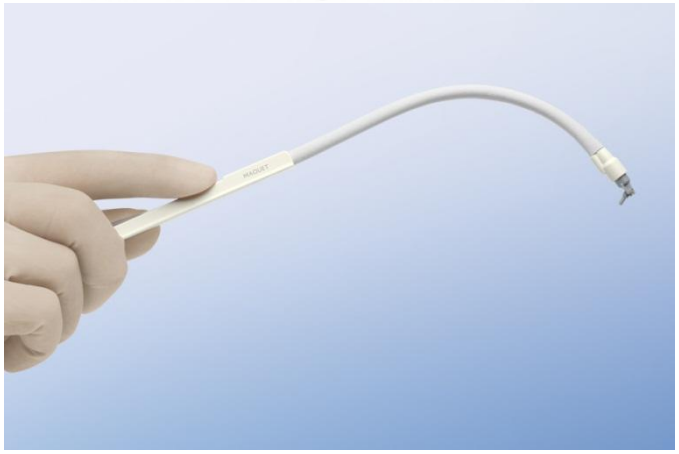
- Anatomic indications
  - Proximal LAD
  - Main RCA
  - Not tight stenosis
  - Deep-seated or intramyocardial LAD
  - Source of collaterals to large territory
- Hemodynamic instability or myocardial ischemia
  - Low systemic BP
  - High PAP
  - High PCWP
  - Arrhythmia

Blower Mister

- Humidified CO2 blower
- CO2 ; 34 times more soluble than air
- 3 ~ 7 (< 8) L/min
- 50 mmHg

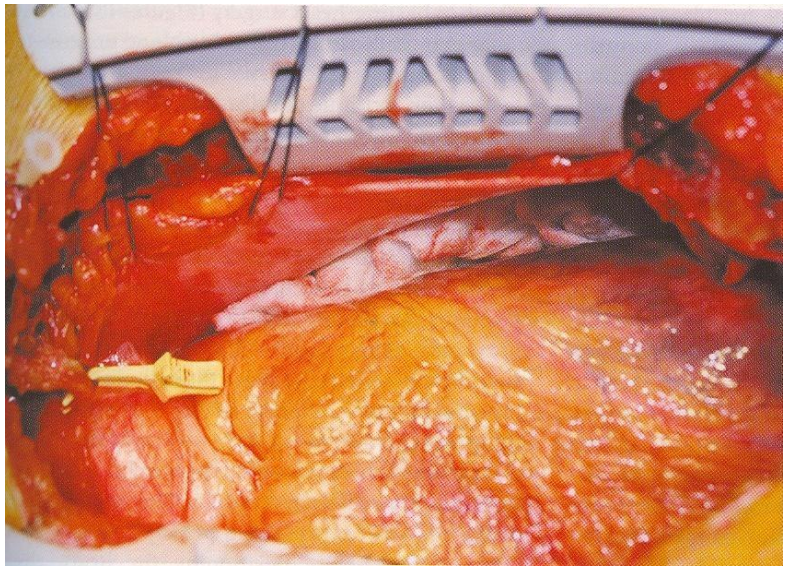


- Air embolism
- Endothelial damage ?

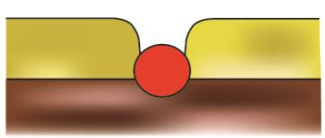


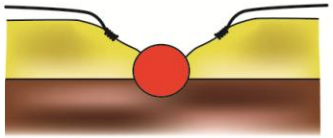
Target Vessel – LAD

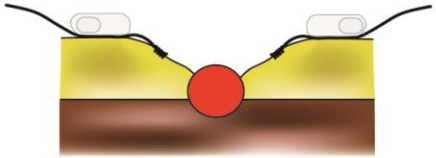
- The easiest target vessel for OPCAB
- Exposure
  - pericardial tenting + gauze pad behind heart
  - no need for positioner in most cases
- Snaring
  - septal br., RV rupture
- Deep seated
  or intramyocardial
  - shunt, epicardial fat tenting

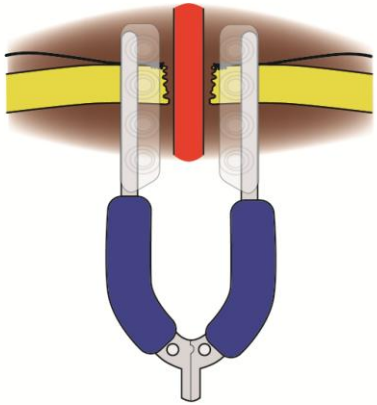


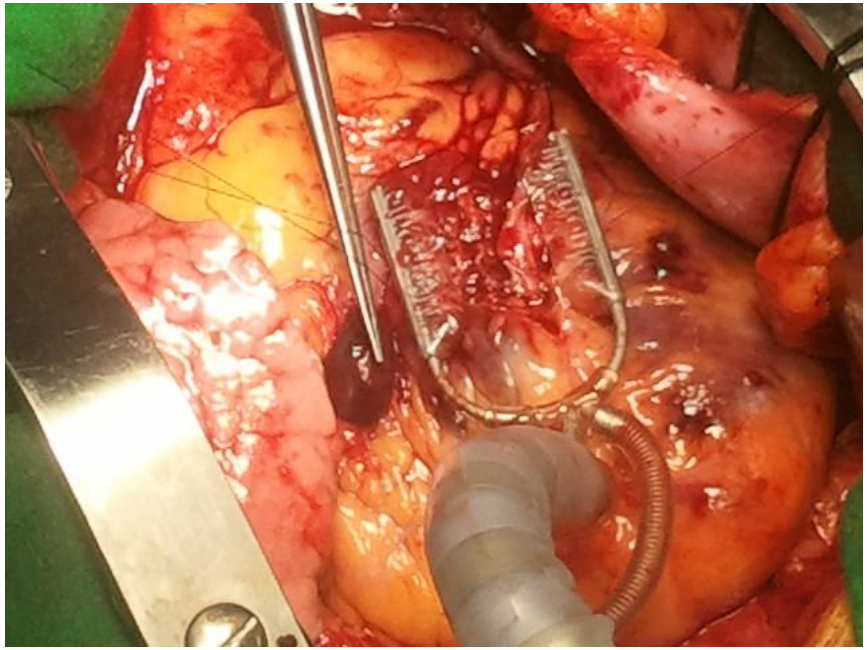
Deep Seated Target Vessel

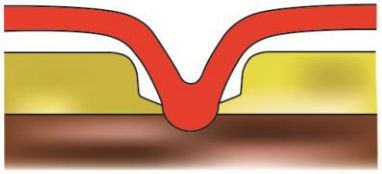


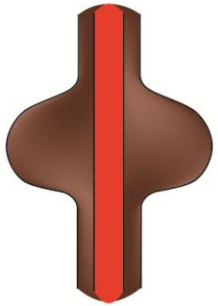












Target Vessel – D & Ramus br.

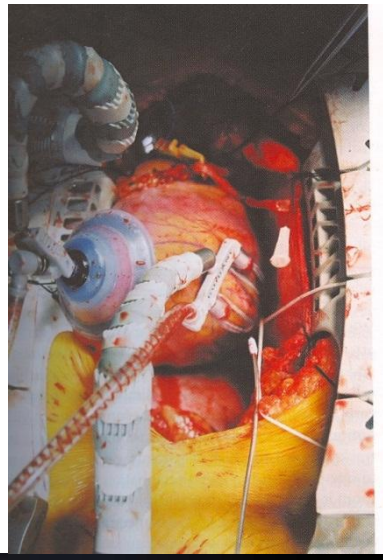
- The 2nd easist target vessel
- Do not compress too much
  - RVOT obstruction
- Pericardial tenting

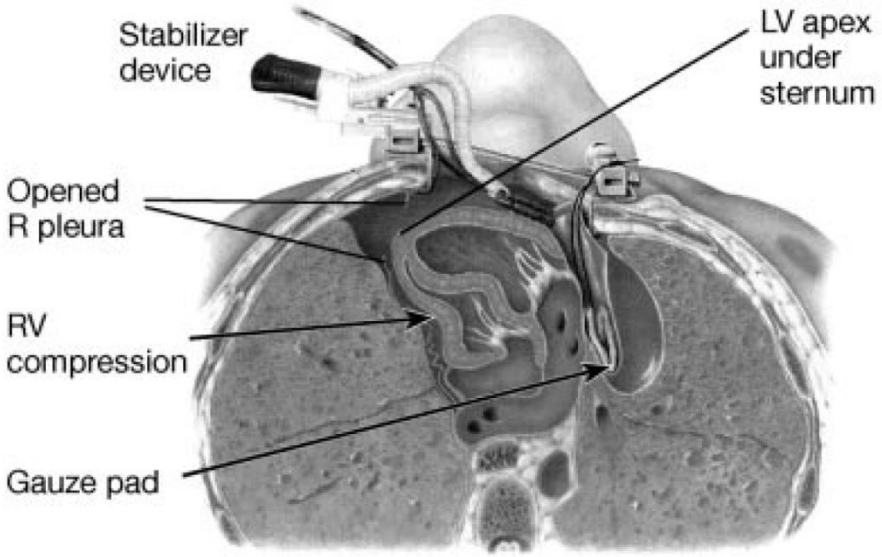
  ± positoner

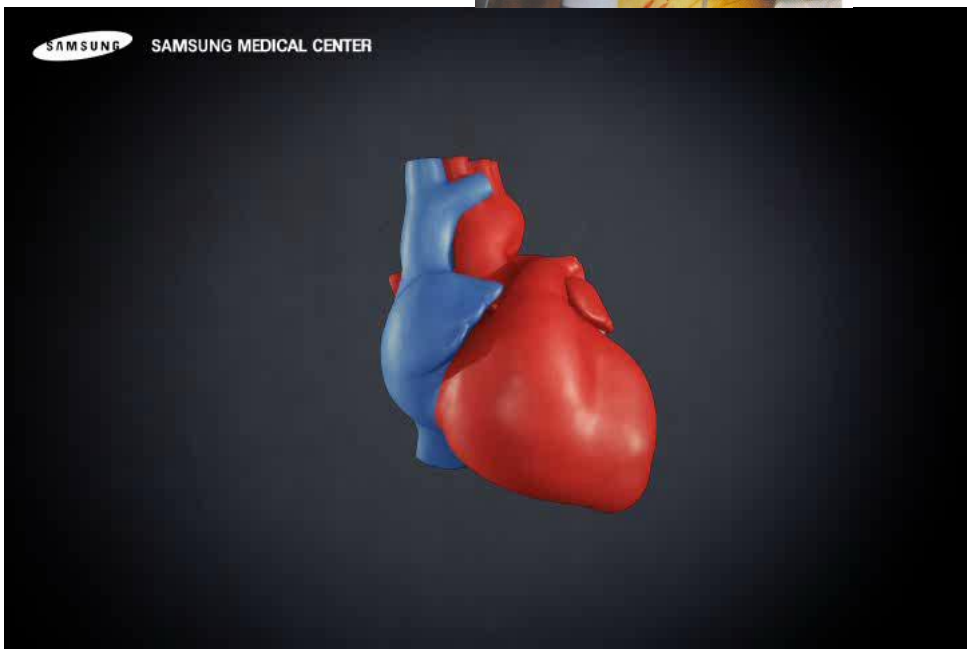
  ± gauze pad

Target Vessel – OM

- Most challenging target vessel
- Positioner, pericardial tenting
- Table : Head down, rt. side down
- Valve regurgitation : distortion
- Tension on LITA to LAD

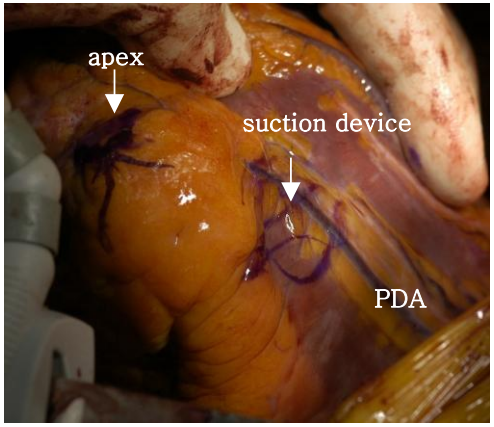


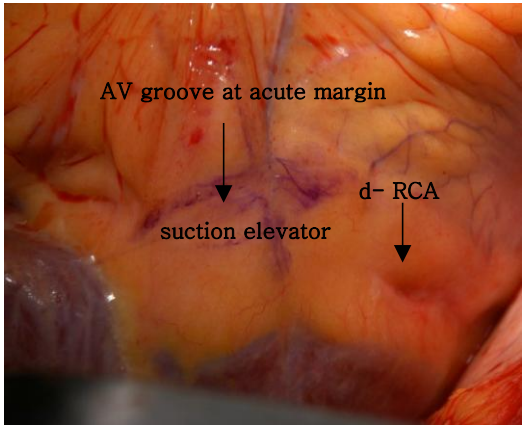


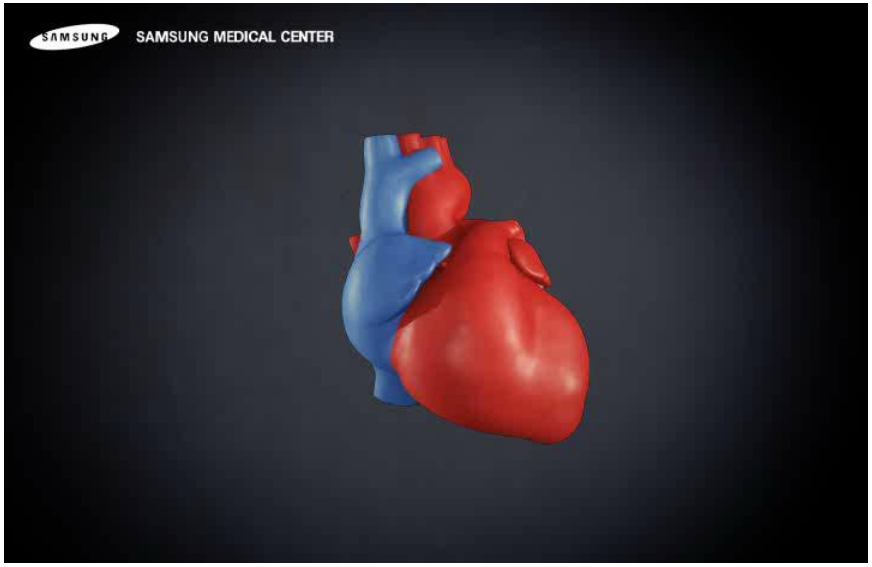


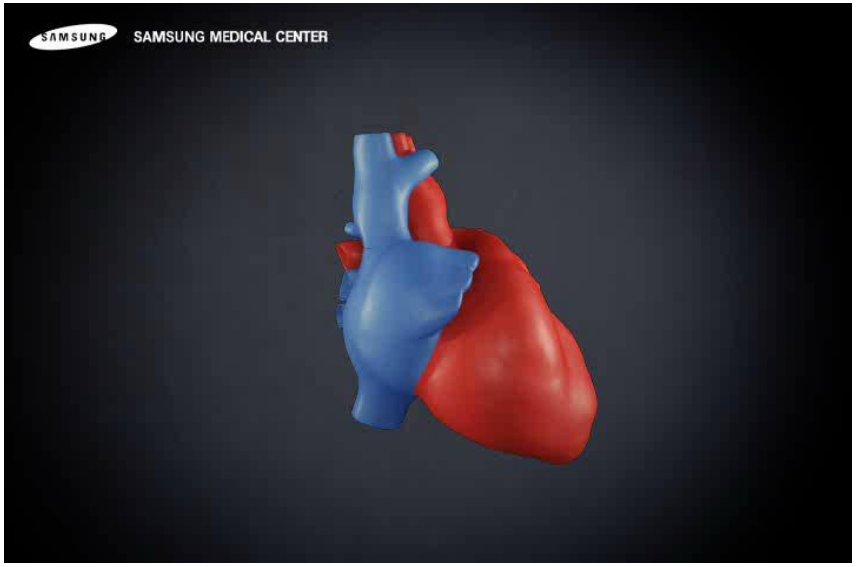
Target Vessel – RCA & PDA

- Proximal RCA – may cause bradycardia
  - shunt or pacing
- Table: head down
- Kinking of the grafts to the other vessels

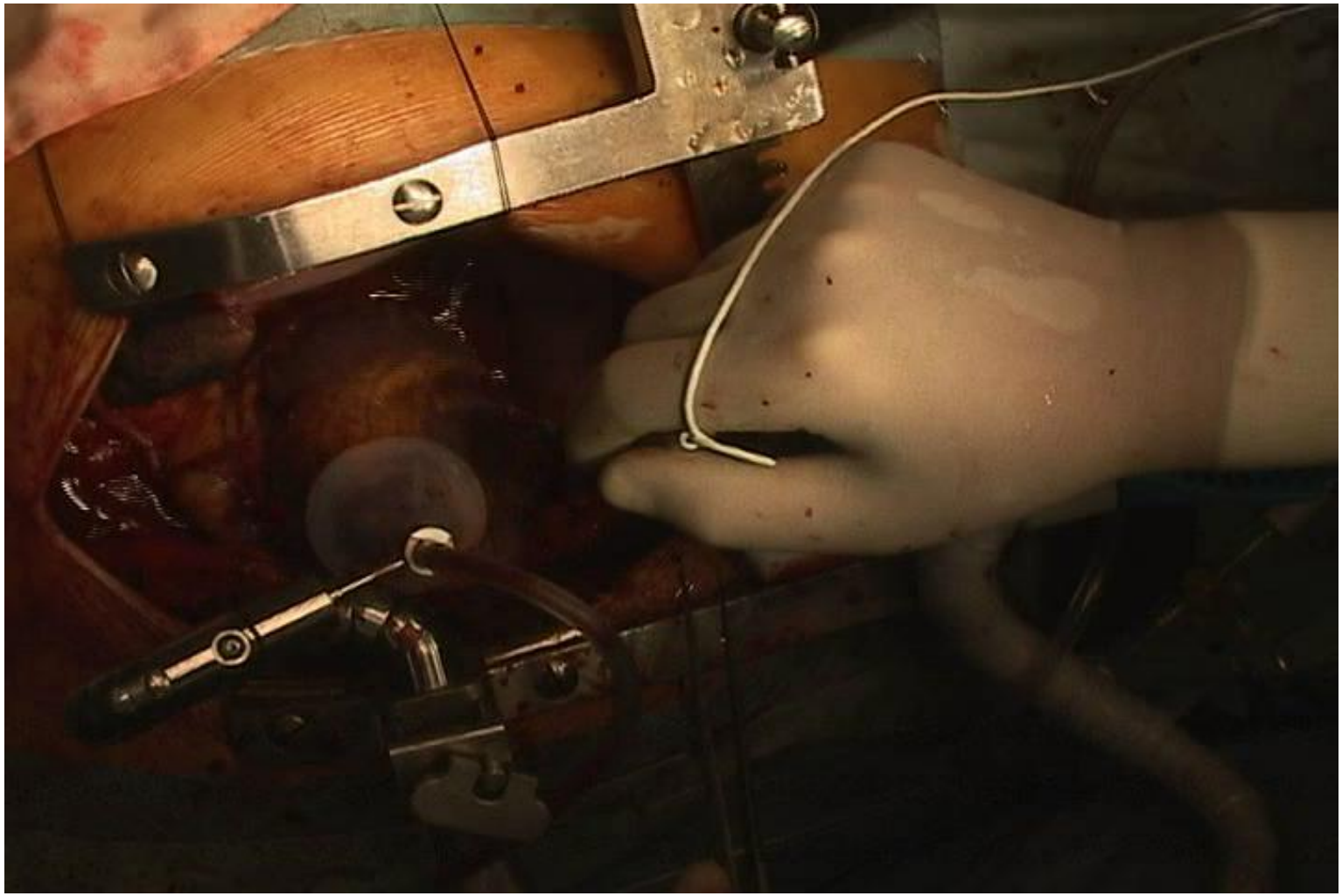








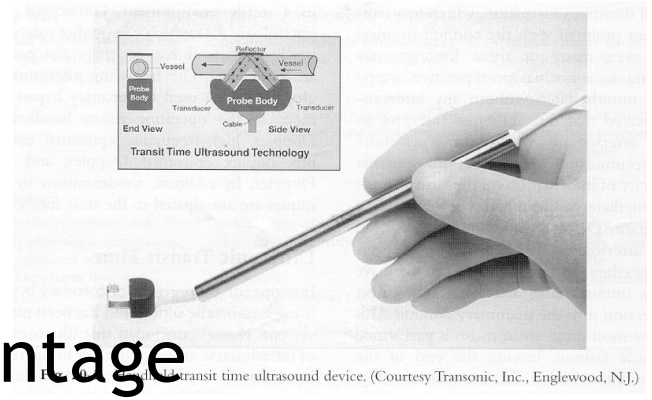
Video



Intraop. Assessment of Graft

- Majority of graft failure – early technical problems
- Methods
  - intraoperative coronary angiography
  - ultrasonic transit time
  - hand-held epicardial doppler
  - high frequency epicardial echocardiograhphy
  - doppler flow wire
  - thermal imaging

Ultrasonic Transit Time



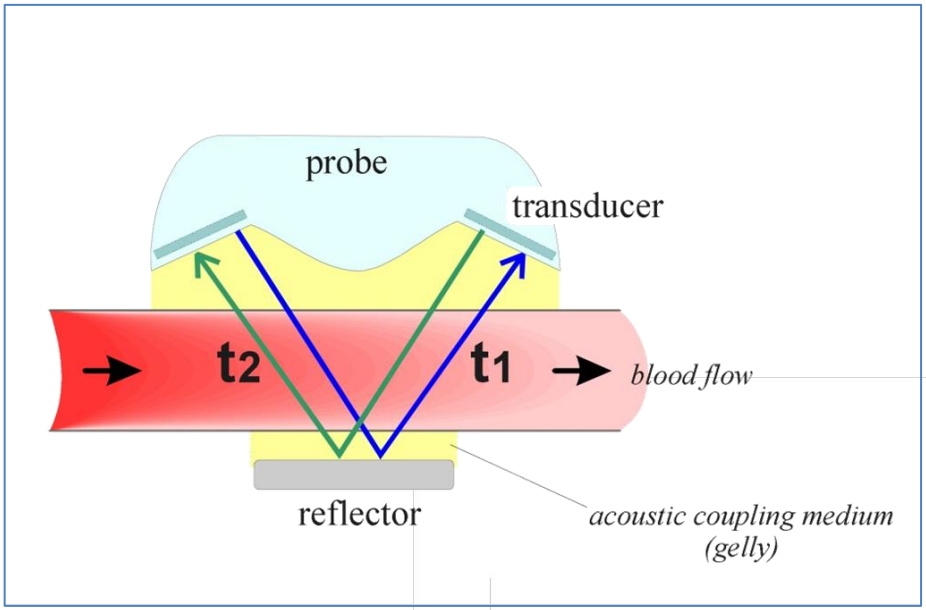
transit time ultrasound device. (Courtesy Transonic, Inc., Englewood, N.J.)

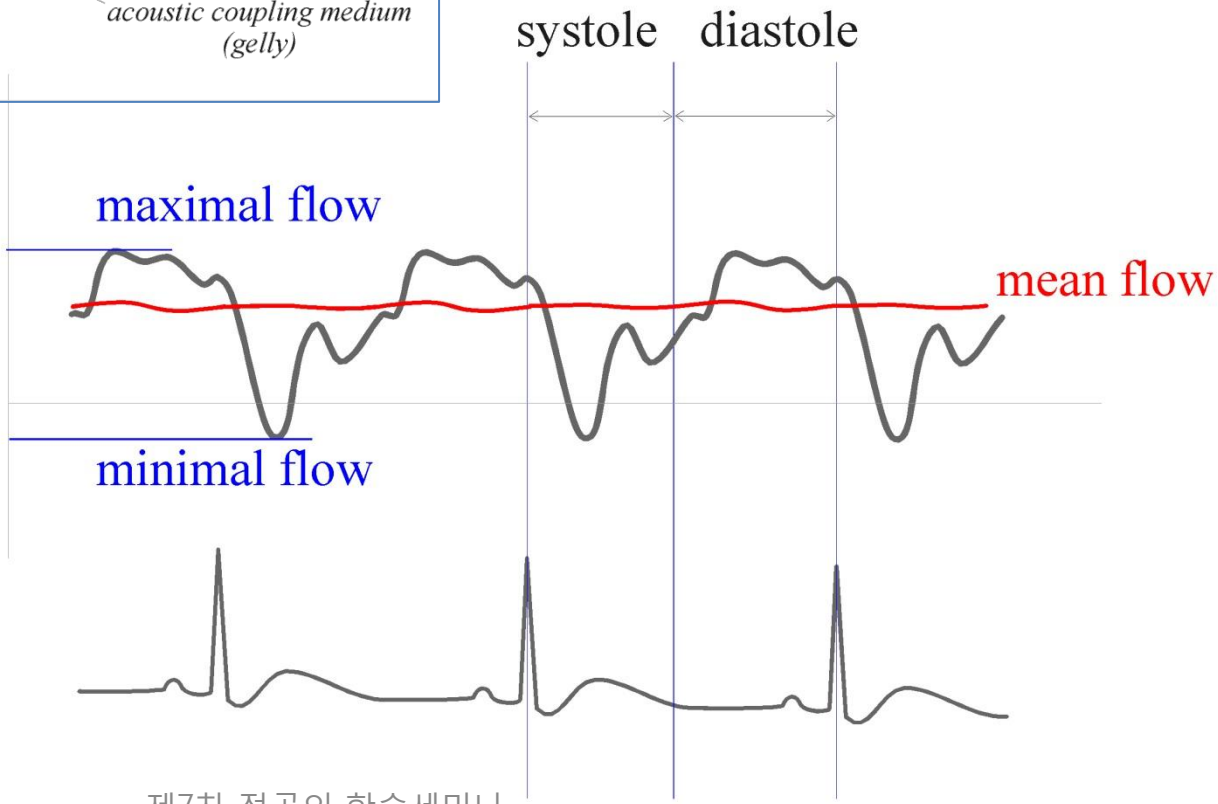
Advantage

- Quick, easy to perform
- Non invasive
- Quantitative measurement of volume flow
- Low cost
- No ionizing radiation

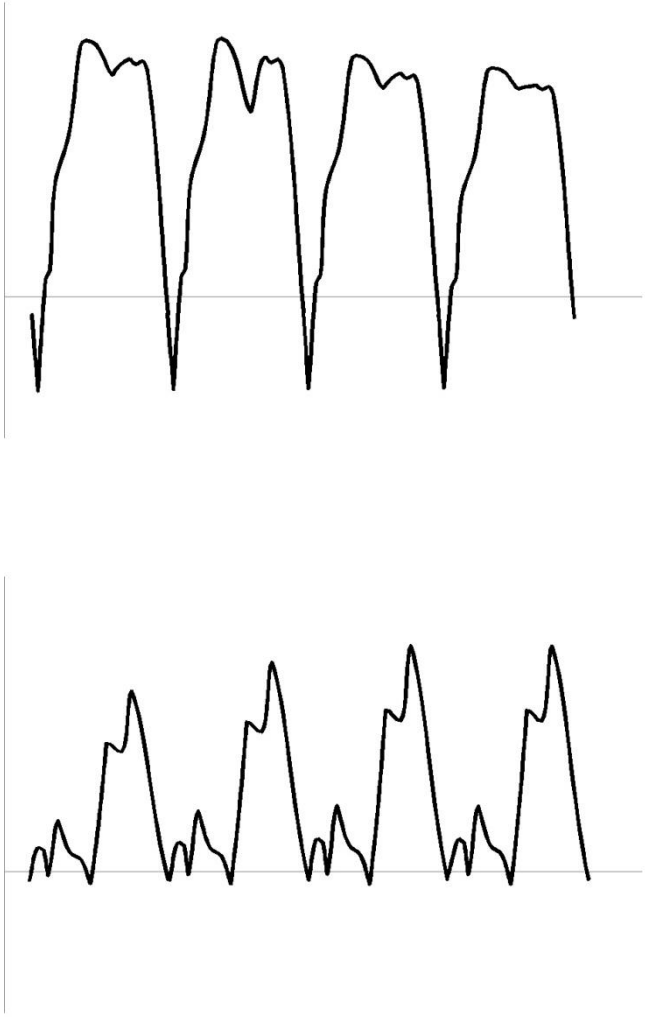
Disadvantage

- No anatomic information
- Depend on dynamic parameters
- Cannot assess anastomosis, distal native vessel

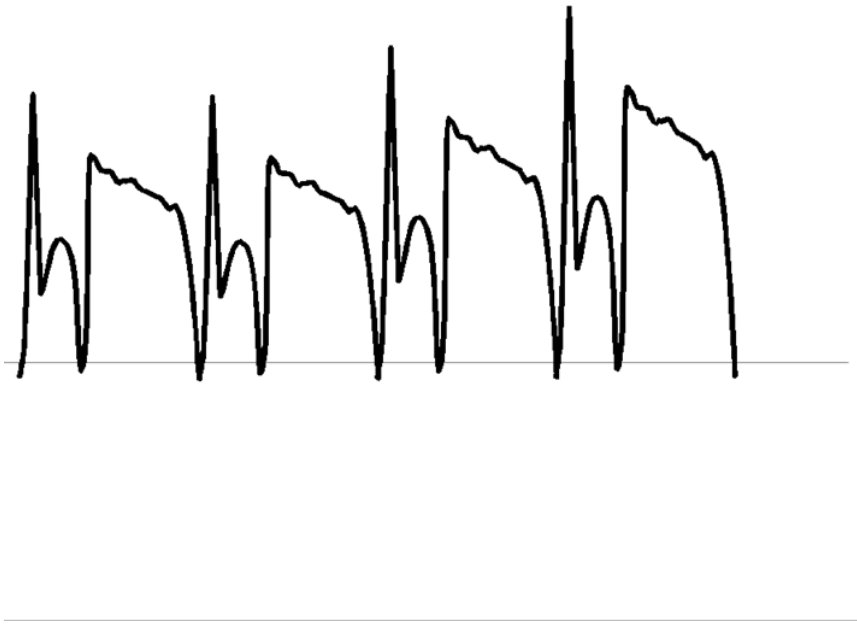

probe
transducer
t2
t1
blood flow
reflector
acoustic coupling medium
(gelly)


systole
diastole
maximal flow
mean flow
minimal flow

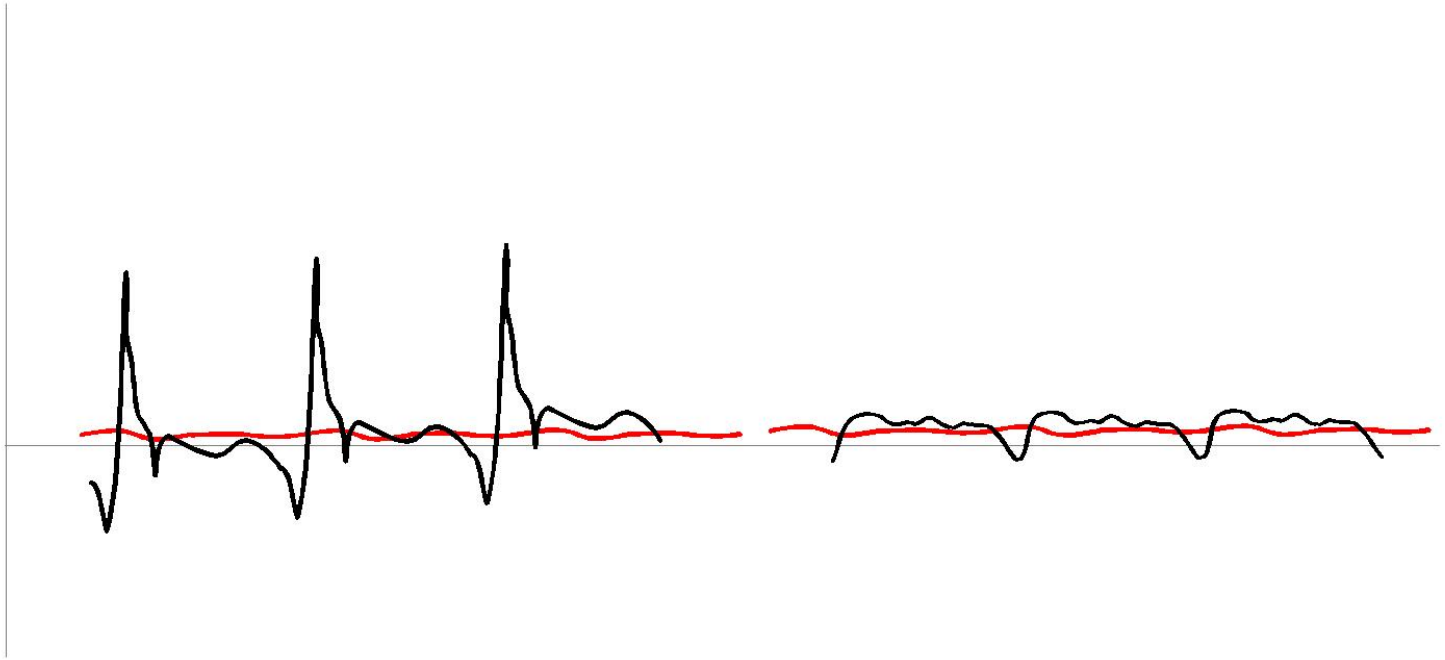
LCA graft



RCA graft



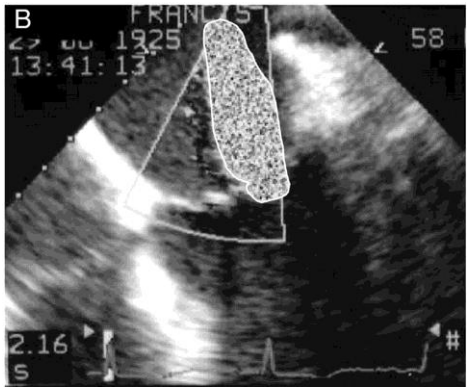
PI: pulsatility index, (maximal flow – minimal flow)/mean flow

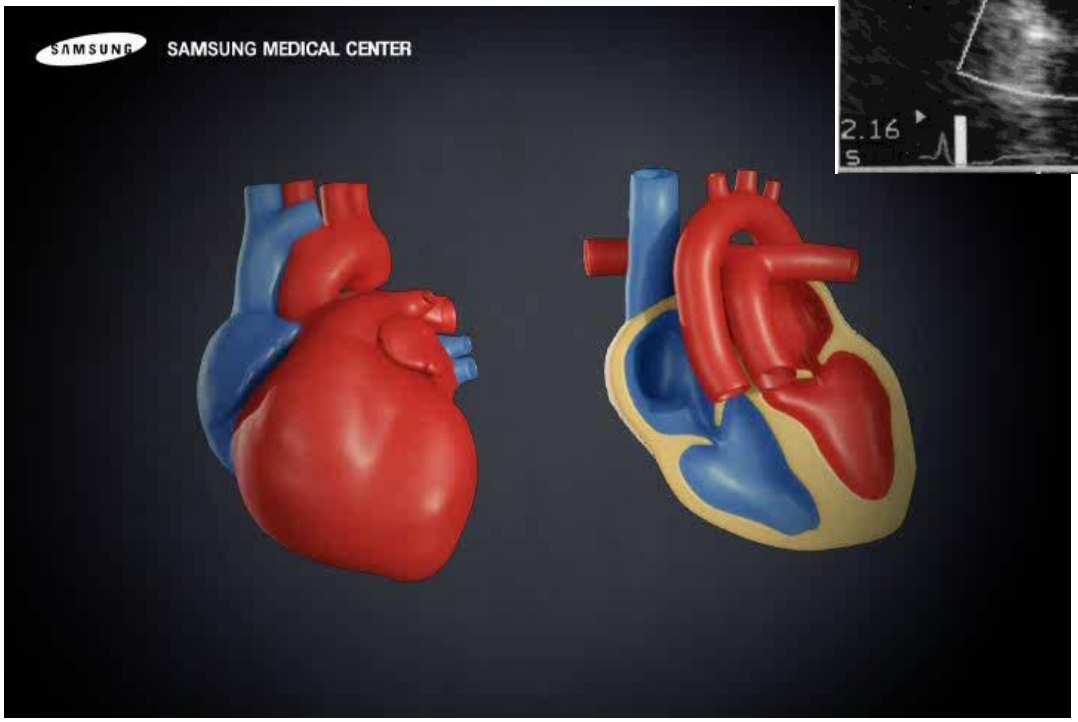


distal problem proximal problem

Hemodynamics

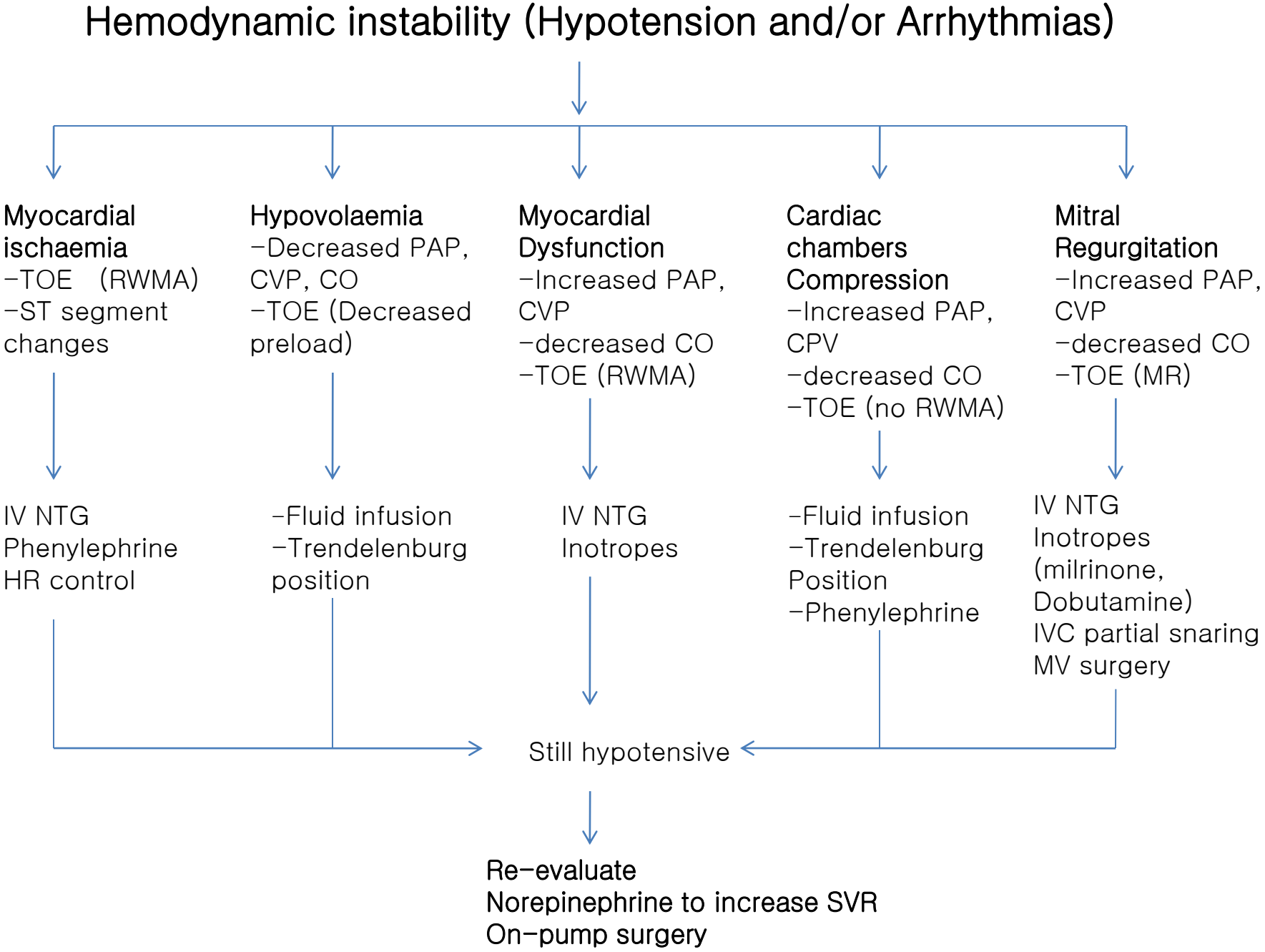
- Atria are situated below ventricles
- Increased filling pressure of atria
- Increased atrial size
- Distortion of MV & TV





Hemodynamic Mx.

- Target BP: MAP > 60-70mmHg
- CO: SvO_2 > 60%, metabolic acidosis (-)
- Buffington ratio: MAP/heart rate < 1
- Fluid administration
- Leg elevation
- Alpha adrenergic drug
  - Phenylephrine
  - Norepinephrine
- Beta blocker
- Pacing: HR < 50 / min


Hemodynamic instability (Hypotension and/or Arrhythmias)
Myocardial ischaemia
-TOE (RWMA)
-ST segment changes
Hypovolaemia
-Decreased PAP, CVP, CO
-TOE (Decreased preload)
Myocardial Dysfunction
-Increased PAP, CVP
-decreased CO
-TOE (RWMA)
Cardiac chambers Compression
-Increased PAP, CPV
-decreased CO
-TOE (no RWMA)
Mitral Regurgitation
-Increased PAP, CVP
-decreased CO
-TOE (MR)
IV NTG
Phenylephrine
HR control
-Fluid infusion
-Trendelenburg position
IV NTG
Inotropes
-Fluid infusion
-Trendelenburg Position
-Phenylephrine
IV NTG
Inotropes (milrinone, Dobutamine)
IVC partial snaring
MV surgery
Still hypotensive
Re-evaluate
Norepinephrine to increase SVR
On-pump surgery

OPCAB시 혈류역학을 안정화 시키려면 ?

- Head down, volume
- Extended T pericardiotomy
- Reduce tidal volume
- α agonist, nitroglycerin
- Minimal compression
- Collateralized vessel first
- Role of anesthesiologist
- Communication with anesthesiologist
- Patience

Indication for Converting to CPB

- Hemodynamics (>15min despite of aggressive tx.)
  - CI < 1.5 L/min/m^2
  - SvO_2 < 60%
  - MAP < 50 mmHg
  - ST segment elevation > 2mV
  - Large new wall motion abnormalities
  - Sustained malignant arrhythmia

- Technical
  - Difficulty in bleeding control
  - Deep intra-myocardial target

Results of OPCAB

- Meta-analysis and/or RCT
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  - Etc.

Off-Pump and On-Pump Coronary Artery Bypass Grafting Are Associated With Similar Graft Patency, Myocardial Ischemia, and Freedom From Reintervention: Long-Term Follow-Up of a Randomized Trial

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Conclusions. In this randomized trial, off-pump and on-pump coronary artery bypass grafting were associated with similar early and late graft patency, incidence of recurrent or residual myocardial ischemia, need for reintervention, and long-term survival.

Off-Pump Coronary Artery Bypass May Increase Late Mortality: A Meta-Analysis of Randomized Trials

Hisato Takagi, MD, PhD, Masafumi Matsui, MD, and Takuya Umemoto, MD, PhD

Conclusions. The results of our analysis suggest that off-pump CABG may increase late all-cause mortality by a factor of 1.37 over on-pump CABG. Longer term mortality from randomized trials of off-pump versus on-pump CABG is needed.

A systematic review of randomized trials comparing revascularization rate and graft patency of off-pump and conventional coronary surgery

Eric Lim, FRCS (C-Th),[a] Andrew Drain, MRCS,[a] William Davies, MRCS,[a] Lyn Edmonds, MCLIP,[b] and Bruce R. Rosengard, FRCS[a]

Methods: A systematic literature search was undertaken of all randomized trials of off-pump coronary surgery in MEDLINE, EMBASE, the Cochrane Library Controlled Trials Register, the National Research Register, and abstracts from major conferences.

Conclusion: In a meta-analysis of randomized trials, patients undergoing off-pump coronary surgery had a lower rate of revascularization and lower graft patency than did patients undergoing conventional coronary surgery.

Off-Pump or On-Pump Coronary-Artery Bypass Grafting at 30 Days

METHODS

At 79 centers in 19 countries, we randomly assigned 4752 patients in whom CABG was planned to undergo the procedure off-pump or on-pump. The first coprimary outcome was a composite of death, nonfatal stroke, nonfatal myocardial infarction, or new renal failure requiring dialysis at 30 days after randomization.

CONCLUSIONS

There was no significant difference between off-pump and on-pump CABG with respect to the 30-day rate of death, myocardial infarction, stroke, or renal failure requiring dialysis. The use of off-pump CABG resulted in reduced rates of transfusion, reoperation for perioperative bleeding, respiratory complications, and acute kidney injury but also resulted in an increased risk of early revascularization. (Funded by the Canadian Institutes of Health Research; CORONARY ClinicalTrials.gov number, NCT00463294.)

Clinical outcomes in randomized trials of off- vs. on-pump coronary artery bypass surgery: systematic review with meta-analyses and trial sequential analyses

Christian H. Møller[1,2*], Luit Penninga[1], Jørn Wetterslev[2], Daniel A. Steinbrüchel[1], and Christian Gluud[2]

Aims To assess the clinical outcomes of off- vs. on-pump coronary artery bypass surgery in randomized trials.

Conclusion Off-pump surgery reduces the risks of postoperative atrial fibrillation compared with on-pump surgery. For death, myocardial infarction, stroke, and renewed coronary revascularization, the evidence is still weak and more low-bias risk trials are needed.

Off-Pump Surgery Is Associated With Reduced Occurrence of Stroke and Other Morbidity as Compared With Traditional Coronary Artery Bypass Grafting : A Meta-Analysis of Systematically Reviewed Trials

Artyom Sedrakyan, Albert W. Wu, Amish Parashar, Eric B. Bass and Tom Treasure

Methods—Studies were identified by searching the MEDLINE, EMBASE and the Cochrane Register 1980 to 2006 (February). We also searched the reference lists of randomized clinical trials (RCT) and reviews to look for additional studies. Study selection: RCTs comparing off-pump surgery to CABG with CPB. No restriction applied on the size of the trial or end point reports. Data extraction: 2 reviewers independently searched for studies, read abstracts and abstracted all data. Data synthesis: combined estimates were obtained using fixed or random effect meta-analyses. Relative risks and risk differences were calculated. Heterogeneity was assessed using χ^2 and I^2 values.

Conclusions—Off-pump CABG is associated with reduced risk of stroke, AF and infections as compared with CABG with CPB. Evidence should be generalized taking into account RCT enrollment limitations, drawbacks related to training requirements, propensity to perform fewer grafts and likely reinterventions after off-pump surgery. (***Stroke.*** **2006;37: 2759-2769.**)

Cognitive Outcomes After On- Versus Off-Pump Coronary Artery Bypass Surgery

Elizabeth Kozora, PhD, Susan Kongs, BS, Joseph F. Collins, ScD, Brack Hattler, MD, Janet Baltz, RN, Michael Hampton, BA, Frederick L. Grover, MD, Dimitri Novitzky, MD, and A. Laurie Shroyer, PhD

Conclusions. At baseline, lower cognitive function, older age, lower education, and ethnicity other than white were predictive of cognitive decline after CABG. Patients in both groups demonstrated low frequencies of cognitive impairment on individual tests at baseline and follow- up, and few patients in either group were classified as impaired at 1-year follow-up on individual tests. In general, the Randomized On versus Off Bypass study documented that neither on-pump nor off-pump CABG adversely impacts long-term brain function.

Off-Pump Coronary Artery Bypass Surgery and Acute Kidney Injury: A Meta-Analysis of Randomized Controlled Trials

Victor F. Seabra,*† Sami Alobaidi,* Ethan M. Balk,†‡ Alan H. Poon,* and Bertrand L. Jaber*†

Conclusions: Off-pump CABG may be associated with a lower incidence of postoperative AKI but may not affect dialysis requirement, a serious complication of cardiac surgery. However, the different definitions of AKI used in individual trials and methodological concerns preclude definitive conclusions.

Results of OPCAB

- Meta-analysis and/or RCT

	OPCAB	Conventional CABG
Postop. morbidity		
Neurologic outcome	> or ≈	
Renal impairment	> or ≈	
Atrial fibrillation	> or ≈	
Long-term results		
Graft patency	< or ≈	
MACE	< or ≈	
Survival	< or ≈	

Controversies in OPCAB

Pros

- No global myocardial ischemia
- Minimal or no aortic manupulation avoiding stroke and aortic dissection
- Avoid systemic inflammatory reaction due to CPB
- Easier to measure the length of grafts

Cons

- Longer learning curve
- No proven benefit regarding long term outcome(?)
- Need for experienced anesthesiologist and perfusionist
- Fewer No. of distal anastomosis and more distal anastomosis
- Exaggerating MR

Conclusions

- OPCAB could be useful strategy to treat ischemic heart disease especially for high risk patients.
- Exposure and stabilization of target vessel with acceptable hemodynamics are the most important part of OPCAB
- However, OPCAB itself is not the goal of revascularization.
- To get a good outcome through complete revascularization of target vessel is the most important.