대한흉부심장혈관외과학회
제11차 전공의 연수교육

일자: 2018년 5월 17일(목)~5월 19일(토)

장소: 롯데속초리조트 Maple룸 (2층)

대한흉부심장혈관외과학회

대한흉부심장혈관외과학회 제11차 전공의 연수교육
프로그램

진행: 교육위원장 박계현

일시: 2018. 5. 17(목) 장소: 롯데속초리조트 Maple룸

12:30～13:00 등 록

13:00～13:15 격려사 김기봉 회장님 / 오태윤 이사장님

13:15～13:45 특 강

13:15～13:45 흉부외과 의사의 개원 김창수 (김창수 의원) ····· 3

13:45～14:00 Coffee Break

14:00～15:45 일반흉부파트 좌장: 조석기

14:00～14:30 Preoperative Evaluation of Lung Cancer 조정수 (부산대학교병원) ····· 19

14:30～15:00 Multi-modality Treatments for Lung Cancer 전재현 (분당서울대학교병원) ····· 26

15:00～15:30 Technical Aspects of Lung Cancer Surgery 조석기 (분당서울대학교병원) ····· 33

15:30～15:45 Q&A

15:45～16:00 Coffee Break

16:00～17:45 일반흉부파트 좌장: 이성수

16:00～16:30 Complications of Lung Surgery 황진욱 (고려대학교 안산병원) ····· 39

16:30～17:00 Congenital and Benign Lung Diseases 박성용 (연세대학교 세브란스병원) ··· 43

17:00～17:30 Pulmonary Metastasectomy 이성수 (연세대학교 강남세브란스병원) ··· 48

17:30～17:45 Q&A

17:45～18:00 Coffee Break

18:00～18:30 특 강

18:00～18:30 대한민국 흉부외과의 역사 박국양 (가천대학교 길병원) ····· 61

18:30～18:45 기념 촬영

19:00～21:30 **저녁 식사 및 친교의 시간** **장소: 일출봉 횟집 ☏ 033-635-2222**
강원도 속초시 대포항희망길 105 (비상의공원 방파제앞)

일시: 2018. 5. 18(금) 장소: 롯데속초리조트 Maple룸

일시: 2018. 5. 18(금) 장소: 롯데속초리조트 Pine룸

16:15～18:15	**초음파 Hands-on (조별진행)**	**좌장: 정진용(가톨릭대학교 인천성모병원)**
	Stage 1: Echo I (TTE)	김도완 (전남대학교병원) ····· 173 장형우 (분당서울대학교병원)
	Stage 2: Echo II (TEE)	김동중 (분당서울대학교병원)
	Stage 3: Vascular SONO	정진용 (가톨릭대학교 인천성모병원) 김우식 (국립중앙의료원)
	Stage 4: Lung SONO & SONO Guided Procedure	김재범 (계명대학교 동산의료원)
19:00～20:00	**저녁 식사**	**장소: Natural Soul Kitchen (콘도 지하1층)**

20:00～이후 자습 및 자유 시간

일시: 2018. 5. 19(토) 장소: 롯데속초리조트 Maple룸

07:40～08:30 **아침 식사** **장소: Natural Soul Kitchen (콘도 지하1층)**

08:30～10:15 **성인심장파트** **좌장: 조민섭**

10:00～10:15 Q&A

10:15～10:45 Coffee Break, 객실 Check-Out (프론트에 객실키 반납)

10:45～12:00 **성인심장파트** **좌장: 조민섭**

11:45～12:00 Q&A

12:00～13:00 **점심 식사** **장소: Natural Soul Kitchen (콘도 지하1층)**

13:00～14:00 **교육평가 설문지 작성 및 시험**

【특 강】

흉부외과 의사의 개원

김창수 의원

김 창 수

이런 일을 했습니다.

- 한가지 질병그룹만 치료 (Chronic venous dis.)
- Varicose vein 만 치료하는 의원으로는 국내 처음.
- Endovenous Laser Ablation 국내 처음 도입(2001).
- 중국 진출(베이징, 상하이, 선양, 옌타이, 우시에 진출)
- 1년에 180회 비행

왜 하지 정맥류만 치료하는 의원을 개설?

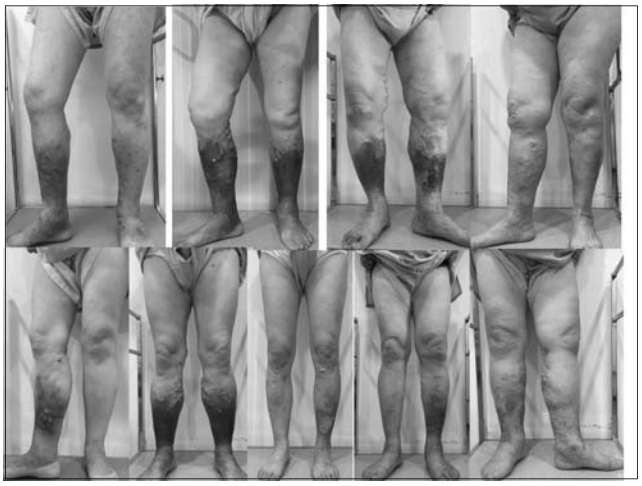
- 1998년 마산의료원 근무하면서 한계 인식
- 하지정맥류는 선진국병이다.
- 한국의 낙후된 하지정맥류 치료에 대한 인식
- 하지정맥류는 전문적인 치료 시설이 필요.
- 그래서 불모지 개척

걸어 온 길

- 2000년 10월 하지정맥류만 치료하는 의원 개설, 마산
- 2001년 부산병원 개원
- 2001년 7월 레이저 치료법 국내처음 도입
- 2002년 서울, 인천, 분당 개원
- 전국에 11개 개원(중국 진출로 지금은 6개로 정리함.)
- 2012년 부터 중국진출 준비
- 2014년 9월 중국 옌타이 개원
- 현재 베이징, 상하이 , 선양, 옌타이 , 우시, 하얼빈 의과대학병원

VARICOSE VEINS?


VARICOSE VEINS은 미용이 아니라
질병입니다.




VARICOSE VEINS 의 치료
1980년대 중반 - 진단및 치료에 초음파 도입
2000년 Endovenous Thermal Ablation
Radiofrequency Ablation
Endovenous Laser Ablation
Stripping surgery → Thermal Ablation
2010년 이후 Chemical Ablation
ClariVein system
VenaSeal closure system - Medical adhesive
(Cyanoacrylate),Medtronic


01 开刀手术
Kimchangsoo
Varicose Vein Clinic International


01 开刀手术


02 激光治疗


03 高周波治疗
COVIDIEN

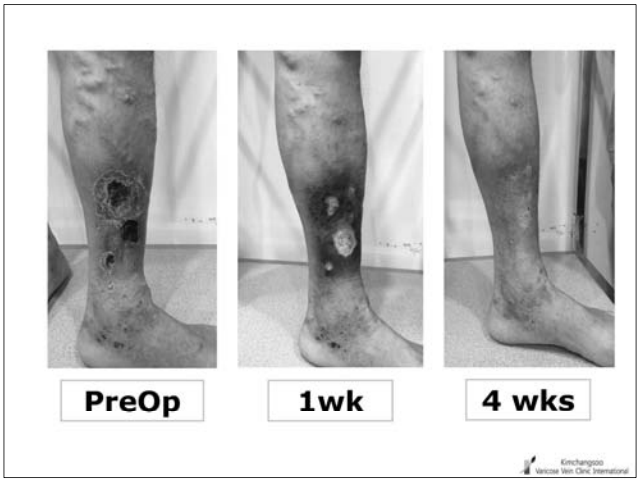

03 高周波治疗
Disposable catheter inserted into vein
Vein heats and collapses
Catheter withdrawn, closing vein
Kimchangsoo
Varicose Vein Clinic International

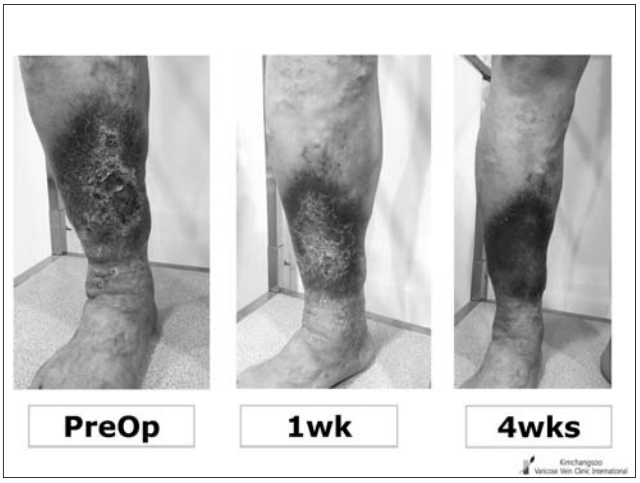

04 VENASEAL
Kimchangsoo
Varicose Vein Clinic International


05 MOCA
Clarivein System
Kimchangsoo
Varicose Vein Clinic International


수술전/후
Kimchangsoo
Varicose Vein Clinic International


PreOP
1 wk
3 wks

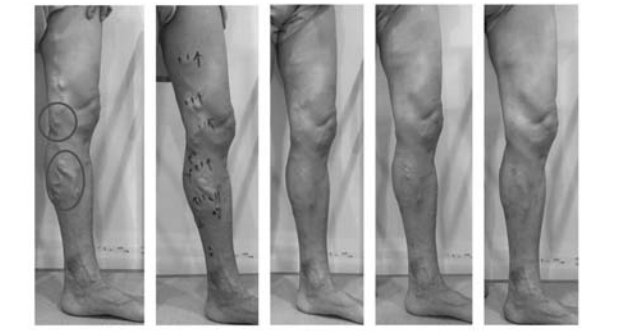

PreOp
1wk
4 wks


PreOp
1wk
4wks

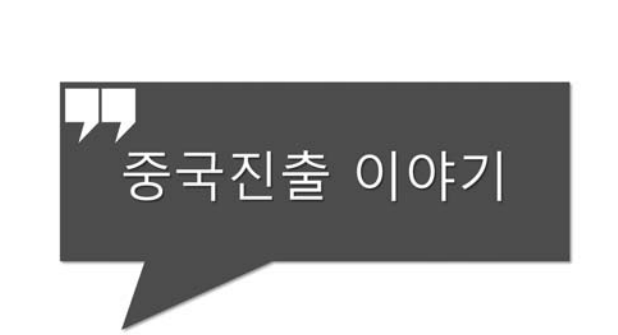

Preop
2
4
11 wks


PreOP
1
3
6
12wks


Preop
2
6
15 wks

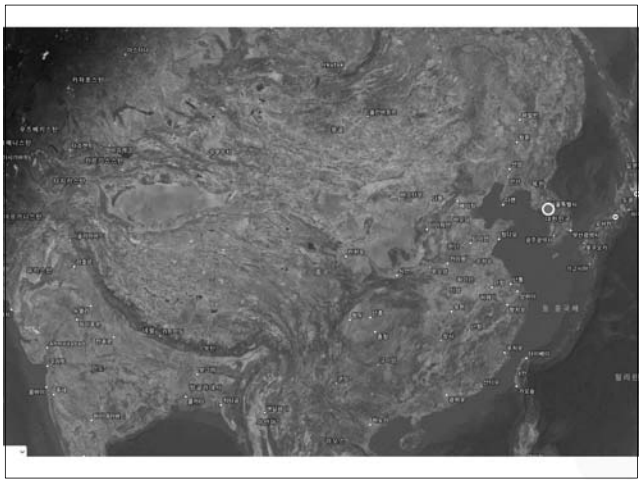

Preop
2
6
15wks


Preop
3
6
14 wks


중국진출 이야기

중국 진출, 왜?

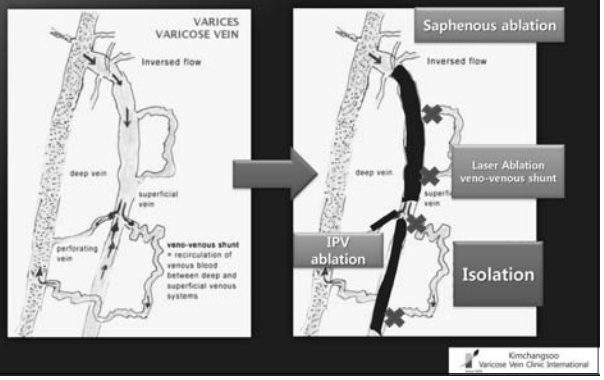
- 중국 대륙에 대한 동경
- 리더로서 미래에 대한 준비
- 인생의 마지막 몸부림



중국 진출 준비

- 2-3년 준비 기간
- 치료법 변화 (KCS isolation technique)
  - 중국치료법과의 차별화
  - 중국환자의 특성에 맞는 치료법
- 중국 투자자
- 중국 혈관외과 학회 진출

KCS isolation technique



연태의학원 부속 광화병원과 MOU 체결, 2014. 5월

2014. 06. 11
중국투자자와의 미팅

2014.10 중국 옌타이 개업식

2015.3.15 연태 진료 현장

2015.3 상해병원 개원

2015.3.28 상해 대강연

2015.9.3 상해 고주파 세미나

多位中国国立的医院血管外科主任医师参加

- 符伟国：复旦大学附属中山医院血管外科主任
  中国血管外科会长
- 张　岚：上海交通大学血管外科主任医师
- 刘　鹏：北京中日友好医院心脏血管外科主任
- 梅志军：上海长海医院血管外科静脉疾病专业负责人
- 陆信武：上海第九人民医院血管外科主任医师
- 金　辉：昆明医科大学第一医院血管外科主任
- 陈　忠：首都医科大学附属北京安贞医院血管外科主任医师
- 刘长建：南京大学医学院附属鼓楼医院外科主任医师
- 李　鸣：浙江大学医学院附属第一医院血管外科主任

……共18位血管外科主任医师参加

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2015.10.9 상해 Endovascology

2015.11.7 상해 2015 CEC


2016.1.24 상해 취양병원 개소
曲陽醫院
QuYang Hospital
特需门诊
咨询电话: 021-65 557770


2016.1.23-24
ClosureFast training course, Shanghai
美敦力第一届
ClosureFast疗法培训班
Medtronic


2016.7.28-30
Harbin medical university hospital


静脉曲张微创精准
哈尔滨医科大学附属第一医院联力院区血管外科
静脉曲张微创精准化治疗培训班


2017. 1. 14 -16
Harbin medical university hospital
Kimchangsoo
Varicose Vein Clinic International


2017.1.14 -16
Harbin medical university hospital


2017. 5. 27 - 28
2nd Asia-Pacific Angiology, Macao


2017. 6. 23
The 6th Shanghai Jiaotong university
Vascular disease Forum
PHLEBOLOGIST


2018-05-03


2017. 11. 29-30
Asia-Pacific angiology (APA), Beijing


Patients informations


POLICE


中华人民共和国
外国医师短期行医
许 可 证
TEMPORARY LICENSE
中华人民共和国
外国医师短期行医
许 可 证
TEMPORARY LICENSE
中华人民共和国
外国医师短期行医
许 可 证
TEMPORARY LICENSE


北医百年历程展


Kimchangsoo
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중국생활
Kimchangsoo
Varicose Vein Clinic International


老作坊

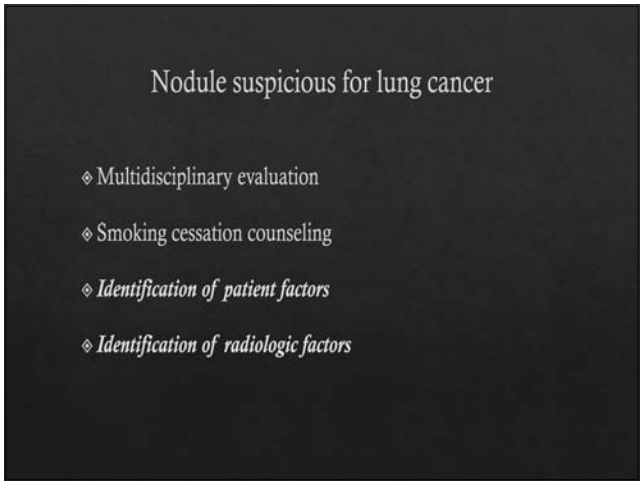
【일반흉부파트】

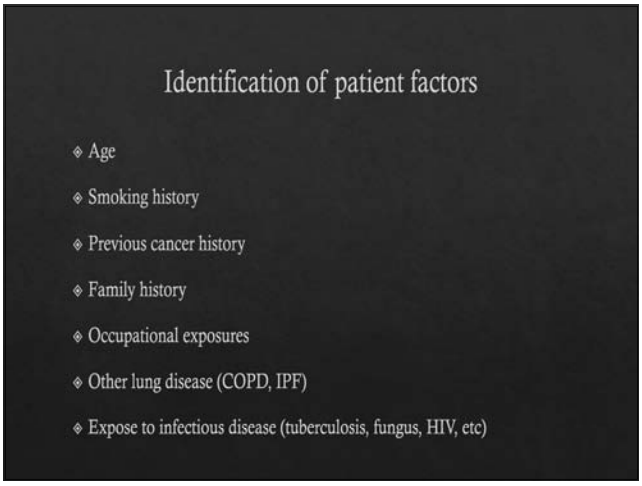
좌장: 조석기

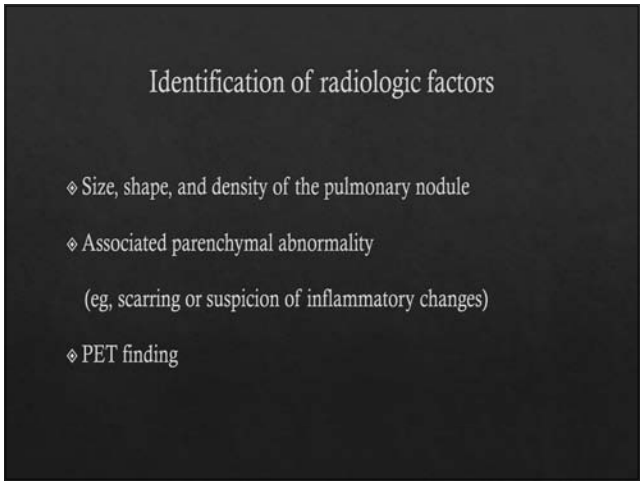
Preoperative Evaluation of Lung Cancer

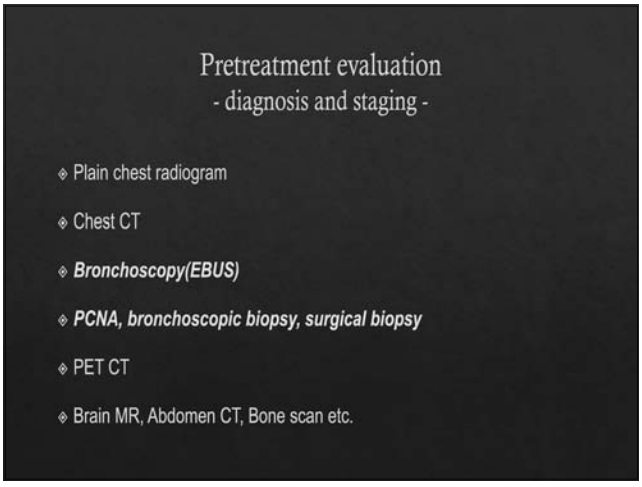
Pusan National University Hospital

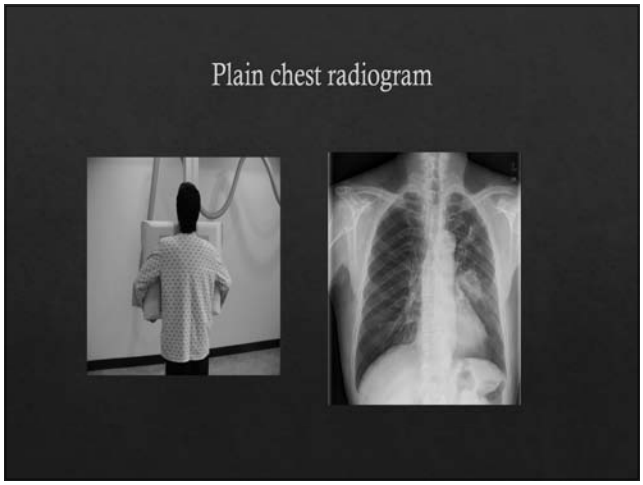
Jeong Su Cho

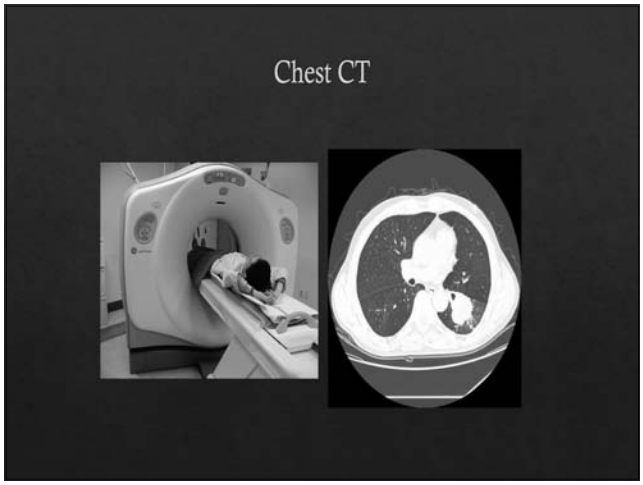


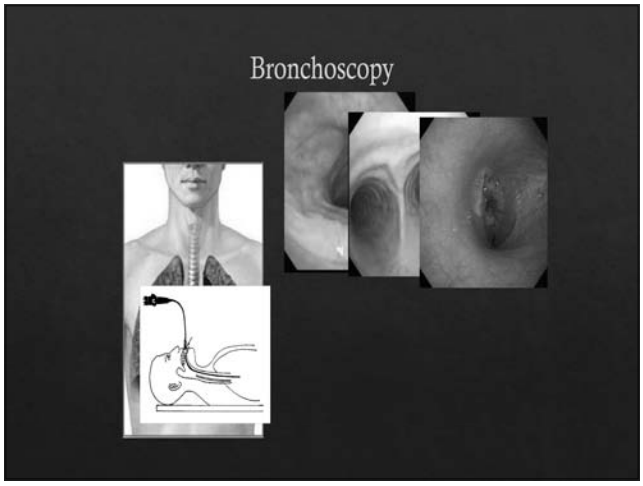


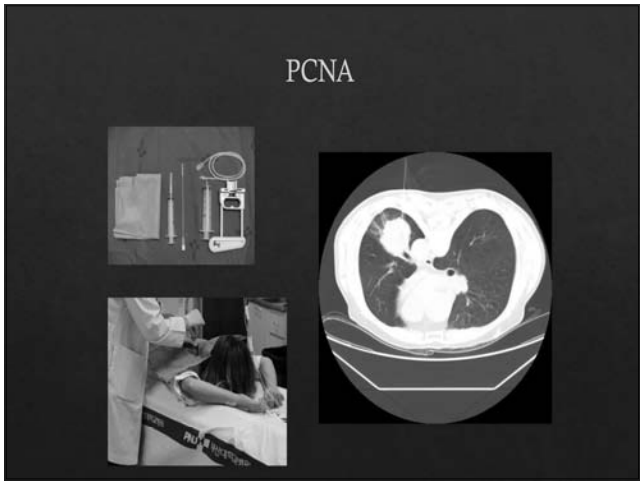


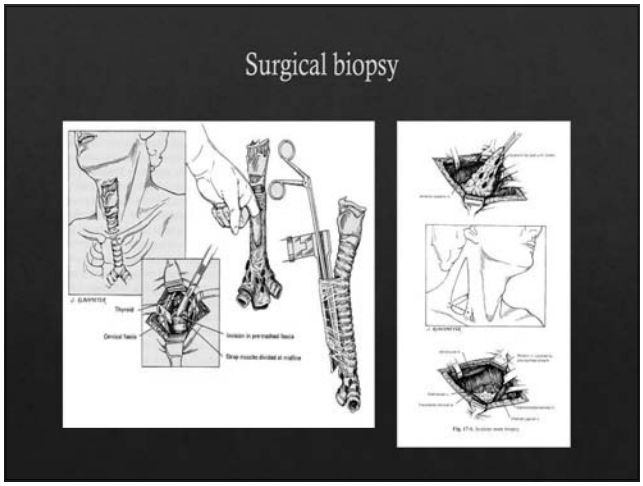


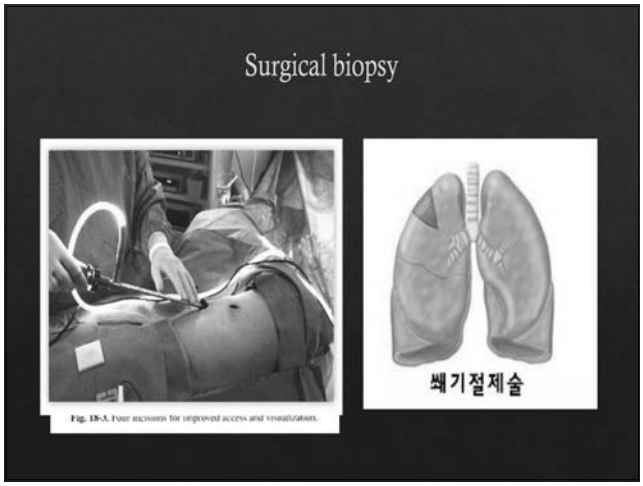

Plain chest radiogram

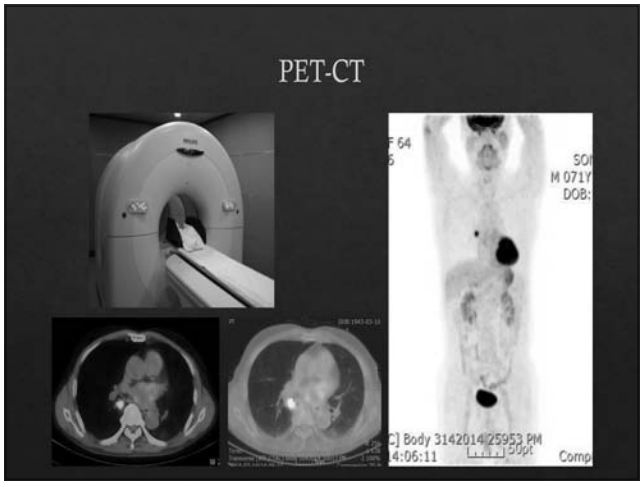

Chest CT

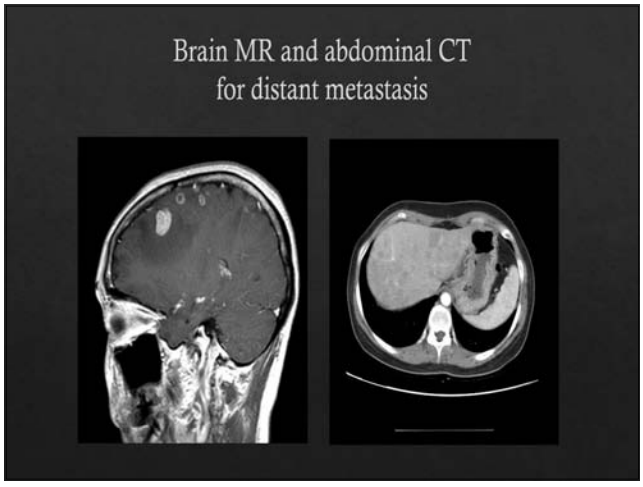

Bronchoscopy

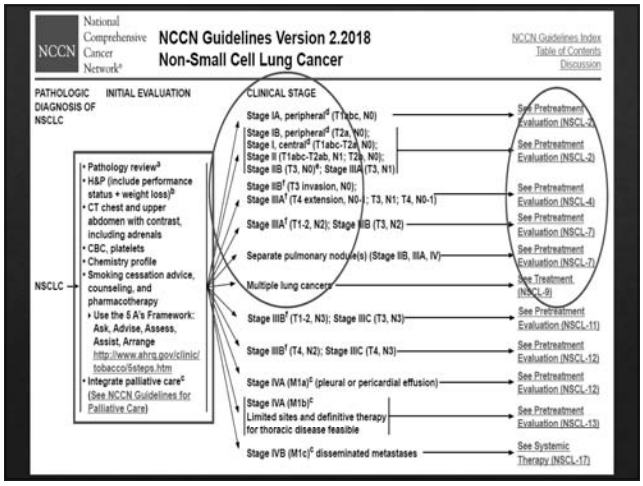

PCNA

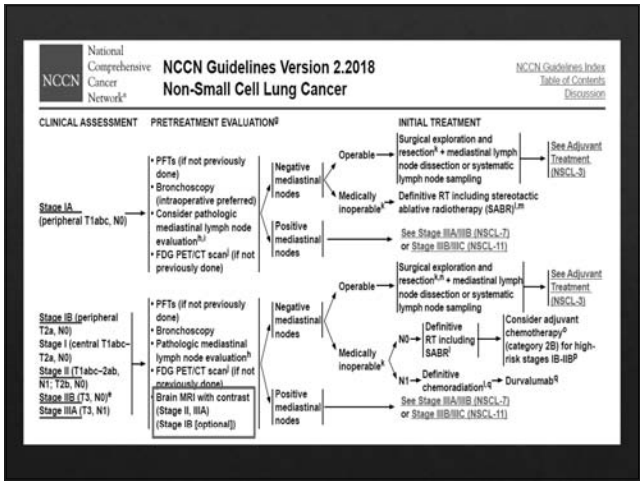

Surgical biopsy

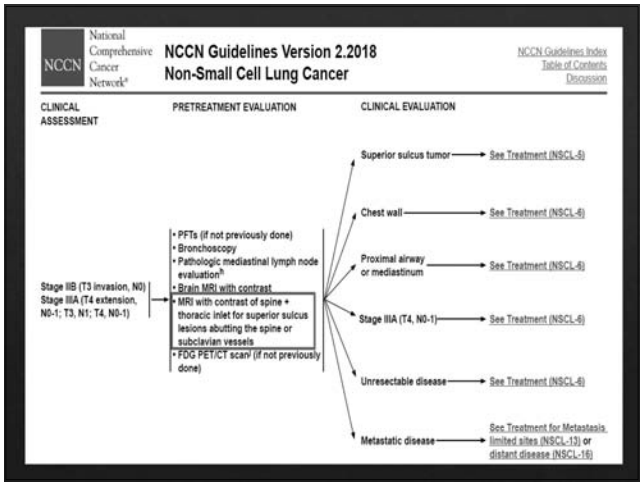

Surgical biopsy
쐐기절제술

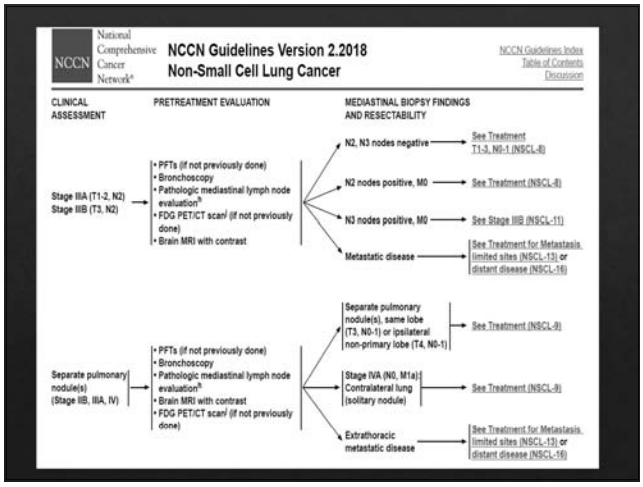

PET-CT


Brain MR and abdominal CT
for distant metastasis


NCCN Guidelines Version 2.2018
Non-Small Cell Lung Cancer
PATHOLOGIC DIAGNOSIS OF NSCLC
INITIAL EVALUATION
CLINICAL STAGE
NSCLC
Pathology review
H&P (include performance status + weight loss)
CT chest and upper abdomen with contrast, including adrenals
CBC, platelets
Chemistry profile
Smoking cessation advice, counseling, and pharmacotherapy
Use the 5 A's Framework: Ask, Advise, Assess, Assist, Arrange
http://www.ahrq.gov/clinic/tobacco/5steps.htm
Integrate palliative care
(See NCCN Guidelines for Palliative Care)
Stage IA, peripheral (T1abc, N0)
Stage IB, peripheral (T2a, N0); Stage I, central (T1abc-T2a, N0); Stage II (T1abc-T2ab, N1; T2a, N0); Stage IIB (T3, N0); Stage IIIA (T3, N1)
Stage IIB (T3 invasion, N0); Stage IIIA (T4 extension, N0-); T3, N1; T4, N0-1)
Stage IIIA (T1-2, N2); Stage IIIB (T3, N2)
Separate pulmonary nodule(s) (Stage IIB, IIIA, IV)
Multiple lung cancers
Stage IIIB (T1-2, N3); Stage IIIC (T3, N3)
Stage IIIB (T4, N2); Stage IIIC (T4, N3)
Stage IVA (M1a) (pleural or pericardial effusion)
Stage IVA (M1b) Limited sites and definitive therapy for thoracic disease feasible
Stage IVB (M1c) disseminated metastases
See Pretreatment Evaluation (NSCL-2)
See Pretreatment Evaluation (NSCL-4)
See Pretreatment Evaluation (NSCL-7)
See Pretreatment Evaluation (NSCL-9)
See Pretreatment Evaluation (NSCL-11)
See Pretreatment Evaluation (NSCL-12)
See Pretreatment Evaluation (NSCL-13)
See Systemic Therapy (NSCL-17)


NCCN Guidelines Version 2.2018
Non-Small Cell Lung Cancer
CLINICAL ASSESSMENT
PRETREATMENT EVALUATION
INITIAL TREATMENT
Stage IA (peripheral T1abc, N0)
Stage IB (peripheral T2a, N0) Stage I (central T1abc-T2a, N0) Stage II (T1abc-2ab, N1; T2b, N0) Stage IIB (T3, N0) Stage IIIA (T3, N1)
PFTs (if not previously done)
Bronchoscopy
Consider pathologic mediastinal lymph node evaluation
FDG PET/CT scan (if not previously done)
Brain MRI with contrast (Stage II, IIIA) (Stage IB [optional])
Negative mediastinal nodes
Positive mediastinal nodes
Operable
Medically inoperable
Surgical exploration and resection + mediastinal lymph node dissection or systematic lymph node sampling
Definitive RT including stereotactic ablative radiotherapy (SABR)
See Adjuvant Treatment (NSCL-3)
See Stage IIIA/IIIB (NSCL-7) or Stage IIIB/IIIC (NSCL-11)
N0
N1
Definitive RT including SABR
Definitive chemoradiation
Consider adjuvant chemotherapy (category 2B) for high-risk stages IB-IIBP
Durvalumab


NCCN Guidelines Version 2.2018
Non-Small Cell Lung Cancer
CLINICAL ASSESSMENT
PRETREATMENT EVALUATION
CLINICAL EVALUATION
Stage IIB (T3 invasion, N0) Stage IIIA (T4 extension, N0-1; T3, N1; T4, N0-1)
PFTs (if not previously done)
Bronchoscopy
Pathologic mediastinal lymph node evaluation
Brain MRI with contrast
MRI with contrast of spine + thoracic inlet for superior sulcus lesions abutting the spine or subclavian vessels
FDG PET/CT scan (if not previously done)
Superior sulcus tumor
Chest wall
Proximal airway or mediastinum
Stage IIIA (T4, N0-1)
Unresectable disease
Metastatic disease
See Treatment (NSCL-5)
See Treatment (NSCL-6)
See Treatment for Metastasis limited sites (NSCL-13) or distant disease (NSCL-16)


NCCN Guidelines Version 2.2018
Non-Small Cell Lung Cancer
CLINICAL ASSESSMENT
PRETREATMENT EVALUATION
MEDIASTINAL BIOPSY FINDINGS AND RESECTABILITY
Stage IIIA (T1-2, N2) Stage IIIB (T3, N2)
PFTs (if not previously done)
Bronchoscopy
Pathologic mediastinal lymph node evaluation
FDG PET/CT scan (if not previously done)
Brain MRI with contrast
N2, N3 nodes negative
N2 nodes positive, M0
N3 nodes positive, M0
Metastatic disease
See Treatment T1-3, N0-1 (NSCL-8)
See Treatment (NSCL-8)
See Stage IIIB (NSCL-11)
See Treatment for Metastasis limited sites (NSCL-13) or distant disease (NSCL-16)
Separate pulmonary nodule(s) (Stage IIB, IIIA, IV)
Separate pulmonary nodule(s), same lobe (T3, N0-1) or ipsilateral non-primary lobe (T4, N0-1)
Stage IVA (N0, M1a) Contralateral lung (solitary nodule)
Extrathoracic metastatic disease
See Treatment (NSCL-9)

Pretreatment evaluation – patient condition-

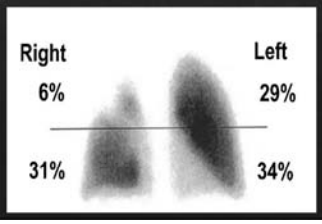
- **Preoperative routine lab**
  - CBC, ESR, LRFT, electrolyte, ABO type
  - HBV, HCV, HIV, VDRL
  - Tumor marker (CEA, CA19-9, cyfra21-1, NSE, SCC etc)
- ***Pulmonary Function Test, Lung perfusion scan***
- ***Cardiac evaluation***
  - Myocardial perfusion, Treadmil test, CAG
  - Echocardiography

Predictive postoperative FEV1

1. Lung perfusion scintigraphy

The percentage of function attributed to the lung not being resected was multiplied by the preoperative measured value of lung function to achieve a predicted postoperative value for lung function

Example)
RUL lung cancer



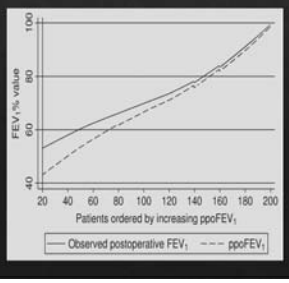
Predictive postoperative FEV1

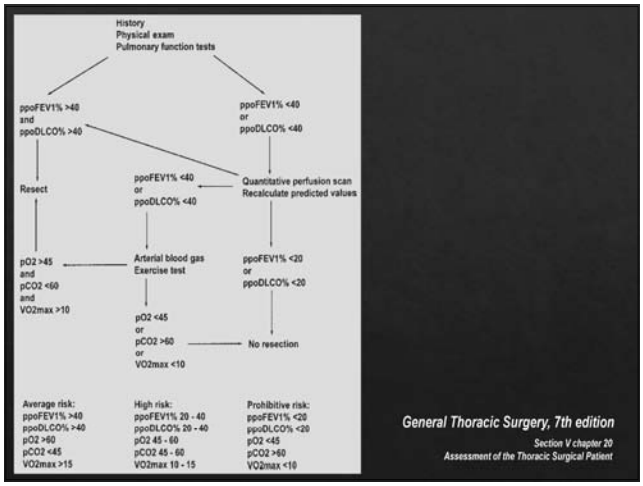
2. The calculation of postoperative lung function using simple equations rather than physiologic tests was originally introduced in 1975: an equal value was assigned to each of the 19 lung segments in order to determine the amount of functioning lung remaining after resection.
3. More recent techniques for calculating predicted postoperative spirometric values use the number of functioning segments as the denominator and the number of functioning segments

$$\text{Postoperative function} = \text{Preoperative function} \times \frac{\text{Functioning segments remaining following resection}}{\text{Functioning segments present prior to resection}}$$

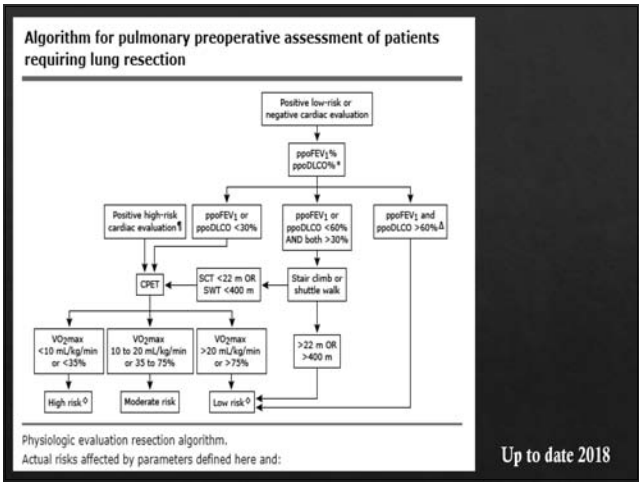
Predictive postoperative FEV1

4. The use of quantitative computed tomography (CT) in estimating relative lung function as a means for calculating predicted postoperative function has been shown to be similar to lung perfusion scintigraphy and segmental percentage loss in the accuracy of predicting postoperative function.





General Thoracic Surgery, 7th edition
Section V chapter 20
Assessment of the Thoracic Surgical Patient



Up to date 2018

Risk group

1. **Low risk** : The expected risk of **mortality is below 1%.** Major anatomic resections can be safely performed in this group

2. Moderate risk: Morbidity and mortality rates may vary according to the values of split lung functions, exercise tolerance and extent of resection. **Risks and benefits of the operation should be thoroughly discussed with the patient.**

3. High risk: The risk of **mortality** after standard major anatomic resections may **be higher than 10%.** Considerable risk of severe cardiopulmonary morbidity and residual functional loss is expected. Patients should be counseled about **alternative surgical (minor resections or minimally invasive surgery) or nonsurgical options.**

Cardiac evaluation

Physiologic reasons for especially high risk of cardiac complications

1. Significant atelectasis, decreased lung compliance, and decreased diffusing capacity after thoracic surgery may lead to hypoxia, hypercarbia, or increased work of breathing, which all decrease **myocardial oxygen** supply and increase myocardial oxygen demand. This **mismatch** may precipitate ischemia, which in turn can lead to arrhythmias, congestive heart failure, or even MI.
2. Postoperative patients develop a **hypercoagulable** state that may exacerbate fixed coronary stenoses, contribute to new coronary plaque rupture, or place strain on the heart through the development of pulmonary emboli.
3. After major lung resections, the decrease in the pulmonary vascular bed results in **increased preload**, which can worsen congestive heart failure.

- Which patients warrant *non invasive cardiac stress testing* (tread mill test, stress echocardiography, or a nuclear stress test)?
- Which patients should proceed directly to *coronary angiography*?
- Who should have *no testing* at all?

Clinical Predictors of Increased Perioperative Cardiovascular Risk (Myocardial Infarction, Heart F

Intermediate
- *Mild angina pectoris* (Canadian class I or II)
- *Previous MI by history or pathologic Q waves*
- *Compensated or prior heart failure*
- *Diabetes mellitus* (particularly insulin-dependent)
- *Renal insufficiency*

Minor
- *Advanced age*
- *Abnormal ECG* (left ventricular hypertrophy, left bundle-branch block, ST-T abnormalities)
- *Rhythm other than sinus* (e.g., atrial fibrillation)
- *Low functional capacity* (e.g., inability to climb one flight of stairs with a bag of groceries)
- *History of stroke*
- *Uncontrolled systemic hypertension*

Table 4 Surgical risk[a] estimate (modified from Boersma et al.[6])

Low-risk <1%	Intermediate-risk 1–5%	High-risk >5%
• Breast • Dental • Endocrine • Eye • Gynaecology • Reconstructive • Orthopaedic—minor (knee surgery) • Urologic—minor	• Abdominal • Carotid • Peripheral arterial angioplasty • Endovascular aneurysm repair • Head and neck surgery • Neurological/ orthopaedic—major (hip and spine surgery) • Pulmonary renal/ liver transplant • Urologic—major	• Aortic and major vascular surgery • Peripheral vascular surgery

[a]Risk of MI and cardiac death within 30 days after surgery.

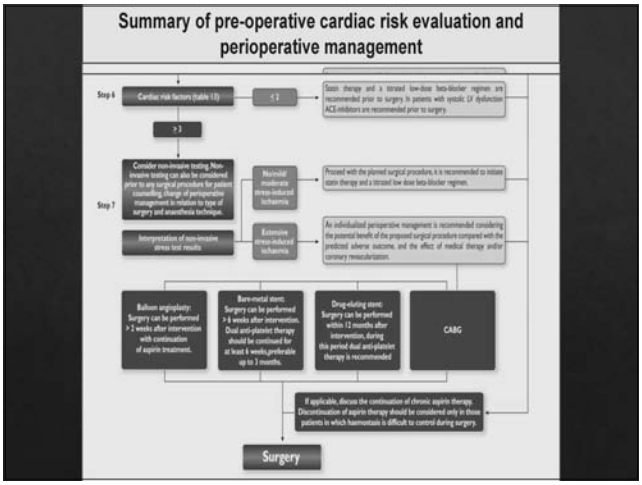
Table 13 Clinical risk factors

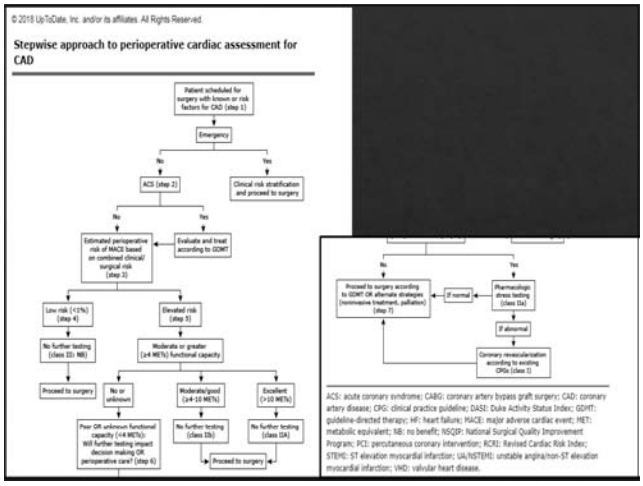
Angina pectoris
Prior MI[a]
Heart failure
Stroke/transient ischaemic attack
Renal dysfunction (serum creatinine >170 μmol/L or 2 mg/dL or a creatinine clearance of <60 mL/min)
Diabetes mellitus requiring insulin therapy

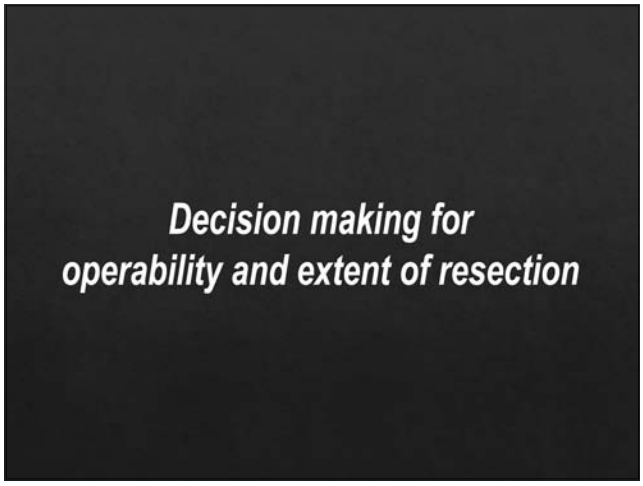
Physical activity	MET

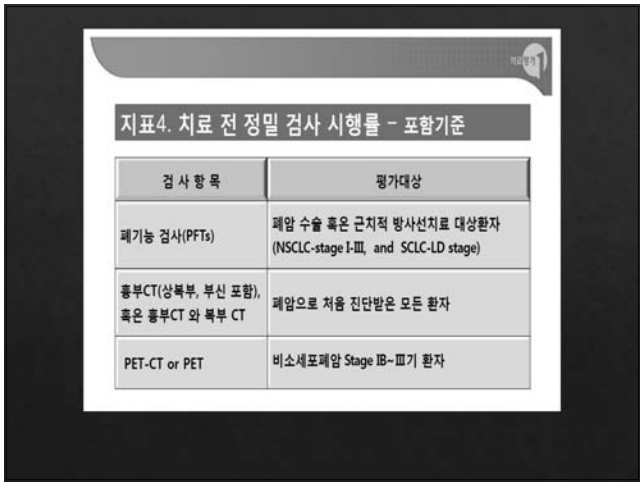
Functional activities (■는 심폐 기능 강화 활동이며 이보다 낮은 강도의 활동은 안전하게 시행 가능합니다.)

METs	활동	METs	활동
☐ 2.0	시속 1.5km로 걷기	☐ 6.0	시속 7.3km의 조깅, 복식 테니스(많이 뛰는) 시속 16km의 자전거
☐ 2.5	계단 내려가기, 개 산책시키기	☐ 6.5	하이킹
☐ 2.8	시속 4km 걷기, 골프, 볼링, 낚시	☐ 7.0	조정, 격렬한 춤동작
☐ 3.5	시속 5km 걷기	☐ 8.0	시속 8km의 조깅, 시속 20km의 자전거
☐ 4.0	계단오르기, 보통 속도의 춤, 수중에어로빅 탁구, 시속 15km의 자전거	☐ 10.0	시속 9.6km의 조깅, 시속 24km의 자전거 단식 테니스, 스쿼시, 라켓볼
☐ 4.5	느린 수영, 골프, 배드민턴(레저)	☐ 13.5	시속 11.2km의 조깅
☐ 5.0	시속 6.4km로 걷기, 빠른 춤동작, 복식 테니스 성생활	☐ 14.0	스피닝



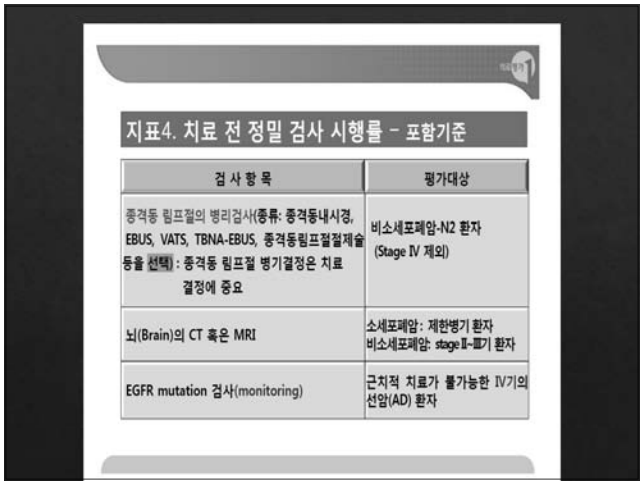






지표4. 치료 전 정밀 검사 시행률 – 포함기준

검 사 항 목	평가대상
폐기능 검사(PFTs)	폐암 수술 혹은 근치적 방사선치료 대상환자 (NSCLC-stage I-III, and SCLC-LD stage)
흉부CT(상복부, 부신 포함), 혹은 흉부CT 와 복부 CT	폐암으로 처음 진단받은 모든 환자
PET-CT or PET	비소세포폐암 Stage IB~III기 환자



지표4. 치료 전 정밀 검사 시행률 – 포함기준

검 사 항 목	평가대상
종격동 림프절의 병리검사(종류: 종격동내시경, EBUS, VATS, TBNA-EBUS, 종격동림프절절제술 등을 선택) : 종격동 림프절 병기결정은 치료 결정에 중요	비소세포폐암-N2 환자 (Stage IV 제외)
뇌(Brain)의 CT 혹은 MRI	소세포폐암 : 제한병기 환자 비소세포폐암: stage II-III기 환자
EGFR mutation 검사(monitoring)	근치적 치료가 불가능한 IV기의 선암(AD) 환자

Multi-modality Treatments for Lung Cancer

Thoracic and Cardiovascular Surgery, Seoul National University Bundang Hospital

Jae Hyun Jeon

Contents

- Adjuvant therapy (Stage I, II and IIIA)
- Neoadjuvant therapy (Stage IIIA)
- Definitive therapy w/o surgery (Stage IIIA)
- Others

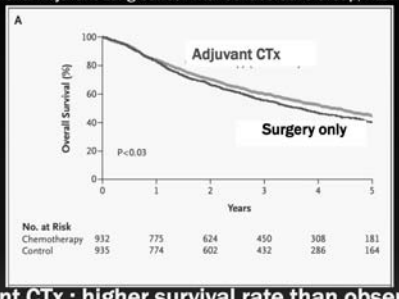
Adjuvant therapy

Adjuvant Chemotherapy

- High postoperative relapse
- Most of the relapses : systemic
  (lung, bone, CNS, adrenal, etc)
- Earlier proof of benefit : breast, colorectal ca..

IALT trial results (2004; stages I-III)

*The International Adjuvant Lung Cancer Trial Collaborative Group; NEJM2004;350;351-60

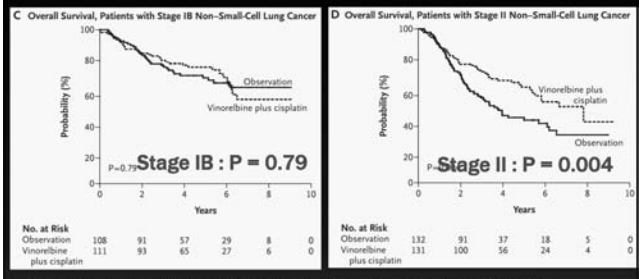


Adjuvant CTx : higher survival rate than observation

5y OS Adjuvant CTx: 44 5% vs Surgery only: 40 4%

HR 0.86 (95% CI, 0.76-0.98; P < 0.03)

JBR.10 trial results (2005; stages 1B-II)



Adjuvant CTx : higher survival rate than observation

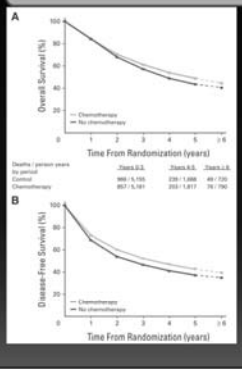
5y OS Adjuvant CTx: 69% vs Surgery only: 54% (P = 0.003)

Benefit from adjuvant CTx : Stage II or more

Meta-analysis

LACE Collaborative Group

J Clin Oncol 2008;26:3552-3559



- stage I,II, + III (27%)
- 5yr absolute benefit : 5.4%
- HR for stage IA = 1.40 (0.95 to 2.06)
- HR for stage IB = 0.93 (0.78 to 1.10)
- HR for stage II = 0.83 (0.73 to 0.95)
- HR for stage III = 0.83 (0.72 to 0.94)

NCCN Clinical Practice Guidelines in Oncology (NCCN Guidelines®)

Non-Small Cell Lung Cancer

Version 4.2018 — April 26, 2018

- Stage IA Surgery -> Observe
- Stage IB Surgery -> Observe or Chemotherapy (*high risk)
- Stage II Surgery -> Chemotherapy (category 1)
- Stage IIIA Surgery -> Chemotherapy (category 1)

*High risk: PD tumors (ex. Neuroendocrine tumors, vascular invasion, wedge resection, tumors > 4 cm, VPI (+), Nx, etc

Multi-modality for N2 NSCLC

; Neoadjuvant treatment

; Definitive CCRT

N2 NSCLC

- Heterogeneity of N2 disease

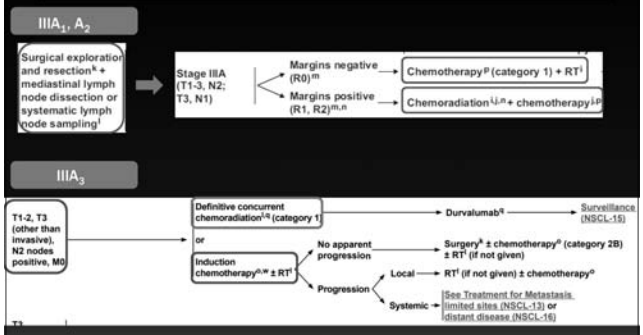
Subset	Description
$IIIA_1$	Incidental nodal metastases found on final pathology examination of the resection specimen
$IIIA_2$	Nodal (single station) metastases recognized intraoperatively ➡ Resectable
$IIIA_3$	Nodal metastases (single or multiple station) recognized by prethoracotomy staging (mediastinoscopy, other nodal biopsy, or PET scan) ➡ Potentially resectable
$IIIA_4$	Bulky or fixed multistation N2 disease ➡ Unresectable

Treatment of Non-small Cell Lung Cancer-Stage IIIA: ACCP Evidence-Based Clinical Practice Guidelines (2nd Edition) Chest 2007;135:243S

Surgery

- No role for single modality treatment
- $IIIA_1$, $IIIA_2$: resectable ➡ Surgery + adjuvant therapy
- $IIIA_3$: potentially resectable ➡ Surgery ?
- $IIIA_4$: unresectable ➡ No surgery

NCCN guideline



NCCN Guidelines Version 4. 2018

How can we select the surgical candidates?

Mediastinal LN staging

Chest CT

- >1 cm short axis diameter with standard CT scan
- sensitivity 57%, specificity 82% *Chest* 2003;123:137S

PET

- meta-analysis *Ann Intern Med* 2003;139:879
  15%~26% PET (-) & pathologic N2 (+)
- recent single institutional study
  6%~16% PET (-) & pathologic N2 (+)

EBUS + EUS

- sensitivity 91.1%, specificity 100% *Chest* 2010;138:795

Prognostic factor

- Single-station > multi-station
- Clinical N factor
  - unsuspected N2 (cN0-1) > known cN2
- Complete resection > incomplete
- Anatomic site of N2
  - Level 7,8, and 9 < all other levels
- Lower T stage
- Skip metastasis > pN1+ *Detterbeck, J Thorac Oncol. 2008;3:289*
- Mediastinal dissection vs sampling?

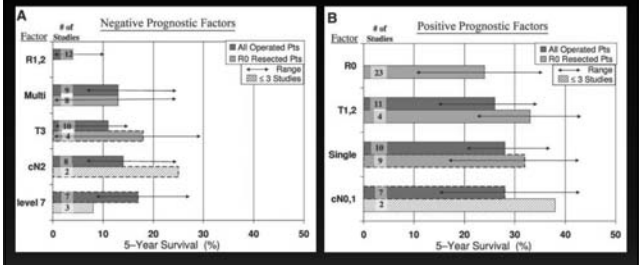
Prognostic factor

TABLE 2. Multivariate Analyses of Factors Predicting Poor Survival in pN2 Patients[a]

Study	n	Multilevel	Node Level: cN2	R1,2	N1+	7	5	1,2	T3,4	Larger Size	Lower Lobe	Pneum	Adeno/ Large	Older Age
Andre et al.[29]	702	<0.0001	<0.0001	NS	—	—	—	—	<0.0001	—	—	—	NS	—
Ichinose et al.[46]	406	<0.0001	NS	—	<0.03	—	—	—	<0.05[b]	—	—	NS	NS	0.02
Riquet et al.[31]	237	<0.05	—	<0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	—
Suzuki et al.[24]	222	<0.001	**<0.001**	0.02	—	—	—	—	NS	0.001	—	NS	NS	NS
Miller et al.[28]	167	<0.05	—	NS	—	<0.05	NS	(NS)[c]	NS	—	—	<0.05	NS	<0.05
Thomas et al.[33]	163	<0.02	—	—	—	NS	—	NS	NS	—	—	—	NS	—
Tanaka et al.[34]	155	NS	NS	0.001	—	—	—	—	0.03	—	—	—	NS	NS
Inoue et al.[32]	154	0.005	**<0.001**	—	—	—	—	—	NS	—	<0.04	—	**0.002**	0.007
Iwasaki et al.[43]	142	NS	—	—	NS	0.002	—	—	NS	—	—	NS	NS	NS
Vansteenkiste et al.[27]	140	0.03	0.04	NS	—	NS	NS	(NS)[c]	0.003	—	NS	NS	0.03	NS
Tanaka et al.[36]	99	**0.01**	**<0.04**	—	—	—	—	—	NS	—	—	—	NS	NS
Ohta et al.[37]	94	—	NS	—	0.03	**<0.001**	—	NS	**<0.001**	NS	NS	—	NS	NS
Prognostic value[d]		High	Mod	Mod	Mod	Mod	—	—	Low	Low	Low	—	—	Low

Detterbeck, J Thorac Oncol. 2008;3:289

Survival



Detterbeck, J Thorac Oncol. 2008;3:2892

Unsuspected N2 ($IIIA_1$, $IIIA_2$)

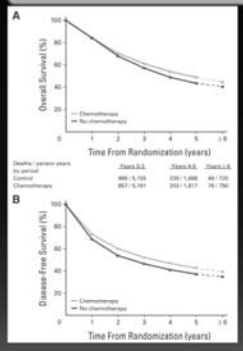
Adjuvant chemotherapy

Resectable N2 ($IIIA_1$/$IIIA_2$)

- Complete resection + adjuvant chemotherapy
- Level of evidence (NCCN): category 1
- Several meta-analyses & RCTs (stage I, II, and IIIA)
- No large RCT designed to include only N2 disease

Meta-analysis

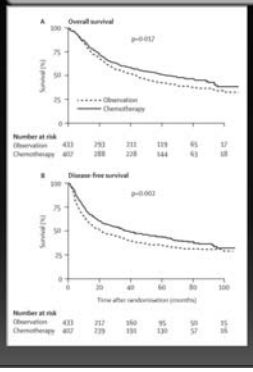
LACE Collaborative Group *J Clin Oncol 2008;26:3552-3559*



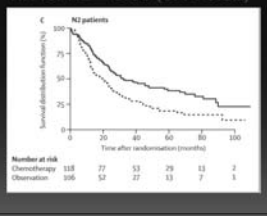
- stage I,II, + III (27%)
- 5yr absolute benefit : 5.4%
- HR for stage IA = 1.40 (0.95 to 2.06)
- HR for stage IB = 0.93 (0.78 to 1.10)
- HR for stage II = 0.83 (0.73 to 0.95)
- HR for stage III = 0.83 (0.72 to 0.94)

RCT

ANITA trial *Lancet Oncol 2006;7:719-27*



- stage IB,II, + IIIA (39%)
- vinorelbine+cisplatin vs observation
- 5yr overall survival benefit : 8.6%
- HR for N2 = 0.60 (0.44-0.82)



Adjuvant radiation

Potential benefit

- Reduce the risk of loco-regional recurrence
- Overall survival ?

Indication

- Close or positive surgical margin
- Involvement of multiple nodal stations
- Extracapsular tumor spread

Adjuvant radiation

PORT Meta-analysis Trialists Group *Cochrane Database Syst Rev. 2005*

- PORT vs surgery alone, 10 RCTs
- N0-1 subset : increased mortality
- N2 subset : no difference in overall survival

SEER database *J Clin Oncol 2006;24;2998*

- Retrospective study
- N2 subset : superior survival rate HR = 0.86 (0.76-0.96)

Adjuvant radiation

From ANITA trial

Int. J. Radiation Oncology Biol. Phys 2008;3:695

- Non-randomized sub-analysis of ANITA trial

Treatment group	pN0	pN1	pN2
Observation (%)	62.3	31.4	16.6
Observation + PORT (%)	43.8	42.6	21.3
Chemotherapy* (%)	59.7	56.3	34.0
Chemotherapy* + PORT (%)	44.4	40.0	47.4

preferably after completion of adjuvant chemotherapy !

Clinical N2 ($IIIA_3$)

Surgical multimodality vs CCRT (definite)

- $IIIA_3$ (potentially resectable)

no progression

Induction chemo ± RT → Surgery ± adjuvant Tx

→ Definite CCRT

Neoadjuvant chemotherapy

Proposed benefits

- A reduction in tumor size → resectability ↑
- Early eradication of micrometastases
- Down-staging of mediastinal LN's
- In vivo test of chemosensitivity
- Better tolerability (> adjuvant chemo)

Response rate : 50~70%

Complete resectability : 50~90%

Median 5yr survival : 20%~30%

Neoadjuvant chemotherapy

Disadvantages

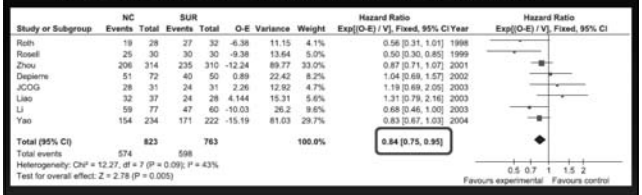
- Increased morbidity and mortality
- Ineffective induction regimen
- Progression of resectable disease

Neoadjuvant chemotherapy

Meta-analysis

J Thorac Oncol. 2010;5:510

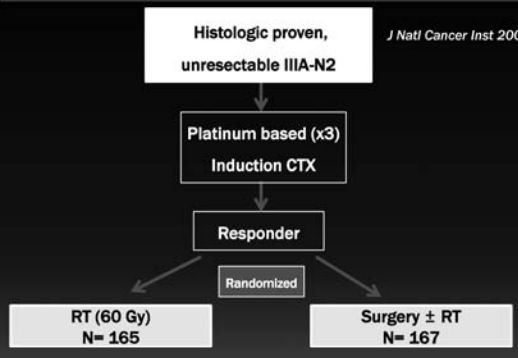
- Neoadjuvant CTX + Surgery **Vs** Surgery alone



- Stage III; combined HR=0.84 (0.75 to 0.95)
- No large RCT designed to include only N2 disease

Surgical multimodality vs Chemoradiation

EORTC 08941



J Natl Cancer Inst 2007;99:442

EORTC 08941

	RT arm (N = 165)	Surgery arm (N = 167)	P
R0 resection		50%	
Down staging		41%	
pathologic CR		5%	
Treatment related mortality	0.7%	4%	
pneumonectomy		7%	
2yr progression-free survival (%)	24 (18 to 31)	27 (20 to 33)	NS
5yr survival (%)	14. (9 to 20)	15.7 (10 to 22)	NS

EORTC 08941

	RT arm (N = 165)	Surgery arm (N = 167)	P
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Treatment related mortality	0.7%	4%	
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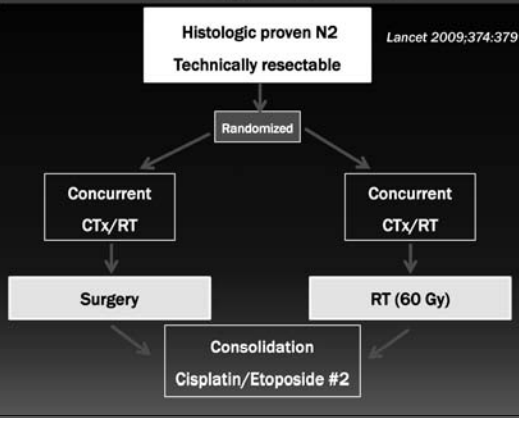
2yr progression-free survival (%)	24 (18 to 31) ≈	27 (20 to 33)	NS
5yr survival (%)	14. (9 to 20) ≈	15.7 (10 to 22)	NS

Intergroup 0139



Lancet 2009;374:379

Intergroup 0139

	CT/RT/S (N = 202)	CT/RT (N = 194)	P
R0 resection	71%		
Down staging	38%		
pathologic CR	12%		
Treatment related mortality	8%	2%	
lobectomy	1%		
pneumonectomy	26%		
5yr progression-free survival (%)	22.4	11.1	0.017
5yr survival (%)	27.2	20.3	NS
5yr survival (%, lobectomy matched)	36	18	0.002

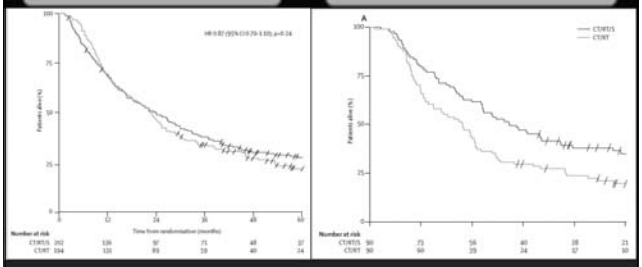
Intergroup 0139

	CT/RT/S (N = 202)		CT/RT (N = 194)	P
R0 resection	71%			
Down staging	38%			
pathologic CR	12%			
Treatment related mortality	8%		2%	
lobectomy	1%			
pneumonectomy	26%			
5yr progression-free survival (%)	22.4	>	11.1	0.017
5yr survival (%)	27.2	NS	20.3	NS
5yr survival (%, lobectomy matched)	36	>	18	0.002

Intergroup 0139

OS by treatment arm

OS by matched lobectomy subset



CTx + RT with or without resection (**preferably lobectomy**)
➡ Treatment options for N2 disease.

Conclusions

- Multidisciplinary evaluation (which includes a thoracic surgeon) is recommended before embarking on definitive treatment.
- Surgery alone is not enough to cure the majority of patients even with resectable disease.
- Need of multimodality approach to the treatment.

Thank you for your attention

Technical Aspects of Lung Cancer Surgery

분당서울대학교병원 흉부외과학교실

조 석 기

초 록

전통적으로 폐암 수술의 표준은 폐엽 절제술과 종격동 임파선 절제술로 알려져 있다. 따라서 환자의 심폐기능이 허용하는 한 표준수술을 시행하는 것이 폐암 수술의 원칙이었다. 폐엽 절제술에는 하나의 폐엽을 절제하는 경우가 대부분이지만, 두 개 이상의 폐엽 절제, 기관지 성형술, 혈관 성형술, 흉벽 절제술 등도 포함될 수 있다. 또한 최근에는 크기가 매우 작은 폐암과 간유리 음영을 동반한 예후가 매우 좋은 폐암이 증가하면서 수술 범위도 점점 작아지는 추세를 보이고 있다. 아직까지 대규모 임상연구의 결과가 나오지는 않았지만 폐엽 절제술 보다 작은 범위의 구역절제술, 쐐기절제술도 점점 늘어날 것으로 생각된다.

수술 범위 뿐만 아니라 수술 접근 방법에도 많은 변화가 있었다. 일반적인 개흉 수술은 20 cm 정도의 피부 절개와 늑골 골절 등을 통해 충분한 시야를 확보한 뒤에 시행하는 방법으로 아직까지 혈관 침범 등으로 위험성이 있거나 복잡한 수술이 동반된 경우에는 여전히 많이 시행되고 있다. 이에 비해 흉강경 수술은 흉부에 3-4개 정도의 구멍을 만들어서 시야는 내시경 카메라에 의존하고 내시경 도구를 이용하여 수술을 하는 방법이다. 수술 후 통증이 적고 기능 회복이 빨라 최근에는 모든 센터에서 적극적으로 시행하고 있다. 내시경 카메라, 수술 도구, 술기 등의 발달에 힘입어 단일공 수술로도 폐엽 절제술을 시행하고 있다. 기관지 성형술, 복잡 수술도 일부에서는 흉강경 수술로 시행하고 있다.

임파선 절제술의 의미에 대해서는 오랜 기간 동안 논란이 되어 왔지만 정확한 병기 설정과 미세전이 임파선에서는 치료 의미가 있다고 할 수 있다. 따라서 종격동 임파선을 포함한 임파선 절제술은 폐암 수술에서 기본적으로 시행해야 한다. 하지만 최근에는 기관지 내시경을 통한 임파선 조직 검사가 활발히 시행되고 있고, 크기가 매우 작은 폐암과 간유리 음영을 동반한 폐암이 증가하면서 일부에서는 임파선 절제를 하지 않거나 하더라도 선택적으로 시행하는 경우가 많다.

이번 강의에서는 실제 수술 비디오를 보면서 폐암 수술의 기술적인 면을 다루고자 한다.

내 용

1. Patients position (slide)

A. Complications of lateral decubitus position

(Operative Techniques in Thoracic and Cardiovascular Surgery, Vol 8, No 2, 2003: pp 51-57)

i. Brachial plexus injury
ii. Entrapment neuropathy of the suprascapular nerve
iii. Median and ulnar nerve injury
iv. Lateral popliteal nerve injury
v. Sciatic nerve injury
vi. Venous thrombosis

vii. Central nervous system damage due to head position

viii. Dependent eye damage

2. Open thoracotomy

(Operative Techniques in Thoracic and Cardiovascular Surgery, Vol 8, No 2, 2003: pp 51-57)

A. Posterolateral thoracotomy (slide)

i. Skin incision

- Started at the level of ant. axillary line over 5th or 6th intercostal space
- Curved around the tip of the scapula
- Continued posteriorly along a line between scapula and spine
- Oblique rather than a horizontal direction

ii. Muscle division

- Latissimus dorsi (division must be perpendicular to its fibers)
- Ant. Portion of the trapezius and rhomboid muscles posteriorly
- Serratus anterior spared

iii. Open intercostal space

- Full length of rib resection
- Posterior 1cm of lower rib resection
- Periosteal elevator (anteriorly above the rib and posteriorly below the rib)
- Spreader retractor (vertical limb placed anteriorly to the surgeon)

iv. Closure

- Chest tube insertion, anterosuperior iliac spine
- Chest tube to apex (placed over the superior border of the rib)
- Chest tube to base (rest against the inferior border of the rib)

3. VATS port placement

A. Considering points

(Kim K. Korean J Thorac Cardiovasc Surg 2011;44:1-8)

i. Ergonomically good position to handle the instruments

ii. Easiness to convert open thoracotomy

iii. Cosmetically good looking

iv. Less postoperative pain

B. Right side (slide)

i. Midaxillary line, 7^{th} ICS 12mm port for right hand instruments (bovie, stapler)

ii. Ant. Axillary line, 5^{th} ICS, 4-5 cm, working window, wound protector, for camera and assistant

iii. Below scapula tip, 7^{th} ICS, 5 mm port incision for left hand instruments (grasper)

C. Left side (slide)

i. Ant axillary line, 7^{th} ICS 12 mm port for right hand instruments (bovie, stapler)

ii. Ant. Axillary line, 5th ICS, 4-5 cm, working window, wound protector, for camera and left hand instruments
iii. Below scapula tip, 7th ICS, 12 mm port incision for camera and assistant

4. Open/VATS instrument (slide)

i. 각 병원에서 실제 사용하고 있는 수술도구의 정확 이름과 사용 용도에 대해서 명확히 파악
ii. Stapler, energy device 등 VATS에 흔히 사용되는 기구들의 작동 메커니즘과 각 제품별 장,단점 등을 파악
iii. 학회 때 제품 부스 등을 방문하여 정보 획득하고 web lab을 통해서 실제로 사용

5. Surgery

A. Inspection

i. One-lung ventilation :
- 잘 안되어 있으면 ventilation이 되는 것인지 collapse가 되지 않는 것인지 확인하고 마취과에 적절히 요구.
- 수술 중 산소포화도가 자주 떨어지는 경우는 double lumen E-tube에 의해서 우상엽이 ventilation이 안 되는 경우가 많음. 따라서 좌측 수술 시에 Right side E-tube를 사용하는 것이 좋음

ii. Identification of mass
- 정확한 위치를 확인해 두고 수술 중에 최대한 건드리는 것을 최소화하는 것이 좋다.
- Visceral pleural invasion이 있는지 확인해 보고 만약에 있다면 주변 또는 전체 흉막 전이의 유무를 더욱 철저히 확인해 본다.
- 약간의 흉수가 존재할 경우 cytology를 의뢰하고, 없더라도 술자에 따라서는 normal saline을 이용하여 lavage cytology를 시행하기도 한다.

B. Right upper lobectomy (video clip)

Fissure 중간에서부터 박리를 시작해서 뒤쪽(좌회전)으로 진행하면서 mediastinal pleura를 열어준다. 이때 upper lobar bronchus와 bronchus intermedius 사이의 interlobar LN (11RS)를 박리하면 좋다. Azygos vein 아래쪽까지 진행하여 upper lobar bronchus와 truncus anterior PA 일부를 노출 시킨다.

다음은 fissure 중간에서부터 posterior segmental vein 아래쪽을 따라서 앞쪽(우회전)으로 진행하면서 mediastinal pleura 열어준다. Upper lobar vein을 확인하고 phrenic nerve를 조심하면서 위쪽으로 계속 진행하고 마지막으로 truncus anterior PA를 완벽히 노출 시킨다.

다음은 fissure중간에서 post. Segmental vein과 inferior division of PA 사이를 박리하기 시작한다. 박리를 위쪽으로 더 진행해서 right upper lobar vein을 360도 완전히 박리한다. Linear stapler를 이용하여 vein을 자른다.

다음은 PA를 박리한다. Truncus anterior PA과 inferior division PA사이의 박리하는데, 이때 이 부분에 있는 hilar LN를 박리한다. CT에서 anthracotic LN가 예상되는 경우에는 매우 조심해서 박리를 시행한다. Truncus anterior PA를 360도 박리한 후에 linear stapler를 이용하여 자른다. 남아 있는 posterior ascending PA를 linear stapler 혹은 크기가 작은 경우에는 hemoclip, interlocking clip, silk tie등을 이용하여 처리한다.

다음은 bronchus를 박리한다. Peribronchial tissue와 주변의 peribronchial LNs들을 박리한다. 이때 bronchial artery들이 적절히 처리해서 bleeding으로 시야가 가려지는 일들이 없게 하는 것이 좋다. Endobronchial lesion이 없는 경우에는 기관지를 원위부까지 충분히 박리해서 linear stapler를 이용하여 자른다. 너무 가깝게 자를 경우 RML bronchus입구가 좁아지는 경우가 많다.

Major fissure가 완벽할 경우에는 수술 후 RML torsion의 우려가 있어서 폐를 부풀린 상태에서 중엽의 위치를 정확히 확인한 후에 허탈시킨 상태에서 중엽과 하엽을 붙이는 anchoring procedure를 여러 가지 방법으로 시행한다.

임파선 절제까지 종료된 후에는 distilled water (or Normal saline)로 irrigation과 함께 airleak test를 시행한다. Pressure는

20 mmH_2O 이상으로 높여서 test한다. 수술 후 중엽, 하엽의 원활한 upward deviation을 유도하기 위해서 inferior pulmonary ligament를 분리한다.

C. Left lower lobectomy (video clip)

먼저 inferior pulmonary ligament를 분리하면서 inferior LN (LN #9)을 박리한다. Inferior PV을 만나면 뒤쪽으로 진행하면서 mediastinal pleura를 열어준다. 이때 vagus nerve의 주행을 확인하면서 최대한 손상되지 않도록 주의한다. Vagus nerve손상은 좌측 폐엽 절제술 후 환자들이 복부 팽만감을 호소하는 이유 중에 하나이다. 위쪽으로 진행하면서 PV의 뒤쪽, bronchus의 뒤쪽, PA의 뒤쪽을 모두 확인하면서 aortic arch 아래까지 열어준다. 이때 폐 쪽으로 최대하 붙여서 박리할 경우 나중에 fissure처리하는데 도움이 된다. 경우에 따라서는 이 과정에서 subcarinal LN, hilar LN 등을 박리할 수도 있다.

다음은 inferior PV에서 앞쪽으로 진행하면서 mediastinal pleura를 열어준다. 이때는 phrenic nerve를 조심하고 superior pulmonary vein 위치까지 박리한다. 폐쪽으로 충분히 붙여서 박리하면 경우에 따라서는 inferior PV이 360도 노출되기도 한다.

다음은 fissure를 박리한다. Fissure가 완벽할 때는 쉽지만 완벽하지 않을 때는 조심해서 박리하면서 이미 열어둔 앞쪽 뒤쪽과의 연결 통로를 확인하면 쉽게 박리할 수 있다. 이 경우 linear stapler를 이용하여 fissure를 분리한다.

다음은 lower lobe로 가는 PA의 바닥을 bronchus 위쪽과 박리한다. 대부분 anthracotic LN가 존재하지 않는 한 앞쪽에서 뒤쪽으로 박리를 시행하면 어렵지 않게 분리할 수 있다. 구조물이 모두 박리되면 편한 순서대로 각각을 자른다.

D. Mediastinal lymph node dissection (LND) (video clip)

i. Paratracheal LND (slide)

- Right side : 각 면의 구조물은 슬라이드 참고
  임파선 주변의 지방조직까지 포함해서 절제하고 되도록 경계부위까지 박리를 하면 임파선이 파쇄되거나 불충분히 되는 경우는 드물다. 오히려 수술 후 출혈이 있거나 유미흉이 생기는 합병증을 줄일 수 있다. 수술도구는 energy device중에 하나를 사용하면 더 쉽게 박리할 수 있다.
- Left side: CT 혹은 PET에서 의미있는 임파선이 있지 않는 한 접근이 어렵고 되돌이 후두 신경의 손상이 흔하기 때문에 잘 시행하지는 않는다.

ii. Subcarinal LND (slide)

- Right side : 각 변의 구조물은 슬라이드 참고
  좌측 주기관지를 확인하는 것, 기관지 동맥을 최대한 보존하는 것, 가급적 vagus nerve의 손상을 줄여주는 것이 중요하다.
- Left side: 충분히 노출시키는 것이 가장 중요, 좌측 주기관지를 최대한 앞쪽, 위쪽으로 당기고 식도와 대동맥을 최대한 뒤쪽으로 당기는 삼각형 모양의 충분한 공간이 확보된다. 수술 전 right side double lumen E tube를 사용하면 좋다. 여기서도 우측 주기관지를 확인하면 충분한 박리가 되었다고 생각할 수 있다. 그리고 수술 후 확인을 위해서 metal clip을 가장 깊은 곳에 물고 나오면 도움이 된다.

iii. Interlobar LND (slide)

- Right side
  - Upper lobar bronchus와 bronchus intermedius사이에 있는 임파선 (#11RS)
  - Middle lobar bronchus와 lower lobar bronchus사이에 있는 임파선 (#11RI)
- Left side
  - Upper lobar bronchus와 lower lobar bronchus사이의 임파선

iv. Aortic LND (slide)

- Subaortic, para-aortic LNs
  - 앞쪽으로 phrenic nerve 뒤쪽으로는 vagus nerve, 아래쪽은 PA trunk를 사이에 둔 공간에 포함된 임파선을 절제
  - 좌측 되돌이 후두 신경의 손상이 발생할 수 있다.

【일반흉부파트】

좌장: 이성수

Complications of Lung Surgery

고려대학교 안산병원 흉부외과학교실

황 진 욱

1. Introduction

폐 수술(lung surgery)은 폐 절제술(pulmonary resection) 및 이와 연관된 기타 처치를 포함하고 있다. 폐 절제술은 절제 범위에 따라 쐐기 절제술(wedge resection), 구역 절제술(segmentectomy), 폐엽 절제술(lobectomy), 전폐절제술(pneumonectomuy)로 분류할 수 있으며, 폐암의 경우 폐 절제술과 함께 종격동 림프절 청소술(mediastinal lymph node dissection)을 동반하여 시행할 경우 이에 따른 합병증도 추가적으로 발생할 수 있다.

폐 수술 환자에서 흔히 접할 수 있는 합병증은 수술 후 지속적 공기 누출(prolonged air leak)이며, 5일 이상의 누출일 경우, 수술적 중재가 필요한 경우도 있다.

또한, 기관 성형술을 동반한 폐절제술(sleeve lobectomy) 후 발생한 기관지 문합부 열상이나, 전폐절제술 후 발생한 기관지 늑막강루(bronchopleural fistula), 폐엽 절제술 후 농흉(post lobectomy empyema)는 발생시 환자의 이환률 및 사망률(mobility and mortality)을 증가시키는 치명적 합병증이 될 수 있다.

수술 후 공기누출이나 피하기종(subcutaneous emphysema)과 같이 대부분의 합병증은 초기에 공통적 증상(sign)을 보인다. 하지만, 이에 대한 진단 및 처치가 적절하지 않을 경우 환자의 이환율 및 사망률을 높일 수 있다.

본 강의에서는 폐 수술 후 접할 수 있는 합병증과 치료방법에 대해 알아보도록 하겠다.

2. Prolonged Air Leak

Definition and diagnosis

Prolonged air leak that last beyond postoperative day 5

Incidence

8-26% after pulmonary resection

Risk factors

- *poor pulmonary function,*
- *use of steroids,*
- *upper lobectomy,*
- *sublobar resection*
- *presence of a pneumothorax coinciding with an air leak*

- *the presence of pleural adhesions*

Management

- *Intraoperative prevention*
- *postoperative chest tube management*
- *Non-surgical management*
- *Surgical management*

3. Bronchopleural Fistula (BPF) and Post Lobectomy Empyema

Definition

a communication between the pleural space and the bronchial tree.

Incidence

1.5-28% after pulmonary lobar resection and pneumonectomy

Risk factors

- *poor nutrition*
- *septic condition associated underlying infection*
- *TB, Aspergillosis etc*
- *Excessive long stump: as proximal as possible*
- *Bronchial blood supply technique fo stump closure*
- *Irradiated stump or disease stump:*

Prevention

Stump closure techniques

Preoperative bronchoscopy

Diagnosis

Sign and Symptom

Management

Acute post pneumonectomy BPF

- *Debridement of bronchial stump*
- *Interrupted suture*
- *Stump coverage: Omentum or pedicled intercostal muscle or mediastinal fat*

Chronic pneumonectomy fistula

- *Open window thoracotomy or Eloesser flap*

- *Intrathoracic muscle transposition*
- *Thoracoplasty*
- *Vacuum Assisted Devices*

Long bronchial stump

- *Transsternal approach for reamputation*

4. Lobar Torsion and Gangrene

Definition

Rotation of bronchovascular pedicle and progress to infarction and gangrenous change

Prevention

Right middle lobe torsion following right upper lobectomy

Avoid unnecessary dissection

Placement of sutures lateral segment of middle lobe

Diagnosis

Unusual lobar consolidation in plain chest x-ray

Chest CT

Management

Early recognition

Immediate reoperation

5. Post Thoracotomy Pain Syndrome

6. Summary

- 폐절제술 후 합병증은 1)환자의 전신 조건, 2)병변의 국소 요인, 3) 수술 방법과 관련하여 발생할 수 있다.
- 수술 후 합병증의 발생은 수술 전 위험인자의 파악, 수술 시 합병증 예방을 위한 노력, 발생시 빠른 진단과 적절한 대처로 치명적 결과를 예방할 수 있다.
- 적절한 비수술적 방법은 환자에 도움이 될 수 있지만, 부적절한 비수술적 치료는 입원 기간의 연장과 치명적 결과를 낳을 수 있으니, 경험 있는 의사의 조언이 반드시 필요하다.

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Congenital and Benign Lung Diseases

연세대학교 의과대학 흉부외과학교실

박 성 용

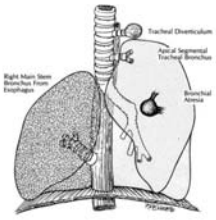
Congenital and Benign lung disease

- Malignant lung diseases
- Benign and congenital lung diseases
  - Congenital lesions of lung and pulmonary vasculature
  - Bullous lung disease
  - Infectious lung disease

Congenital lesions of lung

- Tracheal agenesis and atresia
- Bronchial anomalies
- Congenital lobar emphysema
- Pulmonary dysplasia
- Sequestration
- Bronchogenic cyst
- Congenital cystic adematoid malformation

Bronchial anomalies

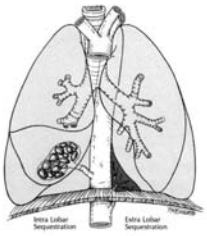


- Tracheal bronchus and diverticulum
- Bronchial atresia
  - Progressive respiratory symptom due to mucocele
- Anomalous bronchi
  - Common from esophagus

Congenital lobar emphysema

- The isolated hyperinflation of a lobe in the absence of extrinsic bronchial obstruction
- Frequent lobe; LUL, RML
- Severe pulmonary distress since infant
- Tx; resection (lobectomy)

Pulmonary sequestration



- Definition
  - a segment or lobe of lung tissue that has no bronchial communication with the normal tracheobronchial tree
  - The arterial blood supply; from a systemic vessel
  - The venous return; usually through the pulmonary veins, sometimes the systemic venous system
- Extralobar Sequestration
  - Seperated from normal lung by visceral pleura
  - 25% of sequestration
  - Left chest; 90%, posterior CPA angle
- Intralobar Sequestration
  - Situated within the normal lung parenchyme
  - Communication through the pores of Kohn may lead to chronic infection in the sequestered lobe
  - Symptoms; hemoptysis, false aneurysm

Congenital cystic adematoid malformation

- Definition
  - A spectrum of cystic and solid lesions of the lung can be identified histologically as CCAMs
  - Type I – III
- Histology
  - An adenomatoid increase of terminal respiratory bronchiole-like structures lined by ciliated columnar epithelium occurs. Interspersed cysts may resemble immature alveoli
  - The mucosa of cysts lined with bronchial-type epithelium may show polypoid overgrowth projecting into the lumen of the cysts
  - Bronchial mucoserous glands and cartilaginous plates are absent throughout the cystic parenchyma

Congenital cystic adematoid malformation

- Symptoms
  - Severe respiratory distress due to space occupying lesions
  - Recurrent pneumonia
  - Several reports of malignancy arising in CCAM; bronchoalveolar carcinoma, pleuropulmonary blastoma
- Timing of operation?

Congenital vascular lesions of lung

- Pulmonary arteries
  - Agenesis of a pulmonary artery
  - Stenosis of a branch or branches of the pulmonary arteries
  - Pulmonary arteriovenous fistula
- Pulmonary veins
  - Abnormal pulmonary venous connection
  - Varicosities of the pulmonary veins
- Lymphangiectasia

Pulmonary arteriovenous fistula

- Congenital malformations that result from errant capillary development, with incomplete formation or disintegration of the vascular septa that normally divide the primitive connections between the venous and arterial plexuses
- Classification
  - I; Multiple small arteriovenous fistulae without aneurysm
  - II; Large single arteriovenous aneurysm, peripheral
  - IIIa; Large single arteriovenous aneurysm, central
  - IIIb; Large arteriovenous aneurysm with anomalous venous drainage
  - IIIc; Multiple small arteriovenous fistulae with anomalous venous drainage
  - Iva; Large single venous aneurysm with systemic artery communication
  - Ivb; Large single venous aneurysm without fistula, varix of pulmonary vein
  - V; Anomalous venous drainage without fistula

Pulmonary arteriovenous fistula

- Symptoms
  - Decreased pO_2 (shunt effect)
  - Stroke
  - Cerebral abscess
  - Seizure
- Treatment
  - Coil obliteration (10-15mm diameter)
  - Surgical resection

Bullous and Bleb Diseases of the Lung

- Bullae; emphysematous spaces larger than 1 cm in diameter in the inflated lung, usually but not necessarily demarcated from surrounding lung by curved hairline shadows
- Blebs; well-circumscribed intrapleural air spaces separated from the underlying parenchyma by a thin pleural covering
- Group I; Bullae and Almost Normal Underlying Lung
- Group II; Bullae Associated with Diffuse Emphysema

Rationale and Indications for Surgery

- Pneumothorax
  - Prolonged air leak
  - High incidence of recurrences (>50%)
- Infection of the bulla (uncommon); Failure to respond to medical treatment
- Hemoptysis (uncommon)
- Chest pain; Pain clearly related to air trapping during hyperventilation
- Treatment of lung cancer
  - Documented cancer or highly suspicious lesion
- Expansion of previously collapsed lung
  - Increase in vital capacity and forced expiratory volume in 1 second
  - Improvement in gas exchange (higher ventilation-perfusion ratio and arterial P_{O2})
- Hemodynamic improvement
  - Increase in cardiac output; better exercise tolerance
- Restoration of normal curve of diaphragm
  - Improvement in diaphragmatic contractility and function
- Restoration of elastic recoil and reduction in airway resistance
  - Bullae increase the loss of elasticity in the emphysematous lung
  - Loss of elastic recoil causes an extrinsic airway obstruction
- Removal of an area of dead space ventilation
  - Reduction in volume of wasted ventilation
  - Decrease in work of breathing

Selection of patients for surgery

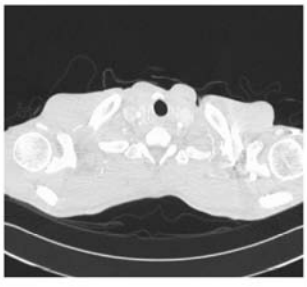
- Is there a localized or enlarging bulla, or both?
- Is the bulla nonfunctional and does it compress adjacent lung, mediastinum, diaphragm?
- Can the compressed lung reexpand and what is its potential to function once reexpanded?
- What is the extent and severity of emphysema in the remaining lung?
- What is the cardiac performance?
- Does the patient have significant associated comorbidities, weight loss, or both?
- Can the patient withstand an operation?

Selection of patients for surgery

Area of Investigation	Technique	Most Suitable for Surgery	Least Suitable for Surgery
Anatomy of bullae	Standard radiographs, CT scan	Large (more than half hemithorax) localized and unilateral bullae Enlargement over time	Multiple, small bilateral bullae No enlargement over time
Function of bullae	V/Q scans, plethysmography	Nonventilated, nonperfused bullae	Ventilated and perfused bullae
Compression index	Standard radiographs, CT scan angiography	High index (≥3/6)	Low index (<3/6)
State of compressed lung	Angiography, V/Q scans, CT scan	Good capillary filling Good washout of xenon	Poor capillary filling Retention of xenon
Severity of emphysema	CT scan, pulmonary function tests, exercise tests	Minimal or no COPD	Severe COPD Respiratory failure
Medical status	Clinical examination, EKG, echocardiography, nutritional evaluation	Young age Normal heart No comorbidities No weight loss	Older age Cor pulmonale Significant comorbidities Significant weight loss

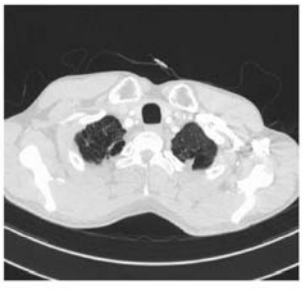
Case; M/59

- Diagnosis; Emphysema
- Operation; Wedge resection of RUL under VATS (2013)
- FEV1 1.05 (35%) → 2.32 (66%)



Case; M/59

- 5 years later,
- FEV1 1.05 (35%) → 2.32 (66%) → 0.84 (29%)



Bacterial Infections of the Lung and Bronchial Compression

- Spectrum of surgical infectious disease
  - Bronchiectasis
  - Lung abscess
  - Organizing pneumonia
  - Pulmonary infection in granulomatous disease of childhood
  - Tuberculosis and fungal disease
  - Thoracic empyema
- Bronchial compressive pulmonary disorders
  - Right middle lobe syndrome
  - Broncholithiasis
  - Inflammatory lymphadenopathy
  - Congenital processes
  - Sclerosing mediastinitis
  - Cardiovascular disease
  - Congenital
    - Vascular ring
    - Aberrant left pulmonary artery
  - Acquired aortic disease
    - Aortic arch aneurysm
    - Traumatic false aneurysm

Bronchiectasis

- Definition; abnormal permanent dilatation of subsegmental airways
- Treatment
  - Medical
    - Prevention and control
    - Antibiotics
    - Postural drainage
  - Surgical
    - Unilateral, segmental, or lobar distribution
    - Persistent, recurrent symptoms when medication is discontinued
    - Recurrent infection and hemoptysis
- Transplantation

Lung abscess

- Principles of Therapy for Lung Abscess
  - Identification of etiologic organism
  - Prolonged antimicrobial therapy
  - Adequate drainage in acute stage
  - Chest physiotherapy
  - Bronchoscopy
  - Percutaneous catheter drainage
  - Emergency surgical treatment
  - External drainage (only in emergent situation)
- Indications for Surgery in Lung Abscess
  - Acute stage (emergency); Complications
    - Bronchopleural fistula
    - Empyema
    - Bleeding
  - Chronic stage (definitive)
    - Persistent symptoms and signs
    - Recurrent complications (empyema, bronchopleural fistula)
    - Suspicion of carcinoma
    - Persistence of lung abscess larger than 6 cm after 8 weeks of treatment

Surgery for Tuberculosis and NTM

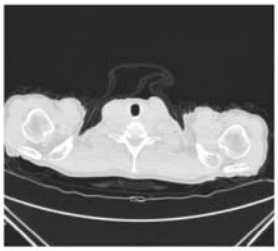
- Classical treatment
  - Collapse therapy (by collapsing cavitary disease, the organisms would be deprived of oxygen and thus die)
- Current surgical indications
  - Destroyed lung by MDR TB
  - Cavitary disease
  - Life-Threatening Hemoptysis in Patients with Tuberculosis
  - Tuberculous Bronchial Stricture
  - Suspected malignancies
- Frequent complications after operation
  - Empyema
  - Broncho-pleural fistula

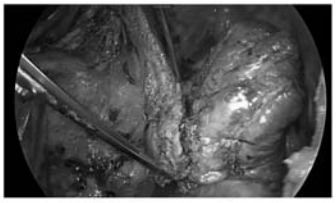
Technical tips for infectious lung disease

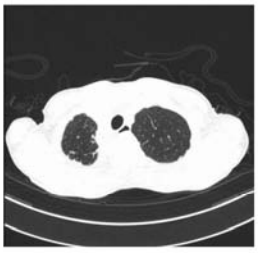
- Proper antibiotics during peri-operative periods
- Cover the bronchial stump! (to prevent BPF)

Case; F/59

- Diagnosis; Drug resistant - NTM infection
- Operation; RLL lobectomy, wedge resection of RML, intercostal muscle flap







Mycotic and Actinomycotic Infections

- Aspergillosis
- Blastomycosis
- Candidiasis
- Coccidioidomycosis
- Cryptococcosis
- Histoplasmosis
- Mucormycosis
- Paracoccidioidomycosis
- Pseudallescheriasis
- Sporotrichosis

- Actinomycosis
- Nocardiosis

Pulmonary Metastasectomy

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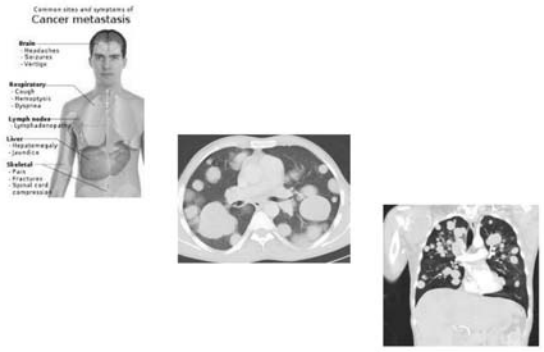
Sungsoo Lee



Metastatic disease : Principle reason for cancer death

Lung metastases : 25~30% of all patients with cancer at autopsy

1882, German surgeon

Pulmonary metastases

BOX 23-1 Primaries Most Commonly Metastatic to the Lung*

- Breast
- Colon
- Kidney
- Uterus
- Prostate
- Oropharyngeal carcinoma

*Most common because of greater prevalence.

BOX 23-2 Tumors with the Highest Predilection for Pulmonary Metastasis

- Choriocarcinoma
- Osteosarcoma
- Testicular tumors
- Melanoma
- Ewing sarcoma
- Kaposi sarcoma

New pulmonary nodule

Primary lung cancer vs. metastasis

Original type of malignancy

	Metastasis	Primary lung cancer
Sarcoma	10	1
Melanoma	10	1
Genitourinary cancer	1	1
Colorectal cancer	1	1
Head and neck cancer	0.5	1

Chest 1995; 107: 322S-332S

First case: 1882, Weinlechner

Criteria for metastasectomy

Primary tumor that has been definitely controlled.
Metastases limited to the lung that can be completely resected.
Ability of the patient to tolerate the planned operation.
Lack of a better alternative treatment.

The number of lung metastases.
The disease-free interval since treatment of the primary tumor.
The tumor doubling time, the presence of lymph node metastases.
The histology of the primary tumor.
Elevated serum markers such as carcinoembryonic antigen.

J Thoracic Oncol 2010; 5: S130-1

GENERAL THORACIC SURGERY

LONG-TERM RESULTS OF LUNG METASTASECTOMY: PROGNOSTIC ANALYSES BASED ON 5206 CASES

The International Registry of Lung Metastases*
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Objectives: **The International Registry of Lung Metastases was established in 1991 to assess the long-term results of pulmonary metastasectomy.** *Methods:* **The Registry has accrued 5206 cases of lung metastasectomy, from 18 departments of thoracic surgery in Europe (n = 13), the United States (n = 4) and Canada (n = 1). Of these patients, 4572 (88%) underwent complete surgical resection. The primary tumor was epithelial in 2260 cases, sarcoma in 2173, germ cell in 363, and melanoma in 328. The disease-free interval was 0 to 11 months in 2199 cases, 12 to 35 months in 1857, and more than 36 months in 1620. Single metastases accounted for 2383 cases and multiple lesions for 2726. Mean follow-up was 46 months. Analysis was performed by Kaplan-Meier estimates of survival, relative risks of death, and multivariate Cox model.** *Results:* **The actuarial survival after complete metastasectomy was 36%**

	5yr survival	10yr survival
Complete metastasectomy	36%	26%
Imcomplere metastasectomy	13%	7%

simple system of classification valid for different tumor types. (J Thorac Cardiovasc Surg 1997;113:37-49)

European Society of Thoracic Surgeons (ESTS)

Lung metastasectomy project

1. Optimal preoperative imaging
2. The role of mediastinal lymph node dissection
3. Surgical approach
4. The extent of surgical resection

Pathophysiology of Pulmonary Metastases

Initiated after cell detachment from the primary tumor mass

↓

Movement from the extracellular space into a vascular compartment (*intravasation*)

↓

Tumor cells bind to pulmonary vasculature

↓

Movement of tumor cells from the circulatory system into the interstitium (*extravasation*)

↓

Tumor cells proliferation and local invasion

Symptoms and Presentation

Approximately 75% to 90% of patients are asymptomatic
(predominantly due to the usual peripheral location of pulmonary metastases)

↓

Discovered incidentally on follow-up radiologic examinations

↓

Symptoms typically occur with endobronchial or pleural involvement, large bulky disease, or central venous obstruction
(cough, hemoptysis, dyspnea, wheezing etc.)

Radiologic Image

Imaging Requirements in the Practice of Pulmonary Metastasectomy

Frank C. Detterbeck, MD, Tomasz Grodzki, MD,† Fergus Gleeson, MD,‡ and John H. Robert, MD§*

Abstract: The primary imaging modality for the detection of pulmonary metastases is computed tomography (CT). Ideally, a helical CT scan with 3- to 5-mm reconstruction thickness or a volumetric thin section scanning should be performed within 4 weeks of pulmonary metastasectomy. A period of observation to see whether further metastases develop does not seem to allow better patient selection. If positron emission tomography is available, it may identify the extrathoracic metastatic sites in 10 to 15% of patients. Despite helical CT scan, palpation identifies the metastases not detected by imaging in 20 to 25% of patients and remains the standard. No data define the optimal interval for follow-up surveillance imaging.

Key Words: Imaging, Pulmonary metastasectomy, Lung metastases, Pulmonary nodule.

(*J Thorac Oncol.* 2010;5: S134–S139)

- What type and protocol of chest computed tomography scan (CT) should be performed in patients suspected to have pulmonary metastases?
- How should the images be reviewed?
- Are all nodules detected significant?
- How recently should a CT scan be done before metastasectomy?
- Is an observation period with serial CT scanning before metastasectomy beneficial?
- Should a positron emission tomography (PET) scan be performed before metastasectomy to diagnose extrathoracic or intrathoracic metastases?
- Is helical CT imaging adequate to avoid palpation of the lung?
- What interval of follow-up CT scans is necessary?

Nonspecific radiographic appearance
Critical importance
Chest CT : standard imaging modality

3 ~ 5mm slice thickness

Within 4 weeks of pulmonary metastasectomy

PET (role out occult distant metastases)

Follow-up
- 4~6 weeks after surgery
- every 6 months for 2 years
- every 1 years for at least 5 years

Tissue Diagnosis

Sputum cytology, which has been replaced by bronchoscopy, is often nondiagnostic because of the peripheral location of most pulmonary metastases

Percutaneous fine-needle aspiration (FNA) is another option
(low sensitivity, difficulty to obtain ample tissue)

VATS with excisional biopsy
(sensitivity and specificity approaching 100%,
therapeutic as well as diagnostic)

Indication for Surgery

Q. Does the pulmonary nodule represent one site of multiorgan spread, thereby contraindicating resection?

↓

Most pulmonary nodules (75% to 85%) are a manifestation of widespread disease

↓

Only 15% to 25% of patients have lesions confined to the lung and are appropriate candidates for curative resection

↓

Thorough preoperative evaluation should exclude extrathoracic disease

Q. Is a nonsurgical therapeutic option available?

Nonsurgical management may be more appropriate for certain cancers

↓

Chemotherapy for nonseminomatous germ cell tumors, with cure rates approaching 90%

Q. Will the patient tolerate the procedure?

Thorough medical assessment with particular attention to their pulmonary and cardiac status

↓

Stress testing, echocardiograms, arterial blood gases, pulmonary function testing, and ventilation-perfusion scans etc.

Q. Are the lesions resectable?

Preoperatively, imaging modalities can only provide an estimate of resectability

↓

Resectability is best determined at operation

↓

Direct metastases to the pleura or pericardium in a discontinuous manner and malignant pleural or pericardial effusions are generally contraindications for resection

Q. Is the primary tumor controlled?

Efficacy of pulmonary metastasectomy depends on the ability to control the primary site of disease

↓

The primary neoplasm should generally be addressed before resection of the pulmonary metastases

BOX 23-3 Selection Criteria* for Metastasectomy

- Local control of the primary tumor or ability to completely resect the primary with synchronous presentations[20]
- Radiologic findings consistent with metastatic disease
- Absence of extrathoracic metastases (i.e., metastasis is confined to the lung)
- Ability to perform a complete resection of the metastases
- No significant comorbidity that would preclude surgery
- No alternative therapy that is superior to surgery

*Approximately one third of patients with metastatic disease meet these criteria.

Surgical Approach

1. Need for palpation

2. Thoracotomy vs VATS

Excellent visualization of the pleural surface
vs
Bimanually palpate the entire lung

3. Bilateral exploration vs unilateral exploration

4. Simultaneous vs staged approach
(in patients with bilateral metastases)

Table 1
Results of the ESTS survey regarding the surgical approach for pulmonary metastasectomy

	No. of Patients	(%)
Which is your preferred approach for unilateral metastases		
Anterolateral thoracotomy	53	(36.3)
Video-assisted thoracic surgery (VATS)	42	(28.8)
Posterior muscle sparing thoracotomy	38	(26)
Posterolateral thoracotomy	33	(22.6)
Horizontal axillary thoracotomy	15	(10.3)
Vertical axillary thoracotomy	10	(6.9)
Sternotomy	2	(1.4)
Other	7	(4.8)
Which is your preferred approach for bilateral metastases		
Bilateral staged thoracotomy	96	(66.2)
Sternotomy (1-stage)	39	(26.9)
Bilateral sequential thoracotomy (1-stage)	28	(19.3)
Bilateral staged video-assisted thoracic surgery (VATS)	18	(12.4)
Bilateral video-assisted thoracic surgery (VATS) (1-stage)	11	(7.6)
Clamshell (1-stage)	11	(7.6)
Other	3	(2.1)

Thorac Surg Clin 22 (2012) 91-99

Comparison of pulmonary nodule detection rates between preoperative CT imaging and intraoperative lung palpation

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KEYWORDS:
Pulmonary metastasectomy;
Thoracoscopy;
CT imaging

Abstract
BACKGROUND: Recent advances in computed tomographic (CT) imaging have improved the detection rate of pulmonary metastasis. The aim of this study was to test the hypothesis that the pulmonary nodule detection rate for preoperative CT imaging and intraoperative palpation are now equivalent.
METHODS: A retrospective review of 108 pulmonary metastasectomies in 84 patients was performed. The number of nodules detected on preoperative CT imaging by radiologist report was compared with the number of malignant nodules identified on pathology. Secondary outcome measures were operative approach and primary malignancy.
RESULTS: Sarcoma metastases were the most common indication for resection (n = 54 [50%]). Thirty-three percent of metastasectomies were performed using a thoracoscopic approach. When thoracotomy was used, significantly more nodules were palpated and resected than were identified on preoperative CT imaging (3.24 vs 2.12, $P \leq .001$). Significantly more of these nodules were confirmed malignant on final pathology (2.40 vs 1.80, $P = .01$). This difference was not seen for thoracoscopic resections.
CONCLUSIONS: Although the sensitivity of CT imaging has improved, a significant number of malignant pulmonary nodules are detected intraoperatively that are not identified on preoperative imaging. Patients undergoing pulmonary metastasectomy require careful intraoperative palpation of lung parenchyma, and therefore open thoracotomy remains the standard of care.

Am J Surg 2011; 201: 619-22

Role of Video-Assisted Thoracic Surgery in the Treatment of Pulmonary Metastases: Results of a Prospective Trial

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Background. A retrospective review revealed a 42% error rate between computed tomographic scan reports and thoracotomy findings; therefore, a prospective study was designed to compare the value of computed tomographic scans, video-assisted thoracoscopic exploration, and open thoracotomy in the management of pulmonary metastases.

Methods. Eligibility included any patient with only one or two ipsilateral pulmonary metastases identified on computed tomographic scan who was being considered for surgical resection. Initially video-assisted thoracic surgery was performed and all lesions identified were resected. A thoracotomy adequate for complete lung palpation was then carried out and any additional lesions found were removed.

Results. Eighteen patients of a planned 50 were treated before closure of the study. Four patients (22%) had no additional lesions found at thoracotomy. The primary sites of tumor were colon (10), breast (3), and one patient each skin (squamous), cervix, kidney, melanoma, and sarcoma. Four patients (22%) did have additional lesions at thoracotomy, which were benign. In the remaining 10 patients (56%) additional malignant lesions were found at thoracotomy after video-assisted thoracoscopic exploration. After 18 patients were entered, analysis of the early results disclosed a 56% failure rate of a computed tomographic scan and video-assisted thoracic surgery to detect all lesions. Being within the 95% confidence interval (32% to 78%), the study was abandoned.

Conclusions. We conclude that video-assisted thoracic surgery should be used only as a diagnostic tool in managing lung metastasis. A thoracotomy is required to achieve complete resection, which is the major survival prognosticator for satisfactory long-term results.

(*Ann Thorac Surg* 1996;62:213–7)

ESTS METASTASECTOMY SUPPLEMENT

What Are the Considerations in the Surgical Approach in Pulmonary Metastasectomy?

Tamas F. Molnar, Cengiz Gebitekin,† and Akif Turna‡*

1. Thoracotomy seems to be the preferred approach
   even with bilateral metastatic disease.
2. Sequential thoracotomy with an interval 3~6 weeks, interval CT.
   (Bilateral metastatic disease)
3. With regard to VATS, the evidence for its superiority is a matter of debate.
4. VATS seems appropriate for diagnostic procedures,
   but it is not the standard for therapeutic pulmonary metastasectomy.
5. No alternative to palpation currently exists.

J Thorac Oncol 2010; 5: S140-4.

Lymph Node Status

TABLE 1. Incidence of Thoracic Lymph Nodes in Patients with Lung Metastases

Publication	Era	Primary	Patients	Nodal Spread	Percent
Loehe et al.[2]	1996–1998	Mixed	63	9	14
Saito et al.[3]	1990–2000	Colorectal	138	20	14
Ercan et al.[4]	1985–1999	Mixed	70	20	29
Pfannschmidt[5]	1996–2001	Mixed	245	80	33
Welter et al.[6]	1993–2003	Colorectal	169	28	17
Menon et al.[9]	2002–2005	Mixed	57	6	11
Weighted average					22

J Thorac Oncol 2010; 5: S166

Prognostic Significance of Lymph Node Metastasis Found During Pulmonary Metastasectomy for Extrapulmonary Carcinoma

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Background. The prognostic significance of lymph node metastasis in cancer patients is well documented. Pulmonary metastasectomy in selected patients is associated with improved survival. Little is known about the prognostic significance of lymph node metastases found during pulmonary metastasectomy for extrapulmonary carcinoma metastatic to the lung.

Methods. The records of all patients who underwent pulmonary metastasectomy and complete mediastinal lymph node dissection for extrapulmonary carcinomas at our institution from November 1965 through July 1999 were reviewed.

Results. Eight hundred eighty-three patients underwent pulmonary metastasectomy. Of these, 70 patients (7.9%) (44 men, 26 women) had concomitant complete lymphadenectomy. Median age was 66 years (range, 31 to 83 years). Median time interval between primary tumor resection and metastasectomy was 34 months (range, 0 to 168 months). Wedge excision was performed in 46 patients, lobectomy in 16, both in 7, and pneumonectomy in 1. Lymph node metastases were found in 20 patients (28.6%) and were classified as intrapulmonary or hilar (N1) in 9, mediastinal (N2) in 6, and both in 3. There were no operative deaths. Median follow-up was 4.6 years (range, 1.1 to 14.6 years). Three-year survival for patients with negative lymph nodes was 69%, as compared with only 38%, for those with positive lymph nodes ($p < 0.001$).

Conclusions. The presence of lymph node metastases at the time of pulmonary metastasectomy for extrapulmonary carcinoma has an adverse effect on prognosis. Complete mediastinal lymph node dissection should be considered at the time of pulmonary metastasectomy for carcinoma to improve staging and guide treatment.

(Ann Thorac Surg 2004;77:1796–91)

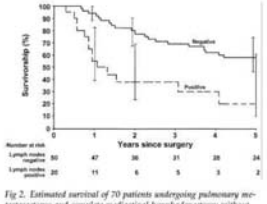

Fig 2. Estimated survival of 70 patients undergoing pulmonary metastasectomy and complete mediastinal lymphadenectomy without metastatic nodal involvement (negative) and with nodal involvement (positive). Zero time on the abscissa is date of first pulmonary metastasectomy and lymph node dissection. ($p < 0.001$).

3-year survival
Negative : 69%
Positive : 38%

Nodal Involvement at the Time of Pulmonary Metastasectomy: Experiences in 245 Patients

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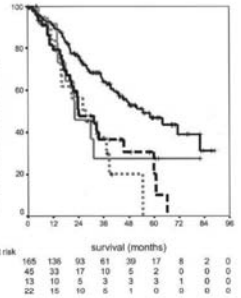
Background. Although routine systematic mediastinal and hilar lymph node dissection contemporary with pulmonary metastasectomy has not been uniformly performed in many thoracic surgical centers, the value of this procedure needs to be investigated.

Methods. Between 1986 and 2001, 245 patients (157 men, 88 women) underwent pulmonary resection of metastatic colorectal carcinoma, sarcoma, and renal cell carcinoma. Generally, systematic mediastinal and hilar lymph node dissection was performed concurrently with pulmonary metastasectomy. Patients were assessed for patterns of lymph node metastases. The frequency of lymph node involvement was determined. Patients and tumor characteristics were assessed to ascertain whether certain factors were likely to predict lymph node spread.

Results. Of the 245 patients (120 primary thoracic procedures), 165 had no lymph node involvement, 45 had pulmonary and hilar metastases, 22 had pulmonary, hilar, and mediastinal metastases, and 13 had only mediastinal involvement without pulmonary and hilar spread. Patients with more than one pulmonary metastasis or metachronous disease were more likely to have thoracic lymph node metastases. The risk for mediastinal lymph node involvement was even more likely for patients who had already pulmonary or hilar lymph node spread; the odds ratios (with 95% confidence intervals) were 1.30 (0.71 to 2.36), 1.32 (0.59 to 2.99), and 5.87 (2.73 to 12.6), respectively. Median survival for the group of patients after complete resection was 36.8 months (95% CI: 40.9 to 68.7); and for the patients with no lymph node involvement, it was 63.9 months (95% CI: 45.3 to 92.6); with N1 disease, 32.7 months (95% CI: 9.2 to 56.2); and with N1 + N2 disease, 20.6 months (95% CI: 5.1 to 36.1). The log-rank test revealed significance between N0 and N1 ($p = 0.018$) and N0 versus N1, 2 ($p = 0.001$).

Conclusions. We conclude that systematic mediastinal and hilar lymph node dissection contemporary with pulmonary metastasectomy offers a further understanding of metastatic disease and provides important information for complete surgical staging.

(Ann Thorac Surg 2006;81:449–54)



Mediastinal evaluation

EBUS, EUS, Mediastinoscopy

Thoracic Lymphatic Involvement in Patients Having Pulmonary Metastasectomy

Incidence and the Effect on Prognosis

Mariano García-Yuste, MD, PhD, Stephen Cassivi, MD, PhD,† and Cristian Paloro, MD‡*

Abstract: Mediastinal and hilar lymph node involvement are rarely reported in the literature concerning pulmonary metastasectomy. The first problem is to determine with accuracy the incidence and location of thoracic lymph node involvement in patients with lung metastases. Determination of the impact on survival of this type of lymphatic spread may contribute to assessing whether metastatic nodal disease identified preoperatively is an absolute contraindication to metastasectomy. Systematic mediastinal lymph node dissection has revealed a statistically significant difference in survival between patients with lymph node involvement and those without lymph node metastases. Videomediastinoscopy to identify involved mediastinal lymph nodes can be safely performed and may have a role in a more accurate staging of the metastatic disease. The authors conclude that attention should be paid to ensuring that we do not operate on patients in whom we will leave behind diseases that we cannot reach. The discovery of mediastinal lymph node involvement may also influence decisions with respect to postresection adjuvant therapy.

Key Words: Pulmonary metastasectomy, Lymphadenopathy, Lymphatic spread.

(*J Thorac Oncol* 2010;5: S166–S169)

and gauge opinion in this respect, it is necessary to conduct the appropriate examination of clinical reports in which, apart from any other prognostic factors, the presence and significance of nodal involvement have been analyzed.

WHAT IS THE TRUE INCIDENCE OF THORACIC LYMPH NODE INVOLVEMENT?

The first problem is to determine the incidence of positive thoracic lymph nodes in patients with lung metastases. In the International Registry of Lung Metastases between 1981 and 1995 of 5206 patients, 4572 (88%) underwent a complete surgical resection of the metastases.[1] Data are available from this source on the incidence of lymph node involvement in a large number of patients. The primary tumor was epithelial in 2660 cases, sarcoma in 2173, germ cell in 363, and melanoma in 328. Metastases to hilar or mediastinal nodes were found in 5% of patients overall (239 cases), corresponding to 11% in germ-cell tumors, 8% of melanomas, 6% of epithelial metastases, and only 2% of sarcomas. This is the largest data set available nevertheless, there are some difficulties in interpreting these results:

1. The incidence of lymphatic spread from the pulmonary metastases to the usual lymphatic drainage of the lung is common.

2. LN involvement = worse survival

3. LN involvement → postresection adjuvant therapy ?

Extent of Surgical Resection

Resection with free margins

Preservation as much normal lung parenchyma as possible.

ESTS survey

Wedge resection >>> Precision excision >> Segmentectomy > Lobectomy

Pneumonectomy (64%-relative contraindication, 23%-absolute contraindication)

ESTS survey

Surgical staplers >> Electrocautery > Direct suture

Other instrument (Harmonic scapel, Ligasure) – rarely used.

J Thorac Oncol 2008; 3: 1257-66

Pneumonectomy for Lung Metastases: Indications, Risks, and Outcome

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Background. Resection of pulmonary metastases (PM) by pneumonectomy is infrequently performed and benefits are uncertain.

Methods. From 1985 to 1995, 42 patients underwent pneumonectomy for PM. Twenty-nine patients had PM from sarcomas, 12 patients from carcinomas, and 1 patient from melanoma. The indications for pneumonectomy were pulmonary recurrences in 12 patients, PM centrally located in 26 patients, and high number of PM in 4 patients. There were 11 intrapericardial and 6 extended pneumonectomies. The average number of PM resected was 3. Twenty-two patients (52%) had lymph nodes involvement.

Results. There were 2 postoperative deaths (4.8%) related to pneumonectomy and one death within 30 days for rapidly evolving disease; 4 patients (9.5%) had major postoperative complications that were medically treated. Five patients (12%) were operated on for recurrences on the residual lung. At the completion of the study, 12 patients were still alive, 8 without recurrences. The median survival was 6.5 months (range, 1 to 144 months); the 5-year survival was 16.8%.

Conclusions. Pneumonectomy should not be considered an absolute contraindication in patients with PM, but the poor outcome of our series suggests strict criteria of selection.

(Ann Thorac Surg 1998;66:1950–3)

INVITED COMMENTARY

Pulmonary resection for metastatic lung disease has been controversial since the first successful resection of pulmonary metastases by Barney and Churchill in 1938 [1]. Nonetheless, since that time many patients have benefited from this procedure and pulmonary wedge excision eventually has emerged as the procedure of choice. For this procedure to be effective, however, metastatic disease must be limited, the amount of lung removed minimal, mortality near zero, and morbidity low. Using these principles, recent 5-year survival for most cancer sites has consistently averaged 25% to 30%.

If pulmonary wedge excision is the preferred treatment, what then is the indication for pneumonectomy? In my opinion, the only indication is a solitary central lesion in a patient with a previous soft tissue or bone tumor, who has a long tumor-free interval, and who had no previous pulmonary resection for metastatic disease. And then only rarely should pneumonectomy be performed. Although Spaggiari and associates did not report isolated results for their 26 patients with central lesions, their operative mortality of 7.1%, complication rate of 9.5%, median survival of 6.5 months, and 5-year survival of 16.8% suggest that pneumonectomy for any more advanced metastatic lung disease should never be done.

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Reference

1. Barney JD, Churchill ED. Adenocarcinoma of the kidney with metastases to the lung cured by nephrectomy and lobectomy. Trans Am Assoc Genitourin Surg 1938;30:75.

Results of Pulmonary Metastasectomy

TABLE 23-2 **Five-Year Survival Rates of Various Histologic Metastatic Resections**

Histology	5-Yr Survival Rate without Metastasectomy (%)	5-Yr Survival Rate with Metastasectomy (%)
All histologies	—	25-40[95,149]
Breast cancer	11[103]	35-50[105,150,151]
Colorectal cancer	<5[54]	40-45[95,152]
Germ cell tumors	—	68[95]
Head and neck squamous cell carcinoma	—	29-60[95]
Melanoma	3-4[128,129]	21-36[97,128,129]
Osteosarcoma	0-17[92,153]	20-40[95,154,155]
Renal cell carcinoma	—	13-54[92,156]
Soft tissue sarcoma	—	20-40[95,79]
Urinary tract cancer	—	25-43[156]

Pulmonary metastasectomy in appropriately selected patients has been shown in retrospective studies to improve survival

(the 5-year survival rate is 25% to 40%)

TABLE 23-3 **Prognostic Factors in Metastasectomy**

Absolute	Equivocal
Complete resectability	Tumor doubling time Disease-free survival Number of nodules Histology Nodal status

BOX 23-4 **Factors Not Affecting Prognosis in Patients with Metastasectomy**

- Age
- Sex
- Unilateral versus bilateral disease
- Wedge resection versus formal lobectomy

Specific Secondary Lung Tumors

Soft Tissue Sarcoma

Only 50% of patients with lung metastases from sarcoma are operative candidates (of those, 80% undergo complete resection)

Extremity soft tissue sarcomas tend to develop pulmonary metastases more frequently than those with sarcomas at other sites

Regardless of histology, primary and repeat metastasectomy has been associated with improved long-term survival

Osteosarcoma

A strong predilection for metastasis to the lung

Tumor recurs in 50% of patients within 1 year and 85% of these patients relapse with recurrent pulmonary disease

Resection of these recurrences is indicated if feasible, as numerous studies have demonstrated improved survival

Only complete resection has consistently been associated with improved survival

Colorectal Cancer

The lung and liver are the most common sites of metastatic disease in colorectal cancer

Pulmonary resection have demonstrated that the survival in selected patients at 5 years ranges from 27% to 61%

Prognostic factors associated with improved prognosis include primary tumor stage and completeness of the resection

Breast Carcinoma

Pulmonary involvement in breast cancer is most commonly associated with widespread disease (thorough search before considering metastasectomy)

A significant 5-year survival advantage for patients who underwent metastasectomy (36% versus11%)

Factors conferring a more favorable prognosis include estrogen and progesterone receptor (ER/PR) status and a complete resection

Head and Neck Carcinoma

Head and neck carcinomas most commonly spread through local lymphatics

The lung is among the more common sites of distant spread

Five-year survival rates after metastasectomy for head and neck cancers range from 29% to 59%

Renal Cell Carcinoma

The lung is a frequent site of renal cell metastases (as high as 72% to 76% in autopsy)

Patients with a solitary renal metastasis fare best, with a 5-year survival of up to 54%

Synchronous metastases, greater than 6 metastases, absence of regional and mediastinal nodes, and resectability have been identified as being important prognostic factors

Germ Cell Tumors

Most germ cell tumors are highly responsive to chemotherapy and even patients with metastatic disease have an excellent prognosis

Surgical intervention for pulmonary metastases from germ cell tumors is primarily reserved for evaluation of a residual mass after chemotherapy

Gynecologic Tumors

The lung represents the most common organ involved in uterine cancer spread

A 5-year survival rate of approximately 50% in well-selected patients

Completeness of resection, longer disease free interval, and three or fewer metastases have been associated with an improved survival rate

Melanoma

The lungs are the second most common site of metastases in patients with melanoma

If a complete resection cannot be performed, little or no benefit is provided in terms of prolonging patient survival

Endocrine Tumors

Slow-growing endocrine tumors, including carcinoids, well-differentiated thyroid cancers, and parathyroid cancers, may benefit from resection of their metastases

Alternative Treatment Options

Stereotactic body radiation therapy (SBRT)

Radiofrequency (RF) ablation

Cryoablation

Summary

Optimal preoperative imaging ?

The role of mediastinal lymph node dissection?

Surgical approach?

The extent of surgical resection?

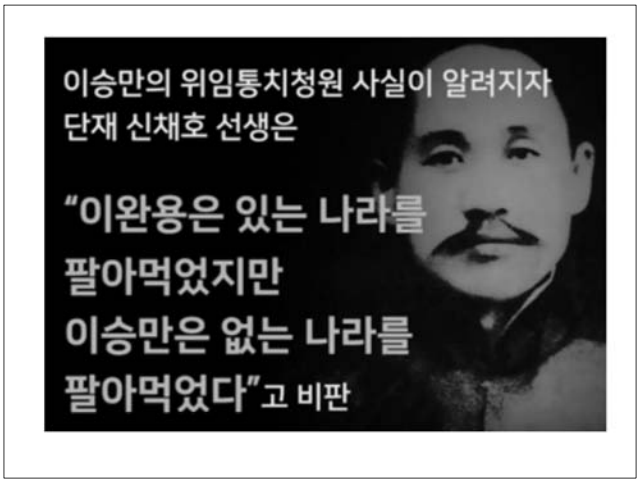
Thank you !

【특 강】

대한민국 흉부외과의 역사

가천대학교 의과대학 흉부외과

박 국 양



1950년대

한국의 심장외과는 흉부외과의 도입 및 정착에 이어 한국전쟁 후 본격적으로 시작되었다. 전쟁 전에는 흉부외과가 미미하였듯이 심장외과는 거의 그 증례를 찾아보기 힘들다. 단지 1940년대 말 당시 서울대병원 외과 한직부 선생이 국소마취로 실시한 교약성 심낭염에 대한 심낭 절제술이 유일한 것이었다.

서울의대의 한직부(韓格富) 교수는 1947년 5월 대한 의학협회 학회 석상에서 유착성 심낭염에 대한 심낭 절제술을 국소마취하에서 시행한 경험을 학술강연 초록으로 간략하게 보고하였다. 해방 이후 의학 수준을 참작할 때 놀라운 일이 아닐 수 없다. 한직부 교수(1915)는 1941년 서울의대를 졸업하고 동교 교수직으로 봉직하였고, 그 후 스웨덴 병원과 국립의료원에서 근무하였으며 외국 유학을 하여 흉부외과를 전공하였다. 또한 대한 흉부외과학회 제1대 회장을 역임하였고 대한 의학협회장 등 의료계 요직을 두루 역임하였다.

개정 농촌 위생연구소의 김영섭(金永燮) 교수는 1953년 국소마취하에 선천성 폐동맥 협착증에 대한 확대수술을 시행하였다. 우측 늑연골을 제거하고 폐동맥을 절개한 후 확대기를 삽입하여 협착부를 확대하였는데 3례중 2례에서는 수술 후 운동량이 증가하였다고 강연 초록에서 보고하였다. 우리나라에서 시행한 선천성 심장병에 대한 첫 수술 성공례이다. 김영섭 교수는 전남의대 교수를 역임하였을 당시 이와 같이 어려운 수술이 이루어진 배경에 대해 6.25사변 후 영국의 퀘이커 교도가 군산 도립병원에 파견되어 외국 의학잡지를 구비해주었는데 이의 도움을 받은 듯 하다고 한다.

1950년대 들어와 미국 문헌 소개, 한국전쟁에 참가하였던 미국 군의관에 의해, 그리고 각 대학교수의 미국 유학의 영향에 힘입어 심장외과 증례가 차차 출현하기 시작하였다. 그 당시 전남대병원 외과 김영섭 교수가 폐동맥협착증(청색증심기형: 활로4징 추정)에 대한 폐동맥 판막 절개술을 폐쇄식 방법으로 수술하였고 세브란스병원에서 활로4징으로 확진된 증례에 고식적 수술을 실시하였다.

1955년 이후 미국에서 흉부외과를 전공한 젊은 외과의가 속속 귀국하여 소속 대학으로 복귀하면서 우리나라 흉부외과는 본격적으로 꽃을 피우기 시작한다. 미국에서는 흉부외과 전문의 수련과정이 2년간이였으며 일반외과 전문의 자격을 가진 자가 지원하게 되어있었다. 2년간의 수련기간 중에 폐, 심장, 식도외과 전반에 걸쳐 교육을 받게 되어 있었으며 기관지경 및 식도경 검사법, 폐기능 외 흉부외과에 필수적인 검사법도 아울러 교육을 받았다. 그러므로 이러한 미국 흉부외과 연수과정은 우리나라 초창기 흉부외과 발전에 크게 이바지했다고 볼 수 있다.

1955년 미국에서 흉부외과 전문의 과정을 마치고 귀국한 세브란스병원의 홍필훈(洪鉍勳, 1921) 교수는 심장내과를 전문한 조광현 교수와 심장 카테터검사를 통하여 심장질환을 진단하였으며, 1956년 8월에 승모판막 협착증 환자에서 폐쇄식 교련부 절개술에 성공하였다. 홍필훈 교수는 세브란스 의전을 졸업(1942)하고 1949년 미국에서 인턴을 마치고 1950~53년 Binghamton City Hospital에서 외과 레지던트, 1953~55년에는 Baylor 의대와 Parkland Memorial Hospital에서 흉부외과 레지던트를 수료하고 한국의사로서는 처음으로 미국의 외과 전문의, 흉부외과 전문의 자격을 취득하였으며 이후 연세의대 교수로 복귀하였다.

서울의대의 이찬범(李燦範) 교수 역시 1958년 10월 승모판 협착증에 대한 교련 절개술을 성공적으로 시행하였다. 우리나라 3개 대학병원에서 승모판 협착증 수술이 연속적으로 성공한 사실은 한국의 심장외과 출발의 신호탄과 같이 작용하여 그 후 여러 곳에서 심장 수술이 시도되었으며 심장외과의 발전 속도가 가속화되었다고 볼 수 있다. 이후 1957년에는 활로 4징으로 확진된 증례에 전류(轉流) 수술을 실시하였다. 또한 전남대학교 외과의 김영섭 교수가 폐동맥협착증(청색증심기형: 활로4징 추정)에 대한 폐동맥 판막 절개술을 폐쇄식 방법으로 수술하였고 개방성 동맥관에 대한 수술이 1950년대 말 서울대학병원에서 보고되었다.

이찬범 교수 별세

[중앙일보] 입력 1967.08.19 00:00 · 중심 기관 자료보기 ▸

서울대의대외과 교수이며 대한 외과학회회장을 역임한 도규계의 권위 이찬범 박사가 19일 상오 11시40분 서울대의대부속병원특실 207호실에서 숙환으로 별세했다. 향년 51세.

이 박사는 해방 전 경성제국대학의학부를 졸업한 뒤 줄곧 서울대학교 외과대학에 봉직해 오면서 흉곽외과 분야에서 획기적인 연구실적을 올렸으며 폐심장수술도 수많이 했다. 장의는 서울의대장으로 21일 정오 집행되며 장지는 포천천주교 묘지이다.

이 교수가 직접 그린 인공심장 그림

서울대병원 흉부외과 김원곤 교수는 병원내 역사박물관 건립에 즈음하여 각종 자료를 정리하던 중 이 강의록을 발견했다.

강의록 본문의 내용은 흉부 해부학과 외과의 역사를 시작으로, 크게 일반흉부외과학과 심혈관외과학으로 나누어 기술돼 있다.

일반흉부질환에서는 오늘날의 취급 질환과 크게 다르지 않아 폐, 식도, 횡격막, 기관 등에 걸쳐 광범위하게 언급돼 있다.

심혈관질환에서는 당시의 상황을 반영하듯 선천성 질환 일부(개방성 동맥관, 대동맥 축착증, 팔로 사징증 등)와 승모판 협착증 등 일부 후천성 심장질환 만이 언급되고 있었다. 인공심폐기에 관한 부분도 강의록에 기록돼 있다.

또한 강의록 중간 중간에는 학생 시험문제 출제를 할 부분을 시(試)자로 표시해 두는 등 저자의 학생교육에 대한 열정을 보여준다.

김 교수는 "요즘에는 인터넷이 발달돼 있어 자료 구하기도 쉬운데다 그림도 복사기를 이용해 간단하게 만들 수 있지만, 당시에는 직접 그리는 방법밖에는 없었다. 하지만 강의록에 있는 그림은 컴퓨터 등 첨단기기가 발전한 오늘날에 볼 때 한 개인의 흔적을 떠나 그 존재 자체로서 이미 역사"라고 평가했다.

그는 또 "이 교수가 직접 그린 그림은 정확하고 세밀하다는 점에서도 놀랍지만 한 의학자의 열정과 노력에 더 많은 경외감을 느낀다"고 덧붙였다.

김 교수는 대한민국 초기 흉부외과 학생교육에 대한 정황의 일부를 살펴보고 과거에 대한 이해를 통한 학문 발전에 도움이 될 것으로 판단, 최근 흉부학회에 관련 논문을 발표할 예정이다.

시험문제 표시

맏을 은목에서 네번째가 이찬범 교수

설준희 교수의 "메디컬 40년 에세이" 회고록중에서

▲ 故 홍필훈 교수.

홍 교수님은 그 후 의료원장에 취임하셨는데 내가 한 번도 찾아뵙지를 않자 나를 부르셨다. 그 자리에서 앞으로 새 세브란스 병원을 건립 추진하시겠다며 설계도를 보여 주시던 기억이 새롭다. 교수님은 내게 "내가 의료원장이 됐는데 뭔이 어때?"하시고 물으셨다. 나는 "다 맡음드려도 됩니까? 다른 교수 분들의 뭔이 어떤지는 모르지만 저는 선생님이 의료원장을 안하셨으면 했습니다. 왜냐하면 저는 선생님이 영원한 학문을 중요시하는 교수님으로 남아 계셨으면 했기 때문입니다"하고 말씀을 드렸다.

첫 흉부외과 전문의 - 홍필훈

1956년 첫 판막수술...개심수술 분야 발전 주도

의사신문 | 승인 2011.11.10 12:42 댓글 0 트위터 페이스북

홍필훈(洪弼壎)은 1942년 세브란스의학전문학교를 졸업하고 평양기독병원에서 인턴과정을 마친 후 평북 만포에서 2년 동안 개업하였다. 1945년부터 대한민국 해안경비대(해군 전신)중위로 군복무를 마치고 1947년 서울 교통병원 외과의사로 근무하다가 1949년 큰 뜻을 품고 미국으로 유학의 길을 떠났다. 뉴욕주 빙햄톤 시립병원에서 인턴 과정과 외과 레지던트 4년 과정을 마친 후 일반외과 전문의 자격을 획득하였으며 미개척분야인 흉부외과학을 연구하기 위하여 텍사스주 달라스시의 베일러 대학병원에서 2년간의 흉부외과 수련을 마치고 한국인으로서는 최초로 미국 흉부외과 전문의 자격을 획득하였다.

홍필훈(洪弼壎)

1956년 귀국하여 세브란스병원 외과학교실 조교수로 부임하여 당시 불모지였던 폐절제 수술을 시작하였다. 전쟁 후 어려운 여건에 처해있던 서울역 앞 세브란스병원에서 미국의 China Medical Board 연구비를 수주하여 폭대기 증에서 폐수술, hypothermia, priming solution 등 개심수술을 하기 위한 동물실험을 시작하였다. 이러한 연구를 바탕으로 1956년에 시설과 장비의 부족 속에서도 승모판 협착증으로 고생하던 22세 남자환자를

1957년에는 팔로 4징후의 2세 여아에게 고식적 수술(palliative surgery)인 Potts-Smith 단락술을 시도하여 성공하였으며 1962년에는 저온법을 이용한 심방중격결손의 봉합에 성공하여, 우리나라 개심수술 분야의 큰 발전을 이룩하였다. 개심수술을 하기 위한 저온법하의 개심술과 체외순환에 대해 끊임없이 동물을 이용한 기초실험을 한 후, 1963년 드디어 18세 남자환자에게 심방중격결손증을 인공심폐기를 이용한 개심술로 수술에 성공하였다. 이는 철저한 동물실험을 바탕으로 개심수술을 준비하여 첫 수술을 성공하는 쾌거를 이룩하였다. 첫 번째 수술 받은 환자는 아직도 생존하고 있다. 이러한 활동은 경북대 이성행 교수와 서울대 이영균 교수와의 경쟁을 통해 더욱 발전하게 되었다.

이후 계속 개심술의 수기와 방법이 발전하면서 치료하는 질병의 범위를 넓혀갔다. 심실중격결손증, 활로씨 4징후의 완전교정술, 대동맥류파열, 심장판막질환 등이 그 예이다.

이 시기에 심장내과 차홍도 선생의 적극적인 참여로 좌심도자법과 경심방중격도자법을 발전시켜 수술 전 정확한 진단이 가능하게 되어 이는 한층 더 심장외과가 발전하는 계기가 되었다. 만성 수축성심낭염 환자의 수술 후 혈역학적 변화, 개심술시 중심정맥압의 변화 등을 연구하여 수술 후 환자관리의 중요성을 역설하였다.

1967년 하와이대학 흉부외과학 교수로 옮긴 후에도 많은 공적을 남겼고 1980년에 다시 귀국한 선생은 불안정성 협심증에 대한 관상동맥우회술의 첫 보고 이후 1983년 23례를 보고하였다. 1980년에 세브란스 외과부장을 맡아 1983년에 성형외과를 성형외과학교실로, 1985년에 흉부외과를 흉부외과학교실로 분리 독립시켜 독자적인 진료, 교육, 연구를 수행케 하였다. 1984년부터 1986년까지 제 7대 연세대학교 의무부총장 겸 의료원장으로 봉직한 후, 1987년 은퇴하여 하와이에서 거주하였다.

1996년에는 선생의 첫 판막수술을 기념하는 판막수술 40주년 기념식을 그랜드힐튼호텔에서 거행하였다.

마지막 거주지 하와이 호놀루루에서 여생을 보내다 향년 83세에 폐암으로 2004년 소천하였다.

집필 : 조범구(연세대 명예교수)

이성행 교수는(1917) 1942년 흉필훈 교수와 같은 해에 세브란스 의전을 졸업하고 1954~57년 미국 George Washington의대에서 fellow를, Pittsburgh 의대에서 레지던트 겸 조교로서 흉부외과를 전공하고 경북의대로 복귀하였다. 저체온법 동물실험을 계속하던 이성행 교수는 1960년 2월 심방중격결손증 봉합을 시도하였으나 성공하지 못하다가 1961년 9월 13일 8세 환아에게서 저체온법을 이용, 봉합에 성공하여 저체온법하 개심술 성공의 1호를 기록하였다. 1957년 12월에는 승모판막 교련 절개술에 성공하였다.

[사진 1-4] 개심술 동물실험 장면(1959년)

1958년 한국에서는 최초로 국립 의료원에 스칸디나비아 의료진의 후원으로 Siemens X-선 기계가 10여 대 들어왔는데 1,000mA~1,500KVP의 고성능 기계와 1초에 6매까지 찍히는 고속연속 촬영기가 포함되어 있었다. 그리하여 우리나라에서 최초로 혈관 조영술이 가능하게 되었는데 이는 우리 흉부외과는 물론 영상의학과(당시 방사선과), 혈관 외과의 발전에 크게 이바지하였다. 그 후 이어서 심장 조영술, 대동맥 조영술이 가능하게 되었는데 기록에 의하면 당시 서울대, 연세대, 가톨릭의대에서도 심장, 혈관 조영술이 필요한 환자가 있으면 국립의료원에 의뢰하여 촬영을 했다고 한다. 타 병원에서는 이와 같은 고가의 장비 구입은 너무 어려웠으며 1965년도에 가서야 일부

[사진 1-11] 국내 최초 개심술(1961년, 당시 5세 환아)을 받은 환자(가운데)와 수술을 집도한 경북대학교 이성행 교수(1988년)

실무형 융합인재 양성
대구가톨릭대학교

每日新聞

사회

[의료 100년 메디시티 대구] 제5부-의료 그리고 의료인 <8>심장과 폐의 선구자-고병간, 이성행, 박희명

'저온법하 개심술' 경북대병원서 국내 최초 성공

고병간
폐검맥 환자 첫 성형술
한국 흉부외과 개척자

이성행
개심술 첫 성공 주역
심도자법 최초 시행

박희명
심폐기능 연구 선구자
고난도 동물 실험 선도

1961년 9월 13일 우리나라 최초로 '저온법하 개심술'이 경북대병원에서 성공적으로 이뤄졌다. 당시 언론은 이번 심장수술의 중요성을 다루며 '새 생명 불어넣은 또 하나의 개가' '밝아오는 의료계' 등의 제목을 달아 대서특필했다. 이런 성공은 일찍감치 의료 선진국이던 미국으로 건너가 당시 첨단의료를 배워온 고병간, 이성행, 박희명 등의 노력이 있었기 때문에 가능했다.

◆한국 흉부외과 창시자, 고병간

고병간은 흉부외과의 개척자이자 대학교육 행정가였다. 1898년 평안북도 의주에서 태어나 선천에 있는 신성중학교에 진학했다. 1919년 3·1운동 때 시위에 나섰다는 이유로 평양형무소에서 1년 6개월간 복고를 치르기도 했다.

Circulation

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IN MEMORIAM

C. Walton Lillehei, the "Father of Open Heart Surgery"

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On July 5, 1999, Clarence Walton Lillehei, one of the world's foremost cardiac surgeons, researchers, and educators, died at his home in Minneapolis, Minnesota, of prostate cancer at 80 years of age. Because Dr Lillehei pioneered a direct, safe approach to open heart operations in the 1950s, he was known as the "father of open heart surgery." Indeed, hardly any other cardiac surgeon has introduced a greater number of innovative techniques and concepts.

Lillehei participated in the world's first successful open-heart operation using hypothermia. Lillehei completed, at age 35, the first successful surgical repair of the heart on September 2, 1952. That historic operation, using hypothermia, was led by his longtime friend and colleague, Dr. F. John Lewis.[4]

서울의대의 이영균(李榮均) 교수(1921)는 1941년에 서울의대를 졸업하였으며 1957~1959년 미국 Minnesota에서 흉부외과를 이수하고 서울의대 교수직으로 복귀하였는데 1965~66년 스웨덴의 Uppsala대학에서 연수하였고 한국 심장외과 발전을 위해 일생을 바쳤다. 1959년 8월 체외순환법으로 심방중격결손증 수술을 시도했으나 실패했다. 당시 초창기 개심술의 환경이 열악하였는지는 당시 개심술의 개척자이신 이영균 교수가 Dr. Lillihei에게 보낸 1961년 7월 22일 자 편지를 보면 알 수 있는데 "수술 때문에 헤파린이 절실히 필요합니다"라고 적었으며 1963년도 3월 27일 자 편지에 "마침내 7, 8번째 수술에서 생존 case를 기록하게 되었습니다. 진심으로 감사드립니다.(중략) 이 성공은 비록 보잘것 없지만 제가 귀국한 뒤 줄곧 저의 목표였습니다. (중략) 저의 바람은 단지 동물실험과 환자 수술을 계속할 수 있는 것입니다"라고 하였다. 1963년 6월 6일 Dr. Lillihei는 이영균 교수에게 "당신이 많은 문제에도 불구하고 개심술을 훌륭하게 출발시킨데 대해 매우 자랑스럽게 생각합니다. 어려움이 있더라도 좌절하지 말기 바랍니다. 승리는 종종 가장 어두울 때 오기 때문입니다"라고 답장을 하였다고 기록되어 있다.

서울의대에서는 1959년과 1961년 심폐기를 이용한 개심술을 시도하였으나 성공하지 못하다가 1963년 3월 26일 이영균 교수가 28세 남자 환자의 심방중격결손증에 대한 개심술에 성공하였다. 이때 사용한 심폐기는 Sigmamotor pump와 기포형 형산화기(bubble oxygenator)로 구성되어 있었다. 이어 연세의대에서는 홍필훈 교수에 의해 1963년 11월 20일 18세의 심방중격결손증 환자를 Zubdi-DeWall 인공심폐기와 열교환기를 사용하여 우측개흉으로 개심술을 시도하여 성공하였다. 대동맥 차단 여부는 기록에 없으나 심장은 박동하였다고 있었다고 되어 있어서 대동맥 차단은 하지 않은 것으로 판단된다.

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◎大韓醫史學會

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The Minnesota Project

- The Influence of American Medicine on the Development of Medical Education and Medical Research in Post-War Korea- *

Ock-Joo Kim** · HWANG Sang-Ik***

1. Introduction

In September 1954 the Seoul National University, while still suffering from the destruction of the Korean War, agreed to receive educational and technical supports from the University of Minnesota.① The International Cooperation Administration under the State Department of the United States made a contract with the University of Minnesota to provide the Seoul National University with staff improvement and equipment aid in engineering, medicine, agriculture, and public administration.② The contract, called as "Minnesota Project" by Koreans and as "The Seoul National University Cooperative Project" by involved Americans, began as a part of America's overall aid program for recovery of the post-war Korea in the context of cold-war situation.③ Late in 1945 the United States military government, which had occupied the South Korea after the World War II, began to provide Korea with economic and educational

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HISTORICAL PERSPECTIVES IN CARDIOLOGY

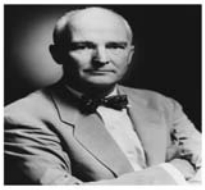
Evolution of Cardiopulmonary Bypass

William S. Stoney

Such a machine would first require a safe method of anticoagulation that could be reversed at the end of the operation; second, it would require a method of pumping blood without destruction of red blood cells; and third, there would have to be a method to oxygenate blood and dissipate carbon dioxide during the time that the heart and lungs were temporarily at rest. The first 2 requirements were easily met. Heparin and protamine were readily available, and there were several pumps being used in the dairy and food industry that could be adapted. The real problem was to develop an artificial oxygenator. This turned out to be difficult.

The first attempts at cardiopulmonary bypass during those years were a series of disasters with an appalling mortality rate. Many years later, Walton Lillehei reviewed all of the open heart operations reported in the surgical literature between 1951 and 1955. During those 4 years, 18 patients were reported to have had an operation using cardiopulmonary bypass at 6 different centers. There were 17 deaths and only 1 survivor. The type of oxygenators used were film (8 patients), bubble (4 patients), monkey lung (5 patients), and autologous lung (1 patient).[3] Word of mouth suggested that there were a number of additional attempts that were never reported in the literature with similar results. There were stories circulated of "5 deaths in a row" and other grim rumors. Some surgeons thought that maybe the heart just would not tolerate any type of surgery no matter how it was done.

1983년 4월 21일 제6차 아시아 흉부및 심장혈관학회(롯데 호텔)에서 Dr. Lillihei 와 함께 (1층 커피숍)



John H. Gibbon, MD. Courtesy of Thomas Jefferson University Archives and Special Collections

The first patient was a 15-month-old child who was thought to have an atrial septal defect. Cardiac catheterization had been attempted but was not completed because of her small size and heart failure. The chest was opened through a right thoracotomy. After she was placed on cardiopulmonary bypass, the right atrium was opened, but no atrial defect was found. Her condition rapidly deteriorated, and she developed cardiac arrest. A postmortem examination revealed a large patent ductus arteriosus. The preoperative diagnosis was wrong.

The second patient was an 18-year-old college student with repeated episodes of right heart failure. Cardiac catheterization confirmed that she had an atrial septal defect. The operation was done on May 6, 1953. The chest was opened through a transverse incision dividing the sternum. After being placed on cardiopulmonary bypass, a large atrial defect was closed with a continuous suture. The patient was on partial bypass for 45 minutes and total bypass for 26 minutes. There was 1 major problem with the heart-lung machine during the operation. Heparinized fresh blood had been used to prime the pump oxygenator. Each 500 mL of blood had received only 10 mg of heparin. Just as Gibbon was ready to close the defect, the oxygen saturation of the blood began to rapidly fall, and clots began to form on the oxygenator screens because of inadequate heparinization. Gibbon had planned to close the defect with a pericardial patch, but because of the drop in oxygenation, it was decided to close the defect as quickly as possible with a continuous suture and to end bypass as rapidly as possible. The patient had no adverse effect from this problem and was awake within an hour after the conclusion of the operation. Gibbon's operative note states that each 500 mL of blood should have received 25 mg of heparin. That evening he made 2 telephone calls, 1 to Alfred Blalock and the second to Clarence Crafoord, telling them the good news.

[사진 1-6] 초창기 심장수술

1960년대

1960년대에는 이 선구적 역할을 한 병원들에서 개심술을 통한 선천성 심기형의 교정 수술이 시행되어 증례의 축적이 이루어지기 시작했다. 1961년 경북대학교병원과 국립의료원(노르웨이 Axel Sandrud 교수)에서는 저체온법으로 심방중격결손증 교정 수술에 처음으로 성공하였으며, 체외순환을 이용한 개심수술은 1963년에 서울대학교병원과 세브란스병원에서 처음으로 성공하게 되었다.

연세의대의 홍필훈 교수는 1962년 6월 8일 남자 26세의 순수판성 폐동맥 판막 협착증 환자에 대해 30℃의 저온법하에서 개심술을 실시하여 혈류 차단을 2분 10초 동안 하면서 0.5cm의 판막 구의 협착을 절개하는데 성공하였으며 환자는 수술 후 12일 만에 퇴원하였다.

Axel Sanderud

Professor og lege **Axel Ingemann Sanderud** (8.5.1915 i Bodin- 27.11.2010) var sønn av jordskiftedommer Johannes Sanderud og Ingrid Johnsen. Gift 1 1945 med Else Torbjørg Amblie (18.2.1920 i Lillehammer-1967). Gift 2 1969 med sykepleier Kari Flattum (9.8.1945 i Singsås-), datter av handelsbestyrer Egil Flattum og Anna Kosberg. Barn: Jon Sanderud (1946-), Gry Sanderud (1948-).

Line Sanderud (1971-), Axel Tobias Sanderud (1972-).

Axel Sanderud ble cand. med. i Oslo 1946. Etter variert praksis kom han til Regionsykehuset i Trondheim, kirurgisk avdeling i november 1966, og ble professor i medisin ved Universitetet i Trondheim fra juli 1975. Godkjent spesialist i generell kirurgi, thoraxkirurgi, og barnekirurgi 1967. Flyttet til Singsås etter endt yrkeskarrière.

Deltakermedalje med stjerne, krigsmedalje 1939-45 Star (Br). Medlem av kompani Linge.

Kilde

1. Birger Kaada. Norges leger 1976

Axel Sanderud

[사진 1-7] 서울대학교 의과대학 개심수술 후 회진(1964년, 가운데 이영균 교수)

1980년대에는 정착화 단계에 돌입하게 된 것이다.

1970년대

1970년 후반기, 일부 대학 및 종합병원에서 개심술을 포함한 심장외과가 정례적 수술로 안착되어 심장수술을 위하여 환자가 선진국으로 가는 일은 드물게 되었다. 1960년대 당시 개심술을 실시했던 병원은 서울대병원, 세브란스병원 2곳뿐이었으나 1970년대에는 국립의료원, 한양대병원, 고려대병원, 가톨릭 성모병원을 비롯해 경북대병원, 전남대병원 등 8개 병원으로 늘어났다.

특히 1977년 박정희 대통령 때 공무원과 300인 이상 사업장을 중심으로 시작된 국민의료보험(현재 건강보험)제도는 1989년 노태우 대통령 때 전 국민을 대상으로 확장되었는데 과다한 수술비가 부족하여 수술을 받지 못했던 일부 사회취약계층의 의료비 부담을 경감시켜 주었고 새세대 심장재단의 발족과 함께 심장수술 환자를 크게 증가시키는 역할을 하였다.

心筋梗塞수술 稀世大手術 狹心症치료에 밝은 展望

특히 1970년대에 들어와서는 심근 보호를 위한 심장외과 의사의 노력이 활발해졌는데 1970년대 후반기부터 임상에 심정지액이 사용되었다. 가톨릭의대의 이흥균, 김세화 등은 cardioplegic solution을 이용한 개심술을 1978년 발표하였으며, 경북의대의 이성행 등은 Young solution으로 급성심정지를 유도한 후 Glucose-Insulin-Potassium(GIK) 액을 주입하는 방법을 1979년 보고하였고, 전남의대의 이동준(李東俊) 등은 1980년 냉혈 potassium 심정지액을 사용하여 심근 보호를 하였는데 심정지액에 혈액을 혼합한 첫 번째 경험이었을 것이다. 서울대에서는 1970년도 말에 브레슈나이더 심정지액을 도입하여 사용하였고 세브란스에서는 미국 Graham fellow를 마치고 돌아온 조범구 교수에 의해 처음 심정지액이 사용됨으로써 개심술의 성적이 크게 향상되는 계기가 되었다. 특히 조범구 교수는 1978년 10월부터 시작하여 1980년까지 27례의 중복 판막 치환술을 보고하였으며 조직판막인 Carpentier-Edwards와 Hancock를 주로 사용하고 조기 사망율은 1명으로 보고하였다. 연세의대의 조범구(趙範九)와 홍승록(洪承祿) 등은 1977년 한국 최초로 관상동맥 우회술의 성공을 보고하였다.

[사진 1-8] 한국최초 관상동맥 우회로 조성술의 실시(1977년)


1994.7.8일 사망(83세)


2004.9.10 관상동맥이식술(58세)


2009.8.4일 사망(57세)


2011.12.17일 사망(70세)


2014.5.10 심장마비(72세)


1984.1.8일 - ?

1980년대

이 시기에는 정부의 지방대학 시설 확장 계획에 따라 지방 각 국립대병원 및 사립대병원에도 개심술 시설이 갖춰지면서 1980년대에서 이르러 한국 심장외과 특히 개심술은 활기를 띄게 된다. 심장수술 증례의 대부분이 개심술을 필요로 하므로 개심술이 가능한 센터는 심장외과의 제 역할을 충실히 하는 기관으로 볼 수 있었던 것이다(1983년 6월 말, 17개 병원 개심술 실시).

전 국민 의료보험이 1989년 실시되면서 심장수술 및 의료수요가 병원마다 크게 늘게 되었다. 특히 1982년 미국 레이건 대통령이 두 명의 선천성 심장병 어린아이를 데리고 귀국 비행기 트랩을 오르는 장면이 전국에 방영되고 국민들에게 우리나라에서는 왜 심장병 수술을 못하나 하는 인식이 커지면서 1984년 발족된 새세대 심장재단(현재 한국심장재단)은 심장수술 확대와 발전에 크게 기여하였다.


[사진 1-1] 충남대학교병원 심장수술 장면(1983년)

1980년대에는 선천성 심장병 수술 증례가 비약적으로 증가하고

심장외과의 출발

년도	집도의	수술명	기타
1947.5	서울대 한격부교수 (1915년생)	유착성심낭염	국소마취, 대한의학협회 학회 발표
1953	전남대 김영섭교수	선천성 폐동맥협착 증확대수술	3례중 2례에서 운동량 증가,군산에서 퀘이커교도의 의학잡지로 공부?
1956.8	세브란스흉필훈교수 (1921년생)	승모판막협착증교련 부절개술	1942년 세브란스의전졸업,최초의 미국외과전문의, 한국흉부외과전문의
1957	서울대 이찬범교수	TOF 환자에서 B-T shunt 수술	
1958.10	서울대 이찬범교수	승모판막협착증교련 부절개술	
1961.9.13	경북의대이성행교수 (1917)	저체온을 이용 ASD 수술성공	1942년 흉필훈교수와 같이 세브란스의전을 졸업
1961?	Axel Sanderud(NMC)	저체온을 이용 ASD 수술성공	
1963.3.26	서울대 이영균교수 (1921년생)	심폐기를 이용한 ASD수술성공(28/ M)	1959년, 1961년도에 실패후
1963.11.20	연세의대 홍필훈교수	ASD수술성공	우측개흉,Zuhdi-DeWall 심폐기사용

폐외과학

1960년대 이전

우리나라에서의 흉부외과의 역사는 해방 후에 시작되었다고 보아야 할 것이다. 1945년 해방 이후 1950년 한국동란이 발발할 때까지 5년여의 세월이 흐르는 동안 한국 폐외과는 틀림없는 발족의 제일보를 시작하였으나 부진한 발전을 했다고 말할 수 있다. 그 이유는 선진국과의 의학지식 교류의 부진, 마취학의 미숙, 항생제나 항결핵제의 보급이 미흡했던 점 등을 들 수 있다. 미국에서는 1920년대부터 현재의 기도삽관 마취가 Magill에 의해 임상에 사용되기 시작하였고 폐절제술의 individual ligation technique이 Blade, Kent, Churchill 등에 의하여 1943년에 발표되고 있었으나 한국에는 1950년까지도 이러한 의학지식이 도입되지 않고 있었음이 사실이다.

개흉과 늑막강에서 어떤 수술 조작을 가하기 위해서는 개흉 후 폐환기를 지속하기 위한 기도 내 삽관 및 양압에 의한 인공호흡이 절대 불가결의 수술 보조 방법으로 믿고 있는 현대 의사로서는 1945년부터 1950년까지는 폐 절제 수술은 불가능할 수밖에 없지 않을까 하고 추측하는 것도 무리가 아닐 것이다.

더욱이 이때에는 Penicillin은 어느 정도 보급되고 있었으나 항결핵제인 PAS, INH, Streptomycine은 도입되고 있지 않았으므로 폐결핵에 관한 폐 절제 수술은 감히 시도도 하지 못했을 것이라고 생각함은 당연할 것이다. 폐결핵환자에 관한 흉곽 성형술은 이때 당시 한국에서도 시행이 가능하였고 또 의학지 보고도 있다.

1948년 10월 6일 대구 의과대학 학장이었던 고병간(高秉幹) 교수(1925년 세브란스 의전 졸업)가 마산 국립 결핵요양소에서 한국 최초로 폐결핵에 대한 흉곽 성형술을 성공적으로 시작하였다는 기록(세브란스 의대의 유승화(劉承華) 선생이 조수)이 있는데 아마도 이것이 한국 흉부외과 역사의 시발점이 되었을 것이다.


[사진 1-15] 고병간 교수

이성행 교수는 1949년부터 대구 의과대학 부속병원에서 이러한 수술에 참여하였는데 이때 폐절제술과 식도-위 문합 수술을 성공하였다고 기록하고 있다(이성행 교수의 '胸部外科小史 1989년' 인용). 또한 1949년 10월 한국외과학회에서 유승화 선생의 결핵환자에 대한 흉곽성형술 15례가 보고되었는데 환자들은 대구의대의 고병간 교수가 집도한 것이었으며 사망은 한 명도 없었다고 한다.

디지털 의사신문

흉부외과학을 개척한 교육행정가 - 고병간

첫 폐절제술 시행…경북대 총장·결핵협회장 역임

고병간(高秉幹)은 1899년부터 1966년까지 생존하였던 흉부외과학의 개척자였으며 대학교육행정가였다. 아호는 명서(鳴西)이다.

의주에서 태어나 신영소학교를 마치고 선천에 있는 신성중학교에 진학하였다.

1919년 3.1독립 운동 때는 중학생의 몸으로 평양형무소에서 1년 6개월의 옥고를 치러야만 했다. 그때가 그의 나이 20세였다.

1921년 세브란스의학전문학교에 입학해서 1925년에 졸업하였다. 그때 세브란스 외과학 교실의 리틀로 교수 밑에서 2년간 수련을 마친 후 1927년 함흥에 있는 기독교계 병원인 제혜병원 외과 과장으로 부임했다.

1934년 일본으로 건너갔다. 교토대학의학부에서 흉부외과를 전공하고자 3년간 연구에 몰두한 보람으로 인체 내 혈체발생에 대한 연구로 1940년 의학박사 학위를 받게 되었

대구의과대학 학술강연(1948) 1948년 6월 26일 대구의대(지금의 경북대학교 의과대학)는 스캇(W. Scott, 앞줄 가운데) 박사를 초청하여 학술강연회를 열었다. 왼쪽에서 세 번째가 고병간 학장이다.

대구의과대학 학술강연(1948) 1948년 6월 26일 대구의대(지금의 경북대학교 의과대학)는 스캇(W. Scott, 앞줄 가운데) 박사를 초청하여 학술강연회를 열었다. 왼쪽에서 세 번째가 고병간 학장이다.

유승화(劉承華, 1919) 교수는 1943년 세브란스 의전을 졸업하고 외과에 근무 중 마산 결핵요양원 외과에 파견근무하여 한국 최초의 흉곽 성형술과 폐절제술에 참여하였으며, 1956년 미국 Herman Kiefer병원과 Harper병원에서 흉부외과 레지던트를 연수하였다. 그 후 1958년 Hahnemann의대 흉부외과의 fellow 과정을 이수하고 이화의대로 복귀하여 우리나라 폐장 외과 발전에 큰 공을 세웠다.

이때 당시 한격부 선생의 흉파성형술례도 추가 보고된 것으로 알려져 있다. 미국에서는 이미 1932년에 John Alexander에 의해 소위 standard thoracoplasty 119례가 보고되고 있었으므로 1940년대 말에는 한국에도 이 술식이 도입된 것으로 짐작된다. 성형술은 물론 폐외과의 하나이기는 하지만 엄격한 의미에서 폐수술이라기 보다는 늑막외흉벽의 수술이므로 당시 기도삽관이나 전신마취 없이 국소마취만으로 실시할 수 있었던 폐결핵에 대한 유효한 외과적 치료의 하나로 등장하게 되었다.

당시 여러 가지 의학적인 여건으로 보아 도저히 폐절제술은 불가능하였을 것이라는 우리들의 예상을 뒤엎고 1940년대 말에 폐결핵환자에 대한 전폐절제술 2례가 성공리에 시술되었다. 2례 모두 국소마취하에 수술은 multi-ligation technique를 사용했었고 수술 후 생존할 수 있었다. 그 제1례는 1948년 6월 7일 고병간 선생이 대구에서(경북의대) 시행하였고, 제2례는 1949년에 유승화(劉承華) 선생이 마산 국립결핵요양소에서 시술했음이 보고되고 있다.

당시 기도삽관 전신마취의 도움 없이 어떻게 개흉이 가능하였나 하는 것이 대단히 궁금하게 생각되어 유승화 선생께 직접 문의해보니 대략 다음과 같다. " '점차적인 환측폐의 위축을 해줌으로 호흡부전에 빠지지 않은 상태, 즉 인공 기흉을 점차로 증가시켜 줌으로 환자가 편측 폐 하나만으로 호흡부전에 빠지지 않고 호흡할 수 있는 시기를 택하여 Procaine 국소마취만으로 개흉이 가능하였다' 한다. 즉 병측 폐를 미리 완전히 위축시킨 다음 개흉한 것이다."

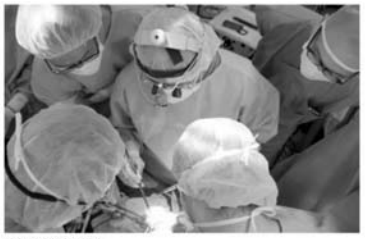
유승화교수의 동생인 유승헌(삼일병원설립자)원장의 인터뷰

"나는 직접 산부인과를 배웠으니깐 이화여대 산부인과 하다가 64년도 우리 삼일병원 산부인과 과장으로 왔지. 우리 형이 유승화 교수라고, 우리나라 Chest Surgeon. 흉곽(흉부)외과의 파이오니아(pioneer) 야. 폐절제술 하고. 미국 허만키파 병원(Herman Kiefer Hospital in Detroit)에서 5년 동안 공부하고. 이화여대 교수로 있으면서 수술 많이 했어. 아주 유명한 사람이지. 그런데 그 양반이 일찍 죽었어요. 88년도에 나이 70에. 그 양반 돌아가고 우리 맏형 돌아가고 나 혼자 하니깐 의사들이 마땅한 사람이 없어"

6.25사변이 발생하여 UN군이 우리나라에 파병되면서 군진 의료단이 속속 상륙하였는데 미국은 육군 야전병원을 한국에 설치하고 Haven Repose Consolidation 병원선을 파한하였고 덴마크는 Judlandia 병원선을 보냈으며 노르웨이 이동외과 병원 및 스웨덴 병원이 개설되었다. 이 시설들은 군전상 환자와 일반인 부상자를 진료하였으며 폐장 및 심혈관 외과의도 의료진에 포함되어 있었다.

미국 병원선과 Judlandia 병원선은 우리나라 젊은 의사들에게 전문분야별로 단기연수를 실시하였는데 1952년 경북의대의 이성행(李聖行) 교수, 서울의대의 이찬범(李燦範) 교수, 이화의대의 유승화(劉承華) 교수, 마취 전문 지망생 조현숙(趙賢淑) 선생 등이 Judlandia 호에서 2개월간 단기연수를 받았다. 이 배는 부산항에 정박하고 있었기 때문에 나룻배를 이용하여 드나들었다고 한다. 이 현대식 병원선에서는 주로 젊은 전상 환자들이 폐손상과 혈흉 등의 수술을 받았는데 이러한 경험이 흉부외과 초창기 원로 교수들에게 많은 자극과 도움이 되었을 것이다. 이 Judlandia 병원선은 1952년 말 철수하였는데 스웨덴 병원은 1950년 미8군 제14야전병원으로 출발하여 UN군 부상병을 치료하다가 휴전 후에는 부산에 머물면서 전쟁 이재민을 치료하였다. 노르웨이 병원도 1950년 개원하여 스웨덴 병원과 같은 시기에 철수하였다.

1980년대



[사진 1-17] 폐이식 수술 장면

흉부외과 전문의는 심장 혈관, 흉부질환 전체를 담당하였으나 전체적으로 증가하는 일반 흉부외과 환자와 1980년 전 국민 의료보험 시행으로 발생한 선천성 심장질환 수술의 급격한 증가로 일반 흉부외과와 심혈관외과의 전문적인 치료가 필요하게 되었으며 분과의 필요성이 대두되었다.

1986년부터 세브란스병원 이두연, 서울대병원 김주현 교수 등이 전문적인 일반 흉부외과 환자 치료와 연구에 주력하게 됨으로써 일반 흉부(폐식도) 수술 분야와 심혈관 수술 분야로 나누어지는 계기가 되었다. 일찍이 백병원 손광현 교수는 일반 흉부외과 수술만을 시행하고 있었고 이 역시 일반 흉부외과의 분가를 알당기는 계기가 되었다.

1988년부터 손광현 교수가 주축이 되어 폐식도 외과 연구회를 발족하였으며 어려운 일반 흉부외과

폐이식의 붐모지였던 우리나라에서 1996년 7월 강남 세브란스병원 이두연, 김해균, 백효채는 폐섬유증 환자에서 폐이식 수술을 시행하였으며 2010년 이후에는 그 숫자가 많이 증가하여 전국에서 매년 약 40례 이상의 폐이식 수술이 시행되고 있다. 현재 연세대 세브란스병원, 서울대병원, 분당서울대병원, 서울아산병원, 삼성서울병원, 양산부산대병원 등에서 시행되고 있으며 더 많은 병원으로 확대되고 있다.

최근까지 이루어진 폐이식 수를 집계한 결과 총 220건으로 다른 장기 이식에 비해 그 수치가 현저히 적다. 뇌사자를 통해서만 이식을 받아야 하는 이유도 있지만 폐질환을 앓고 있는 환자조차도 폐이식이 있는지 모를 정도로 우리나라에서는 홍보가 부족한 탓도 있다.

폐이식은 수술 후 호흡을 통해 다시 감염될 가능성이 크기 때문에 다른 이식 수술보다 이식 성공률이나 예후가 좋지 않은 편이다. 그러나 이식할 폐를 장시간 보존할 수 있는 용액의 개발, 폐이식 수술의 경험 축적, 수술 후 환자를 관리하는 방식의 향상 등을 통해 지금은 5년 생존율이 50%가 넘을 정도로 월등히 좋아졌다.

2000년대

1990년대 중반부터 일부 개척자적인 흉부외과 의사들에 의한 흉강경 폐엽절제술의 경험이 보고되기 시작하였고 국내에서도 2000년대 초반부터 폐암에 대한 흉강 경하 폐엽절제술이 산발적으로 시작되어 2006년 삼성서울병원 주최 VATS symposium에서의 VATS lobectomy live surgery를 계기로 전

일반흉부외과의 출발

년도	집도의	수술명	기타
1948.6.7	고병간교수	전폐절제술 (Pneumonectomy)	대구의대, 국소마취, Multiligation method 이용)
1948.10.6	고병간교수	폐결핵에 대한 흉곽성형술	국립결핵요양소
1949	이성행교수	폐절제술및 식도위문합술	대구의대
1949	유승화교수	전폐절제술	마산국립결핵요양소
1949.10	고병간교수	흉곽성형술 15례 보고	유승화교수(세브란스1943년 졸업)의발표(외과학회), 사망례 없었음
1949-50?	한격부교수	흉곽성형술례 보고	

흉부외과 역사기록보존위원회

- "흉부심장혈관외과 역사자료 발굴 및 보존 활동을 위한 위원회 및 기록위원(Historian) 신설 및 지원에 대한 제안서" 상임위 통과 (2017.3.2)
- "흉부심장혈관외과 역사기록보존위원회" 설치
- 2017.4.5: 1차 모임
- 2017.5.22: 2차 모임

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12	최방실	대한흉부심장혈관외과학회		

기록위원회 활동

- 보존 가능한 모든 흉부외과 회원개인과 단체의 학회활동, 논문 등 기록(문서, 사진)들의 취합 (원로회원 중심)
- 취합된 기록들을 검색가능 한 형태로 분류 선택 보존
- 매년 정기학회에서 발표, 기념전시, 홍보등 예정 (희귀사진전, 역대 회장, 이사장 배너 전시, 공식사진 촬영, 회장강연전 원로 회원및 업적소개)

【소아심장파트】

좌장: 이 철

Sequential Segmental Analysis

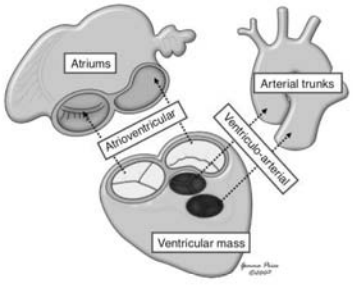
Pediatric Cardiac Surgery, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea

Cheul Lee, MD

Congenitally Malformed Hearts

- We need the most appropriate way of describing the malformations.
- Approach to complex lesions in a simple and straightforward fashion
- Terminology
- Nomenclature

Three Building Blocks (Segments) of the Heart



Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Sequential Segmental Analysis

- Recognition of the topological arrangement of the three cardiac segments
- Analysis of the fashions in which the segments are joined or are not joined to each other

Steps for Sequential Segmental Analysis

- Arrangement of the atrial chambers
- Nature of the atrioventricular junctions
- Arrangement of the ventricular chambers
- Nature of the ventriculo-arterial junctions
- Relationships of the arterial trunks

A Premise for Sequential Segmental Analysis

- The ability to distinguish the morphology of the individual atriums and ventricles, and to recognize the types of arterial trunk taking origin from the ventricles

What is right atrium?

- The atrium located at the right side?
- The atrium connected to the caval veins?
- The atrium connected to the TV?

Morphological Method

- Structures should be recognized in terms of their own intrinsic morphology.
- One part of the heart which is itself variable should not be defined on the basis of another variable structure.

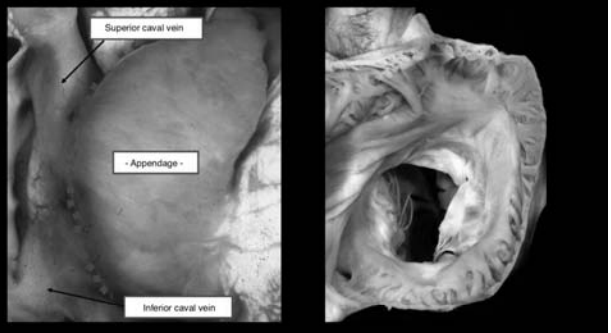
Atrial Appendage

- The most reliable component of atrium which enables us to distinguish between morphologically right and left atriums

Morphological Right Appendage

- Blunt triangular shape
- Broad junction with the remainder of the atrium
  - ✓ External junction: terminal groove (sulcus terminalis)
  - ✓ Internal junction: terminal crest (crista terminalis)
- Extension of the pectinate muscles lining the appendage all round the atrioventricular junction

Morphological RA

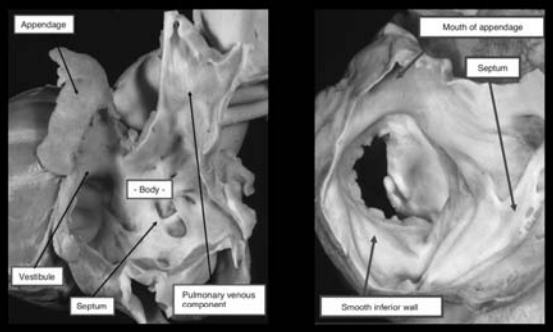


Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Morphological Left Appendage

- Narrow and tubular shape
- Narrow junction with the remainder of the atrium
  - ✓ No terminal groove or terminal crest
- Confinement of the pectinate muscles within the morphological left appendage

Morphological LA



Anderson RH, et al. Paediatric Cardiology. 3rd ed.

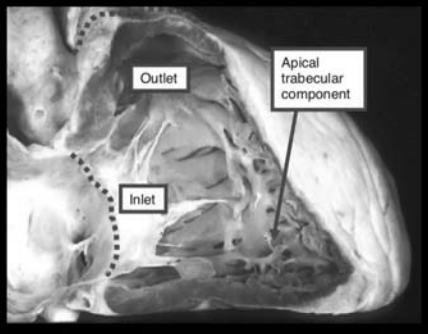
Three Components of Ventricle

- Inlet
- Apical trabecular
- Outlet

Apical Trabecular Component

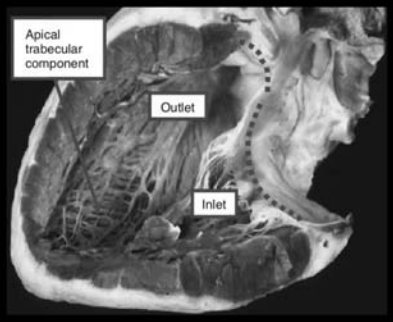
- Most universally present in normal as well as in malformed and incomplete ventricles
- It is the pattern of the apical trabeculations that differentiates morphologically right from left ventricles.

Morphological RV



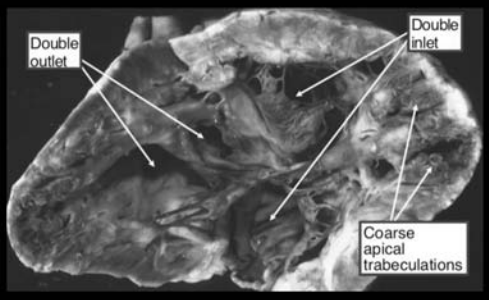
Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Morphological LV



Anderson RH, et al. Paediatric Cardiology. 3rd ed.

A Solitary Ventricle With an Indeterminate Morphology

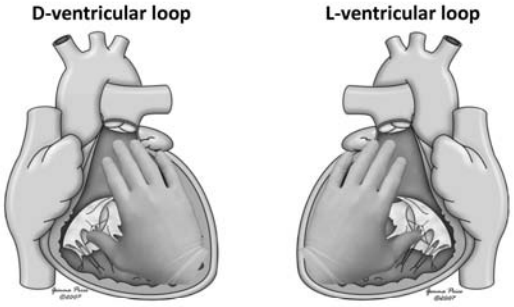


Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Ventricular Topology

- The way in which the two ventricles are related within the ventricular mass
- Two basic patterns
  - ✓ D-ventricular loop
  - ✓ L-ventricular loop

Ventricular Topology

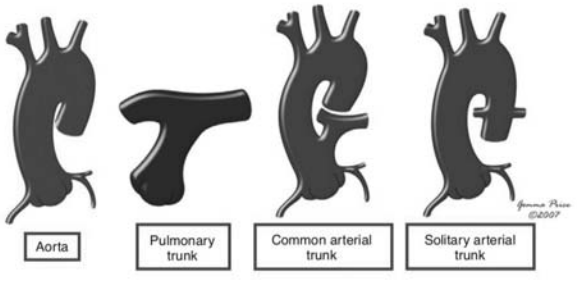


Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Morphology of the Great Arteries

- No intrinsic features which enable an aorta to be distinguished from a pulmonary trunk, or from a common or solitary arterial trunk
- Branching pattern of the trunks

Branching Pattern of Arterial Trunks

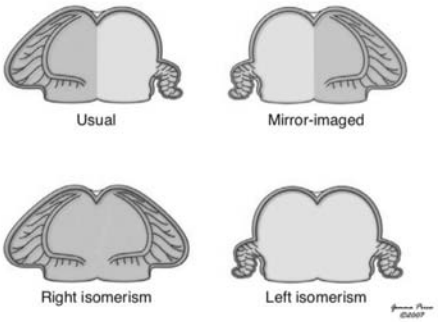


Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Atrial Arrangement

- Situs solitus
- Situs inversus
- Isomerism of the atrial appendages

Atrial Arrangement

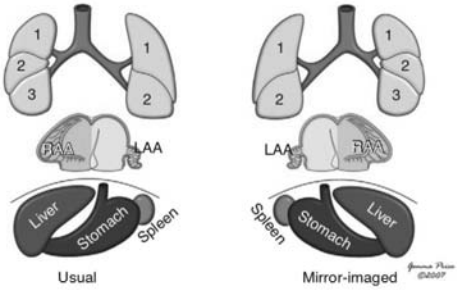


Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Recognition of Atrial Arrangement

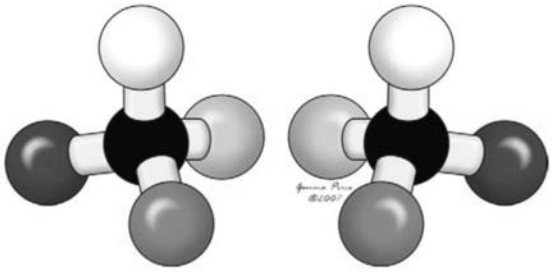
- Extent of the pectinate muscles round the vestibules
- Almost always, the morphology of the appendages is in harmony with the arrangements of the thoracic and abdominal organs.
- In patients with usual and mirror imaged patterns, it is exceedingly rare for there to be disharmony between the location of the organs.

Lateralized Atrial Arrangements



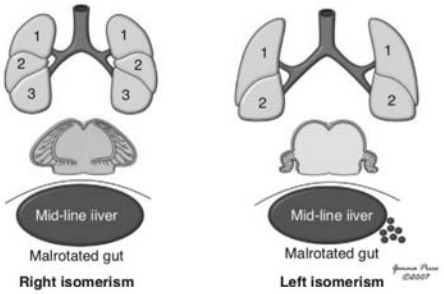
Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Isomerism



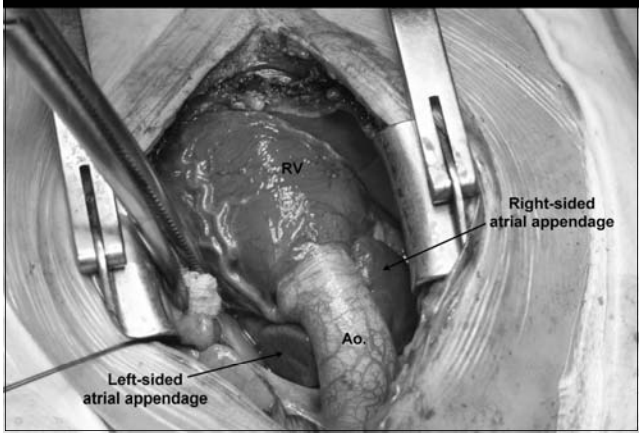
Anderson RH, et al. Paediatric Cardiology. 3rd ed.

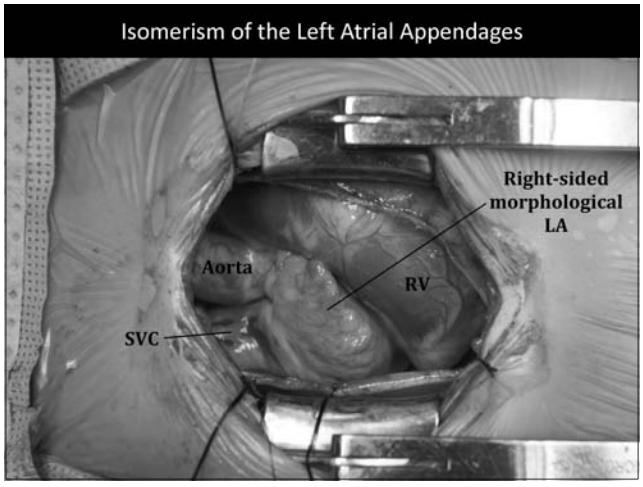
Isomerism of the Atrial Appendages (Visceral Heterotaxy)



Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Isomerism of the Right Atrial Appendages





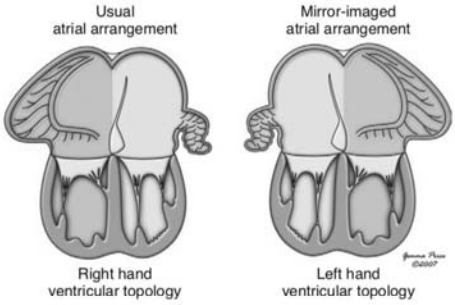
Atrioventricular Connections

- Biventricular atrioventricular connections
- Univentricular atrioventricular connections

Biventricular Atrioventricular Connections

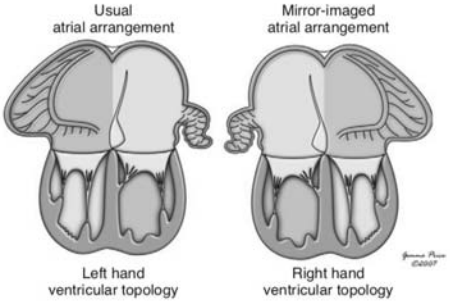
- Concordant atrioventricular connections
- Discordant atrioventricular connections
- Isomerism of the atrial appendages

Concordant Atrioventricular Connections



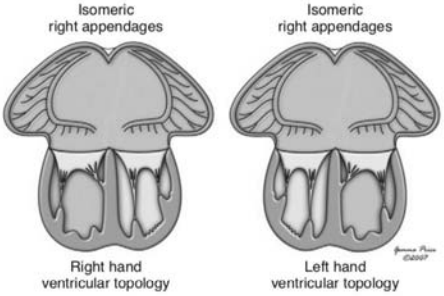
Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Discordant Atrioventricular Connections



Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Biventricular AV Connections in Hearts With Isomerism of the Atrial Appendages

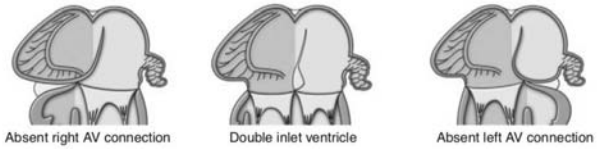


Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Univentricular Atrioventricular Connections

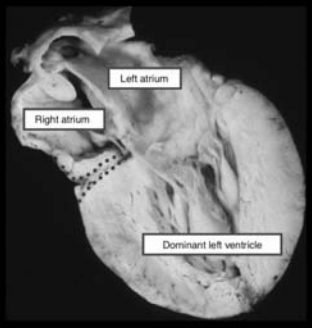
- Double inlet atrioventricular connections
- Absent right-sided atrioventricular connection
- Absent left-sided atrioventricular connection

Univentricular Atrioventricular Connections



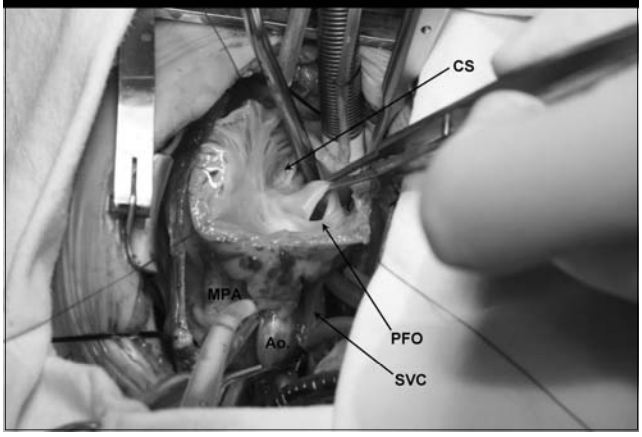
Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Absent Right Atrioventricular Connection (Tricuspid Atresia)



Anderson RH, et al. Paediatric Cardiology. 3rd ed.

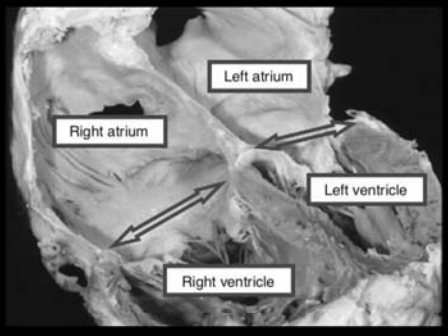
Absent Right Atrioventricular Connection (Tricuspid Atresia)



Arrangements of the Atrioventricular Valves

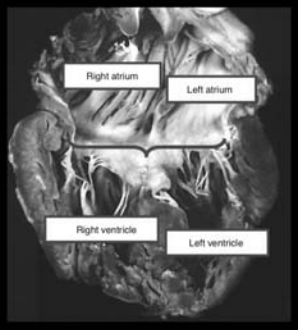
- Two patent valves
- A common valve
- One patent and one imperforate valve
- Straddling and overriding valves

Two Separate Atrioventricular Valves



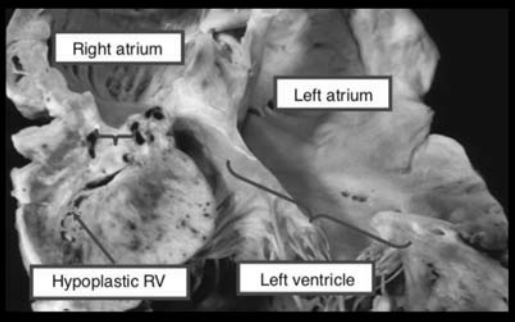
Anderson RH, et al. Paediatric Cardiology. 3rd ed.

A Common Atrioventricular Valve



Anderson RH, et al. Paediatric Cardiology. 3rd ed.

An Imperforate Right Atrioventricular Valve



Anderson RH, et al. Paediatric Cardiology. 3rd ed.

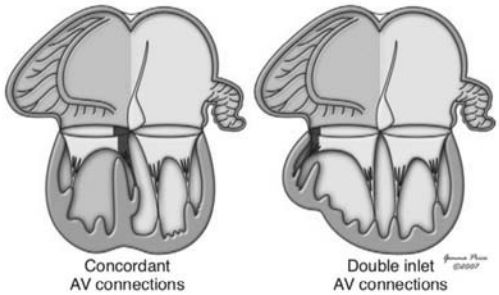
Straddling of a Atrioventricular Valve

- Attachment of its tension apparatus to both sides of a septum within the ventricular mass

Overriding of a Atriovantricular Valve

- Connection of an atrioventricular junction to ventricles on both sides of a septal structure

Straddling and Overriding Atrioventricular Valves



Anderson RH, et al. Paediatric Cardiology. 3rd ed.

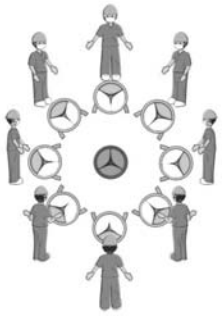
Ventriculo-Arterial Junctions

- Concordant ventriculo-arterial connection
- Discordant ventriculo-arterial connection
- Double outlet connection
- Single outlet connection
  - ✓ Common arterial trunk
  - ✓ Solitary arterial trunk
  - ✓ Single pulmonary trunk with aortic atresia
  - ✓ Single aortic trunk with pulmonary atreisa

Arterial Relationships

- Usually described at valvar level
- Description of aortic valvar position relative to the pulmonary valve

Arterial Relationships

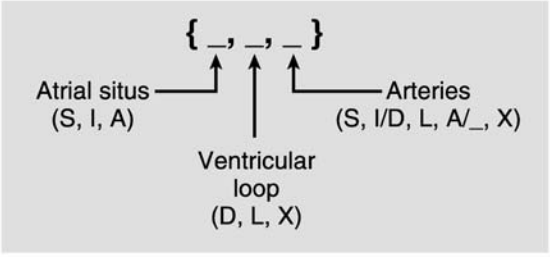


Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Positions of Arterial Trunks

- Spiral fashion
- Parallel fashion

Segmental Set Notation



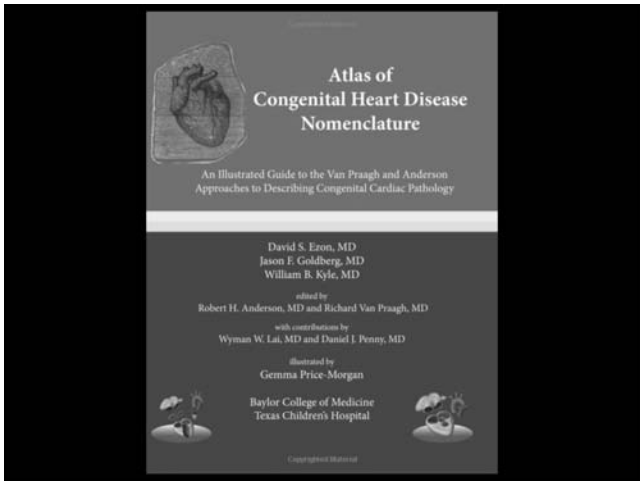
Selke FW, et al. Sabiston & Spencer Surgery of the Chest. 9th ed.

Examples of Segmental Set Notation

- {S,D,S}
- {I,L,I}
- {S,D,D}
- {S,L,L}

References

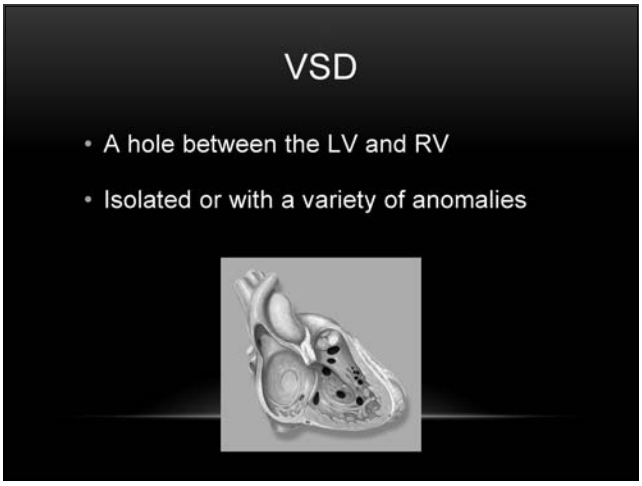
1. Chapter 1. Terminology. In: Anderson RH, et al. Paediatric Cardiology. 3rd ed.
2. Chapter 2. Anatomy. In: Anderson RH, et al. Paediatric Cardiology. 3rd ed.
3. Chapter 105. Segmental Anatomy. In: Selke FW, et al. Sabiston & Spencer Surgery of the Chest. 9th ed.

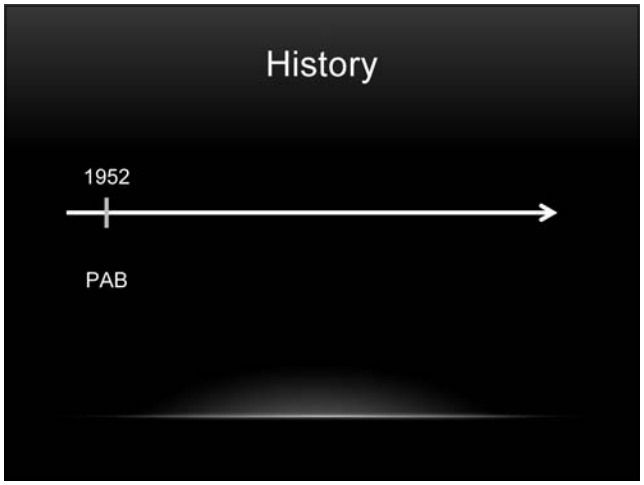

Atlas of
Congenital Heart Disease
Nomenclature
An Illustrated Guide to the Van Praagh and Anderson
Approaches to Describing Congenital Cardiac Pathology
David S. Ezon, MD
Jason F. Goldberg, MD
William B. Kyle, MD
edited by
Robert H. Anderson, MD and Richard Van Praagh, MD
with contributions by
Wyman W. Lai, MD and Daniel J. Penny, MD
illustrated by
Gemma Price-Morgan
Baylor College of Medicine
Texas Children's Hospital

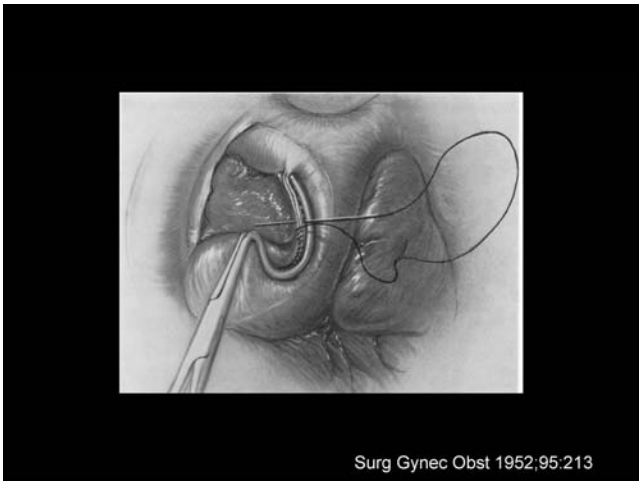
VSD (Ventricular Septal Defect)

울산대학교 서울아산병원 소아심장외과

최 은 석



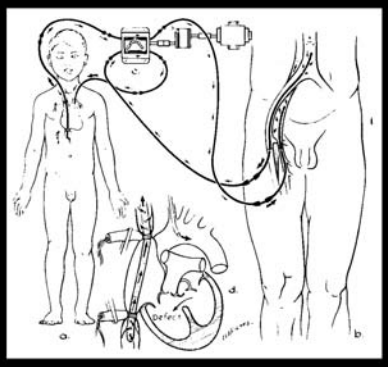




History

1952 1954

PAB Lillehei



Ann Thorac Surg 1986;41:4-21

Table 2. Results of Direct-Vision Intracardiac Operations with Cross-Circulation on 45 Patients from March 26, 1954, to July 19, 1955[a]

Abnormality	Corrective Operation	No. of Patients	Mortality: Hospital	Mortality: Late (30-yr)
VSD	Suture closure	27	8	2
PDA (with severe pulmonary hypertension)	Exploratory ventriculotoiny; division of ductus	1	0	0
Tetralogy of Fallot	Suture closure of VSD; repair of infundibular/valvular pulmonary stenosis	10	5	3
Atrioventricularis communis	Closure of ostium primum, VSD; repair of valvular deformities	5	3	1
Isolated infundibular pulmonary stenosis	Resection of infundibulum	1	0	0
Pulmonary stenosis, ASD, anomalous pulmonary venous drainage	Pulmonary valvotomy; ventricular and atrial cardiotomies; transposition of pulmonary veins; closure of defects	1	1	0
Totals		45	17	6

[a]Cross-circulation was used exclusively from its inception through February, 1955. Beginning March 1, 1955, other bypass methods (bubble oxygenator, drug lung oxygenator, arterial reservoir) were employed for lower risk patients. Cross-circulation was reserved for higher risk patients. By July, 1955, the bubble oxygenator had become the sole method.

Ann Thorac Surg 1986;41:4-21

History

1952 1954 1957 1971

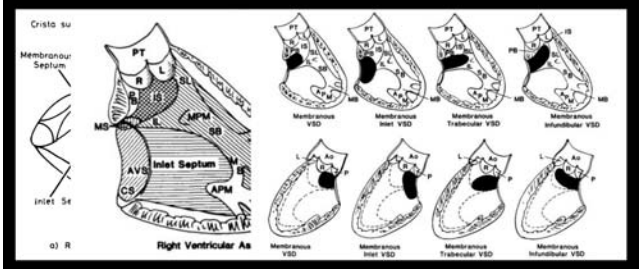
PAB Lillehei Kirklin Barrat-Boyes

Anatomy

- Right ventricular septum
- Tricuspid valve
- Conduction system

Right ventricular septum

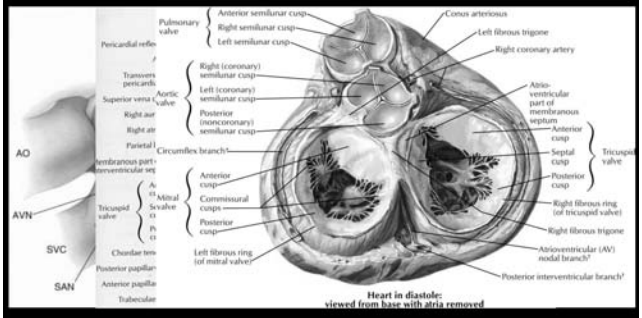
- The membranous septum
- The inlet septum or atrioventricular canal
- The muscular septum
- The trabecula septomarginalis
- The conal septum or infundibular septum



Mayo Clin Proc 1985;60(11):741-52
Br Heart J 1980;43:332-343

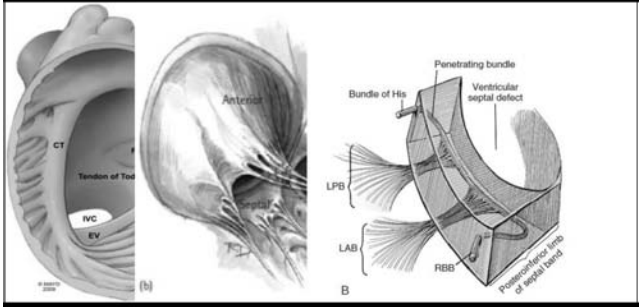
Tricuspid valve

- Three leaflets
  - Anterior, septal, posterior
- Papillary muscles
  - Anterior, posterior, septal (medial)



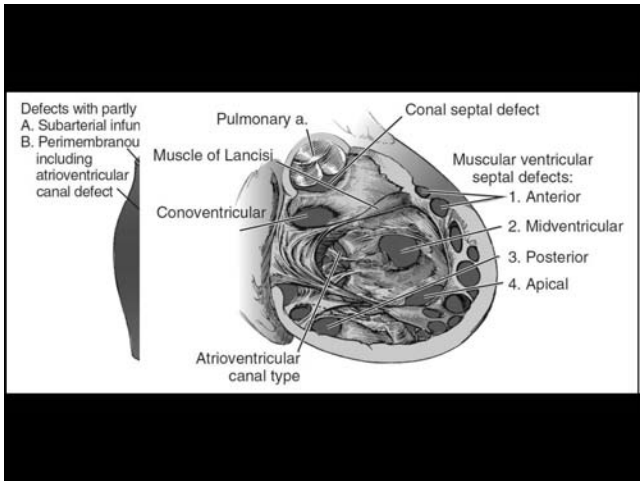
Conduction system

- AV node
  - Triangle of Koch
    - Tendon of Todaro
    - Orifice of the coronary sinus
    - TV annulus
- Common AV bundle of His
  - Posteroinferior rim of the VSD in PM VSD



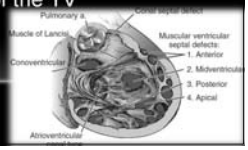
Classification of VSD

- Conoventricular (or membranous) defect
  - Perimembranous (PM)
- Conal (or outlet) VSDs
  - Subarterial (SA)
- Inlet (or AV canal type) VSDs
- Muscular VSDs (single or multiple)



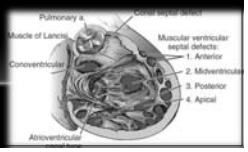
Classification of VSD

- Conoventricular (or membranous) defect: 80%
  - The membranous septum
    - Perimembranous or paramembranous
  - Landmarks
    - Anteroseptal commissure of the TV
    - NCC of AV



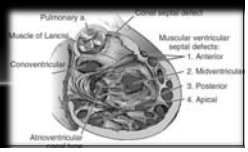
Classification of VSD

- Conoventricular (or membranous) defect
  - Malalignment: conal septum
    - Conal septal plane to ventricular septal plane
    - Anterior: ex) TOF
    - Posterior: ex) IAA



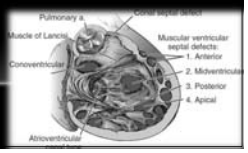
Classification of VSD

- Conal (or outlet) VSDs: 8%
  - Entirely surrounded by muscle
    - Muscular conal VSD
  - Limited upstream by aortic or pulmonary annuli
    - Subarterial VSD



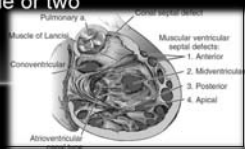
Classification of VSD

- Inlet (or AV canal type) VSDs: 6%
  - Part or all of the AV canal (inlet) septum
  - Immediately underneath the septal leaflet
  - No tissue in between



Classification of VSD

- Muscular VSDs (single or multiple): 10%
  - Described by location
    - Anterior / Midventricluar / Posterior / Apical
  - Through LV side
    - Converge into either a single or two



Associated Defects

- Almost half of patients undergoing surgery for VSD
  - PDA: With large VSD by EchoCG
  - Coarctation of the aorta: More L – R shunt
  - LVOTO: discrete fibromuscular membrane
  - ASD, RVOTO, …

Pathophysiology

- Shunt direction and magnitude
  - Depends on
    - Size of the defect
    - Pressure gradient
    - Relative compliance of both ventricles
    - Pressure relationship during the cardiac cycle

Pathophysiology

- Shunt direction and magnitude
  - Nonrestrictive
    - RV pressure = LV pressure
    - Qp/Qs depends on the ratio of PVR to SVR
  - Restrictive
    - VSD offers resistance to flow

Pathophysiology

- Sequelae of Left-to-Right shunting
  - Increased pulmonary blood flow
    - LA and LV enlarged
    - LAP↑ → pulmonary edema → pulmonary infection
    - Lung compliance↓→ The work of breathing↑
    - Failure to thrive

Pathophysiology

- Sequelae of Left-to-Right shunting
  - Development of pulmonary vascular disease
    - Pulmonary blood flow↓→ Sx improvement
    - Eisenmenger complex
      - Fixed pulmonary hypertension
      - RV hypertrophy, Normal-sized LV
      - Often inoperable

Pathophysiology

- Pulmonary vascular disease
  - Pathology of hypertensive PVD
    - Heath and Edwards
    - Correlate the PVR of patients with VSD with histologic severity of pulmonary vascular changes

The Pathology of Hypertensive Pulmonary Vascular Disease

A Description of Six Grades of Structural Changes in the Pulmonary Arteries with Special Reference to Congenital Cardiac Septal Defects

By Donald Heath, M.D., and Jesse E. Edwards, M.D.

Progressive histologic changes occur in the pulmonary arteries and arterioles, as a complication of chronically elevated pulmonary arterial blood pressure, in patients with congenital septal defects of the heart. This progression is so stereotyped as to allow a division of the structural effects into 6 grades. The histologic features of each grade are described in detail in this communication. These results afford a basis for comparing the magnitude of these changes to the clinical findings.

Circulation 1958;18:533-547

TABLE 1.—*Basis of Grades of Hypertensive Pulmonary Vascular Disease Found in Association with Large Ventricular Septal Defects and Functionally Related Diseases*

	Grade of hypertensive pulmonary vascular disease					
	1	2	3	4	5	6
Type of intimal reaction	←None→			Cellular		
				← Fibrous and fibroelastic →		
				← "Plexiform lesion" →		
State of media of arteries and arterioles			Hypertrophied			
				← Some generalized dilatation →		
				← Local "dilatation lesions" →		
					P H * →	
						←N A †→

* Pulmonary hemosiderosis associated with distended, thin-walled, arterial vessels throughout the lung.
† Necrotizing arteritis.

Circulation 1958;18:533-547

Indications for Surgery

- Natural history of VSD
  - Most membranous and muscular VSDs
    - Tends to close spontaneously
  - Malalignment conoventricular or inlet VSDs
    - Unlikely to close spontaneously

Indications for Surgery

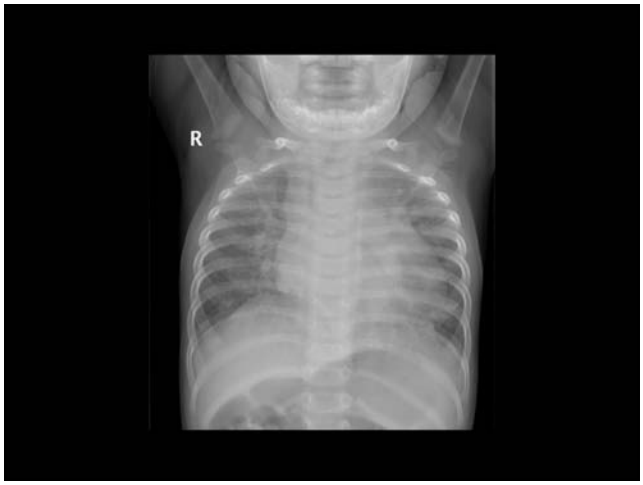
- Congestive heart failure
- Increasing aortic cusp prolapse and regurgitation

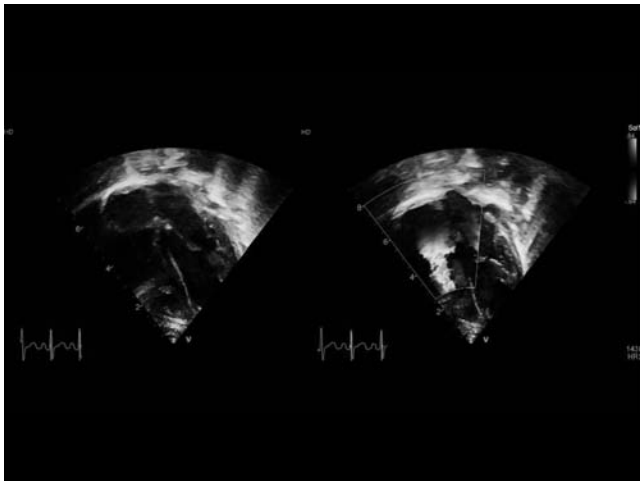
Diagnosis

- Symptoms
  - Tachypnea, profuse sweating during feeding
  - Growth failure
- P/E
  - bulging precordium, pansystolic murmur,
  - enlarged liver, thready pulses

Diagnosis

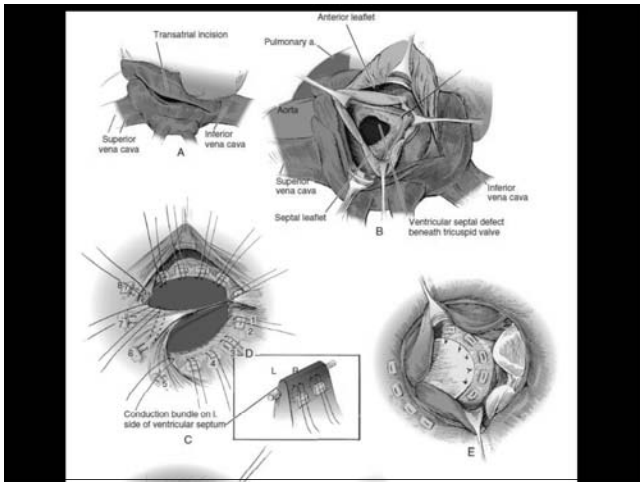
- Chest film
  - Large central and peripheral PA
  - Enlarged LA and LV
- ECG
  - Biventricular hypertrophy
- Echocardiography: essential
- Cardiac catheterization

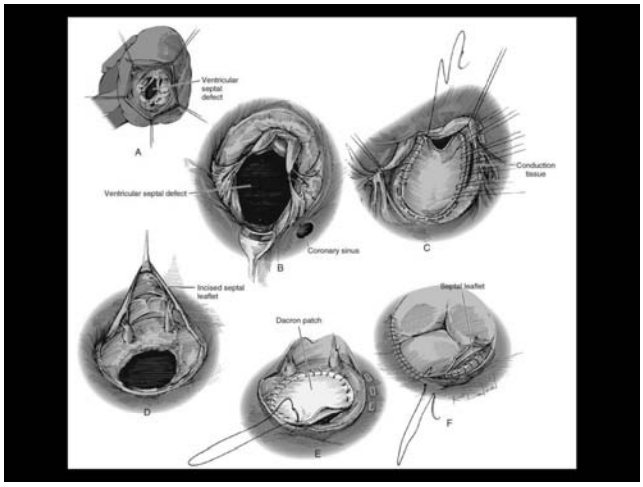


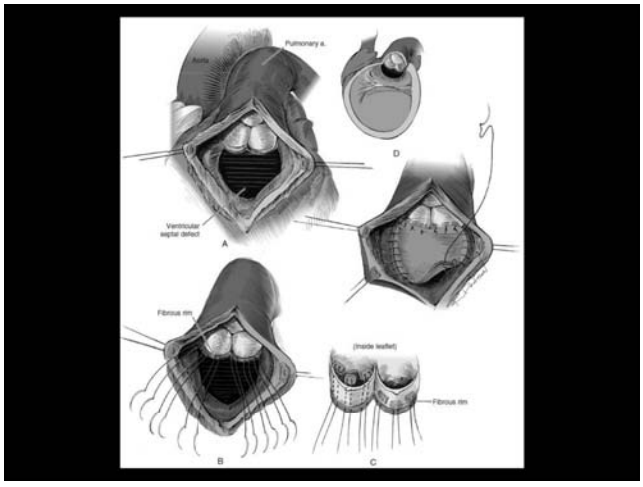


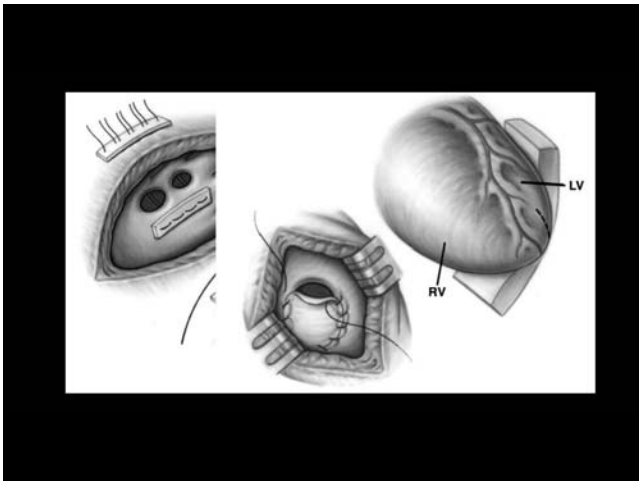
Surgical Technique

- Moderate hypothermia
- Approach
  - RA / MPA / RV / LV
- TV: retraction or detachment
- AV: infusion of CP solution
- Interrupted or continuous suture



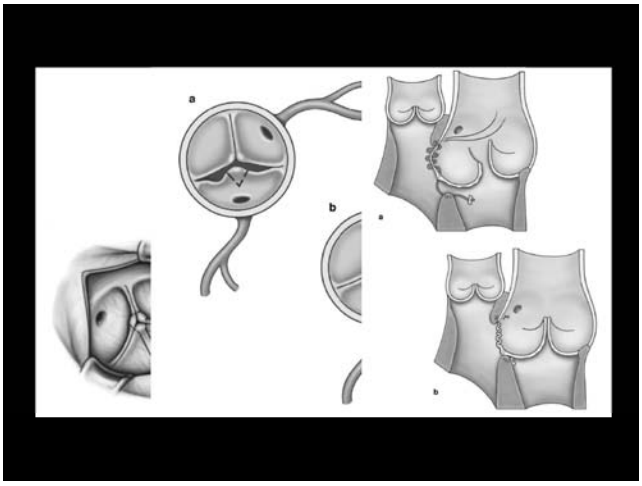






VSD with AI

- Usually older children
- RCC or NCC prolapse into
  - Bernoulli effect
- > moderate AI with cusp retraction
  - Require AV repair



VSD with prior banding

- Multiple muscular VSDs : m/c
- RV hypertrophy
  - Difficult identification of VSDs
- Operative techniques
  - Conventional closure
  - Sandwich technique
  - Intraop device closure

Postoperative Care

- Special treatment is usually not required
- In the unusual case of low cardiac output
  - It is the surgeon's responsibility
  - Bedside echocardiography
    - Large residual VSD
    - Injury to the aortic cusp
    - Tricuspid regurgitation

Postoperative Care

- Complete AV dissociation after CPB
  - Temporary pacing
  - Usually permanent beyond 10 to 14 days
- Pulmonary hype
  - In older patie
  - Prophylactic

Precipitating factors	Management
Tracheal suction Acidosis Hypoxemia High-dose inotropes	Sedation Muscular paralysis Hyperventilation High level of O2 Inhaled NO

Early Results of Surgical Treatment

- Hospital mortality rate: nearly 0%
  - Very low-weight or very young
  - Elevated PVR
- Complete AV dissociation: 0.5% to 3%
- Residual VSD
  - Suture dehiscence in small infants with friable myocardium
  - Small (<3m) ones close spontaneously over a period of months

Late Results of Surgical Treatment

- Normal or almost normal
  - Life expectancy, Growth and cardiac function
- Limitation in exercise tolerance
  - Persistant pulmonary HTN and increased PVR
- Mortality ↑
  - Correction after the age of 5 years, PVR > 7
  - Complete heart block

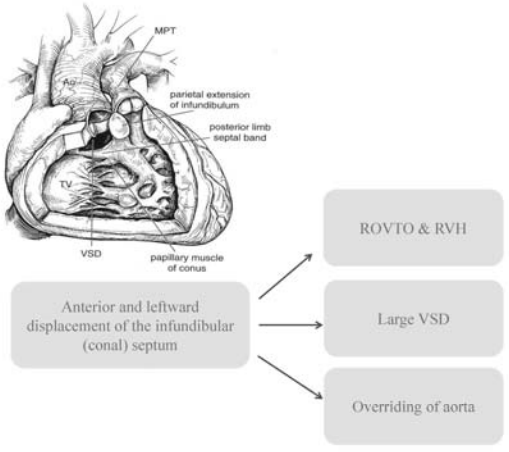
Tetralogy of Fallot

Keimyung University Dongsan Medical Center

Woo Sung Jang, MD, PhD

Definition

- Classic theory
  - Unequal sprial septation of conotruncus
- Van Praagh's theory
  - Underdevelopment of RV infundibulum with **anterior & leftward displacement (malalignment) of infundibular (conal, outlet) septum**



Incidence & Associated anomaly

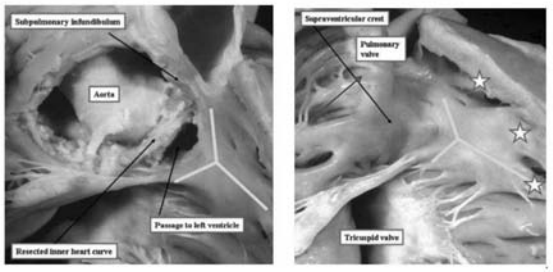
- 3/10000 live birth
- 7~10% of CHD & the most common among the cyanotic defect (50%)
- M>F
- Genetic defect in 28%
  - Chromosome 22q11.2 defect
  - Trisomy 21
  - VACTERL (Vertebral anomaly, Imperforate anus, Cardiac anomaly, TEF, Esophageal atresia, Renal anomaly, Limb defect)

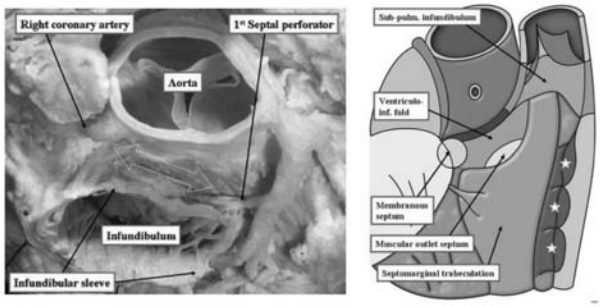
Clinical features

- Severity of RVOTO
  - Degrees of cyanosis
- Mild RVOTO
  - Predominant L to R shunt → CHF (pink TOF)
- Most, commonly, cyanosis is mild at birth and gradually progresses with age
  - increasing hypertrophy of the RV infundibulum
- Mechanism of "cyanotic spell" initiation
  - Reduction of cardiac afterload or preload and tachycardia (dehydration, viral infection, vasodilatation by medication, etc.)

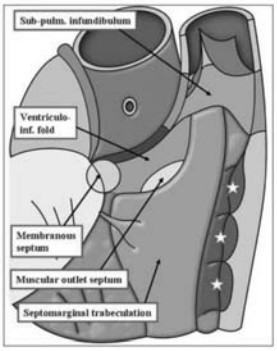
Normal Heart

Crista supraventricularis (Supraventricular crest)
Muscular area separating the attachments of the TV and PV in the roof of the RV

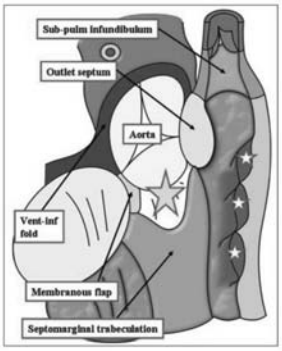




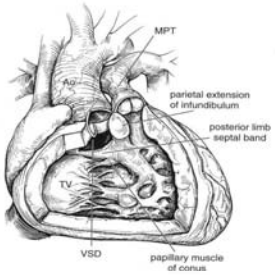
Normal

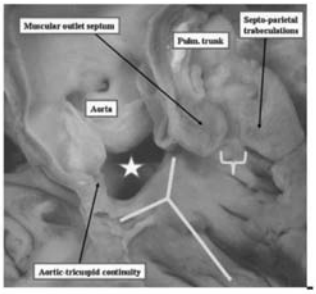


TOF



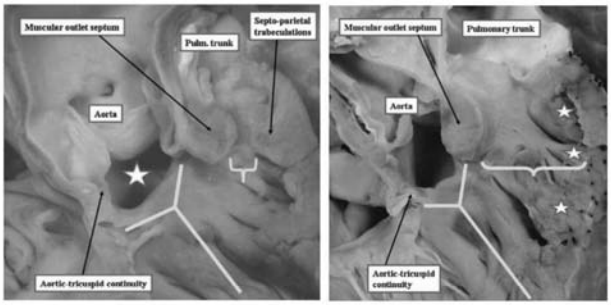
TOF



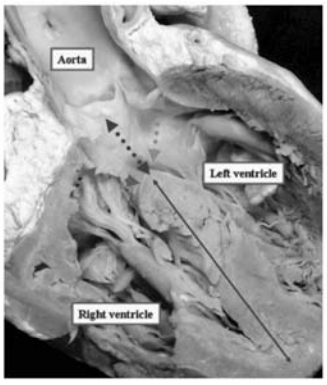


TOF

Anteriorly malaligned VSD
(Eisenmeger defect)



Overriding of the aortic valve

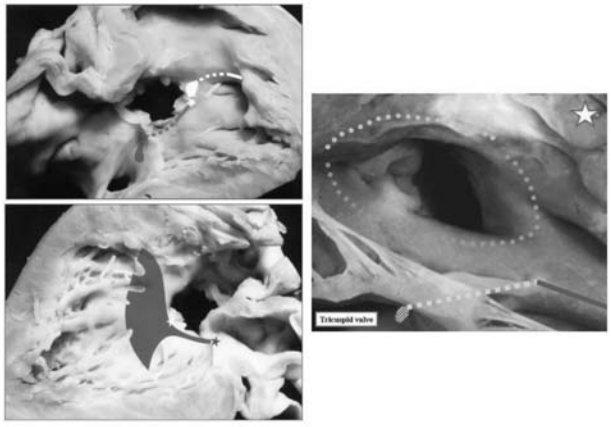


Pulmonary valve and annulus

- Stenosis in 75%
- Leaflets
  - Thickened, tethered to the PA
  - Bicuspid in 75%
  - Vertical or horizontal position

- MPA & branch Pas
  - Usually somewhat diffusely small, often short
  - Narrowest portion of MPA is often at STJ
  - Branch PA stenosis in 10%
    - LPA os

- VSD
  - Large anteriorly malaligned
  - 25%: VIF extends to the posterior limb of TSM
    - Muscle bar beneath TV (MO)
  - Additional VSDs in 3~15%
- Conduction system
  - SA and AV node: normal in location



- Coronary artery
  - 5%, LAD from RCA, dual LAD
  - Very occasionally, RCA from single LCA, LCA from single RCA
  - Crossing over RVOT, rarely in the myocardium
- Other anatomic features
  - PA: 7%
  - Absence of PV leaflet: 5%
  - 25%, right aortic arch

- Outpatient management
  - Relieving hypoxemia and preventing hypoxic spell
  - Beta-blocker : propranolol
    - Not reliable and should rarely be used
  - Protect from viral infections

Indications and timing of surgery

- Symptoms
  - PG dependent neonate
  - Worsening cyanosis
  - Cyanotic spell

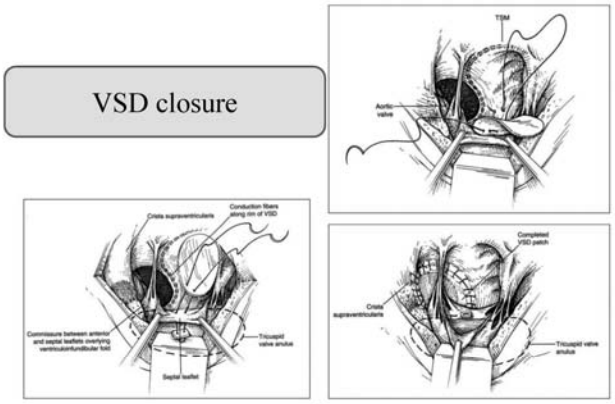
Symptomatic neonates or young infants with TOF

- Shunt vs Early primary repair
- Controversies in "Early primary repair"
  - **Pro**
    - Low operative mortality of early primary repair
    - Avoidance harmful effect of shunt operation and late repair
    - RVH
  - **Con**
    - Neonatal myocardium may be less capable of handling of RV volume load

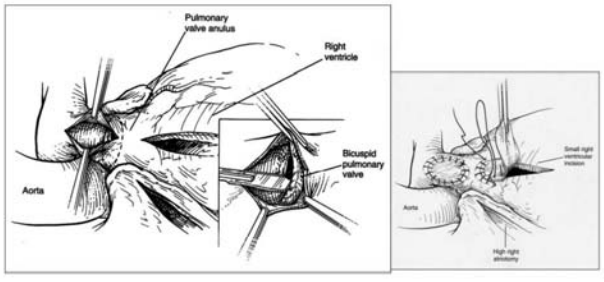
- Potential disadvantages of staged approach
  - Long-standing pressure overload of RV
  - Persistent cyanosis
    - Cardiomyocytic degeneration and interstitial fibrosis
    - Myocardial dysfunction and ventricular arrhythmia
- Potential disadvantage of early primary repair
  - Frequent need of transannular patch
  - Adverse effects of early bypass surgery on the neonatal brain
  - Often complicated and lengthy postoperative recovery in small infants

Surgical Management

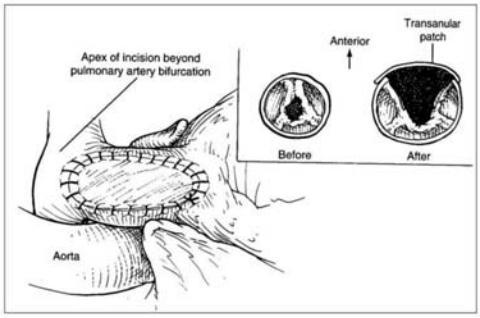
VSD closure



Pulmonary valvotomy



Transannular patch



Transannular patch

Criteria for preservation of pulmonary valve ?

z-valve of pulmonary annulus > -3
diameter of pulmonary annulus (mm) > 0.8mm/kg of body weight

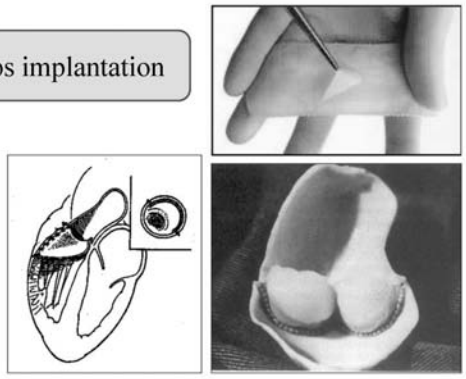
Intraperative relaxed heart, PV annulus > (1-2mm or 0mm ?) + mean PV annulus

Postrepair RV/LV > 0.7

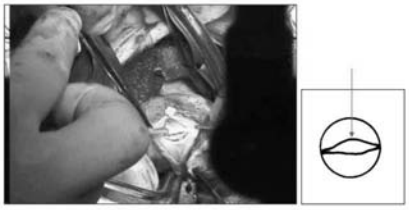
If TAP has not been placed, TAP should be considered.
If TAP has been place, other causes must be considered.
- branch PA stenosis
- hypoplasia of peripheral PAs
- residual VSD
- residual infundibular obstruction

- Often elevation of RV pressure results from dynamic RVOTO.
- Ultra-short acting β-blocker (esmolol) can help in intraoperative differentiation.

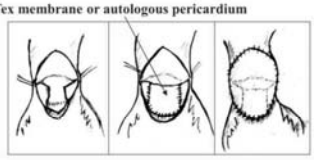
Monocups implantation



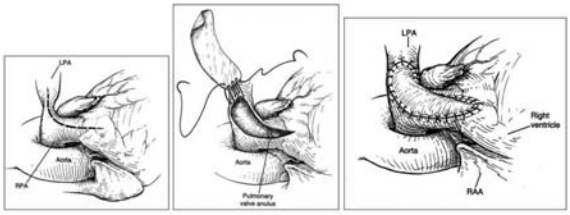
PV annular enlargement with valve reconstruction



Gore-Tex membrane or autologous pericardium

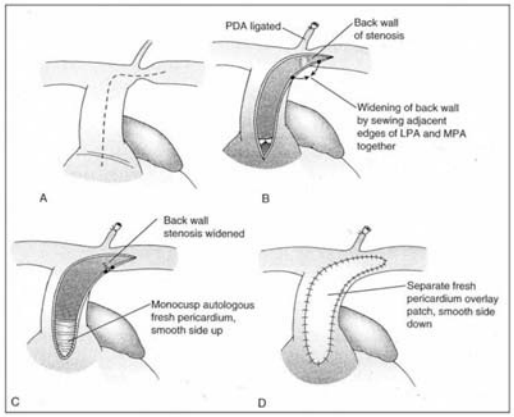


PA angioplasty



Causes of postoperative LPA stenosis

- Inadequate enlargement
- Aneurysmal dilatation of RVOT patch
- Kinking



Acute angle of LPA with or without stenosis

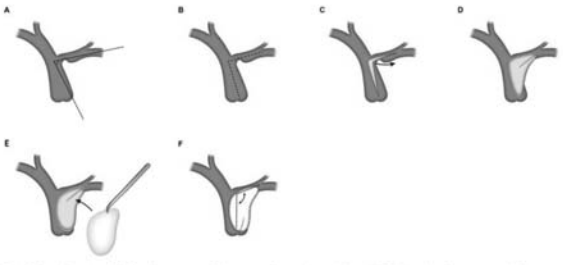


Fig 1. Schematic drawing of a left pulmonary artery (LPA) acute-angle correction angioplasty. (A–B) The main pulmonary artery (MPA)

Jang et al. Ann Thorac Surg 2017;103:862-8

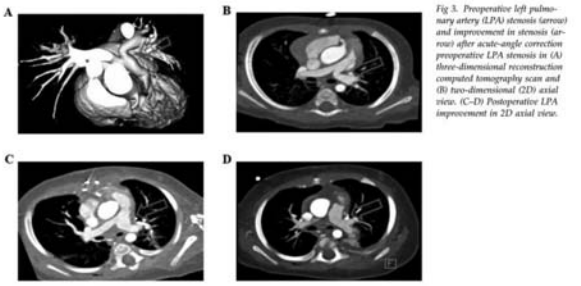


Fig 3. Preoperative left pulmonary artery (LPA) stenosis (arrow) and improvement in stenosis (arrow) after acute-angle correction preoperative LPA stenosis in (A) three-dimensional reconstruction computed tomography scan and (B) two-dimensional (2D) axial view. (C–D) Postoperative LPA improvement in 2D axial view.

Jang et al. Ann Thorac Surg 2017;103:862-8

Special topics in surgical management

- Hypoplastic PA
  - McGoon ratio <1.2
  - Nakata index <70
  - Uncommon in the patients with TOF with PS
  - Hypoplasia is most likely to be a result of underperfusion of the PAs
  - Prompt enlargement can be expected when pressure and flow are restored
  - Intraop RV pr
    - ASD creation or large perforation in the VSD patch

- Use of monocusp valve

Functions transiently at best

Bigras et al. no significant differences in the degree of early postoprative PR or in clinical outcomes (JTCS 1966;112:33)

Gundry et al. 16 of 19 patients had competent monocusp valves immediately after operation, but only one of 7 patients had a competent valve by 24 months postoperatively (JTCS 1994;107:908)

If extensive reconstruction for the branch pulmonary arteries is required or if there is distal disease of the pulmonary vasculature, inclusion of a monocusp in the repair may improve hemodynamics in the immediate postoperative state.

Surgical Results of Monocusp Implantation with Transannular Patch Angioplasty in Tetralogy of Fallot Repair

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Background: Monocusp reconstruction with a transannular patch (TAP) results in early improvement because it relieves residual volume hypertension during the immediate postoperative period. However, few reports have assessed the long-term surgical outcomes of this procedure. The purpose of the present study was to evaluate the mid-term surgical outcomes of tetralogy of Fallot (TOF) repair using monocusp reconstruction with a TAP. **Methods:** Between March 2000 and March 2009, 36 patients with a TOF received a TAP. A TAP with monocusp reconstruction (group I) was used in 25 patients and a TAP without monocusp reconstruction (group II) was used in 11 patients. We evaluated hemodynamic parameters using echocardiography during the follow-up period in both groups. **Results:** At the most recent follow-up echocardiography (mean follow-up, 8.2 years), the mean pulmonary valve velocities of the patients in group I and group II were 2.1±1.0 m/sec and 0.9±0.9 m/sec, respectively (p<0.001). Although the incidence of grade 3-4 pulmonary regurgitation (PR) was not significantly different between the two groups (group I: 16 patients, 64.0%; group II: 7 patients, 70.0%; p=0.735) during the follow-up period, the interval between the treatment and the incidence of PR aggravation was longer in group I than in group II (group I: 6.5±3.4 years; group II: 3.8±2.2 years; p=0.037). **Conclusion:** Monocusp reconstruction with a TAP prolonged the interval between the initial treatment and grade 3-4 PR aggravation. Patients who received a TAP with monocusp reconstruction to repair TOF were not to progress to pulmonary stenosis during the follow-up period as those who received a TAP without monocusp reconstruction.

Key words: 1. Tetralogy of Fallot
2. Transannular patch
3. Monocusp reconstruction

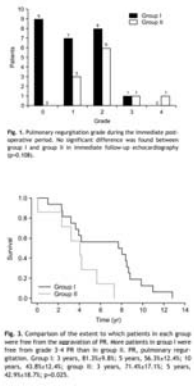
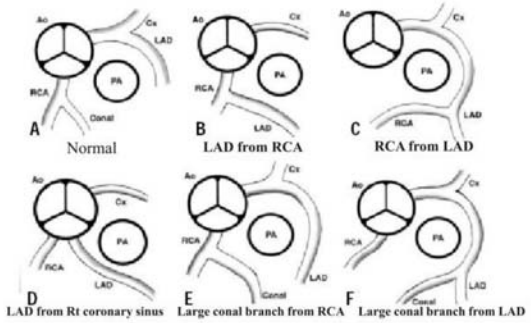


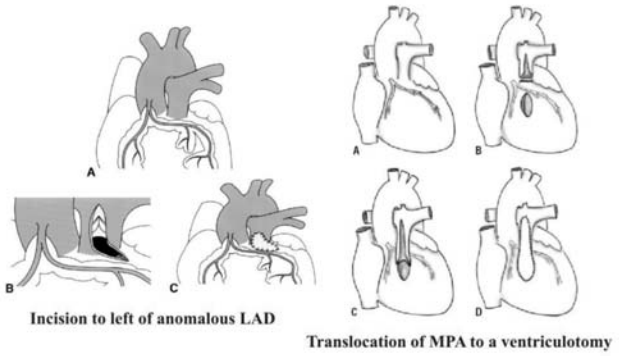
Fig. 1. Pulmonary regurgitation grade during the immediate postoperative period. No significant difference was found between group I and group II in immediate follow-up echocardiography (p=0.108).

Fig. 3. Comparison of the extent to which patients in each group were free from the aggravation of PR. More patients in group I were free from grade 3-4 PR than in group II. PR, pulmonary regurgitation. Group I: 3 years, 81.3%±9.8%; 5 years, 56.3%±12.4%; 10 years, 43.8%±12.4%; group II: 3 years, 71.4%±17.1%; 5 years, 42.9%±18.7%; p=0.025.

- Anomalous coronary artery crossing RVOT

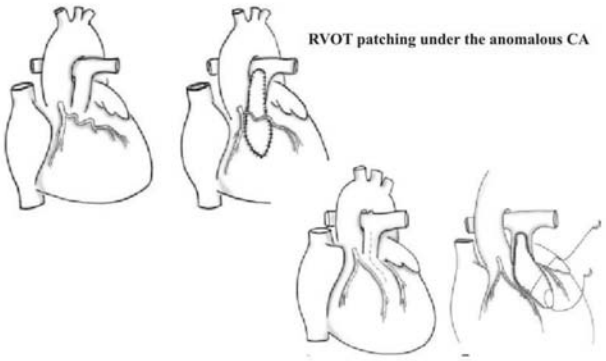


- Surgical management
  - Transatrial and transpulmonary approach
  - Incision through MPA and PA annulus and to left of anomalous LAD
  - RVOT patching under the anomalous coronary artery
  - Conduit reconstruction
  - Translocation of the PA to a distal ventriculotomy
  - Proximally based PA flap-double outlet technique

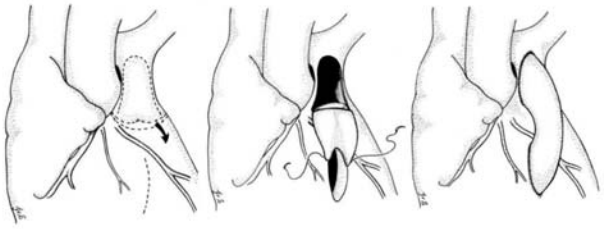


Incision to left of anomalous LAD

Translocation of MPA to a ventriculotomy



RVOT patching under the anomalous CA



Pulmonary artery flap - double outlet technique

Results of reoperation

- RVOTO
- PR
- Residual VSD

- Main causes of cardiac death in long-term survivors
  - Sudden death (Arrhythmia)
  - HF

- PVR
  - 2% of patients at 10-years FU and 12% after 20 years
  - Risk factors
    - TAP (large RVOT patch)
    - Peripheral PA stenosis
    - Residual VSD
    - Duration after TOF repair
    - Early repair or late repair?

- Indication for PVR
  - Symptomatic (decreased exercise tolerance, decreased functional class)
  - Progressive RV enlargement and RV dysfunction
  - LV dysfunction by RV
  - Increasing TR
  - Ventricular or supraventricular arrhythmia
  - RVEDV > 150 ml/㎡

- Valve choice at PVR
  - Bioprosthesis (bovine vs porcine)
  - Mechanical valve
    - When anticoagulation is required
      - Mechanical valve at aortic or mitral position
      - Afib
    - Repaid degeneration of previous tissue valve
    - Previous multiple operation

Arrhythmias

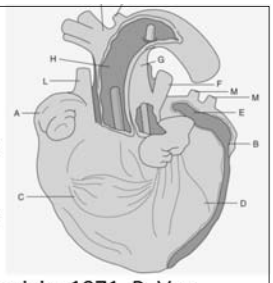
- Follow more than 20 years after TOF
  - 2~4% for Afib/Flutter
  - 3~4% for sustained VT
  - 2~4% for sudden cardiac death
- Holter monitoring
  - 19% for sustained VT
  - 23% for Afib/Flutter
- Risk factors
  - Elevated RV volume and pressure
  - Decreased RV or LV EF
  - PR
  - RVOT aneurysm

Transposition

양산부산대학교병원 흉부외과

김 형 태

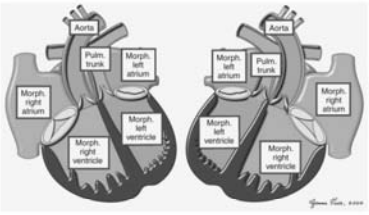
Introduction



- Matthew Baillie, first describe
- 1797
- Mr Langstaff, second describe
- 1811
- According to their ventricular origin, 1971, R. Van Praagh
- An anterior location of the aorta relative to the pulmonary trunk, 1971, L.H.S. Van Mierop

Introduction

- Concordant atrioventricular and discordant ventriculo-arterial connections

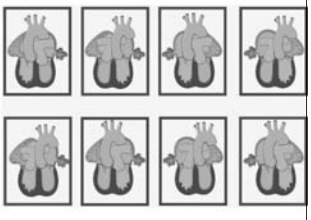


Introduction

- Discordant ventriculo-arterial connections associated also with discordant connections at the atrioventricular junction -> congenitally corrected transposition (ccTGA)
- Discordant ventriculo-arterial connections in combincation with isomeric atrial appendages -> functionally univentricular atrioventricular connections (FSV)

Historical background

- J.R. Farre, 1814, first used the term transposition
- A period becoming the norm to define the entity in terms of the anterior location of the aorta
- The aortic valve should be combined with support from a muscular infundibulum
- Produced the potential for confusion



Historical background

- Definition transposition on the basis of the origin of the great arterial trunks from morphologically inappropriate ventricles
- -> all potentials for confusion are avoided

Prevalence and aetiology

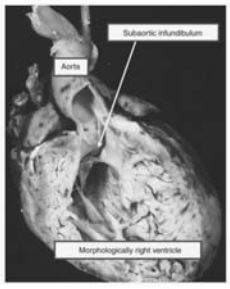
- 1/20 of all congenital cardiac malformation
- 1/5 of cardiac deaths in infancy prior to the era of surgical correction
- Boys, 2-3 times as frequently as girls
- More frequent
  - Infants of diabetic mothers, maternal intake of alcohol, poor nutrition or a stressful event during pregnancy
- Modest reduction
  - Addition of folic acid to the maternal diet

Anatomy and morphogenesis

- Anatomy
- Concordant atrioventricular and discordant ventriculoarterial connections
- Associated malformations
  - VSD
  - LVOTO

Anatomy and morphogenesis

- Basic segmental combinations

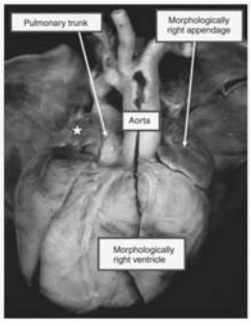


Anatomy and morphogenesis

- Basic segmental combinations
- The internal anatomy of the atrium is basically normal
- Unlike the atrial chambers, ventricular morphology is subtly different from normal
- At birth, the walls of the morphologically left ventricular wall are marginally thicker than those of the right ventricle
- The right ventricular mural thickness then rapidly increases in the first 2 years of life, becoming much thicker than that of the left ventricle

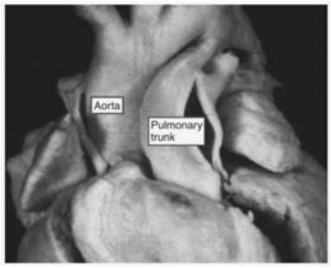
Anatomy and morphogenesis

- Basic segmental combinations
- The aortic root, the right, anterior
- The left, anterior, in the mirror-imaged variant



Anatomy and morphogenesis

- Basic segmental combinations

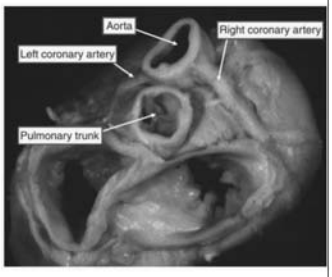


Anatomy and morphogenesis

- Infundibular morphology
- The aorta almost always has a complete muscular infundibulum
- The leaflets of the pulmonary valve are in fibrous continuity with the mitral valve

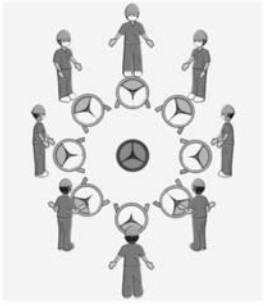
Anatomy and morphogenesis

- Coronary arteries
- The origins of the three major coronary arteries from the aortic sinuses
- Describing their course relative to the vascular pedicle, noting any intramural course
- With attention paid to the location of the artery supplying the sinus node



Anatomy and morphogenesis

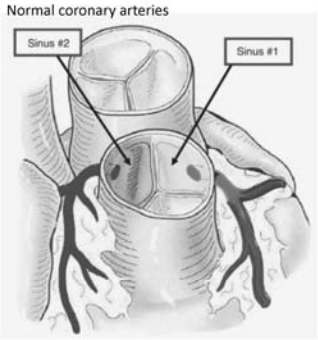
- Coronary arteries
- An observer standing in the non-adjacent aortic sinus and looking towards the pulmonary trunk
- The sinus to the right hand, sinus 1
- The left hand, sinus 2



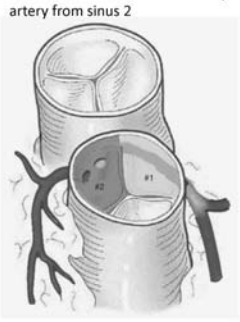
Anatomy and morphogenesis

- Coronary arteries

Normal coronary arteries

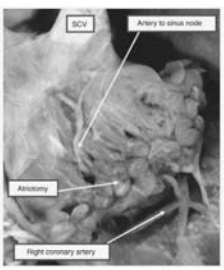


Intramural course of left coronary artery from sinus 2



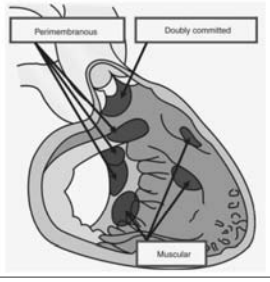
Anatomy and morphogenesis

- Coronary arteries
- Epicardial course
- Retropulmonary
- Antero-aortic position
- The artery to the sinus node
- Crosses the lateral margin of the right atrial appendage -> at surgical risk during a standard atriotomy



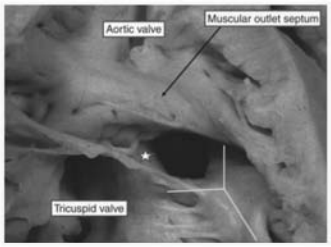
Anatomy and morphogenesis

- Ventricular septal defect
- Can be located within any part of the ventricular septum



Anatomy and morphogenesis

- Ventricular septal defect
- Outlet septum, positioned within the right ventricle
- Pulmonary valve, overrides the septum
- -> greater degrees of overrding
- -> DORV with subpulmonary VSD (Taussig-Bing anomaly)

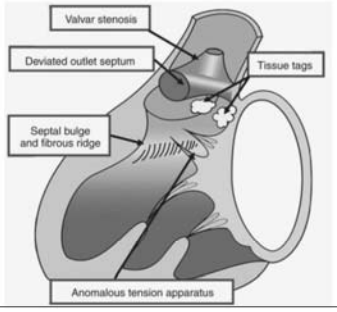


Anatomy and morphogenesis

- Ventricular septal defect
- The defect extends to open into the right ventricular inlet, potential for straddling and overriding of the tricuspid valve
- Other types of defect
  - Multiple muscular defects
  - Solitary apical muscular defects
  - Doubly committed defects

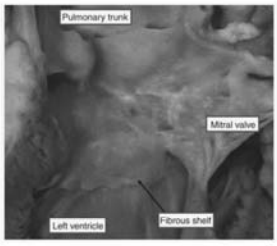
Anatomy and morphogenesis

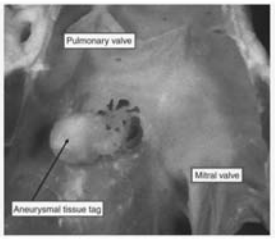
- Obstruction of the left ventricular outflow tract



Anatomy and morphogenesis

- Obstruction of the left ventricular outflow tract
- All can exist with an intact ventricular septum, or in association with a ventricular septal defect





Anatomy and morphogenesis

- Associated malformations
  - PDA
  - Stenosis of the subaortic outflow tract
  - CoA
  - Anomalous pulmonary venous connections

Anatomy and morphogenesis

- Morphogenesis
- The first suggests that the anomaly is the consequence of inappropriate separation of the arterial pole of the heart
- The second theory puts the seat of maldevelopment not in the arterial trunks, but in the ventricular outflow tracts

Pathophysiology

- Circulatory physiology
- In transposition, as two separate and parallel circuits

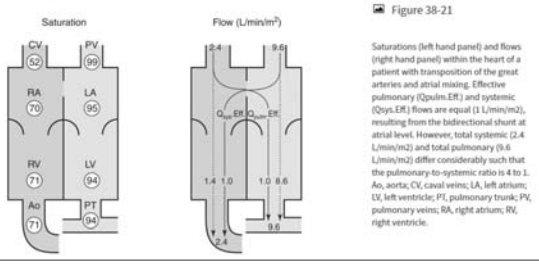


Figure 38-21

Saturations (left hand panel) and flows (right hand panel) within the heart of a patient with transposition of the great arteries and atrial mixing. Effective pulmonary (Qpulm.Eff.) and systemic (Qsys.Eff.) flows are equal (1 L/min/m2), resulting from the bidirectional shunt at atrial level. However, total systemic (2.4 L/min/m2) and total pulmonary (9.6 L/min/m2) differ considerably such that the pulmonary-to-systemic ratio is 4 to 1. Ao, aorta; CV, caval veins; LA, left atrium; LV, left ventricle; PT, pulmonary trunk; PV, pulmonary veins; RA, right atrium; RV, right ventricle.

Pathophysiology

- Determinants of systemic arterial oxygenation and mixing
- The level of systemic arterial saturation is determined by the effective systemic flow, which is proportionate to the degree of circulatory mixing
- At the level of the arterial duct, the direction of shunting largely depends upon the pulmonary vascular resistance
- High pulmonary resistance, commonly associated with a restrictive interatrial communication -> urgent decompression with an atrial septostomy

Pathophysiology

- Ventricular septal defect
- Predispose to early pulmonary vascular disease -> generally evident by 6-12 months of age
- Subpulmonary obstruction, modifies and limits the flow of blood to the lungs -> asymptomatic, protected pulmonary circulation, adequate mixing, and a well-trained left ventricle

Pathophysiology

- Growth and development during fetal life and infancy
- Smaller occipito-frontal circumferences at birth than control
- Majority of children, caught up with their peers by 2 years of age

Clinical diagnosis

- Presentation
- Antenatal diagnosis -> assess the full anatomy -> immediate postnatal initiation of PGE1 -> further intervention with a septostomy
- Cyanosis and circulatory collapse shortly after birth -> urgent balloon atrial septostomy
- Infants with a widely patent arterial duct, and a large unrestrictive VSD -> minimal cyanosis, symptomatic pulmonary over-circulation

Clinical diagnosis

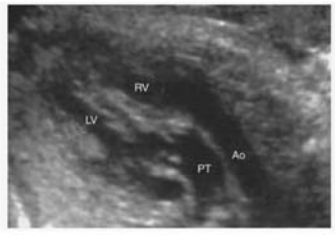
- Chest radiography
- In around 1/3 of neonates, narrow mediastinum, AP relationship of great arteries

Clinical diagnosis

- Electrocardiography
- Normal
- May be RV hypertrophy, right-axis deviation

Clinical diagnosis

- Fetal echocardiography
- Optimal neonatal care and pre-operative management



Clinical diagnosis

- Postnatal echocardiography
- Typically, the aortic valve is positioned anterior and to the right of the pulmonary valve

Clinical diagnosis

- Postnatal echocardiography
- The left ventricular outflow tract, always be carefully examined to exclude any obstruction
- The atrioventricular valves, should be assessed carefully to identify any abnormal attachments of the tendinous cords
- The origin and course of the coronary arteries
- The aortic arch, CoA or interruption
- Difficult to assess, after prostaglandin is discontinued

Clinical diagnosis

- Postnatal echocardiography
- ASD
- PDA

Clinical diagnosis

- Cardiac catheterization
- No longer routinely performed

Clinical diagnosis

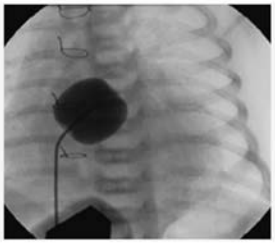
- Magnetic resonance imaging
- CT scaning

Medical management of neonates

- Postnatal stabilization
- Neonates diagnosed antenatally should ideally be delivered in a high-risk obstetric unit, with rapid access to cardiac care
- IV PGE1
- Patients with severe acidosis or hypoxemia -> immediate balloon atrial septostomy
- Inadequate intracardiac mixing and significant cyanosis -> septostomy

Medical management of neonates

- Atrial septostomy
- Introduction by Rashkind and Miller in 1966



Surgical management

- Historical perspective
- The improved survival in infancy after surgical intervention can largely be ascribed to the advent of the balloon atrial septostomy

Surgical management

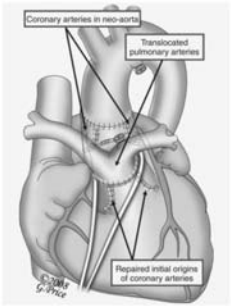
- Atrial redirection procedures
- Physiological correction
- Late complications
  - Baffle obstruction
  - Arrhythmias
  - Ventricular dysfunction
  - End-stage heart failure

Surgical management

- Mustard and Senning procedures
- Senning operation, rerouting of systemic venous blood -> achieved by means of infolding of the atrial walls
- Mustard operation, achieved using synthetic or pericardial tissue

Surgical management

- Arterial switch operation
- The first successful arterial switch operation, by Jatene and colleagues in 1975, in an older infant with an associated VSD
- De-conditioned LV, two-stage repair -> PA banding (+ systemic-to-pulmonary arterial shunting)
- Lecompte maneuver, in 1981
- The first report of successful correction of a neonate with an intact ventricular septum, in 1984
- Early experience, VSD, coronary arterial pattern, aortic arch obstruction -> impact on mortality -> these effects have decreased over time



Surgical management

- Timing of the arterial switch operation
- TGA with IVS, undertaken towards the end of the first week of life
- To avoid the deconditioning of the morphological left ventricle
- Deconditioning, arrested or slowed by
  - VSD
  - Large PDA
  - LVOTO

Surgical management

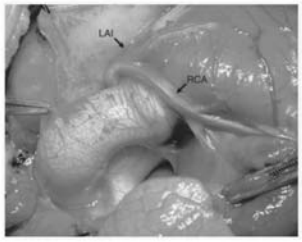
- Timing of the arterial switch operation
- By the Congenital Heart Surgeons Society in 1988, only 14 days, in TGA with IVS
- -> primary repair can be undertaken at up to 2 months of age
- -> in infants at even up to 6 months, but need for temporary mechanical support

Surgical management

- Arterial switch operation
- Ventricular training
- The potential for LV to support the systemic circulation
- PA banding (+ S to P shunt)
- At high risk patients, ASO as the primary procedure -> elective use of a left ventricular assist device immediately after CBP

Surgical management

- Arterial switch operation
- Coronary arterial anatomy
- LAD or LCx arising from sinus 2
- Intramural coronary artery
- Single origin of the coronary arteries



Surgical management

- Surgery for complex transposition
- Transposition with a ventricular septal defect
- Did not affect the outcome for the arterial switch operation in current era

Surgical management

- Surgery for complex transposition
- Surgery in infants with significant pulmonary hypertension
- Pulmonary vascular disease, develops rapidly in TGA with VSD
- PVR > 8 Wood units, insuitable
- Palliative atrial redirection
- Palliative arterial switch

Surgical management

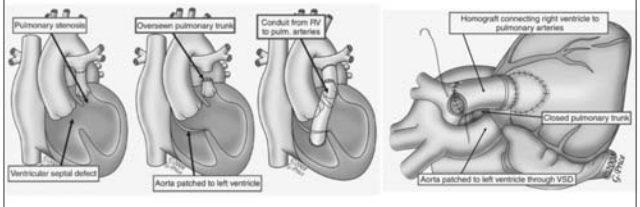
- Surgery for complex transposition
- Transposition with coarctation of the aorta of interruption of the aortic arch
- More common in those with VSD, when it is often associated with anterior deviation of the outlet septum
- Generally accepted that a single-stage operation should be performed
- Augmentation with a patch may occasionally be required

Surgical management

- Surgery for complex transposition
- Surgical options in the presence of obstruction to the left ventricular outflow tract
- LVOTO, most commonly associated with VSD
- Minor degrees, resected at the time of ASO
- Severe or complex forms, to consider an alternative procedure

Surgical management

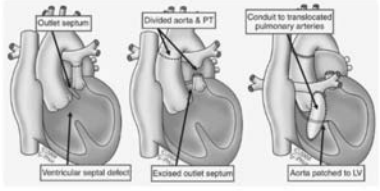
- Rastelli procedure



Postop. LVOTO
RV-PA conduit replacement

Surgical management

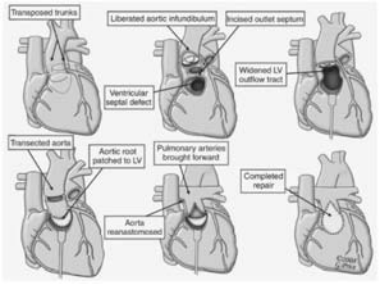
- Reparation a l'Etage Ventriculaire, or REV procedure



Post-operative RVOTO

Surgical management

- Nikaidoh procedure, or aortic translocation



Advantage, systemic outflow is not directed through an intraventricular baffle -> lower risk of obstruction developing in the LVOT

Surgical outcomes

- Atrial redirection procedures

Main indicaions for reop.
1) Obstruction of the venous baffles
2) RV failure
3) TR
4) LVOTO

Atrial bradyarrhythmias and tachyarrhythmias

Surgical outcomes

- Late outcome after the arterial switch procedure
- General health, quality of life, and neurodevelopmental outcome
- Good overall health and quality of life, not significantly different from their peers
- Frequently perform below expectation in
  - Academic achievement
  - Fine motor function
  - Visual-spatial skills
  - Sustained attention

Surgical outcomes

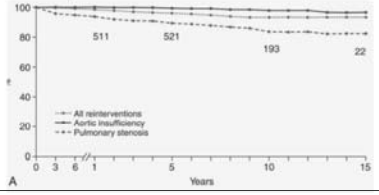
- Late outcome after the arterial switch procedure
- Fate of the coronary arteries
- Coronary arterial problems, 1/10
- 1/3 of late deaths
- Potential mechanisms
  - Anatomical distortion
  - Extrinsic compression
  - Stretching
  - Intimal proliferation

Surgical outcomes

- Late outcome after the arterial switch procedure
- Fate of the neo-aortic root and valve
- 2/5, AR, 20 months f/u
- ½, AR, 10 years f/u
- Ascending aorta dilation
  - AR
  - Abnormal angulation of the aortic arch

Surgical outcomes

- Late outcome after the arterial switch procedure
- Pulmonary arteries
- Obstruction within the pulmonary outflow tract, the most frequent residual anatomical problem
- The most frequent indication for reoperation



Recommendations for long-term follow-up

TABLE 38-1 Protocols Developed by the Canadian Adult Congenital Heart Network for the Assessment of Adults with Transposed Arterial Trunks

Modified from Canadian Adult Congenital Heart Network. Complete transposition. Available at: www.cachnet.org [2].

All patients should have at a minimum – A thorough clinical assessment – An electrocardiogram – A chest radiograph – Oximetry at rest and possibly with exercise
Patients who have had an atrial redirection procedure also require – An echocardiogram to detect baffle obstruction or leak, to detect regurgitation of the atrioventricular valve, to assess the function of the systemic ventricle, and to detect subpulmonary obstruction – A Holter monitor because of the high prevalence of sick sinus syndrome and atrial arrhythmias and possible ventricular arrhythmias in older patients and may require – A transesophageal echocardiogram if there is inadequate visualization of the intra-atrial baffle on the transthoracic study – Radionuclide assessment of myocardial perfusion (if ischaemia is suspected), or of ventricular function – Magnetic resonance imaging to evaluate the baffle for obstruction or leak and ventricular volumes, shapes, and function – Cardiac catheterization including coronary angiography if there are doubts about additional lesions, and if surgical reintervention is planned, or if adequate assessment of the haemodynamics is not obtained by non-invasive means – Exercise testing to evaluate functional capacity, including heart rate and blood pressure measurement, and to assess whether arrhythmias may be provoked
Patients who have had an arterial switch operation also require – An echocardiogram to assess obstruction to the right ventricular outflow tract, ventricular function, neo-aortic root dilation, and regurgitation of the aortic valve and the coronary arterial orifices – Exercise testing for possible coronary ischaemia and may require – Holter monitoring if arrhythmia is suspected – Nuclear assessment of myocardial perfusion periodically – Coronary arteriography if ischaemia is documented on non-invasive testing – Cardiac catheterization if adequate assessment of the haemodynamics is not obtained by non-invasive means or additional lesions are suspected – Magnetic resonance imaging to exclude obstruction of the right ventricular outflow tract

References

- Paediatric cardiology, third edition, by Anderson

【특 강】

Prospect of Cardiothoracic Surgery - "Be Optimistic"

분당서울대학교병원 흉부외과학교실

박 계 현

【대동맥, 혈관】

좌장: 공준혁

Techniques and Complications of Aortic Surgery

Department of Thoracic & Cardiovascular Surgery, Sungkyunkwan University School of Medicine

Kiick Sung, MD, PhD

Arch Aneurysm

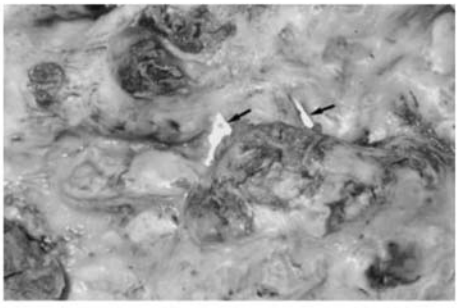
- Open surgery
  - Still demanding procedure
  - Recent progress in technique & materials
    - Axillary cannulation
    - Selective cerebral perfusion
    - Epiaortic US
    - Neurologic monitoring
    - Graft materials, glues, etc
- Endovascular & Hybrid treatment
  - Recently rapidly expansion
  - Relatively good early results in selected patients

Open Repair Strategy

- Incision:
  - Median sternotomy, Clamshell, Lt thoracotomy
- Cannulation site
  - Ascending aorta, Axillary artery, Femoral artery
- Temperature
  - Deep or Moderate hypothermia
- Brain perfusion or protection
- Anastomotic order
  - Arch first
  - Distal first
  - Proximal first

Atheroma

Shaggy aorta



(JACC 1988;32:83-9)

Prevention of Atheroma

- Macroembolism
- Intraoperative identification
  - Aortic cannulation site
  - ACC site
  - Proximal anastomosis of CABG
- Alternative cannulation
- Specially designed cannulae

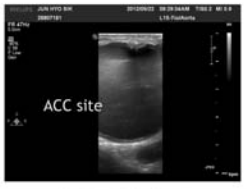
Identification of atheroma

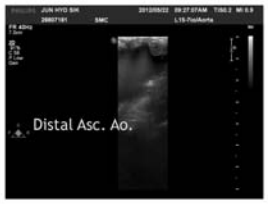
- Soft >> hard
  Mobile >> non-mobile
- Method
  - Digital palpation
    - Do not detect more dangerous soft plaque
  - TEE
    - Limited view (esp, distal ascending aorta)
  - Epiaortic ultrasonography

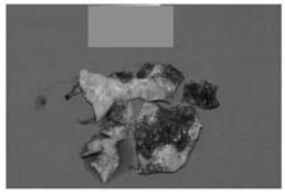
TEE

- Limited view (esp, distal ascending aorta)

Epiaortic Ultrasonography







DP vs TEE vs EAU

An Intraoperative Assessment of the Ascending Aorta: A Comparison of Digital Palpation, Transesophageal Echocardiography, and Epiaortic Ultrasonography

Sujeeth Suvarna, FRCSI,* Andrew Smith, FRCA,† Jan Stygall, MSc,‡§ Shyam Kolvecar, MS, FRCS(CTh),* Robin Walesby, FRCS,* Michael Harrison, FRCP,‡ and Stanton Newman, DPhil, Dip Psych, AFBPS, MRCP(Hon)‡

Objectives: There are a number of techniques available to assess the aorta for atheromatous dise… ative period. This study compared the … the findings of digital palpation (DP), tra… cardiography (TEE), and epiaortic ultra… detection of atheroma in the ascending…

Design: A prospective, observational …

Setting: A single-institution, cardiothe… pital.

Participants: One hundred fifty-four … elective cardiac surgery.

Interventions: The ascending aorta of … elective coronary artery bypass surger… atheroma by means of the 3 techniq… scored as present or absent. The sensitiv… the techniques were compared.

Measurements and Main Results: Assuming EAU provides … the sensitivity of both TEE and DP were … identified only 20 patients (12%); TEE … and, in contrast, EAU detected atheroma … There were 3 and 6 false-positives by … tively.

…ming EAU as the "gold standard" to de- … study has shown that when assessing … neither DP nor TEE appear sensitive. … the proposal that detection of atheroma … by EAU.

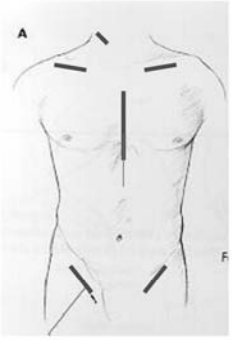
…ning, digital palpation, transesophageal …epiaortic scanning

Sensitivity:
DP (12%),
TEE (20%),
EAU (53%)

False positive:
DP (3/154),
TEE (6/154),
EAU (none)

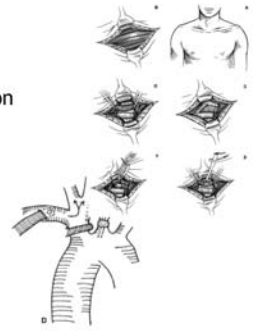
Alternative Cannulation

- Distal arch >> ascending aorta
- Axillary artery
- Femoral artery
- Brachial artery
- Carotid artery
- LV apex

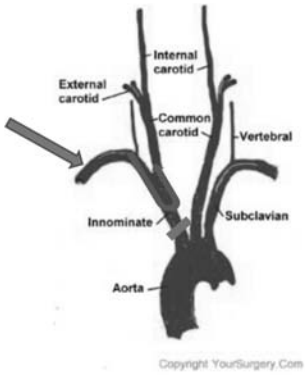


Axillary Artery Cannulation

- Sabik JF et al. (JTCS 1995;109:885-91)
- Advantages
  - Easily exposed
  - Less atherosclerosis
  - Antegrade selective perfusion
- Disadvantages
  - Time consuming
  - Axillary artery dissection
  - Small axillary artery



Cerebrovascular Anatomy



Femoral Artery Cannulation

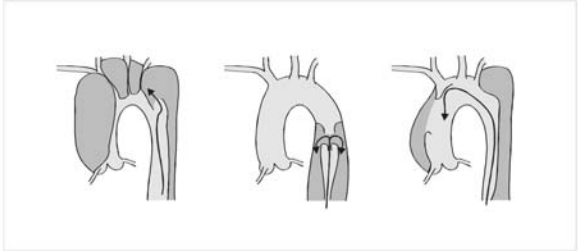
- 1950 ~
- Usually used for thoracic aortic surgery
- Advantages
  - Easy to access & repair
  - Emergency bypass
- Disadvantages
  - Retrograde perfusion of emboli
  - Malperfusion during Type A acute AD surgery
  - Ilio-femoral artery disease

Descending Aorta Mobile Thrombus

- Intraop TEE

Malperfusion During Acute type A AD

- ~ 13%
- Radial artery pressure monitoring
- Re-entry tear: patent false lumen



2. Prevention of Microemboli

- Associated with cognitive dysfunction
- Origin
  - Gas
  - Fat from mediastinal suction fluid
  - Silicon from CPB circuit
- associate with systemic inflammatory response
- Arterial filter (25 > 40μm) is helpful
  - Can reduce microemboli, but not all

Protective Mechanisms

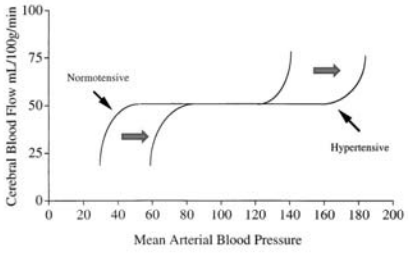
- Air embolism
  - CO2 flushing (more soluble)
  - Avoid too low venous reservoir level
  - Closed systems
  - Dynamic bubble trap
  - Avoid injection of air
- Fat embolism
  - Using a cell saver
  - Arterial & fat filter

3. Prevention of Hypoperfusion

- Brain metabolism
- Autoregulation
- Optimal MAP?
- Optimal Hct?
- Monitoring modalities

Autoregulation of CBF

- CBF maintained constant independent of BP
- MAP: 50 ~ 120 mmHg



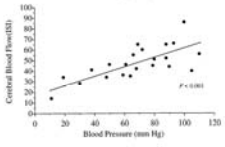
Optimal MAP?

- High risk patients needed higher MAP
  - Hypertension
  - Diabetes
  - Old age
  - CVA Hx.
  - Carotid disease
- More trauma to blood
  Needed larger cannulae
  Increase embolic load

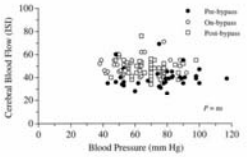
Alpha vs pH stat

- Hypothermia
  - CO_2 content ↓, pH ↑

pH stat
- Add CO_2 to correct pH
- CBP ↑
- Embolic event ↑
- Neonate surgery



Alpha stat
- Maintain CO_2 constant
- Maintain autoregulation
- Adult surgery



Hypothermia

- Decrease brain metabolism
- Oxygen consumption: 3 mL/100g/min
- Flow/metabolism ratio
  - 37°C - 15:1
  - At 28°C
    alpha stat - 30:1
    pH stat - 60:1

Normal CBF: 40 ~ 60 mL/100g/min

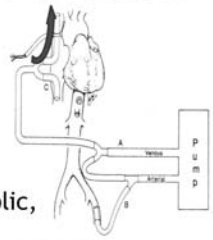
- pH stat can cause unnecessary high flow & high incidence of embolism in adult

Hypothermic Circulation Arrest

- Brain metabolism: 23% at 20°C, 17% at 15°C
- Reactive hyperemia → oxygen debt
- > 25 min: risk of transient neurologic deficit
  > 40 min: risk of stroke
  > 1 hr: mortality increase
- Long bypass time and bleeding

(ATS 2007;83:s799-804)

Retrograde Cerebral Perfusion



- < 25 ~ 30mmHg of CVP
- Flush out embolic debris
- Brain cooling
- No evidence of cerebral metabolic, neurologic or neuropsychological benefit
- Cerebral edema

(ATS 2007;83:s799-804)

Antegrade Selective Cerebral Perfusion

- Physiologic
- Low rates of morality & neurologic morbidity (short CPB time, bleeding risk ↓)
- Methods
  - Unilateral
  - Bilateral
  - Three branches
- Clamping, balloon catheter, snaring
- Complicated arch surgery
- Embolic & Malperfusion risk
- Caution of branch vessel atheroma

(ATS 2007;83:s799-804)

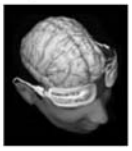
Atheroma of LCC

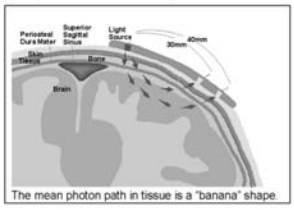
Optimal Flow of Selective Perfusion

- Depend on hypothermia
- Pressure monitoring
  - Radial artery pressure may not be accurate
- Flow
  - Approximately 10 ml/kg/min
  - Cerebral oxymeter may be helpful

Neurologic Monitoring

- Near-infrared spectroscopy (cerebral oxymeter)

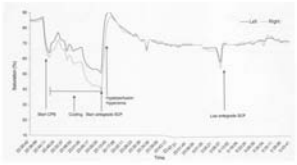




- Transcranial Doppler
- EEG
- Jugular venous oxygen saturation

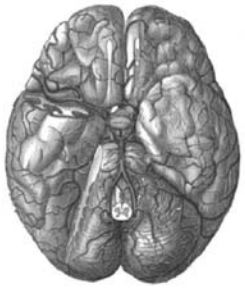
Near-infrared Spectroscopy

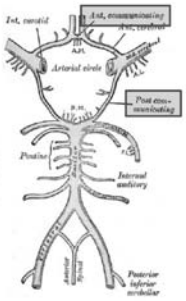
- Merits
  - Non-invasive
  - Continuous, real-time
  - Safe
  - Portable
  - Easy to interpret
- Drawbacks
  - Cannot monitor entire brain
  - Cannot differentiate causes
  - Bilirubin
  - Normal in dead brain



Circle of Willis

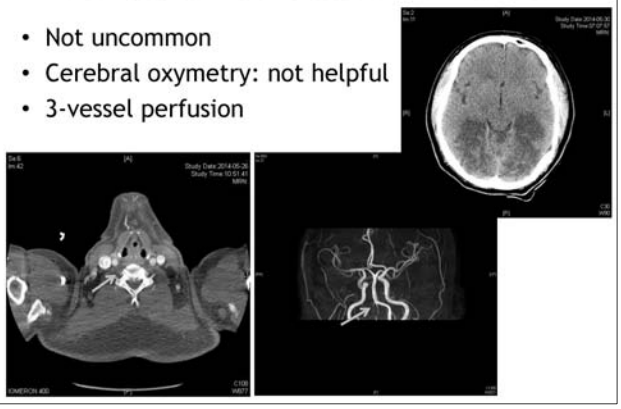
- Not intact: ~15%
- Cerebral oxymeter: usually frontal area





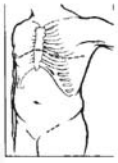
Variation of Circle of Willis

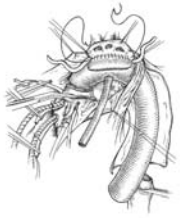
- Not uncommon
- Cerebral oxymetry: not helpful
- 3-vessel perfusion

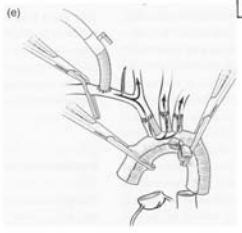


Arch-first Technique (I)

- Kouchoukos NT et al (ATS 2007)
- Extensive arch aneurysm
- Clamshell incision
- En bloc or branched graft technique







Arch-first Technique (II)

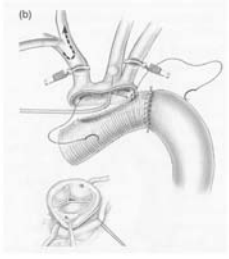
- N = 69
- Brief period circulatory arrest (≠ 10 min)
- Hospital mortality: 7.2%
- Bleeding: 13%

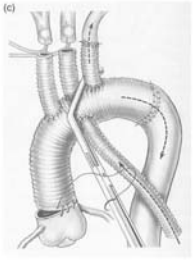
  Tracheostomy: 13%

  No permanent CVA

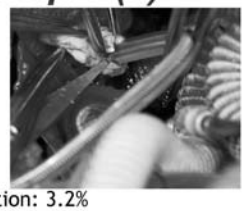
Distal-first Technique (I)

- En bloc or separate graft implantation
  - Antegrade selective cerebral perfusion
  - Moderate hypothermia





Distal-first Technique (II)



- Separate graft technique
- Kazui T et al (ATS 2007)
  - N = 472
  - In-hospital mortality: 9.3%
    (4.1% in recent 266)
  - Permanent neurologic dysfunction: 3.2%
- Sasaki H et al (ATS 2007)
  - N = 305 elective operation
  - Early mortality: 2.3%
  - Permanent neurologic dysfunction: 1.6%

Trifucated Graft Technique

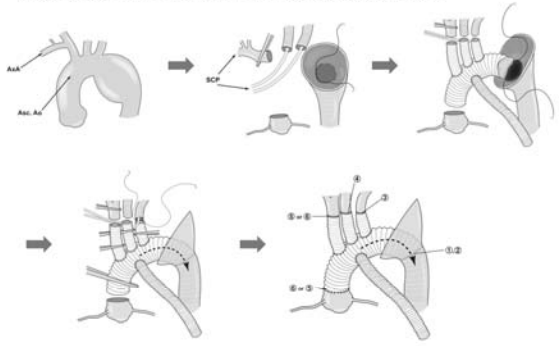
- Spielvogel D. et al (ATS 2007;83:S791-5)
- Axillary a. cannulation
- DHCA & SCP
- Hospital death: 4.7%
- Permanent CVA: 4.1%

SMC Strategy for Total Arch Replacement

- Epiaortic US
- Axillary cannulation
  (ascending aorta cannulation if no atheroma)
- Moderate to deep (cooling to ≈ 25 ~ 27°C) hypothemia
- Selective cerebral perfusion
  - Innominate a. clamping or cannulation
  - Lt. CCA & Lt. Subclavian a. direct balloon cannulae
- Near-infrared spectroscopy
- Distal first technique using separate graft
- Rewarming during arch vessel anastomosis

SMC Technique

- Short segment insertion using separate graft



Thoracoabdominal Aortic Aneurysm

- Most challenging procedure
- High operative morbidity & mortality
  - Pulmonary complication
  - Paraplegia
  - ARF
  - Cerebral complication
  - Etc

OSR Current Results

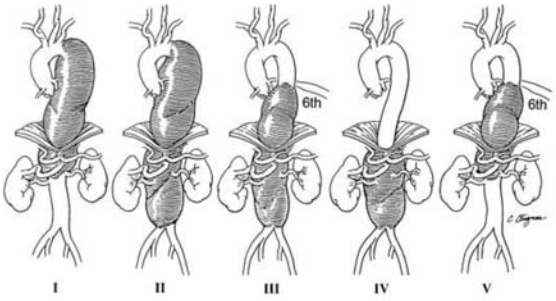
Table 4 Summary of clinical outcomes of open surgery for chronic type B aortic dissection

	First author	30-day mortality [%]	Stroke [%]	Spinal cord ischemia [%]	Renal ischemia [%]	Reoperation for bleeding [%]	Late reintervention [%]	Hospital stay (days)
Historic series	Reul	7 [17]	NR	NR	NR	NR	5 [12]	NR
	Jex	5 [14]	1 [3]	1 [3]	5 [14]	5 [14]	NR	NR
	Gandjbakhch	4 [33]	NR	NR	NR	NR	NR	NR
	Glower	2 [9]	NR	NR	NR	NR	5 [23]	NR
	Kawashima	7 [25]	NR	0	3 [11]	NR	NR	NR
	Fann	5 [15]	0	NR	NR	4 [12]	9 [26]	NR
	Safi	9 [10]	8 [9]	NR	NR	NR	NR	NR
	Okita	12 [15]	2 [3]	5 [6]	12 [15]	8 [10]	12 [15]	NR
	Zanetti	3 [15]	NR	1 [5]	3 [15]	NR	NR	NR
	Miyamoto	0	2 [5]	0	0	2 [5]	4 [10]	NR
Contemporary series	Nienaber	1 [8]	3 [25]	2 [17]	3 [25]	NR	NR	40
	Goksel	2 [13]	NR	0	NR	NR	3 [20]	NR
	Takagi	1 [3]	2 [5]	NR	4 [10]	1 [3]	2 [5]	NR
	Zoli	10 [10]	6 [6]	5 [5]	5 [5]	4 [4]	15 [14]	18.3
	Mutsuga	0	2 [6]	3 [9]	1 [3]	2 [6]	NR	NR
	Pujara	14 [8]	8 [5]	4 [2]	18 [11]	23 [14]	23 [14]	11[a]
	Corvera	2 [2]	1 [1]	3 [3]	1 [1]	4 [4]	8 [9]	NR
	Nozdzykowski	2 [13]	2 [13]	2 [13]	5 [33]	5 [33]	0	24
	Conway	5 [6]	2 [2]	2 [2]	2 [2]	NR	6 [7]	13.5[a]
Mean	Historic series	15.2	5.3	4.6	13.5	NC	16.8	NC
	Contemporary series	7.5	5.9	5.1	8.1	8.1	11.3	NC
	Overall [range]	11.1 [0-33]	5.6 [0-13]	4.9 [0-13]	11.9 [0-33]	9.9 [0-33]	13.3 [0-23]	NC

(Ann Cardithorac Surg 2014;3:340-50)

Classification

- Crawford type



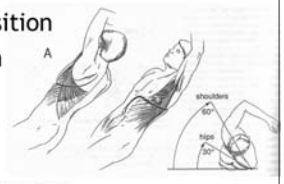
Anesthetic Preparations

- Double lumen E-tube
  - Not necessary lower thoracic aorta involvement only
- A-line
  - Radial artery (Rt >> Lt)
  - Femoral artery (Rt >> Lt), especially distal perfusion
- Large-bore peripheral IV line
- Central line & Swan-Ganz catheter
- Cerebral monitoring
  - Cerebral oxymeter, EEG, etc
- TEE
- Others

Exposure

- Bean bag, semi-lateral position
- Thoracoabdominal incision
- Intercostals
  - Type I & II: 6th ICS
  - Type III & IV: 7th ~ 9th ICS

  : if necessary, rib cutting or resection



- Abdomen
  - Midline vs pararectal incision
  - Transperitoneal vs retroperitoneal
- Diaphragm
  - Circumferential vs radial incision

Surgical Strategies

- To prevent complications
  - Brain injury, Organ ischemia & paraplegia, Pulmonary complications, Bleeding complications, etc
- Without extracorporeal circulation
  - Clamp-and-go technique without bypass
  - Passive shunt
- With extracorporeal circulation
  - LA-femoral without oxygenator
  - Femoro-femoral bypass with oxygenator
    - Mild hypothermia
    - Deep hypothermic circulatory arrest

Clamp-and-Go Technique

- Proximal clamping & hemodynamic disturbances
  - Peripheral vascular resistance & afterload ↑ ↑

  → proximal hypertension

  ventricular stain & stroke work ↑

  pulmonary congestion ↑

  CSF pressure ↑

  → Epi & NE, lactate, renin ↑

  → ischemic injury
- Release of aortic clamp
  - Preload & afterload ↓ ↓

  reperfusion injury, washout metabolites, shock

Clamp-and-Go Technique

- Slow clamp apply & pharmacological mx.
- Tolerable ischemic time: less than 30 (35~45)min
- Merits
  - No anticoagulation
  - Simple
- Limited to simple cases in experienced centers

Table 2. Incidence of p/p Following TAAA Repair in Comparative Studies Evaluating LHB

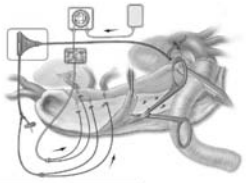
	Extent I			*Extent II*		
Author	*No. Without LHB (%)*	*Total No. of Patients With LHB (%)*	*P Value*	*No. Without LHB (%)*	*Total No. of Patients With LHB (%)*	*P Value*
Bavaria et al[5]*	3/11 (27.3)	0/14	0.072	2/5 (40.0)	2/12 (16.7)	0.330
Safi et al[8]*	2/30 (6.7)	1/56 (1.8)	0.278	9/22 (40.9)	11/85 (12.9)	0.003
Coselli series	13/320 (4.2)	9/290 (3.1)	0.866	29/259 (11.2)	17/375 (4.8)	0.019

(Semin Thorac Cardiovasc Surg 2003)

Passive Shunt

- Gott shunt
  - 1955 Etheredge et al, type IV(?)
  - 1956 DeBakey et al, TAA
- Axillo-femoral bypass
  - 1955 Comerota et al,
  - 1977 Taylor et al,
- No systemic anticoagulation
- Can not regulate pressure & flow actively
- Atherosclerotic aorta partial clamping
- No direct visceral perfusion

LA-Femoral (des. aorta) Bypass



- Coselli, Safi, Svensson et al
- Centrifugal pump
  No oxygenator
- Reduced heparinization
- No suction or reservoir

Variable	Extent I: Without LHB (n = 325)	Extent I: With LHB (n = 290)	Extent I: P Value	Extent II: Without LHB (n = 259)	Extent II: With LHB (n = 376)	Extent II: P Value
Mean intraoperative ischemic times (min):						
Total aortic clamp	51.8	46.3	<0.0001	51.6	60.8	0.0001
Intercostal ischemic	31.9	34.5	0.016	36.3	31.5	0.0939
Renal ischemic	31.6	45.8	<0.0001	42.5	57.0	0.0001
Perioperative complications:						
Mortality						
No. of intraoperative (%)	5 (1.5)	0	0.437	0	1 (0.3)	0.572
No. of 30-d (%)	25 (7.7)	5 (4.1)	0.739	15 (5.8)	28 (7.4)	0.270
No. of in-hospital (%)	31 (9.5)	7 (5.7)	0.100	19 (7.3)	35 (9.3)	0.357
No. of p/p[2] (%)	13 (4.2)	9 (3.1)	0.866	29 (11.2)	17 (4.5)	0.019
No. of acute renal failures[2] (%)	10 (7.1)	5 (4.1)	0.538	26 (10.0)	30 (8.0)	0.096
No. of bleeding complications (%)	5 (1.5)	3 (1.0)	1.000	10 (3.9)	11 (2.9)	0.922
No. of strokes[2] (%)	10 (3.1)	6 (2.1)	0.707	4 (2.0)	1 (0.5)	0.764
No. of cardiac complications (%)	26 (8.0)	26 (9.0)	0.936	24 (9.3)	33 (8.8)	0.719
No. of pulmonary complications[2] (%)	129 (40.0)	93 (32.1)	0.151	97 (37.5)	119 (31.7)	0.278
No. of wound dehiscence[2] (%)	13 (4.1)	10 (3.4)	0.959	9 (3.5)	25 (6.7)	0.298

Total CPB with TCA

- Kouchoukos, Griepp, Fehrenbacher, etc
- Minimal dissection
- No need for proximal & sequential ACC
- No need for selective renal & visceral perfusion
- Easy access to proximal arch & ascending aorta
- Bloodless field
- Return of the majority of shed blood
- Protection of the brain, spine, kidney, visceral
- Excessive blood loss
- Mortality & morbidity (pulmonary cx.) ↑

(Semin Thorac Cardiovasc Surg 2003)

Hypothermic Cardiopulmonary Bypass and Circulatory Arrest for Operations on the Descending Thoracic and Thoracoabdominal Aorta

Nicholas T. Kouchoukos, MD, Paolo Masetti, MD, Chris K. Rokkas, MD, and

N = 192, TAAA (114)
Circulatory arrest time: 38min
No other adjuncts for spinal cord protection
Results:
30-day mortality: 6.8% (15% in type II)
emergent (40%): elective (2.9%)
Paraplegia (2.7%), Renal failure (2.2%),
tracheostomy (9%), CVA (2%), bleeding (5%)
Conclusion
DHCA provides safe and substantial protection against end organs.
Limits
Long cardiopulmonary bypass time
Bleeding & adverse outcome ?

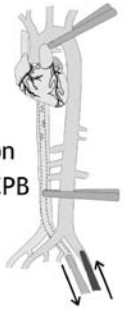
Background. Hy… with circulatory ar… ations on the distal… and the thoracoabd… of this technique w… simple aortic clamp… regional hypotherm…

Methods. One hu… range, 20 to 83 yea… coabdominal aortic… placement of the i… thermic cardiopu… circulatory arrest (n… used when the loca… placement of clamp… or (in 161 patient… thoracoabdominal … the risk for develo… was judged to be i… bar arteries were at… 101 of the 161 patients (63 %) who had extensive aortic replacement. No other adjuncts for spinal cord protection were used.

Results. The 30-day mortality was 6.8% (13 patients). It was 40% (8 of 20) for patients having emergent opera-… rupture) and 2.9% (5 of …e 90-day mortality was …curred in 4 and parapa-… 186 operative survivors …d be assessed postoper-… rvivors with thoracoab-… aplegia occurred in 1 of …2 with extent II, and 2 of …patient (extent II) devel-… stoperative day after a …e 47 patients with aortic …among the 186 operative …equired in 4 patients …ort in 18 (10%), reopera-…anical ventilation ≥ 48 …stomy in 17 (9%). Four …rdiopulmonary bypass …s safe and substantial … renal, cardiac, and vis-… other currently used techniques but without the need of other adjuncts.

(Ann Thorac Surg 2002;74:S1885–7)

Femoro-Femoral Partial Bypass

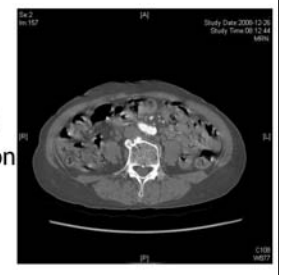


- Stanford university
- Improved exposure & adjunctive equip.
- Enhanced oxygenation
- Myocardial protection
- Systemic hypothermia & organ protection
- Versatility to allow conversion to total CPB
- Versatility in arterial cannulation
- Individually perfuse branch
- Systemic anticoagulation
- Inflammatory responses

(Semin Thorac Cardiovasc Surg 2003)

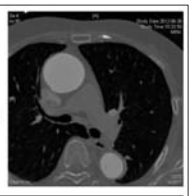
PVD

- Atherosclerotic iliac or femoral arteries
- Not uncommon



- Preop. evaluation
- Rt. Femoral pr. Monitoring
- Descend. aortic cannulation

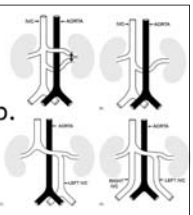
Hostile Aorta



- ACC site calcification or atheroma
  → embolic complications

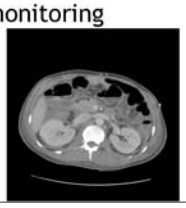
- Preop. evaluation
- Digital palpation
- Epi-aortic probe
- ACC at safe area
  or Total circulatory arrest

IVC Injury



- IVC anomaly: 6.65% in aortoiliac op.
- Occasionally occur in normal IVC

- Preop. evaluation
- Gentle catheter procedure
- TEE monitoring



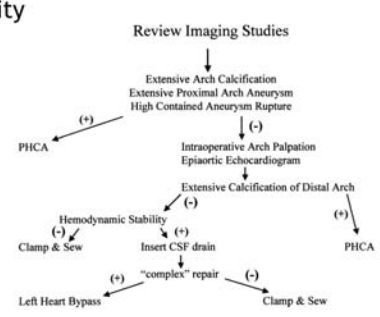
Pulmonary Injury

- Underlying lung problems
- Lung adhesion (ex, redo-aortic surgery)
- Lung injury during dissection
  + CPB with heparin

- Gentle dissection
- Staged operation
  (Elephant trunk, etc)

Integrated Approach ?

- Cornell university
- Complex:
  - Extent II
  - ACC > 30 min
  - LV function ↓
  - Dissection (+)



(Ann Thorac Surg 2005)

Mega Aorta

- F/77
- PMHx: HT (+), hysterectomy (5YA)
- PI: incidentally founded aortic aneurysm during work-up for R/O asthma

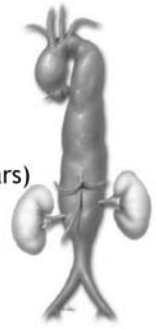
- General condition: not too bad
- Cardiac Echo: TR (+)
- CAG: minimal change
- FEV_1/FVC=1.27/2.15 L

Plan?

- Medication only?
- Intervention?
- Operation?
  - Conventional? Or hybrid?
  - One stage? or 2nd or 3rd stage
  - Single admission or multiple admissions?
  - Interval?
- Present courses
  - '12. 6. 5: Ascend. & total arch repl. + elephant trunk
  - '12. 6.25: Descend. thoracic aorta repl.
  - '12. 7.14: discharge
  - Present: OPD f/u

Mega Aorta Syndrome

- A rare condition
- Multilevel aneurysmal change
- Sometimes, the whole aorta, from the coronary ostia to the iliac
- Disease progression is slow (over years)
- Mostly symptomatic before catastrophic presentation



Treatment Strategy

- Open one-stage total
- Open staged operation with elephant trunk
- Hybrid procedure
  - 1st total arch replacement + 2nd endovascular
  - 1st debranching + 2nd endovascular
- Frozen elephant trunk
  - 1st total arch replacement
  - 1st debranching
- Others

Extended replacement of the thoracic aorta†

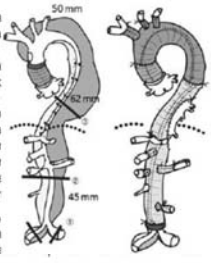
Yutaka Hino, Kenji Okada, Takanori Oka, Takeshi Inoue, Akiko Tanaka, Atsushi Omura, Hiroya Kano and Yutaka Okita*

OBJECTIVES: We present our experience of total aortic arch replacement.

METHODS: Twenty-nine patients (21 males and 8 females; mean age 63.3 ± 13.3 yea went graft replacement. The pathology of the diseased aorta was non-dissecting a aortic dissection in 18 patients (acute type A: one, chronic type A: 11, chronic type

N = 21 (ascending ~ abdominal arota: 8)
Age: 63.3 ± 13.3
Various incision & cannulation techniques
30-day mortality: 2 (6.6%)

Actual survival at 5 Yr: 80.6 ± 9.0%
Freedom from aortic event at 5 Yr: 96.0 3.9%
Conclusion
Satisfactory results using specific strategies and appropriate organ protection.



the subsequent aortic events was 96.0 ± 3.9% at 5 years.

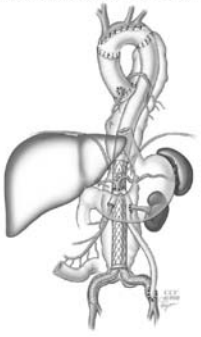
CONCLUSIONS: Our treatment method for extensive thoracic aneurysms achieved satisfactory results using specific strategies and appropriate organ protection according to the aneurysm extension in the selected patients.

Elephant Trunk Procedure: Newer Indications and Uses

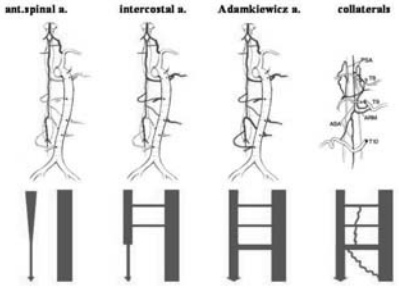
Lars G. Svensson, MD, PhD, Kyung-Hwan Kim, MD, Eugene H. Blackstone, MD, Joan M. Alster, MS, Patrick M. McCarthy, MD Joseph F. Sabik, MD, Richard S. D'Agostino, M Delos M. Cosgrove, MD

Background. The elephant trunk procedure is used for extensive aortic aneurysms. We evaluated its safety, newer ind tion on su *Method* patients t procedure The trunk ing aorta a arch graft left subcl dissection syndrome reoperatic was adju In 15 pati the left subclavian and common carotid arteries. Coronary artery bypass was performed in 36 (38.4%) and aortic

N = 93
1st stage 30-day mortality: 2 (2.2%)
Death during interval: 11 (12.1%)
2nd stage op. : 47 (57%)
Open thoracotomy (40)
Stent graft (7)
Early death: 4 (8.5%)
Conclusion
It is safe and should be used more with initial cardiac surgery.



Spinal Cord Protection during TAAA



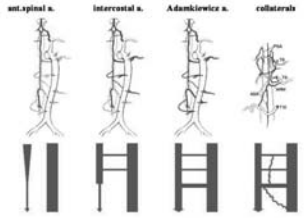
Risk Factors

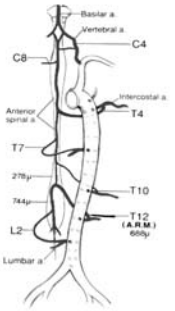
- Extent or coverage of aorta
- Lower thoracic & upper lumbar
- Abdominal aortic pathology or surgery
- Subclavian a. or hypogastric a.
- Old age
- Emergent procedure
- Renal failure
- Bleeding
- Hypotension
- etc

(Semin Vasc Surg 2009;22:187-92)

Blood Supply of Spinal Cord

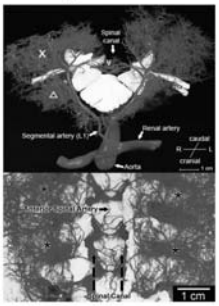
- Anterior spinal artery
- Intercostal arteries
- Adamkiewicz artery
- Collateral network

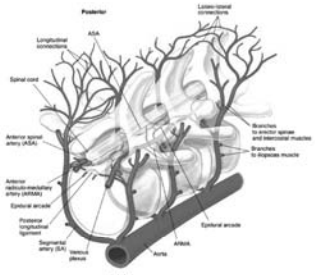




Collateral Network Concept

- Epidural arterial arcades
- Extraspinal network: paraspinal m.

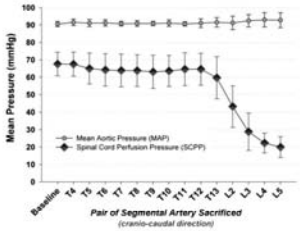


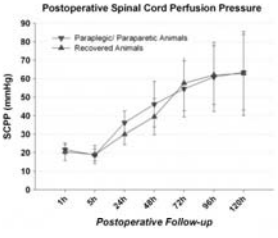


(Perspect Vasc Surg Endovasc Ther 2011;23:214-22)

Spinal Cord Perfusion Pressure

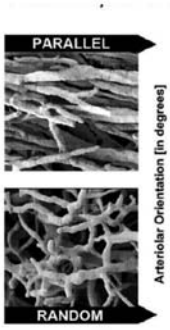
- Lumbar artery cannulation
- Segmental a. clamping in a craniocaudal direction

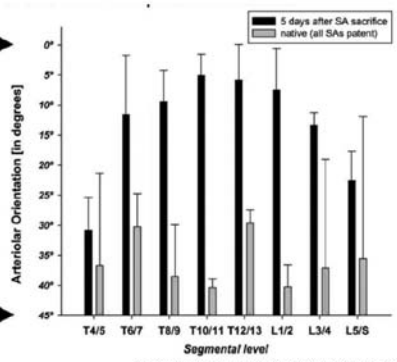




(Eur J Cardiothorac Surg 2011;23:214-22)

Orientation of Collateral Network

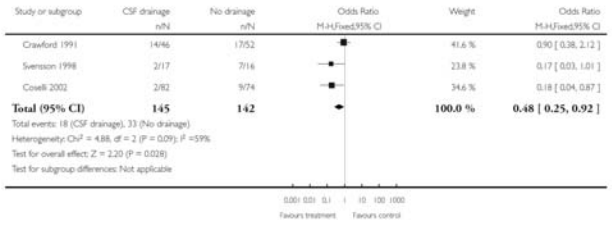




(Perspect Vasc Surg Endovasc Ther 2011;23:214-22)

CSF Drainage

- SCPP = MAP (CNP) - CSF pr.
- Complications (1.5%): SDH, headache, etc



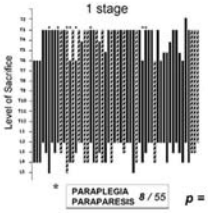
(Cochrane Database Syst Rev 2012;10)

Staged repair significantly reduces paraplegia rate after extensive thoracoabdominal aortic aneurysm repair

Objective: Paraplegia remains a devastating
acoabdominal aortic aneurysms. Strategies t
tery sacrifice—or occlusion, essential for en

Methods: Ninety patients who underwent e
open surgical repair from June 1994 to Dec
age, 65 ± 12 years; 49% were male), most v
had a single procedure (single-stage group),
procedures (2-stage group), usually Crawfor
thoracic aneurysm. The median interval betw
were no significant differences between the
sion, chronic obstructive pulmonary disease
cerebrospinal fluid drainage. In single-stage
tients, left-sided heart bypass was used in 40

Extent of Segmental Artery Sacrifice in Each Patient



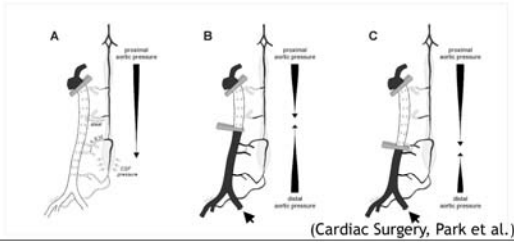
1994 ~ 2007
55 single-stage : 35 two-stage
Results:
No difference in mortality & other morbidities
Spinal cord injury
15% in single-stage : none in two-stage
Conclusion
A staged approach may reduce the incidence of spinal cord injury.

ifferences in mortality, stroke, post-
etween the groups. However, 15%
versus none in the 2-stage group
2-stage group occurred despite a sig-
dian of 14 (11–15) versus 12 (9–15)

ysm repair may reduce the incidence
s involving hybrid or entirely endo-

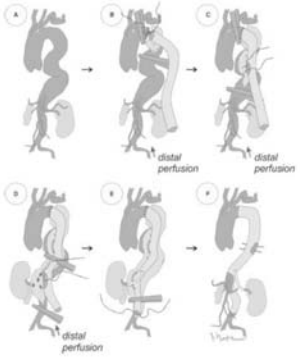
Distal Perfusion & Sequential Clamping

- Proximal clamping
  - Distal ischemia
  - CSF pressure ↑
- Mild hypothermia



(Cardiac Surgery, Park et al.)

Sequential Clamping & Distal Perfusion



Simultaneous Evaluation of the Whole Aorta and Artery of Adamkiewicz by MDCT

Recent technical advancement has allowed simultaneous visualization of the artery of Adamkiewicz and whole aorta by multidetector-row-CT (MDCT). Although we could visualize the artery of Adamkiewicz in a high percentage of patients with thoracoabdominal aortic diseases, CT scanning with an adequate protocol and careful post-processing are necessary for accurate evaluation. Noninvasive evaluation of the artery of Adamkiewicz is useful in planning surgery. Preoperative evaluation of the intercostal arterial level from which the artery of Adamkiewicz originates is reportedly important for preventing postoperative spinal cord ischemia. Although, the usefulness of preoperative information on the artery of Adamkiewicz is still controversial, preoperative identification of the artery of Adamkiewicz by imaging has gradually spread since our first report, and has been included in preoperative evaluation items at many institutions, revealing its contribution to improvement in surgical results. (*English Translation of J Jpn Coll Angiol, 2004, 44: 693-699.)

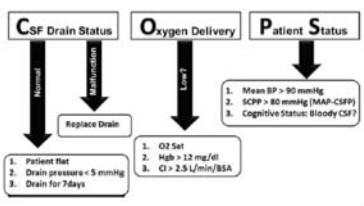
Prevention of Paraplegia During Open Surgery

- Reimplantation of critical segmental arteries
  - Preoperative identification (CT or MRI)
  - MEP or SSEP monitoring
- Maintenance of perfusion pressure
  - Avoidance of proximal hypotension
  - Distal aortic perfusion (LA-femoral or femoro-femoral bypass)
- Minimize ACC or ischemic time
  - Sequential clamping
- Enhancement of cord perfusion
  - CSF drain
  - Avoidance of blood flow steal
  - Intrathecal papaverine ?
- Tolerance to ischemia and reperfusion injury
  - Hypothermia (deep or mild hypothermia)
  - Epidural cooling
  - Pharmacological adjuncts ?

(Cardiac Surgery, Park et al.)

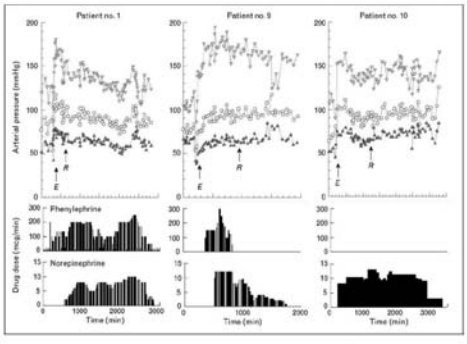
Delayed Paraplegia

- More often than immediate onset
- Mechanism:
  - Apoptosis
  - Hypotension, systemic inflammatory response syndrome, sepsis, diminished oxygen delivery, etc



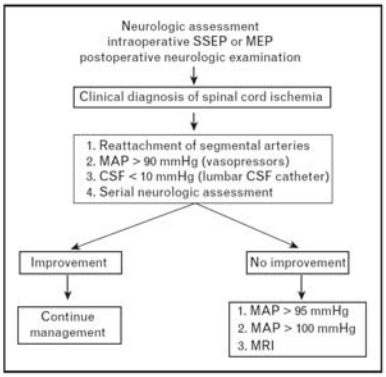
(J Anesth 2013)

High Blood Pressure



(Curr Opin Anaesthesiol 2010;23:95-102)

Algorithm for Detection & Treatment

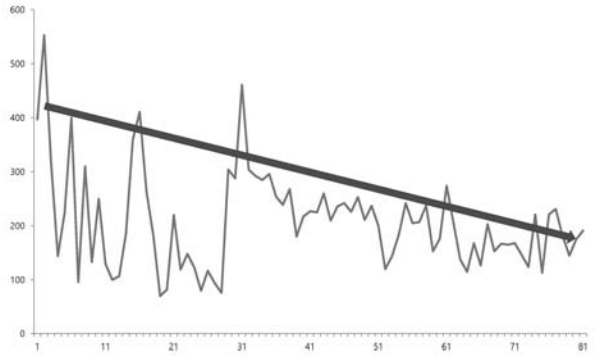


(Curr Opin Anaesthesiol 2010;23:95-102)

Operative Strategy in SMC

- Thoracoabdominal aortic aneurysm (TAAA)
  high risk descending thoracic aortic aneurysm (TA)
- CSF drainage
- MEP & SSEP monitoring (since 2006)
- Moderate hypothermia
- Femoro-femoral partial bypass if ACC possible
- Sequential clamping
- Minimize back bleeding
- Intercostal a. reimplantation (2~3 pairs)
- Perioperative high blood pressure

Trend of Pump Time by Cases



Techniques and Complications of EndoVascular Aortic Repair

Department of Thoracic & Cardiovascular Surgery, Dongguk University Ilsn Hospital

Jae Hang Lee, MD

Contents

- TEVAR
  - Indications & contraindications
  - Procedure & technical tips
  - Hybrid TEVAR (debranching techniques)
- EVAR
  - Indications & contraindications
  - Procedure & technical tips
  - Advanced techniques (Chimney, Sandwich, coiling, plugging)
- Complications in (T)EVAR

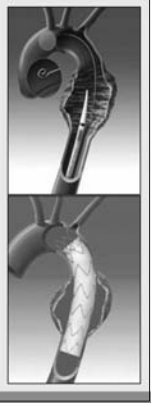
Definition..!!!!

- Aneurysm — Diameter > 50%, all 3 layers (intima, media, adventitia)
- Pseudoaneurysm — Disruption of arterial wall with extravasation Blood contained by periarterial connective tissue (not by the arterial wall)
- Ectasia — Arterial dilatation < 150%
- Aortic dissection — Disruption of the media layer Bleeding within and along the wall of the aorta
  - Acute aortic dissection
  - Chronic aortic dissection
  - Subacute aortic dissection

TEVAR

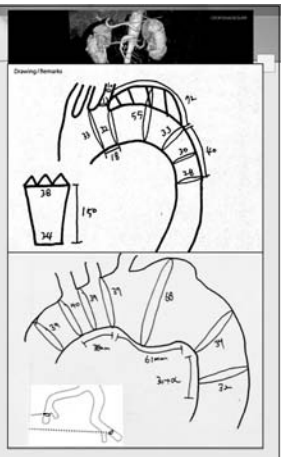
TEVAR (Thoracic EndoVascular Aortic Repair)

- Indication
  - Aortic aneurysm (>6.0cm, 1cm/yr, symptomatic)
  - Aortic dissection (ex. Complicated type B AoD)
  - Traumatic aortic injury
- Contraindication
  - Hypersensitivity in stent-graft
  - Condition that threatens to infect the graft



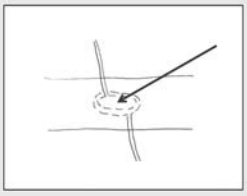
Planning

- Condition of access vessel
  - Iliofemoral artery & abd aorta
  - Tortousity & stenosis
- Proximal and distal landing zone
  - Angle & length
- Size of stent-graft
  - >10-15% than native aorta
  - Tapered vs straight
  - Etiology
    - aneurysm, dissection, shock



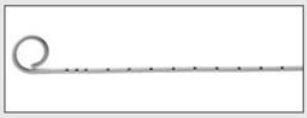
Approach

- Percutaneous
  - Preclosing with Perclose devices
  - Learning curve, costs....
- Exposure
  - Small incision
  - Purse-string suture (Prolene 5-0, x2)



Guidewire & catheter insertion in TEVAR

- Approach
  - 5Fr sheath insertion
  - Open vs. pre-closing
- 5Fr sheath
  - Soft wire (260mm) → pig-tail catheter (for angio & sizing)
- Open vs. pre-closing
  - Soft wire (260mm) → long catheter (ex. DAV) → super-stiff wire (260mm, ex. Lunderquist) → stent-graft deployment

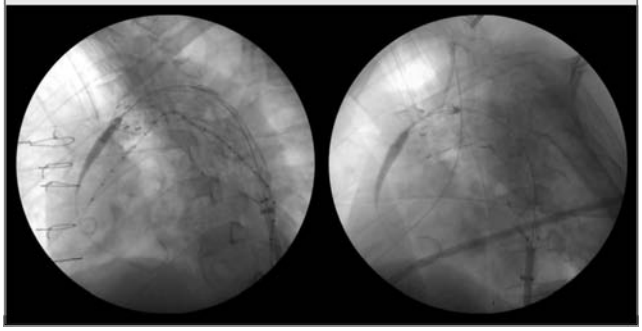


Initial aortography

- Angle 을 맞추는 것이 가장 중요!!
  - LAO vs RAO
  - cranial vs caudal

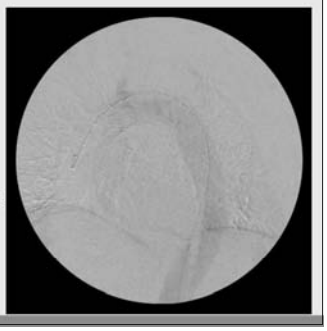
Stent-graft deployment

- Alignment of radiopaque markers!!



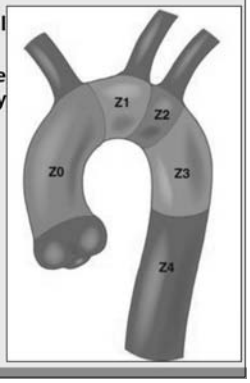
Stent-graft deployment

- Prevent migration of stent-graft!!
  - Fixation of left hand
  - Lower blood pressure
  - Rapid ventricular pacing
- Final angiography
  - Stiff wire 는 가능한 제거한 후 보는 것이 원칙이다

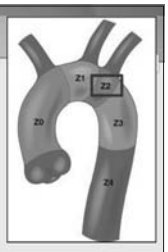


Hybrid TEVAR – proximal landing zone

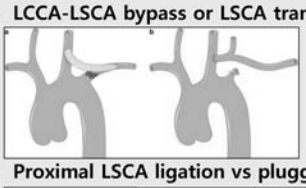
- Zone 0: ascending aorta and proximal arch to innominate artery
- *Zone 1:* segment between innominate artery and left common carotid artery
- *Zone 2:* segment between left common carotid and left subclavian arteries
- *Zone 3:* segment beyond left subclavian along curved portion of distal arch
- *Zone 4:* straight portion of descending thoracic aorta starting at level of the 4th thoracic vertebra



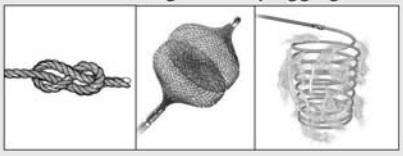
Zone 2 TEVAR



- LCCA-LSCA bypass or LSCA transposition

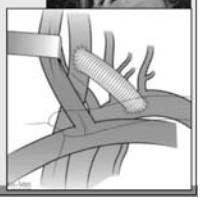


- Proximal LSCA ligation vs plugging vs coiling

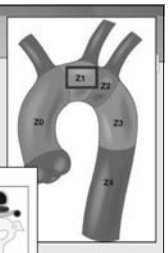


Consideration for zone 2 TEVAR

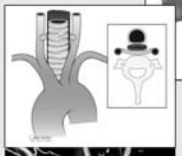
- LSCA bypass or not..??
  - Indication of LSCA revascularization
    - LIMA bypass
    - left vertebral dominance
    - isolated left brain hemisphere
    - left upper extremity dialysis access
    - Younger or left-handed patients
- LCCA-LSCA bypass
  - Supraclavicular incision
  - Not difficult..!!!!

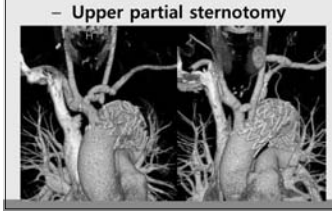


Zone 1 TEVAR

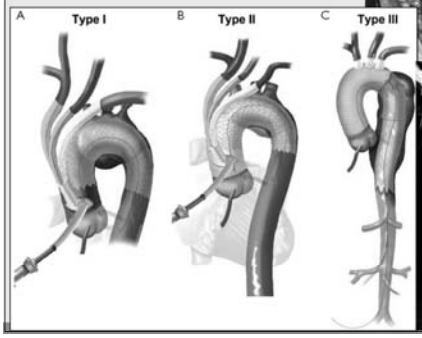


- Carotid-carotid bypass
  - Retropharyngeal route
  - Subcutaneous route
- IA-LCCA-LSCA bypass
  - Upper partial sternotomy





Zone 0 TEVAR



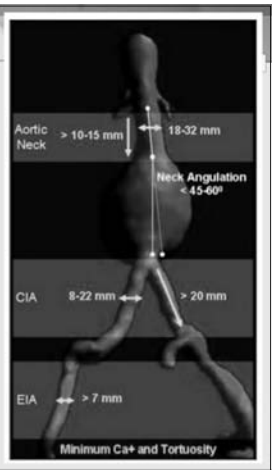
EVAR

Surgical / Endovascular indication for AAA

- Symptomatic or ruptured AAA
- Diameter > 50mm
- Rapid growing (>5mm for 6mo)
- Saccular aneurysm

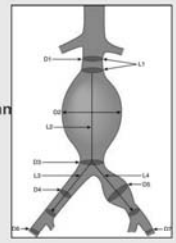
Patient selection for EVAR

- Proximal landing zone
  - Diameter / Length
  - Shape (conical)
- Distal landing zone
  - Diameter / CIA length
- Angulation
  - Proximal neck / Iliac
- Ilio-femoral condition
  (for access)



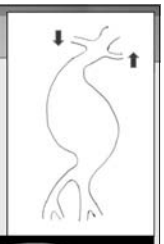
Patient selection

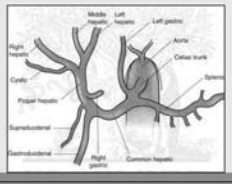
- IFU (Indication For Use) : *ex. OOO stent-graft*
  - Adequate iliac/femoral access that is compatible with vascular access techniques, devices and/or accessories
  - Proximal neck length of ≥10 mm
  - Infrarenal neck angulation of ≤60°
  - Aortic neck diameters with a range of 19 to 32 mm
  - Distal fixation length(s) of ≥15 mm
  - Iliac diameters with a range of 8 to 25 mm
  - Morphology suitable for aneurysm repair



Initial aortography (1)

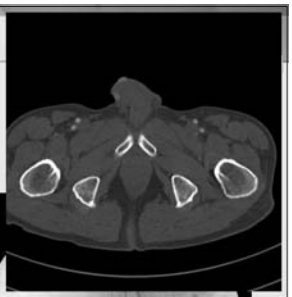
- Renal arteries
  - Usually between L1 & L2
  - Should check the lowest renal artery
  - Should not be confused celiac trunk
    (common hepatic a & splenic a)

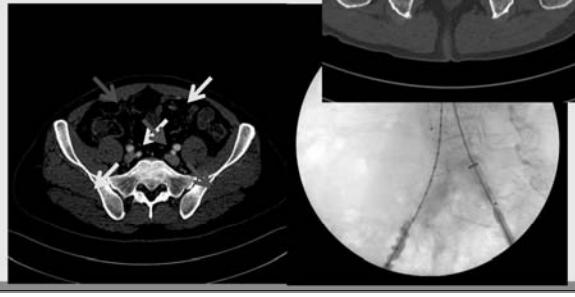




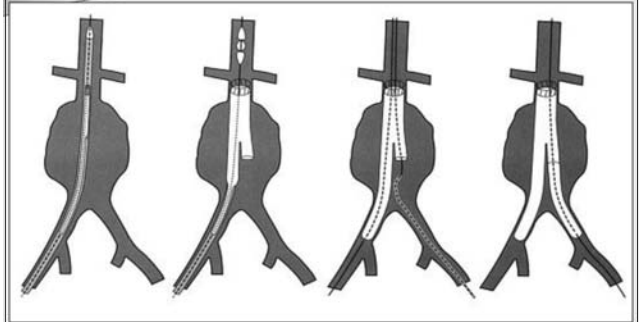
Initial aortography (2)

- Iliac bifurcation
  - LAO (Rt.) / RAO (Lt.) view



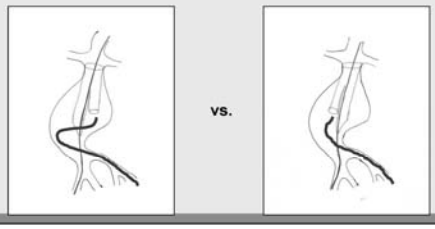


Procedure



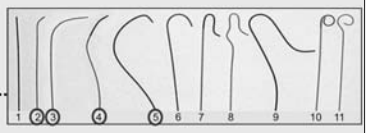
Main body deployment

- Contralateral limb의 방향이 매우 중요..!!!!
  - 등쪽이 아닌 배쪽으로 contralateral limb 이 펼쳐져야 한다
  - Iliac artery의 주행에 따라 정방향으로 할지, Ballerino position으로 할지 결정한다



Contralateral limb selection

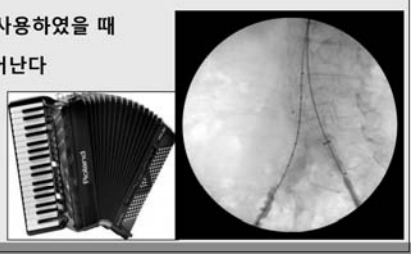
- Catheter
  - Cobra, Davis /MP, H1 ....



- Main body 내부에 guidewire 가 위치하는지 반드시 확인한다
  - 360도 C-arm을 돌려본다
  - Main body 안에서 contrast injection 을 해본다
  - Main body 안에서 pigtail cath를 돌려본다
  - Balloon을 중간에 해서 snowman을 만들어본다

Iliac tortousity

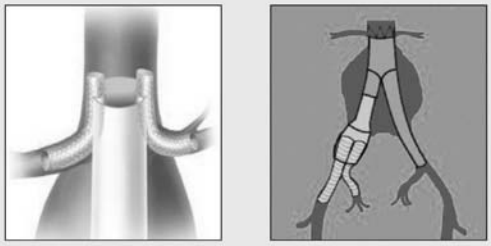
- Severe angulated & calcified iliac artery
  → rupture risk ↑ ↑
- Super-stiff wire 를 사용하였을 때 straightening 이 일어난다
  - Accordion effect



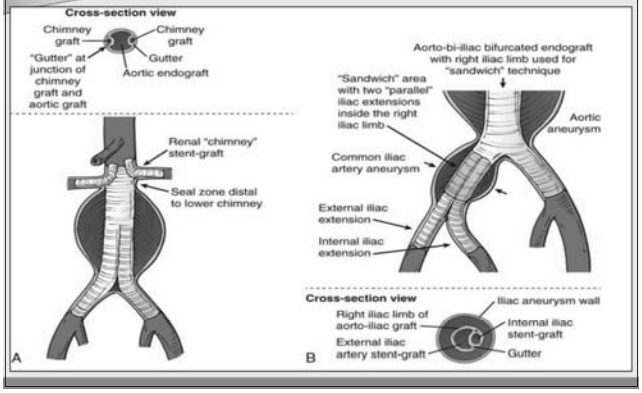
Iliac tortousity - case

Advanced procedure

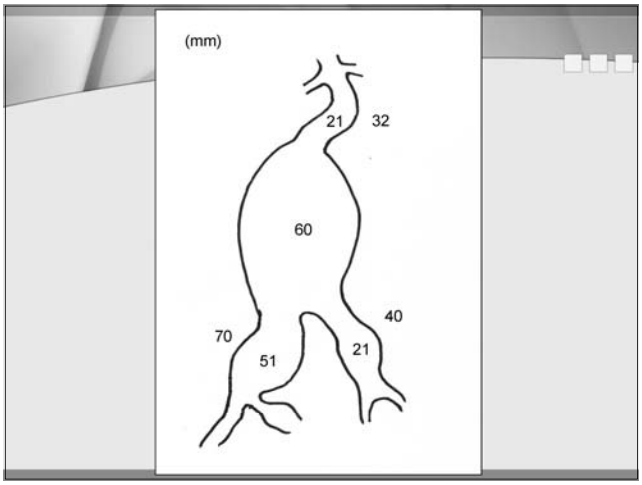
- Chimney technique / Sandwich technique
  - Stent-graft 가 필요 (ex. Viabahn, Lifestream stent-graft)

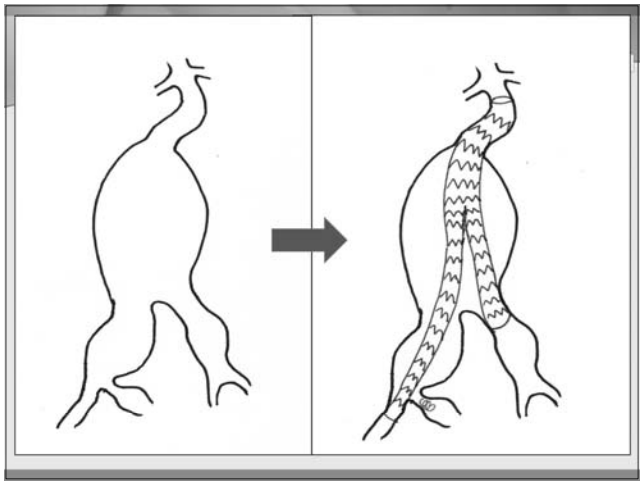


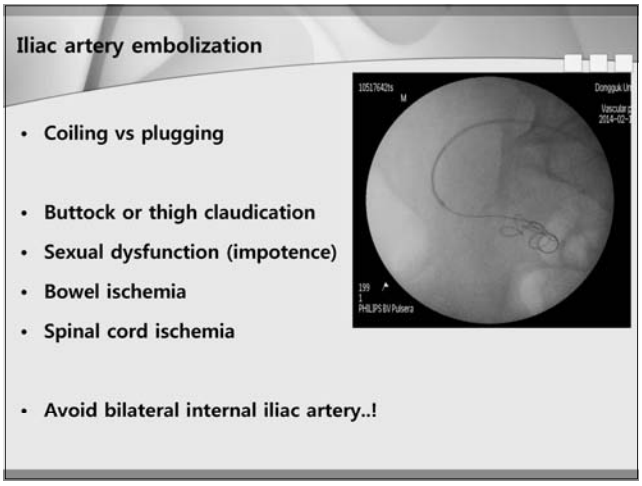
Chimney technique / Sandwich technique




Case


(mm)
21
32
60
70
40
51
21




Iliac artery embolization
• Coiling vs plugging
• Buttock or thigh claudication
• Sexual dysfunction (impotence)
• Bowel ischemia
• Spinal cord ischemia
• Avoid bilateral internal iliac artery..!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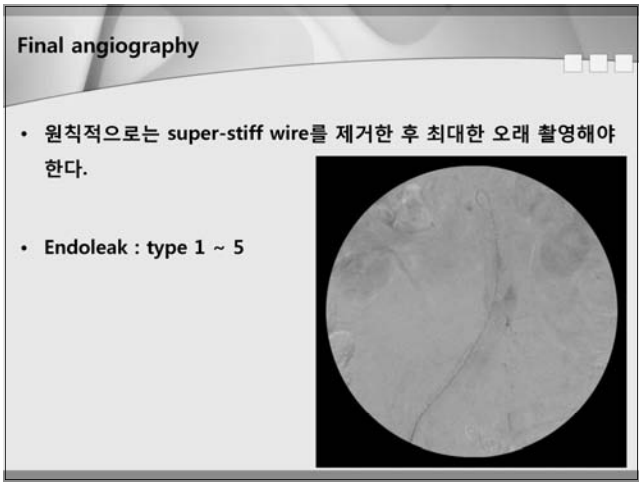
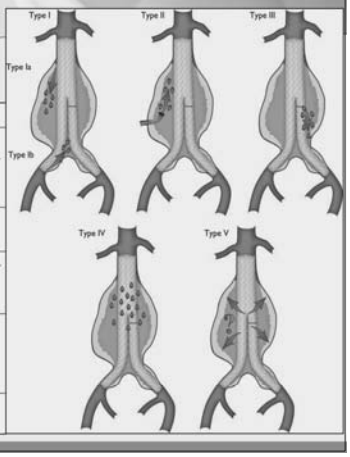

Final angiography
• 원칙적으로는 super-stiff wire를 제거한 후 최대한 오래 촬영해야 한다.
• Endoleak : type 1 ~ 5

Endoleak

Type	Definition
Type I	Persistent filling of the aneurysm sac due to incomplete seal or ineffective seal at the proximal (type IA) or distal (type IB) end of the stent graft
Type II	Persistent filling of the aneurysm sac due to retrograde branch flow from collateral vessels
Type III	Blood flow into the aneurysm sac due to inadequate or ineffective sealing of overlapping graft joints or rupture of the graft fabric
Type IV	Blood flow into the aneurysm sac due to the porosity of the graft fabric, causing blood to pass through from the graft and into the aneurysm sac
Type V	Aneurysm sac expansion without clear evidence of endoleak origin

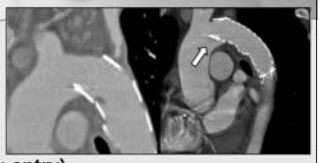


Type 1a endoleak

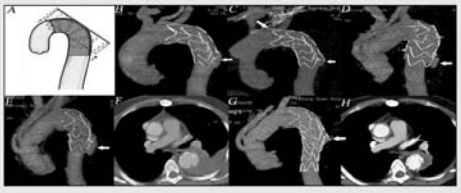
Complications (1)

- **Device related**
  - Graft migration, kinking, endoleak
- **Procedure related**
  - Dissection, malpositioning,
  - renal failure, thromboembolism, ischemic colitis, paraplegia
  - Groin hematoma, wound infection
- **Systemic complications**
  - Contrast induced nephropathy (CIN)
  - Post-implantation syndrome (PIS)

Complications (2) - TEVAR

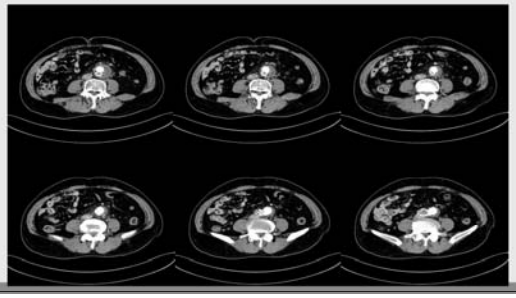


- **Bird-beak appearance**
  - d/t Aortic arch curvature
- **SINE (stent-graft induced new entry)**
  - In aortic dissection



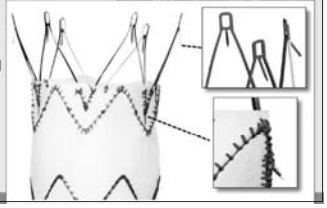
Complications (3) - EVAR

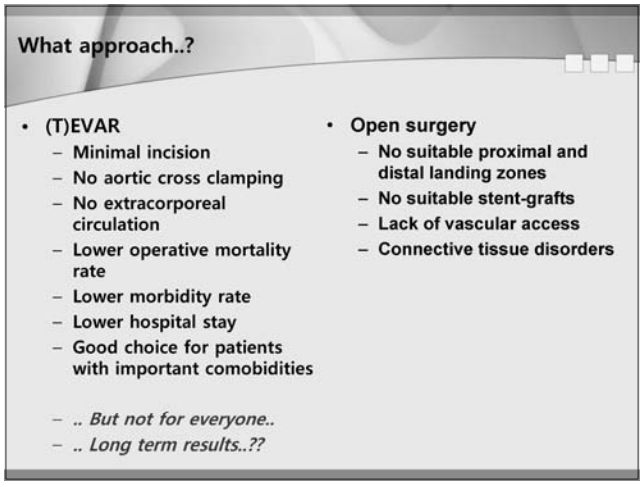
- **Limb occlusion**
  - Small & angulated aortoiliac anatomy



Open surgery after EVAR

- **무리하게 stent-graft 를 제거하려 하지 말 것..!!**
  - Stent-graft 위 또는 아래에 clamping 은 어렵다.
  - Barb (hook) 로 인하여 aortic wall injury를 줄 수 있다.
  - Stent-graft 의 strut을 cutting 한 후에 aortic wall 과 함께 suture 하면 된다.




What approach..?
• (T)EVAR
– Minimal incision
– No aortic cross clamping
– No extracorporeal circulation
– Lower operative mortality rate
– Lower morbidity rate
– Lower hospital stay
– Good choice for patients with important comobidities
– .. But not for everyone..
– .. Long term results..??
• Open surgery
– No suitable proximal and distal landing zones
– No suitable stent-grafts
– Lack of vascular access
– Connective tissue disorders


Thank you for your attention~!

Basic Knowledge for Catheter-based Intervention

메디플렉스 세종병원 흉부외과

공 준 혁

말초동맥질환의 혈관내시술은 현재 핵심적인 역할을 하고 있으며, 연관된 시술기구의 발전으로 그 역할이 증대되고 있다. 이번 연수교육에서는 가장 기본적인 장골-대퇴동맥질환(ilio-femoral disease)에 사용되는 시술기구들에 대해 기구 개념을 위주로 정리하고자 한다.

Unit

- Inch - Wire
- French - Sheath, Catheter
- mm - Balloon, Stent

- 1mm = 0.039 inch = 3F
- 25.2mm = 1 inch

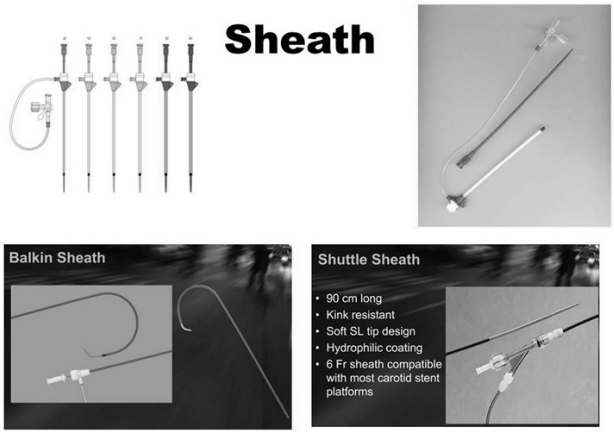
1. Sheath (카테터 유도초)

Sheath는 3부분으로 구성되어 있고, 그 구성은 Dilator, hemostatic valve를 가진 cannula 그리고 sideport이다. Sheath 크기는 내부 직경(inner diameter)에 따라 분류되고, French (Fr) 단위로 사용되며, 3 Fr는 1 mm에 해당된다(1 Fr=0.33 mm). 병변의 위치, 성상, 혈관의 석회화 및 굴곡의 정도(tortuosity), 시술자의 선호도 등에 따라 접근로(access)와 유도초가 결정된다. 일반적으로 4 Fr부터 9 Fr 크기의 유도초가 이용되는데, 진단적 목적으로 사용될 경우에는 보다 작은 크기의 4 Fr 내지 5 Fr 유도초가 사용되고, 시술 목적인 경우에는 5 Fr부터 9 Fr의 유도초가 사용된다. 유도초 삽입 전 피부절개는 작은 크기(4-5 Fr)의 경우 필요하지 않지만, 보다 큰 크기의 유도초(6-9 Fr)가 사용될 경우에는 시행되는 것이 필요하다.

병변의 위치와 특성에 따라 접근로가 선택되는데, 1) 대퇴동맥질환이 장골-대퇴동맥 분지에 가까운 경우와 1) 서혜부 또는 대퇴골두에 가까운 경우는 반대편 대퇴 동맥을 이용한 Cross-over (contralateral) approach가 일반적이다. 이 경우 일반적으로 직경 5-8 Fr, 길이 90-110 cm의 Vista Bright Tip Contralateral I, II (Cardinalhealth), Balkin (COOK), Shuttle sheath 등이 사용될 수 있다. 하행 대동맥(lower abdominal aorta) 장골 분지부(iliac bifurcation)의 각도가 매우 심한 경우에는 8 Fr Balkin 유도초가 보다 유용하다. 8 Fr Balkin 유도초는 지지력(back-up support)가 매우 강하고, 큰 직경의 기구(large profile device)를 사용하는데 보다 적합하며, 특히 죽상반 절제 기구(atherectomy device)를 사용해야 되는 경우에 유용하다.

1) 병변이 대퇴동맥의 기시부 천자부위에서 어느 정도의 거리가 확보되면 동측(ipsilateral antegrade approach)을 이용하는 것이 효과적이고, 대개의 경우 직경 5-8 Fr의 5 cm 짧은 길이 유도초(5 cm short sheath)로 충분하다.

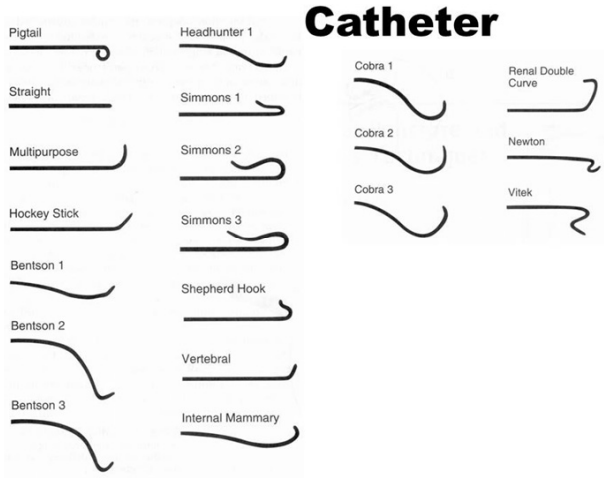
1) 장골동맥의 완전 폐쇄병변에서 양측 대퇴 동맥 천자가 필요한 경우, 2) 병변이 대동맥-장골동맥 분지부위의 완전 폐쇄 병변의 경우에 접근로 자체를 상완 동맥(brachial artery)을 사용하는 경우가 있는데, 이런 경우는 앞서 언급한 7-8 Fr Shuttle sheath, Vista Bright Tip I 등이 사용될 수 있다.



2. Catheter (카테터)

카테터 크기는 외부 직경(outer diameter)에 따라 분류되고, French (Fr) 단위로 사용된다. 진단용(Diagnostic) 또는 Gliding 카테터는 매우 다양하다. 각각의 카테터는 그 고유의 특성과 모양을 가지고 있고 장단점이 있다. 따라서, 표적 혈관과 병변의 특성, 이상적인 접근 방법 등을 고려하여 카테터를 선택하는 것이 매우 중요하다.

진단을 위해서는 4-6 Fr 카테터가 사용된다. 대부분 장골동맥과 대퇴동맥의 병변은 cross-over tehchnique에 의해 시술되므로, 카테터는 일반적으로 대동맥 분지부위의 각도(aortic bifurcation angle)와 모양에 따라 선택된다. Cobra, Headhunter, Omni, Glide catheter, multipurpose, Judkin Right 4 (JR4) coronary catheter 등이 사용된다. 카테터는 시술자의 선호도에 따라 선택될 수 있는데, 개인적으로는 Cobra 카테터를 선호하고, 카테터의 진입이 용이하지 않은 해부학적 모양이나 만성폐쇄성 병변이나 심한 석회화 병변의 경우 Glide catheter가 유용하다. Omni 카테터는 도관의 재질이 단단하고 지지력이 있어 유리하나 side hole이 없어 카테터가 충분히 반대편으로 들어가 있지 않으면 조영술 사진이 선명하지 않을 수 있다.



3. Guide-wires (유도철선)

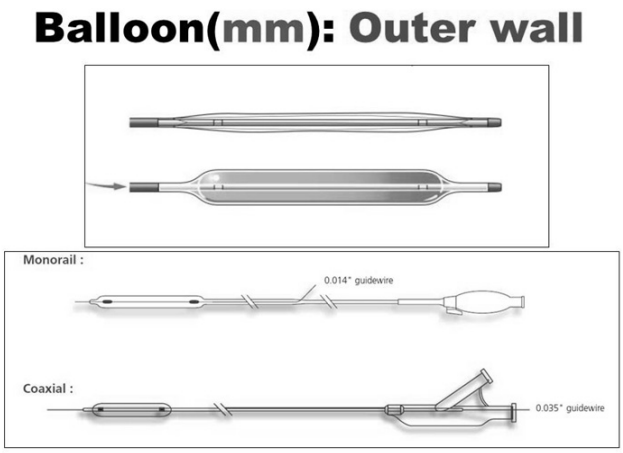
일반적으로 유도 철선의 선택은 시술자의 선호도, 병변의 모양과 특성에 따라 선택된다. 유도철선 크기는 외부 직경(outer diameter)에 따라 분류되고, Inch (in) 단위로 사용된다. 가장 흔히 사용되는 유도철선은 Terumo사의 hydrophilic radiofocus guidewire 이다. 외부 직경에 따라 0.014, 0.018, 0.035 inch 가 있는데 대개의 경우 0.35 inch를 사용한다. 0.014, 0.018 inch 유도철선을 사용해 시술할 경우, 지지력을 얻기 위하여 microcatheter를 사용하는 것이 편리할 수 있고, 말초혈관 시술을 위한 microcatheter로 2.6 Fr CXI support catheter (COOK), 2.4 F Renegrade STC18 (Boston scientific) 등이 유용 할 수 있다.

Amplatz super stiff wire (Boston scientific)은 0.035 또는 0.038 system으로 굴곡이 매우 심한 혈관을 포함하여 난해한 해부학적 구조를 가진(difficulty anatom) 증례에 유용하다. Amplatz super stiff wire로 해결이 안 되는 경우에는, 035체계에서 가장 강력한 지지력을 가지고 있는 Lunderquist wire (COOK)이 도움이 될 수 있다.

4. Balloon (풍선)

현재까지 많은 제조사에서 다양한 풍선이 개발, 출시되어 사용되고 있다. 1) 표적병변(target lesion)의 석회화 정도, 병변의 길이, 석회화 및 완전폐쇄 유무등과 같은 특성 및 2) 참조혈관(reference vessel)의 직경(diameter) 등을 고려하여, 적절한 풍선 길이와 직경을 선택해야 한다. 일반적으로 혈관 파열(rupture)의 위험도를 고려하여, 최초의 풍선 직경 선택에 있어 장골 병변(iliac lesion)의 경우, 6.0-8.0 mm 크기를, 대퇴부 병변(fermoral lesion)의 경우에는 4.0-6.0 mm를 추천한다. 제조사마다 각각의 풍선의 장점을 홍보하고 있는데, 실질적으로는 제조사에 따른 풍선의 종류보다는, 1) 적절한 풍선크기를 선택하여 2) 보다 오랜 시간 동안(최소 1-2분) 충분히 풍선 확장을 하는 것이 중요하다. 장골과 대퇴부 병변에서의 풍선은, 주로 035 long terumo wire를 사용하는 것이 흔한 시술 형태이므로 0.035 inch 유도철선용 OTW (over the wire) type으로 충분하다. 간혹 1) 심한 석회화병변이나 2) 스텐트 재협착병변에는 cutting balloon이 유용할 수 있다.

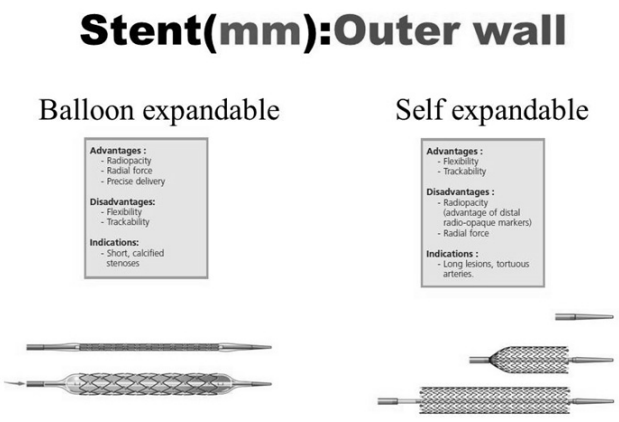
일반 풍선에 비해 pacilitaxel이 코팅된 약물코팅 풍선(drug coated balloon)이 재협착율이 낮은 곳으로 보고되고 있다. Medtronic 사에서 IN.PACT Admiral, IN.PACT pacific 등이 출시되어 사용되고 있으며, stent 삽이술 후 재협착 치료에 있어서 매우 유용할 것으로 생각된다.



5. Stent (스텐트)

스텐트의 도입은 말초혈관 시술 영역에서 획기적인 발전을 가져왔다. 특히, nitinol stent는 재발률을 낮추는데 많은 공헌을 했다. 현재까지 iliac lesion에는 풍선확장술 후 stent 삽이할 경우 3년 개존율은 90% 이상으로 알려져 있다. 대퇴부 병변일 경우 TASC II 분류에 따른 치료권고안이 마련되어 있다. 일반적으로 1) 풍선확장술 후 적절한 결과를 얻지 못한 경우, 2) 심한 recoiling, 3) flow limiting dissection, 4) balloon angioplasty 단독치료에 반응하지 않는 매우 심한 석회화 병변이나 eccentric 병변에서 스텐트를 삽입하는 것이 도움이 되는 것으로 알려져 있다.

스텐트는 풍선팽창형(balloon expandable)과 자가팽창형(self expandable)의 2가지 유형이 있다. 풍선팽창형 스텐트는 1) 방사선에 잘 관찰되어(good radioopacity) 정확한 위치에 스텐트를 거치시킬 수 있고, 2) 확장력 방사상 힘(radial force)이 좋다는 장점이 있다. 따라서, 1) 석회화가 심한 짧은 병변, 2) eccentric 병변처럼 강력한 radial force가 요구되는 경우나, 3) 대동맥분지부, 대퇴부 분지부처럼 정확한 스텐트거치가 요구되는 경우에 유용하다. 반면에 자가 팽창형 스텐트는 신축력(elasticity)와 굴곡력(flexibility)을 장점으로 하기 때문에 1) 굴곡이 심한 병변, 2)반대측 혈관에 스텐트를 해야 하는 경우에 추천된다.



【초음파】

좌장: 정진용

Echocardiography I & II (TTE & TEE)

분당서울대학교병원 흉부외과학교실

김 동 중

Anatomy and Basic Approach (Ultrasound for Venous System 중심으로)

가톨릭대학교 인천성모병원 흉부외과학교실

정 진 용

I. Introduction

1. 초음파 검사법의 장점 및 단점

장점

1) 비침습성 및 반복성: 통증이 없으며 방사선 노출이 없다. 또한 반복적으로 시행할 수 있다
2) 검사의 간편성 및 즉시성: 최근 휴대용 기기가 개발되어 장소에 관계없이 검사할 수 있다
3) 신속한 진단 가능: 동영상을 통하여 실시간 진단이 가능하다
4) 국소병변 관찰 용이: 상세한 관찰 및 진단이 가능하다
5) 선별검사에서 정밀검사까지 가능: 일차적 선별검사부터 정밀검사까지 모두 시행 가능하다
6) 영상진단과 기능평가 모두 가능: 해부학적인 진단이 가능하며 또한 도플러를 이용한 기능평가도 가능하다

단점

1) 관찰영상의 제약성: 탐촉자의 종류, 주파수, 영상의 확대 정도에 따라서 범위가 한정되어 있다
2) 단면적 영상의 재구성이 필요: 2차원 영상을 주관적으로 재구성하여 평가한다. 최근 3차원 영상 초음파도 개발되고 있다
3) 검사 시간이 길다: 자세한 관찰을 위하여 많은 시간이 요구된다.
4) 기능 평가는 부분적인 평가에 불과함: 어떤 영역의 혈류 관측 및 지표 측정은 가능하지만 이는 전체 기능을 나타내는 것이라고 볼 수 없다.
5) 관찰 불가능한 병변 존재: 장내 가스, 심한 비만, 삽입된 금속 등으로 관찰이 제한될 수 있다
6) 검사자의 숙련성이 요구됨: 초음파 검사는 검사자의 숙련도에 따라서 진단결과가 달라질 수 있다.

2. 초음파 검사

1) 탐촉자 종류와 사용법

선형 탐촉자(5-8 MHz): 장골정맥, 하퇴정맥 기시부 검사에 사용
(10-12 MHz): 표재용으로 사용. 하지정맥 전반에 사용
볼록형 탐촉자(3-5 MHz): 주로 복부검사에 사용. 하대정맥, 장골정맥
부채꼴 탐촉자: 혈관검사에 잘 사용하지 않음

2) 초음파 영상 표시법

영상 결과의 약속된 표현

혈관 종단면 영상: 좌측이 머리쪽, 우측이 다리쪽
혈관 횡단면 영상: 환자의 왼쪽이 화면의 오른쪽, 환자의 오른쪽이 화면의 왼쪽
후방에서 관찰한 영상 표시: 환자의 왼쪽이 화면의 왼쪽, 환자의 오른쪽이 화면의 오른쪽

3) 정맥초음파검사 측정항목

혈전크기, 정맥 역류 시간, 혈관 직경, 피부 및 근육의 두께

4) 정맥초음파 검사시 주의사항

심부정맥혈전증이 의심되는 경우 급성 또는 만성에 따라서 압박 여부 결정
피부궤양이나 염증환자 검사: 감염 악화, 전염
여성환자 검사
초음파 젤 차갑지 않게 사용
서서 검사하는 경우 넘어질 수 있으므로 특히 노약자 검사시 주의

II. Anatomy of Venous system

정맥은 혈액을 심장으로 환류시키는 기능이 있으며, 혈액을 저장하는 기능도 있어 외부 환경 변화에 대응 조절하는 기능도 있다. 정맥내 압력은 낮고 혈관벽의 신전성 및 탄력성은 높은 편이다. 조직학적으로 내막, 중막, 외막 3층으로 되어있는데 각 층의 두께는 동맥보다 얇고 동맥에 존재하는 외탄성판, 내탄성판이 없다, 특히 대퇴정맥, 장골정맥, 대정맥 등 큰 정맥은 평활근 세포가 적어 수축 능력이 떨어져 저장기능이 미비하다.

사지정맥은 표재정맥, 심부정맥, 관통정맥으로 분류된다. 일반적으로 직경이 1 mm 이상 되는 정맥안에는 판막이 존재하여 한 방향으로 혈액이 흐르도록 한다. 하지만 상,하대정맥, 내장정맥, 간문맥, 두경부정맥, 폐정맥 에는 판막이 없다.

1. 경부정맥

두경부정맥이 대부분은 내경정맥에 모이고 일부는 쇄골하정맥과 연결된다. 내경정맥과 쇄골하정맥의 접합부를 정맥각이라 하는데 좌측에는 흉관이, 우측에는 우림프액들이 들어온다. 외경정맥은 쇄골하정맥에 합류한다.

2. 상지정맥

표재정맥

1) 요측피정맥
2) 척측피정맥
3) 전완정중피정맥
4) 주정중피정맥

심부정맥

1) 쇄골하정맥
2) 액와정맥
3) 상완정맥
4) 요골정맥
5) 척골정맥

3. 체간정맥

흉부

1) 상대정맥: 길이 약 7.5 cm, 직경 2 cm

골반, 복부

1) 외장골정맥
2) 내장골정맥
3) 총장골정맥: * 좌측 총장골정맥은 우측보다 길며 우총장골동맥이 가로 질러가므로 DVT 호발(May-Thrner syndrome)
4) 하대정맥: 직경 3.5 cm

4. 하지정맥

표재정맥

1) 대복재정맥맥
2) 소복재정맥

심부정맥

1) 전경골정맥
2) 후경골정맥
3) 비골정맥
4) 슬와정맥
5) 총대퇴정맥

근육내정맥

1) 비복정맥
2) 가자미정맥

관총정맥

1) Cockett 관통정맥
2) boyd 관통정맥
3) Dodd 관통정맥

III. Basic Approach

1. 경부정맥, 상지정맥 검사

1) 내경정맥

초음파 적응증: 중심정맥 카테터 삽입 시술, 유치된 카테터 주변의 혈전증 관찰, 악성종양에 의한 정맥혈전증 진단
흉쇄유돌근을 따라 총경동맥의 바깥쪽에 위치
내경정맥을 강하게 압박하면 정맥이 보이지 않는다
안면정맥 유입부 - 쇄골하정맥 접합부 까지 관찰 가능

2) 쇄골하정맥

적응증: 상지정맥혈전증 진단, 쇄골하정맥 찬자후 중심정맥 삽입술 시

3) 액와정맥

정맥혈전증 진단

4) 상지정맥

상지정맥혈전증 진단, 우회술에 적합한 정맥의 검색, 정맥주사 주입 경로

2. 복부정맥, 골반정맥 검사

1) 장골정맥
2) 하대정맥
3) 신정맥
4) 문맥계정맥

3. 하지정맥 검사

해부학적으로 심부정맥 검사 - 표재정맥 검사 및 관통정맥 검사
기능적으로 폐쇄성 질환의 검사 - 역류성 질환의 검사 - 폐쇄성,역류성 혼합 질환 검사

1) 심부정맥

심부정맥혈전증의 진단, 폐색전증의 원인 검색, 수술전 심부정맥혈전증의 선별검사, 상세불명의 하지부종

2) 표재정맥

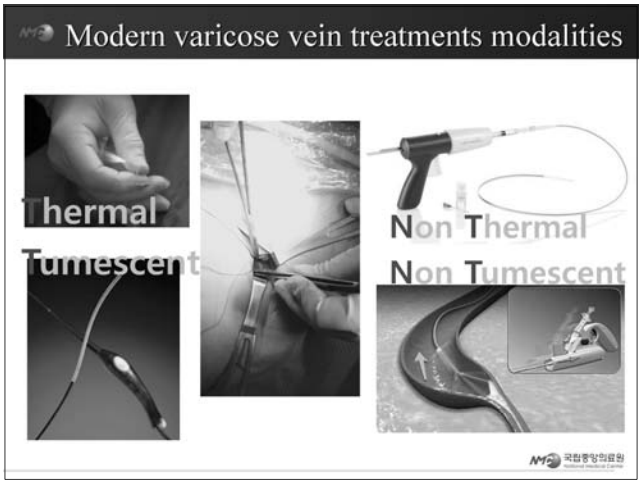
정맥류의 원인정맥 검사, 복재정맥의 역류 범위, 심부정맥 판막부전, 심부정맥 혈전증 합병 유무

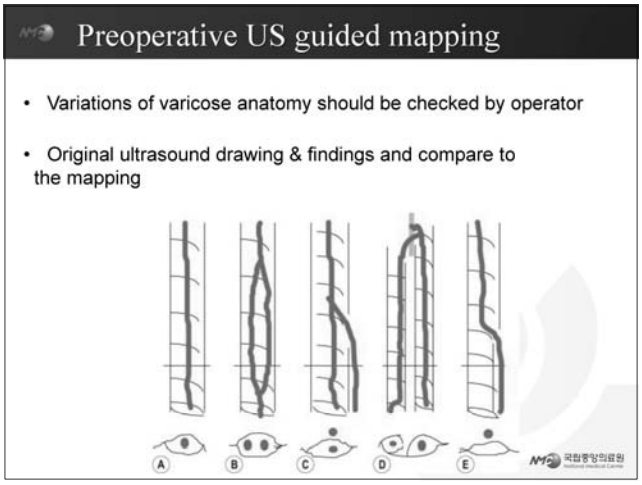
3) 관통정맥

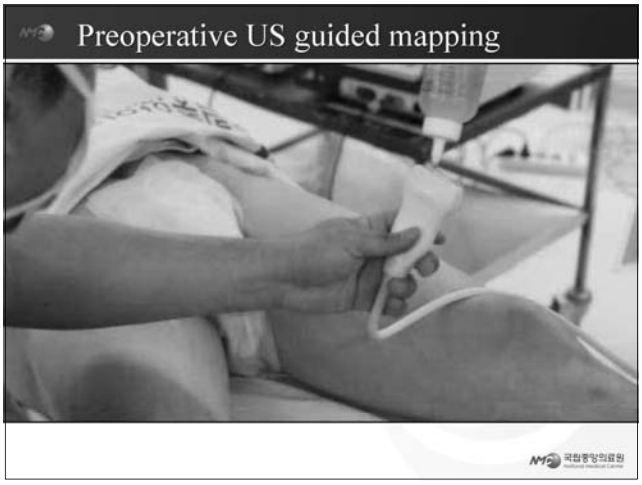
Vascular SONO II (Endovenous Treatment)

Department of Thoracic & Cardiovascular Surgery, National Medical Center

Woo-shik Kim, MD

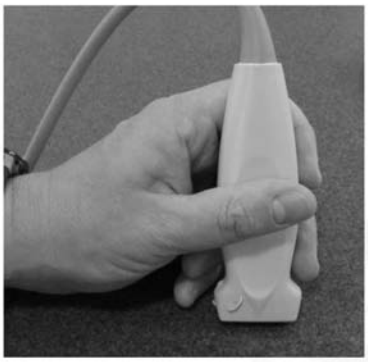






Holding the probe for venous ascees

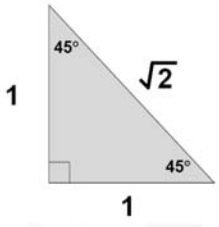
Holding the probe for venous access



Holding the probe for venous ascees

Venous access

- Close to the skin surface
- Free from branches or tortuosity
- At least 2 mm in diameter



Venous access

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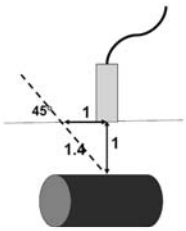
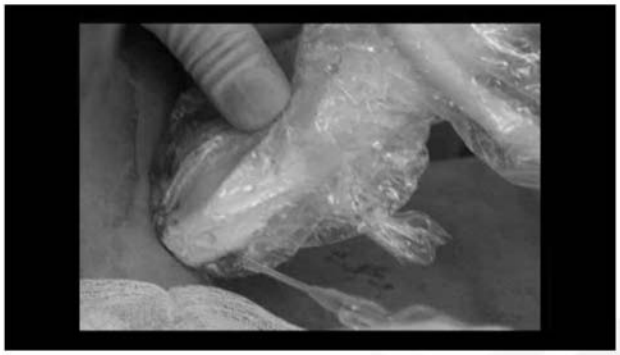
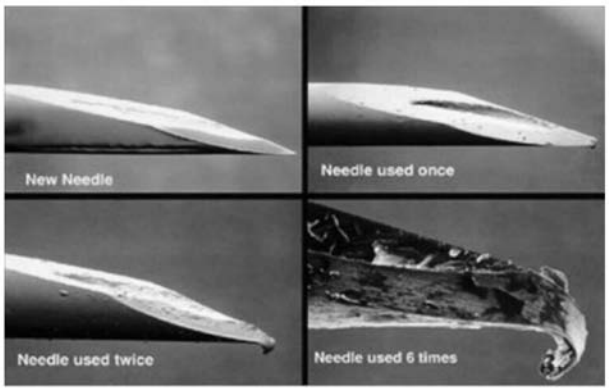


Venous access

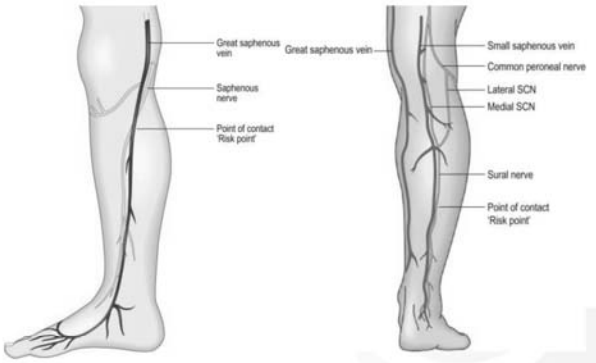


Venospasm

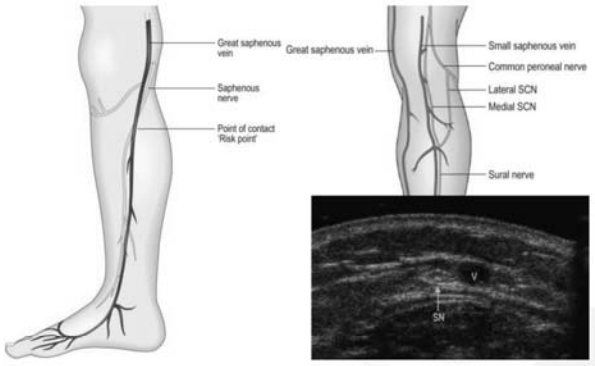
- Venospasm may occur
- Cause of venospasm
  - cold room
  - cold patient
  - nervous patient
  - multiple needle stick
  - extended access time



To avoid nerve damage



To avoid nerve damage



Catheter Advancement

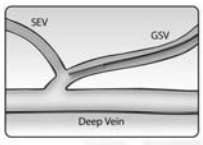
- Avoid long way journey
- Rubber tourniquet can help
- Use reverse trendelenburg position
- Use skin stretch for tortous varicosity
- Avoid resistance of distal tip within vein

Catheter Placement

GSV tip position should approximate 2.0cm from SFJ and spare the SEV

"Minimization of the thermally induced thrombosis of the SFJ.. Safe position for catheter tip placement"

Agis H, Kabnick L, Ombrellino M, Mortiz M. *Int Angiol* 2009;28(4) supp.

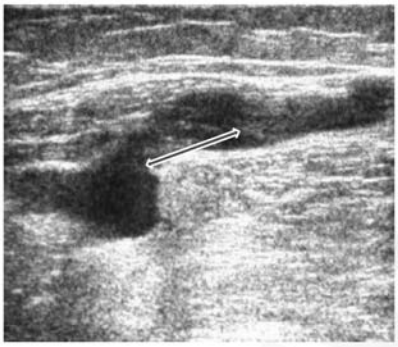


Catheter Placement

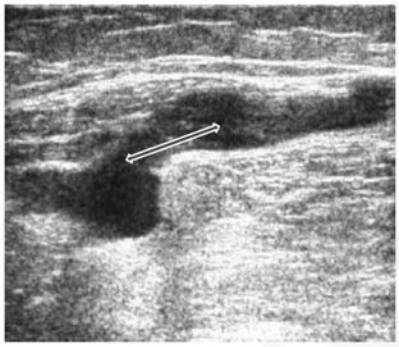
- Forward heating
  - beyond catheter tip occurs due to ejection of luminal fluid from catheter lumen upon heating
  - May result in vein occlusion 0.5cm (on average) past original tip position
    : occlusion up to 1.75cm has been observed

Robert F. Merchant 2007 ACP congress

How can we measure the 2cm from SFJ



How can we measure the 2cm from SFJ



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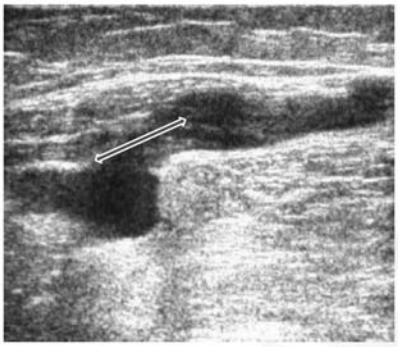
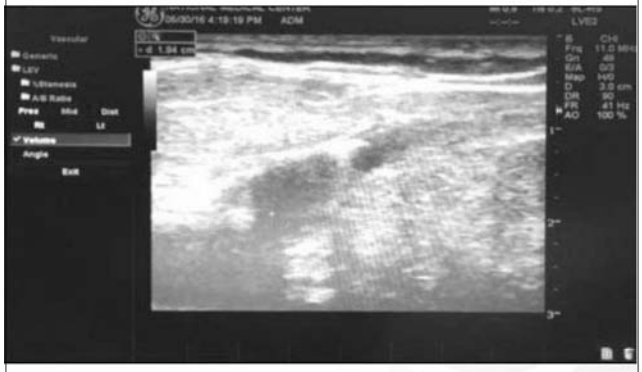
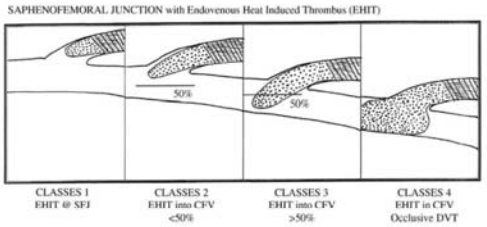


How can we measure the 2cm from SFJ



Endovenous Heat Induced Thrombosis

- Thrombus extention from the superficial venous system into the deep venous system
- Occur within 24 to 48 hours after vein ablation



Kabnick LS. Vascular 2006;14:S31-32

Endovenous Heat Induced Thrombosis

Endovenous Heat Induced Thrombosis

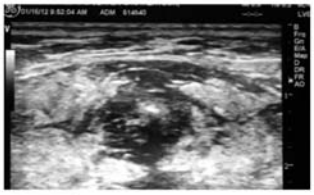
- 2470 RFA and 350 EVLT
- RFA 0.7% DVT (0.2% EHIT)
- EVLT 1% DVT (0.9% EHIT)
- Routine post-operative duplex ultrasound scanning is always recommended

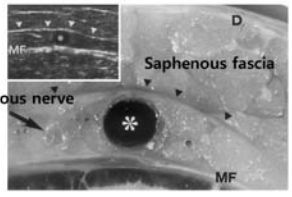
Marsh et al :Eur J Vasc Endovasc Surg 2010;40(4):521-527

Tumescent Anesthesia

- Use of large volume administration of dilute anesthetic
- Invented by Dr. Klein 1986
  : Liposuction
- TA apply on Endothermal Ablation by Dr. Ron Bush 1999
  - Regional anesthesia
  - Heat sink properties

Tumescent Anesthesia





D – Dermis
MF - muscle (deep) Fascia
* - Great saphenous vein

Caggiati A Circulation. 1999;100:2547-2549

Tumescent Anesthesia

Tumescent Anesthesia – "Allergic reaction"

- Methylparabens (Preservatives)
- Anti-oxidants (Sulfites)
- Latex allergy

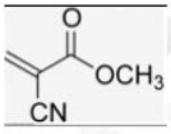
Endovenous Ablation

Thermal Ablation Complications

Cyanoacrylate Glue Venaseal ™

Cyanoacrylate Glue (Venaseal ™)

- A New modality for treating varicose veins with medical adhesive without thermal energy
  - European Conformite Europeenne (CE) Mark approval in september 2011
  - US FDA approved Feb 2015
  - Hong Kong, Australia, Singapore, New Zealand, Canada



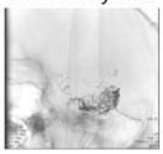
Adhesive in Medicine

Adhesive	Date	Use
Cyanoacrylate Adhesives	1950s	Wound Adhesives
Histoacryl Blue™*	1980s	Skin Incisions
Dermabond™*	1998	Skin Incisions/Lacerations
Ethicon OMNEX™*	1998	Surgical Adhesives
Trufill™*	2000	Liquid Embolic System, AVM Embolization
Indermil™*	2002	Skin Incisions/Lacerations

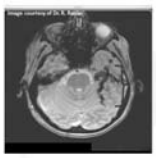
Pollak J, White R. The use of cyanoacrylate adhesives in peripheral embolization. J Vasc Interv Radiol 2001; 12:907-913 p.908

Cyanoacrylate use

- **Vascular closing agent for:**
  - Cerebral Arteriovenous Malformations (AVM)
  - Pelvic Congestion Syndrome and Varicoceles
  - Gastric Varices
  - Aortic Aneurysms



Adhesive cast in AVM delivered via micro catheter



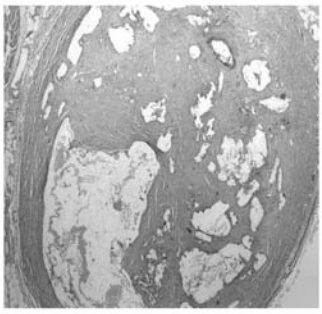
Large amounts of adhesive/thrombus left in AV M, seen on MRI

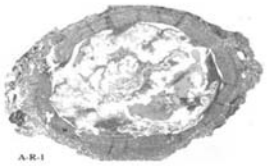
Cyanoacrylate Polymerization in Action

Cyanoacrylate monomers polymerize quickly on contact with anions in blood plasma

Almeida J. et al Cyanoacrylate adhesive for the closure of truncal veins: 60 day swine model results. Vasc and Endovasc Surg 000(00) 1-5. DOI 10.1177/1538574411413938 http://ves.sagepub.com

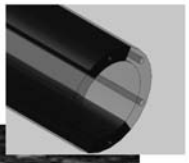
Foreign body reactions

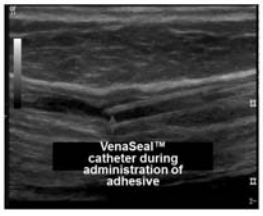


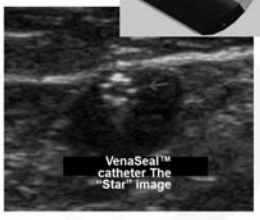


VENASEAL™ closure system

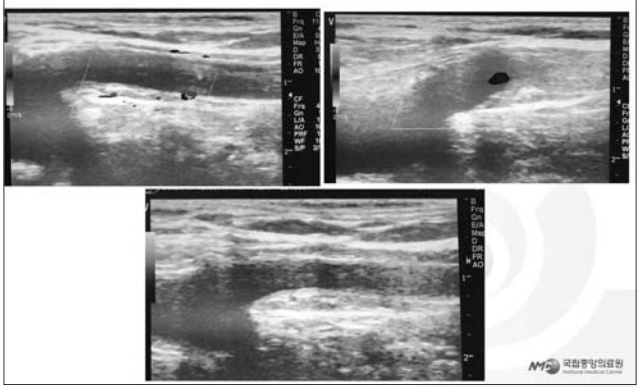
Ultrasound of Venaseal ™ catheter





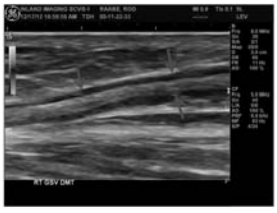


Post Treatment 1 day F/U US

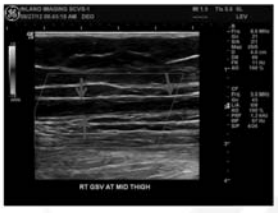


US Images 8 Weeks Post Treatment

VenaSeal™ Procedure Closure



RFA Procedure Closure



Venaseal procedure

VenaSeal Studies

Study	size	F/U	Occusion	Patient pain score (VAS)	Return to normal activities/work	Major complications
Almeida et al. 2015	39	3 years	1year -92.0% 2 year – 92.0 % 3 year – 94.7%	N/A	1 day / 1 day	DVT 6 month 21.1% Phlebitis 21%
Morrison et al. 2015	108	23years	immediate 99% 6 months – 94.3% 2 years – 94.4%	N/A	N/A	None Phlebitis 20%
Proebstle et al. . 2015	70	1 year	1 years – 92.9%	N/A	N/A	None Phlebitis 11.4%
J. Aim 2014	251	2 years	2 years -100%	1.4	N/A	None Phlebitis 5.3% (Inflammation23.8%)
YC Chan et al. 2017	57	1 year	1 year – 78.5 %	N/A	N/A	None
Gibson K et al 2017	70	1 year	1 year – 100 %	N/A	N/A	None Phlebitis 20%
Insoo Park 2017	63	1 year	1 year – 100 %	N/A	N/A	None Phlebitis 17.4%
Langefellner 2015	86Pt. 130 limbs	3 months	3 months – 95.4 %	N/A	N/A	None Phlebitis 8.8%
Zierau 2015	795Pt. 1139 limbs	6 months	6 months – 97.8 %	N/A	N/A	None Phlebitis 11.7%

Cyanoacrylate glue Merits

- Eliminates need for tumescent anesthesia
- No risk of thermal injury
- Rapid return to normal activities
- No capital equipment
- Advanced venous disease status C5,C6 (LDS, Ulcer)
- Thin skinny patient
- Nervous, Anxious patient
- Segmental ablation (No variable pull back rate)
- No post treatment compression

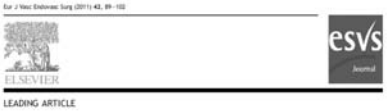
Cyanoacrylate glue Demerits

- Foreign body left (Plastic implant)
- Slow resorption > 5 years
- Long term side-effects of cyanoacrylate are unknown
- Size limitation to <12 mm
- Phlebitic reaction, Hyperpigmentation (vein adherent to dermis)
- Routine NSAID medication after procedure
- Manual compression required
- Tortous vein dfficulty
- Too expensive for short length varicose vein

	RFA / EVLT	VenaSeal / Clarivein
Risk of thermal damage to nerves, skin, surrounding tissue-paresthesia	Yes	No
Require tumescent anesthesia	Multiple injections	No
Percutaneus access	6Fr or Larger	4-6Fr.
Generator purchase (capital equipment)	Yes	No
Equipment maintenance costs	Yes	No – totally disposable
Anatomical treatment suitability	GSV & SSV (not ideal for SSV nerve damage)	GSV & SSV and small veins down to ankle
Positioning & pull back speed	2cm from SFJ / 6-8cm per min	5cm VenaSeal / 2cm Clarivein
Patient pain & bruising	More	None / little

Alun Davies . Comparative effectiveness in the treatment of Venous disease : Presented at the 2013 union of international phlebology; September 9, 2013; Boston, US.

Postoperative duplex ultrasound



LEADING ARTICLE

Duplex Ultrasound Investigation of the Veins of the Lower Limbs after Treatment for Varicose Veins – UIP Consensus Document CME

M. De Maeseneer [a,b,*], O. Pichot [c,d], A. Cavezzi [e], J. Earnshaw [f], A. van Rij [g], F. Lurie [h], P.C. Smith [i]

- To obtain a consensus of international experts to be used for assessment after treatment
- Ideal non-invasive method for follow-up
  : anatomical and haemodynamic information

Timiming of Post-treatment DUS evaluation

Immediate : 1-4 weeks after treatment

- Whether the intervention has achieved the intended immediate goal
  - postoperative change of saphenous vein lumen
- Whether the recurrence occur due to inadquete therapy
  - residual incompetent GSV trunk after stripping
- The presence of post-treatment deep vein thrombosis should also be assessed

Timiming of Post-treatment DUS evaluation

Late follow-up

- To evaluate recurrence
- Monitor venous recanalization and new site of venous reflux
- Short term – 1 year
  Midterm – 2~3 years
  Long-term – 5 years or more

Modern varicose vein treatments modalities

Basics of Lung Ultrasound

전남대학교병원 흉부외과학교실

Do Wan Kim

Usefulness of ultrasound

- Ultrasonography : routine approach tool in evidence based medicine
- Management of real-time crisis
- Indispensable technique from bedside assessment to facilitate intervention
- The clinical area is expanding
  - Critical care setting
  - Intraoperative field
  - OPD based

Seven principles

- Lung ultrasound is performed at best using simple equipment.
- Thorax, gas and fluids have opposite locations, or are mingled by pathologic processes, generating artifacts.
- The lung is the most voluminous organ. Standardized areas can be defined.
- All signs arise from the pleural line.
- Static signs are mainly artifactual.
- The lung is a vital organ. The signs arising from the pleural line are foremost dynamic.
- Almost all acute life-threatening disorders abut the pleural line, explaining the potential of lung ultrasound.

Lichtenstein DA. **Lung ultrasound in the critically ill.** Ann Intensive Care. 2014 Jan 9;4(1):1.

Principle

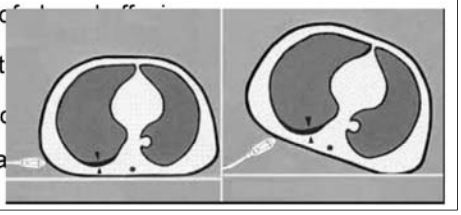
- 5-MHz Microconvex/Linear probe (4 -12 MHz)
  - 1 -17cm range of exploration
- Normal lung : invisible
- Air : non transmitter
- Fluid : good mediator
- Pneumothorax : interrupt of visceral pleura
- Pleural effusion : identification of visceral pleura

Principle

- High frequency (5 -10 MHz)
  - Greater resolution
  - Less penetration
  - Superficial structure
- Lower frequency (2 – 3.5 MHz)
  - Greater penetration
  - Less resolution
  - Deep structure

PLAPS-point

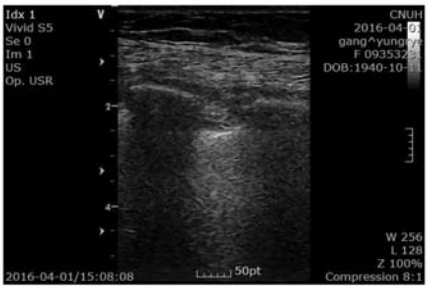
- Posterior axillary line + Lower BLUE point
- Alveolar syndrome : consolidation
- Pleural syndrome : pleural fluid
- Milestone o
- The lowest
- BLUE proto
  pneumonia



Bat sign

- Location of the lung – 1st sign, landmark
- Upper rib, lower rib, pleural line
- Pediatrics : same as adult
- Normal : do not distinguish visceral and parietal pleura
- More important indicator than lung sliding sign

Bat sign ??



A-lines

- First letter of Alphabet
- Horizontal, Reverberations, Motionless
- Manifestation of air
- Only finding in two third of normal lung
- A-line + lung sliding = A profile
- A-line only without sliding = A' profile

Lung sliding

- Pleural sliding (visceral pleura movement)
- Lung touching chest wall
- Greatest in lower thorax
- Absence : pneumothorax, intrathoracic adhesion, critical parenchymal disease, esophageal intubation
- M-mode : Seashore sign

B-lines

- **Comet-tail sign : water contained anatomy**
- **Originates from pleura,** absence of air
- Hyperechoic, vertical narrow bands
- Obliterate A-line, move with lung sliding
- 3 more at once : abnormal interstitial pathology, lesion in alveoli, lung rockets
- Join of B-lines : severity

Lung rockets

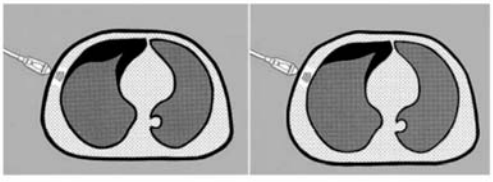
- PLAPS point : non specific (d/t gravity)
- Bilateral all fields : cardiogenic edema
- Localized : consolidation (pneumonia, interstitial diseases)
- Lung rockets + lung sliding = B profile
- Lung rockets without sliding = B' profile

Stratosphere sign

- Barcode sign
- Absence of lung sliding
- D/D with lung pulse
- Pneumothorax in M mode

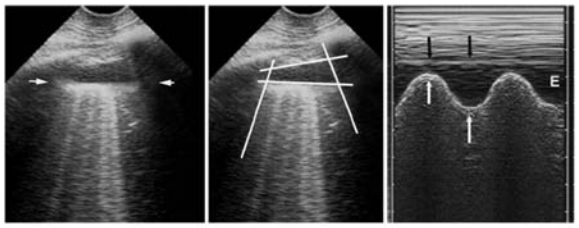
Lung point

- Indicator of pneumothorax
- Abrupt appearance
- Lateral side : Pneumothorax size ⬆
- On
- On
- Pne
pne



Quad sign

- PLAPS point
- Dependent position
- Static sign, pleural and lung line, rib
- Deep boundary of the collection : regular
- Roughly parallel to the pleural line
- Sub B-lines

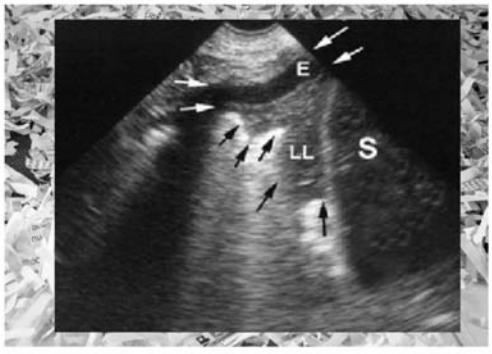


Lichtenstein DA. **Lung ultrasound in the critically ill.** Annals of Intensive Care 2014, 4:1

Shred sign

- Alveolar consolidation
- More common
- Boundary – pleural line, air-consolidative border
- Fractal line
- The nontranslobar sign of consolidation
- Mixed pattern :aerated lung and consolidation
- Tissular pattern

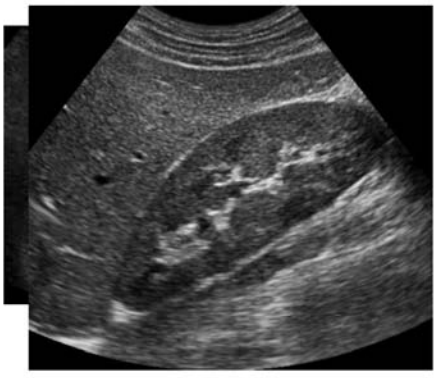
Shred sign



Tissue like sign

- The sign of translobar consolidation
- Hepatization
  - Disorder looking like a solid organ
- No sinusoid sign : a size remains steady
- No fractal line

Tissue like sign



BLUE-protocol

- Acute respiratory failure
- Very fast (< 3 min.)
- Upper point : upper lobe
- Lower point : middle lobe, lingular segment
- PLAPS point : lower lobe

Accuracy

- U/S sensitivity : 98%
- U/S specificity : 95%
- X-ray sensitivity : 67%
- X-ray specificity : 85%

Francesca C, et al. **Lung ultrasound is an accurate diagnostic tool for the diagnosis of pneumonia in the emergency department**. Emerg Med J 2012;29:19-23

Pneumothorax

- High frequency probe
- Disappearance of lung sliding
- Presence of lung point
- Evaluation of whole respiratory cycle
- Presence of B-line : r/o pneumothorax
- Supine : lower BLUE point
- Fowler's : upper BLUE point

Pneumothorax

- High frequency probe
- Disappearance of lung sliding
- Presence of lung point
- Absence of lung pulse
- Presence of B-line : r/o pneumothorax
- Supine : lower BLUE point
- Fowler's : upper BLUE point

level A of evidence

Pleural effusion

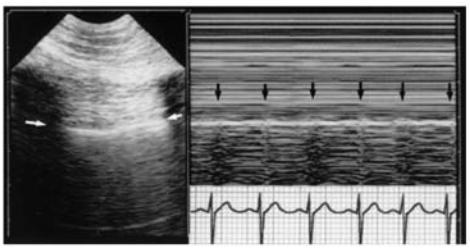
- Amount : > 20ml
- The volume does change with respiration
- Quadrangular shape with a regular lower border
- Useful Indicator of drainage site
- Transudate : anechoic
- Exudate : echogenic feature
- Sub B-line

Lung pulse

- Disappearance of lung sliding
- Heart beating
- r/o pneumothorax
- D/D pneumothorax : no lung pulse
- Atelectasis : selective intubation, ARDS

Lichtenstein DA, et al. **The "lung pulse": an early ultrasound sign of complete atelectasis.** Intensive Care Med. 2003 Dec;29(12):2187-92.

Lung pulse

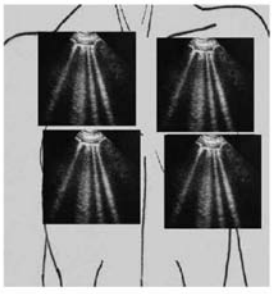


Lichtenstein DA, et al. **The "lung pulse": an early ultrasound sign of complete atelectasis.** Intensive Care Med (2003) 29:2187–2192

Pulmonary edema

- Anterior-predominant bilateral B line (more > 4)
- Presence of lung sliding
- B-profile
- Smooth pleura
- Abrupt onset of B-line : endpoint of fluid therapy
- Proceed to C-profile

Pulmonary edema



Lichtenstein DA. **Relevance of lung ultrasound in the diagnosis of acute respiratory failure: the BLUE protocol.** Chest. 2008 Jul;134(1):117-25.

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Check for updates

Review
Pulmonary
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Lung Ultrasound (in the Critically Ill) Superior to CT: the Example of Lung Sliding

Daniel A. Lichtenstein

Author information ▶ Article notes ▶ Copyright and License information ▶

Conclusion
- Gold standard in the critical settings and even beyond.

Limitation

- Probes are potential source of nosocomial infection
- Equipment cost : early investment
- Pneumomediastinum
- Do not evaluation of trachea
- Dressing and drain tube
- Subcutaneous emphysema
  - Not Bat sign but E-lines

Take home message

- Understanding of basic principle
- Take matters easy
- Allows quickly approach of thoracic disorders
- Lung ultrasound has evolved from a critical care management to an other clinical intervention
- The future of ultrasound appears as Almighty decision tool

Sono-guided Vessel Access & Intervention

계명대학교 동산병원 흉부외과/중환자의학과

김 재 범

Introduction

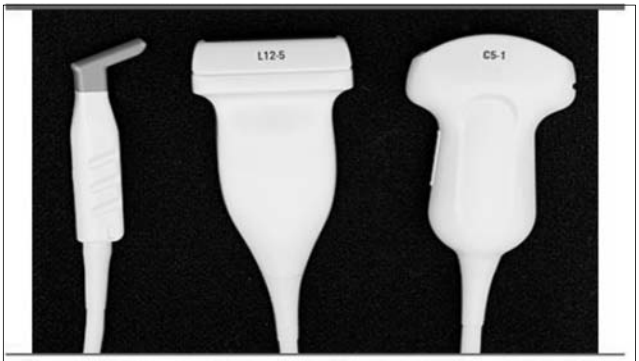
- Mode: B-mode and Doppler mode
- Probe: Higher frequency probes (>7 MHz) are preferred over lower frequency probes (<5 MHz)
- probe orientation relates to the image display.
- Probe movement

Probe orientation

- structures beneath the left aspect of the ultrasound probe marker (denoted by a light or a notch on the side of the probe) are always displayed on the left side of the imaging screen.
- when working from the head of the bed, as is often done for internal jugular vein access, the probe marker should be oriented towards the operator's left (also the patient's left) for both right and left internal jugular vein access.

Probe orientation

- When working from beside the patient, as for femoral vein central line or peripherally-inserted central catheter (PICC) insertion, this marker should be oriented to the patient's right on transverse views. Using this orientation, the patient's right will be displayed on the left-hand side of the ultrasound monitor.



The center probe, a linear 12-5 mHz transducer, is most often used for peripheral vascular imaging. The left-hand probe, called a "hockey stick", can be useful in tight locations. The right-hand probe is a curved, lower frequency transducer that allows for greater tissue penetration in obese patients.

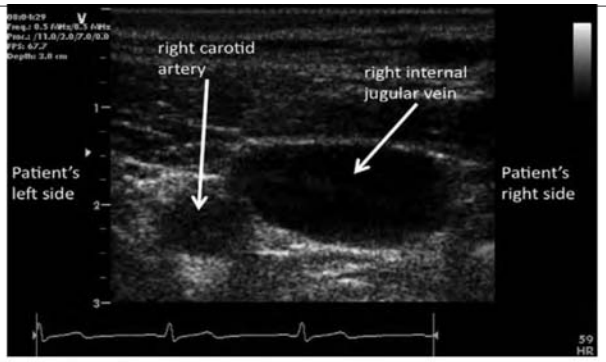


Figure 1 Right neck central vein cannulation. The ultrasound probe is held so that each side of the screen displays ipsilateral structures. With the probe mark placed on the upper left corner of the image, the displayed structures will move in the same direction with the probe.

영상유도천자 Vs 해부학적 천자

- Higher primary puncture rate
- Nearly 100% success rate
- Rare complication
- Shorter procedure time

Indications/Contraindications

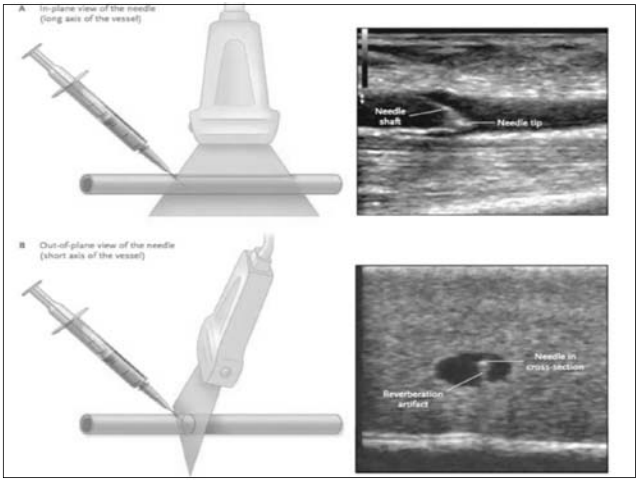
- real-time ultrasound imaging during needle placement reduces time to venous cannulation and reduces the risk of complications during central venous and peripheral venous access.
- When used appropriately by qualified personnel, there are no absolute contraindications to using ultrasound as a procedural adjunct for vascular guidance.

Indications/Contraindications

- The subclavian vein is more difficult to localize than the femoral or internal jugular vein because of the proximity of the clavicle.
- Moderate to severe volume depletion may interfere with ultrasound localization of venous structures.

Short-Axis Vs Long-Axis Visualization

- Short-Axis: Out-of-Plane
  Long-Axis : In-Plane
- The short-axis view allows the needle approach to be over the center of the vein.
- The long-axis view has the advantage of allowing visualization of the entire needle shaft and tip.
- No different in time and complications required for vascular access regardless of short axis or long axis technique



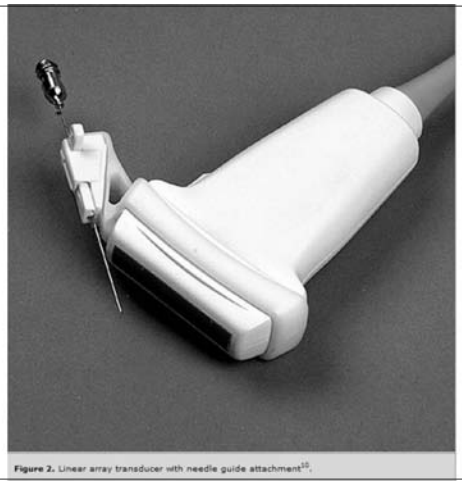
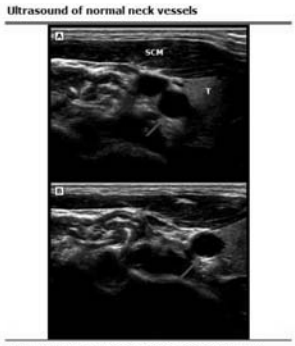


Figure 2. Linear array transducer with needle guide attachment[10].

Differentiating Arteries From Veins

- Veins are distinguished from arteries on ultrasound because they have thinner walls, are more easily compressed, may have visible valves, and lack arterial pulsations.
- veins usually distend with maneuvers that impede or augment venous return, such as application of limb tourniquets, the Valsalva maneuver, and putting the patient in the Trendelenburg position.
- Doppler imaging may also be used to identify blood flow and to help differentiate arterial from venous flow.



Static Vs Dynamic Ultrasound Guidance

- The static approach uses ultrasound to determine the vessel location and patency, assess surrounding structures, and mark the location to provide optimum placement for needle introduction. After determining this location, the procedure is performed without real-time ultrasound.

Static Vs Dynamic Ultrasound Guidance

- In a dynamic approach, the procedure is performed using real-time ultrasound observation of needle entry and placement.(with a sterile technique that includes sterile gel and sterile probe covers)
- The dynamic approach allows for real-time visualization of the needle tip placement and has been shown to be superior to the static approach in most situations.

One-Person Vs Two-Person Technique

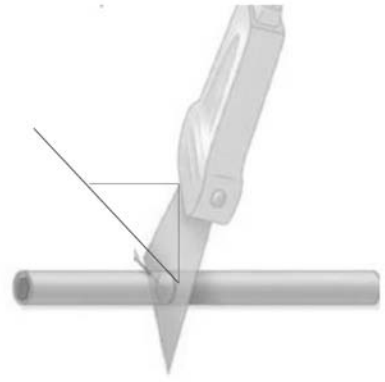
- Using dynamic visualization, it is possible for one person to perform the ultrasound while another person performs the procedure ("two-person dynamic approach").
- In a one-person dynamic approach, the person performing the procedure holds the needle with one hand while directing the ultrasound probe in the other hand.(most advanced practitioners, as it allows for real-time hand-eye coordination)

Site Selection and Preparation

- 1st: USG for the choice of site should include factors such as vessel size, depth, course, surrounding structures, and adjacent pathology such as cellulitis. Also vessel patency, course, and other anatomic issues such as vein valves.
- 2nd: pre-procedural local anesthesia
- 3rd: skin preparation and Maximal sterile barrier precautions with probe cover kits (include sterile cover for the probe and sterile gel)

Performing the Procedure

- Using ultrasound to identify the depth of the center of the intended vessel, the point of skin entry should be about the same distance from the probe, assuming an approximately 45° angle, set back from the probe a distance approximately equivalent to the depth of the vessel ("triangulating" the path of the needle toward the vessel lumen)
- Trace the catheter or needle
- Vessel puncture: target sign, Doppler mode, double puncture technique(only PICC)



Use of Ultrasound After the Procedure

- Catheter, guide wire
- "postprocedure flush": injecting a small amount (<10 mL) of saline that has been agitated with air and then had large air bubbles removed from the syringe. When the catheter is properly placed, injection of agitated saline produces hyperechoic contrast within the lumen of the vessel, verifying the proper position.

Ultrasound-Guided Central Venous Catheterization

Advantages and disadvantages of central vein approaches

Approach	Advantages	Disadvantages
External jugular	Superficial vessel that is often visible Coagulopathy not prohibitive Minimal risk of pneumothorax (especially with US guidance) Head-of-table access Prominent in elderly patients Rapid venous access	Not ideal for prolonged venous access Poor landmarks in obese patients High rate of malposition Catheter may be difficult to thread
Internal jugular	Minimal risk of pneumothorax (especially with US guidance) Head-of-table access Procedure-related bleeding amenable to direct pressure Lower failure rate with novice operator Excellent target using US guidance	Not ideal for prolonged access Risk of carotid artery puncture Uncomfortable Dressings and catheter difficult to maintain Thoracic duct injury possible on left Poor landmarks in obese/edematous patients Potential access and maintenance issues with concomitant tracheostomy Vein prone to collapse with hypovolemia Difficult access during emergencies when airway control being established
Subclavian	Easier to maintain dressings More comfortable for patient Better landmarks in obese patients Accessible when airway control is being established	Increased risk of pneumothorax Procedure-related bleeding less amenable to direct pressure Decreased success rate with inexperience Longer path from skin to vessel Catheter malposition more common (especially right SCV) Interference with chest compressions
Femoral	Rapid access with high success rate Does not interfere with CPR Does not interfere with intubation No risk of pneumothorax Trendelenburg position not necessary during insertion	Delayed circulation of drugs during CPR Prevents patient mobilization Difficult to keep site sterile Difficult for PA catheter insertion Increased risk of iliofemoral thrombosis

US: ultrasound; SCV: subclavian vein; CPR: cardiopulmonary resuscitation; PA: pulmonary artery.
With permission from: Factor P, Sznajder JI. Vascular cannulation. In: Principles of Critical Care, Hall JB, Schmidt GA, Wood LDH (Eds), McGraw-Hill, New York, 1992. Copyright 1992 McGraw-Hill.

Sono-guided Vs intervention complication

- Immediate(mechanical)
  - pneumothorax
  - accidental arterial puncture
- Early (Infectious)
  - catheter related infection or sepsis
- Late(thrombotic)
  - Stenosis
  - thrombosis

Immediate complication
(Accidental arterial puncture, hematoma, pneumothorax)

- Accidental arterial puncture:

  femoral > jugular > subclavian approach
- Pneumothorax, hemothorax: subclavian>jugular

Early complication (Catheter related infection or sepsis)

- Femoral vein > Subclavian vein
- Internal jugular vein = Femoral vein ?
- Internal jugular vein = Subclavian vein

Catheter insertion site는 contamination의 가능성이 적은 곳으로 선택되어야 한다.

- 가능한 femoral은 피한다.
- burn or infected skin, adjacent tracheostomy site, open surgical wound를 피한다.

Late complication (Stenosis/Thrombosis Incidence)

Subclavian vs Internal Jugular

	Subclavian	Internal Jugular
Cimochowski(1990)	50%	0%
Schillinger(1991)	42%	10%
Trerotoal(2000)*	13%	3%

*thrombosis

초음파 유도천자(천자 정맥 결정)

- 천자 정맥 종류
  internal jugular vein : 가장 선호 (특히 우측)
  > subclavian vein
  > Femoral vein
- Right Internal Jugular Vein
  larger calliber
  shorter and direct course
  easy approach
  less complication

Ultrasound Guidance for Internal Jugular Cannulation (general)

- ultrasound guidance for IJ vein cannulation improves first-pass and overall success rates and reduces the risk of procedure-related complications.
- ultrasound guidance for IJ vein insertion using real-time guidance is recommended.
- one-person dynamic ultrasound guidance is recommended for a CVC at the IJ vein site.

Ultrasound Guidance for Internal Jugular Cannulation

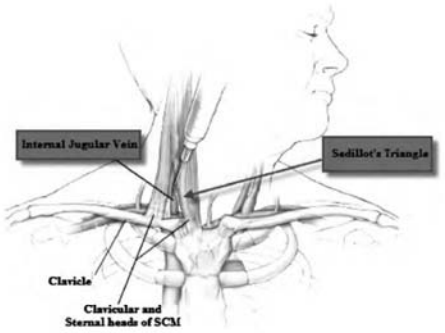


Figure 8 External landmarks for IJ cannulation. *SCM*, Sternocleidomastoid muscle. *Modified from N Engl J Med*.[4]

Ultrasound Guidance for Internal Jugular Cannulation

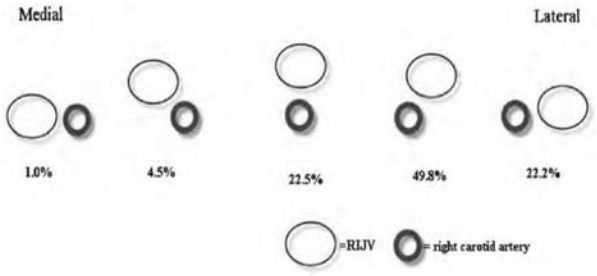
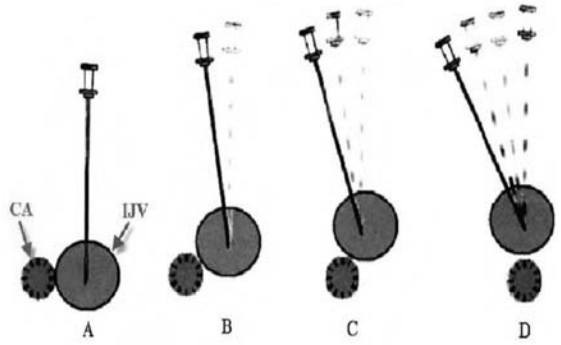


Figure 7 Variable overlap between CA and IJ vein. *RIJV*, Right IJ vein. *Adapted from J Vasc Interv Radiol*.[24]

Ultrasound Guidance for Internal Jugular Cannulation



Ultrasound Guidance for Internal Jugular Cannulation (technique)

- Trendelenburg position to maximize the IJ vein size and minimize the possibility of air embolism.
- The operator should be positioned at the head of the bed, with the ultrasound screen facing the operator in a position where it can be easily visualized during the procedure.

Ultrasound Guidance for Internal Jugular Cannulation (technique)

- In a transverse or short-axis view, the probe indicator should be oriented to the operator's left, corresponding to the left of the patient and the left side of the screen as it is viewed.
- After procedure: Echo, Lung ultrasound for lung sliding

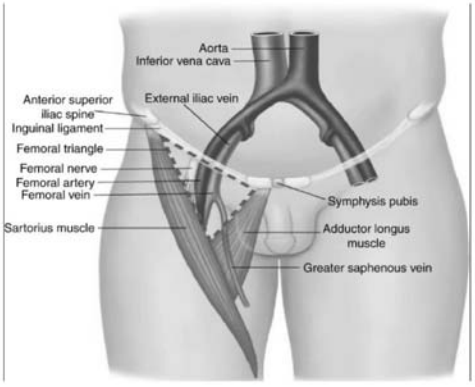
Ultrasound Guidance for Femoral Venous Access (general)

- not usually preferred because of higher infection rates.
- ultrasound guidance for femoral vein access may improve the success rate and reduce complications for femoral venous cannulation.(this benefit may be more important with novice operators, in pediatric patients, or in patients without adequate pulses for landmark guidance.

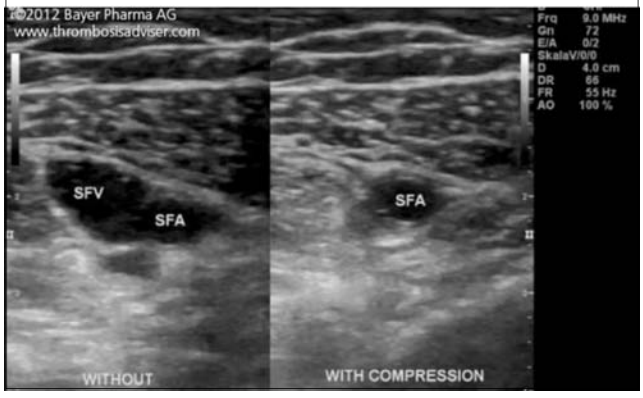
Ultrasound Guidance for Femoral Venous Access (technique)

- "frog leg" position : supine position with the leg slightly externally rotated.
- Because of the close relationship of the artery and vein in this area, it is particularly important that the guide wire is appropriately placed before advancement of the dilator.
- After securing the catheter, appropriate placement may be confirmed by visualizing the inferior vena cava and/or right atrium during a saline flush.

Ultrasound Guidance for Femoral Venous Access



Ultrasound Guidance for Femoral Venous Access



Ultrasound Guidance for Peripherally Inserted Central Catheters

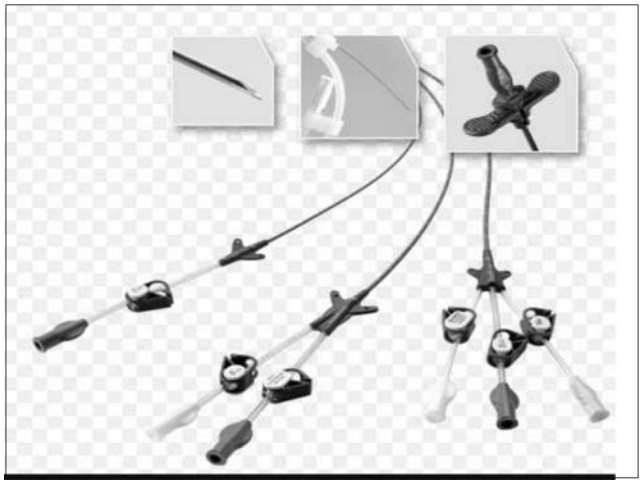
- Instead of CVC
- Peripherally inserted central catheter lines should be avoided in patients with advanced kidney disease to preserve future dialysis access.

Ultrasound Guidance for Peripherally Inserted Central Catheters

- When using a "blind" approach to PICC line placement, most practitioners rely on a landmark such as an artery to find the adjacent vein (ie, the brachial artery and adjacent veins in the upper arm). In addition to clarifying the relationship of adjacent arteries and veins, ultrasound can find and guide access to veins that do not travel with arteries (such as the basilic vein), minimizing the risk of arterial puncture.

Ultrasound Guidance for Peripherally Inserted Central Catheters

- initial ultrasound examination of the upper arm to determine the best site(basilic, cephalic, or brachial veins) for needle puncture and PICC site location.
- recumbent, supine position with the extremity of choice extended on a flat surface, palm up.
- modified Seldinger technique



The many uses, the better.

초음파 Hands-on (조별진행)

[1]전남대학교병원, [2]분당서울대학교병원, [3]가톨릭대학교 인천성모병원, [4]국립중앙의료원, [5]계명대학교 동산의료원

김도완[1], 장형우[2], 김동중[2], 정진용[3], 김우식[4], 김재범[5]

1. Stage 1: Echo I (TTE) (담당: 김도완, 장형우)
2. Stage 2: Echo II (TEE) (담당: 김동중)
3. Stage 3: Vascular SONO (담당: 정진용, 김우식)
4. Stage 4: Lung SONO & SONO Guided Procedure (담당: 김재범)

【성인심장파트】

좌장: 조민섭

How to Review Coronary Angiogram before CABG: Normal Coronary Artery

Department of Thoracic and Cardiovascular Surgery,
Yonsei University, Wonju College of Medicine, Wonju Severance Christian Hospital

Soonchang Hong

The major vessels of the coronary circulation;
1. the left main coronary that divides into **left anterior descending** and **circumflex**branches
2. the right main coronary artery.

The **left and right coronary arteries** originate at the base of the aorta from openings called the **coronary ostia** located behind the aortic valve leaflets.

Lie on the surface of the heart, and therefore are sometimes referred to as the **epicardial coronary vessels**, and distribute blood flow to different regions of the heart muscle.

When the vessels are not diseased, they have a low vascular resistance relative to their more distal and smaller branches that comprise the microvacular network.

The arterioles branch into numerous capillaries that lie adjacent to the cardiac myocytes. A high capillary-to-cardiomyocyte ratio and short diffusion distances ensure adequate oxygen delivery to the myocytes and removal of metabolic waste products from the cells (e.g., CO_2 and H^+).

Capillary blood flow enters venules that join together to form cardiac veins that drain into the **coronary sinus** located on the posterior side of the heart, which drains into the right atrium.
There are also **anterior cardiac veins** and **thesbesian veins** drain directly into the cardiac chambers.

The regions of the heart that are generally supplied by the different coronary arteries
: This anatomic distribution is important because these cardiac regions are assessed by 12-lead ECGs to help localize ischemic or infarcted regions, which can be loosely correlated with specific coronary vessels.

Anatomic Region of Heart	Coronary Artery (most likely associated)
Inferior	Right coronary
Anteroseptal	Left anterior descending
Anteroapical	Left anterior descending (distal)
Anterolateral	Circumflex
Posterior	Right coronary artery

The features of coronary blood flow:

•Flow is tightly coupled to oxygen demand. This is necessary because the heart has a very high basal oxygen consumption (8-10 ml O_2/min/100g) and the highest A-VO_2 difference of a major organ (10-13 ml/100 ml). In non-diseased coronary vessels, whenever cardiac activity and oxygen consumption increases there is an increase in coronary blood flow (active hyperemia) that is nearly proportionate to the increase in oxygen consumption.

•Good autoregulation between 60 and 200 mmHg perfusion pressure helps to maintain normal coronary blood flow whenever coronary perfusion pressure changes due to changes in aortic pressure.

•Adenosine is an important mediator of active hyperemia and autoregulation. It serves as a metabolic coupler between oxygen consumption and coronary blood flow. Nitric oxide is also an important regulator of coronary blood flow.

•Progressive ischemic coronary artery disease results in the growth of new vessels (termed angiogenesis) and collateralization within the myocardium. Collateralization increases myocardial blood supply by increasing the number of parallel vessels, thereby reducing vascular resistance within the myocardium.

•Extravascular compression (shown to the right) during systole markedly affects coronary flow; therefore, most of the coronary flow occurs during diastole. Because of extravascular compression, the endocardium is more susceptible to ischemia especially at lower perfusion pressures. Furthermore, with tachycardia there is relatively less time available for coronary flow during diastole to occur – this is particularly significant in patients with coronary artery disease where coronary flow reserve (maximal flow capacity) is reduced.

•Activation of sympathetic nerves innervating the coronary vasculature causes only transient vasoconstriction mediated by α_1-adrenoceptors. This brief (and small) vasoconstrictor response is followed by vasodilation caused by enhanced production of vasodilator metabolites (active hyperemia) due to increased mechanical and metabolic activity of the heart resulting from β_1-adrenoceptor activation of the myocardium. Therefore, sympathetic activation to the heart results in coronary vasodilation and increased coronary flow due to increased metabolic activity (increased heart rate, contractility) despite direct vasoconstrictor effects of sympathetic activation on the coronaries. This is termed "functional sympatholysis."

•Parasympathetic stimulation of the heart (i.e., vagal nerve activation) elicits modest coronary vasodilation (due to the direct effects of released acetylcholine on the coronaries). However, if parasympathetic activation of the heart results in a significant decrease in myocardial oxygen demand due to a reduction in heart rate, then intrinsic metabolic mechanisms will increase coronary vascular resistance by constricting the vessels.

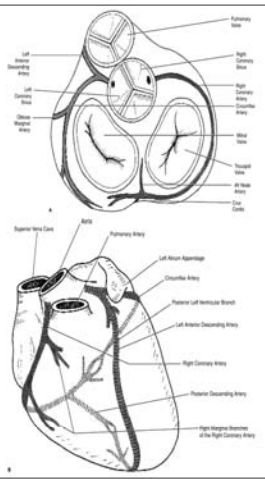
In the presence of coronary artery disease, coronary blood flow may be reduced. → increase oxygen extraction from the coronary blood and decrease the venous oxygen content. → leads to tissue hypoxia and angina.

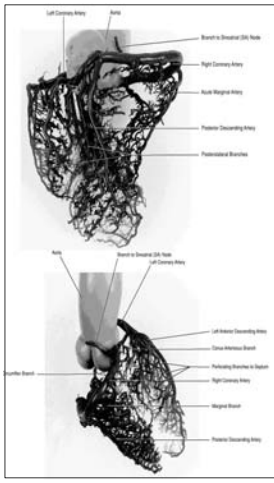
If the lack of blood flow is due to a fixed stenotic lesion in the coronary artery (because of atherosclerosis), blood flow can be improved within that vessel by
1) placing a stent within the vessel to expand the lumen,
2) using an intracoronary angioplasty balloon to stretch the vessel open, or
3) bypassing the diseased vessel with a vascular graft.

If the insufficient blood flow is caused by a blood clot (thrombosis), a thrombolytic drug that dissolves clots may be administered. Anti-platelet drugs and aspirin are commonly used to prevent the reoccurrence of clots. If the reduced flow is due to coronary vasospasm, then coronary vasodilators can be given (e.g., nitrodilators, calcium-channel blockers) to reverse and prevent vasospasm.

Relationships of the coronary arteries around the heart.

A, The left coronary artery is in red and the right coronary artery is in blue.
B, The right coronary artery and the circumflex arteries form a circle around the atrioventricular sulci. The left anterior descending and the posterior descending arteries form a semicircle around the interventricular sulci.





Cast of the coronary arteries viewed from the inferior face of the heart.

The right coronary artery is in blue. It is dominant and supplies all the inferior wall and part of the left lateral wall of the heart. The aorta is in yellow. The left coronary artery is in red.

Cast of the coronary arteries in lateral view.

The right coronary artery is in blue. The left coronary branches are in red and supply the anterior part of the left lateral wall of the heart.

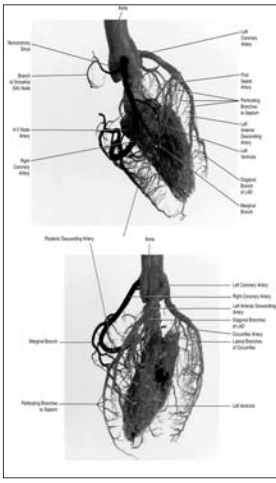


Figure 13.38. Cast of the coronary arteries in right oblique view and their relationships with the left ventricle. The right coronary artery is in blue and gives rise to the posterior descending artery, which extends toward the apex of the heart close to the distal portion of the left anterior descending artery (in red).

Figure 13.39. Cast of the coronary arteries in a left oblique view and their relation with the left ventricle. The left coronary artery and its branches are in red. The right coronary artery is in blue. LAD, left anterior descending.

The left main coronary artery : variable length and a diameter ranging from 5 to 10 mm.
In about 1% of the hearts studied in a series, there was no left main coronary artery and two orifices were found in the left coronary sinus, with the left anterior descending and circumflex arteries originating separately from each one.

The left main coronary artery bifurcates into two vessels:
the left anterior descending (LAD): running over the anterior interventricular sulcus
the circumflex artery related to the left atrioventricular sulcus.

The left main coronary artery in a few cases may give rise to a third vessel: the intermediary artery, also called diagonalis artery, which is located between the LAD and circumflex artery and supplies the free lateral wall of the left ventricle.

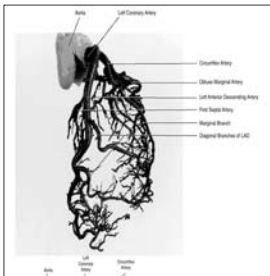
The LAD extends down ending proximal, at or distal to the apex. In this last situation, the LAD goes up into the posterior interventricular sulcus. The length of the LAD is thus extremely variable.

The main branches of the LAD are the diagonal and septal branches.

1. The diagonals vary in number and size. These vessels arise in an acute angle from the LAD and supply the anterolateral wall of the left ventricle. Most frequently, there is a major artery, which is identified as the first diagonal branch.

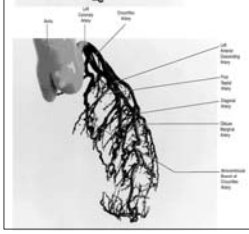
2. The septal branches in number of four to six, or more, originate from the LAD in right angle, coursing close to the endocardium on the right side of the interventricular septum. They anastomose with the septal branches coming from the posterior descending artery. In the majority of hearts, it is possible to identify a bigger septal branch called the first septal artery, originating from the proximal portion of the LAD.

In some hearts, the LAD has an unusual configuration: it is short and divided into two parallel vessels called "dual" LAD. One vessel running over the interventricular sulcus gives off the septal branches and the other, lying in the anterior left ventricular wall, originates the diagonal branches.



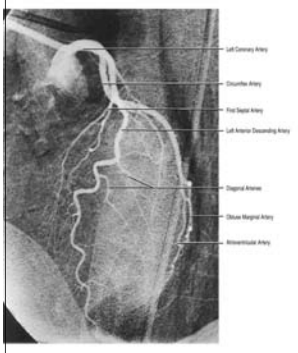
Cast of the left coronary artery in a left oblique view.

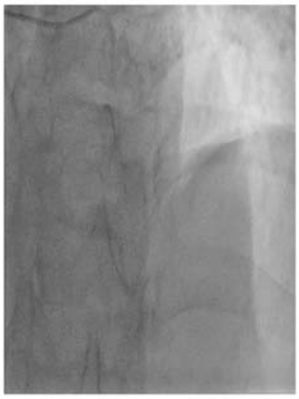
The coronary artery is in blue and the aorta is in yellow.



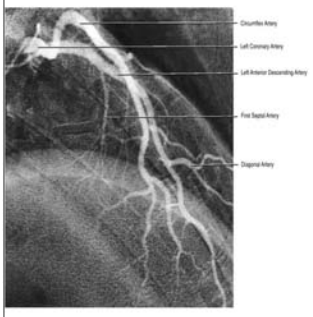
Cast of the left coronary artery in a right oblique view.

The coronary artery is in blue and the aorta is in yellow.

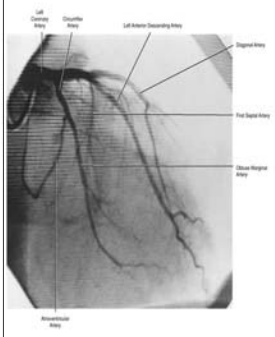




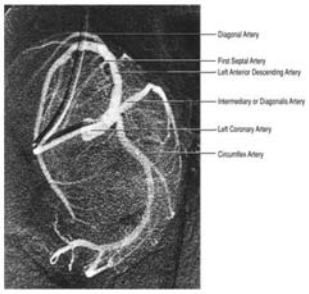
Angiogram of the left coronary artery in the cranial left anterior oblique projection.

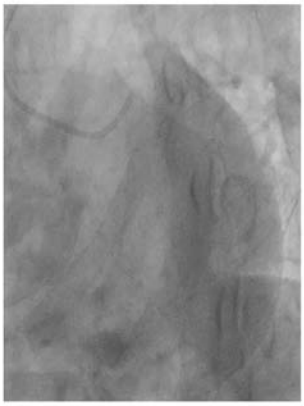


Angiogram of the left coronary artery in the cranial right anterior oblique view. The origin of the septal and diagonal arteries is well demonstrated in this projection.



Angiogram of the left coronary artery in the right anterior oblique view.





Left coronary artery angiogram obtained in the caudal left anterior oblique or spider projection showing the origin of the left anterior descending artery, the circumflex artery, and the diagonal branch.

The circumflex artery is the other principal vessel originating from the left main coronary artery.

It emerges in a right or acute angle and is covered by the left atrial appendage in its proximal portion, and then takes position in the left atrioventricular sulcus. The circumflex artery may terminate proximal to the obtuse margin of the left ventricle, before, at, or beyond the crux cordis.

The principal branches of the circumflex artery are the marginal arteries and the left atrial branch.

In 40% of hearts, the sinus node artery arises from the circumflex artery.

The marginal arteries are variable in number, but are usually three. The most prominent marginal artery runs on the obtuse margin of the heart and extends distally close to the apex. When the circumflex artery reaches the crux cordis, it gives origin to the posterior descending and to the atrioventricular node arteries.

The right coronary artery has its origin at the right coronary aortic sinus.

Often a small branch may arise directly from the aortic sinus in an isolated ostium and supply the right ventricle infundibulum. This branch is called the conus artery, which anastomoses with a left conus branch coming from the left coronary artery to form the arterial anulus of Vieussens.

The right coronary artery gives rise to the sinus node artery in 60% of hearts.

The right coronary artery goes into the right atrioventricular sulcus and has a variable form of termination. If it is a short artery, it terminates between the acute margin of the right ventricle and the crux cordis as a small branch (left dominance).

When there is a dominant right coronary artery, it extends further from the crux, supplying the posterolateral wall of the left ventricle with a variable number of posterolateral branches.

The right coronary artery gives origin to the right marginal or acute marginal artery that supplies the free anterior wall of the right ventricle. The shorter the left circumflex artery, the longer will be the terminal posterolateral branches of the right coronary artery. At the crux cordis, the right coronary gives origin to the posterior descending artery, which runs into the posterior interventricular sulcus and supplies the inferior portion of the interventricular septum through a variable number of septal branches. Several of these small septal branches anastomose with the septal branches coming from the anterior descending artery. Just distal to the crux, the right coronary artery makes an inverted "U" turn, giving origin to the atrioventricular node artery.

Angiographic Aspects

All the details of the lesions as well as their locations should be properly defined. To reach these goals, several angiographic projections are used.

Because the anatomic aspects of the coronary arteries are variable, a number of appropriated projections with special angles of the x-ray beam are used for each different individual. All the principal vessels must be visualized in at least two orthogonal projections.

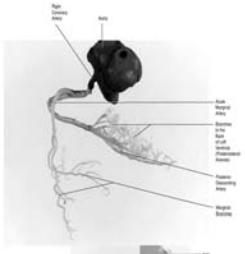
The elongated or cranial left oblique view shows the left main coronary artery, the LAD, and the diagonal branches. The caudal left oblique projection (spider view) shows the left main coronary artery, its bifurcation, and the proximal circumflex artery.

To visualize the LAD, the septal and the diagonal branches, either the cranial or the caudal right oblique views are indicated. The circumflex artery and its marginal branches are well defined in the elongated left oblique and in the caudal right anterior oblique projections.

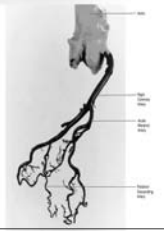
The anteroposterior view is a good projection to study the left main coronary artery and its bifurcation. In some cases, the caudal anteroposterior or the true lateral views may help visualize the proximal portion of the LAD and of the circumflex artery.

The right coronary artery is well visualized in the majority of the cases in the conventional right and left oblique projections .

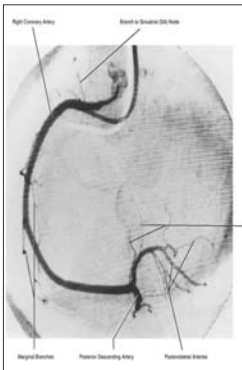
The origin of the posterior descending and the posterolateral branches are defined in the caudal left anterior oblique view.



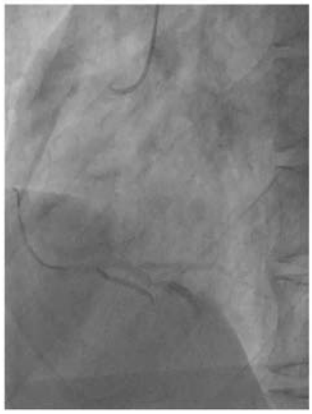
Cast of the right coronary artery in a left oblique view.

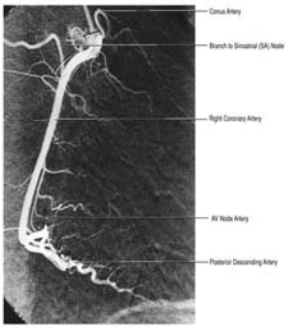


Cast of the right coronary artery in a right oblique view.

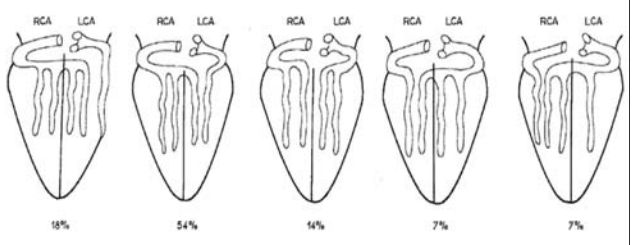


Angiogram of the right coronary artery in the left anterior oblique projection. The branches to the AV node are multiple.





Angiogram of the right coronary artery in the right anterior oblique projection. Dominant right coronary artery in the left anterior oblique view. The posterior descending artery arises from the right coronary artery at the crux cordis.



Distribution of the coronary branches to the posterior surface of the heart.
(According to Campbell 1929).

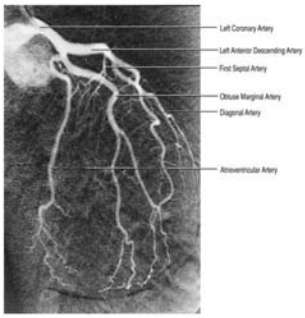


Figure 13.52. Left coronary artery angiogram in the caudal right anterior oblique projection. The circumflex artery is short and divides into a well-developed obtuse marginal artery and an atrioventricular artery.

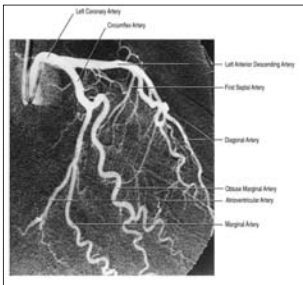


Figure 13.53. coronary artery in the caudal right anterior oblique projection. The left anterior descending artery is short and divides into two parallel arteries: one running over the interventricular sulcus supplying the interventricular septum. The other runs in the anterior wall of the left ventricle and originates the diagonal arteries. It is called the dual left anterior descending artery.

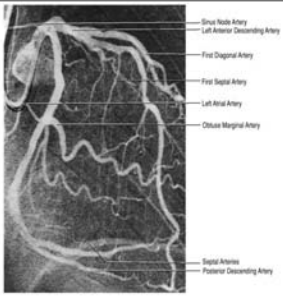


Figure 13.54. Dominant left coronary artery. The posterior descending artery arises distally from the circumflex artery. The sinus node artery is originated from the proximal circumflex artery. This is an angiogram in the cranial right anterior oblique projection.

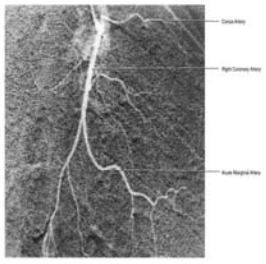


Figure 13.56. Angiogram showing a nondominant right coronary artery in the right anterior oblique projection.

Cardiacangiographic CT

The coronary arteries run in grooves on the surface of the heart surrounded by epicardial fat. This allows CT imaging to use its strength of depicting objects of different density to great advantage.

When intravenous contrast material is given, the coronary arteries surrounded by fat clearly stand out from the remainder of the heart. 3D volume images along with maximum intensity projection images are used to evaluate the coronary arteries.

This allows for visualization of the left main coronary artery, right coronary artery, left anterior descending coronary artery, and the left circumflex coronary artery.

In addition, branches such as diagonals, obtuse marginals, and the posterior descending coronary artery can be seen down to a diameter of 1 mm.

Although many different projections are used to visualize the coronary arteries in clinical practice, the fact that the coronary arteries lie on the surface of the heart makes 3D volume reconstruction the most useful way to study the anatomy.

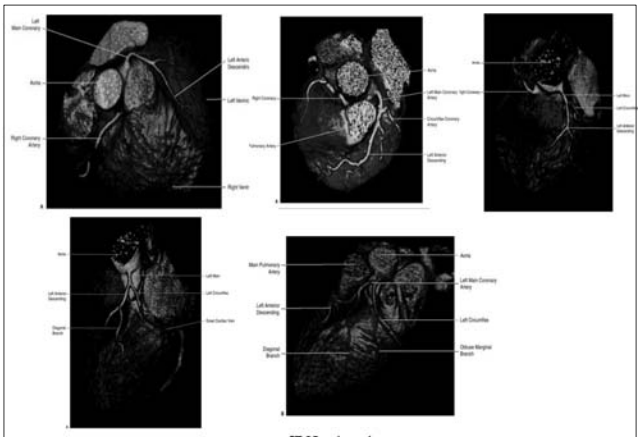
The origin of the coronary arteries can be well visualized on a cranial view with the more superior structures removed.

In this projection both the right and left coronary origins are seen clearly and any anomalies can easily be excluded.

Rotating the image to a cranial left anterior oblique defines the left main coronary artery and its bifurcation into the left anterior descending and left circumflex coronary arteries.

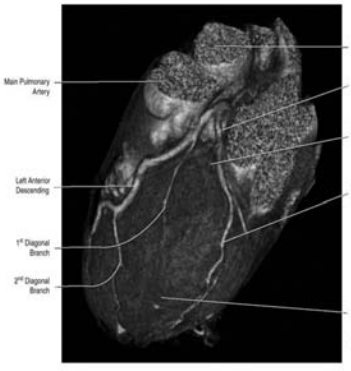
The LAD runs in the anterior interventricular groove with its diagonal branches serving the anterior wall of the left ventricle.

The circumflex coronary artery runs in the atrioventricular groove with obtuse marginal branches serving the lateral wall of the left ventricle.



CT 3D volume image.
A-C, Three examples of normal origins of the right and left coronary arteries.

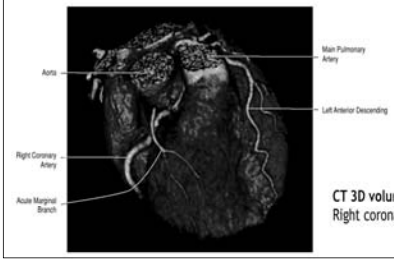
CT 3D volume image.
Left anterior descending coronary artery in anterior interventricular groove with multiple diagonal branches.



CT 3D volume image.
Left anterior descending coronary artery with diagonal branches and left circumflex coronary artery with obtuse marginal branch.

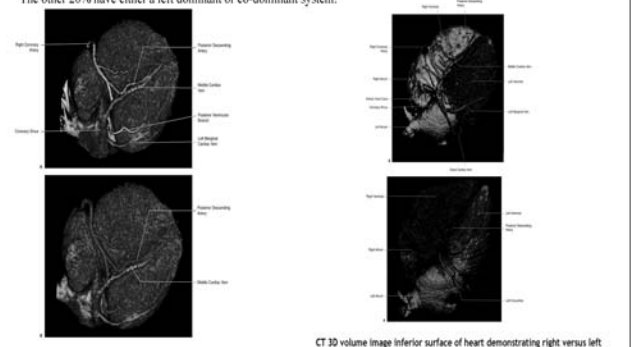
The right coronary artery undergoes rapid complex motion during the cycle of the beating heart. Until recently, this prevented imaging of this vessel because of excessive motion or blurring artifact. Modern scanners are now quick enough to "stop" the motion of the right coronary artery. Small branches less than 1 mm in diameter are difficult to visualize, but larger branches such as the acute marginal artery can be well visualized.

Computer workstations allow these vessels to be displayed in a wide variety of formats, which can be used depending on clinical necessity.



CT 3D volume image.
Right coronary artery with acute marginal branch.

After removing the diaphragm, the inferior surface of the heart can be evaluated. About 80% of people have a so-called "right dominant" system, in which the right coronary artery provides flow to the posterior descending coronary artery. The other 20% have either a left dominant or co-dominant system.



CT 3D volume image with two methods of display. A, Inferior surface of heart with distal right coronary artery giving rise to posterior descending artery. **B,** CT image with highlighted distal right coronary circulation. Note distinction from venous drainage into coronary sinus.

CT 3D volume image inferior surface of heart demonstrating right versus left dominance.
A, Right dominant with right coronary artery supplying flow to the posterior descending coronary artery (PDA). Note slight variant anatomy with early take-off of PDA. **B,** Left dominant with circumflex supplying PDA. Note veins and coronary sinus removed to better demonstrate distal left circumflex artery.

Characteristics and Harvesting Technique of Coronary bypass Conduits

가톨릭대학교 성빈센트병원 흉부외과학교실

조 민 섭

Surgical Techniques of CABG

울산대학교 의과대학 서울아산병원 흉부외과학교실

김 준 범

ASAN Medical Center — UNIVERSITY OF ULSAN COLLEGE OF MEDICINE

Standard CABG

- **Use of CPB**
- Aortic cannulation
- Aortic clamping
- Cardioplegic arrest
- Contact of blood to the foreign materials
  - Inflammatory responses
  - Destruction of blood components

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Off-Pump CABG

Cardiac stabilizing devices

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Revival of Off-Pump CABG

•1967
- First performed by Kolessove in Soviet Union

•1970s~1980s
- CPB and cardioplegic arrest became routine
- OPCAB disappeared from the center stage

•1990s
- OPCAB has been rediscovered and refined.

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Off-Pump vs. On-Pump CABG

- Continuous debates since revival of off-pump CABG in 1990's
- Off-pump CABG may be better in terms of…
  - Avoidance CPB-related complications
  - Less bleeding
  - Less renal dysfunction
  - Less neurologic damages

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Studies in Early 2000's

Pitfalls of Conventional CABG:
CPB Related Effects

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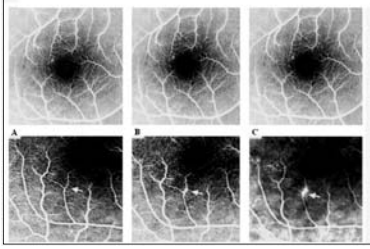
Circulation

American Heart Association

Retinal and Cerebral Microembolization During Coronary Artery Bypass Surgery : A Randomized, Controlled Trial

Raimondo Ascione, Arup Ghosh, Barnaby C. Reeves, John Arnold, Mike Potts, Atul Shah and Gianni D. Angelini

Circulation. 2005:112:3833-3838



OPCAB:
- Less embolism
- Less microbleeding

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Pulmonary Outcomes of Off-Pump vs On-Pump Coronary Artery Bypass Surgery in a Randomized Trial*

Gerald W. Staton, MD, FCCP; Willis H. Williams, MD; Elizabeth M. Mahoney, ScD; Jeff Hu, MD; Haitao Chu, PhD; Peggy G. Duke, MD; and John D. Puskas, MD

(*CHEST 2005; 127:892–901*)

*—Mortality and Pulmonary Readmissions Within 30 Days**

Variables	CACB/CPB (n = 97)	OPCAB (n = 100)	p Value
Death within 30 d	2	1	NS
Readmission diagnoses			
Pulmonary edema	1	1	NS
Pneumonia	1	0	NS
Pleural effusion	2	4	NS

*From Puskas et al.[32] Data are presented as No.

OPCAB:
- early extubation
- better gas exchange

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ELSEVIER

European Journal of Cardio-thoracic Surgery 27 (2005) 1057-1064

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

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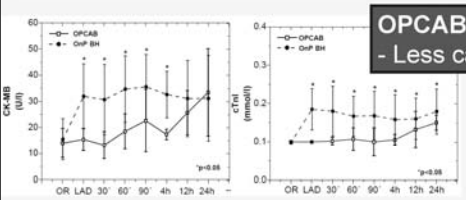
On-pump beating heart versus off-pump coronary artery bypass surgery—evidence of pump-induced myocardial injury☆

Ardawan Julian Rastan*, Hartmuth Bruno Bittner, Jan Fritz Gummert, Thomas Walther, Claudia V. Schewick, Evaldes Girdauskas, Friedrich Wilhelm Mohr



OPCAB:
- Less cardiac injury

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Economic Evaluation of Coronary Artery Bypass Grafting Surgery With and Without Cardiopulmonary Bypass: Cost-Effectiveness and Quality-Adjusted Life Years in a Randomized Controlled Trial

*Sharif Al-Ruzzeh, †David Epstein, *Shane George, *Mahmoud Bustami, *Jo Wray, *Charles Ilsley, †Mark Sculpher, and *Mohamed Amrani

Mean costs by CPB and OPCAB groups to 6 months

	CPB		OPCAB		Difference		
	Mean	SE	Mean	SE	Mean	SE	*P* value
Theater procedure	1673	43	1304	26	369	50	<0.001
Postoperative recovery	5107	530	3871	309	1235	615	0.05
Readmissions	235	117	361	224	−126	270	0.64
Total cost	7015	550	5537	381	1478	670	0.03

OPCAB: More cost-effective

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Findings Summary

Findings Favoring On-Pump CABG or OPCAB

Findings favoring OPCAB
- Probably less bleeding
- Probably less renal dysfunction
- Probably less short-term neurocognitive dysfunction, especially if aorta is calcified
- Possibly shorter overall length of hospital stay

Findings favoring on-pump CABG
- Less technically demanding
- Shorter "learning curve"
- Possibly better long-term graft patency
- Easier to graft posterior (circumflex) bypass targets
- Probably more bypass grafts constructed

(*Circulation*. 2005;111:2858-2864.)

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Contraindications

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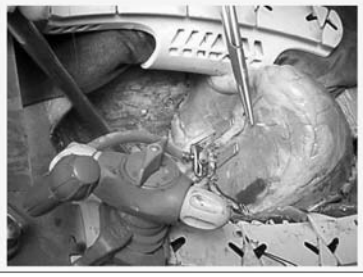
Absolute Contraindication of Off-Pump CABG

- Unstable hemodynamics during CABG
  (Cardiac positioning: posterior surface)



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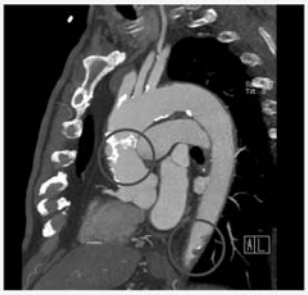
Absolute Contraindication of On-Pump CABG

- No adequate arterial cannulation site



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On-Pump CABG

- Pump
- Gauzes or Hands

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Off-Pump CABG

- Stabilizer
- Apical stabilizer (suction)
- CO2 blower
- Coronary shunt




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On- and Off-Pump CABG

- Anastomosis order:
  "LAD first" vs. "LAD last"
- Coronary atriotomy:
  More caution in on-pump CABG

- Length / configuration adjustment
  Easier with off-pump CABG

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On- vs. Off-Pump CABG

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The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 NOVEMBER 5, 2009 VOL. 361 NO. 19

ROOBY Trial
By Residents >60%

and Dimitri Novitzky, M.D., Ph.D., for the Veterans Affairs Randomized On/Off Bypass (ROOBY) Study Group

METHODS

We randomly assigned 2203 patients scheduled for urgent or elective CABG to either on-pump or off-pump procedures. The primary short-term end point was a composite of death or complications (reoperation, new mechanical support, cardiac arrest, coma, stroke, or renal failure) before discharge or within 30 days after surgery. The primary long-term end point was a composite of death from any cause, a repeat revascularization procedure, or a nonfatal myocardial infarction within 1 year after surgery. Secondary end points included the completeness of revascularization, graft patency at 1 year, neuropsychological outcomes, and the use of major resources.

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ORIGINAL ARTICLE

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

André Lamy, M.D., P.J. Devereaux, M.D., Ph.D., Dorairaj Prabhakaran, M.D., David P. Taggart, Ph.D., Shengshou Hu, M.D., Ernesto Paolasso, M.D.,

CORONARY Investigators Trial
Expert surgeons only! (> 100 cases)

Toomas-Andres Sulling, M.D., Richard P. Whitlock, M.D., Yongning Ou, M.Sc., Jennifer Ng, M.Sc., Susan Chrolavicius, B.A., and Salim Yusuf, D.Phil., for the CORONARY Investigators*

BACKGROUND

The relative benefits and risks of performing coronary-artery bypass grafting (CABG) with a beating-heart technique (off-pump CABG), as compared with cardiopulmonary bypass (on-pump CABG), are not clearly established.

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.

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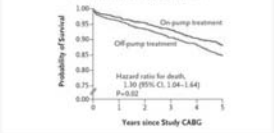
5-Year Outcomes

ORIGINAL ARTICLE

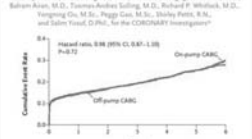
Five-Year Outcomes after On-Pump and Off-Pump Coronary-Artery Bypass



ROOBY:
On-pump better

ORIGINAL ARTICLE

Five-Year Outcomes after Off-Pump or On-Pump Coronary-Artery Bypass Grafting



CORONARY Investigator:
Comparable on- and off-pump

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Cardiac Surgery

Long-Term Survival Following Coronary Artery Bypass Grafting

Off-Pump Versus On-Pump Strategies

Joon Bum Kim, MD, PhD,* Sung-Chul Yun, PhD,† Jae Wong Lim, MD,* Soo Kyung Hwang, MD,* Sung-Ho Jung, MD,* Hyun Song, MD, PhD,‡ Cheol Hyun Chung, MD, PhD,* Jae Won Lee, MD, PhD,* Suk Jung Choo, MD, PhD*

Seoul, South Korea

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Methods

CABG between April 1989 and April 2012
at the Asan Medical Center, Seoul, Korea,

N=6658

Exclusion
- Combined surgery (n=1123)
- Emergent / urgent surgery (n=332)

N=5203

Off-pump CABG N=2333 (44.8%)

On-pump CABG N=2570 (55.2%)

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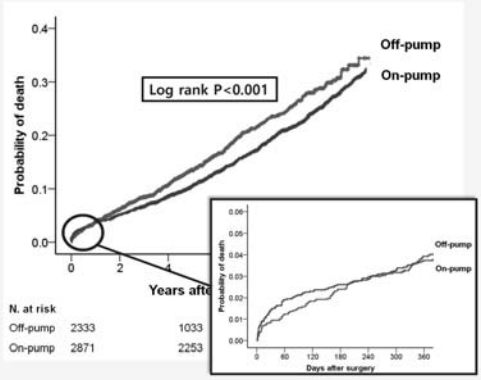
Unadjusted Death Rates



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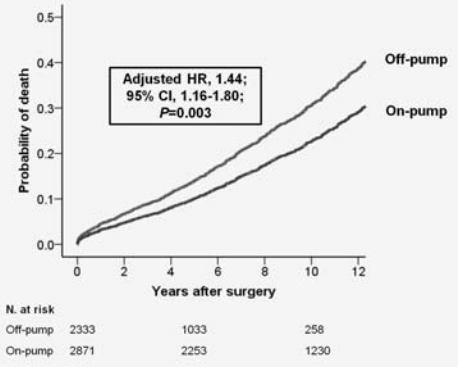
Adjusted Mortality (IPTW)



N. at risk

Off-pump	2333	1033	258
On-pump	2871	2253	1230

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Korea Nationwide Results

- South Korea:
  - Strong enthusiasm for off-pump CABG (>50%)
  - Universal nationwide claims database of the National Health Insurance Service (mandatory for all residents)
  - Detailed data on baseline, procedural and follow-up parameters are available. (100% complete)
- Sound environment to allow analyses on comparative effectiveness between the on- and off-pump CABG reflecting real-world practices.

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28,650 patients
Aged 18 years or older receiving CABG between Jan 2004 and Dec 2013

4,822 Excluded
96 Revascularization within 2 years before
4,649 Acute myocardial infarction at index day
77 Unstable hemodynamics

23,828 patients

12,639 Off-pump

11,189 On-pump

PS matching

6,483 Off-pump

6,483 Off-pump

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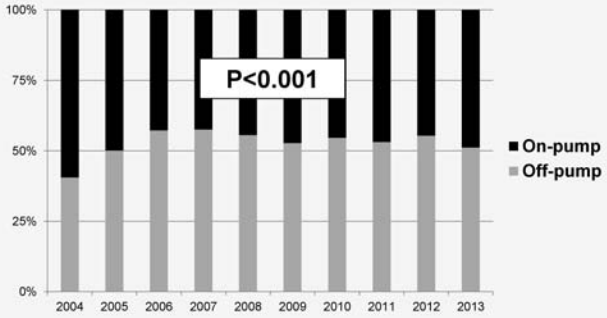
Yearly Trends



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Worldwide Trends

15%~20% of CABG are performed using the "Off-Pump Technique"

The STS 2009 Report.
Adult Cardiac Database Executive Summary

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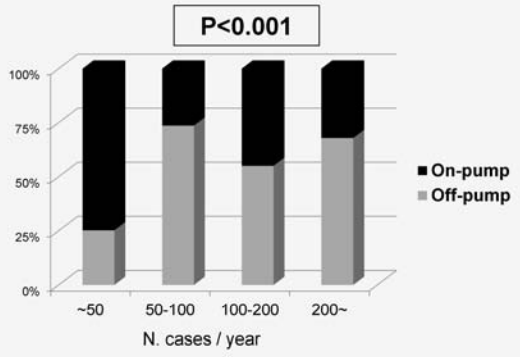
Trends Depending on Center Volumes



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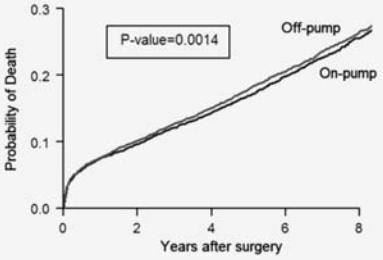
Adjusted Death in PS Matched Cohort



N. at risk

Off-pump	6483	5366	4160	2886	1565
On-pump	6483	5362	4150	2806	1589

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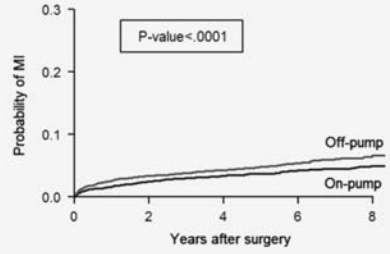
Adjusted MI in PS Matched Cohort



N. at risk

Off-pump	6483	5216	4028	2779	1498
On-pump	6483	5256	4036	2724	1540

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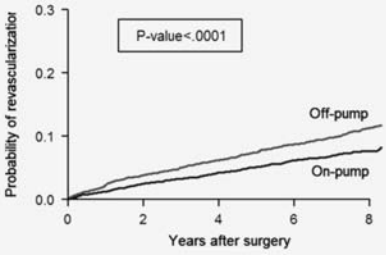
Adjusted Reintervention in Matched Cohort



N. at risk

Off-pump	6483	5171	3922	2649	1417
On-pump	6483	5240	3995	2653	1481

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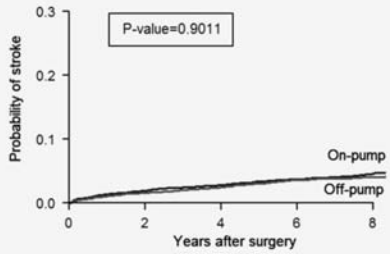
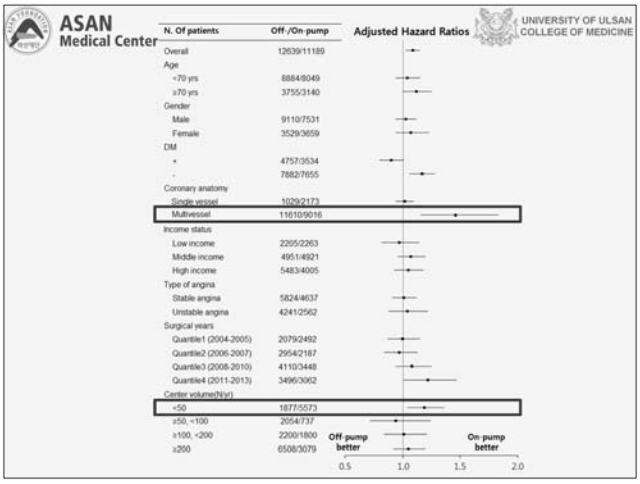
Adjusted Stroke in PS Matched Cohort



N. at risk

Off-pump	6483	5301	4091	2809	1527
On-pump	6483	5290	4076	2734	1537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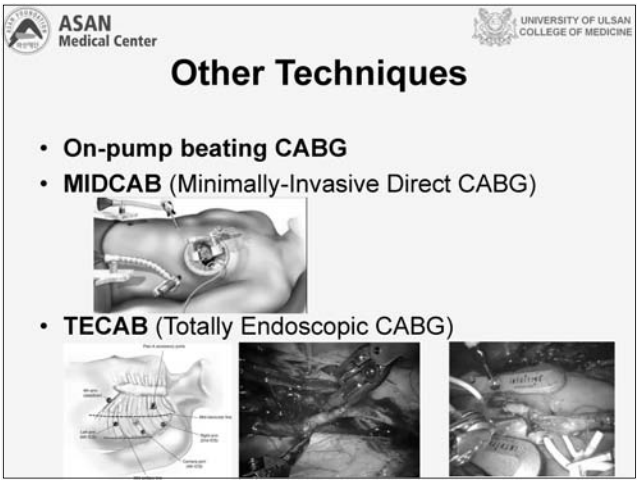
N. Of patients
Off-/On-pump
Adjusted Hazard Ratios
Overall 12639/11189
Age
<70 yrs 8884/8049
≥70 yrs 3755/3140
Gender
Male 9110/7531
Female 3529/3659
DM
+ 4757/3534
- 7882/7655
Coronary anatomy
Single vessel 1029/2173
Multivessel 11610/9016
Income status
Low income 2265/2263
Middle income 4951/4921
High income 5483/4005
Type of angina
Stable angina 5824/4637
Unstable angina 4241/2562
Surgical years
Quantile1 (2004-2005) 2079/2492
Quantile2 (2006-2007) 2954/2187
Quantile3 (2008-2010) 4110/3448
Quantile4 (2011-2013) 3496/3062
Center volume(N/y)
<50 1877/5573
≥50, <100 2054/737
≥100, <200 2200/1800
≥200 6508/3079
Off-pump better
On-pump better
0.5
1.0
1.5
2.0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Other Techniques
• On-pump beating CABG
• MIDCAB (Minimally-Invasive Direct CABG)
• TECAB (Totally Endoscopic CABG)

Mechanical Complications of Ischemic Heart Disease

경북대학교병원 흉부외과학교실

김 근 직

Decision-making on Coronary Intervention: Indication of PCI and CABG

서울대학교병원 흉부외과학교실

황 호 영