대한흉부심장혈관외과학회
제9차 전공의 연수교육

일자: 2016년 5월 26일(목)~5월 28일(토)

장소: 대명리조트 비발디파크 메이플동 토파즈홀

대한흉부심장혈관외과학회

대한흉부심장혈관외과학회 제9차 전공의 연수교육
프로그램

진행: 교육위원장 나국주

일시: 2016. 5. 26(목) 장소: 대명리조트 비발디파크 메이플동 토파즈홀 2층

12:00～12:20 등록(12:00～), 숙소배정(Check In 14:00～)

12:20～12:30 격려사 회장 **박창권**

12:30～16:15 일반흉부파트 좌장: 나국주, 이성수

진행: 이성수, 김관창

19:00～ 저녁식사 장소: 단지내 식객 033-439-4470 (내선7447)
<위치: 오션월드 맞은편, 소노펠리체 입구>

일시: 2016 5. 27(금) 장소: 메이플동 토파즈홀 2층

08:00～09:00	**아침 식사**	**장소: 메이플동 지하1층 쉐누 뷔페 033-439-7437**

09:00～12:15	**성인심장 파트**	**좌장: 박계현**
09:00～09:40	How to Review Coronary Angiogram in Preparation for CABG	박계현 (서울의대) ····· 53
09:40～10:10	Graft Harvesting and Conduit Selection	강신광 (충남의대) ····· 59
10:10～10:40	CABG / PCI	김근직 (경북의대) ····· 62
10:40～10:55	Coffee Break	
10:55～11:35	Techniques of Conventional and Off-pump CABG	이재항 (동국의대) ····· 67
11:35～12:15	Mechanical Complications of IHD	제형곤 (부산의대) ····· 73

12:30～13:00	**점심 식사**	**장소: 메이플동 지하1층 쉐누 레스토랑**

13:00～14:00	**논문작성법**	이성수 (연세의대) ····· 95

14:00～18:00	**초음파 교육**	**장소: 메이플동 에메랄드홀 2층**
14:00～14:30	Lung Ultrasonography: Basic Application	김도완 (전남의대) ····· 99
14:30～15:00	Basic Echocardiography	김동중 (서울의대) ····· 110
15:00～15:30	Sono-guided Vessel Access & Intervention	김재범 (계명의대) ····· 111
15:30～15:50	Coffee Break	
15:50～18:00	초음파 Hands-on Course (조별 진행) 기본 영상 획득 및 해부학적 구조 판별.	김태식, 김재범, 김동중, 김도완····· 119

18:30～	**저녁식사**	**장소: 메이플동 지하1층 쉐누 레스토랑**

일시: 2016. 5. 28(토) 장소: 메이플동 토파즈홀 2층

08:00～09:00	**아침 식사**	**장소: 메이플동 지하1층 쉐누 뷔페 033-439-7437**
08:00～11:00	객실 Check Out (프론트에 객실키 반납)	1층 프론트

09:00～12:00	**소아심장파트**	**좌장: 이 철**
09:00～09:30	Normal Cardiac Anatomy	장우성 (계명의대) ····· 123
09:30～10:00	PDA, ASD, VSD	최은석 (세종병원) ····· 131
10:00～10:30	Tetralogy of Fallot with Pulmonary Stenosis	김형태 (부산의대) ····· 136
10:30～10:50	Coffe Break	
10:50～11:20	Transposition of the Great Arteries	신홍주 (충북의대) ····· 145
11:20～12:00	Single Ventricle	이 철 (가톨릭의대) ····· 158

12:00～13:00	**점심 식사**	**장소: 메이플동 메이플동 지하1층 쉐누 레스토랑**

13:00～15:00	**외상, ECMO, 중환자**	**좌장: 박철현**
13:00～13:30	외상환자의 중등도 분류 및 국내 외상 프로그램	장성욱 (단국의대) ····· 171
13:30～14:00	다발성 외상 환자의 초기 치료	현성열 (가천의대) ····· 179
14:00～14:30	ECMO - 과거, 현재, 미래	정재승 (고려의대) ····· 187
14:30～15:00	New Definition of Sepsis	이현주 (서울의대) ····· 199

15:00～16:00	**교육평가 설문지 작성 및 시험**

【일반흉부파트】

좌장: 나국주, 이성수

흉막질환

이화여자대학교 목동병원 흉부외과학교실

김 관 창

Pleura

Parietal pleura

Visceral pleura

fluid : 10-20 cc, 흉막강을 이동하는 흉막액의 양은 하루에 5000-10000 ml에 이른다.

▶ Blood supply

1. Parietal pleura (pain sensitive)
   - posterior intercostal a.
   - internal mammary a.
   - superior phrenic a.
   - ant. mediastinal a.
2. Visceral pleura : pulmonary a.

▶ Pressure

- always negative pressure
- end inspiration시 pressure가 가장 낮다.

* intrabronchial Pr(-2～+2 cm H2O)
* intrapleural Pr (-3～-9 cm H2O) 증가시엔 venous return이 안되어 심박출량이 줄어든다.

- insp. -8～-9 cm H2O
- exp. -3～-6 cm H2O

Chest Tube

▶ Chest tube insertion의 목적

- 흉막강내의 흉막수, 혈액 혹은 공기의 배출
- 흉막강의 폐쇄
- 폐의 완전한 팽창
- Instillation of chemotherapeutic agent after removal of mal. effusion

- Prophylactic PTx, Mx

* air-leak가 있는 Pt.의 transport
  - single open chest tube
  - oneway flag valve
  - (+) pr. ventilator

▶ 적응증

- 기흉, pleural effusion, hemothorax
- 개흉술후 : pleural space에 삽입
- 개심술 후 : pericardial & mediastinal space에 삽입
- 흉복부의 관통상
- 기흉의 증거가 없는 늑골 골절혹은 흉부 관통상 환자의 경우 곧 수술이 예정되어 있거나 기도삽관후 양압 호흡이 필요할 때

▶ 삽관시 주의점

- 피부절개 : tube의 pleural entry site에서 1-2cm아래 떨어진 곳에
- tube의 last hole은 반드시 pleural spaceso에 위치하도록 한다.
- subcutaneous tunnel을 만든다.
- 통상의 tube 삽입위치는 air drainage를 위한 경우는 mid-clavicular line의 제2-3 ICS이고, fluid drainage를 위한 경우는 mid-axillary line의 제 5-6 ICS이다.

▶ 수술후 흉관관리에 있어서 매일 check해야할 사항

- 배액량
- 공기유출 유무
- 흉관 개방성 유무
- 흉부 방사선 사진: 흉관의 위치, 폐확장유무, 무기폐의 유무, 사공간의 유무
- 늑막액 잔존 유무

▶ 흉관의 관리

- 밖으로 나온 tip은 병 속 fluid에 2-3 cm 잠기도록(Pt와 bottle사이의 거리는 50 cm)
- chest bottle은 항상 환자보다 낮은 위치에 있도록 하고, tube가 꼬이거나 꺽이지 않도록 주의
- 공기누출이 있는 환자에서는 어느 경우에도 tube의 clamping은 금기이다. 또 tube내에 fluid 가 너무 많아 drain을 방해하지 않도록 bottle을 갈아주어야 한다.
- 매일 CXR 추적검사를 원칙으로 한다.

▶ 흉관의 제거

- 흉관의 제거시는 흉관을 통한 공기유출이 없고 하루 24시간 동안 폐액된 양이 100 ml 이하이고 흉부방사선소견상 폐가 완전히 확장되어 있으며 늑막액이 잔존하지 않을 때
- 흉관을 뽑을 때에는 흉관을 clamping 하고 suction을 제거한 후 valsalva maneurver를 하는 짧은 시간에 순간적으로 뽑는다.

- 흉관제거후 흉부방사선 사진을 찍어서 반드시 기흉유무를 확인해야 한다.
- 흉관을 제거한 후에는 공기가 들어가지 않도록 occlusive dressing을 48시간동안 한다.

Pleural Space Disease

- spontaneous pneumothorax : primary, secondary
- spontaneous hemothorax
- chylothorax
- pleural effusion
- bronchopulmonary fistula
- fibrothorax
- postthoracotomy pleural space

Spontaneous Pneumothorax

♠ Definition: accumulation of gas in the pleural space ; collapse of the lung

- primary
- secondary
- catamenial
- neonatal

【Primary Spontaneous Pneumothorax】

▶ 생리적 동력학

폐의 무게에 의한 기계적 긴장이 폐첨부 > 폐기저

폐첨부 폐포벽내에 긴장 증가로 폐포확장 - 폐기저폐포의 압박

폐첨폐포의 과팽창 및 파열

→ 폐포가스가 폐엽중격을 따라 박리 → pneumomediastinum, subpleural bleb 형성

→ bleb, bulla의 wall이 기관지 내압에 의해 확장되면 긴장을 받아 파열되고 흉강으로 공기가 빠져나간다 → pneumothorax

* if check valve 형성, 계속 air leak → tension PTX (positive pressure in pleural space)

▶ Clinical Feature

- M:F = 5-8:1
- 40세 이하 : 85% (키 크고 마른 젊은 남자) 20,30대
- Rt > Lt
- apical > middle or lower (apical portion의 alveoli가 크므로)
- bilateral in 10%
- mostly occur d/t rupture of primary pulmonary bleb
- Sx : abrupt pleuritic pain, dyspnea
- associated underlying lung disease (+) : in 20%
- ddx with large bullae : lateral decubitus view

primary PTX → air가 퍼짐

bulla → no change

- small amount PTX : expiration CXR 찍으면 pneumothorax가 조장되어 (+)로 나옴
- 재발율 50% (2년내) (같은 쪽에 생길 확률: 75%)

【Secondary Spontaneous PTX】

(spontaneous의 20%)

▶ Definition

: 뚜렷한 폐의 선행질환 때문에 이차적으로 기흉이 생기는 상태

▶ Associated disease

- COPD (bullous emphysema) : m/c
- lung abscess
- pneumonia
- asthma
- mycotic infection
- Tbc, malignancy

▶ 임상 양상

일반적으로 환자의 나이가 많고 폐기능도 나쁜 상태이기 때문에 기흉정도에 비해 호흡곤란 등의 증상이 훨씬 심하면 위험성도 크다

Neonatal PTX

secondary to hyaline membrane disease, Potter syndrome

Catamenial PTX

▶ 정의 및 발병 양상

- 월경과 연관되어 생김
- 20-30대
- 대부분 (90%) 우측에서 발생
- 월경 시작후 48-72시간안에 생김
- 배란이 일어나지 않을 때는 절대 생기지 않는다.

▶ 치료

일반적인 자연기흉과 같이 치료하고, 그 후에 ovulatory suppressive drug을 투여한다

♠ Complication of spontaneous PTX

1. hemothorax : localized adhesion between parietal & visceral pleura
   → 이 부위의 pneumonia시 rupture되면서 bleeding
2. respiratory failure : COPD 있는 elderly patient에서는 소기흉이라도 resp. failure 可
3. empyema : secondary pneumonia (Tbc, abscess)후에 흔함
4. chronic pneumothorax
5. tension PTX : in 2-3%
   mediastinal shift, disturbance in venous return → 심한 순환장애

♠ Treatment of spontaneous PTX

1. goal
   - Cx. recognize
   - Sx ↓
   - Prevention of recurrence
2. thoracentesis Vs thoracostomy
   - mild (<20%) : observation - 매일 1.25%의 공기가 흡수
   - moderate : needle aspiration (thoracentesis) - 근래에는 많이 시행되지 않는다. 또 찬다
   - severe : chest tube drainage (thoracostomy) - closed thoracotomy. 대개 이것 사용
3. pleurodesis : secondary PTX에서 수술 불가능하고 recur 가능성 ↑
   - chemical : tetracycline
   - mechanical : bleb excision + mechanical pleurodesis (spongy로 pleura 문질러 피낸다)

* Chest tube insertion의 Ix
- 단기간의 치료가 필요한 경우
- 20%이상의 기흉이 있는 경우
- tension PTX
- Sx이 있는 경우
- contralateral lung에 ds. 있는 경우
- CXR상 PTX 점점 증가하는 경우

* Indications for open thoracotomy in patients with spontaneous PTX
- massive air leak that prevents re-expansion of the lung
- persistant air leak for more than 5 days
- recurrent PTX (second episode)
  cf. 3회 이상의 PTX에서 재발율 : 70%
  4회 이상의 PTX에서 재발율 : 80-90%
  (첫 attack후 20-50%재발, 90%는 같은 쪽 lung에 생김)
- specific surgical indications for conditions that cause secondary spontaneous PTX
- occupational indications after first episode
  • airline pilots

  - scuba divers
  - individuals in remote area
- previous contralateral PTX
- bilateral simultaneous PTX
- presence of large cysts visible on chest film

Spontaneous Hemothorax

▶ Etiology

1. Pulmonary pathology

- bullous emphysema
- necrotizing infections
- pulmonary embolus with infarction
- Tbc
- AV malformation
- hereditary hemorrhagic telangiectasia

2. Pleural pathology

- torn pleural adhesions secondary to spontaneous PTX
- neoplasms
- endometriosis

3. Pulmonary neoplasms

- primary
- metaststic
  - melanoma
  - trophoblastic tumors

4. Blood dyscrasia

- thrombocytopenia
- hemophilia
- complication of systemic anticoagulation
- von Willebrand's disease

5. Abdominal pathology

- pancreatic pseudocyst
- splenic a. aneurysm
- hemoperitoneum

6. Thoracic pathology

- ruptured thoracic aortic aneurysm
  - usually result from spontaneous PTX & pul. AV malformation
  - frequent in young male (20대)

▶ Pathophysiology

주위의 심장 및 폐의 물리적 진탕작용 때문에 섬유소가 제거되어 곧 액화된다
→이 차감염, fibrothorax

▶ Treatment

- 원인에 따라
- C-tube insertion → drainage
- if 8주간 치료후에도 CXR상 지속적 음영이 있으면
  → open thoracotomy & decortication
- 원인 병변의 국소 절제술
- 만약 치료 안하면 organization되어 fibrothorax 초래

1) <10일 : C-tube 위치확인 → 다음 두가지중에서
   - replace : 성공/실패
   - minithoracotomy

2) Delayed (>10일) : thoracocentesis → 다음 세가지중에서
   a. C-tube 성공하면 끝/실패하면 tube뽑고
   b. 4-5주후 : pleural decortication
   c. occasionally successful : 끝

Chylothorax

▶ Anatomy & Physiology

- cistern chyli로부터 시작 (intraabdominal)
- vertebra 오른쪽으로 타고 올라가다 T5 level에서 왼쪽으로 가서 상행
- Lt. subclavian vein과 Lt. jugular vein이 만나는 곳으로 drain
- rate of lymph flow : 1.38 ml/kg/hr
  mostly from liver & intestinal lymphatics (95%)
- thoracic duct lymph : 0.4-6.0 gm of fat/100 ml
  60-70% → thoracic duct 통해 systemic circulation으로
  MCFA → portal vein
- forward flow : one direction (아래 → 위)
  d/t negative intrathoracic pressure
  one way valve
  자연율동적 수축 운동

- 1일에 1.5-2L의 fluid 이동
  cf. pleural fluid : 5-10 L

▶ Etiology

1. congenital : atresia, birth trauma
2. traumatic :m/c
   - blunt
   - penetrating
   - surgery (多)
     cervical : LN dissection, RND
     thoracic : PDA, CoA, esophagectomy, Lt. pneumonectomy, Fontan op.
     abdominal : radical LN dissection
   - diagnostic procedure
3. neoplasm : direct invasion, obstruction (lymphoma, lymphatic obstruction)
4. infections : Tbc, Filariasis
5. 기타 : venous thrombosis, pulmonary lymphagiomatosis

▶ Dx & ddx

fluid에서 chylomicron 발견
turbid → empyema는 세워두면 가라앉음
chylothorax는 계속 turbid (TG > 110 mg, cholesterol/TG ratio < 1)
cf. pseudochyle : cholesterol or lecithin ↑
chol/TG ratio >1
chronic inflammation
lymphangiogram, Tc-99m antimony colloid

* Characteristics of chyle
  - milky appearance with creamy later on standing clears when fat is extracted by alkali & ether
  - fat globules stain with Sudan Ⅲ
  - alkaline, odorless
  - sterile, bacteriostatic
  - S.G. 1.012 to 1.025
  - lymphocyte 400-6,800/mm^3
  - RBC 50-600/mm^3

▶ Treatment

- conservative Tx for 2wk
- NPO, parenteral (MCFA : portal vein으로 흡수) + chest tube insertion
  if 자연 폐쇄가 이루어지면 tube 제거전에 고지방식을 주어 보아 확인

- surgical Tx : conservative Tx가 효과 없을 때, 하루에 1500cc이상(어른),
  metabolic derangement
  direct closure of fistula
  sutrue of leaking mediastinal pleura
  supradiaphragmatic ligation of thoracic duct (azygous v – Aorta사이 잘 박리하면 보임)
  *pleuro-peritoneal shunt in SVC syndrome patient
  ♣ 수술시 thoracic duct visualize
  - preop 3hr전 우유나 ice cream → lymph flow↑ → 우유색 flow (leaking point찾기 용이)
  - vital dye subcutaneous injection (preop 6hr전)

Pleural Effusion (CHF, Cirrhoisis, NS...)

▶ Pathophysiology

- pleural space : a pontential space
  1일 5-10L가 parietal → visceral pleura로 이동
  이동 기전 : systemic hydrostatic Pr. – major
  pulmonary hydrostatic Pr. – major
  osmotic Pr. gradient – minor
- content : protein (1.5g%)

* Lab test for ddx of effusion (heparin syringe에 air sealing해서 보낼것)

- volume
  massive → malignancy, Tbc, empyema
- color & cell content
  clear – transudate
  turbid – exudate
- microscopic & bacteriologic exam
- amylase ↑ : esophageal perforation, acute pancreatitis
- glucose ↓ : Tbc, RA, empyema, malignancy
- pH : parapneumonic effusion시 Tx 결정 인자
  pH 〈7.2 : empyema에 준해 치료 – tube drainage
  pH 〉7.2 : reactive effusion – drain×
- cytology : malignant cell
- biopsy : Tbc, malignancy
- LDH/protein

▶ Transudate vs Exudate (뒤에)

▶ Treatment

- thoracentesis : malignancy

- chemical pleurodesis (Tc, anticancer drug) – malignant recurrent시
- surgical pleurodesis – malignant, recurrence시
- closed thoracotomy
- open thoracotomy
- pleuro-peritoneal shunt
- radiation

* Tb pleurisy : chest tube insertion하지 않고 9 month medicatio

	Transudate	Exudate
protein pleural prot/serum prot LDH pleural LDH/serum LDH pleural LDH	<3 g/dl <0.5 <200 IU <0.6 <2/3 * normal s-LDH	>3 g/dl >0.5 >200 IU >0.6 >2/3
Causes	CHF cirrhosis nephrotic syndrome myxedema peritoneal dialysis hypoproteinemia Meig's syndrome Sarcoidosis	Neoplastic metastatic mesothelioma lymphoma chest wall tumor Meig's syndrome Infectious Tbc viral, parasitic bacterial pneumonia Pulmonary infarction Collagen vascular disease RA, SLE GI pancreatitis, pseudocyst esophageal rupture subphrenic abscess hepatic abscess Trauma hemothorax, chylothorax Miscellaneous

Empyema

▶ Definition

- accumulation of pus in pleural space
- pleural effusion이 육안소견상 purulent하거나 pleural effusion에서 세균이 검출될 때

▶ Causes

다음과 같은 원인이 있으나, 약 50%에서는 폐의 일차적인 병변으로 인해 이차적으로 흉막강이 오염되어 생긴다.

- parapneumonic or postpneumonic – m/c
- lung abscess
- 인접장기에서 염증의 침범 : liver abscess, subphrenic abscess, esophageal perforation
- 흉부외상 (foreign body, dirty open wound)
- spontaneous PTX의 합병증
- surgical trauma
- generalized sepsis

▶ Three phase of natural history

1. aucte or exudative phase
   - pre-empyema phase
   - aseptic exudate가 축적, fibrin이 흉막 표면에 침착
   - 이 때의 흉막액은 정도가 낮고 WBC도 적으며, LDH치도 낮다. glucose와 pH치는 정상
   - 적절한 항생제만으로도 치료가 가능하고 흉관삽입은 대개 필요없다
2. transitional, fibrinopurulent phase
   - 흉막액은 더 혼탁해지고 PMN가 증가
   - 또 fibrin이 흉막에 심하게 침착되면서 흉강내 loculation 형성 (peel formation)
   - 이러한 loculation은 흉관을 통한 흉막강외 완전한 배출을 어렵게 만든다.
   - 흉막액의 pH치와 glucose치는 점점 낮아지고 LDH치는 높아진다.
3. chronic, organizing phase
   - capillary와 fibroblast가 pleura로부터 pleural effusion안으로 자라들어와 organization됨
   - 흉막의 기질화는 보통 농흉이 시작된지 7-10일에 시작되어 4-6주 후면 본격적인 만성기로 들어간다.

★ causes of chronic empyema (acute에서 chronic phase로 되기 쉬운 경우)

: 초기에 진단이 되지 않은 경우 또는 급성기에 적절한 치료가 이루어지지 않은 경우

not organized, no treatment
premature removal of drainage tubes
Tb origin
underlying lung ds. with inadequate lung expansion
associated with bronchopleural fistula
endobronchial foreign body

★ complication of empyema

empyema necessitasis : subcutaneous abscess로 보통 fifth costochondral jx 근처에 호발
bronchopleural fistula
metastatic abscess : 드물게 brain이나 vertebrae에 간다.
chondritis, osteomyelitis of the rib
pericarditis

mediastinal abscess

▶ Management

▷ antibiotics with drainage

▷ I & D

- chest-tube insertion
- thoracocentesis
- open thoracotomy

* parapneumonic effusion시 closed thoracostomy의 결정
  - pH <7.0
  - glucose <40 mg/dl
  - LDH >1000 u/L

* reexpansion of lung with obliteration of dead space

▷ decortication : thickened pleura를 벗겨냄

▷ thoracoplasty

▷ Clagett's procedure : decortication 후 dead space를 sterile solution으로 irrigation한 후 antibiotics solution으로 채움

▷ myoplasty : muscle, omentum 등으로 dead space를 채움

♠ 만성 농흉의 치료

open drainage

rib resection drainage

Eloesser's open flap procedure : rib 절제 후 skin, muscle flap으로 open window 만들어 배농시켜준다.

decortication

space-reducing operation

thoracoplasty

muscle transposition 〈box〉

♠ Post-pneumonectomy empyema

- space가 완전히 obliteration되지 못함 → infection ↑
- Tx : BPF가 있을 때 stump는 잘라내고 꿰메어 우선 fistula를 막고 empyema cavity는 muscle, omentum, Clagett's로 stability 유지

Bronchopleural Fistula

▶ Etioloty

- traumatic
- post-surgical : biopsy, thoracotomy, pneumonectomy or partial resection 후
- infection : necrotizing pneumonia, pulmonary infection, aspergillosis, coccidioidomycosis, etc.

▶ Treatment

- 매우 어렵고 사망률 15-30%
- acute : post-op → C-tube drainage
  반대쪽으로의 침범을 방지하기 위해 아픈쪽으로 돌아눕게
  if 24-48 hr 이내 → 재봉합
  op
- chronic : op

Fibrothorax

▶ Etiology

- hemothorax의 organization
- chronic Tb exudate
- bacterial empyema
  * thickened pleura, lung volume ↓

▶ Treatment

반드시 decortication - thickened pleura(parietal) 모두 제거

Pleural Disease

진단율(biopsy)
Tb : 60-80%
malignancy : 40-60%

▶ Pleural Tb

1. Dx

- clinical evaluation : nonproductive cough, pleuritic pain, dyspnea, G/W, Wt. loss
- CXR
- sono
- CT
- biopsy
- thoracoscopy
  * confirm by sputum AFB(+)
    - pleural fluid or pleural bx에서 AFB culture(+)
    - pleural bx에서 tuberculous granuloma 발견

2. Etiology

- extension from parenchymal ds.

- shedding from involved hilar LN

3. Incidence

5% of pulmonary Tb patients

4. Course

초감염 후 3-6mon.

5. Clinical feature

- abrupt onset : 2/3
- positive culture : 30-60%
- positive biopsy : 60-80%

6. Treatment

- medical
- blood clot(+) → adequate evaluation
- Tb empyema가 되면 resection/decortication (수술 후 dead space 유무가 중요)

▶ Pleural Calcification

1. Etiology

- chronic pleuritis
- unabsorbed hemothorax
- empyema or Tb origin

▶ Tumors

1. 대개 metastatic lesion (90-95%)

: lung > breast > LM

2. primary (5-10%)

- benign : lipoma, endothelioma, angioma, cyst
- malignant : 대개 primary pleural mesothelioma
  - 90% diffuse : malignant, pleural thickening, young : Px very poor
  - 10% localized : benign, solitary, 주로 visceral pleura, elderly female

〈Staging of Malignant Mesothelioma〉

Stage	Characteristic
I	tumor confined to ipsilateral pleura or lung
II	tumor involving chest wall, mediastinum, pericardium or contralateral pleura
III	tumor involving both thorax & abdomen or lymph nodes outside the chest
IV	distant blood-borne metastasis

3. Treatment

- benign : early stagy op
- malignant : pleuropneumonectomy with diaphragmatic excision and ipsilateral pericardiectomy

The Mediastinum

Pusan National University

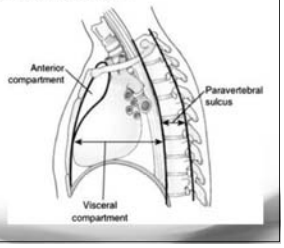
Jeong Su Cho

Contents

- Anatomy
- Non invasive and invasive Investigations
- Mediastinal infection
- Primary mediastinal tumors and syndromes associated with mediastinal lesions
- Mediastinal cysts

Anatomy

- Subdivision
  - Ant compartment
  - Middle or visceral compartment
  - Post compartment or paravertebral sulcus

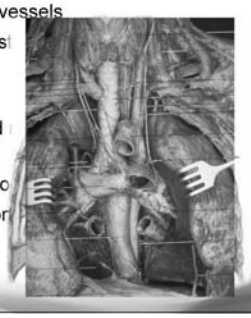


Anatomy

- Ant compartment
  - **Thymus**
  - Internal mammary vessels
  - Lymph nodes
  - Connective tissue with fat

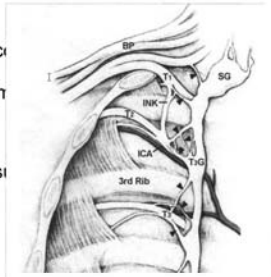
Anatomy

- Middle compartment
  - Pericardium, heart, and great vessels
  - Trachea, proximal portions of s
    esophagus
  - Extensive lymphatic tissues
  - Vagus and phrenic nerves and
    and fibers
  - Supra-aortic and para-aortic bo
  - Thoracic duct, the proximal por
  - Connective tissue and fat



Anatomy

- Post compartment
  - Proximal portions of the interc
  - Thoracic spinal ganglions, syn branches
  - Connective and lymphatic tiss



Non invasive Investigations

- Chest plain film including lateral view
- Chest CT
- Chest MRI
- Radionuclide studies
- Mediastinal tumor markers

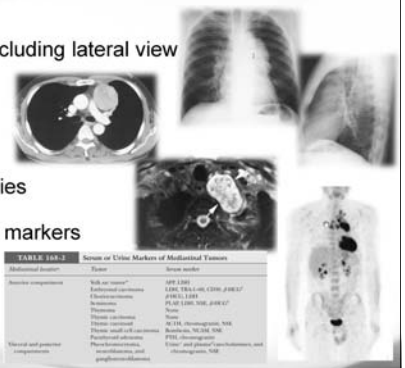


TABLE 168-2 Serum or Urine Markers of Mediastinal Tumors

Mediastinal Source*	Tumor	Serum marker
Anterior compartment	Yolk sac tumor*	AFP, LDH
	Embryonal carcinoma	LDH, TRA-1-60, CD30, β-HCG*
	Choriocarcinoma	β-HCG, LDH
	Seminoma	PLAP, LDH, NSE, β-HCG*
	Thymoma	None
	Thymic carcinoma	None
	Thymic carcinoid	ACTH, chromogranin, NSE
	Thymic small cell carcinoma	Bombesin, NCAM, NSE
	Parathyroid adenoma	PTH, chromogranin
Visceral and posterior compartments	Pheochromocytoma, neuroblastoma, and ganglioneuroblastoma	Urine* and plasma* catecholamines, and chromogranin, NSE

Invasive Investigations and surgical approaches

- Transcervical mediastinal LN sampling and Lymphadenectomy
  - Mediastinoscopy: extended, video-assisted
- Video-assisted thoracic surgery
- Sternotomy and Thoracotomy
- Posterior Mediastinotomy

Mediastinal infections

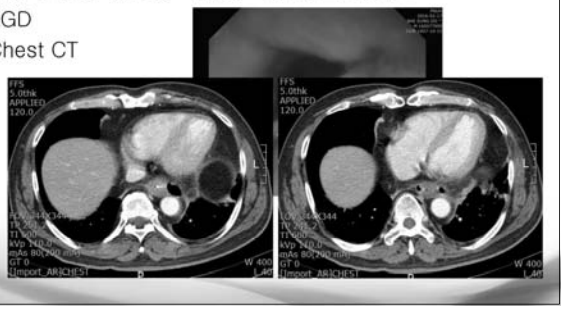
- **Acute and chronic mediastinitis**
  - **Perforation of the aero-digestive tract**
  - **Postoperative sternal infection and mediastinitis**
  - **Descending necrotizing mediastinitis**
  - **Sub-acute mediastinitis**
  - **Fibrosing mediastinitis**

Perforation of the aero-digestive tract

- Four principles of treatment
  1. **Eliminate source of soilage** by primary repair or diversion away from the esophageal perforation
  2. **Provide thorough and wide mediastinal drainage** to control on going mediastinal suppuration occurring after primary repair or diversion. In addition, gastrostomy tube decompression should be performed to decrease gastric reflux and mediastinal soilage.
  3. **Appropriate antibiotics** should be administered to augment host defenses, which must be effective against both gram positive and gram negative bacteria and against both aerobic and anaerobic bacteria.
  4. **Maintain adequate nutrition.**

Case

- 56/M
- 내원 수일전 매운탕 먹다가 목에 이물감 발생
- EGD
- Chest CT



Postoperative sternal infection and mediastinitis

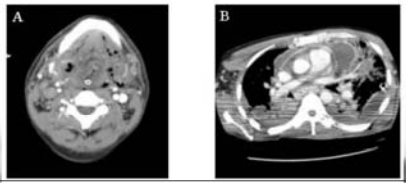
- Risk factor
  - Sternotomy: incomplete closure
  - Tracheostomy
  - CPB duration
  - Postoperative bleeding
  - Infection
  - Low cardiac output
  - Poor general condition
  - Steroid

Descending necrotizing mediastinitis

- Acute purulent mediastinitis due to oropharyngeal infection
- uncommon but still lethal form of mediastinitis
- 60 ~ 70%, secondary to odontogenic infections
- Peritonsillar abscess, Retropharyngeal and parapharyngeal abscess, Epiglottitis
- Other less common causes
  - trauma to the neck, including neck or mediastinal surgery
  - cervical lymphadenitis, endotracheal intubation

Case

- 43세 여자 환자가 고열과 전신무력감 호소
- Present illness : 최근 치통으로 충치치료를 지속적으로 받고 있었으나 잘 조절되지 않아 발치를 하였으며 이후 고열과 전신무력감이 심해짐
- V/S : BP 80/50, PR 120/min, BT 38.9°C
- P/Ex: 턱 아래쪽과 목 주위가 부어 있었으며 발적과 함께 열감과 동통
- Chest CT



- 진단은?
- 치료는?
- 예후는?

Sub-acute mediastinitis

- The definition of subacute mediastinitis is unclear, but this term should embrace those inflammatory processes involving the mediastinum that produce minimal to mild and evanescent symptomatology (substernal pain, fever, night sweats) and an identifiable anterior or visceral mediastinal mass by radiographic or CT examination.
- These infections most often are the result of fungal, mycobacterial, or, rarely, actinomycotic organisms.
- Such subacute infections are observed only infrequently in previously normal, healthy persons but are becoming more common in immunocompromised patients, particularly those with AIDS.

Fibrosing mediastinitis

- Fibrosing mediastinitis is an uncor
  resulting in the deposition and pro
  tissue through out the visceral cor
  mediastinum.
- This chronic inflammatory proce
  and compression of vital mediast

Primary mediastinal tumors and syndromes

- Thymic tumors
- Myasthenia Gravis
- Benign LN disease
- Germ cell tumor
- Neurogenic tumors

Thymic tumors

Classification of Thymic Tumors

Epithelial cell tumors
- Thymoma
  - Type A (Spindle cell, medullary)
  - Type AB (Mixed)
  - Type B1 (Predominate cortical, lymphocyte-rich, organoid)
  - Type B2 (Cortical)
  - Type B3 (Epithelial)
- Other types
  - Micronodular thymoma with lymphoid stroma
  - Metaplastic thymoma
  - Microscopic thymoma
  - Sclerosing thymoma
- Combined thymoma and thymic carcinoma
- Thymic carcinoma

Neuroendocrine cell tumors
- Thymic carcinoid, well differentiated
- Atypical thymic carcinoid, moderately differentiated
- Small cell carcinoma, poorly differentiated

Tumors of adipose tissue
- Thymolipoma
- Thymoliposarcoma

Miscellaneous tumors
- Thymic hemangioma
- Neuroblastoma and ganglioneuroblastoma
- Primary malignant melanoma
- Myoid tumor
- Lymphoid tumors

Thymoma

- Neoplasm of the thymus that originates in the gland's epithelial tissue.
- Incidence: 0.15 /100,000 person years (United States)
- Typically slow-growing tumors
- Spread by local extension
- Metastases are usually confined to the pleura, pericardium, or diaphragm, whereas extrathoracic metastases are uncommon.

The New World Health Organization Histologic Classification of Thymic Epithelial Tumors

- Type A thymoma (medullary)
- Type AB thymoma (mixed)
- Type B thymoma[a]
  - Type B1 (organoid)
  - Type B2 (cortical)
  - Type B3 (epithelial)
- Type C (thymic carcinoma)

[a]May include combinations of B2 and B3 as well as B1 and B2.

TABLE 188-7 Staging Schemes of Thymoma

Stage	*Bergh, et al.*[31]	*Masaoka, et al.*[179]
I	Intact capsule or growth within the capsule	Macroscopically, completely encapsulated; microscopically, no capsular invasion
II	Pericapsular growth into mediastinal fat tissue	
IIA		Macroscopic invasion into surrounding fatty tissue or mediastinal pleura
IIB		Microscopic invasion into capsule
III	Invasive growth into the surrounding organs, intrathoracic metastases, or both	Macroscopic invasion into a neighboring organ (e.g., pericardium, great vessels, or lung)
IVA		Pleural or pericardial dissemination
IVB		Hematogenous or lymphogenous metastases

5 year survival rate
Stage I — 94 - 100 %
Stage II — 86 - 95 %
Stage III — 56 - 69 %
Stage IV — 11 - 50 %

Clinical presentation

- Thoracic symptoms
  - Related to the size of the tumor and its effects on adjacent organs
    : chest pain, shortness of breath, cough, phrenic nerve palsy, superior vena cava obstruction
  - Systemic ("B") symptoms
    : fever, weight loss, and/or night sweats

Paraneoplastic disorders

- Myasthenia gravis
- Pure red cell aplasia
- Immunodeficiency
- Thymoma-associated multiorgan autoimmunity

Treatment

National Comprehensive Cancer Network®

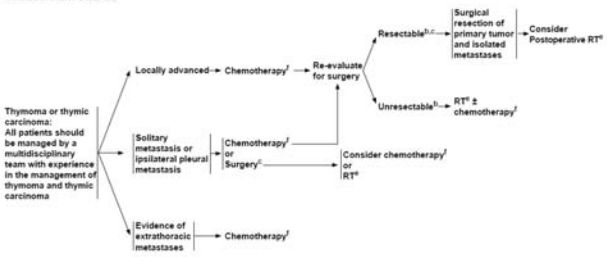
NCCN Guidelines Version 2.2016

NCCN Guidelines Index

NCCN Guidelines Version 2.2016
Thymomas and Thymic Carcinomas

NCCN Guidelines Index
Thymic Table of Contents
Discussion

LOCALLY ADVANCED, ADVANCED, OR RECURRENT DISEASE — TREATMENT



Prognosis

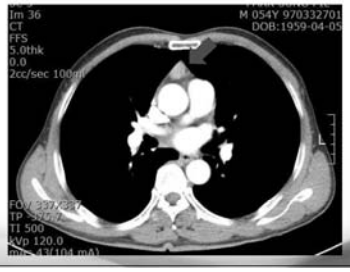
- Thymomas
  - usually slow-growing tumors
  - presence of invasion is an important adverse prognostic marker
- The overall five-year survival : 70 %
  - 50 % with local invasion
  - 75 % without invasion
- 10-year survival : 50 %
  - 30 % with invasion
  - 60 % without invasion

Myasthenia Gravis

- Neuromuscular junction disorder
- caused by the autoimmune destruction of the acetylcholine receptors of voluntary muscle
- Sx: diplopia, ptosis, dysphagia, weakness, fatigue
- 30 - 50 % of patients with thymomas have myasthenia gravis
- rare in thymic carcinoma

Case

- 57세 남자 환자가 복시 현상 및 저녁이 되면 무기력함을 호소하여 응급실을 방문하였다. 시행한 흉부전산화단층촬영에서 아래와 같은 병변이 관찰되었다.



- 진단을 위한 검사는?
- 진단은?
- 적절한 그 다음 조치는?

Benign LN disease

Benign Mediastinal Lymphadenopathies

I. Mediastinal granulomatous disease
  Tuberculosis
  Fungal infection
  Sarcoidosis
  Silicosis
  Wegener's granulomatosis
II. Castleman's disease
III. Others
  Systemic lupus erythematosus
  Infectious mononucleosis
  Reactive lymph node hyperplasia
  Amyloidosis
  HIV–associated *Pneumocystis carinii*

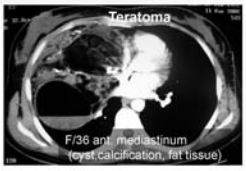
Source: Machevsky MA, Kaneko M. *Surgical Pathology of the Mediastinum*. New York: Raven Press, 1984:174. With permission.

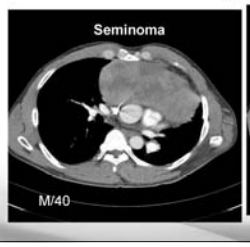
Germ cell tumor

1. Benign germ cell tumors
2. Primary seminomas
3. Non-seminomatous malignant germ cell tumors

Mediastinal Tumor

- Anterior mediastinum
- Thymoma? Lymphoma? Teratoma? or other
- Biopsy?
- Operation?
  - When?
  - (VATS or sternotomy? thoracotomy?)
- Postop. ?





Classification

양성 생식세포종 (Benign GCT)	***Epidermoid cyst***	***Teratomatous tumor***
	Dermoids (dermoid cyst)	*Mature teratoma*
	Teratoma (mature teratoma)	*Immature teratoma*
		Teratoma with additional malignant component
정상피종 (Seminoma)		***Non-teratomatous Tumors***
비정상피종성 생식세포종 (NSGCT)	*Malignant teratoma*	
	Choriocarcinoma	
	Yolk sac carcinoma *(endodermal sinus tumor)*	
	Embryonal carcinoma	
	Teratocarcinoma	

GCT; Germ cell tumor NSGCT; non-seminomatous germ cell tumor

Mullen & Richadson (1986)
WHO (Mostofi and Sobin, 1977) - Mediastinal Germ Cell tumors(1977a)
Testicular GCT (British testicular Tumor Panel; 1953, 1973, 1976)

Incidence

5-10% (extra-gonadal, mediastinum)	of Germ cell tumor
15% (85% benign) 25% (children, 대부분 benign)	of Anterior mediastinal tumors *Mullen & Richardson (1986)*
42 (10%) (50% benign)	400 mediastinal mass *Duke Univ. medical center (1930-1982)*

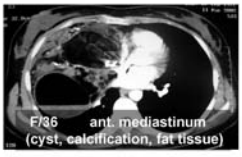
Benign GCT (Teratoma) *Shirodkar (1997)*

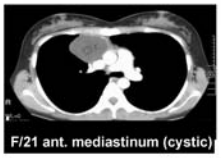
97-98% anterior mediastinum
3-8% posterior mediastinum

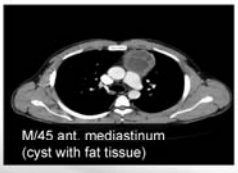
Malignant GCT

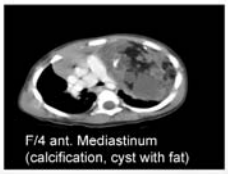
1-5% of all germ cell neoplasm
3-5% of mediastinal tumors
Seminoma 50% / Non-seminomatous GCT 50%

Benign Germ Cell Tumors









- **Three primodial layers**
  - Ectoderm; skin, hair
  - Mesoderm; bone, fat, muscle
  - Endoderm; respiratory epithelium, GIT
- Mature cells or tissues – **Mature teratoma**
- Less well-differentiated tissues – **Immature**
  - Infant; behave similarly to mature teratoma
  - Older patient; more aggressive (malignant teratoma)

Ruptured mediastinal Teratoma

- Incidence of spontaneous rupture

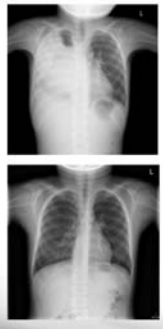
  up to 36% into lung & bronchial tree,
  pleural space,pericardial space, great vessels

- Hypothesis of rupture

  - **Autolysis** : most compelling cause, digestive enzymes (pancreatic tissue, salivary gland tissue)
  - **Chemical inflammation** : sebaceous gland secretions
  - **Ischemia** : rapid enlargement
  - **Pressure necrosis** : thinning of the cyst wall d/t secretions
  - **Infection** : tumor wall fragile(pulmonary or hematologic)

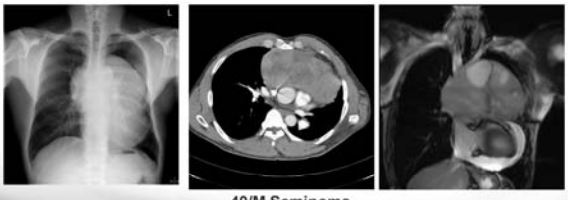
Spontaneous rupture of benign mature teratomas of the mediastinum
Am J Roentgenol. 1998 Feb:170(2):323-328
Teratoma with malignant transformation in the ant. Mediastinum
Korean J Radiol. 2000 Jul-Sep:1(3):162-4

10 months old male
Huge mediastinal mass with pleural effusion



Seminoma

- **Second common mediastinal GCT / TMC malignant mediastinal GCT**
- **3 rd ~ 5 th decade men, white men predominant**
- **Slow-growing tumors with lobular appearance including necrosis, hemorrhage**
  - **encapsulation – half of time, calcification – infrequently**



40/M Seminoma

Seminoma

Young man with anterior mediastinal tumor

Serum Tumor markers
hCG AFP LDH

(+) hCG * (-) AFP — *Seminoma (pure)*

(++) hCG (+) AFP — *Mixed tumor or NSGCT* / *NSGCT*

Testicular exam. : bimanual exam. & U/S
Abdominal CT/ Bone scan/ Brain CT or MR

Biopsy Mediastinoscpy or Sternotomy
VATS

Seminoma

Radiotherapy or adjuvant radiotherapy
Surgery

Chemotherapy

Poor Prognostic factor

Age greater than 35 years
Bulky mediastinal disease
SVC obstruction
Lymphadenopathy

Platinum-based
complete remission 88 ~ 100 %
5 YSR 70 ~ 85 %

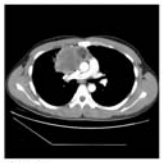
International Germ Cell Cancer Collaboration Group
J Clin Oncol 1977

Good Prognosis		
	Any Primary site	**90% of seminomas**
	No NPVM	**5 year PFS 82 %**
	Normal AFP, hCG, LDH	**5 YSR 86 %**
Intermediate Prognosis		
	Any Primary site	**10% of seminomas**
	NPVM (liver, bone, brain)	**5 year PFS 67 %**
	Normal AFP, hCG, LDH	**5 YSR 72 %**

NPVM non-pulmonary visceral metastasis
PFS progression free survival

Non-seminomatous GCT

- Potentially curable with surgery
- Exclusively in young adult, men (fewer than 30 cases reported in women)
- Rapid local growing tumors with early metastasis (85-90% at diagnosis)
- In-homogenous mass with multiple areas of necrosis & hemorrhage


30/ M
Choriocarcinoma

24/ M
Endodermal sinus tumor

NSGCT

Incidence

	Moran & Suster (1997) 229 cases	강창현 (2008) 29cases
Teratocarcinoma	41 %	9.5 %
58% non-germ cell component (sarcoma, epithelial carcinoma)		
Endodermal sinus (Yolk sac) tumor	35 %	42.9 %
Choriocarcinama	7 %	4.8 %
Embryonal carcinoma	6 %	9.5 %
Mixed	11 %	9.5 %
Unknown		23.8 %

Differ from testis origin

- ***Pure endodermal sinus tumor, extremely rare in testis***
- ***Embryonal carcinoma, much higher in testis***
- ***Non-germ call histologies is more common in mediastinum***

NSGCT

Tumor markers

hCG or AFP	90%
AFP with/without hCG	80%
hCG	30-35%
LDH	80-90%

APF 이 증가된 경우는 조직검사상 pure seminoma로 보인다고 해도 NSGCT와 같이 치료
hCG가 100 ng/ml 이상은 pure seminoma에서 uncommon

Differ from testis origin

Testicular NSGCT AFP & hCG equal frequency

NSGCT

Associated syndromes

Hematologic malignancies

Acute non-lymphocytic leukemia	Acute lymphocytic leukemia
Erythroleukemia	Acute megakaryocytic leukemia
Myelodysplastic syndrome	Malignant histiocytosis

Hartmann(2000) 2% (287 mediastinal NSGCT) — *Median survival 5 months; No patient more than 2 years*

Idiopathic thrombocytopenia

Hemophagocytic syndrome — *single case of endodermal sinus tumor*

Klinefelter's syndrome — *not associated with testicular GCT; common underlying germ cell defect*

NSGCT

Young man with anterior mediastinal tumor

Serum Tumor markers
hCG AFP LDH

- (+) hCG * (-) AFP — *Seminoma (pure)*
- (++) hCG (+) AFP — *Mixed tumor or NSGCT*

Biopsy, least invasive approach
Excess 500 ng/ml of hCG or AFP not delay chemotherapy due to biopsy

Platinum-based
Long-term survival 41 %

Chemotherapy

Surgery ? or not

Poor Prognostic factor
Bulky mediastinal disease – incomplete surgical resection
Histology – pure endodermal sinus tumor
Pre-chemotherapy hCG concentration

NSGCT

Initial Chemotherapy (3-4 cycles)

- hCG, AFP (N) CXR (N) → f/u for 24 months *during first 2 yrs 20% relapse*
- hCG, AFP (N) CXR (residual tumor) → **Surgical Resection**
- hCG, AFP ↑ → Salvage Chemotherapy → hCG, AFP ↑

Surgical Resection →
- Benign teratoma and/or Necrotic tumor → f/u for 24 months
- Viable GCT Resected → Chemotherapy add 2 cycles
- Viable GCT Incompletely Resected → Salvage Chemotherapy
- Viable non-GCT Resected → Investigational treatment or Supportive care

Fig 187-7 Shield, General Thoracic Surgery

NSGCT

International Germ Cell Cancer Collaboration Group ***J Clin Oncol 1977***

	AFP	*hCG*	*LDH*	non-semonomas	
Good Prognosis					
Testis/retroperitoneal				56%	
No NPVM				5 year PFS	82 %
Good markers	< 1000	< 1000	< 1.5 x N	5 YSR	86 %
Intermediate Prognosis					
Testis/retroperitoneal				28%	
No NPVM				5 year PFS	75 %
Intermediate markers	1,000~ 10,000	1,000~ 10,000	1.5 x~ 10 x N	5 YSR	80 %
Poor Prognosis					
Mediastinal primary				16%	
NPVM (liver bone, brain)				5 year PFS	41 %
Poor markers	> 10,000	> 10,000	> 10 x N	5 YSR	48 %

NPVM non-pulmonary visceral metastasis
PFS progression free survival

Neurogenic tumors

TABLE 196-1 Mediastinal Neurogenic Tumors in Infants and Children

Tumors of autonomic ganglia	*Neuroblastoma*	*Ganglioneuroblastoma*	*Ganglioneuroma*
Tumors of nerve sheath origin	Schwannoma	Neurofibroma	Neurogenic sarcoma
Tumors of neuroectodermal origin	Melanotic progonoma	Askin's tumor	
Tumors of paraganglia	Paraganglioma		

Mediastinal cyst

- Foregut cyst
- Gastroenteric and Neurenteric cyst

흉벽질환, 다한증, 흉곽출구증후군

연세대학교 강남세브란스병원 흉부외과학교실

이 성 수

Chest Wall Deformity

Deformities of the anterior chest wall are widely recognized,
poorly understood and
generally neglected.

- Charles W. Lester

Pectus Excavatum

- ***Funnel chest*** is an **oval depression** which involves the **sternum** as well as the **costal cartilages**.
- Usually it is already evident **in infancy**, and it becomes more marked as the child reaches maturity.
- The degree of the deformity varies from a mild depression on the sterno-xiphoid angle, to a severe "cave-in" of most of the anterior chest wall with the lower sternum touching the vertebral column.

- Pectus excavatum is a relatively common anomaly
  - occurs in about one in 300–400 live births
  - three times more frequent in males
  - often associated with connective tissue disorders, such as Marfan's disease or Ehlers-Danlos syndrome
- Symptoms
  - palpitation, exertional dyspnea, fatigue and dull precordial pain, paradoxical breathing, exercise intolerance
- The deformity is also often emotionally disturbing, especially in adolescents, who often avoid active sports and become shy and retiring.

Etiology

- heredity :about 20 to 50% of patients have a family history of pectus deformities - Williams 1872
- an overgrowth of the costal cartilages – Flesch 1873
- arrested growth of the sternum - Ebstein 1882
- various intrauterine compressive forces such as pressure by the chin, knee or elbow
- latent mediastinitis – Raubitsch
- undue traction exerted upon the sternum by the diaphragmatico-sternal ligament - Lincoln Brown 1939(1596)

Repair of PE

- Initially surgical intervention
  - only for patients with severe sternal depression
  - aimed primarily at relieving cardiac compression
  - cosmesis played a secondary role
- Deformed chest
  - a potential source of embarrassment
  - especially during adolescence and in young adulthood
  - operative correction is now recommended by most practitioners even in the absence of other symptoms
- Earlier operations - easy to perform, better results
  - at a later age :chest is less pliable and less accommodating

Historical period

- The first surgical intervention of pectus excavatum
  - Wilhelm Meyer in 1911
  - resected right 2nd and 3rd costal cartilages
  - significantly improved dyspnea
- Sauerbruch performed a more radical procedure in 1913
  - 5th to 9th costal cartilage, left hemisternum
- Judet in 1954 performed a sternal turn-over procedure
  - reattaching the resected sternochondral apron in the anterior chest wall

The modern era

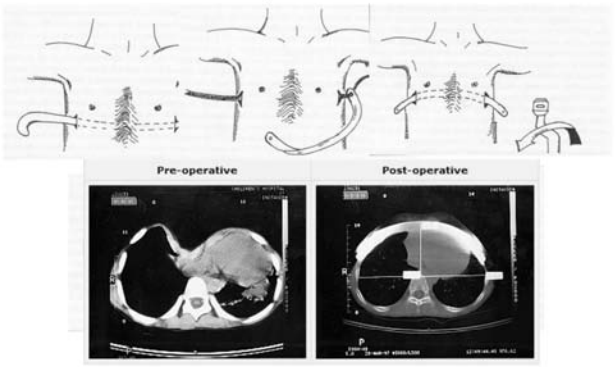
- less than satisfactory late outcomes
- corrected position of the sternum using substernal support
- The principles of modern pectus excavatum surgery
  - Ravitch in 1949.

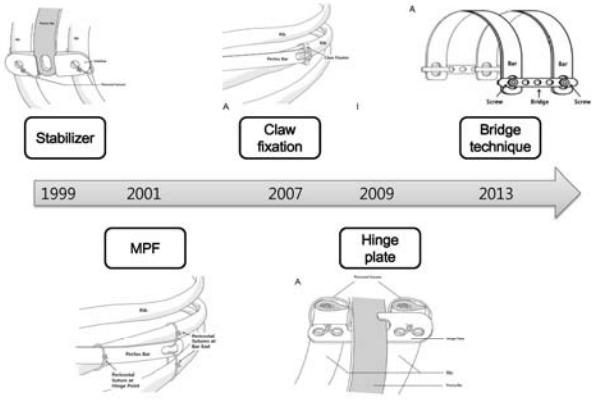
  (a) the removal of deformed cartilages,
  (b) division of the xiphisternal articulation,
  (c) transverse cuneiform osteotomy of the sternum at the upper level of the deformity
  (d) maintenance of the corrected position of the sternum

New Pectus Excavatum Surgery

- "minimally invasive repair of pectus excavatum" by Donald Nuss in 1998
- the number of patients operated for pectus excavatum has more than tripled in the last few years

Nuss procedure





Vaccum Bell

- Klobe's suction cup for pectus excavatum:

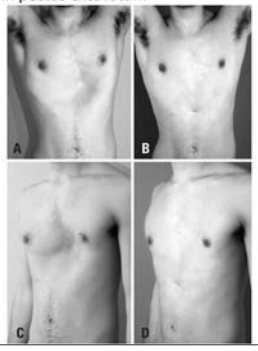
"If the chest can be pushed out, can it be pulled out"

Magnetic Mini Mover Procedure (3MP)

- uses two magnets to slowly reconfigure the child's chest, similar in concept to orthodontics.
- By adjusting the external magnet (Magnatrac), the internal magnet (Magnimplant) can slowly reconfigure the chest

Silastic molds

- Allen and Douglas implanted Silastic molds into the subcutaneous space to fill the depression in pectus excavatum



Pectus Carinatum

- Pectus carinatum is 16.7% of all chest wall deformities in the Boston children's hospital experience.
- Chondrogladiolar type : most frequent form
  - anterior protrusion of the body of the sternum
  - protrusion of the lower costal cartilages
- Chondromanubrial or "pouter pigeon" deformity : least frequent form
  - protrusion of the upper costal cartilages
  - relative depression of the body of the sternum.

Pectus Carinatum

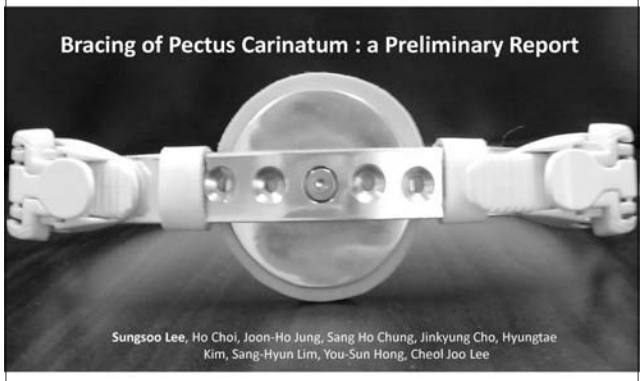
- Etiology : not clear
  - an overgrowth of the costal catilages with forward buckling of the cartilages and anterior displacement of the sternum
  - genetic basis : 26% had a family history of chest wall deformity and 12% of scoliosis.
  - more frequent in boys than in girls - 3:1
- PC is rarely present at birth
  - deformity was not identified until after the eleventh birthday
  - deformity often progresses during early childhood particularly in the period of rapid growth at puberty.

Surgical repair

- The current correction of Pectus Carinatum is surgical, often involving resection of costal cartilages and sternal osteotomy and recently there are minimally invasive modifications using thoracoscope.
- The majority of these operations are variations of the procedure first described in 1949 by Ravitch.

Compressive bracing for Pectus carinatum

Bracing of Pectus Carinatum : a Preliminary Report



Sungsoo Lee, Ho Choi, Joon-Ho Jung, Sang Ho Chung, Jinkyung Cho, Hyungtae Kim, Sang-Hyun Lim, You-Sun Hong, Cheol Joo Lee

Results

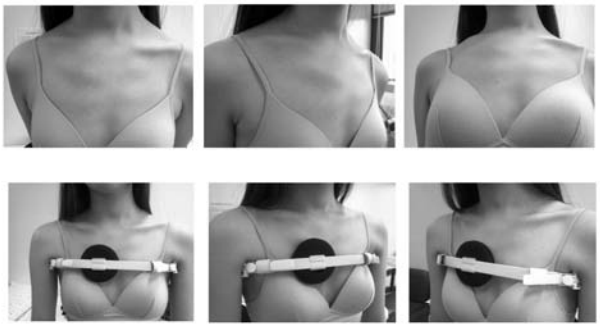
- 13 (72.2%) patients have completed treatment (mean bracing time, 4.9 ± 1.4 months).

- Minimal recurrence of pectus carinatum after removal of the compressive brace occurred in 5 (38.5%) of 13 patients.
- All these patients stopped wearing the compressive brace in 4 months against our advice.

New brace

Overcorrection

Atypical lesion



Flared rib

Brace with Excercise

Sydney A Haje, MD – Dynamic Remodeling

Poland's syndrome

- In 1841, while Poland was a medical student, he described congenital absence of the pectoralis major and minor muscles associated with syndactyly
- Incidence of 1 in 30,000 to 32,000
- Associated with
  - Unilateral palsy of the abducens oculi muscle and facial muscles
  - Abnormalities of the hand
    - Syndactyly
    - Hypoplasia of the thumb
    - Hypoplasia or aplasia of the middle phalanges
    - Rarely, complete absence or hypoplasia of the hand and forearm

Hyperhidrosis

Hyperhidrosis

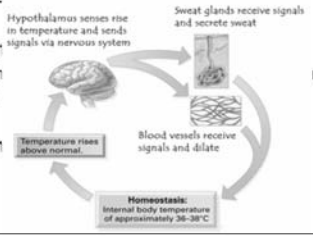
- Pathologic condition of *excessive sweating* in amounts *greater than physiologically needed for thermoregulation*

Pathogenesis

- **Eccrine sweat glands are responsible for hyperhidrosis**
  - mixture of the two [apo/eccrine] glands may play a role in axillary hyperhidrosis
- **A sympathetic signal is carried to sweat glands by cholinergic a**
- **Idiopathic (**
  - Sweat glan
  - Abnormal

nally normal.

- **Genetic com**



Types of hyperhidrosis

- **Focal or primary hyperhidrosis**
  - face, palms, soles, or axillae
- **Generalized sweating(secondary)**
  - Excessive heat and obesity
  - Infections, endocrine disorders, neuroendocrine tumors, malignancy, neurologic disorders, toxins, and previous spinal cord injuries
  - Present as adults and have excessive sweating that occurs both while awake and asleep

Treatment

- **Nonsurgical Treatment**

Table 2. Comparison of Therapies for Primary Hyperhidrosis

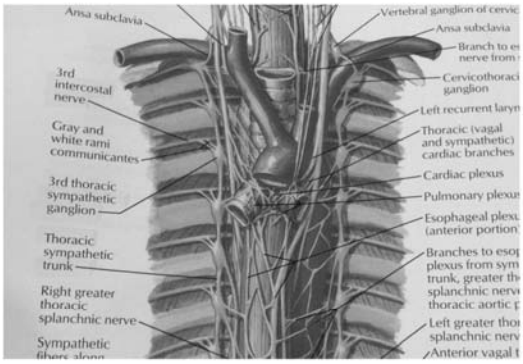
Treatment	Cost[a]	Side Effects
Topical, 20% to 35% aluminum chloride	$288+/year	Skin irritation, localized burning, stinging, desquamation, poor efficacy, temporary (lasts about 48 hours per application)
Iontophoresis (usually 20 mA 3 to 4 treatments a week for 30 to 40 minutes each)	$500/device	Irritation, dryness or peeling of skin, burning or stinging during therapy, temporary (one treatment lasts 1 to 4 weeks). Not recommended for women who are pregnant or for persons with pacemakers or substantial implants (eg, joint replacements)
Oral therapy (glycopyrrolate, atropine, acetylcholine inhibitors)	$240+/year	Dry mouth, dry eyes, constipation, mydriasis, difficulty urinating, blurry vision
Botulinum toxin (Botox A or B)	$2,250/session	Pain from injections, muscle weakness, headache, hematoma, swelling, need for repeat procedures
Liposuction/VASER	$3,000/session	Hematoma, superficial skin erosion, alopecia, paresthesia
Endoscopic thoracic sympathotomy	$15,000	Compensatory hyperhidrosis, bradycardia, pneumothorax, postoperative pain, Horner's syndrome

[a] Approximate cost in US dollars.

Nomenclature for Sympathetic Surgery

- **Rib- oriented nomenclature**
  - Too many patients having mediastinal fat that can obscure clear identification of the specific ganglia
  - Many anatomical variations in the ganglion anatomy
- **Type of interruption**
  - Clipped, cut, or cauterized, or a segment removed
- For example
  - Clipped R5, top
  - cauterized, top R4, bottom R4

Nomenclature for Sympathetic Surgery



Patient Selection

- Surgical consultation should include
  - Secure diagnosis of **primary focal** hyperhidrosis
  - **Anatomic locations** involved
  - **Amount** of hyperhidrosis
  - Full discussion of the options to surgery and potential complications
- The patients should be made aware that the most satisfied patients are those with palmar or palmar-axillary hyperhidrosis, or both.

Location of Interruption of Sympathetic Chain

- **Palmar hyperhidrosis**
  - **R4 alone** interruption(*Yang and colleagues,2007*)
    - Limits the degree of CH
    - May lead to moister hands
  - **R3, R4** interruption
    - Completely dry hands
    - Higher risk of CH
- **Palmar and plantar hyperhidrosis**
  - **R4** interruption
    - Reduce incidence of CH
  - **R4 and R5** intervention
    - Drier feet

Axillary Hyperhidrosis

- ETS for axillary hyperhidrosis
  - often less successful and has higher "regret rates" than ETS for palmar hyperhidrosis.
- **R4 and R5 transection is suggested**
  - Palmar-axillary, palmar-axillary-plantar, or pure axillary hyperhidrosis
- A qualitative review shows a trend of lower incidence of CH with fewer interruptions
  - Incidence of CH *(Munia and colleagues, 2008)*
    - R3/R4 ETS 100% and higher severity
    - R4 ETS alone (42%)
  - Patients who underwent R5 clipping alone experienced no CH, and none regretted having the surgery *(Chou and associates)*

Craniofacial Hyperhidrosis

- R2 vs R3
  - R3: 9% regretted the procedure, and 27% reported CH
  - R2: 16.7% regretted and more than 40% experienced CH
- R2 vs R2+R3
  - significantly higher CH rate in the group that underwent the R2 and R3 transection (95%), as compared with the R2 group (83%)
- **R3-alone interruption is suggested**
  - It reduces the risk of CH and the risk of Horner's when compared with R2 or an R2 and R3 transection

Type of Interruption

- Transection? Resection? Ablatation with a cautery? Division with a harmonic scalpel? or Clipping?
  - No clear differences
    - If the correct level division was achieved
  - Enough separation between the ends of the chain
    - Regrowth is impossible

Complications and Treatment

- Primary side effects of hyperhidrosis surgery
  - CH, bradycardia, and Horner's syndrome
    - The higher the level of blockade on the chain, the higher is the expected regret rate

Compensatory Hyperhidrosis

- **The most common side effect**
  - which occurs in the literature from 3% to 98%
- **The most common risk factor**
  - T2 ganglion interruption(R2, R3)
  - The number of levels interrupted has been inconclusive as a risk factor
- **Preoperative testing**
  - Injecting bupivicaine
    - reversibly achieve sympathetic nerve blockade observe for CH
- **Treatment**
  - Ditropan or other anticholinergic medications in escalating doses

Horner's syndrome

- **0.7% and 3% after ETS**
- **Addressed in patients with craniofacial hyperhidrosis**
  - Direct injury by cautery, traction, or surrounding inflammation can occur owing to improper localization of the second rib
  - The risk of this complication may be minimized with procedures performed below the second rib (R2)
  - Anatomically, the stellate ganglion can be lower on the left side down to R3

- **Permanent bradycardia**
  - Resting heart rate less than 55 or 50 beats per minute
    - who may require a pacemaker
- **Recurrent hyperhidrosis**
  - Incidence rates vary considerably and have been described as 0% to 65%
- **Others**
  - pneumothorax requiring chest tube drainage (1%)
  - pleural effusion (1%)
  - acute bleeding or delayed hemothorax (1%)
  - Chylothorax
  - persistent intercostal neuralgia (1%)

Thoracic Outlet Syndrome

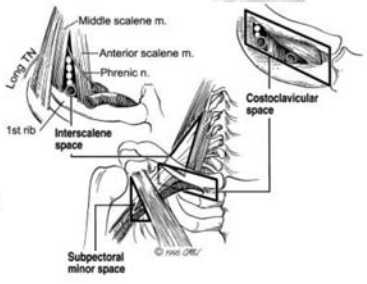
What is TOS

- TOS is a group of anatomically related, conditions caused by compression of neurovascular structures that serve the upper extremity.

Scalene triangle

Costoclavicular space

Pectoralis minor space



Classification

Type	Characteristics
Neurogenic TOS 85 – 90%	Caused from **brachial plexus compression** Symptoms include **pain, dysesthesia, numbness, weakness – not localized** in specific peripheral nerve distribution
Venous TOS	Caused from **subclavian vein compression** Symptoms include **swelling, paresthesias** in the fingers
Arterial TOS	Caused from **subclavian artery compression** Almost always associated with a **cervical rib** or **anomalous rib** Symptoms include **hand ischemia** with **pain, pallor, paresthesia, coldness**

Cause

- Congenital abnormality
  - Cervical rib
  - Prolonged transverse process
  - Muscular abnormality(ant. scalene m., sickle-shaped scalene m.)
  - Fibrous connective tissue anomalies.
- **Trauma**
  - **Whiplash injury**
- **Repetitive strain**
- Etc.
  - Tumor
  - Hyperostosis
  - Osteomyelitis

Evolution of TSO surgery

Table 1 Evolution of thoracic outlet syndrome surgery

Name of operation	Year first performed	Surgeon who introduced it
Cervical rib resection	1861	Coote
First rib resection	1908	Murphy
Scalenotomy	1927	Adson/Coffey
First rib resection – posterior approach	1961	Clagett
First rib resection – supra- and infraclavicular approach	1960s	Various surgeons
First rib resection – transaxillary approach	1966	Roos
Scalenectomy	1938	Adson
Refined scalenectomy	1979	Sanders
Combined approach (transaxillary first rib resection followed immediately by transcervical anterior and middle scalenectomy)	1989	Atasoy

(Adson and Coffey 1927; Atasoy 1996, 2004b)

TOS Surgery Cases

- Barnes-Jewish Hospital : 285 cases/2014
- USA : about 2000 cases annually
- More than 100 cases : 5 institutes in USA
- In KOREA **Neglected 333 cases ?**
- Thoracic Surgery data registry
- 4.2 cases annually for 5 years

Message

TOS surgery is one of thoracic surgeon's area.

Thank you for your attention!

Diseases of Trachea and Chest Wall

Department of Thoracic and Cardiovascular Surgery, Ajou University School of Medicine, Suwon, Korea

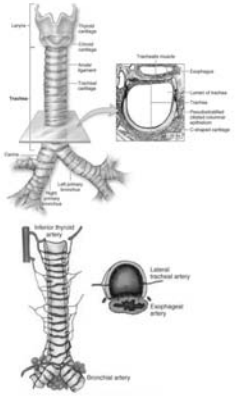
Seong Yong Park, M.D., Ph.D.

Agenda

- Trachea disease
- Acquired chest wall disease

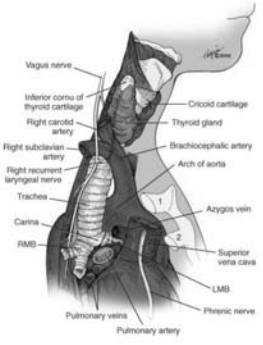
TRACHEAL DISEASE

Anatomy of Trachea



- C-ring structure
- Blood supply from inferior thyroidal artery and bronchial artery
- Segmental vascular supply
- Submucosal blood supply (perfusion pressure 20~20mmHg)
- Recurrent laryngeal nerve

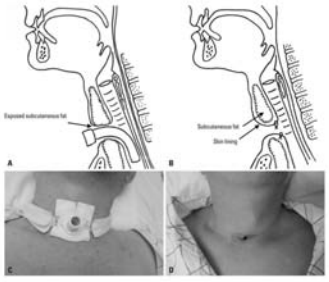
Recurrent Laryngeal Nerve



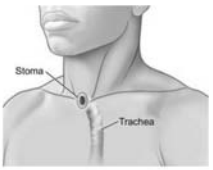
Disease of Trachea

- Benign disease
  - Tracheal stenosis
  - Tracheal perforation
  - Tracheo-esophageal fistula, Tracheo-innominate artery fistula
  - Tracheal malacia
- Malignant disease
  - Primary tracheal tumor
  - Secondary tracheal tumor

Tracheostomy



Standard tracheostomy Tracheal fenestration



Permanent stoma
(mediastinal tracheostomy)

Tracheostomy tube

Portex tube

Vocalaid tube

Koken tube

Adjustable tube

Primary Tracheal Tumor

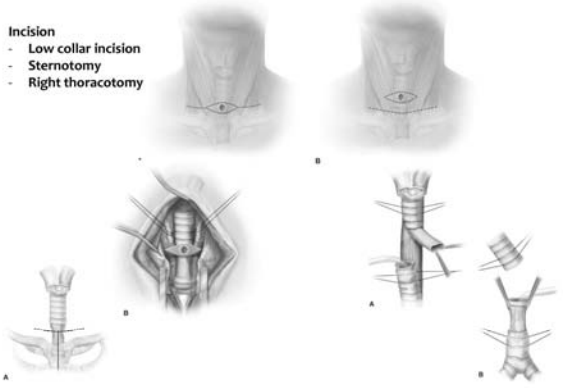
- Most common pathology
  - Adenoid cystic carcinoma
  - Squamous cell carcinoma
- Symptoms
  - Adult onset asthma
  - Stridor
- Diagnostic tools; CT, bronchoscopy, BUS
- Treatment
  - Surgical resection; Length of resection and radial margin
  - Endoscopic procedures
  - Radiotherapy

Secondary Tracheal Tumor

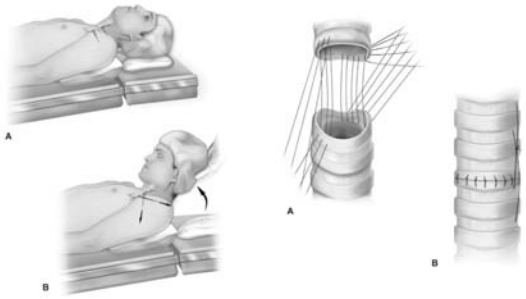
- Most common pathology
  - Direct invasion from lung, esophagus, thyroid..
  - Metastasis; breast cancer, renal cell carcinoma..
- Treatment
  - Surgical resection with en bloc manner
  - Conservative treatment; to maintain the airway patency

End-to-End Anastomosis of Trachea

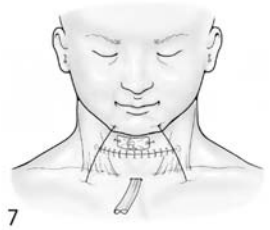
Incision
- Low collar incision
- Sternotomy
- Right thoracotomy



End-to-End Anastomosis of Trachea



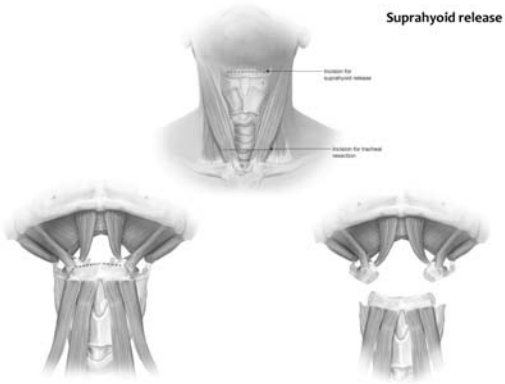
End-to-End Anastomosis of Trachea



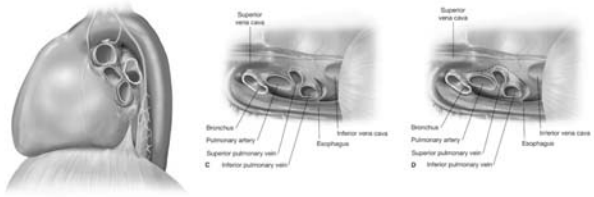
- Possible resection length; about 4-6cm
- Contraindication
  - Expected prolonged intubation (mechanical ventilation)
  - Steroid use
- Principles of postOp. management
  - Early extubation
  - Keep neck flexion
  - Bronchial toileting

7

Release Maneuver



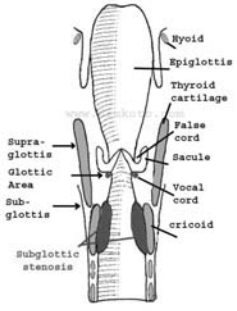
Release Maneuver



Hilar release

Intubation related Injury

- Subglottic stenosis
- Stoma stenosis
- Cuff-related stenosis
- Tracheal laceration (perforation)

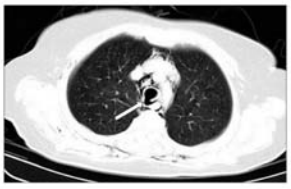


Subglottic stenosis

Tracheal stenosis

- Most common cause
  - Prolonged intubation (subglottic stenosis) & tracheostomy (cuff related stenosis)
  - High cuff pressure
    - Cuff pressure < 23~25mmHg
    - Cuff pressure < Capillary perfusion pressure of mucosa
- Management
  - Bougination
  - T-tube
  - Silicon stent
  - End-to-end anastomosis

Tracheal Perforation

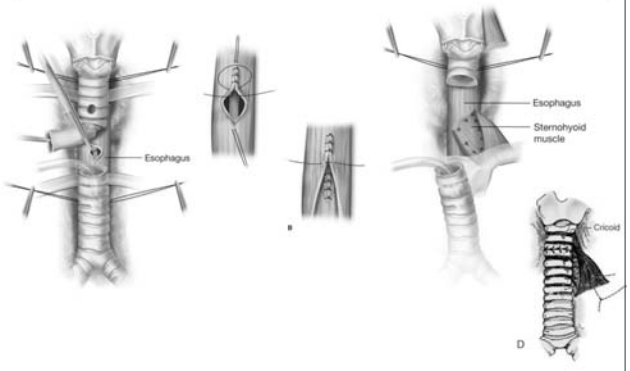


- Post-intubation tracheal tear
- Cause
  - Intubation injury
  - Procedure-related injury
- Treatment
  - Conservative care
  - Surgical repair
  - Tracheal stenting

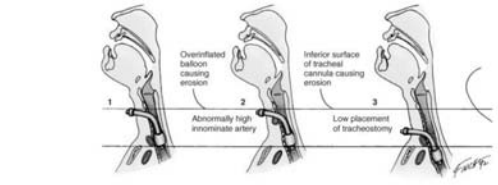
Tracheo-esophageal fistula

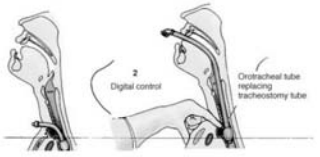
- Key of treatment; ventilator!
- Weaned off the ventilator
  - One-stage repair
- Keep the ventilator
  - Remove nasogastric tube
  - Tracheostomy tube; low pressure, below the fistula
  - Gastrostomy and feeding jejunostomy
  - Frequent suctioning
  - Weaning from the ventilator

Repair of TEF



Tracheo-innominate artery fistula

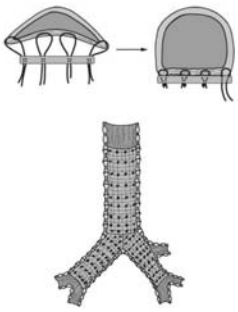




- Mortality; more than 80%
- Principles of management
  - Keep airway
  - Control of bleeding
  - Resuscitation

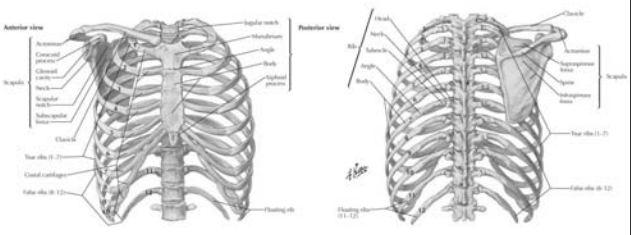
Tracheomalacia

- Segmental vs. Diffuse
- Congenital vs. Acquired (trauma, postintubation injury, emphysema..)
- Diagnosis
  - Dynamic airway CT
  - Functional bronchoscopy
- Benefit from surgical treatment
  - Segmental tracheomalacia
  - Patients with good lung function
- Operation
  - Tracheoplasty (splinting)
  - Tracheal stenting



ACQUIRED CHEST WALL DISEASE

Chest wall anatomy



Acquired Chest Wall Disease

- Chest wall tumor; rare (300 case / year in USA)
  - Benign chest wall tumor
  - Malignant chest wall tumor
    - Most common; Lung cancer direct invasion
  - (bone and cartilage tumor vs. soft tissue tumor)
- Infectious chest wall disease
  - Osteomyelitis; rib, sternum
  - Sternoclavicular joint infection
- Radionecrosis
- Most important symptom; chest wall pain

Diagnostic Tools

- Chest CT
- PET or bone scan (metastasis evaluation)
- MRI
- Ultrasound sonography
- Biopsy
  - Needle aspiration
  - Core needle biopsy
  - Excisional biopsy

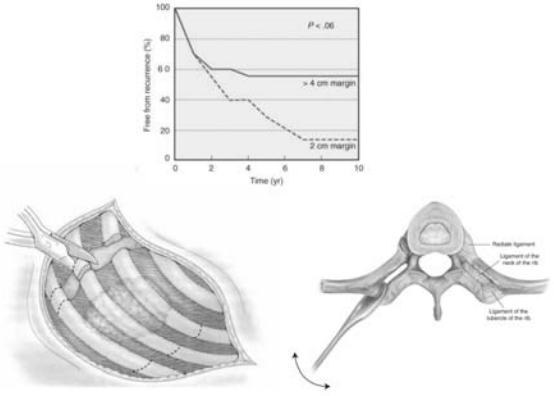
Primary chest wall neoplasms

	Bone and cartilage tumor	Soft tissue tumor
Benign	Osteochondroma Chondroma Fibrous dysplasia Eosinophilic granuloma	Lipoma Fibroma Neurilemmoma Fibrolipoma
Malignant	Chonrosarcoma Plasmacytoma Osteosarcoma Ewing's carcinoma	Desmoid Fibrosarcoma Malignant fibrous histiocytoma Leiomyosarcoma Hemangiosarcoma Primitive neuroectodermal sarcoma

Principle of chest wall resection

- Resection
  - En bloc resection (Obtain the proper resection margin)
  - Start with the easier side to expose
- Restoration of skeletal stability
  - Normal breathing (prevent paradoxical movements)
  - Protection of intrathoracic organs
  - Restoration of physiologic volume of rib case
  - Satisfactory cosmetic results
- Soft tissue coverage

Surgical Technique



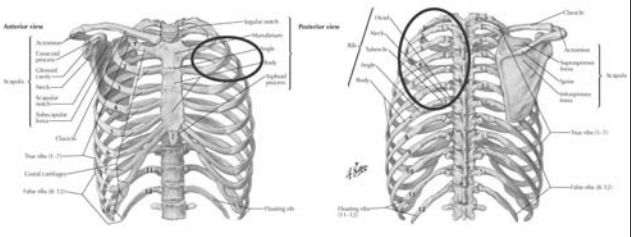
Consideration for chest wall defects

- Location
- Size
- Depth
  - Partial thickness
  - Full thickness
- Duration
- Condition of local tissue
  - Irradiation
  - Infection
  - Residual tumor
  - Scarring
- General condition of patient
  - Chemotherapy
  - Corticosteroid
  - Chronic infection
- Lifestyle and type of work
- Prognosis

Factors for Paradoxical Movements

- Size of defect
  - No absolute length
  - >5cm of two consecutive ribs
- Location of defect
  - Non-critical area; apical (1-3th ribs) or posterior area
  - Critical area; lateral, anterior, basal and SC joint

Non-critical area

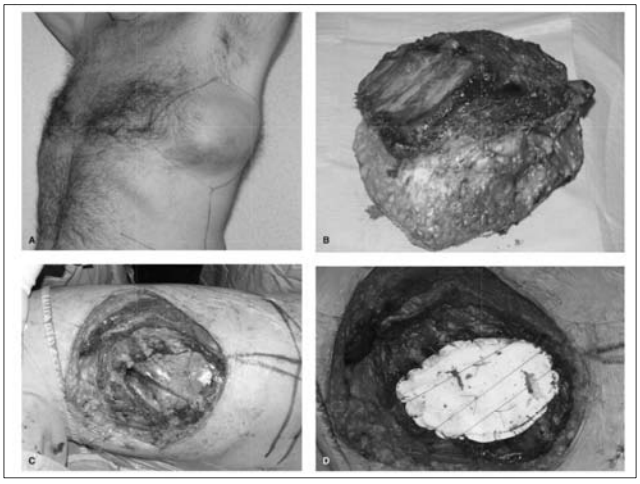


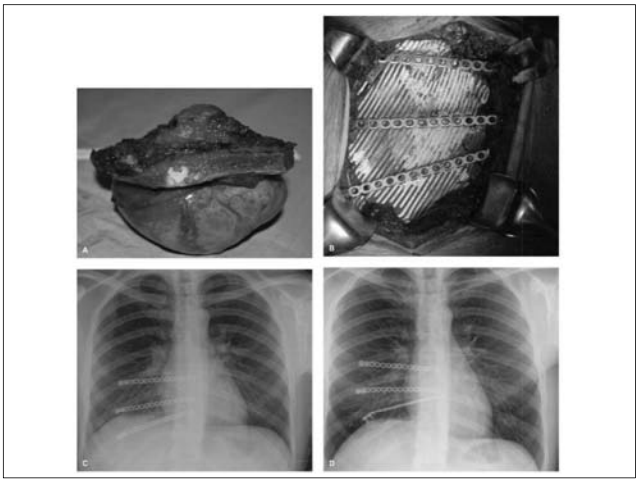
Ideal materials for reconstruction

- Strong enough to withstand physiologic stresses
- Elastic and flexible
- Light and smooth
- Incorporable into host tissue
- Solid
- Securely flexible
- Biocompatible
- Durable and not subject to deterioration over time
- Resistant to infection and radiation
- Not dangerous in case of blunt trauma
- Radiolucent and nonmagnetic
- Inexpensive
- Readily available

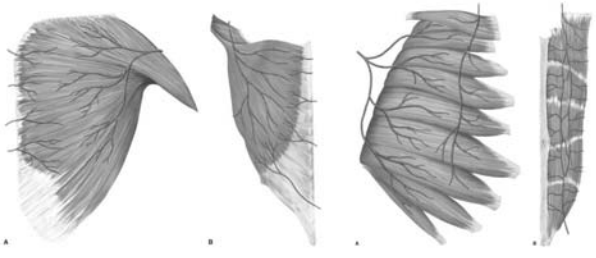
Alloplastic and Synthetic Materials

- Plates and Struts
  - Metal
    - Tantulum steel
    - Stainless steel
  - Other materials
  - Lucite
  - Fiberglass
- Synthetic Materials
  - Sheets and meshes
  - Polytetrafluorethylene (Teflon) sheeting and patch
  - Nylon
  - Polypropylene
  - Prolene mesh
  - Vicryl mesh
- Solid and Firm Prosthetics
  - Acrylic
  - Teflon
  - Silastic
  - Silicone
  - Composite
  - Marlex mesh combined prosthesis



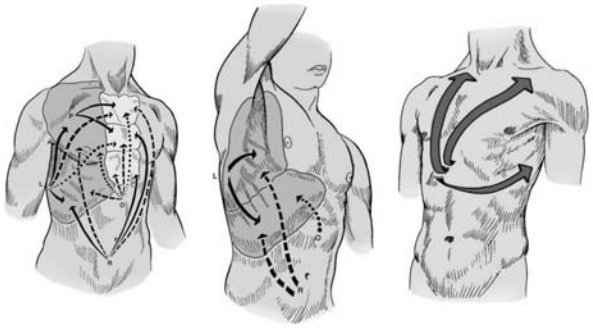


Muscle flap

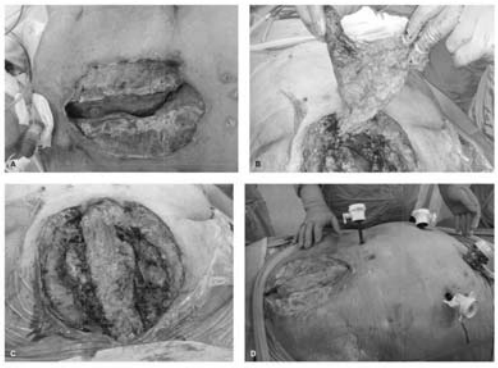


Pectoralis major | Latissmus dorsi | Serratus anterior | Rectus

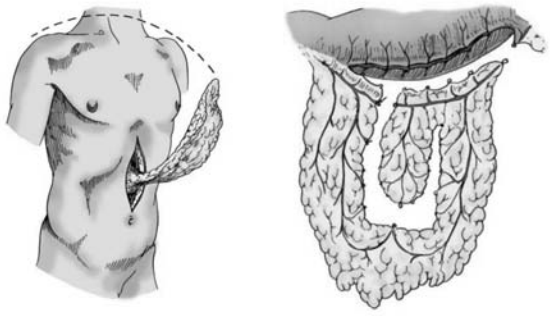
Muscle flap



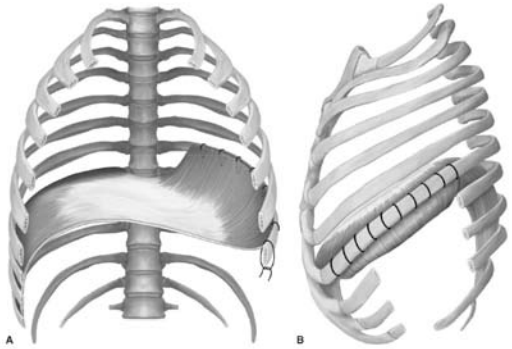
Omental flap



Omental flap



Lower Chest Wall Reconstruction



EndNote 사용법

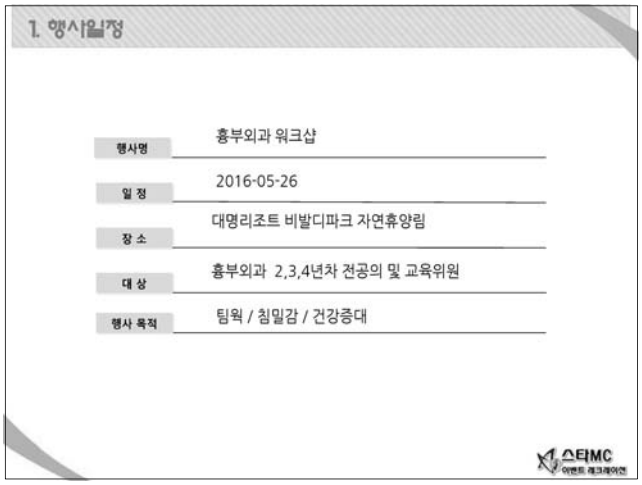
세종병원 흉부외과

장 형 우

【두릉산 자연휴양림
트래킹 C코스 2.5 km】

트래킹 프로그램

스타MC 이벤트 레크레이션



4. 세부프로그램- 진행팀 소개 및 몸풀기

구분	항목	시간	내용	비고
환영 팀빌딩	Warm up	20 분	• 아이스 브레이킹 - 팀별 안마 박수, 상호인사	
	팀장 및 팀명, 팀 구호		• 각 팀 별 팀장 선발, 인터뷰 및 의지표현의 시간 • 팀장의 진행으로 팀 별 파이팅 구호 선정	
	몸풀기 운동		• 몸풀기 운동	
	BASE		• 전체 파이팅- 팀 별 자리에서 일어나서 점프를 하여 파이팅을 외치는데 가장높이 점프하는 팀에게 점수 부여 후 언저 출발기회	

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5. 치유의 숲 코스

C코스 (1포스트-2포스트-3포스트-4포스트)

▪ 치유의 숲 C코스- 2.5KM(80분)

두룽산 치유의 숲이란?
인체의 면역력을 높이고 건강을 증진시키기 위하여 산림의 다양한 환경요소를 활용할 수 있도록 조성한 산림이며, 다양한 치유 프로그램등을 통해 숲을 치유의 공간으로 활용하는 숲

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6. POST 해결과제 세부내용 (1/8)

거미줄 통과
(Escape-Spider web)

- 과 제 명 거미줄 통과
- 개 요 5명이 다른 팀원들의 도움을 받아 거미줄 형태의 장애물을 건드리지 않고 통과하는 과제
- 소요인원 8명 (운반조 5명 / 통과조 3명)
- 사용도구 Frame 1Set / 방울 3개 / 고무줄
- 개발역량 협력, 위기관리, 창의적 아이디어

볼 바운딩
(Ball-Bounding)

- 과 제 명 볼 바운딩
- 개 요 8명이 볼바운딩 판의 끈을 나누어 잡고, 공을 10회 바운딩하는 과제 협력자는 공을 던져주거나, 떨어지는 공을 던져주는 역할을 수행
- 소요인원 9명 (실행조 8명 / 협력자 1명)
- 사용도구 볼바운딩 판 / 탱탱볼
- 개발역량 신속한 판단, 신뢰, 책임

스타MC 이벤트 레크레이션

6. POST 해결과제 세부내용 (8/8)

몸으로 말해요

- 과 제 명 몸으로 말해요
- 개 요 주어진 문제시트를 통해 팀원전체가 돌아가며 문제를 낸다.
  몸짓으로만 힌트를 줄 수 있다.
  정해진 시간에 몇 문제를 맞추는가로 점수측정
- 소요인원 전원
- 사용도구 문제지
- 개발역량 창의력, 아이디어, 커뮤니케이션

디비디비딥

- 과 제 명 디비디비딥
- 개 요 팀전체가 강사와 디비디비딥 게임을 진행.
  연속으로 디비디비딥을 실시 했을때, 탈락선수는 다시 줄을서서 대결한다
  평균통과 시간 측정
- 소요인원 전체
- 사용도구
- 개발역량 몸짓, 스피드

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7. 행사제작물 – 에어아치 개선문

스타MC 이벤트 레크레이션

8. 트래킹코스 이미지

9. 예산기획

구분	항목	내역	금액	비고
인건비 및 소요장비 비용	프로그램 사회자	-팀웍 강사		
	포스트 교관	-포스트 운영 교관		
	음향장비	- 행사진행에 필요한 음향장비 일체 및 음향감독		
	POST게임도구	-포스트 준비물 일체		
	경상비	-포스트 교관, 장비 등 왕복 차량 유류 통비		
	팀 조끼	-60명분 (세탁비)-팀 별 다른 색상		
	음료	- 60명분 생수		
	에어아치	사각기둥 대형 에어아치,현수막(550cm*80cm) 전기리드선, 설치작업		
	아이스 박스/얼음	- 아이스박스, 얼음(대)		
총 계			1,500,000	

스타MC 이벤트 레크레이션

Thank you

::: End of Document :::

회사명	스타엠씨
주 소	경기도 하남시 하남대로 770 (102-406)
대표 전화	010-7385-2828 / 070-8200-9983
F A X	02-6442-9983
홈페이지	www.starmc.kr

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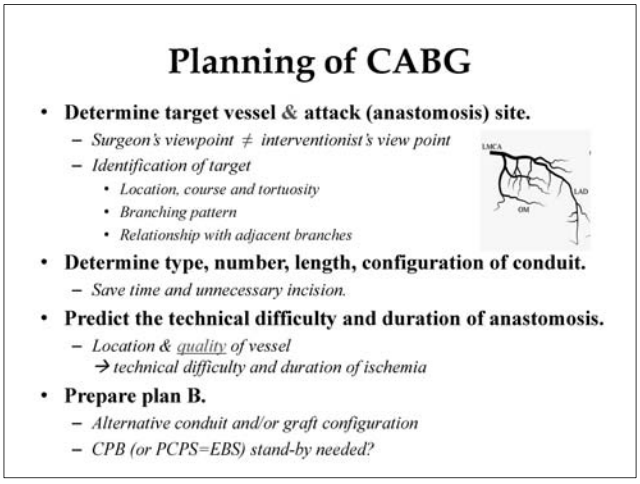
【성인심장 파트】

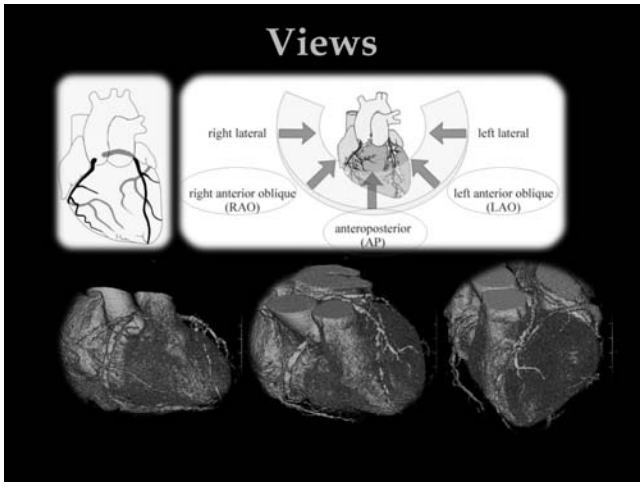
좌장: 박계현

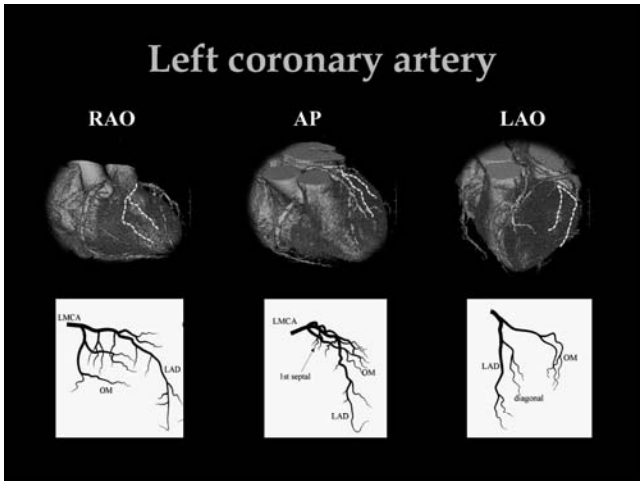
How to Review Coronary Angiogram in Preparation for CABG

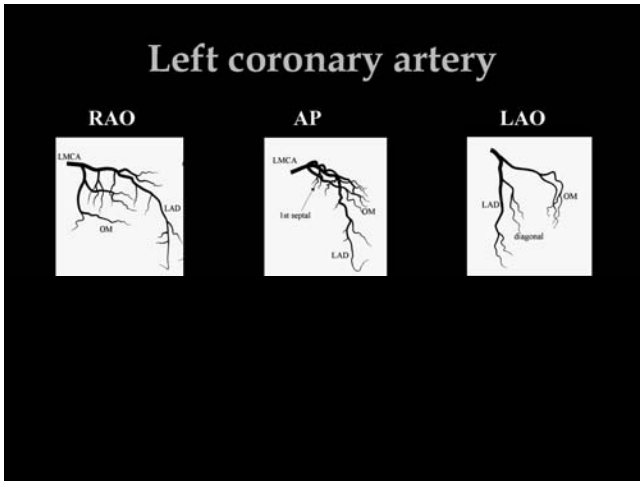
Thoracic and Cardiovascular Surgery, Seoul National University Bundang Hospital

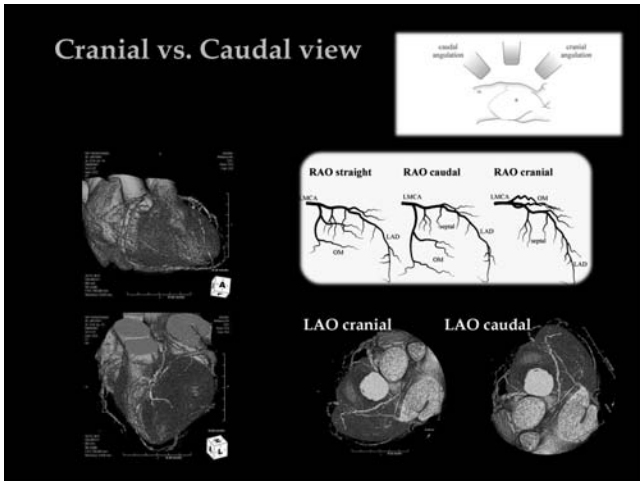
Kay-Hyun Park, M.D.

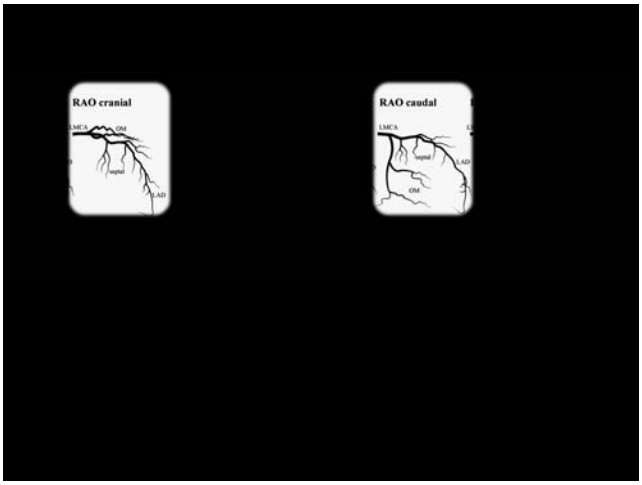


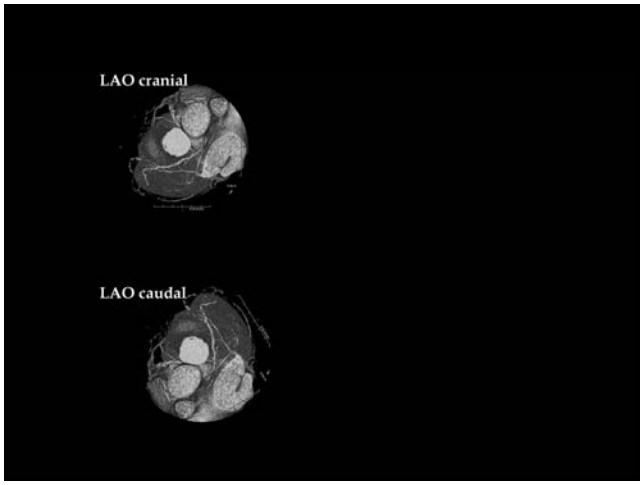


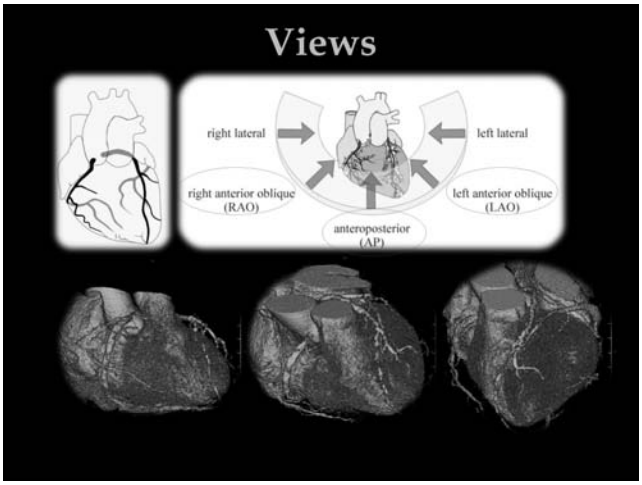


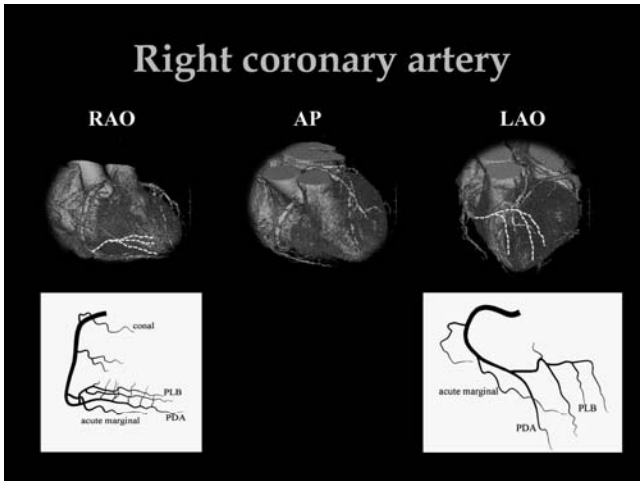


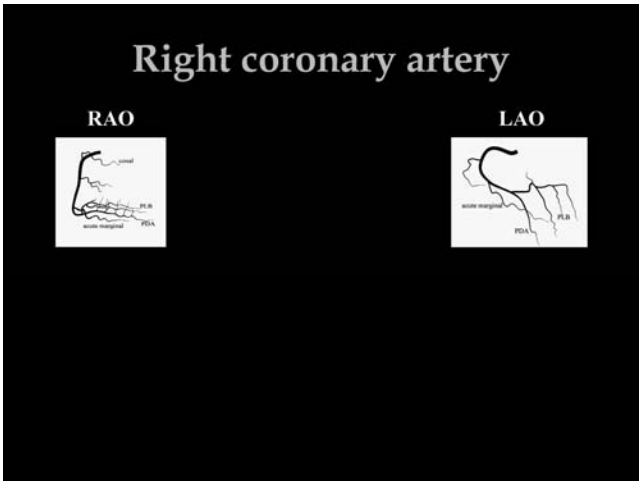

Cranial vs. Caudal view
caudal angulation
cranial angulation
RAO straight
RAO caudal
RAO cranial
LMCA
OM
septal
LAD
LAO cranial
LAO caudal

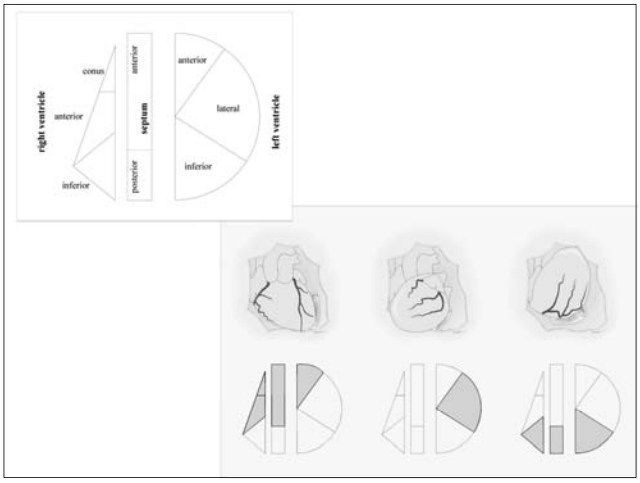

RAO cranial
RAO caudal
LMCA
OM
septal
LAD

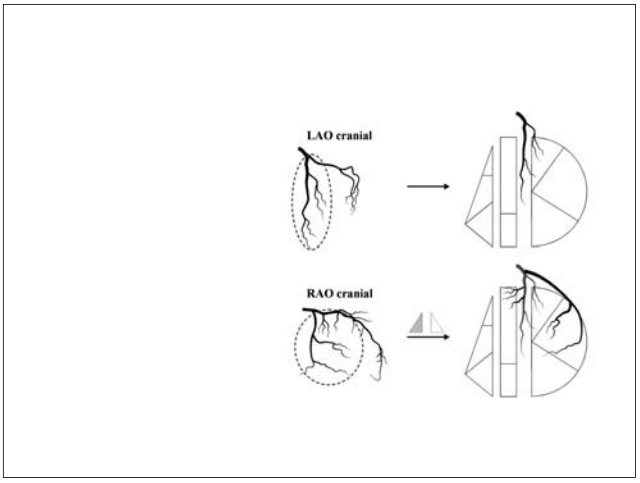

LAO cranial
LAO caudal

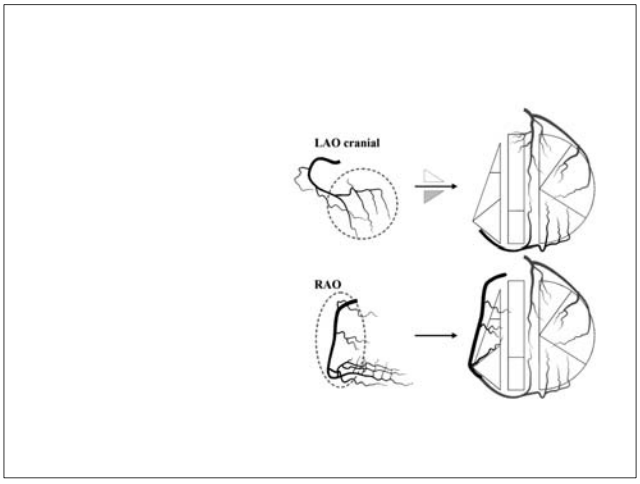

Views
right lateral
left lateral
right anterior oblique
(RAO)
left anterior oblique
(LAO)
anteroposterior
(AP)

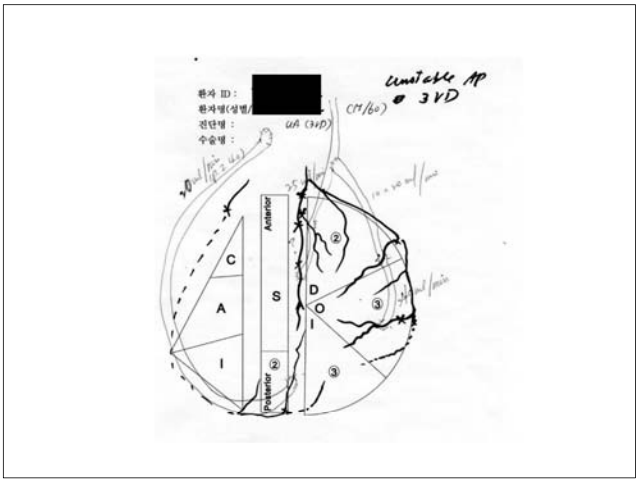

Right coronary artery
RAO
AP
LAO
conal
PLB
acute marginal
PDA


Right coronary artery
RAO
LAO
conal
PLB
acute marginal
PDA





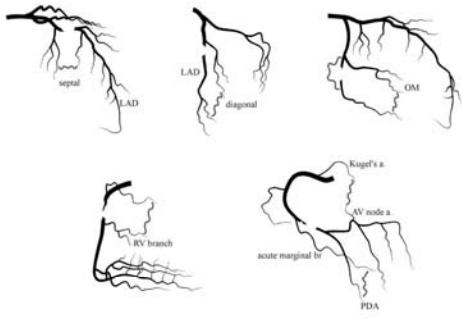


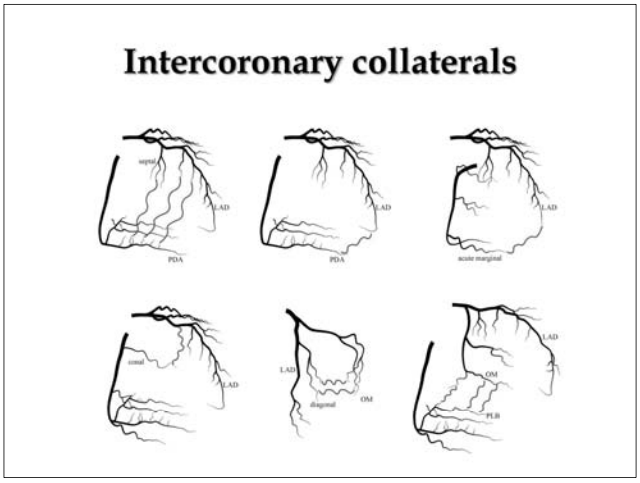


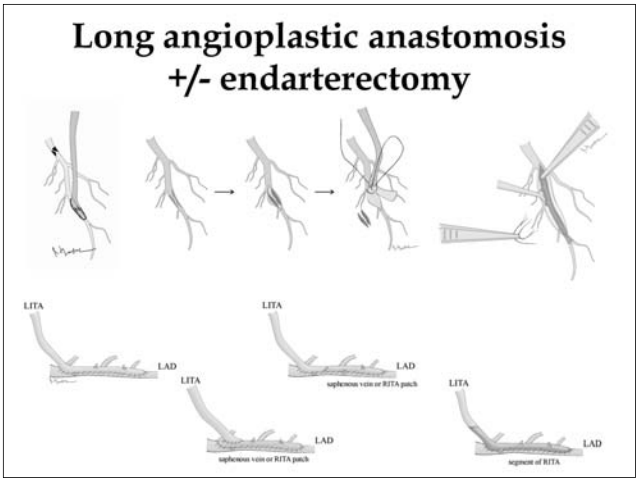
Pitfalls

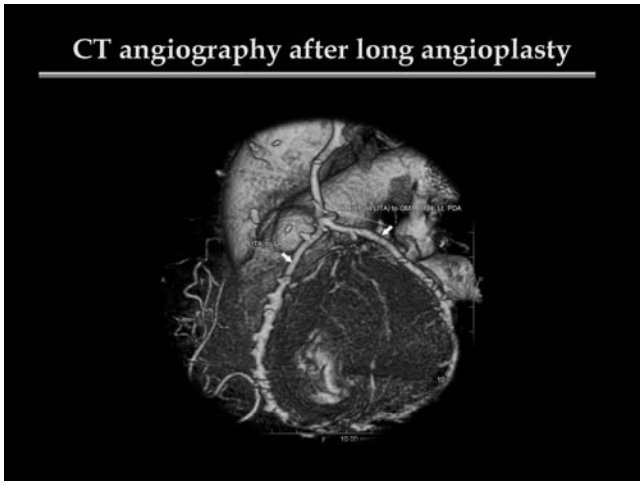
- Faint or no visualization
  - Truly obliterated lumen vs. patent & graftable lumen
  - RCA : total occlusion vs. left dominancy
- Multiple plaques / plaque at branching point
  - Where and how to make anastomosis ?
- Diffuse disease
  - Where and how to make anastomosis ?
- Calcified vessel
  - Calcification vs. contrast enhancement
- Deep-seated or intramyocardial vessel

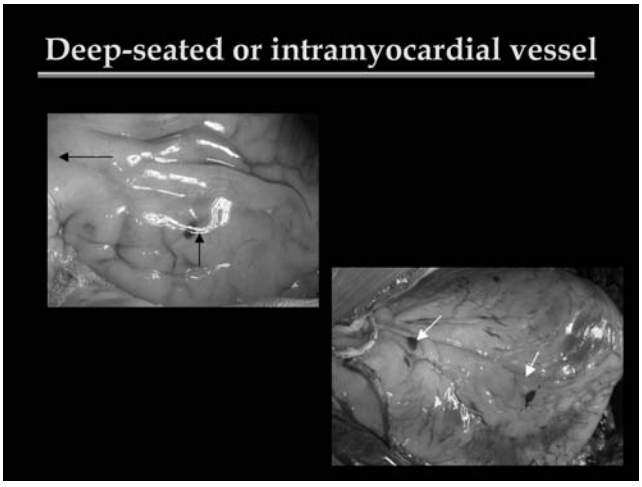
Intracoronary collaterals

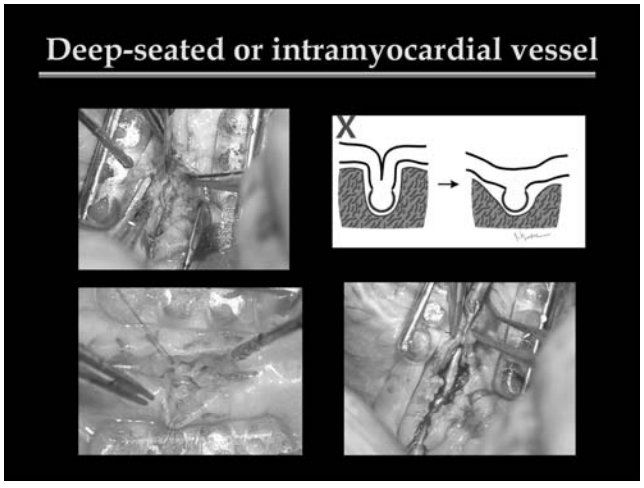


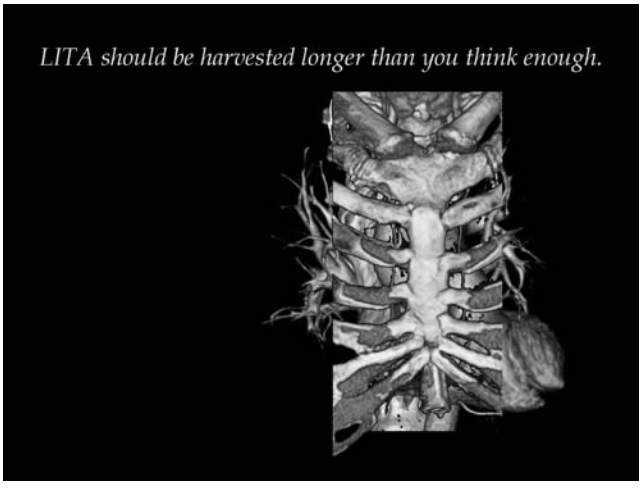

Intercoronary collaterals
LAD
PDA
LAD
PDA
LAD
acute marginal
septal
LAD
LAD
diagonal
OM
LAD
OM
PLB


Long angioplastic anastomosis
+/- endarterectomy
LITA
LAD
LITA
LAD
saphenous vein or RITA patch
LITA
LAD
saphenous vein or RITA patch
LITA
LAD
segment of RITA


CT angiography after long angioplasty


Deep-seated or intramyocardial vessel

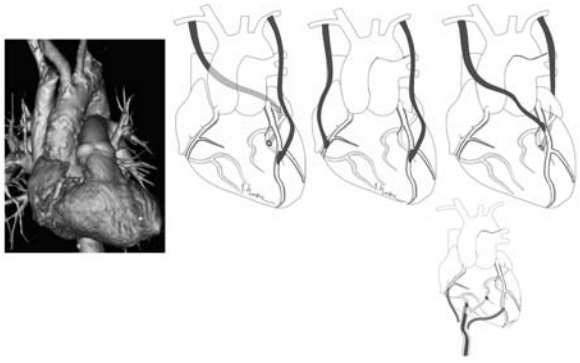

Deep-seated or intramyocardial vessel
X


LITA should be harvested longer than you think enough.

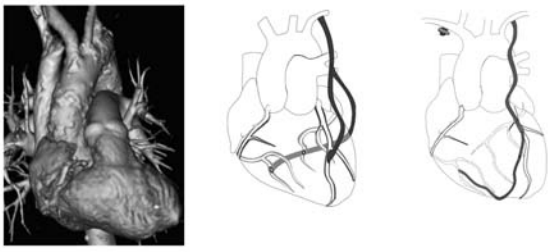
Other things to see in preop. imaging

- Internal thoracic arteries (& subclavian arteries)
- Ascending aorta and arch
- Valve calcifications & insufficiency
- Cardiac size

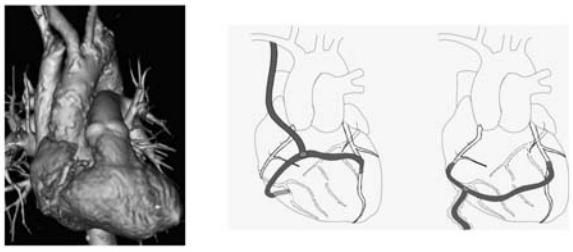
No-Aorta-Touch Technique
- OPCAB with pedicled arterial graft only -



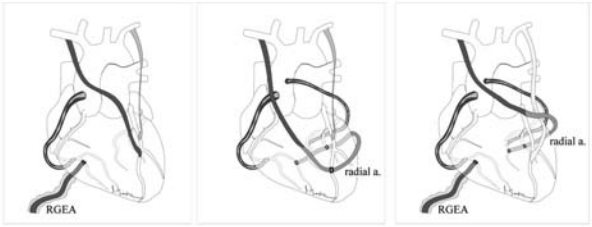
No-Aorta-Touch Technique
- OPCAB with pedicled arterial graft only -



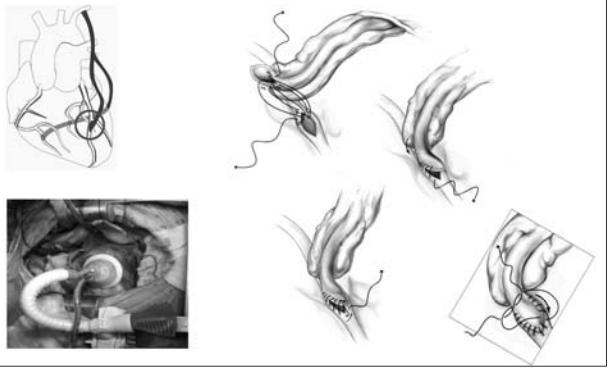
No-Aorta-Touch Technique
when left IMA is unavailable



No-Aorta-Touch Technique
when left IMA is unavailable

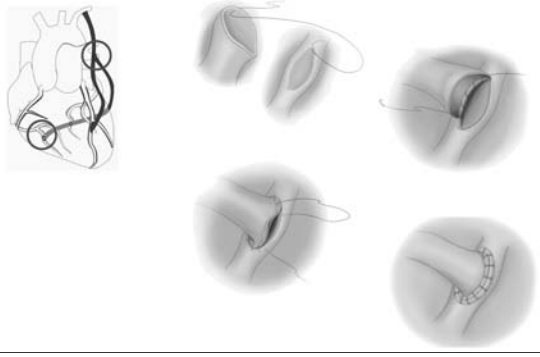


End-to-side anastomosis

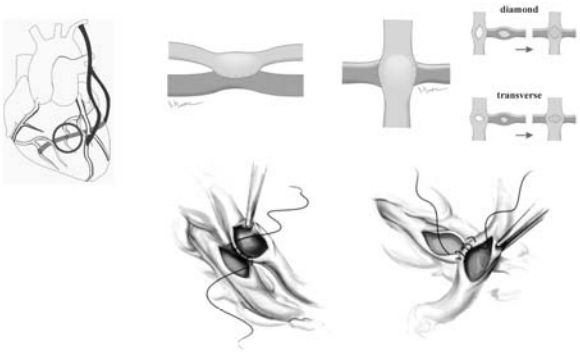


End-to-side anastomosis

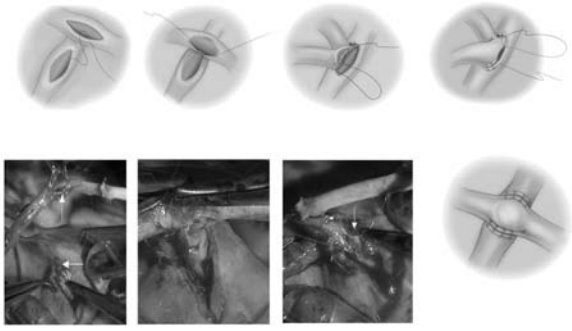
- perpendicular -



Side-to-side anastomosis

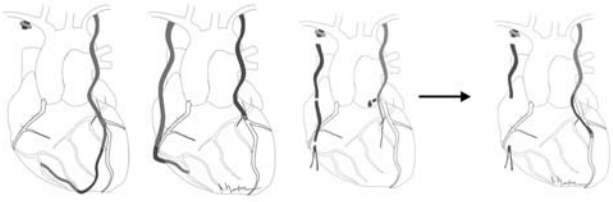


Side-to-side anastomosis

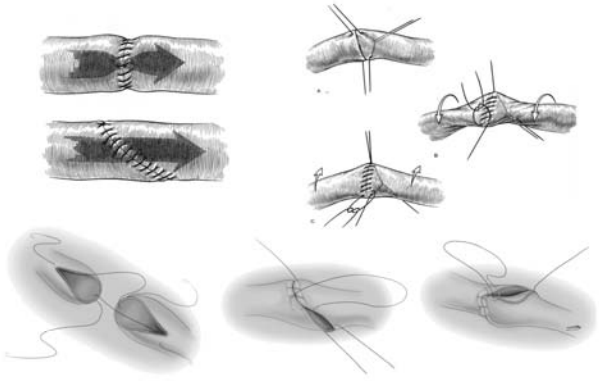


End-to-end anastomosis

- Revision for graft kinking / torsion / redundancy
- Graft extension (I-graft)
- Use of arterial graft injured during harvesting



End-to-end anastomosis



Take-home messages

- Tragedies occur more from wrong planning than from poor execution.
- Seeing angiogram is not just about ‘where’, it should be also about ‘how’.
- There is no royal road to mastering coronary angiogram but practice.
- Drawing by yourself may be the best start.

Graft Harvesting and Conduit Selection

충남대학교 의과대학 흉부외과학교실

강 신 광

Preoperative preparation is essential for intraoperative planning (myocardial protection strategy and conduit selection)

- ✓ SBP difference of upper arms >20 mmHg; significant subclavian stenosis → free graft or alternate conduits
- ✓ varicosities or previous operation of lower vein
- ✓ postprandial pain → Imaging to determine disease in celiac-mesenteric axis; contraindicates gastroepiploic artery use, endoscopy, stomach cancer in Korea
- ✓ CKD for HD ⇒ free ITA graft, radial artery(x)
- ✓ Risk of sternal complication; severe obese, DM, COPD
- ✓ Radial artery; Raynaud syndrome, recent arterial puncture, Allen test
- ✓ Carotid bruit(+); TCD. MRA
- ✓ Previous TIA/stroke → Atherosclerotic disease involving arch vessels → carotid duplex examination and echocardiography; possible need for CT or MRI angiogram to elucidate disease extent
- ✓ Recent stroke(+) ⇒ delay 4 weeks
- ✓ Combined CABG and carotid endarterectomy → controversial
- ✓ Bilateral ITA (x) ; emergency operation, insulin-dependent diabetes mellitus, obesity, and severe COPD for which the patient requires oral or intravenous glucocorticoid therapy
- ✓ Skeletonization; no impact long-term survival of graft patency, while decreasing sternal complications
- ✓ Free or pedicled ITA; little difference, short pedicled graft(x) → free graft
- ✓ Unsatisfactory flow (<20 ml/min); spasm, small size, or intraoperative injury such as an intimal dissection → free graft, end-to-end anastomosis, alternate graft
- ✓ Claudication → Peripheral vascular disease → Assess peripheral and central pulses; brachial-ankle index, echocardiography to assess ascending aortic calcification, high op risk (5 times), risk of IABP or VAD use
- ✓ Diabetes mellitus → Poor wound healing; difficult glycemic control perioperatively → Consider skeletonized harvesting
- ✓ Previous sternal irradiation → Internal thoracic artery damage → May contraindicate use of internal thoracic artery
- ✓ Lower extremity vein stripping → Lack of greater saphenous vein → Choose alternative conduits
- ✓ Previous abdominal laparotomy → Possible contraindication to gastroepiploic artery use → Choose alternative conduits
- ✓ Chronic steroid use → Poor wound healing postoperatively; consider steroid withdrawal postoperatively; difficult glycemic control perioperatively → May contraindicate use of bilateral internal thoracic artery use
- ✓ Clubbing → Bronchiectasis; chronic pulmonary hypertension; lung malignancy Chest radiograph; echocardiography

to determine cardiac anatomy

Preoperative medications

- ✓ Aspirin and cardiac medications → continue
- ✓ Digoxin → stop 1 day before
- ✓ Warfarin → stop at least 5days and LMWH (INR <2.0)
- ✓ Clopidogrel → stop at least 5 days, pt with DES within 1 yr → continue
- ✓ ACEI → s-Cr (>25% baseline) → stop

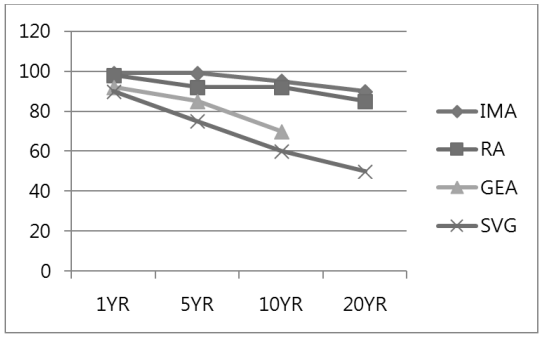
Harvest technique

- ✓ Internal mammary artery
- ✓ Radial artery
- ✓ Gastroepiploic artery
- ✓ Saphenous vein
- ✓ Other conduits

Strategy of grafting

- ✓ In situ grafting
- ✓ Composite arterial grafting
- ✓ Vein grafting
- ✓ Competition

Reported graft patency in CABG



Comparison of published guidelines

variable	ACCF/AHA 2011	ESC/EACTS 2014	STS 2015
IMA to LAD	I/B	I/B	I/B
IMA to 2nd graft	IIa/B		IIa/B In appropriate patients
BITA			IIa/B No excessive risk of sternal complication
2nd radial graft	IIb/ C >70% on left or >90% on right		IIa/B Severe stenosis
Total arterial grafting	IIc/C age<60	IIa/B Reasonable life expect. I/C poor vein	
ITA skeletonization		IIa/B all patients I/B DM or BITA use	IIa/B

References

1. Surgery of the Chest , Sabiston and Spencer, 9th edi.
2. Mastery of Cardiothoracic Surgery, Kayser, 3rd edi.
3. Cardiac Surgery operative technique, Doty, 2nd edi.
4. 간결한 관상동맥우회술, 이영탁, 박계현, 1st edi.
5. Advancing the State of the Art in Surgical Coronary Revascularization. Puskas JD, Ann Thorac Surg. 2016.
6. The Society of Thoracic Surgeons Clinical Practice Guidelines on Arterial Conduits for Coronary Artery Bypass Grafting. Aldea GS, Ann Thorac Surg. 2016.

CABG/PCI

Thoracic and Cardiovascular Surgery, Kyungpook National University Hospital, Daegu, Korea

Gun Jik Kim, M.D.

2011 ACCF/AHA Guideline for Coronary Artery Bypass Graft Surgery

CLINICAL SUBSETS

Applying Classification of Recommendations and Level of Evidence

CABG in Patients With Acute MI

I IIa IIb III
B

- Emergency CABG

1) Primary PCI has failed or cannot be performed.
2) Coronary anatomy is suitable for CABG.
3) Persistent ischemia of a significant area of myocardium at rest and/or hemodynamic instability refractory to nonsurgical therapy.

I IIa IIb III
B

- Emergency CABG

Undergoing surgical repair of a post-infarction mechanical complication of MI(ventricular septal rupture, mitral valve insufficiency or free wall rupture)

CABG in Patients With Acute MI

I IIa IIb III
B

- Emergency CABG

Cardiogenic shock and who are suitable for CABG irrespective of the time interval from MI to onset of shock and time from MI to CABG.

I IIa IIb III
C

- Emergency CABG

Patients with life-threatening ventricular arrhythmias in the presence of LM stenosis ≥ 50% and/or 3VD

CABG in Patients With Acute MI

- Multivessel CAD with recurrent angina or MI within the first 48 hours of STEMI.

- Early revascularization with PCI or CABG

Selected patients 〉 75 Yrs with STEMI or LBBB who are suitable for revascularization irrespective of the time interval from MI to onset of shock.

CABG in Patients With Acute MI

- Emergency CABG **should not be performed** with persistent angina and a small area of viable myocardium who are stable hemodynamically.

- Emergency CABG **should not be performed** with no-reflow (successful epicardial reperfusion with unsuccessful microvascular reperfusion).

Life-Threatening Ventricular Arrhythmias

- Resuscitated sudden cardiac death or sustained VT thought to be caused by significant CAD (≥50% stenosis of LM and/or ≥70% stenosis of 1, 2, or all 3 epicardial coronary arteries) and resultant myocardial ischemia.

- CABG **should not be performed** in patients with VT with scar and no evidence of ischemia.

Emergency CABG After Failed PCI

- Emergency CABG

Failed PCI in the presence of ongoing ischemia or threatened occlusion with substantial myocardium.

- Emergency CABG

Failed PCI for hemodynamic compromise in patients without impairment of the coagulation system and without a previous sternotomy

Emergency CABG After Failed PCI

- Emergency CABG

Failed PCI for retrieval of a foreign body (most likely a fractured guidewire or stent) in a crucial anatomic location.

- Emergency CABG

Failed PCI for hemodynamic compromise in patients with impairment of the coagulation system and without previous sternotomy.

- Emergency CABG

Failed PCI for hemodynamic compromise in patients with previous sternotomy.

Emergency CABG After Failed PCI

- Emergency CABG **should not be performed** after failed PCI in the absence of ischemia or threatened occlusion.

- Emergency CABG **should not be performed** after failed PCI if revascularization is impossible because of target anatomy or a no-reflow state.

CABG in Association With Other Cardiac Procedures

- Noncoronary cardiac surgery

≥50% luminal narrowing of the LM.

≥70% luminal narrowing of other major coronary arteries.

- LIMA is reasonable to bypass a significantly narrowed LAD.

- Moderately diseased coronary arteries (≥50% luminal narrowing).

CAD REVASCULARIZATION :REVASCULARIZATION TO IMPROVE SURVIVAL

Heart Team Approach to Revascularization Decisions

- Heart Team approach to revascularization is recommended in patients with unprotected LM or complex CAD.

- Calculation of the STS and SYNTAX scores is reasonable in patients with unprotected LM and complex CAD

Left Main CAD Revascularization

- CABG

Significant (≥50%) LM stenosis.

- PCI

Selected stable patients with significant (≥50%) UPLM CAD

1) Anatomic conditions associated with a low risk of PCI procedural complications.
2) Clinical characteristics that predict a significantly increased risk of adverse surgical outcomes.

Left Main CAD Revascularization

- PCI

UA/NSTEMI if not a candidate for CABG.

- PCI

Acute STEMI when distal coronary flow TIMI <3, and PCI can be performed more rapidly and safely than CABG.

Left Main CAD Revascularization

- PCI

Stable patients with significant (≥50% stenosis) UPLM

1) Anatomic conditions associated with a low - intermediate risk of PCI complications and intermediate to high likelihood of good long term outcome(SYNTAX score<33, bifurcation LM).
2) Clinical characteristics that predict an increased risk of adverse surgical outcomes(mod-severe COPD, disability prior stroke or prior cardiac surgery).

- PCI to improve survival **should not be performed** in stable patients who have unfavorable anatomy.

Non-Left Main CAD Revascularization

- CABG

1)Significant(≥70%) stenoses of 3 VD (± proximal LAD)

2)Proximal LAD + Significant(≥70%) stenoses 2 VD

CABG

- CABG or PCI

Survivors of sudden cardiac death with presumed ischemia-mediated VT caused by significant(≥70%) stenosis.

PCI

Non-Left Main CAD Revascularization

- CABG

Significant(≥70%) stenoses without proximal LAD disease in 2 VD with extensive ischemia.

- CABG

Mild–moderate LV systolic dysfunction (EF 35%-50%) and significant (≥ 70%) stenosis multi-vessel CAD or proximal LAD stenosis.

Non-Left Main CAD Revascularization

- CABG with a LIMA graft

Significant (≥70%) stenosis in the proximal LAD and evidence of extensive ischemia.

- CABG

Complex 3-vessel VD(SYNTAX score >22) ± proximal LAD.

- CABG

Multivessel VD and DM, particularly if a LIMA graft can be anastomosed to the LAD.

Non-Left Main CAD Revascularization

- CABG or PCI **should not be performed** with the primary or sole intent to improve survival in patients with SIHD with 1 or more coronary stenoses that are not anatomically or functionally significant, involve only the LCX or RCA, or subtend only a small area of viable myocardium.

CAD REVASCULARIZATION :REVASCULARIZATION TO IMPROVE SYMPTOMS

Revascularization to Improve Symptoms

- CABG or PCI

≥1 significant (≥70%) stenoses amenable to revascularization and unacceptable angina despite GDMT.

- CABG or PCI

≥1 significant (≥70%) stenoses and unacceptable angina for whom GDMT cannot be implemented because of medication contraindications, adverse effects, or patient preferences.

Revascularization to Improve Symptoms

- PCI

Previous CABG, ≥1 significant (≥70%) stenoses associated with ischemia, and unacceptable angina despite GDMT.

- CABG

Complex 3-vessel CAD(SYNTAX score >22) ± proximal LAD.

Revascularization to Improve Symptoms

- CABG

Previous CABG, ≥1 significant (≥70%) stenoses not amenable to PCI, and unacceptable angina despite GDMT.

- CABG or PCI to improve symptoms **should not be performed** in patients who do not meet anatomic (≥ 50% LM or ≥ 70% non– LM) or physiological criteria for revascularization.

2016 ACC/AHA Guideline Focused Update on Duration of Dual Antiplatelet Therapy in Patients With Coronary Artery Disease
A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines

Recommendations for CABG

COR	LOE	Recommendations
I	C-EO	In patients treated with DAPT after coronary stent implantation who subsequently undergo CABG, $P2Y_{12}$ inhibitor therapy should be resumed postoperatively so that DAPT continues until the recommended duration of therapy is completed.
I	C-LD	In patients with ACS (NSTE-ACS or STEMI) being treated with DAPT who undergo CABG, $P2Y_{12}$ inhibitor therapy should be resumed after CABG to complete 12 months of DAPT therapy after ACS (52-54,118-120).
I	B-NR	In patients treated with DAPT, a daily aspirin dose of 81 mg (range, 75 mg to 100 mg) is recommended (56-60,75-78).
IIb	B-NR	In patients with SIHD, DAPT (with clopidogrel initiated early postoperatively) for 12 months after CABG may be reasonable to improve vein graft patency (121-125).

2016 ACC/AHA Guideline Focused Update on Duration of Dual Antiplatelet Therapy in Patients With Coronary Artery Disease
A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines

7.4. Duration of DAPT in Patients With ACS Treated With CABG: Recommendation

See *Online Data Supplement 4 and 11* for evidence supporting this recommendation.

Recommendation for Duration of DAPT in Patients With ACS Treated With CABG

COR	LOE	Recommendation
I	C-LD	In patients with ACS being treated with DAPT who undergo CABG, $P2Y_{12}$ inhibitor therapy should be resumed after CABG to complete 12 months of DAPT therapy after ACS (52-54,118-120).

Recommendations for CABG

- UPLM 
- 3VD with and without proximal LAD disease
- Complex 3VD 
- 2VD with proximal LAD disease 
- 2VD without proximal LAD disease with extensive ischemia 
- 1 proximal LAD disease with LIMA 
- LV dysfunction(EF 35% -50%) 
- Survivors of sudden cardiac death with presumed ischemia-mediated VT 

Techniques of Conventional and Off-pump CABG

Department of Thoracic & Cardiovascular Surgery, Dongguk University Ilsan Hospital

Jae Hang Lee

Introduction

- Conventional CABG
- On-pump beating CABG
- Off-pump CABG

Conventional CABG

Conventional CABG

- Use of cardiopulmonary bypass
- Use of cardioplegia
  - Arrested heart
- Hypothermia
  - Fibrillated heart

- Free graft >> composite graft or in-situ graft

Conventional CABG

- Optimal operative conditions
  - *Bloodless, motionless…*
- CPB related complications
  - Systemic inflammatory response
  - Increased bleeding risk
  - Increased neurologic deficit
  - …….

Prevention of neurologic Cx

- Mechanisms of cerebral injury
  - Hypoperfusion
  - Micro- and macroemboli
  - Inflammatory response
- Risk factors
  - Old age, previous CVA..
  - Calcified ascending aorta
  - Carotid stenosis

Evaluation of ascending aorta

- Chest X-ray
- CAG
- Chest CT or CT angiography
- Epiaortic scan

Evaluation of carotid artery

- Carotid US

Ascending aorta manipulation

- Meticulous palpation of aortic wall
  - SBP < 50~60mmHg
- *If) no bleeding after aortotomy..??*
  - *→ presence of soft atheroma*
- Epiaortic scan

Ascending aorta manipulation

- Hostile ascending aorta
  - Off-pump technique
  - On-pump beating technique
  - Fibrillating heart
  - Femoral or axillary or innominate cannulation
  - Avoid partial clamping for graft anastomosis
    - In-situ graft >> free graft
    - Proximal sealing system (Heartstring® device)

Proximal sealing system (Heartstring® device)

Cannulation

- Arterial cannulation
  - Ascending aorta
  - Femoral or axillary or innominate cannulation
- Venous cannulation
  - Single cannula (two-stage cannula)
  - Bicaval cannulation (combined procedure, ex. Ischemic MR)
- LV vent catheter insertion

Cardioplegia (1)

- Antegrade infusion
  - *via root cannula*
  - Caution of AR, heart elevation
    - LV dilatation & perfusion pr.↓↓
- Retrograde infusion
  - *via coronary sinus (retrograde CPS cannula)*
  - 150~200cc/min, < 40mmHg
  - Back-flushing

Cardioplegia (2)

- Blood cardioplegia
- Crysalloid cardioplegia
  - HTK solution (Custodiol®)

Main procedure – anastomosis (1)

- Coronary exposure
  - Hand, gauze, spongy stick.. : 2nd assistant
  - Use of stabilizer
- Decision of graft configuration & length
  - After blood filling inside heart

  → Prevention of graft kinking or stretching

Main procedure – anastomosis (2)

- Prevention of air embolism
  - Avoid of excessive venting
  - Avoid of high CO2 blowing
  - Deairing before graft anastomosis

On-pump beating CABG

On-pump beating CABG

- Conventional CABG → off-pump CABG

On-pump beating CABG

- Controlled CPB drainage
  - Avoid of flattened heart
  - Avoid of LV dilatation
- Controlled body temperature
  - Prevention of ventricular fibrillation
  - Shorten the duration of CPB

Off-pump CABG (OPCAB)

OPCAB vs ONCAB

Off-pump CABG

- Prevent complication caused by CPB
  - Avoid inflammatory response
  - Reduce myocardial injury
  - Reduce cerebral injury
  - Reduce renal injury
  - Reduce atrial fibrillation
  - Reduce transfusion, hospitalization time, cost

  .....
  - But technically more demanding

General consideration

- Heparinization
  - 1.5~2.0mg /kg
  - ACT > 300sec
- Maintain body temperature
  - Prevention of ventricular arrhythmia
  - blanket, warm saline, OR temperature ↑....
- *Co-operation with anesthesiologist..!!!!*

Monitoring

- ECG, ABP, CVP, PAP, SaO2
  - Swan-Ganz cath
  - 5-lead ECG
- TEE
  - RWMA, contractility, MR grade
- Cerebral oxymeter

V/S maintenance during OPCAB

- BP ↓ & PAP ↓
  - Trendelenbrg position
  - Volume loading, vasoconstrictor..
- BP ↓ & PAP ↑
  - Heart reposition & rest
  - Intracoronary shunt
  - Avoid repeated positive inotropes
  - Consider CPB

Conversion to ONCAB

- Unstable V/S
- Myocardial ischemia
- Cardiac arrest
- Inadequated anastomosis
- Diffuse calcified arteries & Intramyocardial vessels
- *surgical failure (X), modification (O)*

Exposure of coronary arteries

- LAD
  - Gauze or glove ball at posterior pericardium
  - Stabilizer only
- OM & PLb
  - Apical suction device
  - Deep pericardial suture
- PDA
  - Suction device at apex or acute margin

Coronary anastomosis – end to side

- Parallel anastomosis
  - "cobra head"
  - 12-14 stitch
- Perpendicular anastomosis
  - Small arteriotomy (< 3 - 4mm)
  - 8-10 stitch

Coronary anastomosis – side to side

- Parallel anastomosis
  - Ex) LITA – D- LAD
- Perpendicular anastomosis
  - Ex) composite graft – OM – PDA
  - Short arteriotomy..!!!!
    - Prevent sea-gull effect
  - Diamond shape & transverse shape


ONCAB vs OPCAB..????
No shame in using CPB
We are CARDIAC SURGEONS
dongguk
UNIVERSITY
MEDICAL CENTER


Thank you for your attention~!
dongguk
UNIVERSITY
MEDICAL CENTER

Mechanical Complications of IHD

부산대학교 의과대학 흉부외과학교실

제 형 곤

Contents

- Ischemic MR (Chp. 92)
  - Carpentier's type IIIB dysfunction
  - Acute Papillary Muscle Rupture
  - Chronic Type II Ischemic Mitral Regurgitation
- Post-MI VSD & Ventricular Rupture (Chp. 93)
- Left Ventricular Aneurysm (Chp. 100)

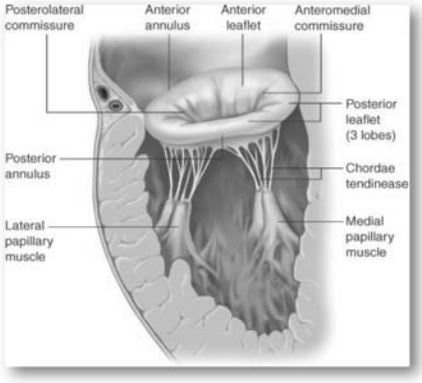
Ischemic MR

부산의대 제형곤

Ischemic MR Definition

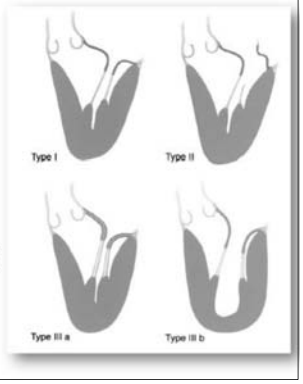
- **Etiology:** MI with regional or global dysfunction
- **Primary lesion:** tethering of the valve leaflets
- **Valve dysfunction:** MR restriction of leaflet motion, in systole **(Carpentier's type IIIB dysfunction)**

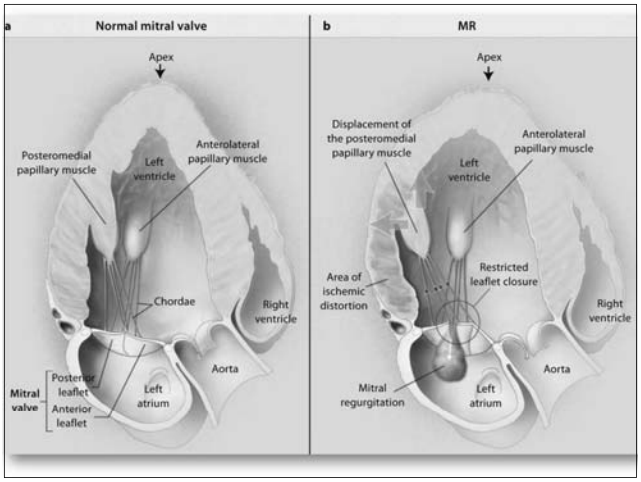
Mitral valve anatomy



Functional classification of MR

- Type I : nl motion,leaflet perforation, annular dilatation
- Type II : chordae elongation or rupture
- Type IIIa : restricted motion(sys and dia) d/t rheumatic change
- **Type IIIb : restricted motion(sys) secondary to PM displacement**





Prevalence of IMR

- "Contaminated", usually mild & disappear
- 17%-55% develop mitral systolic murmur or echocardiographic evidence of IMR early after AMI
- 18% cardiac catheterization within 6 hrs of the onset of Sx of AMI

Degree of the of IMR

- Significant 2' mitral regurgitation:
  - Regurgitant volume ≥ 30 mL
  - Effective regurgitant orifice area ≥20 mm^2
  - Flow-convergence proximal isovelocity surface area > 8~9, rather than > 10

TEE Assessment of IMR

- **Downgrading of MR** d/t unloading effect of anesthesia
- **Provocative testing :**
  - Preload challenge; PCWP 15~18 mmHg
  - Afterload challenge; mean AP > 100 mmHg
  - if positive, inspection & repair of MV

Byrne et al, Brigham & Women's Hospital, The Lancet '00

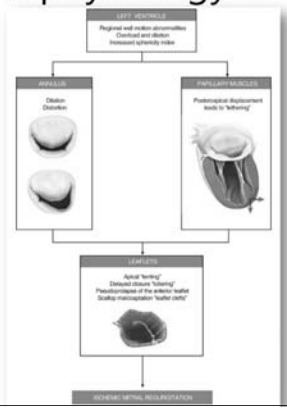
Clinical Presentation

- Acute MR d/t papillary muscle rupture after AMI
- Majority:
  - Prior MI, generally permanent and chronic
  - Incidental finding at echo
  - Symptoms and signs of heart failure

2 Most common clinical scenarios

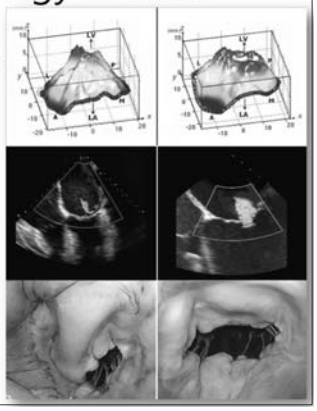
	Primarily Ischemia	Primarily Heart Failure
		
Mechanism	Posterior leaflet restriction	Leaflet restriction and annular dilation
Severity of MR	Mild to moderate	Moderate to severe
LV dysfunction	Mild to moderate	Moderate to severe
Ejection fraction (%)	30-50	15-40
Indication for surgery	Coronary artery disease	Congestive heart failure

Pathophysiology of IMR



Pathophysiology of IMR

- LV sphericity is more important than LV volumes or EF
- Inf. MI: tethering in medial posterior leaflet
- Ant. MI: widespread tethering of both leaflets



Long term outcome

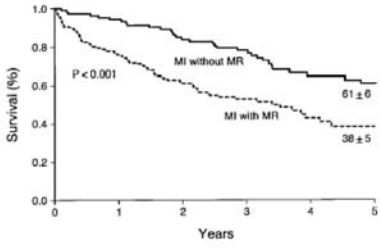
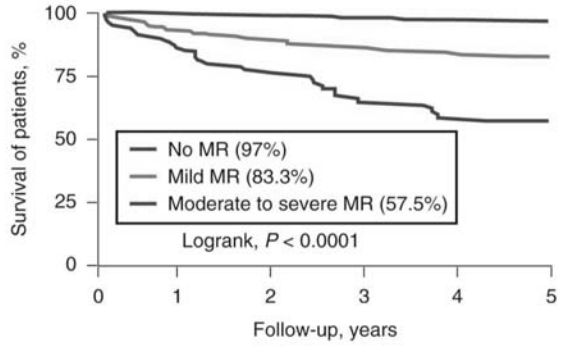


Figure 1. Survival (±SE) after diagnosis according to presence of IMR.

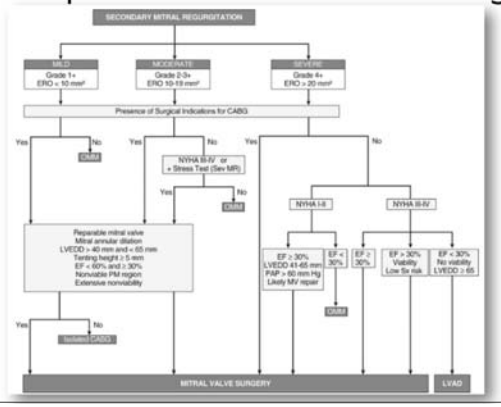
Worsens long term Px, increasing mortality

- Grigioni, Circulation 2001

Survival after PCI



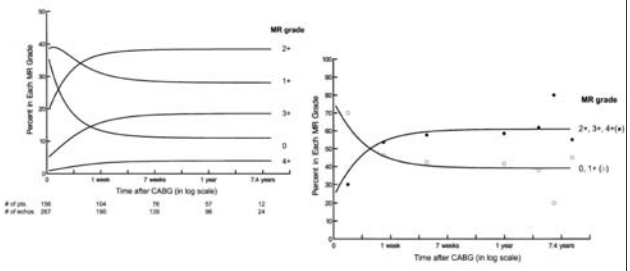
Preoperative Decision Making



Therapeutic Targets in IMR

- Coronary Artery Disease: CABG
- **Mitral Annulus: Principal target**
- Subvalvular Apparatus
- Leaflets
- Left Ventricle

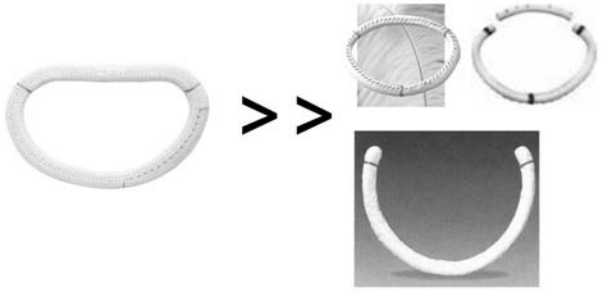
CABG alone or CABG + MV



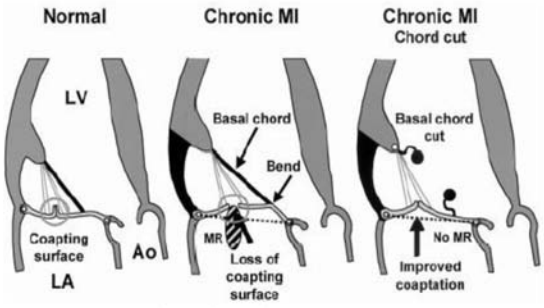
- *"Treatment of Mitral valve should be considered if the degree is 2+ more ."* *Lam, Gillinov 2005 ATS*

Annulus: Restrictive annuloplasty

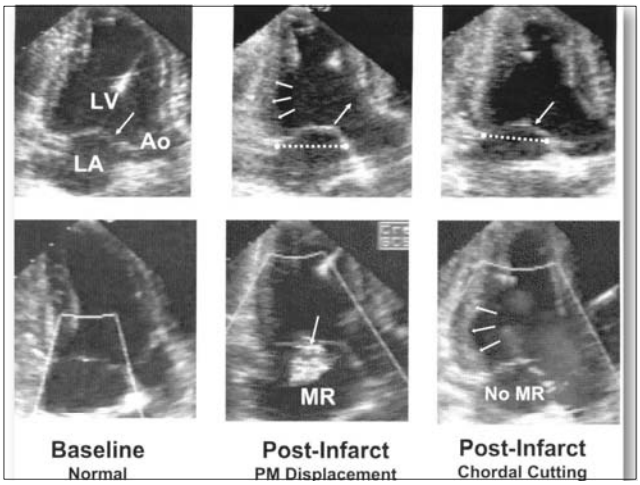
- Complete rigid or semirigid rings are preferred
- Incomplete annuloplasty, flexible bands: not reduce the SL dimension



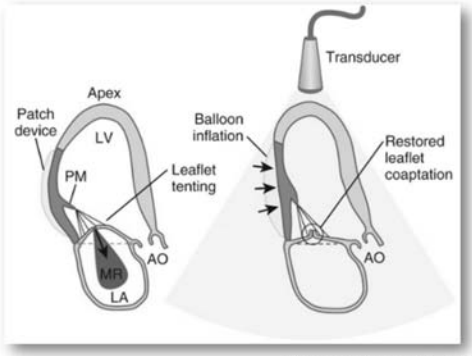
Subvalvular Apparatus; Chordae cutting



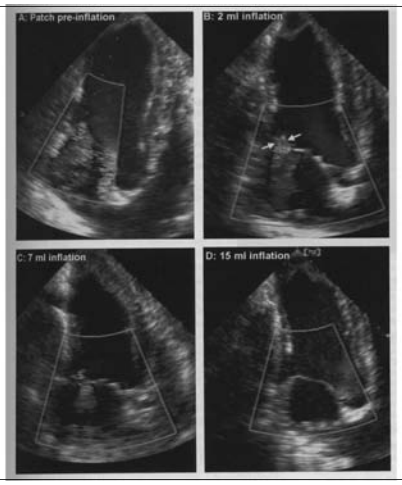
Surgical approach to " Tethering " ; Cutting the secondary chordae to the AMVL
Messas Circulation 2003



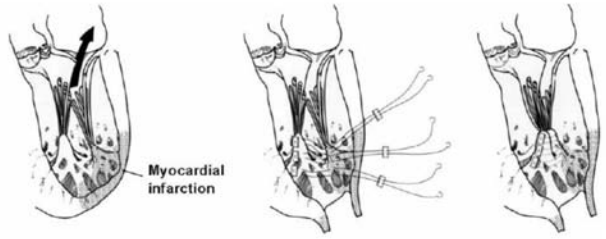
Subvalvular Apparatus; External devices



Hung J, Guerrero, et al, MGH, Circ '02

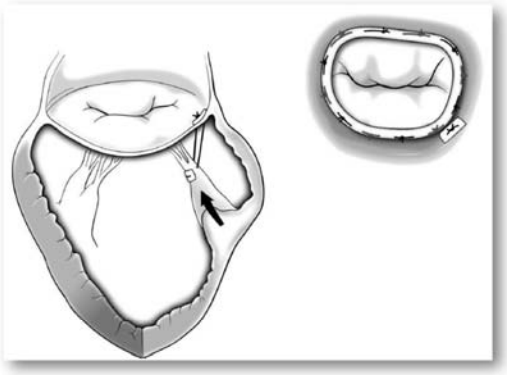


Subvalvular; PM reapproximation



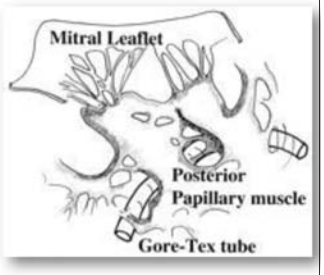
Surgical approach to " Tethering "; APM & PPM reapproximation
Matsui JTCS 2004

Subvalvular; PM Kron-repositioning



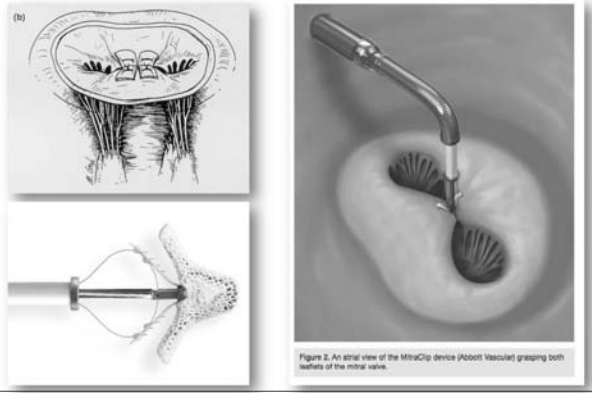
Subvalvular; Papillary Muscle Sling

- Hvass and Joudinaud, Paris.
- Goretex 4mm tube passed around both PM and approximated
- 37 pts since 2000
- 2 op deaths
- LVEDD 70 -> 56 at 1 yr
- EF 30-> 49

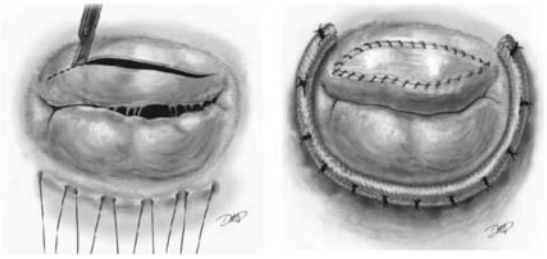


J Thorac Cardiovasc Surg 2010;139:418-23

Leaflets; Edge-to-edge



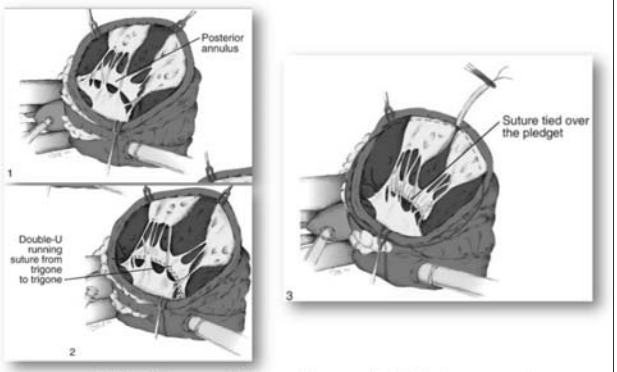
Leaflets; AMVL augmentation



AMVL augmentation (bovine pericardium)
Kincaid ATS 2004

Leaflets; PMVL augmentation

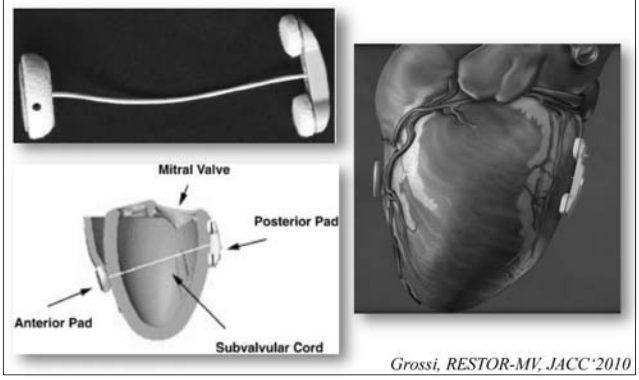
Left Ventricle; Menicanti's



MVP with Intraventricular papillary muscle imbrication, Heart Fail Review 2004

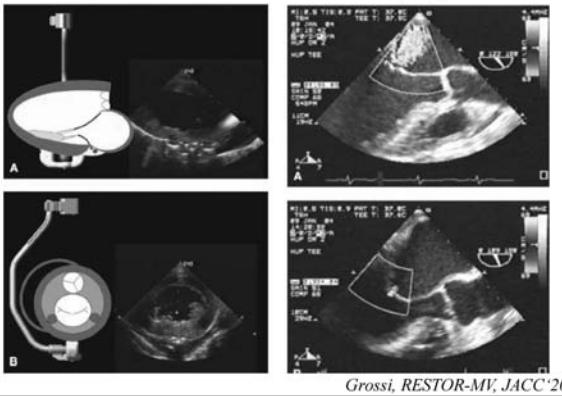
Left Ventricle; Dor operation

Left Ventricle: Coapsys



Grossi, RESTOR-MV, JACC'2010

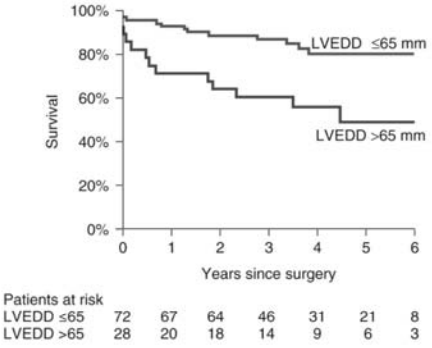
Left Ventricle: Coapsys



Grossi, RESTOR-MV, JACC'2010

Chordal Sparing Replacement

Annuloplasty: preoperative LVEDD

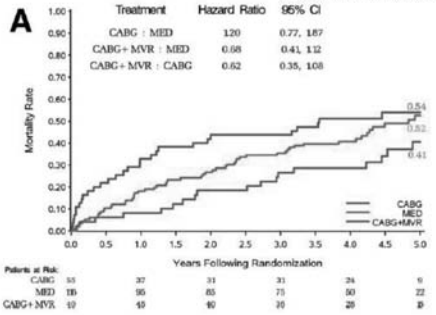


Patients at risk

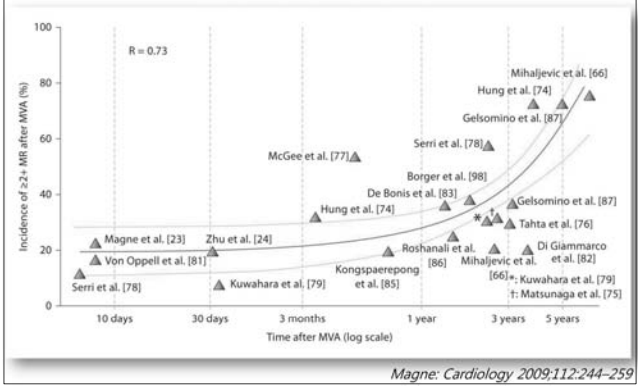
LVEDD ≤65	72	67	64	46	31	21	8
LVEDD >65	28	20	18	14	9	6	3

STICH: 3-4+ IMR: Trend towards CABG alone worse than Med Rx, worse than CABG + MV Repair

Circulation. 2012;125:2639-2648

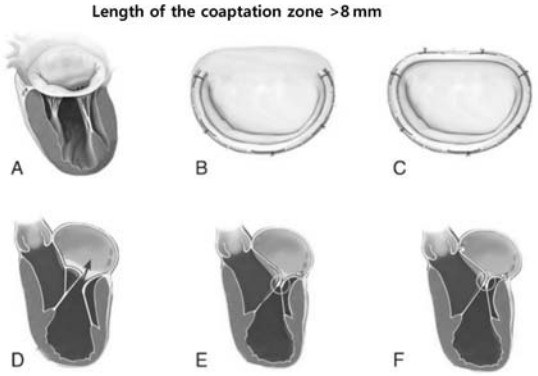


MR > 2+ After Annuloplasty

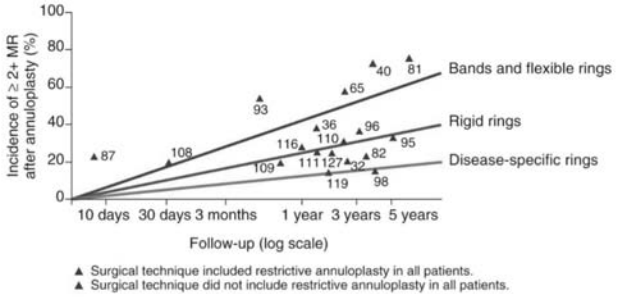


Magne: Cardiology 2009;112:244–259

Possible Mechanisms of Residual MR



Ring type and Residual MR



Predictors of Recurrent MR after Annuloplasty for IMR

- TTE- Indicators of Severe Mitral Valve Tenting
  - Systolic tenting area ≥ 2.5 cm^2
  - Systolic tenting height ≥ 10 mm
  - Posterior mitral leaflet angle ≥ 54 degrees
  - Distal anterior mitral leaflet angle ≥ 19 degrees
  - Posterior mitral leaflet angle ≥ 45 degrees
  - Anterior mitral leaflet tethering angle ≥ 39.5 degrees
  - MR jet direction: central or complex

Predictors of Recurrent MR after Annuloplasty for IMR

- TTE- Indicators of Advanced LV Remodeling
  - LVESD > 51 mm, LVEDD > 65 mm, LVESV ≥ 145 mL
  - Interpapillary muscle distance > 20 mm
  - Systolic sphericity index ≥ 0.7
- TTE other:
  - Myocardial performance index ≥ 0.9
  - Wall motion score index ≥ 1.5
  - Diastolic LV function: restrictive filling

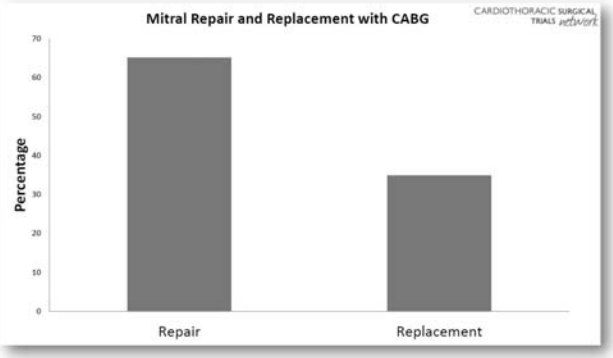
Predictors of Recurrent MR after Annuloplasty for IMR

- TEE:
  - Mitral annular diameter in diastole > 3.7 cm
  - Tethering area > 1.6 cm2
  - MR severity > 3.5
- Surgical:
  - Use of flexible ring
  - Use of incomplete ring
  - Inadequate ring sizing
  - Length of leaflet coaptation < 8 mm
  - Residual MR at OR or discharge
  - Absence of early LV remodeling (decrease of LVESV < 15%)

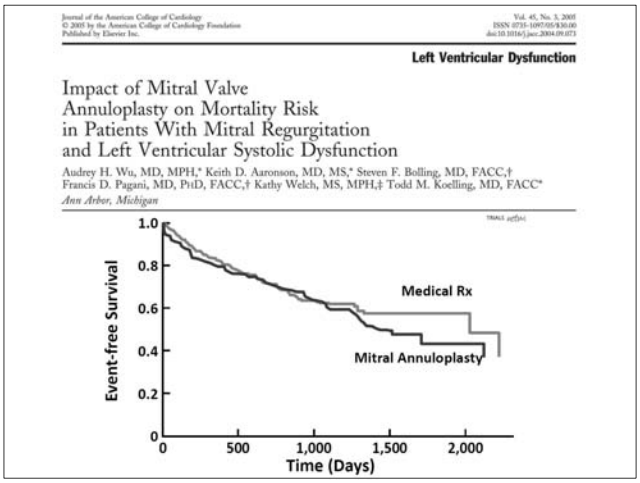
MVP for IMR: in Sabiston

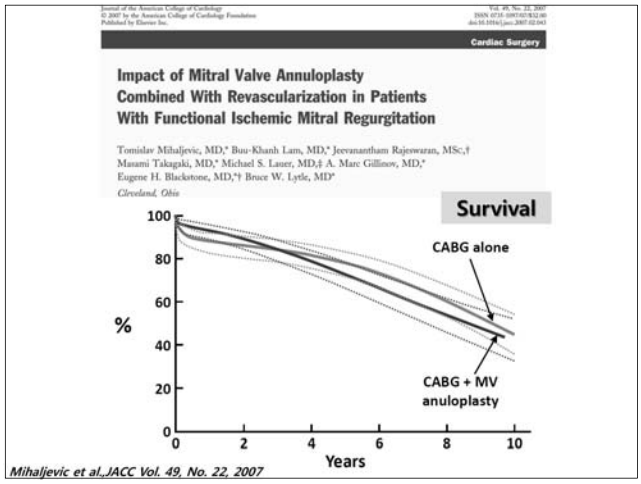
- Severe IMR: should be corrected at CABG
  - MVR is a reasonable option
- Moderate IMR: No consensus but…
  - MVP should undergo unless prohibitive risk:
    - Extensive MAC
    - Strong indication for OPCAB: heavily diseased aorta
  - MVR: unclear efficacy and safety

Surgeons Prefer Repair

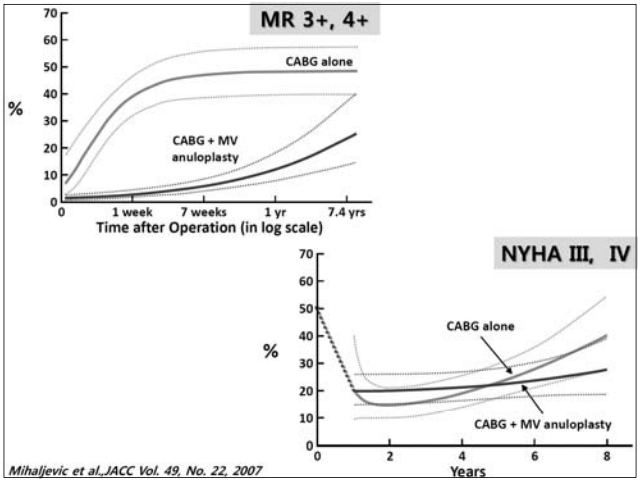


Years 2008-2012, The Adult Cardiac Surgery Database, The Society of Thoracic Surgeons





Mihaljevic et al.,JACC Vol. 49, No. 22, 2007




The NEW ENGLAND JOURNAL of MEDICINE
370:23-32. 2014
ORIGINAL ARTICLE

Mitral-Valve Repair versus Replacement for Severe Ischemic Mitral Regurgitation

Michael A. Acker, M.D., Michael K. Parides, Ph.D., Louis P. Perrault, M.D., Alan J. Moskowitz, M.D., Annetine C. Gelijns, Ph.D., Pierre Voisine, M.D., Peter K. Smith, M.D., Judy W. Hung, M.D., Eugene H. Blackstone, M.D., John D. Puskas, M.D., Michael Argenziano, M.D., James S. Gammie, M.D., Michael Mack, M.D., Deborah D. Ascheim, M.D., Emilia Bagiella, Ph.D., Ellen G. Moquete, R.N., T. Bruce Ferguson, M.D., Keith A. Horvath, M.D., Nancy L. Geller, Ph.D., Marissa A. Miller, D.V.M., Y. Joseph Woo, M.D., David A. D'Alessandro, M.D., Gorav Ailawadi, M.D., Francois Dagenais, M.D., Timothy J. Gardner, M.D., Patrick T. O'Gara, M.D., Robert E. Michler, M.D., and Irving L. Kron, M.D., for the CTSN*

ABSTRACT

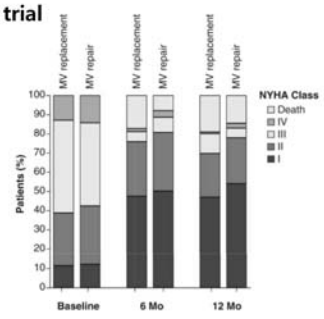
BACKGROUND

Ischemic mitral regurgitation is associated with a substantial risk of death. Practice guidelines recommend surgery for patients with a severe form of this condition but

MVP vs. MVR for IMR

NEJM, Acker et al. 370:23-32. 2014

- **1st multicenter, randomized trial**
- No difference in
  - Survival
  - LV remodeling
  - QoL at 12 months
- MVP: higher recurrent MR
  - at 12 mo. (32.6% vs. 2.3%)



Repair for Moderate Ischemic MR

- Longer CPB and ACC times
- More transfusions, Afib
- Greater LOS
- **Perhaps: improved functional status**
- **Definitely: no survival benefit**

Ischemic MR: Today's Options

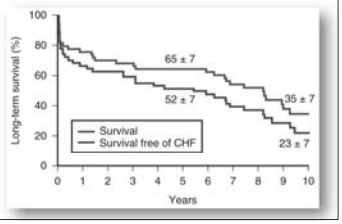
- **Residual regurgitation: poor long-term outcomes**
- Severe ischemic MR
  - Repair: trend of survival benefit STICH -> only if simple: **coaptation depth < 1.0 cm, tenting area < 2.5 cm², LVEDD < 65mm, (anterior tethering angle < 26, posterior tethering angle < 45)**
  - **Replace: high risk pts.** (STS PROM > 4, frail, aged)
- Moderate ischemic MR
  - Replacement: rarely needed
  - Repair: improve Sx. and LV, LA dilation but **NO SURVIVAL BENEFIT of annuloplasty**
  - CABG+MV repair < **CABG alone**

Acute Papillary Muscle Rupture

- Historically, up to 5% of STEMI
- Reduced remarkably in the era of early reperfusion
- Post. PM: susceptible to ischemia d/t single vascular supply
- Ant. PM: dual supply from LAD and Diagonal br.
- About 1 week after AMI
- Sx: new systolic murmur, hemodynamic collapse, shock
- DDx: infarct VSD, LV free-wall rupture, global LV dysfunction

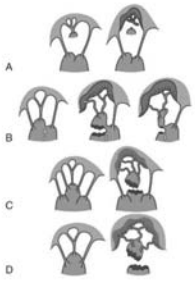
Acute Papillary Muscle Rupture

- Surgery should not be delayed
- MVR: most common Tx
- MVP with reimplantation of PM
- Hospital mortality: 20%



Chronic Type II IMR

- Chronic elongation, thinning, and fibrosis or rupture of PM
- Fibrotic and thinned-out PM with normal chords
- Usually repairable
- PTFE-NCF, chordal transfer, PM-transposition, downsized annuloplasty

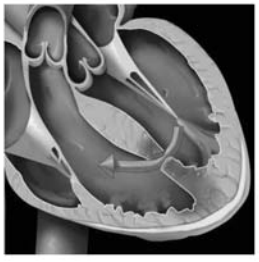


Classification of papillary muscle rupture

Post-MI VSD & Ventricular Rupture

부산의대 제형곤

History of VSR



- Latham in 1845
  - First described at autopsy
- Cooley in 1956
  - First successful surgical repair in a patient after 9 weeks through RVtomy after VSR
- Heimbecker,Allen,Woodwark,Iben
  - Late 1960s: surgery for acute phase

Incidence and Demographics

- 1-2% of AMI and **0.2% in thrombolytic era**
- 5% of early deaths after MI
- Male : Female = 3 : 2
- 1 vessel (64%), 2 vessels (7%), 3 vessels (29%)
- Average age: 62 yrs (range, 44-81)
- Most often after the 1st AMI

Etiology and Pathogenesis

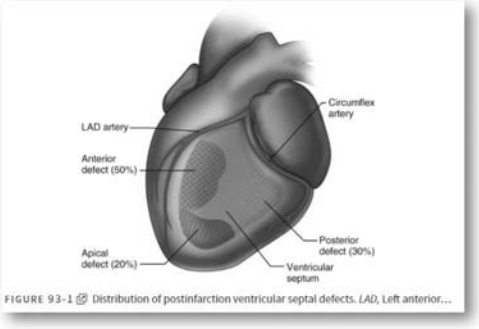
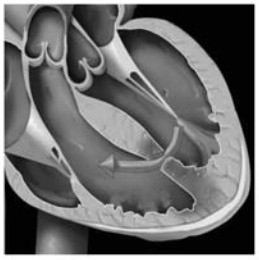


FIGURE 93-1 Distribution of postinfarction ventricular septal defects. *LAD*, Left anterior...

Etiology and Pathogenesis

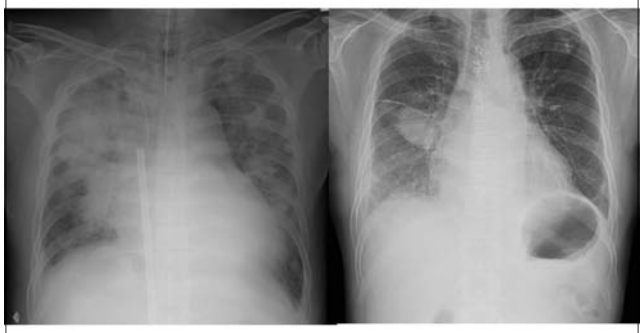
- Post MI VSD:
  - Timing: usually 2 ~ 4 days
  - A few hours ~ 2 weeks
  - Closer to 1 day in thrombolytic era
  - Chronic VSR: more than 4 ~ 6 weeks
- LV free-wall rupture:
  - Occur 4%-8% of AMI
  - 15% of deaths after AMI
  - typically occurs 1-4 days after MI
  - Dx: echocardiogram

Pathophysiology



- Heart failure
  - Size of infarction
  - Amount of L-R shunt
- Anterior septal rupture
  - LV dysfunction
- Posterior septal rupture
  - RV dysfunction

Pathophysiology



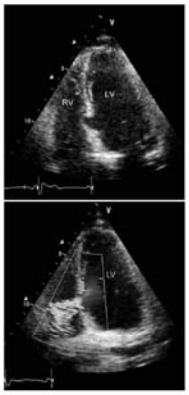
Natural History

- Without surgical intervention:
  - 25% of pts: Died within first 24 hours
  - 50% of pts: Died within 1 week
  - 75% of pts: Died within 1 month
  - 7% of pts: Lived longer than 1 year
- Defer early op: deprives chance for successful op.

Clinical Presentation

- Harsh new holosystolic murmur: radiate to axilla
- recurrent chest pain
- RV failure and pulmonary edema is rare ??
- Resemble acute MR with PM rupture
  - VSD: Ant. AMI with conduction abnormality
  - IMR with PM rupture: post. AMI, no conduction abn'l

Diagnosis

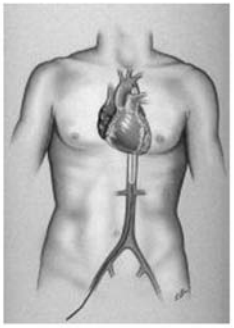


- History of AMI
- Physical Examination and Monitoring
  - New systolic murmur
  - Abrupt deterioration in hemodynamics
- Imaging Studies
  - Echo: Gold standard
  - Coronary angiography
  - LV catheterization : Not recommended
    - 9% step-up in the O_2 saturation

Preoperative Management

- Dx: indication for operation
- Shock: surgical emergency
- Preop multisystem organ failure:
  - unlikely to survive
  - benefit from a mechanical bridge: IABP, VAD
- Intermediate status: within 12 to 24 hours
- Completely stable(<5%): semi-elective

Preoperative Management



- IABP
  - Cardiac output ⇑
  - Lt. to Rt. shunt ⇓
  - Coronary Perfusion ⇑
- Medications
  - Inotropics
  - Diuretics
  - Vasodilators (?)

Predictors of Risk

TABLE 93-1 Preoperative Predictors of Death after Surgical Repair of Postinfarction VSD

Variable	Predictor of Early Death	Predictor of Late Death
Need for preoperative catecholamines	$P = 0.001$	P = NS
Emergent operation	$P < 0.0001$	P = NS
Anterior VSD	$P = 0.04$	P = NS
Age > 65 years	$P = 0.009$	P = NS
Right-sided heart failure	$P = 0.01$	$P = 0.005$
Elevation in blood urea nitrogen	$P = 0.02$	P = NS
Elevation of serum creatinine	P = NS	$P < 0.05$
Previous myocardial infarction	P = NS	$P < 0.05$
Presence of left main coronary disease	P = NS	$P < 0.05$

Predictors of Risk

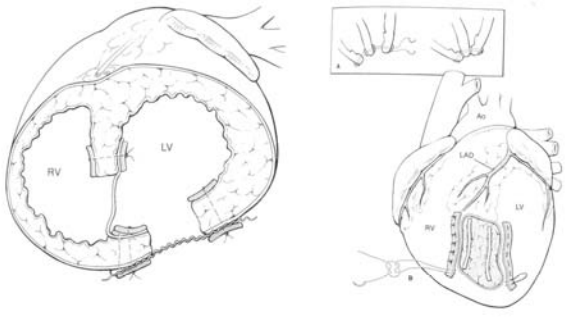
- Post. VSD increased operative mortality:
  - Technically difficult
  - Risk of mitral regurgitation is increased
  - RV failure with RV infarction
- Proximal VSDs strongly predict early mortality
  - Largest infarctions

Goal of Surgery

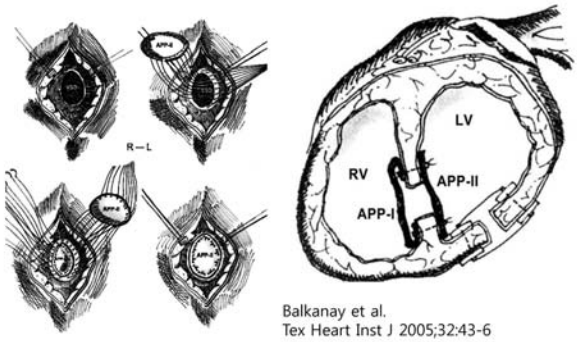
Exclusion or removal of infarcted myocardium

Elimination of Lt. to Rt. shunt

Resection of Infarcted Myocardium



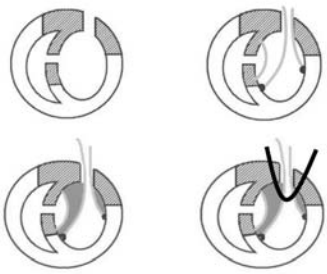
Double Patch Repair of VSR



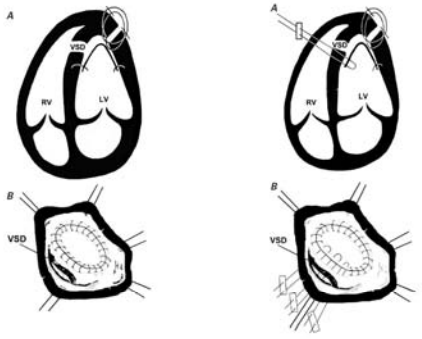
Balkanay et al.
Tex Heart Inst J 2005;32:43-6

Surgical Techniques

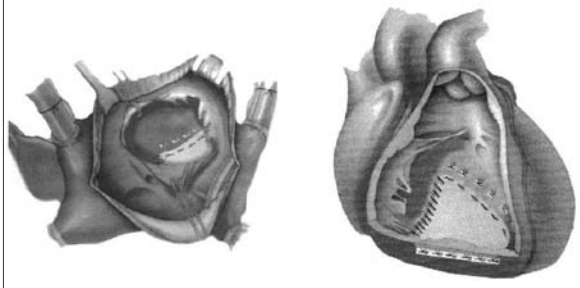
Three Patch Technique



Infarct Exclusion Technique

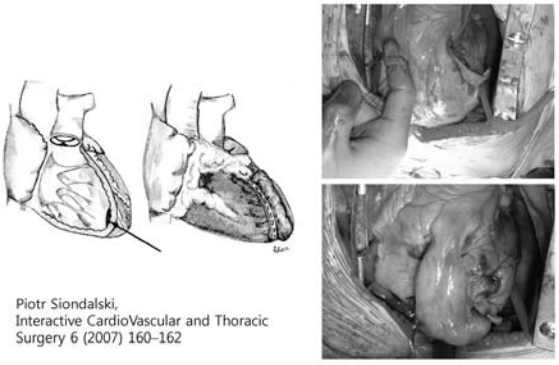


Repair through Rt. Atrium



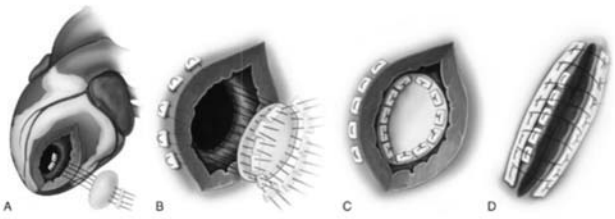
Massetti et al. (J Thorac Cardiovasc Surg 2000;119:784-9)

Closure of VSR on Beating Heart

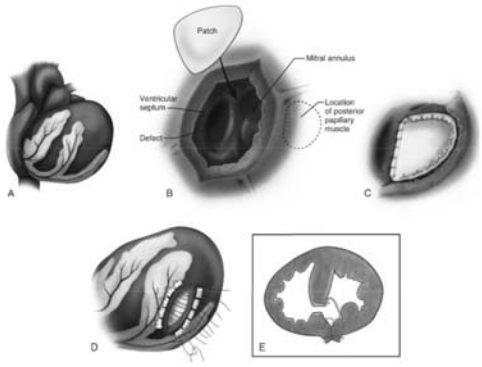


Piotr Siondalski,
Interactive CardioVascular and Thoracic Surgery 6 (2007) 160–162

Repair of Ant. PMI VSD



Repair of Post. PMI VSD



Weaning from CPB

- Bleeding
- Low cardiac output
  - IABP, Milrinone
- RV failure (especially posterior VSR)
  - Volume loading, Inotropics
  - PGE-1 (0.5 to 2.0 mg/min), NO gas (20 to 80 ppm)
- VAD, ECMO

Outcomes

- Operative mortality: 30% to 50%
- Most common cause of death
  - Low cardiac output: 52%
  - Technical failures(recurrent or residual VSD): 22%
  - Sepsis:17%, Recurrent infarction: 9%
  - CVA: 4%, Intractable ventricular arrhythmias

Long-Term Results

TABLE 93-2 Recent Clinical Experience* with Surgical Repair of Postinfarction V Septal Defect

Institution	City	Year	Patients (N)	Hospital Mortality (%)	5-year Survival (%)
Massachusetts General Hospital[7]	Boston	2002	114	37	45
University Hospital[43]	Zurich	2000	54	26	52[†]
Glenfield General Hospital[27]	Leicester	2000	117	37 (30-day)	46
The Toronto Hospital[24]	Toronto	1998	52	19	65[†]
Southhampton General[25]	Southampton	1998	179	27	49
MidAmerica Heart Institute[44]	Kansas City	1997	76	41	41
Green Lane Hospital[11]	Auckland	1995	35	31 (30-day)	60[†]
Hôpital Cardiologique du Haut-Lévêque[23]	Bordeaux	1991	62	38	44
CHU Henri Mondor[22]	Créteil	1991	66	45	44

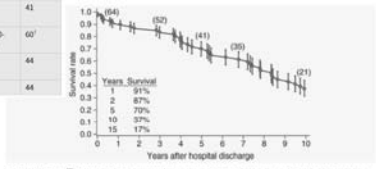
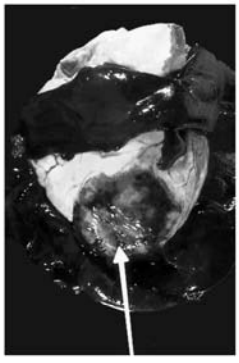


FIGURE 93-4 Postdischarge survival rates after repair of postinfarction ventricular sept...

History of Free wall Rupture



- William Harvey
  - First described the free wall rupture of the heart after AMI in 1647
- Hatcher, FitzGibbon, Montegut
  - First successful repairs in early 1970s

Incidence

- 11% of AMI (VSR x 10)
- Elderly women, first infarction, within 5 days
- Ant. > Lat.
- Simple versus complex (50:50)

Pathogenesis and Pathophysiology

- Transmural MI
- Infarct expansion
  - Acute regional thinning and dilatation of infarct zone
- Systemic HT, lack of collateral
- After extensive hemorrhagic transformation of AMI

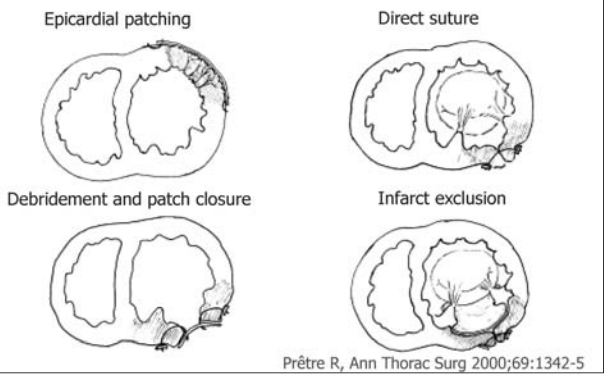
Diagnosis

- Clinical picture of pericardial tamponade
- Echocardiography
  - Effusion thickness > 10mm
  - Echo-dense masses in the effusion
  - Ventricular wall defect

Natural History

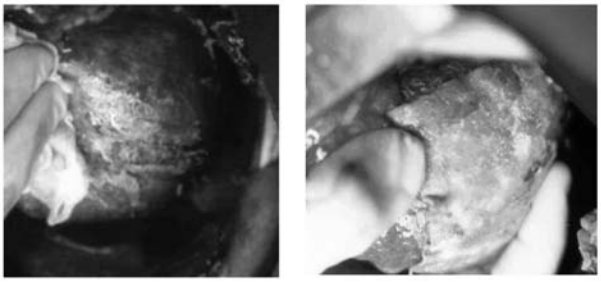
- Acute
  - Death in a few minutes
- Subacute
  - Median survival : 8 Hours
  - Smaller tear, temporarily sealed by clot or fibrinous pericardial adhesions
- Chronic
  - False aneurysm

Surgical Technique



Prêtre R, Ann Thorac Surg 2000;69:1342-5

Sutureless Tech.



Left Ventricular Aneurysm

부산의대 제형곤

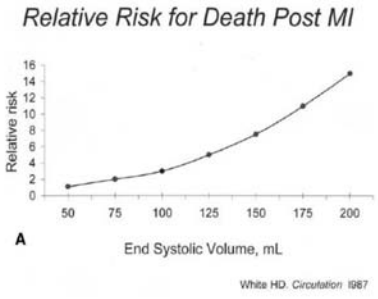
Historical background

- 1957, Bailey: 1st successful surgical correction of an LV aneurysm
- 1958, Denton Cooley: open resection and simple closure on CPB
- 1968, Favaloro: 130 patients, resection for LV aneurysm, with 13% mortality

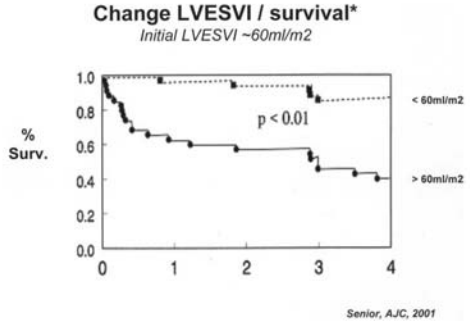
Natural course

- Recent 5YRS for medically managed LV dyskinesia : 47~70%
- Cause of death
  - Arrhythmia 44% : Heart failure 33%
  - Recurrent MI 11% : Non cardiac cause 22%
- Factors influencing survival of LV dyskinesia
  - Age : HF score : Coronary disease severity
  - Angina duration : Prior infarction : MR
  - Function of residual ventricle

Direct correlation between LV volume and survival



LVESVI greater than 60ml/m^2 : poor long term prognosis



Left Ventricular Remodeling

Box 100-1
Left Ventricular Remodeling

Myocardial Changes

- Myocyte loss
- Necrosis
- Apoptosis

Alterations in Extracellular Matrix

- Matrix degradation
- Replacement fibrosis

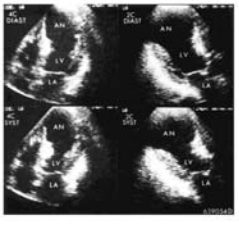
Alterations in LV Chamber Geometry

- LV dilation
- Increased LV sphericity
- LV wall thinning
- Mitral valve insufficiency

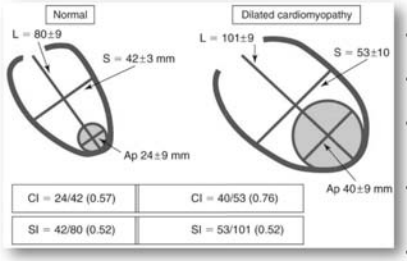
LV, Left ventricular.

Diagnostic modality

- Echocardiography
  - Screening method for detecting LV aneurysm
  - Useful for assessing MV function
- Cardiac MRI



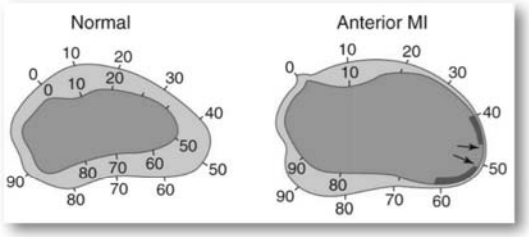
Geometric measures



- Sphericity index (SI): short- to long-axis ratio (S/L)
- Conicity index (CI): apical to short-axis ratio (Ap/S)
- Apical diameter: best fits the apex
- SI has the same value in normal subjects and in patients with DCM
- Because the elongation of LV is proportional to the increase in width
- Whereas the CI is markedly abnormal in the patients.

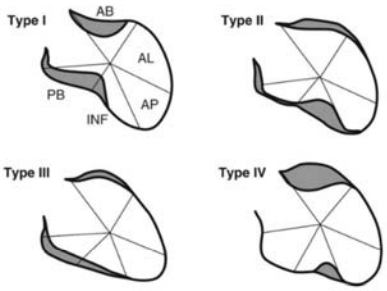
Shape of LV

- Apex: enlarged(less conical) and shifted downward and toward the mitral plane in both systole (inner line) and diastole (outer line)



Silhouettes of LV shape abnormalities

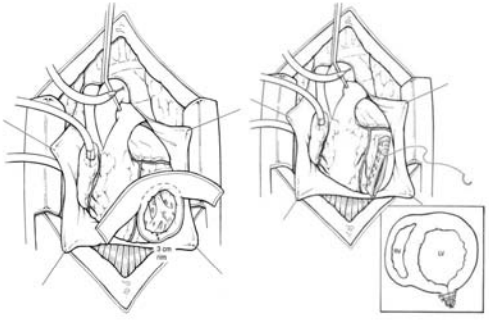
Angiographic LV silhouettes—RAO 30



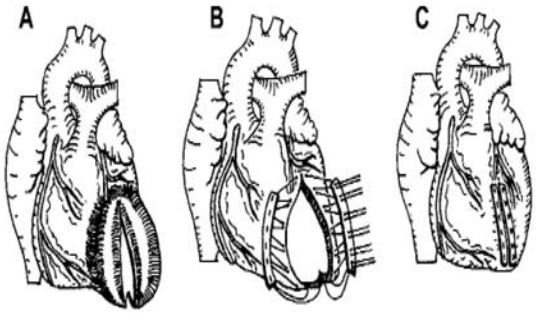
SVR for ICMP

- Dor, 1984: LV reconstruction
  - If needed, CABG ± MVP or MVR
- Technique: not standardized, many variations
  - Jatene: linear closure
  - Mickleborough: modified linear closure
  - Dor and Menicanti: circular closure with patch
  - McCarthy: double cerclage closure without patch

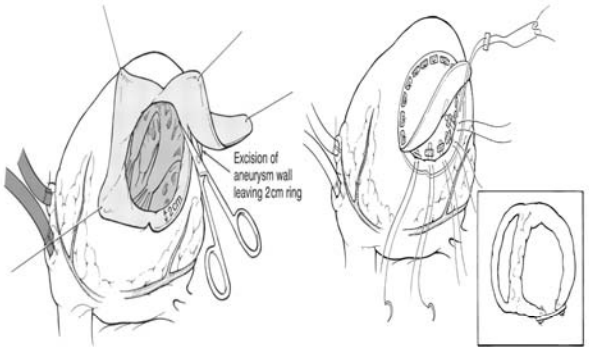
Linear closure by Jatene



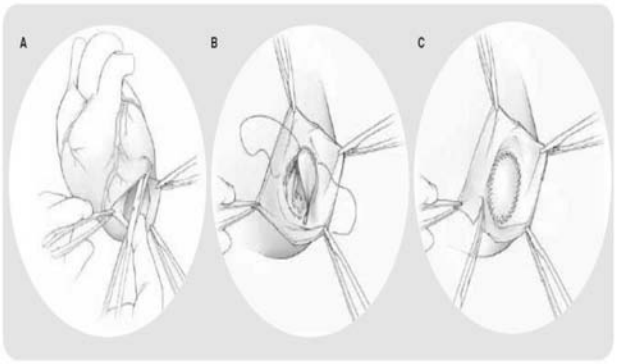
Mickleborough procedure



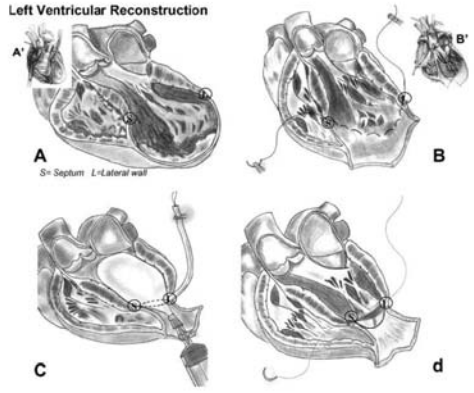
Circular patch plasty



Endoventricular patch plasty



Surgical Ventricular Restoration



Surgical pitfalls during SVR

Box 100-3
Surgical Pitfalls

- Incorrect indications
- Incomplete revascularization
- Embolism
- Cavity dimension: too large or too small
- Cavity shape: spherical or distorted

Surgical Details of Anterior SVR

- Menicanti, 2001: RESTORE Group
  - If needed, CABG ± MVP 26mm sizer
- Mannequin:
  - 50 to 60 mL/m^2
  - New apex = apex of the Mannequin
  - Start 2/0 endoventricular circular suture
  - Reduces risk: too small residual cavity
  - Rebuilding of LV: in elliptical way
- If closure plane is parallel to MV: spherical LV

Surgical Ventricular Restoration

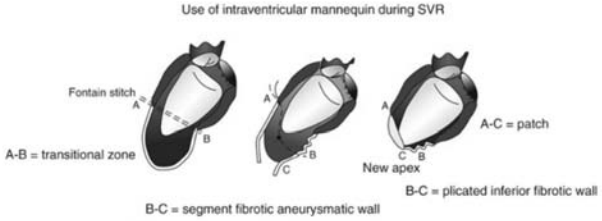
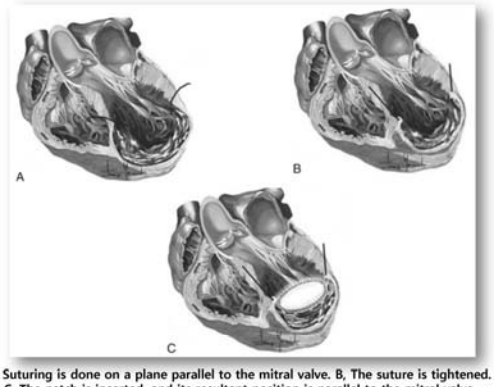


FIGURE 100-11 The use of the intraventricular mannequin during surgical left ventricle reconstruction

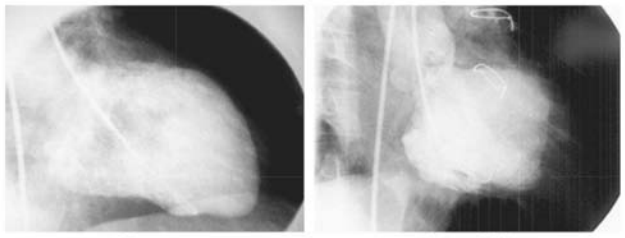
Suboptimal endoventricular suture



A, Suturing is done on a plane parallel to the mitral valve. B, The suture is tightened. C, The patch is inserted, and its resultant position is parallel to the mitral valve

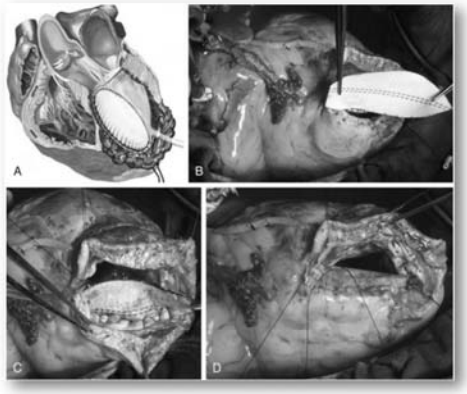
Suboptimal endoventricular suture

Note the spherical left ventricular chamber achieved after surgery



Pre-op Post-SVR

Surgical Ventricular Restoration



Outcomes and Prognosis

- Low early mortality
  - 2-13%
- Acceptable 5 and 10 year mortality
  - 5 year survival 58-80%
  - 10 year survival 30% (better than medical Tx)
- Most patients experience increased LV performance
  - LVEF ↑ PHTn ↓ LV volume ↓ MV O_2 demand ↓ Exercise tolerance ↑

The STICH trial

(Surgical Treatment for Ischemic Heart Failure)

- Target registry 2800 patients with 90 participating centers
- Objectives to seek best treatment for coronary disease and heart failure (Inclusive of SVR)
- Groups
  - Medical therapy alone
  - Medical therapy & CABG
  - Medical therapy & CABG and SVR

STICH SVR Trial Design

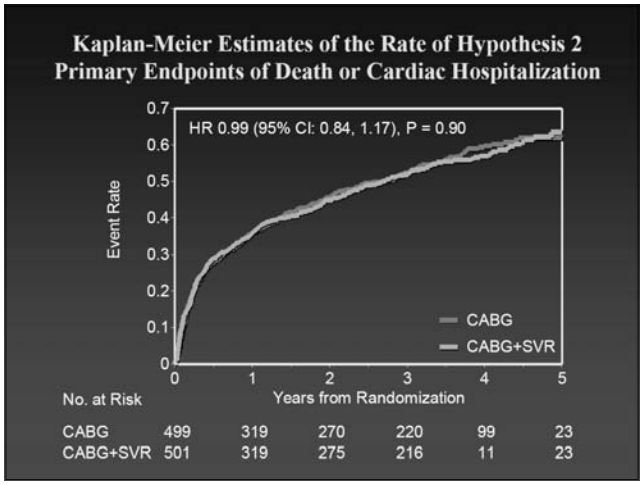
1000
Patients randomized 2002-2006
CAD, EF ≤ 35%
Anterior akinesia/dyskinesia amenable to SVR

Randomized

499
CABG only

501
CABG + SVR

Follow-up 99% complete at 48-months
~ 50% Mild Angina/ ~ 41% CCS III
~ 50% Class I/II NYHA/ ~ 43% Class III
Range for ESVI was 23 – 284 ml/m²



Insights into the STICH Trial

- CABG alone or CABG +SVR-Hypothesis 2
- SVR + CABG: no impact over CABG alone
  - Mortality
  - Heart failure hospitalizations
  - Exercise tolerance
  - Quality of life

limitations of the STICH trial

(1) Pt. inclusion bias: not randomized,

(2) Smaller reduction of ESV
  - Questions: performed properly in a majority?

- SVR Goal: LVESVI < 60 mL/m^2
- ESC & EACTS: COR IIb, LOE B
  - **Scar in the LAD territory**
  - **Baseline LVESVI ≥ 60 mL/m^2**

Summary of SVR

- Choice to add SVR to CABG should be based on
  - heart failure symptoms
  - LV volumes
  - mitral valve: geometry and MR severity
  - transmural extent of myocardial scar tissue and viability
  - surgical expertise
- Appropriate patient selection criteria:
  (1) ventricular properties - better hemodynamic effects
  (2) hemodynamic - clinical outcomes

【논문작성법】

논문작성법

연세대학교 강남세브란스병원 흉부외과학교실

이 성 수

【초음파 교육】

장소: 메이플동 에메랄드홀 2층

Lung Ultrasonography: Basic Application

Department of Thoracic and Cardiovascular Surgery, CNUH

Do Wan Kim

Principle

- 5-MHz Microconvex/Linear probe (4 -12 MHz)
  - 1 -17cm range of exploration
- Turn off filters : for artifacts
- 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

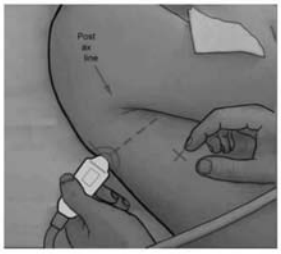
Check point

- Boundary
  - Sternum
  - Anterior axillary line
  - Posterior axillary line
- Area
  - Upper BLUE point
  - Lower BLUE point
  - PLAPS (Posterior/ Lateral, Alveolar / Pleural syndrome) point

BLUE point

Lichtenstein DA. **The BLUE-points: three standardized points used in the BLUE-protocol for ultrasound assessment of the lung in acute respiratory failure.** Crit Ultrasound J (2011) 3:109–110

BLUE point



Lichtenstein DA. **The BLUE-points: three standardized points used in the BLUE-protocol for ultrasound assessment of the lung in acute respiratory failure.** Crit Ultrasound J (2011) 3:109–110

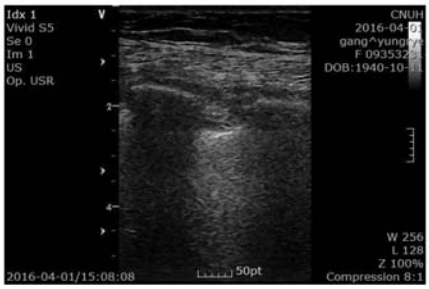
PLAPS-point

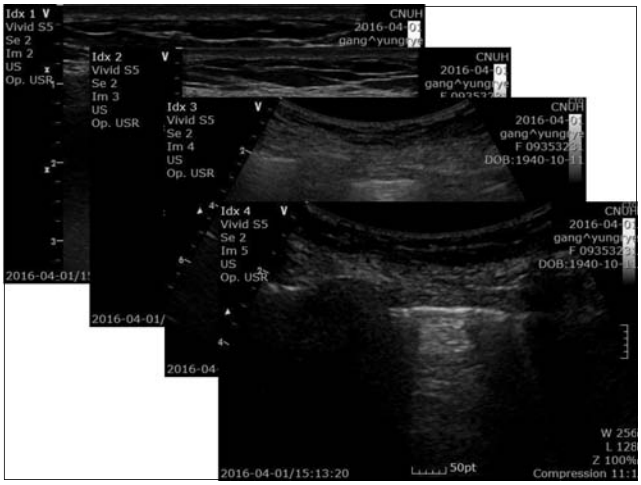
- Posterior axillary line + Lower BLUE point
- Alveolar syndrome : consolidation
- Pleural syndrome : pleural fluid
- Milestone of pleural effusion
- The lowest point of the lung
- BLUE protocol : not pulmonary edema but pneumonia

Manipulation

- Correct angle – right angle of pleura
- Carmen maneuver
- Zero pressure
- Pleural line : 0.5 cm below the rib line
- Distance of the ICS : 2 cm
- Neonate : Same as adult

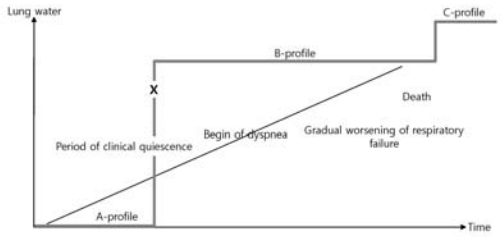
Bat sign ??





10 signs

- Bat sign
- A line
- Lung sliding
- Stratosphere sign
- Lung point
- Sinusoid sign
- Quad sign
- Shred sign
- Tissue like sign
- B line



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

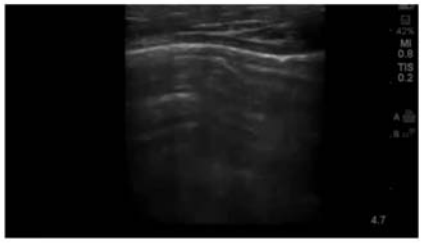
Bat sign

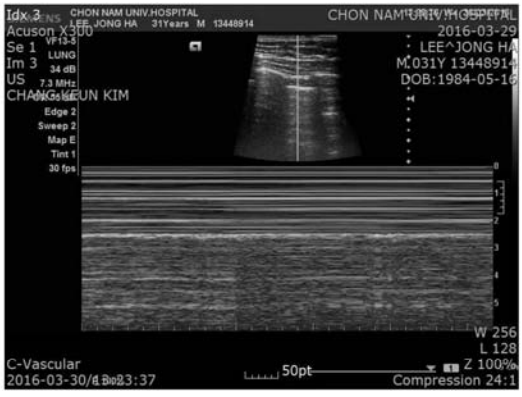
A-lines

- 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

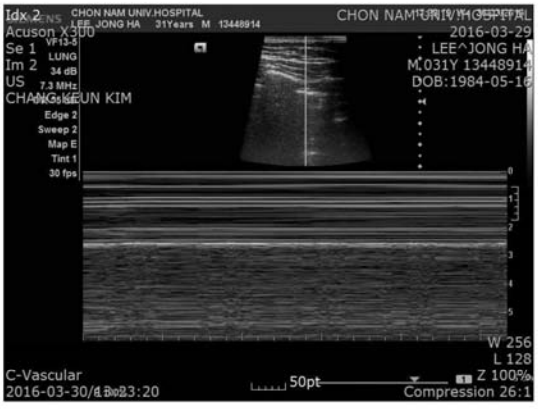
- PLAPS point : non specific (d/t gravity)
- Bilateral all fields : cardiogenic edema
- Localized : consolidation (pneumonia, interstitial diseases)
- Lung rockets + lung sliding = B profile
- Lung rockets without sliding = B' profile

B-lines

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

Stratosphere sign

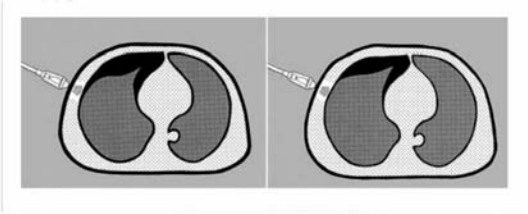
- Barcode sign
- Absence of lung sliding
- D/D with lung pulse
- Pneumothorax in M mode



Lung point

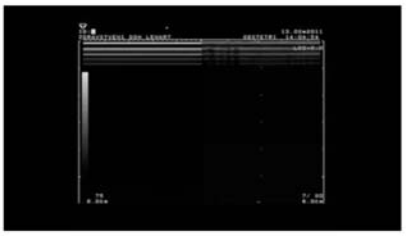
- Indicator of pneumothorax
- Abrupt appearance
- Lateral side : Pneumothorax size ↑
- On one side : lung sliding preserve
- On the other side : lung sliding absent
- Pneumothorax with no lung point : massive pneumothorax (total collapse)

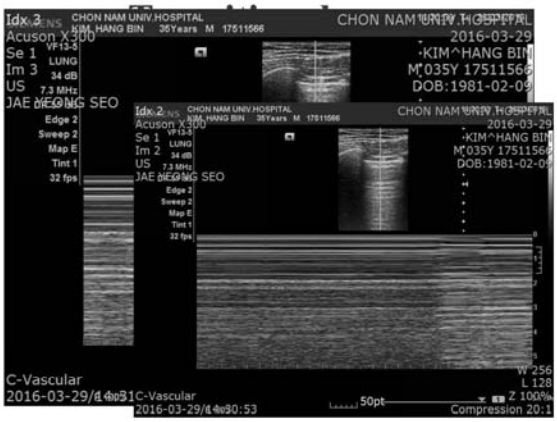
Lung point



http://www.emcurious.com/blog-1

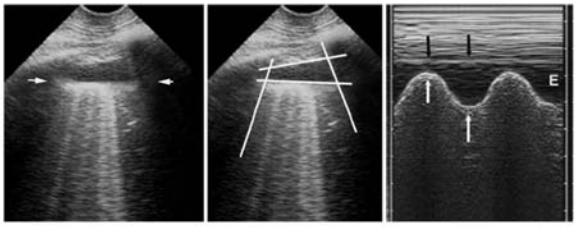
Lung point





Lung point

- D/D with Mangrove variant
- End expiration or inspiration pause
- Moderate use of M-mode
- Progressive pattern
- Entire lung area



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

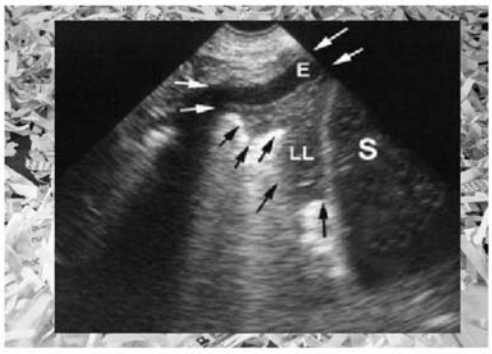
Quad sign

- 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

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

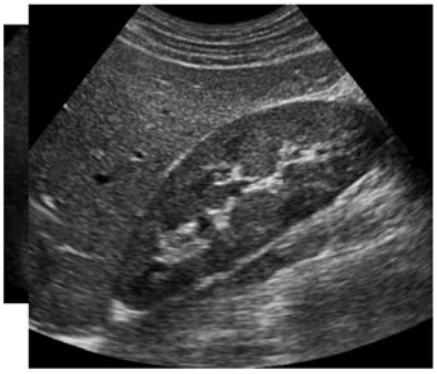
Shred sign



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

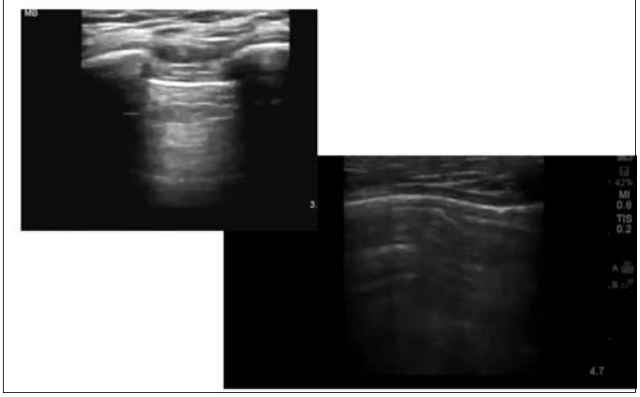
- U/S sensitivity : 98%
- U/S specificity : 95%
- X-ray sensitivity : 67%
- X-ray specificity : 85%

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

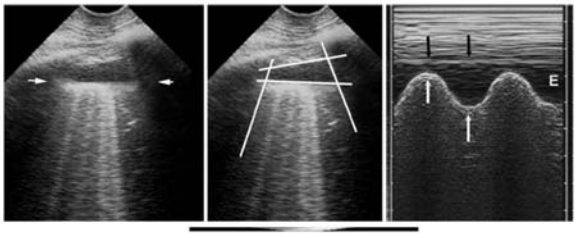
Pneumothorax



Pleural effusion

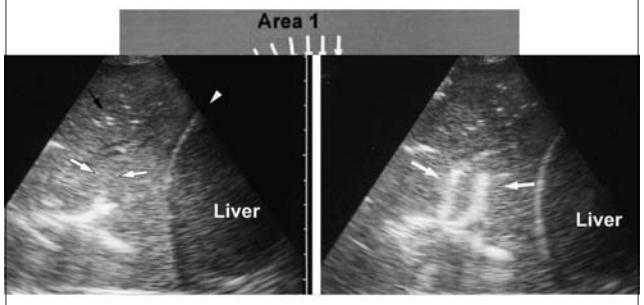
- Amount : > 20ml
- The volume does change with respiration
- Quadrangular shape with a regular lower border
- Useful Indicator of drainage site
- Transudate : anechoic
- Exudate : echogenic feature
- Sub B-line

Pleural effusion



Alveolar syndrome

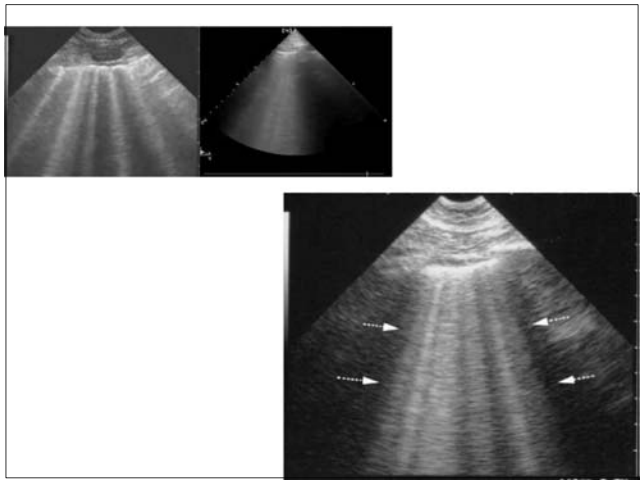
- Water contained alveoli
- m/c in PLAPS point
- Does not change with respiration
- D/D with abdominal organ (etc liver.)
- Visible state of lung tissue
- Hepatization
  - Consolidated lung looks like liver
  - Air bronchogram indicate parenchymal syndrome



Lichtenstein DA. **Ultrasound diagnosis of alveolar consolidation in the critically ill.** Intensive Care Med (2004) 30:276–281

Interstitial syndrome

- Thickened interlobular septum
- B-lines, Lung rockets sign
- Upper and lower BLUE point
- B1 = 7mm apart (moderate air loss)
- B2 = 3mm apart (severe air loss)
- D/D with Z-line
- PLAPS point : less clinical importance

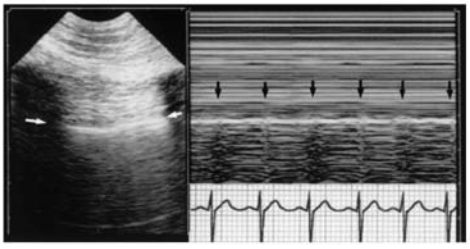


Lung pulse

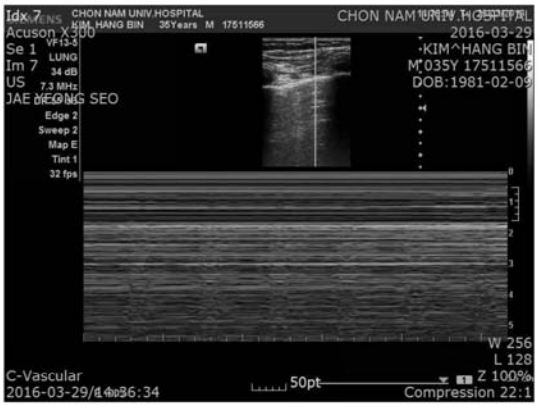
- Disappearance of lung sliding
- Heart beating
- r/o pneumothorax
- D/D pneumothorax : no lung pulse
- Atelectasis : selective intubation, ARDS

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



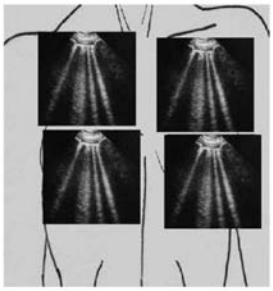
Lichtenstein DA, et al. **The "lung pulse": an early ultrasound sign of complete atelectasis.** Intensive Care Med (2003) 29:2187–2192



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

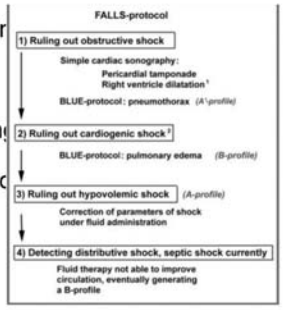
Pulmonary edema



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

FALLS-Protocol

- Not yet supported by clir
- Dichotomy
- Change of A-lines to lun
- Direct biomarker of clinic



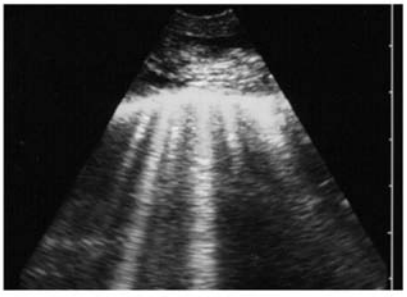
Lichtenstein DA. **BLUE-protocol and FALLS-protocol: two applications of lung ultrasound in the critically ill.** Chest.2015 Jun;147(6):1659-70.

BLUE protocol

- Lung rockets : only anterolateral part
- Pulmonary edema : diffuse B-line + lung sliding
- Pneumothorax : A-line + Lung point + sliding(-)
- Pneumonia : B-pattern + sliding(-), A-profile +PLAPS, A/B profile, C-profile

Limitation

- Do not evaluation of trachea
- Chest tube
- Dressing
- Subcutaneous emphysema
  - No Bat sign
  - E-lines
- Huge bullae
  - finding of lung sliding
  - D/D with pneumothorax

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Basic Echocardiography

서울대학교 의과대학 흉부외과학교실

김 동 중

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.

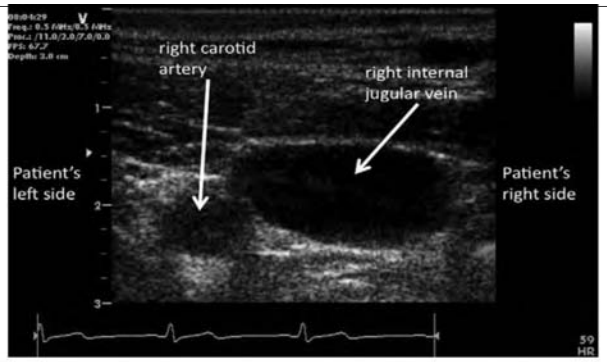


Figure 1 Right neck central vein cannulation. The ultrasound probe is held so that each side of the screen displays ipsilateral structures. With the probe mark placed on the upper left corner of the image, the displayed structures will move in the same direction with the probe.

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.

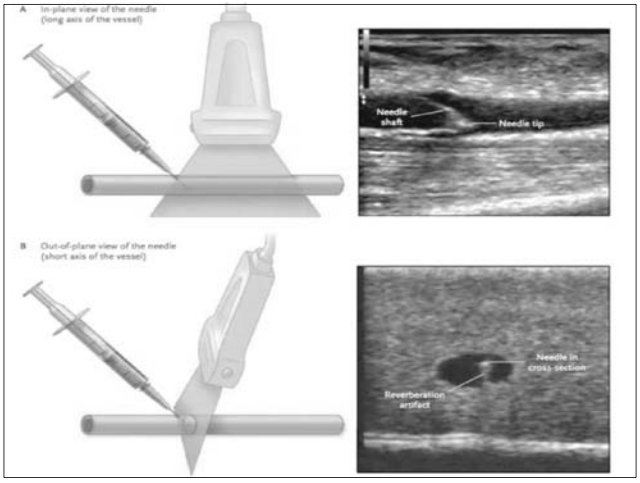
Qualifications of the Ultrasound User for Vascular Access

Table 2 Recommended training objectives for ultrasound-guided vascular cannulation

Cognitive skills
1. Knowledge of the physical principles of ultrasound
2. Knowledge of the operation of the ultrasound equipment, including the controls that affect the imaging display
3. Knowledge of infection control standards for performing vascular access and sterile preparation of the ultrasound probe for real-time use
4. Knowledge of the surface anatomy specific to the access site and ultrasound anatomy that allows identification of the target vessel and structures that are to be avoided
5. Ability to recognize the location and patency of the target vessel
6. Ability to recognize atypical anatomy of vessel location and redirect the needle entry to minimize complications
7. Knowledge of the color flow and spectral Doppler flow patterns that identify arterial and venous flow characteristics
Technical skills
1. Ability to operate the ultrasound equipment and controls to produce quality information to identify the target vessel
2. Dexterity to coordinate needle guidance in the desired direction and depth on the basis of the imaging data
3. Use of needle guides for coordination of needle insertion with imaging data when operator dexterity is lacking or clinical conditions make dexterity coordination challenging
4. Ability to insert the catheter into the target vessel using ultrasound information
5. Ability to confirm catheter placement into the target vessel and the absence of the catheter in unintended vessels and 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



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: preprocedural 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 callber

  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

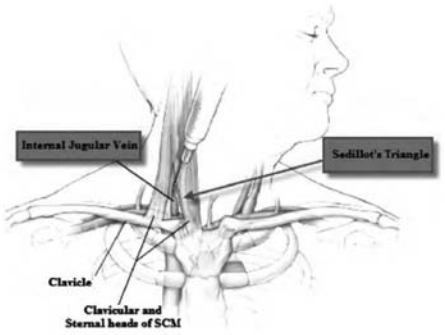


Figure 8 External landmarks for IJ cannulation. *SCM*, Sternocleidomastoid muscle. *Modified from N Engl J Med*.[4]

Ultrasound Guidance for Internal Jugular Cannulation

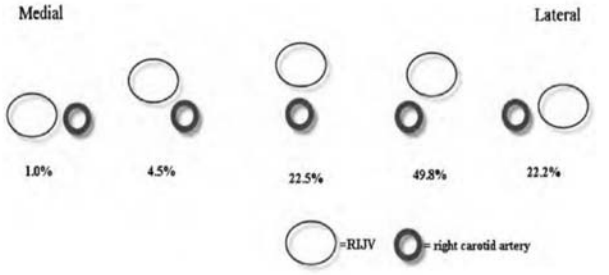
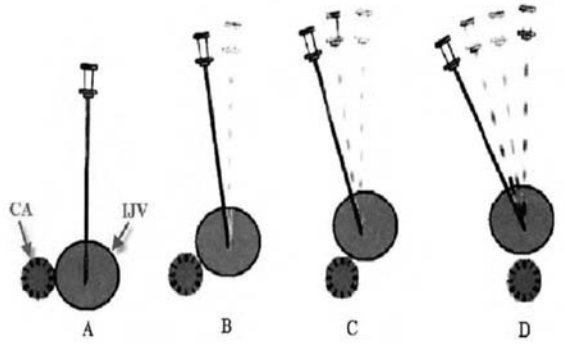


Figure 7 Variable overlap between CA and IJ vein. *RIJV*, Right IJ vein. *Adapted from J Vasc Interv Radiol*.[24]

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

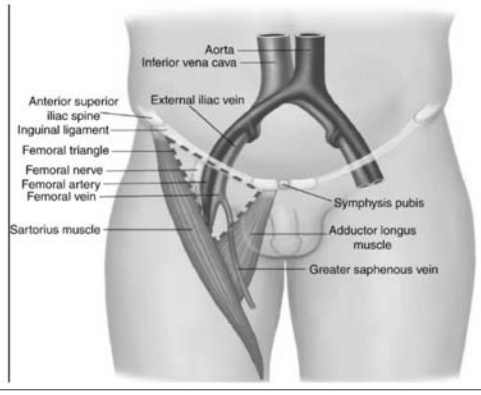
Ultrasound Guidance for Femoral Venous Access (general)

- 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.

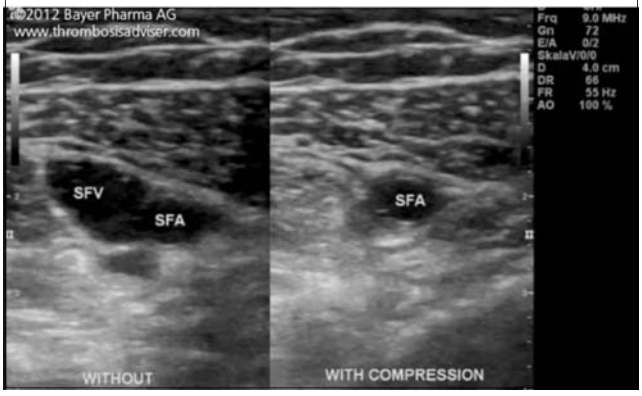
Ultrasound Guidance for Femoral Venous Access (technique)

- "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 Course (조별 진행)

김태식, 김재범, 김동중, 김도완

1. Heart1 (담당: 김태식)

Parasternal long/short axis (aortic valve, mitral valve, papillary muscle level) view

2. Heart2 (담당: 김동중)

Apical 4-/5-chamber view with coronary territories

3. Lung (담당: 김도완)

BLUE point

Bat sign

Lung sliding

Lung pulse on M-mode

4. Vessel (담당: 김재범)

Internal Jugular vein with access point

Basilic vein with access point

Radial artery with access point

5. Vascular access simulation with training model

6. Self-training

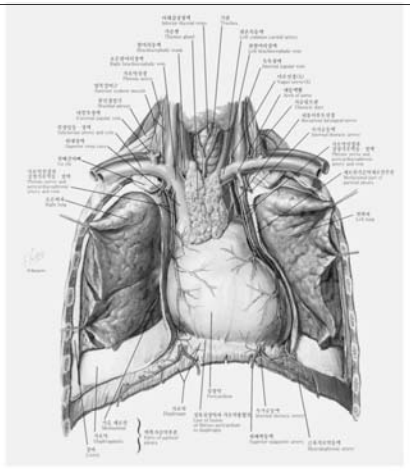
【소아심장파트】

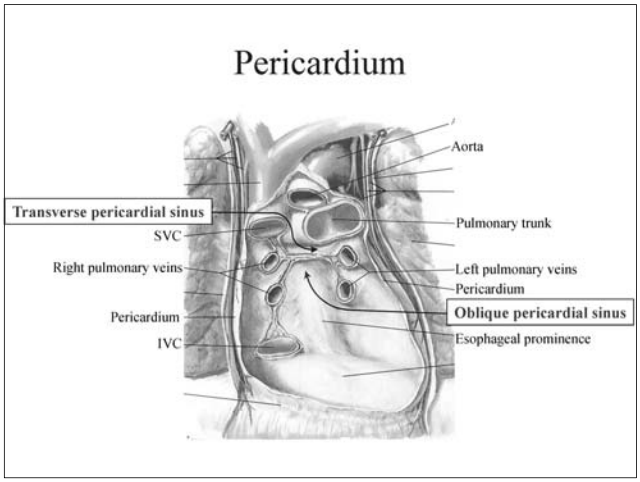
좌장: 이 철

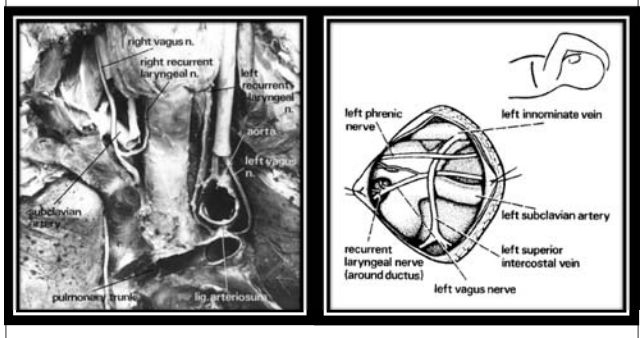
Normal Cardiac Anatomy

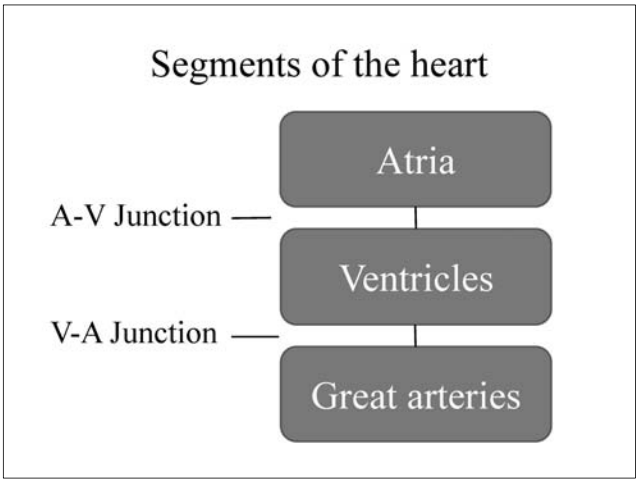
Keimyung University Dongsan Medical Center

Woo Sung Jang, M.D., Ph.D.







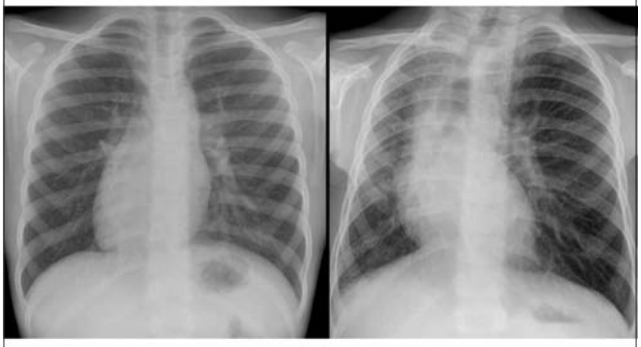


Three Facets

- Morphology
- Relationship
- Connection

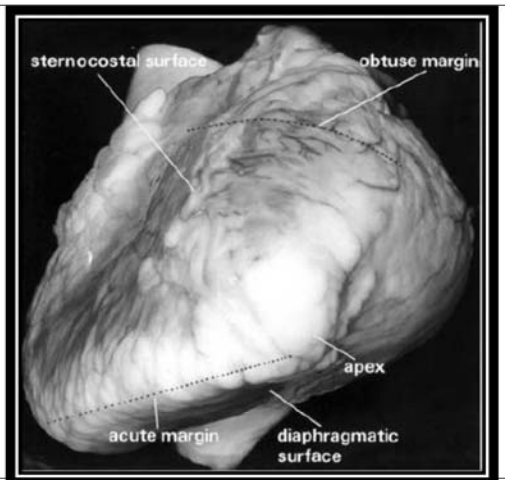
Heart Position

Levocardia Mesocardia Dextrocardia

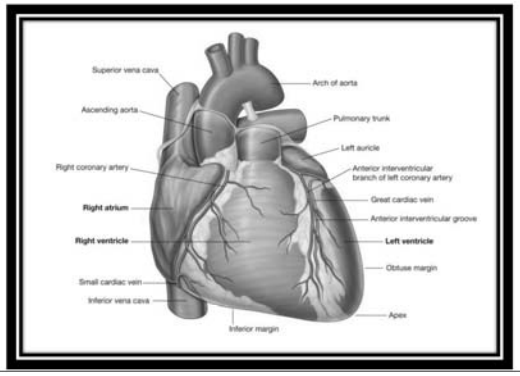


'Dextrocardia' VS "Displacement"

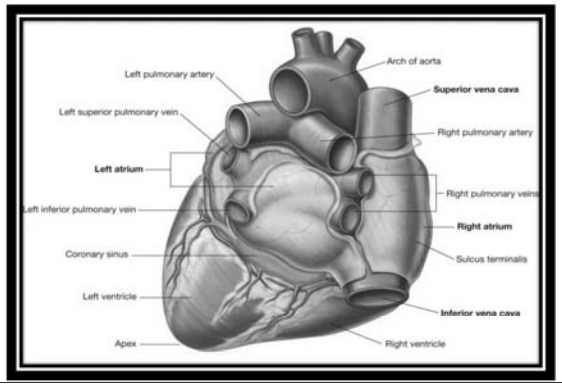
Normal cardiac anatomy



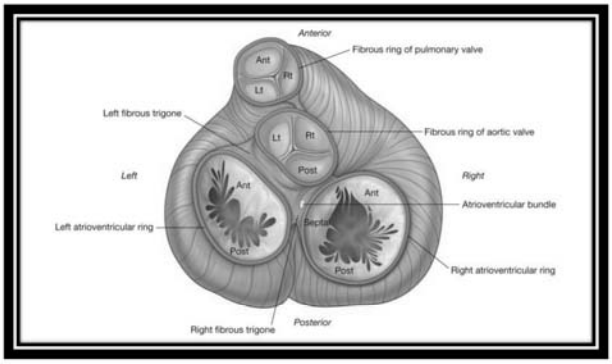
Anterior Surface

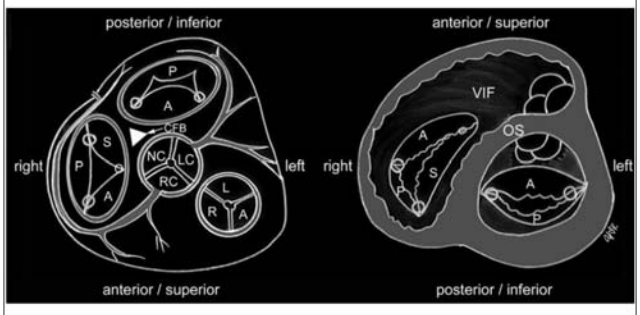


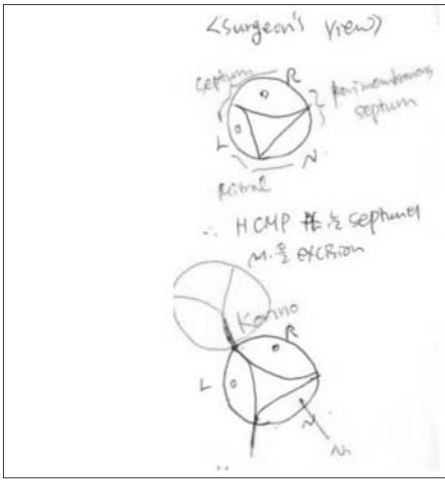
Posterior Surface



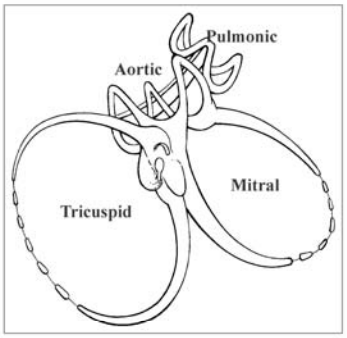
Heart Valves







Fibrous Skeleton

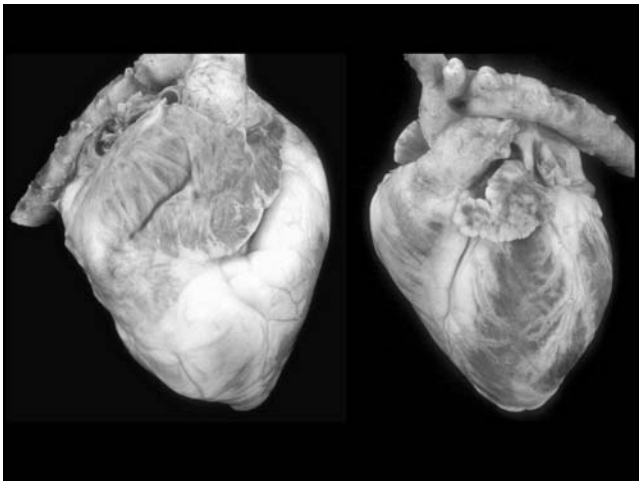


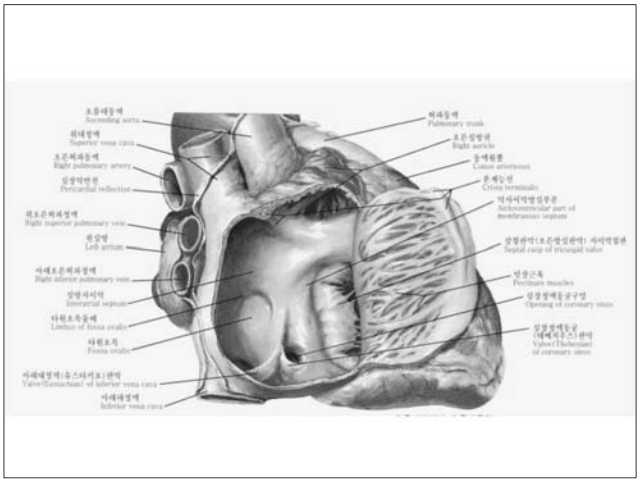
Atrial Identification

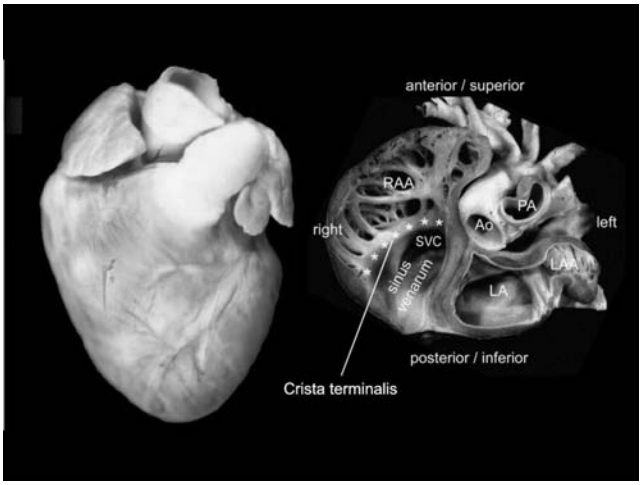
- Atrial appendages
- Pectinate muscles
- Crista terminalis
- Septal morphology
- Not by venous connections

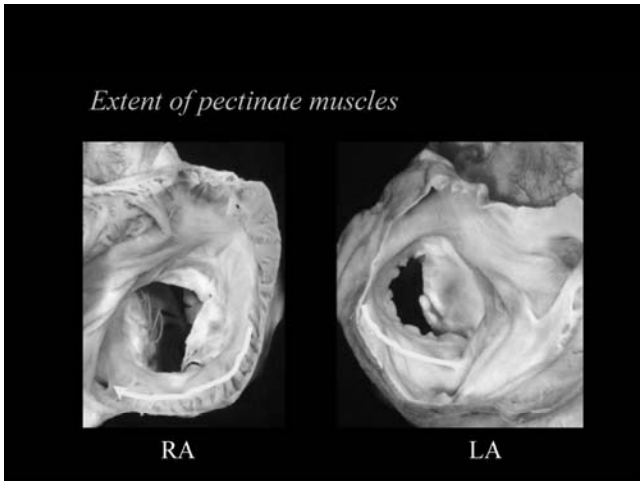
Atria

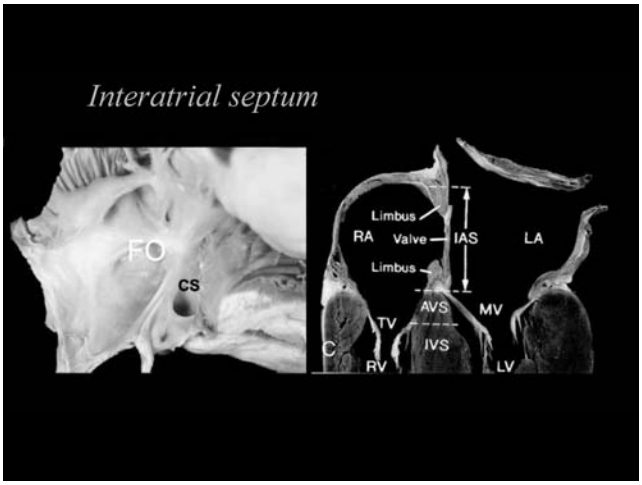
Right atrium	Left atrium
• Triangular appendage with a broad junction • Pectinate muscles extending to AV junction • Crista terminalis • Fossa ovalis with a limb	• Finger-like appendage with a narrow junction • Pectinate muscles not extenting to AV junction • No crista terminalis • No fossa ovalis

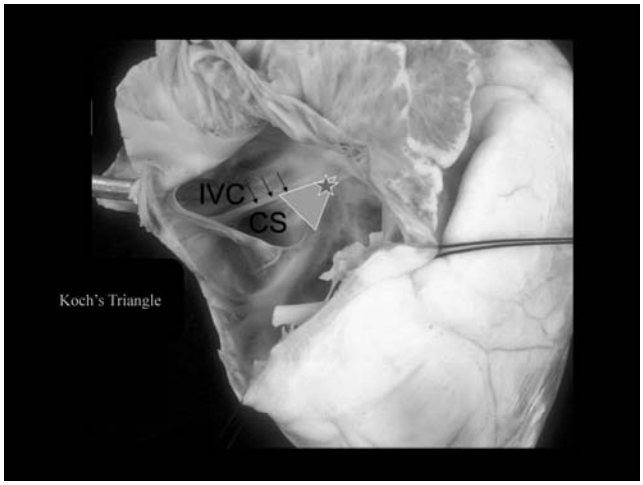


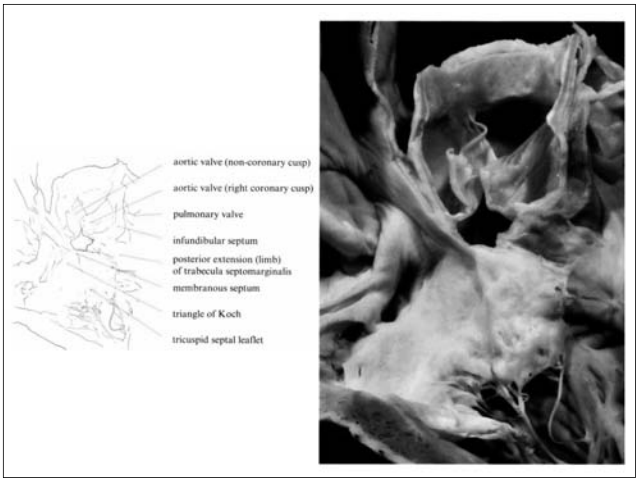












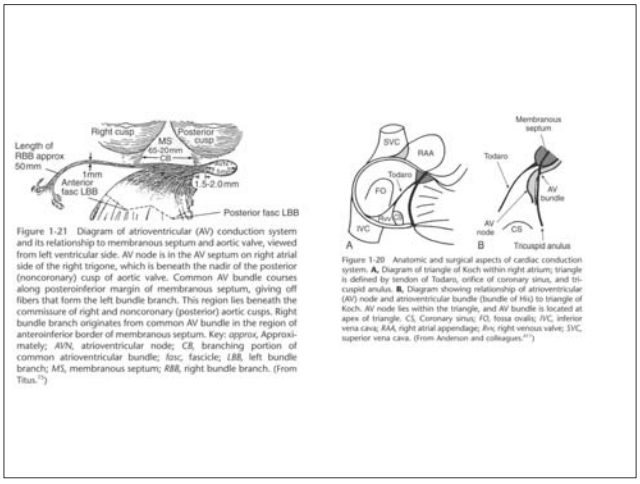
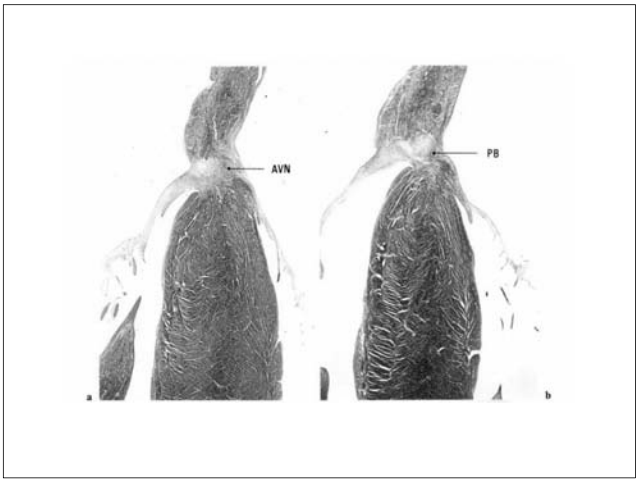
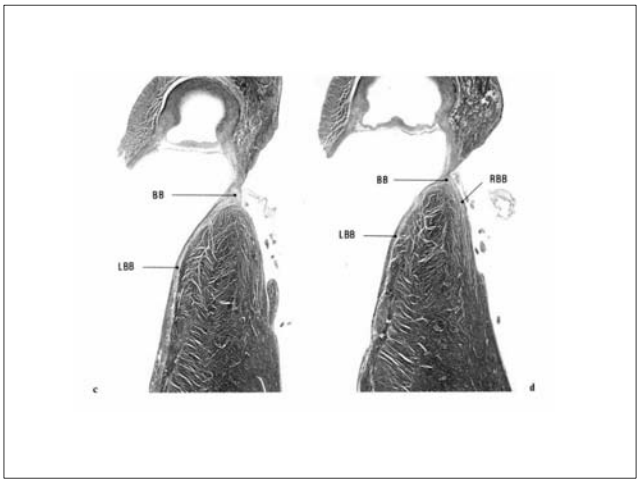
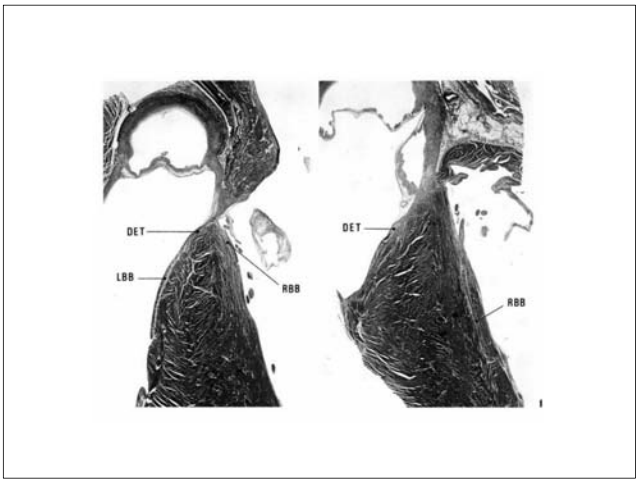


Figure 1-21 Diagram of atrioventricular (AV) conduction system and its relationship to membranous septum and aortic valve, viewed from left ventricular side. AV node is in the AV septum on right atrial side of the right trigone, which is beneath the nadir of the posterior (noncoronary) cusp of aortic valve. Common AV bundle courses along posteroinferior margin of membranous septum, giving off fibers that form the left bundle branch. This region lies beneath the commissure of right and noncoronary (posterior) aortic cusps. Right bundle branch originates from common AV bundle in the region of anteroinferior border of membranous septum. Key: *approx*, Approximately; *AVN*, atrioventricular node; *CB*, branching portion of common atrioventricular bundle; *fasc*, fascicle; *LBB*, left bundle branch; *MS*, membranous septum; *RBB*, right bundle branch. (From Titus.[76])

Figure 1-20 Anatomic and surgical aspects of cardiac conduction system. **A**, Diagram of triangle of Koch within right atrium; triangle is defined by tendon of Todaro, orifice of coronary sinus, and tricuspid anulus. **B**, Diagram showing relationship of atrioventricular (AV) node and atrioventricular bundle (bundle of His) to triangle of Koch. AV node lies within the triangle, and AV bundle is located at apex of triangle. *CS*, Coronary sinus; *FO*, fossa ovalis; *IVC*, inferior vena cava; *RAA*, right atrial appendage; *thv*, right venous valve; *SVC*, superior vena cava. (From Anderson and colleagues.[77])



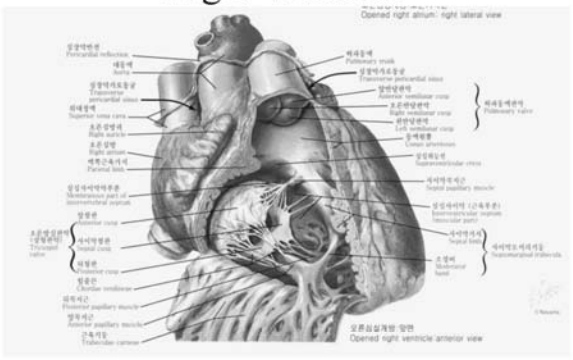


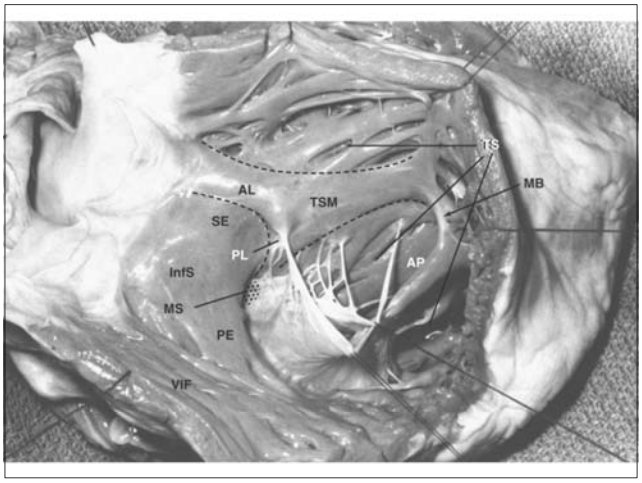


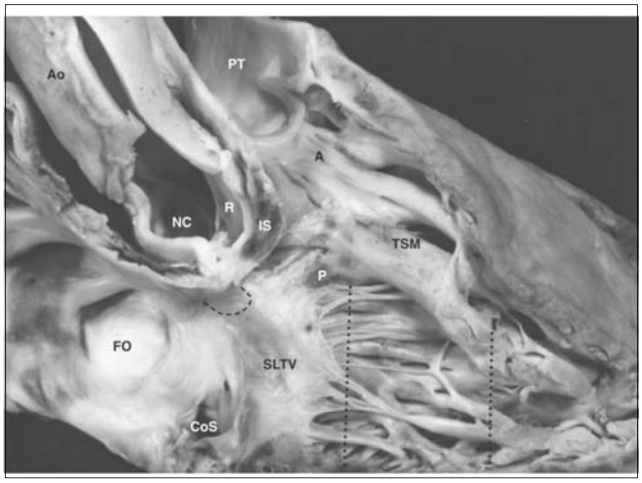
Ventricles

RV	LV
Trabeculations: heavy and irregular	Trabeculations: fine and regular
Moderator band	No moderator band
Septal attachment of AV valve: more apical	Septal attachment of AV valve: more cranial
Septal attachment of papillary muscles	No septal attachment of papillary muscles

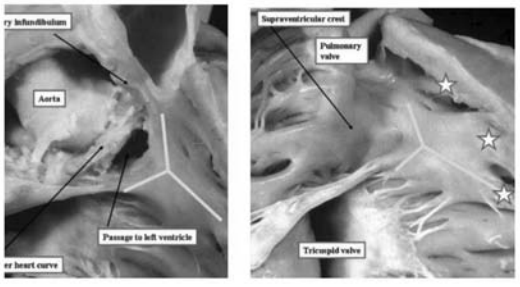
Right Ventricle

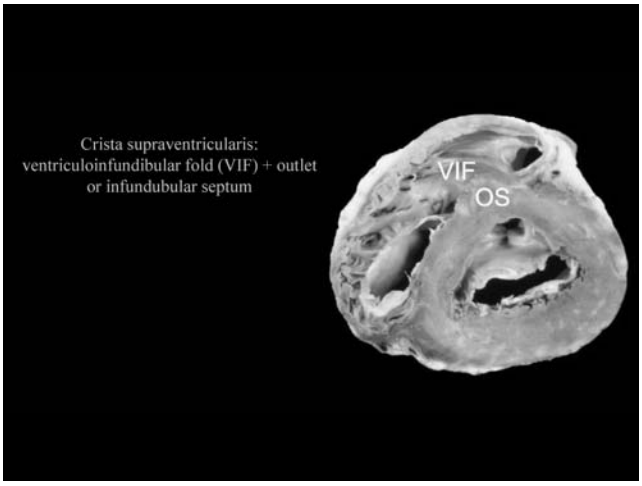


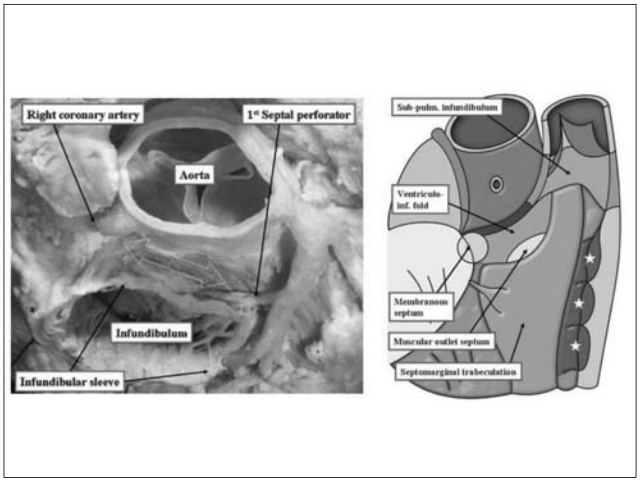


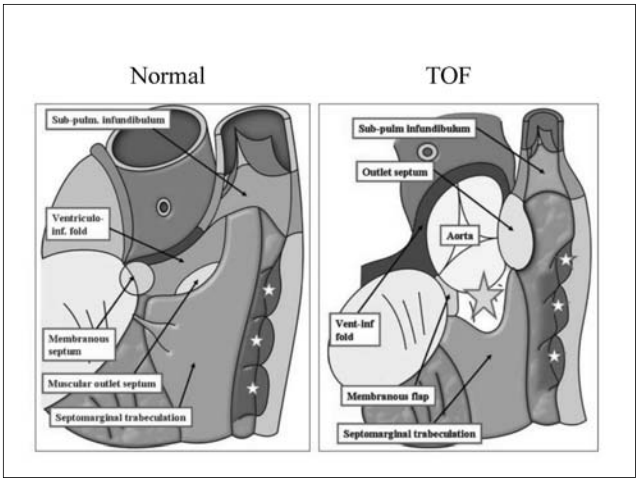


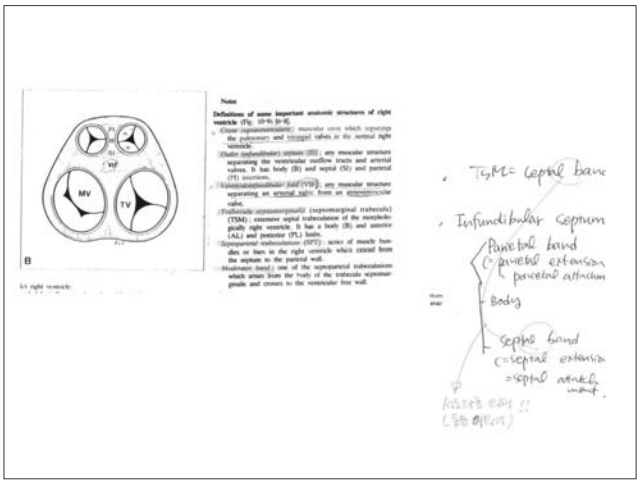
"Crista supraventricularis (Supraventricular crest)"
defined as the muscular area separating the attachments of the tricuspid and pulmonary valves in the roof of the right ventricle

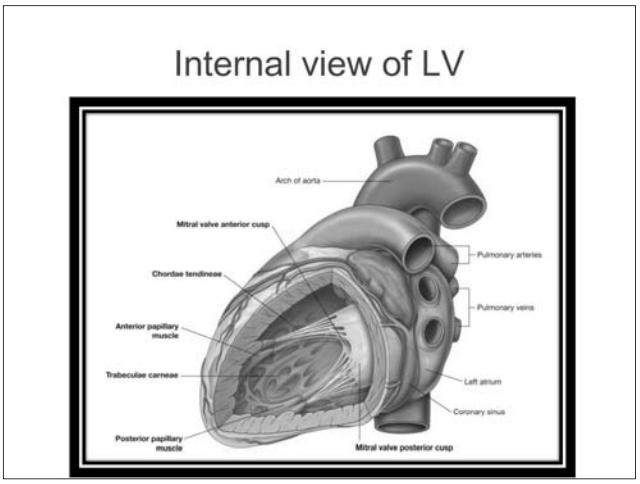


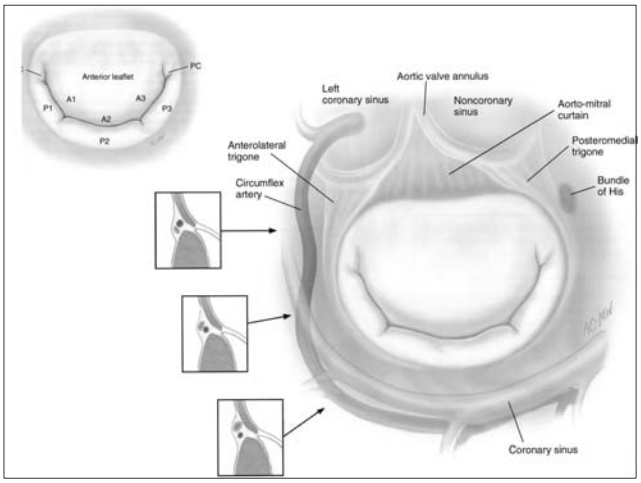


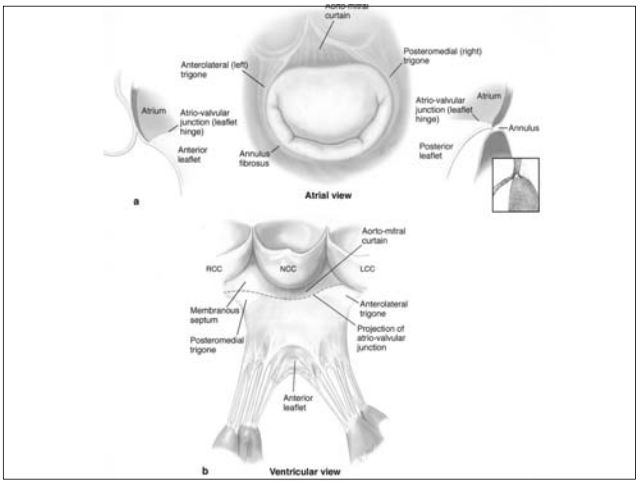

Right coronary artery
1st Septal perforator
Aorta
Infundibulum
Infundibular sleeve
Sub-pulm. infundibulum
Ventriculo-inf. fold
Membranous septum
Muscular outlet septum
Septomarginal trabeculation


Normal
TOF
Sub-pulm. infundibulum
Ventriculo-inf. fold
Membranous septum
Muscular outlet septum
Septomarginal trabeculation
Sub-pulm infundibulum
Outlet septum
Aorta
Vent-inf fold
Membranous flap
Septomarginal trabeculation


MV
TV
B
Notes
Definitions of some important anatomic structures of right ventricle (Fig. 10-9)
TSM= septal band
Infundibular septum
Parietal band
Body
Septal band


Internal view of LV
Arch of aorta
Mitral valve anterior cusp
Pulmonary arteries
Chordae tendineae
Pulmonary veins
Anterior papillary muscle
Trabeculae carneae
Left atrium
Coronary sinus
Posterior papillary muscle
Mitral valve posterior cusp


Anterior leaflet
PC
P1
A1
A3
P3
A2
P2
Aortic valve annulus
Left coronary sinus
Noncoronary sinus
Aorto-mitral curtain
Posteromedial trigone
Anterolateral trigone
Circumflex artery
Bundle of His
Coronary sinus


Aorto-mitral curtain
Anterolateral (left) trigone
Posteromedial (right) trigone
Atrium
Atrio-valvular junction (leaflet hinge)
Anterior leaflet
Annulus fibrosus
Posterior leaflet
Annulus
Atrial view
a
RCC
NCC
LCC
Membranous septum
Posteromedial trigone
Projection of atrio-valvular junction
Anterior leaflet
b
Ventricular view

References

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- Carpentier's Reconstructive valve surgery From valve analysis to valve reconstruction. Saunders/USA, 2010
- H. Kurosawa, A.E. Becker, Atrioventricular conduction in congenital heart disease. Springer-Verlag/1987
- Sabiston Textbook of Surgery, 17th ed. Elsevier/2004
- Ciba collection

ASD, VSD, PDA

세종병원 흉부외과

최 은 석

Congenital Heart Disease

- Acyanotic heart lesions
  - Lt. to Rt. shunt lesions: ASD, VSD, PDA, AVSD, AP window, etc.
- Cyanotic heart lesions: TOF, TGA, etc.
- Others

Features of heart failure in infants

- History
  - Poor feeding
  - Poor weight gain
- Physical Examination
  - Tachypnea
  - chest retraction
  - Hepatomegaly

Management

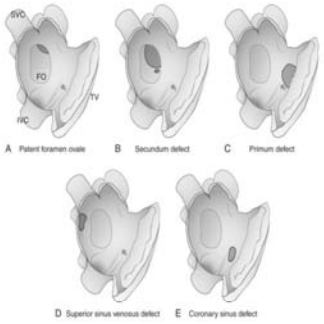
- Surgical indication
  - Symptom (+)
  - Significant amount of shunt: Qp:Qs ≥ 1.5, LV volume overload
- Contraindication
- Treatment modality
  - Surgery
  - Intervention

ASD

(Atrial Septal Defect)

Type

- Secundum (m/c)
  - Primum
- Sinus venosus
  - SVC / IVC type
  - PAPVR
- Coronary sinus



CPA

EchoCG

Management

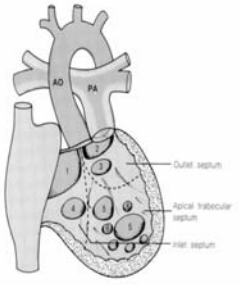
- Treatment
  - Intervention: ≥ 12kg
  - Surgery
    - Limb deficiency
    - Sternotomy vs. thoracotomy vs. minimally invasive
- Contraindication

VSD

(Ventricular Septal Defect)

Type

- Subarterial
- Perimembranous (m/c)
- Inlet
- Muscular
- Gerbode



Clinical manifestation

- Size of defect / amount of shunt
  - Small
  - Moderate
  - Large:
    - Low Rp: large shunt – severe congestion
    - High Rp: Eisenmenger syndrome: no shunt or reverse shunt

CPA

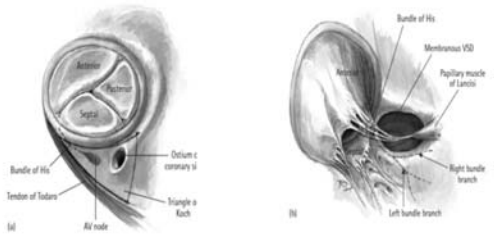
EchoCG

Natural history

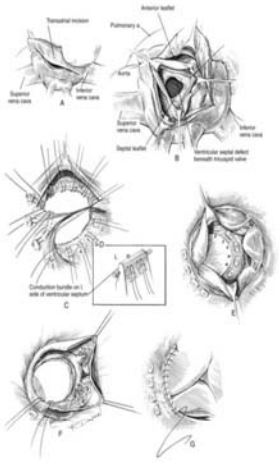
- Spontaneous closure: ± septal aneurysm
  - Subarterial type
- AV prolapse: ± AR
  - Subarterial / perimembraneous type
- Infundibular narrowing
- Pulmonary vascular disease

Conduction system in VSD

Koch's Triangle



VSD patch closure



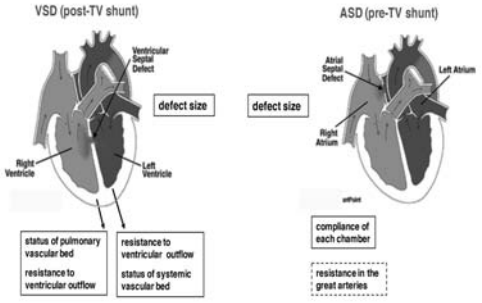
Management

- Surgical indication
  - Significant amount of shunt
  - AV prolapse ± AR
- Contraindication
- Treatment
  - Operation
  - Intervention: muscular VSD

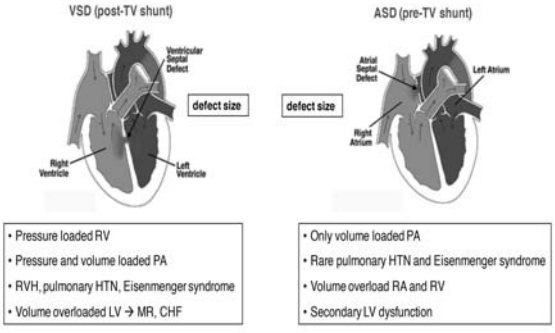
Postoperative care

- Pulmonary hypertension
- Arrhythmia
  - JET (Junctional Ectopic Tachycardia)
  - AV block
- Aortic insufficiency
- Tricuspid regurgitation
- Residual shunt

Hemodynamic in ASD / VSD



Hemodynamic in VSD / ASD



PDA

(Patent ductus arteriosus)

Anatomy

- Ductus from 6th arch
- Aorta from 4th arch

Clinical manifestation

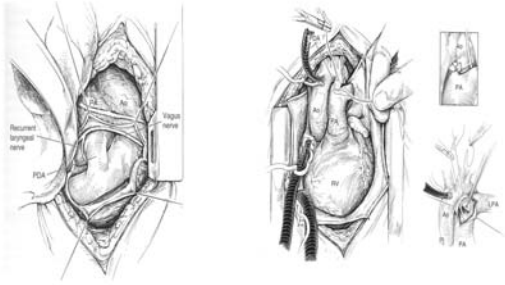
- Nearly same as that of VSD
  - Continuous murmur
- Size
  - Small
  - Moderate
  - Large

EchoCG

Management

- Surgery
  - Thoracotomy vs. sternotomy
  - Ligation / division / patch closure
- Intervention
  - ≥ 6kg

Surgical treatment



Thank you for your intention

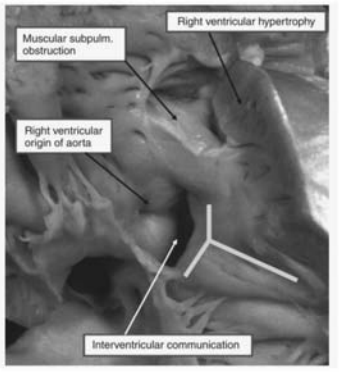
Tetralogy of Fallot with Pulmonary Stenosis

양산부산대학교병원 흉부외과학교실

김 형 태

TOF with PS

- Tetralogy of Fallot
- Interventricular communication
- Biventricular origin of the aorta
- Muscular obstruction within the right ventricular outflow tract
- Right ventricular hypertrophy

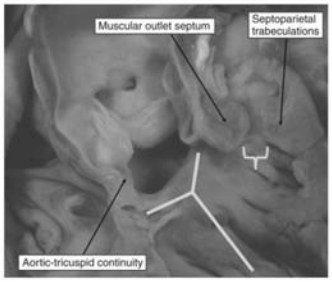


Incidence, prevalence, and aetiology

- 3.5%, of infants born with congenital heart diseass
- 0.28 per 1,000, or 1 in 3,600, live births
- Males and females equally affected
- The risk of recurrence in siblings, about 3% if there are no other affected first-degree relatives
- Microdeletions of the q11 region of chromosome 22, Di George syndrome and the velocardiofacial syndrome, conotruncal anomaly face syndrome
- No differences are found in the incidence of affected children according to whether it is the mother of father who had the lesion initially
- However, the risk is much higher, at above two-fifths, if the affected parent has a sibling with the same or a similar cardiac anomaly

Anatomy and morphogenesis

- Phenotypic features
- Antero-cephalad deviation of the insertion of the muscular outlet septum relative to the limbs of the septomarginal trabeculation, coupled with an arrangement of the septoparietal trabeculations which produces a squeeze at the mouth of the infundibulum

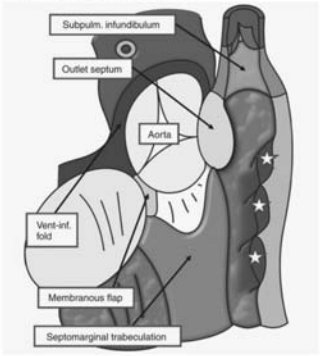


Anatomy and morphogenesis

- Phenotypic features
- The outlet septum can be markedly deviated in antero-cephalad direction without there being subpulmonary stenosis, despite the presence of hypertrophied septoparietal trabeculations, so-called Eisenmenger complex ventricular septal defect

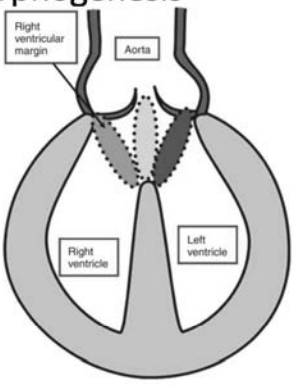
Anatomy and morphogenesis

- Phenotypic features
- Variability in the margins of the ventricular septal defect
- Directly beneath the overriding aortic valve orifice, outlet defect
- Antero-cephalad limb of the septomarginal trabeculation, which forms the anterior margins of the defect
- The roof of the defect is formed by the attachments of the leaflets of the overriding aortic valve to the ventriculo-infundibular fold



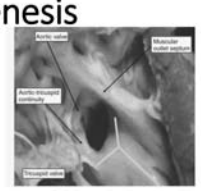
Anatomy and morphogenesis

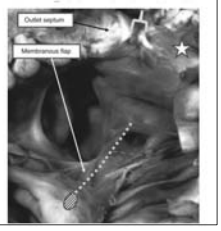
- Phenotypic features
- Variability in the margins of the ventricular septal defect



Anatomy and morphogenesis

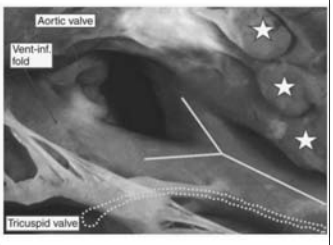
- Phenotypic features
- Variability in the margins of the ventricular septal defect
- In that the postero-inferior margin is an area of fibrous continuity between the leaflets of the aortic and tricuspid valves, perimembranous
- The septal remnant itself, called the membranous flap, is safe tissue for anchorage of sutures when such stitches are placed with care





Anatomy and morphogenesis

- Phenotypic features
- Variability in the margins of the ventricular septal defect
- Second most common pattern, interruption of the area of fibrous continuity between the aortic and tricuspid valves by a muscular fold, muscular outlet



Anatomy and morphogenesis

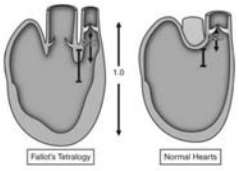
- Phenotypic features
- Variability in the margins of the ventricular septal defect
- The doubly committed and juxta-arterial defect, by far the least common in the Western World, but commoner in the Far East and South America
- Both subaortic and subpulmonary as a consequence of failure of formation of the muscular subpulmonary infundibulum

Anatomy and morphogenesis

- Phenotypic features
- Variability in the margins of the ventricular septal defect
- Inlet defects, associated with straddling and overriding of the tricuspid valve, or the ventricular component of an atrioventricular septal defect associated with common atrioventricular junction

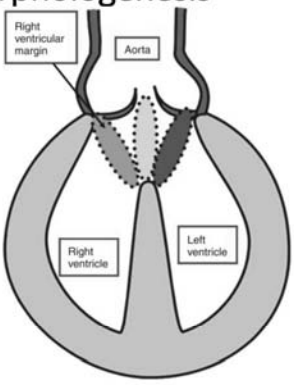
Anatomy and morphogenesis

- Phenotypic features
- Narrowing of the subpulmonary infundibulum
- Subpulmonary stenosis, an essential part of tetralogy, due to the squeeze between the antero-cephalad deviation of the outlet septum and the abnormal arrangement of the distal septoparietal trabeculations
- The infundibulum is longer in the setting of the malformation
- Obstruction at valvar level, two leaflets
- Pulmonary arterial stenosis



Anatomy and morphologenesis

- Phenotypic features
- Overriding of the aortic valve
- Much larger patch will be required, the larger part of the VSD circumference is supported by the right ventricle



Anatomy and morphogenesis

- Phenotypic features
- Other lesions of the pulmonary circulation
- Pulmonary valvar stenosis, stenosis of a bicuspid valve or to stenosis of a valve with three leaflets
- Absence of the leaflets of the pulmonary valve (absent pulmonary valve syndrome), with dilation of the pulmonary trunk and its branches -> airway problems
- Left pulmonary artery connected by the arterial duct
- Right pulmonary artery may arise directly from the ascending aorta
- Major systemic-to-pulmonary collateral arteries are sometimes present, but in association with normal right and left pulmonary arteries

Anatomy and morphogenesis

- Phenotypic features
- Associated anomalies
- ASD
- AVSD, straddling of the tricuspid valve
- Anomalous origin of the anterior interventricular coronary artery from the right coronary artery
- Right aortic arch
- Aortic incompetence, commoner in older patients

Anatomy and morphogenesis

- Morphogenesis
- Study of embryos, in which developmental stages of these malformations were observed, showed that the factory for production of the lesions was within the ventricular outflow tracts
- Deletion of chromosome 22q11 also support the existence of malseptation of the outflow tracts in humans, and point to this being due to problems in migration of cells from the neural crest

Clinical diagnosis

- Dominated by the degree of muscular obstruction of the right ventricular outflow tract
- Modified by associated anomalies, such as persistent patency of the arterial duct, or presence of large systemic-to-pulmonary collateral arteries

Clinical diagnosis

- Presentation when subpulmonary obstruction is severe from birth
- Presentation in the neonatal period
- Severe arterial desaturation, metabolic acidosis -> increased respiratory rate -> concomitant fall in arterial content of carbon dioxide -> compensatory respiratory alkalosis
- Cyanosis, dominant clinical picture, increases with crying, feeding, other activities
- Sometimes, pulmonary circulation is duct-dependent -> maintenance of ductal patency, usually by infusion of prostaglandin E

Clinical diagnosis

- Presentation when subpulmonary obstruction is moderate at birth
- Acyanotic at birth
- Development of cyanosis, dependent on increasing infundibular stenosis, and not on the degree of aortic override

Clinical diagnosis

- Presentation when subpulmonary obstruction is minimal at birth
- Similar to those of a large ventricular septal defect
- Increasing right ventricular hypertrophy -> subpulmonary obstruction more marked -> shunt is reversed -> exhibit the signs and progression as the group with moderate obstruction

Clinical diagnosis

- Presentation with absent pulmonary valve
- Absence of the leaflets of the pulmonary valve
- Respiratory symptoms of inspiratory and expiratory stridor, dyspnea caused by lobar collapse or, at times, lobar emphysema
- Compression of the bronchial tree by the grossly dilated proximal pulmonary arteries

Clinical diagnosis

- Squatting
- Causes an abrupt increase in systemic venous return and a rise in systemic vascular resistance -> right-to-left shunt decresed
- Hypercyanotic attacks
- Lead to reduced cardiac output, and be accompanied by transient loss of consciousness
- Most common between 6 months and 2 years of age

Clinial diagnosis

- Hypercyanotic attacks
- Initial presentation, a history of episodic loss of consciousness, convulsions, episodes of going floppy or pale, transient vacant episodes, episodes of becoming deeply cyanosed followed by loss of consciousness or sleep
- Episodes of very rapid deep respiration or hyperpnoea, or a high-pitched abnormal cry
- Spells results from infundibular spasm or shutdown

Clinical diagnosis

- Hypercyanotic attacks
- Shutdown, secondary to other primary physiologic influences, such as dehydration, or tachycardia-induced reduction in right ventricular preload, systemic vasodilation in response to fever, or other sympathetic activity
- Prompt treatment with continuous b-blockade, and referral for surgery or interventional catheterization

Clinical diagnosis

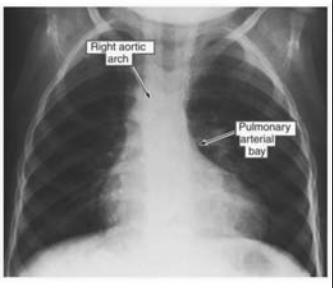
- Physical examination
- Cyanosis
- Auscultation, a systolic ejection murmur with a single second heart sound
- Overt clubbing of fingers and toes, not detected until 2 or 3 months of age
- Some degree of facial dysmorphism, associated syndromes, DiGeorge, Goldenhauer, or Down syndromes
- All patients should now undergo chromosomal analysis (22q11 deletion)
- Loud continuous murmur, more likely to originate from flow through large major systemic-to-pulmonary collateral arteries than the arterial duct

Clinical diagnosis

- Physical examination
- Subpulmonary obstruction, minimal or absent, tachpnoea, dyspnea, and intercostal or subcostal recession (heart failure symptoms)

Clinical diagnosis

- Investigations
- Confirmation is now provided largely by cross sectional echocardiography
- Chest radiograph
- Up to one-third of patients with tetralogy right aortic arch
- Reduced pulmonary vascular markings
- Pulmonary bay
- The apex of the heart may be upturned, because the hypertrophied right ventricle forms the apex in the postero-anterior projection

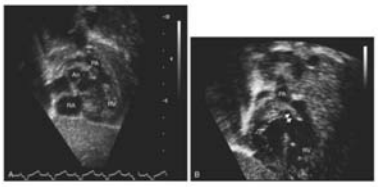


Clinical diagnosis

- Investigations
- Electrocardiography
- Normal or rightward QRS axis and overt right ventricular hypertrophy
- After surgery, right bundle branch block with prolongation of the QRS duration is frequent

Clinical diagnosis

- Investigations
- Echocardiography
- Subcostal paracoronal view, narrowed subpulmonary outflow tract, with malalignment of the anteriorly displaced muscular outlet septum



Clinical diagnosis

- Investigations
- Echocardiography
- Parasternal long-axis views, aortic override

Clinical diagnosis

- Investigations
- Echocardiography
- Four-chamber view, straddling or overriding tricuspid valve, common atrioventricular junction in hearts with deficient atrioventricular septation
- When the pulmonary trunk is traced to its bifurcation, it is possible to determine the size of the pulmonary arteries to the level of their first bifurcation, but not the more distal pattern of branching
- To confirm normal systemic and pulmonary venous connections
- Anomalous arteries can be identified crossing the subpulmonary infundibulum (coronary arterial anatomy)

Clinical diagnosis

- Investigations
- Echocardiography
- Post-operative assessment
- Presence of residual lesions
- Pulmonary regurgitation
- Right ventricular performance

Clinical diagnosis

- Investigations
- Magnetic resonance imaging
- Post-operative evaluation and decision-making
- Quantitative assessment of right ventricular volume, mass, and function
- Imaging of delayed enhancement using gadolinium, any scarring or fibrosis of the ventricles, contributing to an increased propensity for arrhythmias, or formation of aneurysms in the right ventricular outflow tract

Clinical diagnosis

- Investigations
- Cardiac catheterization and angiography
- To assess the haemodynamics within, and connections between, the individual vessels
- Dilation and stenting of the right ventricular outflow tract
- Pre-operative balloon dilation of the pulmonary arteries, stenting of the arterial duct, interventions on the aortopulmonary collateral arteries
- Additional postoperative interventions
- CT angiography

Haemodynamics and physiology

- Dominated by the severity of obstruction within the subpulmonary right ventricular outflow tract
- The relative flows in the pulmonary and systemic circuits depend on the relative resistances, or impedances

Therapeutic options

- Medical management
- In the knee-chest position and administer oxygen by face mask
- Intravenous line, small dose of morphine sulphate, at 0.1mg per kg
- B-blocking agent such as propranolol (reduce tachycardia and increase systemic resistance, reduce hypercontracility)
- Accompanying metabolic acidosis should be corrected
- Intubation and ventilation in extreme cases, intravenous vasoconstrictor, phenylephrine
- Emergency systemic-to-pulmonary shunt

Therapeutic options

- Surgical management
- Those over a few months of age, definite surgery
- Neonates and young infant, surgical palliation by construction of a systemic-to-pulmonary arterial shunt, balloon dilation and stenting of the right ventricular outflow tract, and stenting of the arterial duct

Therapeutic options

- Surgical management
- Palliative procedures
- Modified BT shunt, now frequently performed through a median sternotomy
- Heparin in the initial post-operative period, followed by aspirin until the time of corrective surgery
- Stenosis of the PA, potential damage to the recurrent laryngeal or phrenic nerves, and adverse physiologic effects such as increased flow of blood to the lungs, systemic steal syndrome

Therapeutic options

- Surgical management
- Definitive repair
- Rarely performed via a large ventriculotomy, with tranatrial closure of the septal defect now almost universal
- Hypertrophied outlet septum, together with its parietal and septal extensions, is excised (infundibulectomy)
- Transannular patch repair vs. pulmonary annulus saving or small annulotomy
- MVOP (monocusp valved outflow patch)
- Ideal surgery, normal right ventricular pressures, absence of any gradient in the right ventricular outflow tract -> to preserve the pulmonary valve, even at the expense of a modest degree of residual stenosis (minimize the adverse late effects of pulmonary incompetence, and retain the integrity of the outflow tract, avoiding late dilation and formation of aneurysms)

Therapeutic options

- Surgical management
- Definitive repair
- The timing of definitive repair, based on the results in the institution offering treatment, usually between 3 and 6 months of age

Therapeutic options

- Surgical management
- Early outcomes
- First feature, diffusely small pulmonary arteries, the ratio of the combined diameter of the right and left PAs, measured just before of their first bifurcation, to that of the descending aorta is less than 1.5 to 1, not attempting primary repair
- Second factor, PAs abnormalities, anomalous origin of one artery, or stenosis of either artery at its origin
- Third factor, small pulmonary valvar orifice (small annulus)
- Final factor, age at repair, both old and young, more than 5 years

Therapeutic options

- Surgical management
- Early post-operative complications
- Post-operative low cardiac output, inadequate relief of subpulmonary obstruction, or an obstructed or restrictive pulmonary vascular bed
- Post-operative pulmonary incompetence
- Consists of maintenance of sinus rhythm and right ventricular preload, keeping the central venous pressure at 12 to 15mmHg, early drainage of resulting effusions, and early extubation
- Early post-operative restriction is a transient phenomenon, usually resolving within 72 hours, although reappearance in the later postoperative follow-up period

Therapeutic options

- Surgical management
- Late outcomes of intervention
- The adverse affects of pulmonary incompetence, previously considered to be a benign side-effect of relief of the obstructed right ventricular outflow tract

Therapeutic options

- Surgical management
- Physical response to correction
- Residual ventricular septal defect
- Right bundle branch block, duration of the QRS complex lengthening in response to dilation of the right heart
- Pulmonary incompetence, remain asymptomatic for up to 20 years, but thereafter freedom from symptoms declines
- Right-sided failure, arrhythmias, and sudden death
- Decreased exercise performance, and right ventricular function
- Nowadays, pulmonary incompetence be measured directly and accurately by cardiac magnetic resonance

Therapeutic options

- Surgical management
- Physical response to correction
- In the context of the mechanical dysfunction of the right ventricle, increasingly appreciated that additional left ventricular dysfunction seems to co-exist in many patients with tetralogy -> biventricular resynchronization -> significant increase in cardiac output
- Aortic dilation and valvar incompetence increasingly with duration of follow-up

Therapeutic options

- Surgical management
- Post-operative conduction disturbances and arrhythmias
- Ventricular arrhythmias, rather than conduction defects, are more likely to be the basis for sudden death
- Older age at operation, more extensive surgery, extent of the ventriculotomy are associated with an increase in ventricular arrhythmias
- Sudden death occurs in about 6% of patients over the long term
- QRS prolongation, right ventricular dilation, sustained ventricular arrhythmias, related to late sudden death
- It must also not be forgotten that atrial arrhythmias

Therapeutic options

- Surgical management
- Treatment of arrhythmias and conduction disturbances at follow-up
- The aims of treatment are relief of symptoms and prevention of sudden death
- Routine treatment of asymptomatic patient with non-sustained tachycardia is not currently indicated
- Implantable defibrillator
- Atrial arrhythmias -> medical therapies, catheter-based ablation, additional maze procedure

Therapeutic options

- Surgical management
- Treatment of pulmonary valve incompetence
- Surgical replacement of the pulmonary valve in symptomatic patients
- Optimal timing of pulmonary valvar replacement, a threshold of right ventricular end-diastolic volume for intervention, in order to preserve the likelihood of adequate reverse remodeling, is in the resion of 170 to 200 mL per square meter of body surface area
- Transcatheter implantation of the pulmonary valve

Therapeutic options

- Surgical management
- Other reinterventions
- Residual pulmonary stenosis, resection of residual infundibular stenosis, or placement of a patch in the right ventricular outflow tract
- Excision of the aneurysmally dialted patch
- Severe tricuspid insufficiency, valvar annuloplasty
- Aortic valve replacement, or the aortic root replacement (>55mm in diameter)
- Residual VSD closure
- RPA or LPA stenosis, balloon dilation, stent insertion, or surgery

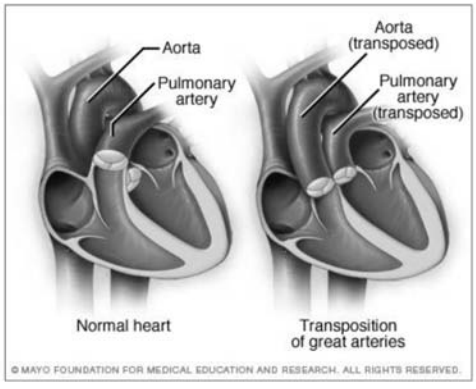
Recommendations for long-term follow-up

- Investigations and frequency
- All patients should have regular follow-up by an appropriately trained cardiologist at least once per year
- Pregnancy
- All patients with tetralogy, cardiologic counseling prior to conception, and follow-up by an appropriately trained cardiologist during pregnancy
- Genetic counselling
- The risk of recurrence in offspring of parents with tetralogy, 2% if the mother affected, 1.4% if the father has tetralogy of Fallot
- 22q11 deletion, the risk of transmission, 50%
- The risk of pregnancy in patients with tetralogy of Fallot after corrective surgery depends on the haemodynamic state
- In patients with significant residual obstruction across the right ventricular outflow tract, severe pulmonary regurgitation, tricuspid regurgitation, and right ventricular dysfunction as well as left ventricular dysfunction, the increased volume load of pregnancy may lead to right heart failure and arrhythmias
- Peripartal antibitotic prophylaxis is recommended

Transposition of Great Arteries

Department of Thoracic and Cardiovascular Surgery,
Chungbuk National University College of Medicine, Cheongju, Korea

Hong Ju Shin



http://www.mayoclinic.org/~/media/kcms/gbs/patient%20consumer/images/2013/08/26/11/07/ds00733%20mcdc7_transpositionthu_jpg.png

학습목표

- TGA의 수술시기를 알 수 있다
- Coronary artery pattern을 기술할 수 있다
- Atrial switch operation을 이해한다
- TGA,VSD,PS의 수술방법을 구분할 수 있다
- Arterial switch operation후의 long-term complication을 이해할 수 있다

Definition

- Concordant atrio-ventricular connections
- Discordant ventriculo-arterial connections

History

- Baillie가 1797년 처음 형태학적으로 기술하였고, 1814년 Farre가 전위(transposition) 라는 표현을 사용하였다. 1971년 Van Praagh가 명확히 정의하였다
- Senning 과 Mustard 가 1959년과 1963년에 각각 심방전위술을 처음으로 성공시켰다. 1975년 Jatene 등에 의해 처음으로 성공적인 동맥전환술(arterial switch operation, ASO)이 시행되었다

Anatomy of TGA

- Intact ventricular septum ("Simple" TGA) = 50%
- VSD (perimembranous) = 25%
- VSD and pulmonary stenosis = 25%
- Patent foramen ovale in nearly all
- Coarctation rare

Incidence

- 모든 선천성 심기형의 5-7% 빈도로 발생
- 청색증 심장기형 중 활로 4징증에 이어 두 번째로 흔하다.
- 남자에서 약 3:1로 발생빈도가 높다

Classification

- TGA with IVS – 신생아기 수술 필요
- TGA with VSD – 3개월 이내 수술 필요
- TGA with VSD, PS(LVOTO) – Pailliative 수술후 수술시기 결정

Physiology

- Separate parallel circulation
- Degree of cyanosis depends on mixing
- VSD patients less cyanotic
- LV thickness/function diminished > 1 month

Clinical Presentation

- Cyanosis: simple >VSD
- Earlier presentation: simple > VSD and PS > VSD
- Soft systolic murmur

Diagnosis

- CXR
  - Normal at birth
- Echo
  - Posterior branching great vessel
  - Intracardiac anatomy defined
  - Coronary ostia defined
- Catheterization
  - Septostomy or coronary anatomy

Medical management

- Prostaglandin E1 infusion to maintain PDA
- Balloon atrial septostomy (Rashkind, 1966)
- Correct acid-base abnormalities
- Increase pulmonary blood flow / mixing

Pathophysiology

- Two parallel circulations
- Mixing between the parallel circulations: PDA, ASD, VSD
- Rapid progression of pulmonary vascular disease
- LVOTO
- LV pressure
- 관상동맥형태
  Single / Intramural

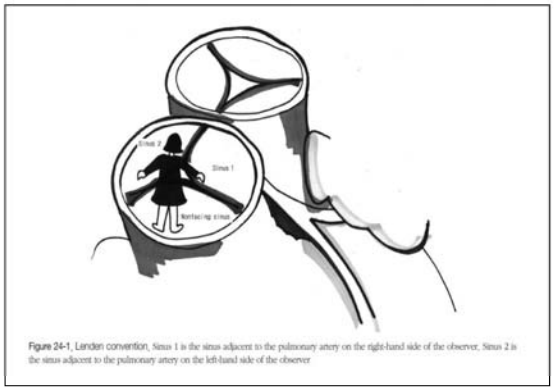


Figure 24-1. Lenden convention. Sinus 1 is the sinus adjacent to the pulmonary artery on the right-hand side of the observer. Sinus 2 is the sinus adjacent to the pulmonary artery on the left-hand side of the observer

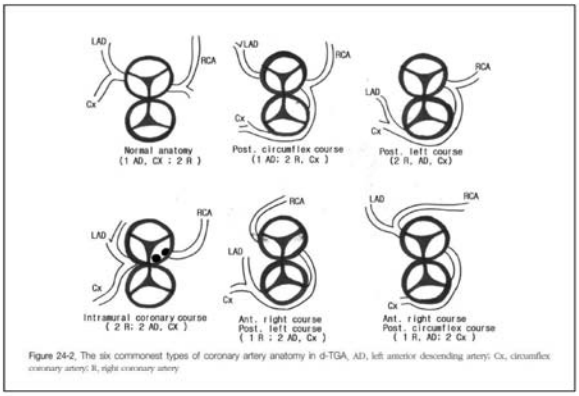


Figure 24-2. The six commonest types of coronary artery anatomy in d-TGA. AD, left anterior descending artery; Cx, circumflex coronary artery; R, right coronary artery

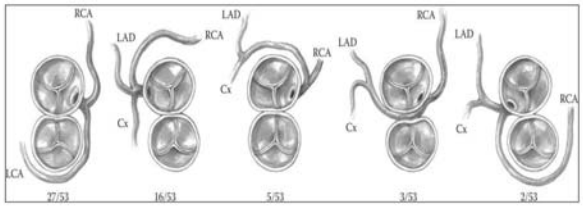
Coronary Anomalies

- Intramural coronary artery
- Single coronary ostium
- Coronary ostial atresia, stenosis

Intramural Coronary Artery

Anderson RH. Paediatric cardiology. 3rd ed. 2010

Single Coronary Artery

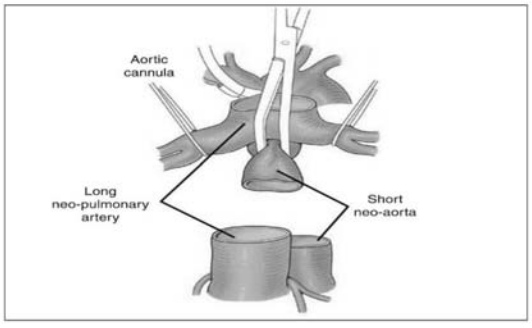


Jonas RA. Comprehensive surgical management of congenital heart disease. 2nd ed. 2014

Surgical Management

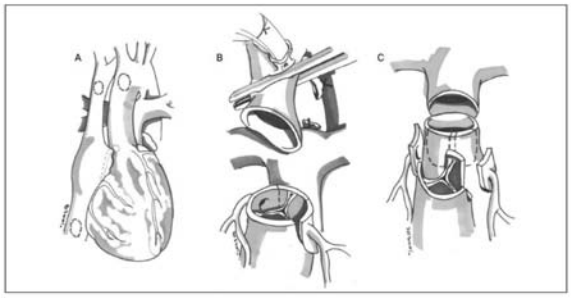
- Atrial switch procedure (Senning, Mustard)
- Arterial switch procedure
- Rastelli / REV / Nikaidoh procedure
- Arterial switch after LV retraining

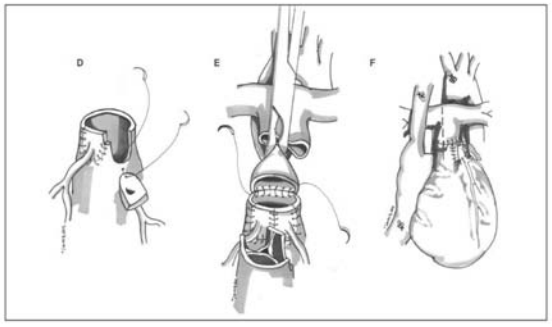
Lecompte Maneuver



Cardiol Young 2005;15(Suppl 1):93-101

Arterial Switch Operation

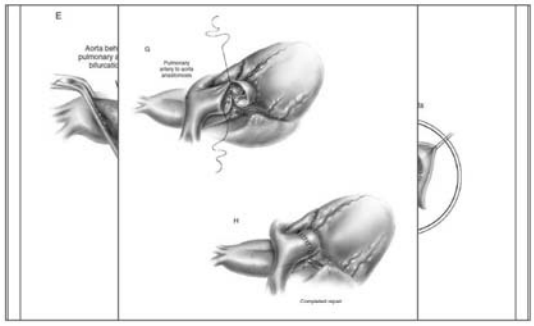




Steps in Arterial Switch Procedure

- Excision coronary arteries
- Transfer coronary arteries to neo-aorta
- LeCompte maneuver
- Neo-aorta anastomosis
- Reconstruct neo-pulmonary root - pericardium

Arterial Switch Operation



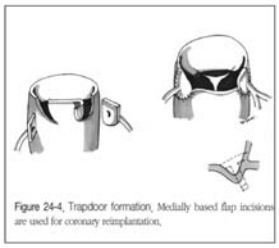


Figure 24-4. Trapdoor formation. Medially based flap incisions are used for coronary reimplantation.

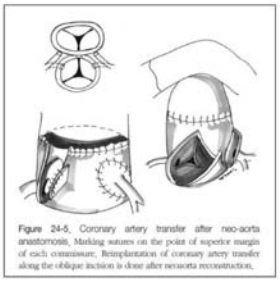


Figure 24-5. Coronary artery transfer after neo-aorta anastomosis. Marking sutures on the point of superior margin of each commissure. Reimplantation of coronary artery transfer along the oblique incision is done after neoaorta reconstruction.

Open technique

Close technique

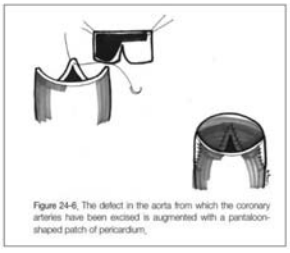


Figure 24-6. The defect in the aorta from which the coronary arteries have been excised is augmented with a pantaloon-shaped patch of pericardium.

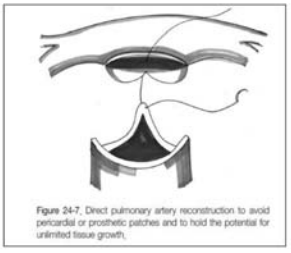


Figure 24-7. Direct pulmonary artery reconstruction to avoid pericardial or prosthetic patches and to hold the potential for unlimited tissue growth.

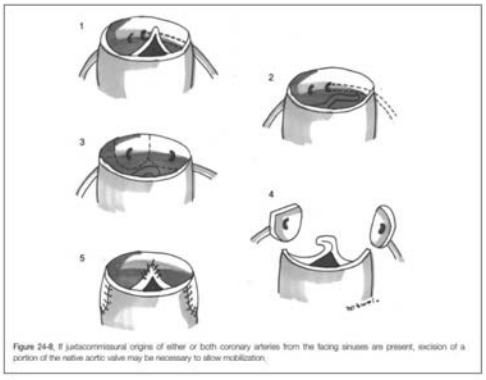
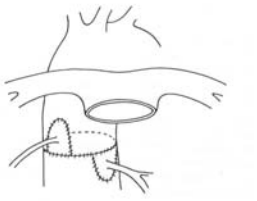
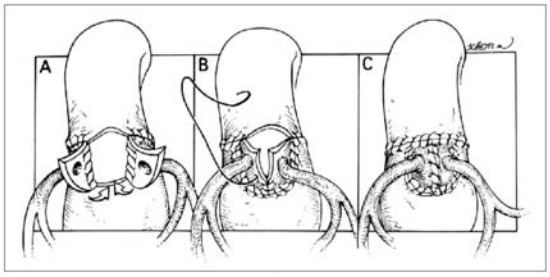


Figure 24-8. If juxtacommissural origins of either or both coronary arteries from the facing sinuses are present, excision of a portion of the native aortic valve may be necessary to allow mobilization.

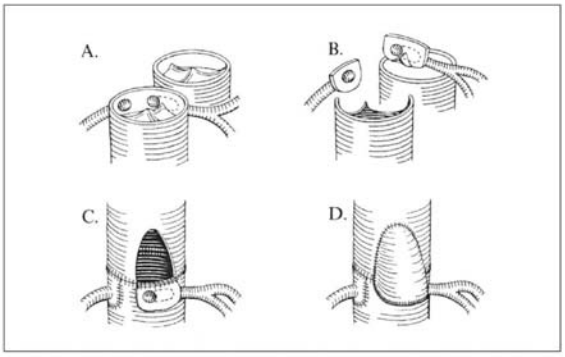
- Preserve a harmonious curve of the coronary trunks.
- In the middle of the appropriate sinus



J Thorac Cardiovasc Surg 1988;96:354-63

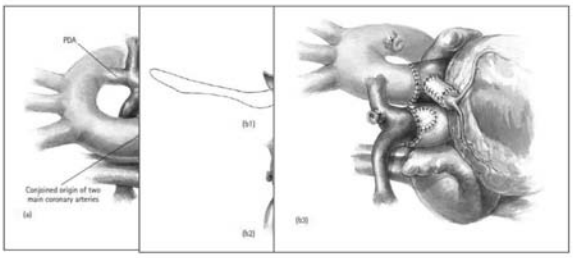


Eur J Cardio-thorac Surg 1994;8:74-8



J Thorac Cardiovasc Surg 1992;104:706-12

Single Coronary Artery



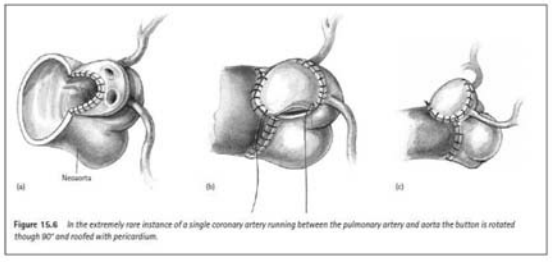


Figure 15.6 *In the extremely rare instance of a single coronary artery running between the pulmonary artery and aorta the button is rotated though 90° and roofed with pericardium.*

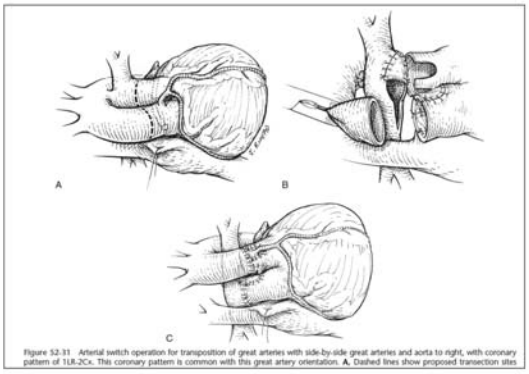


Figure 52-31 Arterial switch operation for transposition of great arteries with side-by-side great arteries and aorta to right, with coronary pattern of 1LR.2Cx. This coronary pattern is common with this great artery orientation. **A**, Dashed lines show proposed transection sites

Postoperative care

- Respiratory and supportive care
  - Adequate ventilation
  - mild respiratory alkalosis (pH 7.50 – 7.60, pCO2 28 – 35 mmHg)
  - Sedation and pain relief -> ↓ oxygen consumption, metabolic expenditure, prevention of pulmonary hypertensive crisis

Postoperative care

- LV is poorly compliant after ASO
- Rapid infusion of fluid should be avoided.
- Boluses of fluid are generally given by infusion in quantities of 5 –10 ml/kg.
- High LAP or CVP pressure should be avoided

Postoperative care

- Increased afterload might result in low cardiac output and ventricular failure.
- Afterload reduction should be maintained at least 48 – 72 hours during the period of LV adaptation to the SVR
- Blood pressure : 50 – 70 mmHg

Postoperative care

- Retraining the left ventricle after arterial switch operation: emerging uses for the left ventricular assist device in pediatric cardiac surgery

J Cardiothorac Vasc Anesth. 2000 Aug;14:454-6

- ECMO

Results of Arterial Switch

- Operative mortality = 2-5%
- Higher mortality
  - single coronary/intramural coronary
- Supravalvular PS = 10-15%
- Sinus rhythm > 95%
- 90% survival at 5 years

Risk Factors for ASO

- Presence of an intramural coronary artery
- Low birth weight
- Older age of patients with simple TGA
- longer periods of circulatory arrest
- Multiple VSD's
- Augmentation of the aortic arch

Senning Procedure

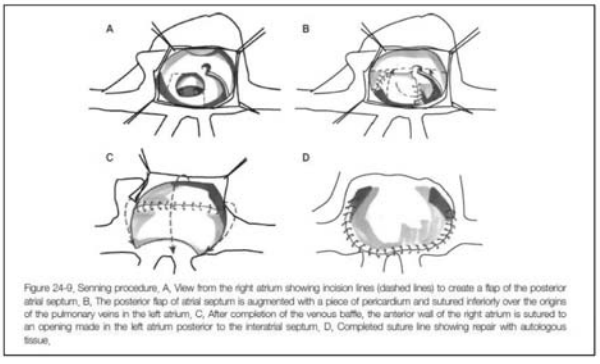
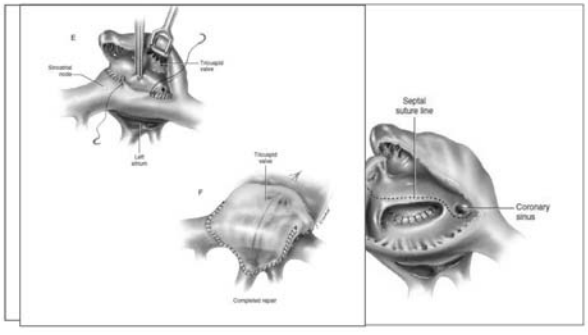
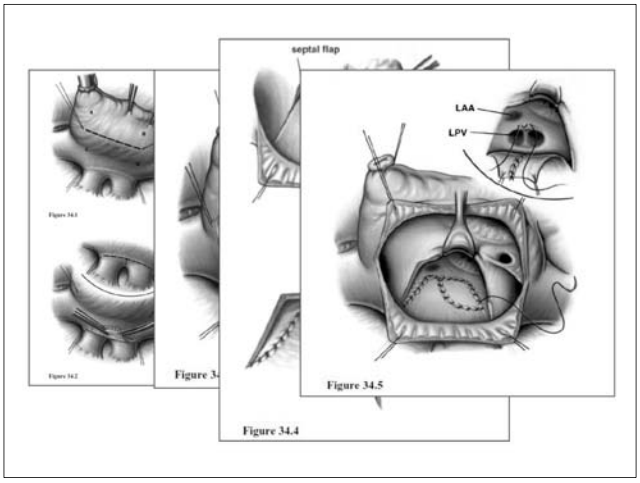


Figure 24-9, Senning procedure. A, View from the right atrium showing incision lines (dashed lines) to create a flap of the posterior atrial septum. B, The posterior flap of atrial septum is augmented with a piece of pericardium and sutured inferiorly over the origins of the pulmonary veins in the left atrium. C, After completion of the venous baffle, the anterior wall of the right atrium is sutured to an opening made in the left atrium posterior to the interatrial septum. D, Completed suture line showing repair with autologous tissue.

Senning Procedure




septal flap
LAA
LPV
Figure 34.5
Figure 34.4

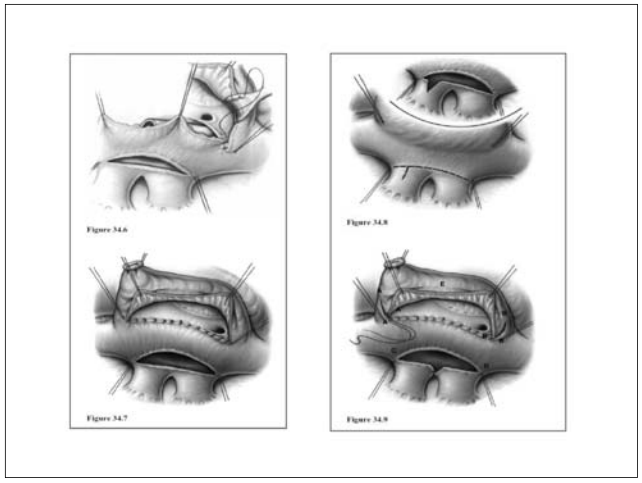


Figure 34.6
Figure 34.8
Figure 34.7
Figure 34.9

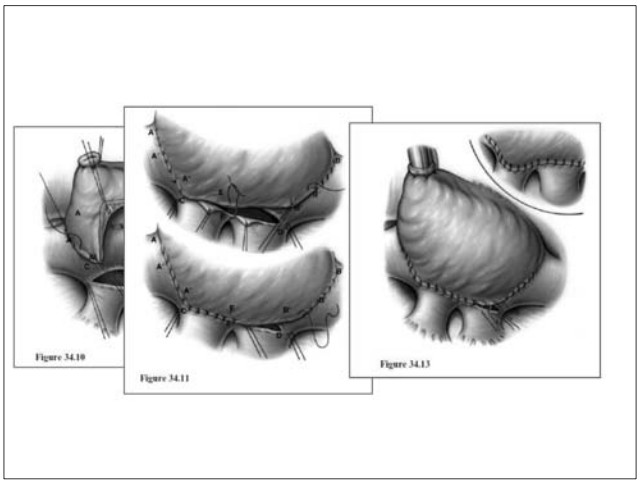
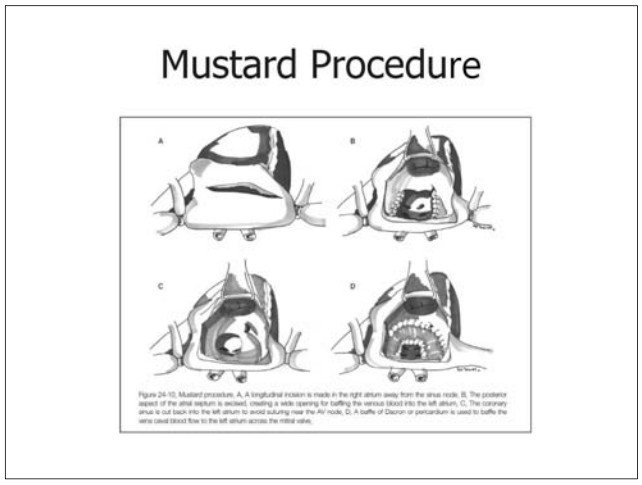
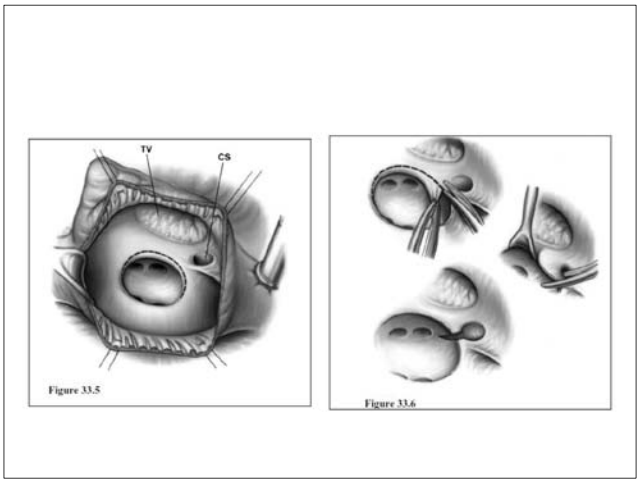
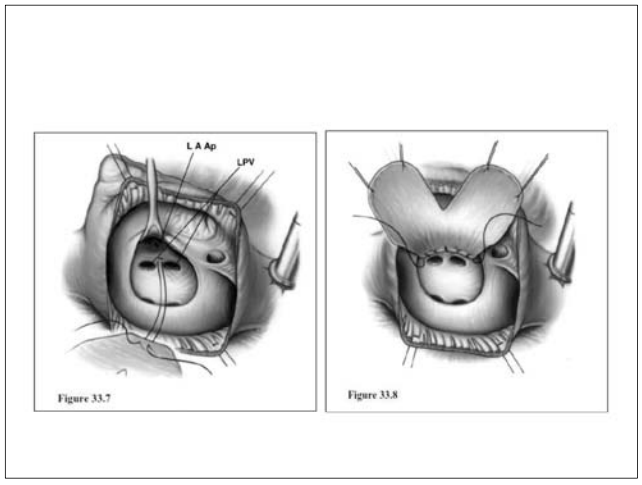


Figure 34.10
Figure 34.11
Figure 34.13


Mustard Procedure
A
B
C
D


TV
CS
Figure 33.5
Figure 33.6


L A Ap
LPV
Figure 33.7
Figure 33.8

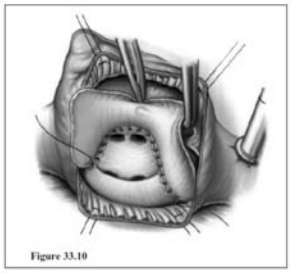


Figure 33.10

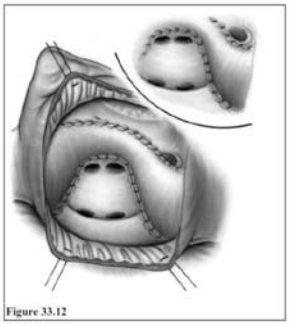


Figure 33.12

Disadvantages of Atrial Switch

- SVC obstruction - Mustard > Senning
- Supraventricular arrhythmias
- Baffle leaks
- Tricuspid insufficiency
- Late RV failure

TGA, VSD and PS

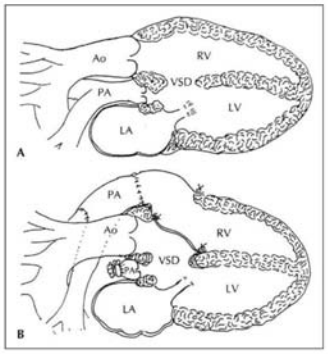
- Shunt when symptomatic as infant
- Rastelli repair - 1-2 years of age
- Operative mortality = 5-10%
- Late reoperation for conduit replacement
- Atrial Septectomy

TGA, VSD and PS

- Goals of surgery
  1. Unobstructed LV outflow tract / RV outflow tract
  2. Competent aortic and pulmonary valve
- Surgical options
  1. Arterial switch ± LVOTO relief
  2. Rastelli procedure
  3. REV procedure
  4. Nikaidoh procedure or its variants
  5. Pulmonary root translocation

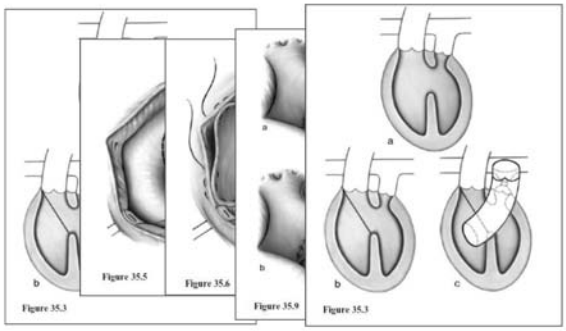
Rastelli Procedure

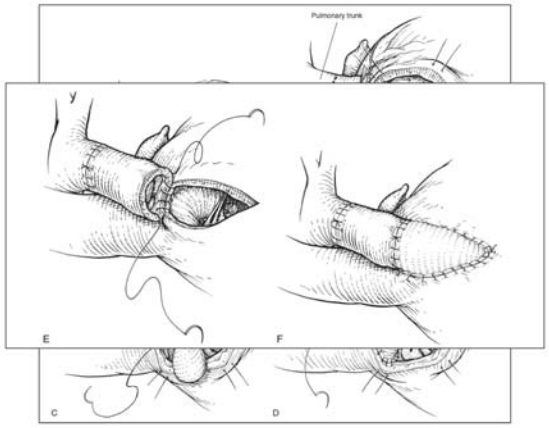
- LV to aorta baffling ± VSD enlargement
- RV to pulmonary artery (valved) conduit
- Poor long-term survival reported
- LVOTO, RVOTO, arrhythmia, sudden death



Ann Thorac Surg 2005;79:2089-93

Rastelli operation

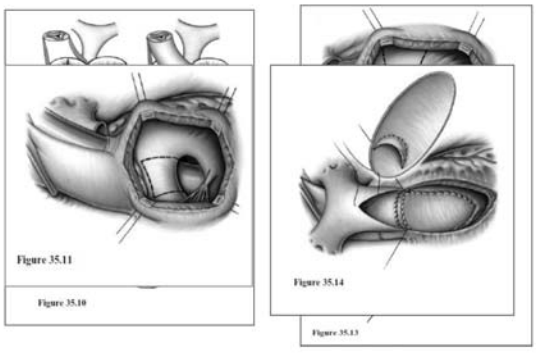




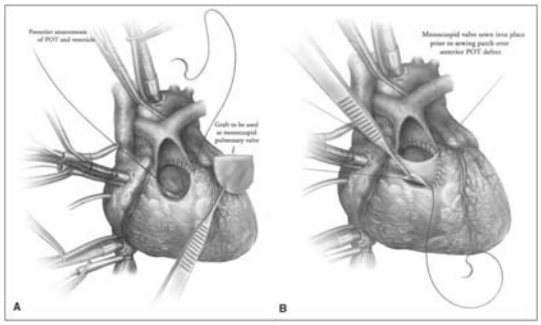
REV Procedure

- Aggressive VSD enlargement to prevent LVOTO
- Avoidance of the use a RV to PA conduit

REV Procedure



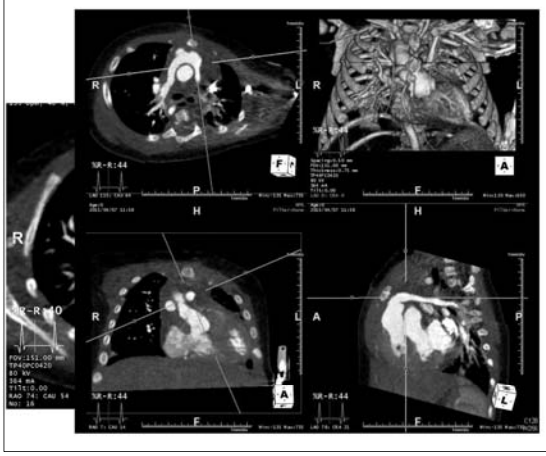
REV Procedure (RVOT Reconstruction)



Oper Tech Thorac Cardiovasc Surg 2003;8:150-9

Nikaidoh Procedure

- Aortic translocation
- Half-turned truncal switch
- Double root translocation
- Ross-Switch-Konno

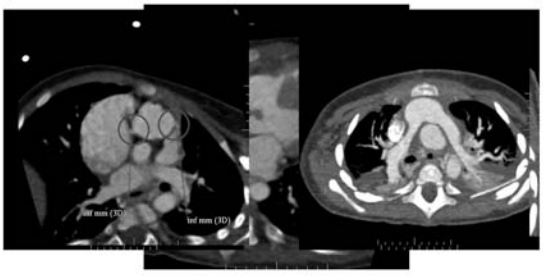


Patient

- 20Mo / 9.8Kg / M
- TGA with
  - VSD (PM)
  - PS (valvar and subpulmonary by post. Deviated conal septum)
- 9 days: BAS
- 22 days: RMBT

Surgical Options

Rastelli or REV
Nikaidoh Modification



Aortic root translocation

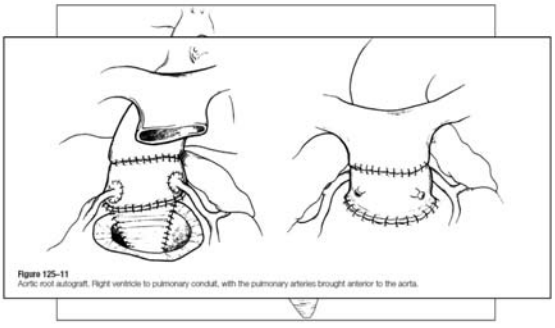
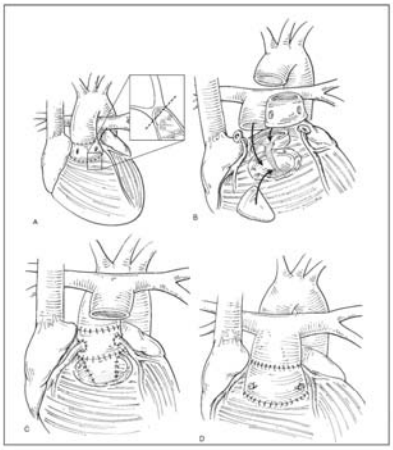
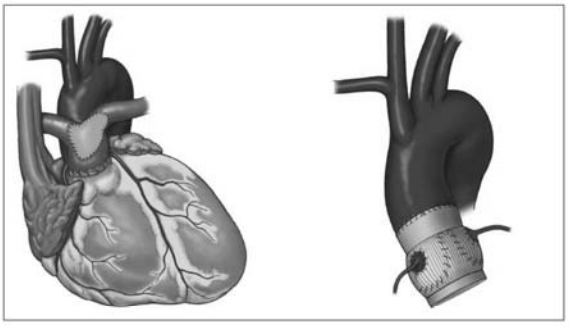


Figure 125–11
Aortic root autograft. Right ventricle to pulmonary conduit, with the pulmonary arteries brought anterior to the aorta.



Reoperation After ASO



Ann Thorac Surg 2013;95:2105-13

Reoperation After ASO

- Supravalvular pulmonary stenosis
  - The most common cause for re-operation (7-28%)
  - Possible causes
    - Pericardial patch constriction
    - Anastomotic site tension
    - Suture purse-string effect
    - Inadequate dissection of pulmonary artery

Reoperation After ASO

- Supravalvular pulmonary stenosis
  - Double pericardial patch -- should be avoided(Paillole, 1988)
  - A single large pantaloon pericardial patch
  - More extensive dissection and mobilization of pulmonary a. into the hila (Yamaguchi, 1990)
  - Balloon angioplasty for postoperative pulmonary artery stenosis(Nakanishi, 1993) -- 50% success rate

Reoperation After ASO

Factors implicated for neoaortic insufficiency

- Previous pulmonary artery banding
- Thickening and deformity of the pulmonary valves and sinuses
- Aortic root dilation
- Distortion of the commissure
- Deformity of the neoaortic root
- Discrepancy in size between the PA and and aorta
- Regurgitation preoperatively

Reoperation After ASO

- Supravalvular pulmonary stenosis
- Neoaortic insufficiency
- Coronary stenosis
  - 2 – 11%
  - Cause of early death and morbidity
  - Late coronary events – < 2%

학습목표

- TGA의 수술시기를 알 수 있다
- Coronary artery pattern을 기술할 수 있다
- Atrial switch operation을 이해한다
- TGA,VSD,PS의 수술방법을 구분할 수 있다
- Arterial switch operation후의 long-term complication을 이해할 수 있다

Summary

- TGA/IVS simple - Arterial switch < 14 days
- TGA/IVS simple with intramural L main - Mustard/Senning
- TGA/VSD - neonatal switch and VSD closure
- TGA/VSD/PS - shunt; Rastelli 1-2 years

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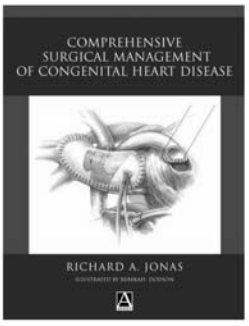
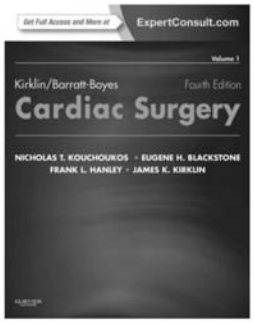
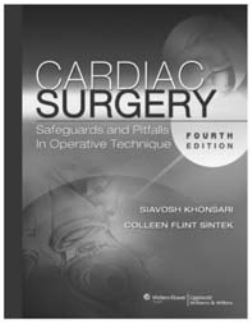






Thank You

충북대학교병원
CHUNGBUK NATIONAL UNIVERSITY HOSPITAL

Single Ventricle

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

Cheul Lee, M.D.

Contents

1. Classification
2. Pathophysiology
3. Surgical management
4. Outcomes of surgery

Terminology

- Single ventricle
- Functionally univentricular heart
- Broad category of hearts that lack two well devel-oped ventricles

Congenital Heart Surgery Nomenclature and Database Project: Single Ventricle

Marshall L. Jacobs, MD, and John E. Mayer, Jr, MD

Section of Cardiothoracic Surgery, St. Christopher's Hospital for Children, Philadelphia, Pennsylvania, and Department of Cardiac Surgery, Children's Hospital, Boston, Massachusetts

The extant nomenclature for single ventricle (SV) hearts is reviewed for the purpose of establishing a unified reporting system. The subject was debated and reviewed by members of the STS-Congenital Heart Surgery Database Committee and representatives from the European Association for Cardiothoracic Surgery. Efforts were made to include all relevant nomenclature categories using synonyms where appropriate. Although many issues regarding single ventricle or univentricular hearts remain unresolved among anatomists and pathologists, a classification is proposed that is relevant to surgical therapy. A comprehensive database set is presented, which is based on a hierarchical scheme. Data are entered at various levels of complexity and detail, which can be determined by the clinician. These data can lay the foundation for comprehensive risk stratification analyses. A minimum data set is also presented that will allow for data sharing and would lend itself to basic interpretation of trends. Outcome tables relating diagnoses, procedures, and various risk factors are presented.

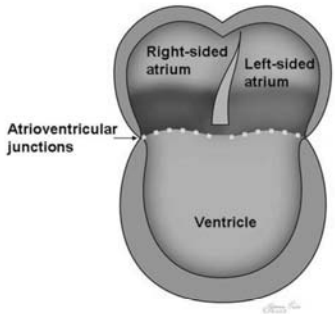
(Ann Thorac Surg 2000;69:S197–204)

Congenital Heart Surgery Nomenclature and Database Project: Single Ventricle

- Double inlet left ventricle (DILV)
- Double inlet right ventricle (DIRV)
- Mitral atresia
- Tricuspid atresia
- Unbalanced AV canal defect
- Heterotaxia syndrome
- Other

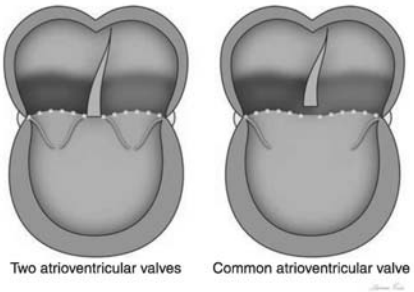
Ann Thorac Surg 2000;69:S197-204

Double Inlet Ventricle



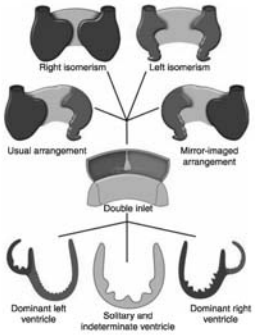
Cardiol Young 2006;16 Suppl 1:22-6

Double Inlet Ventricle



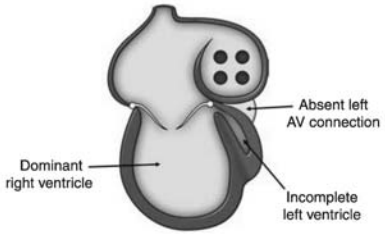
Cardiol Young 2006;16 Suppl 1:22-6

Double Inlet Ventricle



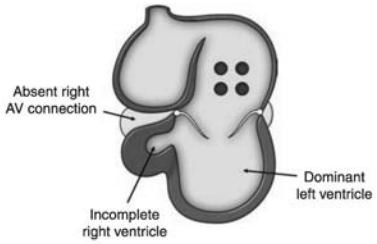
Cardiol Young 2006;16 Suppl 1:22-6

Mitral Atresia



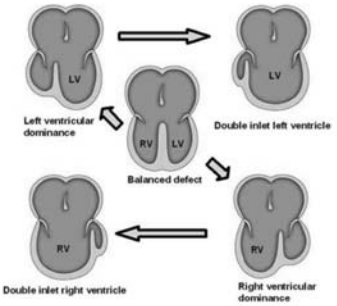
Cardiol Young 2006;16 Suppl 1:27-34

Tricuspid Atresia



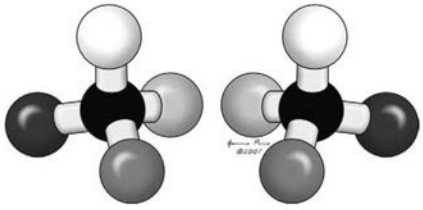
Cardiol Young 2006;16 Suppl 1:27-34

Unbalanced AV Canal Defect



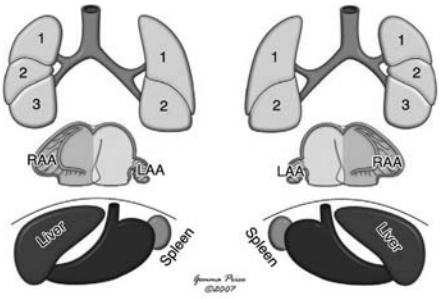
Cardiol Young 2006;16 Suppl 3:43-51

Isomerism



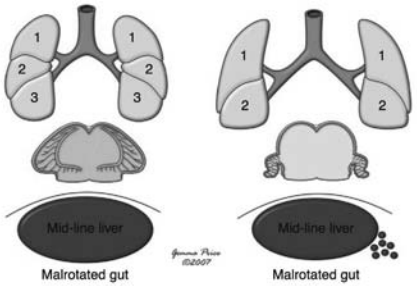
Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Usual Body Arrangement and Its Mirror Image



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

Heterotaxia Syndrome (Isomerism of the Atrial Appendages)



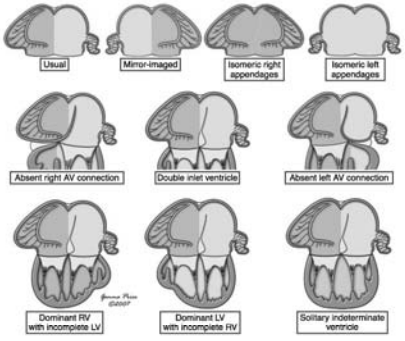
Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Congenital Heart Surgery Nomenclature and Database Project: Single Ventricle

Single ventricle, Heterotaxia syndrome, **DORV, CAVC, Asplenia**
Single ventricle, Heterotaxia syndrome, **DORV, CAVC, Polysplenia**
Single ventricle, Heterotaxia syndrome, **Single LV**
Single ventricle, Heterotaxia syndrome, **Other**

Ann Thorac Surg 2000;69:S197-204

Univentricular Atrioventricular Connections

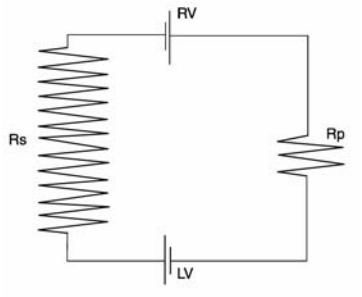


Anderson RH, et al. Paediatric Cardiology. 3rd ed.

Circulatory System vs Electrical Circuit

- $BP = Q \times R$
- $V = I \times R$

Normal Heart

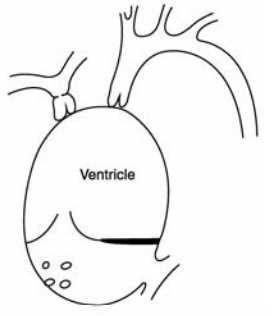


Cardiol Young 2003;13:316-22

Normal Heart

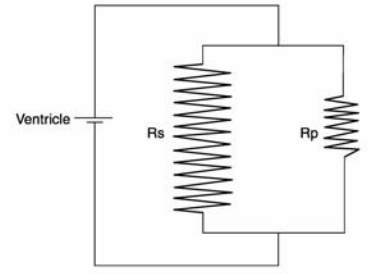
- Serial systemic and pulmonary circulations
- Different BP and O_2 saturation in each part
- CO = Qp = Qs (Qp/Qs = 1)

Single Ventricle



Cardiol Young 2003;13:316-22

Single Ventricle



Cardiol Young 2003;13:316-22

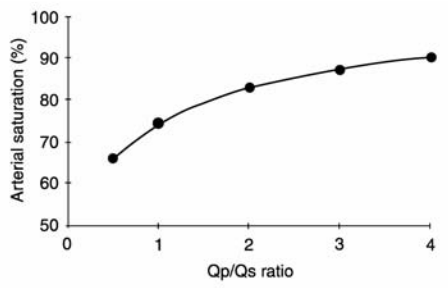
Pathophysiology of Single Ventricle (1)

- Parallel systemic and pulmonary circulations
- BP in each part of the circulation is the same, if there is no obstruction to systemic and pulmonary outflow.
- O_2 saturation is the same in the aorta and the pulmonary arteries, if complete mixing of desaturated and saturated blood occurs within the single ventricle.

Pathophysiology of Single Ventricle (2)

- CO = Qp + Qs
- Because of the different vascular resistance in each component, flows are different.
- Qp/Qs = (BP/Rp)/(BP/Rs) = Rs/Rp
- Arterial O_2 saturation is determined by the ratio between the pulmonary blood flow and the systemic blood flow (Qp/Qs).

O_2 Saturation in Single Ventricle



Cardiol Young 2003;13:316-22

"Balanced" Single Ventricle

- Qp = Qs
- Natural obstruction to pulmonary blood flow
- Arterial O_2 saturation of approximately 80%
- Volume overloaded (double the normal CO)

Manipulation of Pulmonary Vascular Resistance

Manoeuvres that increase pulmonary resistance	Manoeuvres that decrease pulmonary resistance
Acidosis	Alkalosis
Increasing positive end expiratory pressure	Nitric oxide
Vasopressor agents (noradrenaline, adrenaline)	Isoproterenol
High arterial partial pressure of carbon dioxide hypoxia, added nitrogen	Lowering mean airway pressure
	High concentration of inspired oxygen
	Phosphodiesterase inhibitors, nitrates

Cardiol Young 2003;13:316-22

Clinical Presentaion

- Determined by Qp/Qs and the associated cardiac lesions
- Cyanosis
- Congestive heart faiure

Ultimate Goal of Surgery

- Separation of systemic and pulmonary circulations, with the single ventricle connected to the systemic circulation (creation of in-series systemic and pulmonary circulations)
- Best achieved by optimizing compliance of the single ventricle as well as by minimizing the total resistance between the systemic veins and the ventricular chamber

Fontan Operation

- Final palliative surgery for single ventricle
- Total cavopulmonary connection
- Staged interventions are necessary to prepare for the successful Fontan operation.

Three-Stage Surgical Management

1. 1st stage palliation
2. Bidirectional cavopulmonary connection
3. Fontan operation

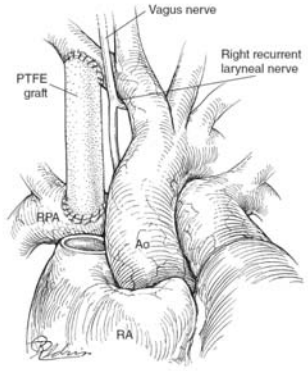
1st Stage Palliation

- Goal: balancing systemic and pulmonary blood flow (Qp/Qs = 1)
- Usually performed during neonatal or early infantile period
- The choice of procedure is determined by the amount of pulmonary blood flow and presence of systemic outflow obstruction.

1st Stage Palliations for Inadequate Pulmonary Blood Flow

- Pulmonary outflow obstruction
  → Systemic-to-pulmonary arterial shunt
- Obstructed TAPVC
  → TAPVC repair
- Restrictive ASD
  → Atrial septectomy or balloon septostomy

Modified Blalock-Taussig Shunt

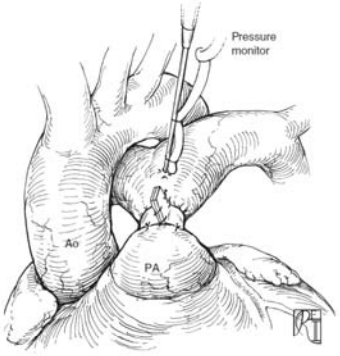


Mavroudis C, et al. Pediatric Cardiac Surgery. 4th ed.

1st Stage Palliation for Excessive Pulmonary Blood Flow

- No pulmonary outflow obstruction
  → Pulmonary artery banding

Pulmonary Artery Banding

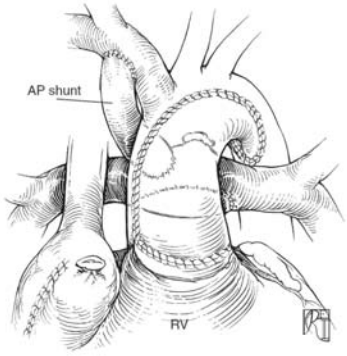


Mavroudis C, et al. Pediatric Cardiac Surgery. 4th ed.

1st Stage Palliations for Systemic Outflow Obstruction

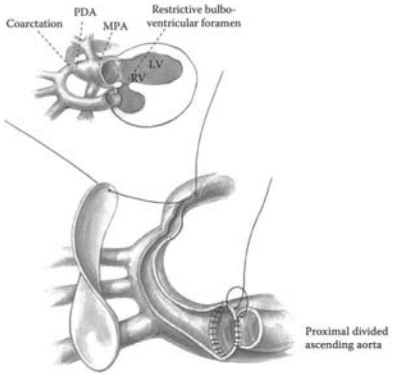
- Aortic and subaortic obstruction
  → Norwood or Damus-Kaye-Stansel procedure

Norwood Procedure



Mavroudis C, et al. Pediatric Cardiac Surgery. 4th ed.

Damus-Kaye-Stansel Procedure

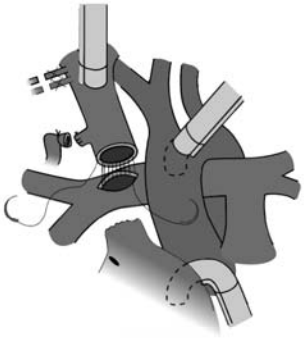


Jonas RA. Comprehensive Surgical Management of Congenital Heart Disease. 2nd ed.

Bidirectional Cavopulmonary Connection

- Also referred to as "bidirectional Glenn"
- 2nd stage palliation
- Usually performed at 3-6 months of age

Bidirectional Cavopulmonary Connection



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

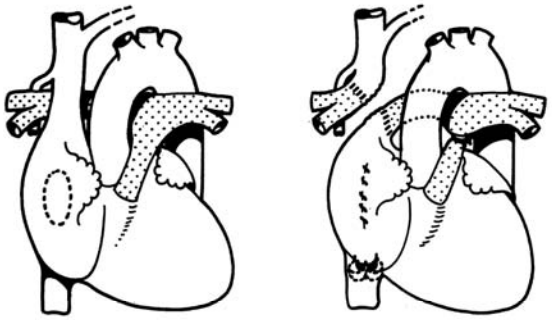
Advantages of BCPC

- More desaturated blood (systemic venous rather than arterial) is shunted to the lungs, with therefore a much greater efficacy on increments of arterial oxygen saturation.
- Diversion of approximately one-third of the systemic venous return to the lungs reduces the volume load on the heart, whereas an arterial shunt constitutes an additional ventricular volume and workload.

Fontan Operation

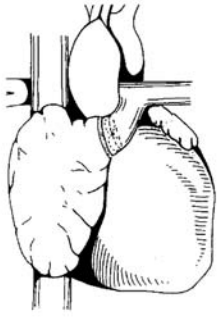
- 3rd stage (final) palliation
- Complete separation of systemic and pulmonary circulations
- Usually performed at 2-3 years of age

Original Fontan Operation



Thorax 1971;26:240-8

Kreutzer's Atriopulmonary Connection

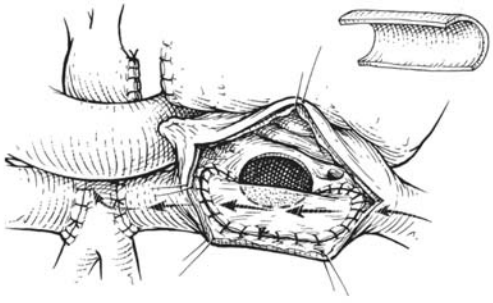


J Thorac Cardiovasc Surg 1973;66:613-21

Complications of AP Fontan

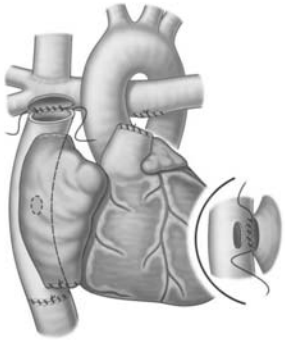
- Exposure of the RA to the high pressure of the Fontan circuit → huge dilatation of RA
- Supraventricular tachycardia
- Pulmonary venous obstruction
- Atrial thrombi

Lateral Tunnel Fontan



Kouchoukos NT, et al. Kirklin/Barratt-Boyes Cardiac Surgery. 4th ed.

Extracardiac Conduit Fontan



Stark JF, et al. Surgery for Congenital Heart Defects. 3rd ed.

Extracardiac Conduit vs Lateral Tunnel Fontan

Extracardiac conduit	Lateral tunnel
Technically simpler, more easily reproducible with variable patient morphology	Judgment required
"Minimizes" atrial suture lines	Heavier atrial suture burden
No atrial tissue at high pressure	Thin strip of atrial tissue at high pressure
Difficult to fenestrate	Easy to fenestrate
No catheter access to atrium	Catheter access to atrium available
No growth potential	Grows
Avoids CPB + cross-clamp	Short clamp time, CPB mandatory

CPB = cardiopulmonary bypass

Jonas RA. Comprehensive Surgical Management of Congenital Heart Disease. 2nd ed.

BOX 129-1 The "Ten Commandments" for Selection of Patients with Tricuspid Atresia for the Fontan Procedure

1. Minimum age 4 years
2. Sinus rhythm
3. Normal caval drainage
4. Right atrium of normal volume
5. Mean pulmonary artery pressure ≤15 mm Hg
6. Pulmonary arterial resistance <4 U/m^2
7. Pulmonary artery to aorta diameter ratio ≥0.75
8. Normal ventricular functions (ejection fraction >0.6)
9. Competent left atrioventricular valve
10. No impairing effects of previous shunts

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

ELSEVIER

European Journal of Cardio-thoracic Surgery 31 (2007) 344–353

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

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Factors influencing early and late outcome following the Fontan procedure in the current era. The 'Two Commandments'?☆

Riad B.M. Hosein[a], Andrew J.B. Clarke[a], Simon P. McGuirk[a], Massimo Griselli[a], Oliver Stumper[b], Joseph V. De Giovanni[b], David J. Barron[a], William J. Brawn[a,*]

[a]Department of Cardiac Surgery, Birmingham Children's Hospital, United Kingdom
[b]Department of Cardiology, Birmingham Children's Hospital, United Kingdom

Selection Criteria for Fontan Operation

- The pulmonary vasculature and ventricular function remains the most important selection criteria for successful outcome after the Fontan operation.
- Pulmonary vascular resistance: < 4 U/m^2
- Mean pulmonary artery pressure: < 15 mm Hg
- Ventricular end-diastolic pressure: < 10-12 mmHg

Issues After Fontan Operation

- Atrial arrhythmias
- Venovenous collaterals
- Pulmonary arteriovenous fistulas
- Thromboembolism
- Protein-losing enteropathy
- Plastic bronchitis
- Fontan failure

Management of Failing Fontan

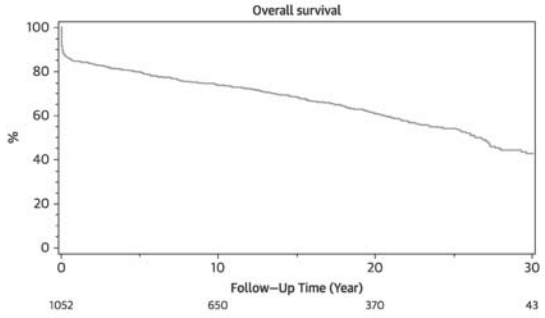
- Fontan conversion
- Heart transplantation
- Mechanical circulatory support

40-Year Follow-Up After the Fontan Operation

Long-Term Outcomes of 1,052 Patients

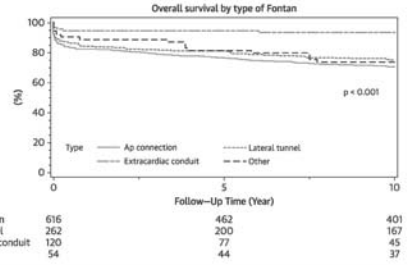
Kavitha N. Pundi, MD,* Jonathan N. Johnson, MD,*† Joseph A. Dearani, MD,† Krishna N. Pundi, BS,‖ Zhuo Li, BS,‖ Cynthia A. Hinck, RN, BSN,* Sonja H. Dahl, RN, DNP,* Bryan C. Cannon, MD,*† Patrick W. O'Leary, MD,*† David J. Driscoll, MD,* Frank Cetta, MD*†

J Am Coll Cardiol 2015;66:1700-10



J Am Coll Cardiol 2015;66:1700-10

FIGURE 2 **Overall Survival by Type of Fontan Procedure**



Ap connection	616	462	401
Lateral tunnel	262	200	167
Extracardiac conduit	120	77	45
Other	54	44	37

The type of procedure performed greatly impacted survival; patients who had their Fontan with an extracardiac conduit had significantly less mortality. Ap = atriopulmonary.

J Am Coll Cardiol 2015;66:1700-10

European Journal of Cardio-Thoracic Surgery 48 (2015) 825–832
doi:10.1093/ejcts/ezv072 Advance Access publication 13 March 2015

ORIGINAL ARTICLE

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Results of extracardiac conduit total cavopulmonary connection in 500 patients†

Toshihide Nakano[a,*], Hideaki Kado[a], Hideki Tatewaki[a], Kazuhiro Hinokiyama[a], Shinichiro Oda[a], Hiroya Ushinohama[b], Koichi Sagawa[b], Makoto Nakamura[b], Naoki Fusazaki[c] and Shiro Ishikawa[b]

[a] Department of Cardiovascular Surgery, Fukuoka Children's Hospital, Fukuoka, Japan
[b] Department of Cardiology, Fukuoka Children's Hospital, Fukuoka, Japan
[c] Department of Neonatal Cardiology, Fukuoka Children's Hospital, Fukuoka, Japan

* Corresponding author. Department of Cardiovascular Surgery, Fukuoka Children's Hospital, 5-1-1, Kashii Teriha, Higashi-ku, Fukuoka 813-0017, Japan. Tel: +81-92-6827000; fax: +81-92-6827300; e-mail: nakano.to@fcho.jp. (T. Nakano).

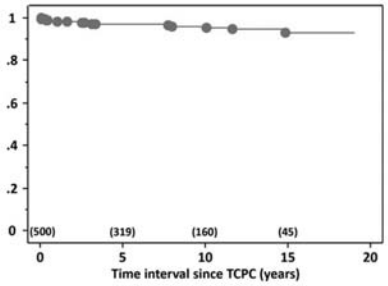

Figure 1: Actuarial survival. The Kaplan–Meier estimated actuarial survival rates after operation were 96.2% at 10 years and 92.8% at 15 years. The number of patients at risk are shown in parenthesis.

Eur J Cardiothorac Surg 2015;48:825-32

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European Journal of Cardio-thoracic Surgery 31 (2007) 1008–1012

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

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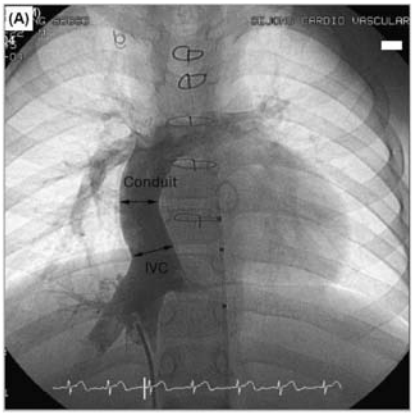
Midterm follow-up of the status of Gore-Tex graft after extracardiac conduit Fontan procedure☆

Cheul Lee [a], Chang-Ha Lee [a,*], Seong Wook Hwang [a], Hong Gook Lim [a], Soo-Jin Kim [b], Jae Young Lee [b], Woo-Sup Shim [b], Woong-Han Kim [c]

[a] *Department of Thoracic and Cardiovascular Surgery, Sejong Heart Institute, Sejong General Hospital, Bucheon, South Korea*
[b] *Pediatric Cardiology, Sejong Heart Institute, Sejong General Hospital, Bucheon, South Korea*
[c] *Department of Thoracic and Cardiovascular Surgery, Clinical Research Institute, Seoul National University, College of Medicine, Seoul National University Children's Hospital, Seoul, South Korea*



Eur J Cardiothorac Surg 2007;31:1008-12

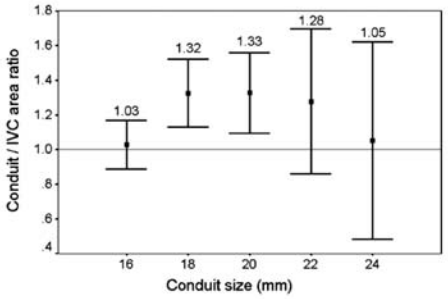


Fig. 5. Conduit-to-IVC cross-sectional area ratio according to conduit size. Filled squares denote mean values (numbers above error bars) and error bars represent 95% confidence interval for means.

Eur J Cardiothorac Surg 2007;31:1008-12

【외상, ECMO, 중환자】

좌장: 박철현

외상등록체계

단국대학교 의과대학 흉부외과학교실

장 성 욱

역 할

외상 환자의 일반적 데이터베이스 등록의 목적으로는 의료의 질 향상, 역학, 임상/연구 분야의 활용, 의료정책의 반영을 들 수 있다. 외상 환자의 등록은 1970년대 미국의 일부 외상 센터를 중심으로 외상 환자의 역학적 조사에서부터 시작되었으며, 1982년 이후부터 체계화된 National Trauma Data Bank (NTDB) 사업으로 확대되었다. 이 밖에 독일, 노르웨이, 스웨덴, 핀란드, 덴마크, 일본, 호주/뉴질랜드, 캐나다 등의 선진국과 중국, 파키스탄, 우간다 등 개발도상국까지 외상 데이터뱅크 시스템을 구축하고 있다.

1. 환자치료의 평가 및 개선

등록 데이터는 참여병원의 의료 행위를 비교할 수 있어 적정 치료 방침에 대한 정도 관리(quality control)에 유용한 도구를 제공한다. Jurkovich 등은 1987년부터 10년 동안 외상 시스템의 효용성에 대해 발표한 11개의 논문을 체계적으로 검증하였다. 검증된 논문들은 통합된 외상 데이터뱅크 시스템을 갖춘 병원과 그렇지 않은 병원에 대해 비교하였거나 한 병원에서 외상 데이터뱅크 시스템을 갖추기 전과 후를 비교한 논문이었다. 검증 결과 많은 논문에서 외상 데이터뱅크 시스템의 효용성이 높았다는 것을 주장하고 있었으나 연구 기관마다 시스템이 다르고, 데이터의 일관성이 부족하며, 비교 방법적인 한계가 있었음을 지적하였다. 따라서 통합적인 시스템이 필요하다고 할 수 있다. Nathens 등은 미국 31개 외상 센터의 데이터를 이용하여 외상 센터의 크기와 외상 환자의 치료 결과의 상관성을 조사하였다. 이 연구에서는 연간 650예 이상의 환자를 진료하는 외상 센터에서 사망률 감소와 평균 재원 기간 단축이 의미 있게 나왔다고 발표하였다. 외상 데이터뱅크 시스템을 갖추고 효율적인 데이터 관리와 그 결과를 임상에 적용하여 개선했을 때, 치료 결과의 호전이 있음을 의미한다고 볼 수 있다.

2. 부상 예방의 동기부여

외상 데이터뱅크 시스템을 운용하여 외상의 다양한 원인에 대한 자료를 충분히 모은다면, 자료의 홍보를 통하여 외상 방지를 할 수 있다. 외상 등록 데이터에는 외상의 기전과 수상 당시의 환경을 등록하도록 한다. 데이터를 잘 활용하면 유사한 유형의 외상 위험을 낮출 수 있다. 예를 들면, 자전거 도로에서 부상 예방을 위해 아스팔트를 우레탄으로 바꾸어 부상 지면의 환경을 개선하거나, 오토바이 주행시 헬멧의 착용, 법적 허용이 가능한 알코올 농도의 제한 등을 반영하도록 요구할 수 있다. 데이터가 축적되면 예방 활동 이전과 이후의 사망률과 후유증 발생률을 비교할 수도 있다.

3. 연구 분야 활용

외상 데이터 등록의 가장 큰 목적들 중의 하나는 연구 가설의 발전과 이에 대한 적용이다. 객관화되고 표준화된 데이터를 이용하여 발표되는 연구 논문은 치료의 가이드라인을 제공하여 새로운 치료 방법을 모색할 수 있도록 한다. 미국에서는 NTDB의 데이터를 이용한 논문의 이용이 2003년에 3편에서 2010년에 33편으로 증가하였고, 일본에서도 데이터뱅크 시스템을 도입한 이후에 데이터

베이스를 이용한 각 프로젝트가 끝나고 1-2년 이내에 이를 이용한 논문 발표가 증가하는 것을 알 수 있다 (그림 1)데이터뱅크에서 추출된 데이터는 논문에 활용되고, 새로운 가이드라인과 새로운 시도를 하는 데에 반영된다.

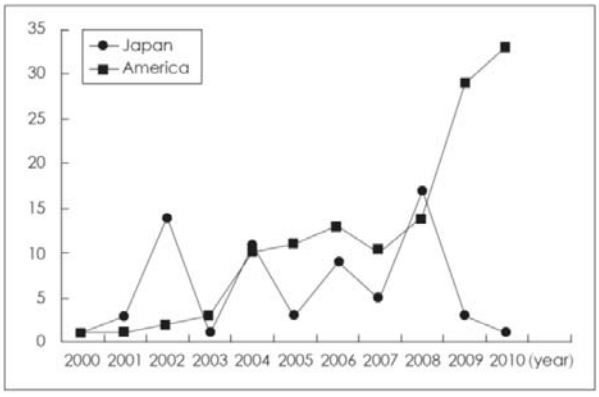


그림 1. 데이터 뱅크를 이용한 논문 발표.

각국의 데이터뱅크 시스템과 역사

1. 미국의 데이터 뱅크 시스템

컴퓨터를 이용한 외상 데이터베이스의 시작은 1969년 시카고의 Cook hospital에서 시작되었다. 이 데이터베이스 시스템은 일리노이주의 외상환자 등록의 근간이 되어 1971년 50개의 외상 센터가 참여하는 시스템을 구축하게 되었다. 이후 규모가 확대되어 37개 주에서 여러 외상 센터가 참여하는 외상 등록으로 확대되었다. 초기의 등록 작업은 일관성이 부족한 데이터베이스였으며, 주로 외상 환자의 역학적 조사에 초점이 맞추어져 있었다. 주로 외상 환자의 치료 관점에서 의료의 질 향상을 위한 국가적 표준을 마련하는 것이 주목적이었다. 2008년에는 National Trauma Data Standard (NTDS)을 정하여 표준화된 데이터수집을 체계화하였으며, 지난 2013년 전체 814,663명의 환자가 등록되었으며, 한 개 병원당 약 986명을 등록하였고 전체 758개 병원이 참여하였다. 전체적인 사망환자 비율은 4.7%로 매우 낮은데 이는 매우 다수의 경증환자를 진료하고 있기 때문임. ISS가 9점 이상인 경우가 48%정도이다.

2. 일본의 데이터뱅크 시스템

일본에서는 일본외상외과학회와 일본응급의학회의 주도하에 외상 센터 방문 환자의 자료를 구축하고 있음. 2014년 234개 참여기관에서 자료를 수집하여 총 116,466명의 외상 환자가 등록되어 있다, 등록된 사례의 사망률은 10.1%에 달하였다 (Japan Trauma Data Bank Report, 2014). 그러나 일본의 경우 ISS가 9점 이상인 경우가 77.9%로 중증도가 높고, 1급 구급구명센터에서만 외상을 치료하는 것이 아니기 때문에 이 자료시스템에 참여하지 않은 훨씬 많은 환자들의 자료가 체계적으로 누락되고 있다. 미국과 인구비례로 살펴보면 전체 인구는 미국이 3배인데, 외상센터 등록 자료는 1/10 정도만 환자수가 등록되고 있다. 따라서 이러한 병원기반 자료 등록시스템은 해당 병원을 제외한 환자가 체계적으로 누락된다는 문제가 있다고 하겠다.

3. 캐나다 데이터뱅크 시스템

캐나다에서는 Canadian Institute for Health Information (CIHI)을 통해 표준화된 국가 외상 등록체계(National Trauma Registry, NTR)(CIHI 2013)를 운영하며 이를 통해 연간 보고서를 발간하고 있다. 이 감시체계는 International Classification of Disease (ICD)체계상 손상의 외인 코드에 해당하고 손상의 중증도를 평가하였을 때 Injury Severity Score(ISS)가 12점을 넘은 환자 중 병원에 입원하였거나, 입원하지 않았어도 해당병원의 응급실에서 치료를 받았거나, 응급실에서 치료를 시작한 후에 사망한 환자

를 대상으로 하여 중증의 손상환자를 주요한 대상으로 삼고 있다. 손상의 중증도와 관련된 항목은 Predot injury Codes, Severity Codes and ISS Body Regions, MAIS Code by ISS Body Region, Injury Severity Score가 있다.

4. 한국의 데이터뱅크 시스템

국내 외상등록체계는 미국 NTDB를 응용한 2012년 KTDB를 개발하여 2013년부터 기선정된 외상센터를 중심으로 등록사업을 시행하고 있다. 하지만 아직 데이터 결과 보고 및 질관리가 되고 있지 않다. 코드기준은 증상(UMLS 코드), 처치/수술(EDI 표준수가코드), 진단(KCD-6th) AIS(update 2008)를 사용하고 있다.

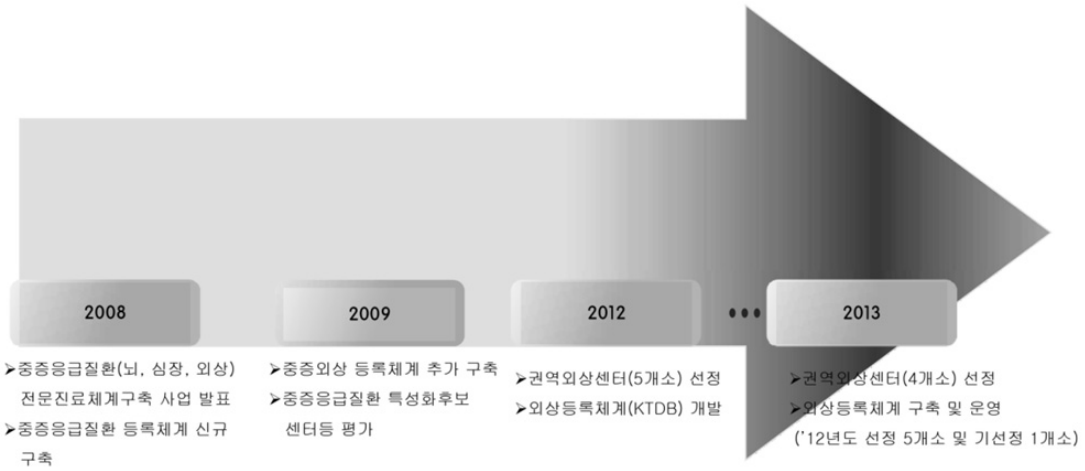


그림 2. KTDB 추진도.

5. 기타 선진국 및 개발도상국에서의 데이터뱅크 시스템

국제적으로, 많은 수의 국가들이 인구학적 근거에 기초한 국가 외상환자 등록 사업을 추진하고 있다. 북유럽 국가 가운데 노르웨이는 Norwegian National Trauma Registry, 스웨덴에는 Swedish Trauma Registry Standard (KVIT-TRA), 핀란드에는 TOOLO, 덴마크에는 Odense와 같은 등록 시스템이 있으며, 독일에는 Trauma Registry of the German Society for Trauma Surgery, 호주와 뉴질랜드에는 National Trauma Registry Consortium 등이 있다.

개발도상국에서의 외상 환자 등록은 전무하거나 만약 있더라도 원시적이고 불완전한 데이터가 대부분이다. 대부분의 데이터는 외상 환자에 대한 역학적인 데이터로서 기억에 의존하는 후향적 수집이며, 외상 정도에 대한 정보가 부정확하다. 비용이 많이 들고 제대로 된 숙련된 기술 인력이 부족하기 때문에, 제대로 된 데이터뱅크 디자인은 매우 어려운 실정이다. 파키스탄에서는 외상 환자의 입원시마다 Trauma and Injury Severity Scoring (TRISS)를 이용하여 생존 예측을 할 수 있는 소프트웨어를 통해 환자를 등록하고 있다. 우간다에서는 19가지의 아이템을 포함하는 비교적 간단한 형태의 데이터 등록을 시행하고 있다. 등록에 필요한 내용은 한 페이지 분량으로 적은 데이터이지만 역학, 외상의 원인, 치료 후 결과를 모두 포함하고 있다. 외상 환자 등록 사업을 추진하는 데에 많은 어려움과 방해 요인이 있지만, 개발도상국 일부 국가에서는 이를 활용하여 향상된 임상 결과를 제공하고, 외상을 예방하는 데에 적극적으로 활용할 수 있는 데이터를 수집하여 성공하고 있다.

손상척도 분류 체계

현재 각국에서는 대부분 AIS(abbreviated injury scale)을 외상등록의 기본분류 체계로 하여 등록을 시행하고 있다(표 1). 앞으로 다양한 중등도 평가 지표를 살펴보고자 하나 주로 AIS에 대해 설명하고자 한다.

표 1. 각국의 외상 분류체계

지역	국가(주)	종류	개소(년)	자금	데이터 등록방법	AIS	항목수
아시아	일본	국내	2004	참가비, 조성금	홈페이지	AIS98	92
	말레이시아	국내	2006	정부	등록용지, 홈페이지	불명확	36
	UAE	국내	2003	불명확	홈페이지	불명확	100
	이스라엘	국내	1995	불명확	홈페이지	불명확	300
북미	미국	국내	1993	정부, 학회, 데이터 이용료	데이터 전송	AIS80~AIS2005	107
	캐나다	국내	1997	정부	데이터 전송	AIS90 (~2012.3) AI2005 (2012.4~)	46
유럽	영국	국내	1989	참가비	홈페이지	AIS98 (2009.5) AIS2005 (2009.6~)	250+
	독일	국내	1993	조성금	등록용지, 홈페이지, 데이터 전송	AIS98, AI2005	287
	그리스	국내	2005	학회	불명확	불명확	150
	프랑스	국내	1995	불명확	등록용지	AIS90	23
	이탈리아	국내	2004	정부	홈페이지	AIS98 (~2008) AIS2008 (2008~)	110~130
	Euro TARN	다국간	2002	국제협력	데이터전송	불명확	237
오세아니아	빅토리아주	주	2001	정부, 데이터 이용료	홈페이지	AIS98 (~2010.6) AIS2008 (2010.7~)	36
	뉴사우스웨일즈주	주	2002	정부	홈페이지	AIS98 (~2007.6) AIS2005 (2007.7~2009)	>32
	퀸즈랜드주	주	1998	정부, 보험공사, 대학	홈페이지	AIS90 (1998~2008) AIS2008 (2009~)	97
	남오스트레일리아주	주	1994	정부, 대학	등록용지	AIS98	95

1.생리학적 지표

생리학적 지표로는 환자의 의식상태를 평가하는 데 널리 사용되는 Glasgow Coma Scale (GCS), 수축기 혈압과 호흡수, GCS를 이용한 Revised Trauma Score (RTS), circulation, respiration, abdominal/thoracic, motor, speech (CRAMS) scale과 중환자실에서 환자 평가에 주로 사용되는 Acute Physiologic and Chronic Health Evaluation (APACHE) 등이 있다.

1) GCS

GCS는 두부외상환자의 신경학적 평가를 정확하고도 간편하게 행하기 위해 Jannett 등이 발표한 기준이다. 개안, 통증자극으로 인한 사지의 반응 및 언어기능의 3대항목이 각각 4(4 : 자발적 개안, 3 : 부르는 소리에 개안, 2 : 통증자극시 개안 1 : 개안하지 않음, 6 (6 : 자발적, 5 : 동통부위 인식가능, 4 : 도피굴곡가능, 3 : 이상굴곡반응, 2 : 사지진전반응, 1 : 전혀 움직이지 않음) 및 5(5 : 대화가 가능 4 : 회화혼란, 3 : 언어혼란, 2 : 이해할 수 없는 신음소리, 1 : 없음) 단계로 수치화되고 합계점수(만점 : 15)로 환자의 상태를 평가할 수가 있다. GCS는 환자의 예후판정에 유용하고 7이하는 예후불량이라는 보고가 많다.

2) Revised Trauma Score (RTS)

RTS는 호흡수, 수축기 혈압, Glasgow coma scale 이상 3개의 생리학적 임상지표를 사용한다. 각각 0-4점까지 점수로 구분하며 0-12점까지로 구분하며 11점 이하인 경우는 적절한 병원으로 이송이 필요하다고 할 수 있다.

revised trauma score=(points for respiratory rate)
+ (points for systolic blood pressure)
+ (points for Glasgow coma score)

코드화된 RTS는 다음과 같이 계산할 수 있다.

RTSc = 0.9368 GCSc + 0.7326 SBPc + 0.2908 RRc

표 2. Revised trauma score)

Parameter	Finding	Points
respiratory rate	10-29 per minute	4
	>29 per minute	3
	6-9 per minute	2
	1-5 per minute	1
	0	0
systolic blood pressure	>89 mm Hg	4
	76-89 mm Hg	3
	50-75 mm Hg	2
	1-49 mm Hg	1
	0	0
Glasgow Coma Score	13-15	4
	9-12	3
	6-8	2
	4-5	1
	3	0

나머지 생리학적 지표는 외상에서 잘 사용하지 않으므로 생략한다.

2. 해부학적 지표

해부학적 손상지표로는 국제질병분류(International Clas sification of Disease; ICD)와 1950년대에 처음 개발되어 신체부위별로 손상의 중증도를 점수화한 목록으로 이루어진 Abbreviated Injury Scale(AIS), AIS의 신체부위별 점수를 이용한 Injury Severity Score (ISS), Anatomic Profile 등이 있다.

1) Injury Severity Score (ISS)

Abbreviated injury scale (AIS)은 신체부위별로 발생하는 수 백가지의 손상을 각각 점수를 매겨 평가하는 것으로, minor 1점, moderate 2점, serious 3점, severe 4점, critical 5점, maximum 6점의 점수를 매겨 환자의 손상을 구분하고 있다. AIS가 각각의 신체손상에 대한 평가라면, ISS는 다발성 외상시 신체부위별 손상 정도를 총괄하여 해부학적인 중증도를 평가하는 지표이다. 신체부위를 두부 및 경부, 안면부, 흉부, 복부 및 골반강, 사지 및 골반, 그리고 외부(열상, 화상)의 6부위로 나누고 손상 정도를 점수화하여(AIS: 1-5점) 손상이 큰 부위로부터 세 곳의 제곱을 더하여 산출하여 계산하며 점수의 범위는 1점부터 75점까지 얻을

수 있다. 외상환자 사망률 평가방법론으로 가장 널리 사용되는 것 중의 하나이며 일반적으로 ISS 점수 15 이상을 중증 외상 환자 환자라고 간주한다.

$$ISS = AIS\ (1)^2 + AIS(2)^2 + AIS(3)^2$$

표 3. Injury severity

Injury Severity	Abbreviated Injury Score
minor injury	1
moderate injury	2
severe but not life-threatening	3
potentially life-threatening but survival likely	4
critical with uncertain survival	5
Unsurvival	6

3. 생리, 해부지표의 병합된 사망예측 평가법

1) Trauma and Injury Severity Score (TRISS)

외상환자의 중증도를 평가하는 데 있어서 생리학적인 지표와 해부학적 손상지표를 한꺼번에 이용하여야 한다는 것이 일반적인 견해이다. 이러한 개념에 입각한 대표적인 사망률 평가방법론이 TRISS와 A Severity Characterization of Trauma (ASCOT)이다. 1982년에서 1989년에 걸쳐 160개 이상의 병원이 제출한 17만명 이상의 중증외상환자에 대한 자료를 이용한 대규모 외상환자 사망률에 대한 연구인 MTOS가 시행되었다. 이 연구는 중증도를 평가하는 방법론을 보다 정교하게 하고, 외상환자 진료의 국가적인 표준을 설정하며, 이를 이용하여 개별 의료기관의 질적 수준을 평가할 수 있는 객관적인 자료를 제공하는 것을 가능하게 하였다. 이 연구에서 이용된 방법론이 바로 TRISS이다. 1981년에 처음 도입된 TRISS는 후향적으로 외상환자 생존확률을 산출하는 가장 대표적인 방법론으로 북미에서 외상환자등록사업에서 사용되고 있다.

TRISS는 손상기전을 기준으로 둔상(blunt injury)과 관통상(penetrating injury)으로 구분 하고, 각각의 환자군에 대하여 ISS와 RTS, 연령 변수를 이용한 로짓회귀 분석모형(logistic regression model)을 구축함으로써 외상환자의 생존확률을 예측하는 도구이다. 사망률 예측도구의 타당도는 민감도, 특이도, 차이(disparity) 등으로 평가될 수 있는데, 이 도구의 예측도는 매우 훌륭한 것으로 나타났다. MTOS의 연구결과 둔상에서는 민감도 64.3%, 특이도99.1%, 차이 0.614로 나타났고, 관통상의 경우 민감도 84.2%, 특이도98.7%, 차이 0.810으로 나타났다. TRISS에 의한 외상환자 생존확률은 아래 식에 의하여 계산된다. 동일한 중증도의 외상에 있어서 환자의 연령이 55세 이상인 경우 사망확률이 더 높기 때문에, 아래 식에서 55세 이상인 경우는 AGE=1이 되고, 55세미만인 경우는 AGE=0이 된다. 북미에서 외상환자 진료의 질적 수준에 대한 국가적인 표준(norm)을 설정하기 위하여 수행되었던 MTOS의 각 변수별 회귀계수는 다음과 같다.

$$Ps = 1/(1+e^{-b})$$

$$b = b0 + b1(RTS) + b2(ISS) + b3(AGE)$$

2) ICD- 9 based Injury Severity Score (ICISS)

TRISS나 ASCOT 와 같은 방법론을 적용하기 위해서는 AIS의 목록에 의거하여 손상을 기술해야 하기 때문에, 외상환자등록체계와 같은 별도의 자료수집체계를 갖추어야 한다. 그런데 이러한 자료수집체계를 갖추기 위해서는 많은 노력과 비용이 소요되기 때문에, 전국적인 수준에서 많은 의료기관을 대상으로 적용되기 곤란하다는 문제점이 지적되어 왔다. 외상환자 등록체계가 가장 발달되어있는 미국에서조차도 이러한 자료수집체계는 일반화되어 있지 못하다. 미국 전체 50개 주 중 24개 주에서만 외상환자등록체계를 갖추고 있으며, 전체 외상환자의 20% 미만에서만 진료과정에 대한 평가가 이루어지고 있고, 영국과 호주, 뉴질랜드 등에서도 소수의

병원에서만 연구의 목적으로 운영되고 있다. 그러나 최근 들어 병원에서 일상적으로 생성되는 퇴원요약자료(discharge abstract)의 ICD-9코드를 활용하여 외상환자의 중증도를 평가하기 위한 시도가 이루어져 왔다. 그 중 가장 뛰어난 성과를 보이고 있는 것은 Osler 등이 개발한 ICISS이다. ICISS는 기존의 퇴원환자 자료를 이용하여 특정 상병을 가진 환자의 기대생존확률(survival risk ratio; SRR)을 경험적으로 계산해낸 것이다. 경험적인 외상환자 데이터베이스에 계산된 기대생존확률은 0에서 1 사이의 값을 갖는데, 중증도가 낮은 손상은 높은 생존확률 값을 갖고, 중증도가 높은 손상은 낮은 생존확률 값을 갖는 것이다. Osler 등의 연구에서는 ICISS가 ISS에 비하여 더 나은 성적을 나타냈고, ICISS에 연령, 손상기전, RTS를 추가하였을 때는 TRISS보다 우수한 예측 타당도를 나타냈다. 이러한 방법론을 이용한 ICISS에서는 별도의 자료수집체계가 필요 없기 때문에 큰 비용을 들이지 않고도 많은 의료기관을 대상으로 외상환자 진료성과에 대한 평가가 가능하다는 것이 가장 큰 장점이다. 그 밖에도 ICISS에서는 특정 환자의 생존확률이 그 환자의 여러 손상의 개별 생존위험확률의 곱으로 표현되는데, 이는 기존의 ISS에서 중증도를 평가하는 사용되었던 손상의 수를 3개로 제한하였던 문제를 극복한 것으로 보인다. 즉, ISS가 다발성손상의 중증도를 평가하는데 있어서 안고 있었던 문제를 어느 정도 해결한 것이다. 또한 이와 마찬가지로 외상환자에서 이전에 지니고 있는 다른 질환의 생존확률에 대한 영향을 고려할 수 있다는 장점을 지니고 있다.

ICISS=SRRinj(1)×SRRinj(2)……×SRRinj(10) ICISS full model은 기존 ICISS에 RTS를 추가한 것으로 계산식은 다음과 같다.

$$Ps=1/(1+e-b)$$

$$b=b0+b1(RTS)+b2(ICISS)+b3(Age\ Index)$$

외상 데이터뱅크 시스템의 구축

1. 데이터뱅크 시스템 구축을 위한 핵심요소

효율적인 외상 데이터뱅크 시스템을 구축하기 위한 필요한 핵심 요소로는 1) 연구계획의 수립 2) 포함/제외 기준의 설정 3) 수집자료의 변수 결정 4) 등록 소프트웨어 5) 입력요원의 선정과 교육 6) 자료를 관리하는 전략을 들 수 있다. 이러한 외상 데이터뱅크 시스템의 각 요소를 잘 이해하는 것은 매우 중요하며, 데이터뱅크 시스템을 발전시키고 적용하는 데에 반드시 고려해야 한다.

2. 연구계획의 수립(Study design)

데이터 수집의 목적과 향후의 활용을 어떻게 할 것인가에 따라 데이터뱅크의 규모와 데이터 범주가 달라질 수 있다. 단일 기관이나 지역 단위의 기관이 참여할지 국가적인 규모에서 할지 참가의 범위를 설정해야 한다. 세계 각국에서 추진하고 있는 데이터뱅크 시스템에는 참여병원의 범위와 포함 기준/제외 기준을 명확하게 명시하고 있다 데이터 수집을 하기 이전에 미리 연구의 목적과 목표를 설정하고 계획된 연구의 방법을 포함하는 프로토콜을 만들어야 한다. 이러한 프로토콜에는 1) 연구의 목적과 포함/제외 기준 명시 2) 각 변수의 명확한 정의 3) 숙련된 데이터 수집 및 입력 요원의 확보 4) 표준화된 데이터 수집 방법 및 서식 5) 데이터뱅크 위원회의 정기적인 모임을 통한 데이터 운영의 문제 도출 및 해결 6) 데이터의 지속적인 모니터링과 관리가 포함되어 있어야 한다

3. 포함/제외 기준의 결정

모든 외상 환자의 등록 시스템은 포함 기준(inclusion criteria)과 제외 기준(exclusion criteria)을 명확히 하고 있다. 좋은 데이터를 얻기 위한 연구의 목적이 뚜렷하다면 기준을 잘 정의하여야 한다. 캐나다의 등록된 외상 환자 6,839명 중 포함 기준을 만족하지 못해 등록에서 제외된 환자를 분석하였는데, 포함 기준을 Injury Severity Score (ISS) 15점으로 높게 적용한 치료 제외 환자에서 사망률 및 요양 기간 재활 치료의 비율이 높았음을 보고하였다.

4. 데이터 변수의 결정

미국 외상 데이터뱅크의 데이터 변수에서는 환자 정보(demographic information)와 외상 기전에 대한 변수로서 자동차, 자전거,

오토바이, 보행자 사고와 같은 교통 사고의 종류와 낙상 사고도 낙상 높이와 바닥의 상태를 자세히 기술하며, 스포츠 손상도 운동의 종류, 충돌의 종류, 창상 및 관통상 여부를 기술한다. 치료의 종류 및 경과, International Classification of Disease (ICD-9)를 이용한 임상적 진단 분류, 재원 기간, 합병증 및 사망률도 변수로서 기술하도록 하고 있다. 또한 부상의 정도 [abbreviated injury scores (AIS)], 치료비용, 치료 부담의 주체, 추적 관찰 결과 등도 변수에 포함하고 있다.

데이터 변수의 각 아이템에는 데이터화하기 편리하도록 주관적인 표현이나 숫자로 등급을 표시하게 되는 경우가 많다. 약물 치료의 반응 정도를 "Excellent/Good/ Fair/Poor"로 나눈다면 각 단계의 정의가 명확해야 한다. 참여 기관마다 외상 환자 등록에 관한 변수를 어떻게 정의하는가에 따라 다양하게 해석할 수 있으므로 명확히 할 필요가 있다. 수상 시간을 표시할 때에도 분 단위로 할지 시 단위로 할지를 명확하게 정의해야 한다. 재원 기간의 경우에도 날짜로 표현하거나 시간으로 표현할 수 있다. 수술의 방법과 치료 약물의 용량, 사용 방법이 병원마다 다양하므로 이를 표준화하는 것은 어려운 과정이 될 수 있다.

빠른 데이터 수집과 결과의 도출을 위해서는 수상 기전, 치료와 환자의 치료 결과를 객관적으로 부호화해야 한다. 이 부호화는 서로 통용이 가능하고 쉽게 비교할 수 있도록 일반화해야 한다. 미국의 NTDS는 데이터 변수와 반응 정도를 부호화하도록 하고 있다. 외상 환자의 최초 수상 정도의 평가에는 Glasgow Coma Score, Revised Trauma Score, ISS가 활용된다. 생존 가능성을 예측하는 평가로는 TRISS가 사용되며, 국가 간 데이터의 비교를 할 때 유용하다

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다발성 외상 환자의 초기치료

가천대학교 길병원 흉부외과학교실

현 성 열

다발성 외상은 한부위 이상의 신체 부위 및 장기에 생명을 위협하는 정도의 외상(life-threatening injury)이 발생한 경우로 사망률과 이환율이 매우 높고, 손상의 첫 1시간(golden time of trauma)이내에 가장 많은 사망이 발생하므로 이러한 외상환자의 사망률을 감소시키기 위해 외상전문팀에 의한 조직적인 전문외상처치술(advanced trauma life support, ATLS)의 적용이 필요하며 특히 중증 또는 다발성 외상환자에서는 최대한 빠른 시간내에 평가 및 처치가 동시에 이루어져야 한다. 또한 다발성 외상 환자가 응급실에 도착하였을 때 대분의 환자들은 쇼크(shock) 상태이므로 이에 대한 진단 및 처치가 중요하다.

쇼크는 세포 대사에 필요한 기관 관류(organ perfusion)와 조직 산소화를 제공하는 순환계의 부전이며 외상으로 인한 쇼크는 출혈성(hemorrhagic)과 비출혈성(nonhemorrhagic)으로 분류할 수 있고 출혈로 인한 저혈량과 연관된 경우가 가장 흔하지만, 비출혈성 원인으로 인한 쇼크가 촉발될 수 있다. 심인성쇼크(cardiogenic shock)는 강력한 둔상외상으로 인해 심근부전과 연관되어 나타날 수 있고, 분포성 쇼크(distributive shock)인 신경성 쇼크(neurogenic shock)는 급성 척수손상과 동반되어질 수 있으며, 폐쇄성 쇼크(obstructive shock)는 심낭압전과 긴장성 기흉 등에서 볼 수 있다.

치료하지 않은 외상성 쇼크환자에 대한 초기 생리학적 반응은 빈맥과 혈관수축등이 있는데 이시기를 보상성 쇼크(compensated shock)라 한다. 비보상성 쇼크(decompensated shock)는 관류 결여와 독성 효과를 생산하여 세포손상을 야기하는 혐기성 대사(anaerobic metabolism)를 일으키는 일시적인 상태이며, 이 단계서의 쇼크는 가역적이다.

불가역적인 쇼크는 수액과 약물치료에도 반응이 없는 지속적인 저혈압, 심한 산증과 응고장애가 발생할 때 일어나고, 궁극적으로 사망을 초래한다.

세포수준에서의 저관류(hypoperfusion)는 막횡단전위(transmembrane potential)의 유지를 요하는 ATP 이용성을 감소시키고, 누출(leak)되는 세포막은 간질액 섭취와 심한 세포부종의 원인이 된다. 이 부종은 인접한 모세혈관을 막아서 산소전달을 감소시킨다. 불충분하게 관류된 세포들은 필수기질을 빼앗고, 젖산(lactic acid)과 자유기(free radical)를 생성하는 혐기성 대사로 이동한다. 이들 세포독성물질은 부전된 순환에 의해 제거되지 않고 산성화를 일으키며 이미 허혈된 세포에 더욱 손상을 주게 된다. 따라서 염증 연쇄반응(cascade)이 시작되고 염증 인자들은 음성 변력(negative inotropes)으로 작용하고 에너지-의존 칼슘통로는 작동하지 않게 되어 혈관이완과 비보상성 및 불가역적 쇼크의 상태를 일으킨다.

혐기성 대사는 내인성 열생산을 못하게 하고, 차가운 수액과 혈액의 투여, 그리고 노출에 의해 저체온증(hypothermia)은 더욱 악화된다. 저체온증은 아드레날린성 경로를 통해 혈관수축을 촉진하고, 저관류가 악화되며, 생체기관을 위태롭게 한다. 결국 진행되는 혈관이완과 모세혈관 누출은 카테콜아민과 체액에 대한 반응 소실을 일으킨다.

외상에서 발생하는 복합응고장애는 많은 요소가 관여하는데 응고 연쇄반응(coagulation cascade)에 제일 먼저 관여하는 조직의 손상을 일으키고, 저관류가 플라즈미노겐 활성물 억제제(plasminogen activator inhibitor)를 억제하는 동안 허혈은 내피 플라즈미노겐 활성물(endothelial plasminogen activator)을 활성화 시키고 따라서 과섬유소용해(hyperfibrinolysis)를 증진시킨다. 또한 쇼크는 항응고 단백질 C (anticoagulant protein C) 과정의 전신적인 활성을 초래하게 된다

정질액(crystalloids), 교질액(colloids) 또는 농축적혈구(packed red cells)의 투여를 통한 혈액희석(hemodilution)은 저체온증이

혈소판 기능에 음성적인 효과를 가지는 동안 응고장애를 악화시킨다.

산혈증은 응고인자의 활성을 억제하고 섬유소원(fibrinogen)의 파괴를 증가시킨다.

따라서 심각한 출혈을 가지는 외상환자에서 "lethal triad(triad of trauma)"는 급성 응고장애, 대사성 산증과 저체온증의 복합이다.

외상환자 쇼크의 원인을 파악하기 위해 적절한 병력청취와 주의깊은 신체검진을 시행하는 것이 중요하다. 하지만 환자의 치료우선순위는 환자의 손상과 활력징후, 소변량, 의식수준등은 필수적이다. 그리고 손상기전을 바탕으로 결정한다. 즉 쇼크의 진단과 치료는 거의 동시에 이루어져야 한다. 이 과정은 생명위협 손상의 즉각적인 발견과 이것을 동시에 해결하는 과정으로 진행하는데, 다발성 외상환자의 대부분은 처음 치료를 시작할 때 다른 원인의 쇼크라는 증거가 없는 한 저혈량쇼크로 생각하여 치료해야 하며 기본적인 치료 원칙은 출혈을 멈추고 소실된 순환량을 보충하는 것이다.

다발성 외상 환자에서 수축기 혈압이 정상이더라도 일차평가 과정에서 신체검사를 통해 환자가 쇼크 상태인지를 초기에 감별해야 한다. 환자가 불안해하거나, 창백하고, 식은땀이 나며, 빈호흡을 보이면 이는 쇼크의 초기 징후일 수 있으며 빈맥은 이런 징후보다 늦게 나타날 수도 있다. 또한 혈압은 실혈량이 30% 이상일 때 비로소 감소하므로 혈압으로 쇼크를 판단해서는 안되며 표 1은 쇼크 환자의 진단 기준을 요약한 것이다.

표 1. 쇼크의 진단 기준

급성 병색이 있거나 의식이 저하되었을 때
맥박수>100/분
호흡수>22/분 또는 $PaCO_2$<21 mmHg
동맥 염기결핍<-5 mEq/L 또는 젖산>4 mM/L
소변량<0.5 mL/kg/hr
20분 이상 저혈압 지속

신체검사는 일차평가인 ABCDE (표 2)의 원칙에 따른다.

표 2. 일차 평가

Airway maintenance with cervical spine protection (기도유지와 경추보호)
Breathing and ventilation (호흡과 환기)
Circulation with hemorrhage control (순환과 출혈조절)
Disability: Neurologic status (장애/신경학적 평가)
Exposure/Environmental control (노출/환경 조절)

적절환 환기와 산소화로 기도개방을 수행하는 것이 우선적이고 산소포화도를 95% 이상 유지하도록 산소를 공급한다. 순환에 대해서는 명백한 출혈을 조절하고, 적절한 정맥로를 확보하며, 조직관류를 평가하여야 한다. 외부상처로부터의 출혈은 출혈부분에 직접적인 압박으로 조절될 수 있다. PASG (pneumatic antishock garment) 또는 pelvic binder를 사용하여 골반 또는 하지골절로 인한 출혈을 조절할 수 있다.

간단한 신경학적 검진으로 의식수준, 안구운동, 동공반사, 근력, 감각등을 평가한다. 이 검사는 뇌의 혈액순환이 적절한 지 평가하고 추후 신경학적으로 어느정도 회복될 수 있는지 예측해 볼 수 있다. 저혈량쇼크의 결과로 저혈압을 나타내는 환자에서 중추신경계 기능의 변화는 직접 두개골내 손상을 의미하지 않고, 부적절한 뇌관류를 반영하는 것이다. 두개골내 손상 회복노력보다는 뇌관류와 산소화의 회복을 우선적으로 이루어져야만 한다.

생명위협손상환자는 완전히 옷을 벗기고, 동반된 손상을 찾기 위해 머리에서 발끝까지 주의깊게 검진하는데 옷을 벗긴환자는

저체온증을 예방하는것이 필수적이다. 수액가온, 외부수동및 능동가온방법등으로 저체온증을 예방할 수 있다.

위확장은 외상환자에서 흔히 발생하는데 의식이 없는 환자에서 위내용물의 흡인 위험성을 증가시킬 수 있고, 소아에서는 설명할 수 없는 저혈압 또는 부정맥, 과도한 미주신경자극에 의한 서맥을 일으킬 수 있다. 따라서 levein관등을 이용하여 위감압을 시행하여야 한다.

방광도뇨관은 혈뇨에 대한 소변을 평가하고, 소변배출량을 모니터링하면서 신관류의 지속적인 평가를 위해 수행되어져야만 한다.

즉시 혈관확보를 해야 하고 중심정맥선 삽입을 고려하기 전에 2개의 큰 구경(최소 16 gauge)의 말초정맥관으로 삽입한다. 유속은 관 직경의 4배압에 비례하고 관의 길이와 반비례 한다. 따라서 이런 이유로, 짧고, 큰 구경의 말초정맥선은 많은 수액을 빠르게 주입할 수 있는 것이다. 또한 수액가온기와 rapid infusion pump는 대량 출혈과 심한 저혈압이 있을 때 사용되어질 수 있다. 성인에서 말초의 경피적 정맥선에 대한 가장 적절한 부위는 전완부(forearm)과 전주정맥(anticubital vein) 등이다. 6살 이하의 소아에서 중심정맥선을 삽입하기 전에 골내주사의 삽입을 시도할 수 있다.

x-ray 검사는 신중하게 시행되어야 하고 x-ray검사를 위해 소생술을 지연해서는 안된다. x-ray 촬영은 이동식 촬영기로 소생구역에서 시행해야 하고 외상 x-ray series인 chest AP, c-spine lateral, & pelvis AP등을 기본적으로 시행하고 이차 평가 기간에 한해서 CT등을 시행할 수 있으며, CT가 필요한 경우 척추를 보호한 상태와 혈역학적으로 안정화된 후 시행한다.

쇼크환자의 경우 일차평가와 응급치료를 하면서 가능하다면 초음파로 쇼크의 원인을 감별하는 것이 중요하다. 외상초음파(Focused Assessment Sonography in Traum: FAST)는 복강내 액체와 심낭내 액체를 확인할 수 있는 빠르고, 비침습적이고, 민감도가 높은 방법이고, 복강내 고형장기의 손상 유무도 확인 가능하며 임산부에서도 사용이 가능하다는 장점이 있으므로, 환자평가 초기에 시행되어야 한다. 기본적으로 간신장와(hepatorenal recess), 비장신장와(splenorenal recess), 골반내 혹은 골창자자궁와(Douglas pouch), 심낭주변등 4군데의 해부학적 구조물 부위에 액체 저류가 있는지를 확인하며, 최근에는 기흉이나 혈흉 등도 확인할 수 있다. 단 외상초음파는 소장, 대장 등의 유강장기나 공기가 있는 장기들은 초음파의 특성상 확인이 어려우며, 고형장기내에 국한된 열상이나 출혈처럼 복강내 액체 저류를 일으키지 않는 손상이나 후복막 손상 등은 확인하기 어려운 단점이 있다.

출혈은 손상후 쇼크의 가장 흔한 원인이고, 다발성 손상을 가진 모든 환자는 저혈량의 요소를 갖는다. 대부분의 비출혈성 쇼크상태는 수액보충에 부분적 또는 간결하게 반응한다.

만일 쇼크의 징후가 존재한다면 치료는 저혈량성인 것처럼 시작한다. 또한 치료를 시작하면서 심낭압전, 긴장성 기흉, 척수손상 또는 둔상 심장손상과 같은 이차적인 다른 원인을 찾는 것이 중요하다.

심근부전을 일으키는 원인으로 둔상심장손상, 심낭압전, 공기색전증 또는 드물게 환자의 손상과 동반되는 심근경색증 등이 있으며, 이로 인해 심인성 쇼크가 발생할 수 있다. 따라서 모든 흉곽둔상 손상을 받은 환자는 손상 유형과 부정율동을 찾기 위해 지속적인 심전도 모니터링이 필요하고 혈액 CK와 심근의 특이한 동위원소 검사, FAST및 심초음파 등을 시행하여 진단과 치료에 도움을 받을 수 있다.

혈압, 심박수, 체온, 소변배출량과 GCS (Glasgow coma score)를 포함하는 생리학적 측정은 쇼크의 처치에서 생명유지에 필수적이다. 동맥선(arterial line)은 혈압의 지속적인 사정을 허용하고 pH를 모니터링하기 위한 동맥혈가스분석(ABGA)을 위해 규칙적으로 시행하고, 중심정맥 삽관을 하여 CVP의 모니터링과 혼합된 정맥 산소포화도(mixed venous oxygen saturation)의 순차적인 측정을 하는 것은 수액보충에 대한 길잡이로서 도움이 된다.

젖산(lactate)은 혐기성 대사에 의해 생성되며, 산소 빚(oxygen debt), 조직 저관류 그리고 출혈성쇼크의 중증도의 간접적인 표지자로 사용되어질 수 있다. 젖산수치가 높고, 젖산수치가 정상으로 되돌아가는데 오랜 시간이 걸리면 다발성 장기손상 동반을 추정할 수 있다.

염기결핍(base deficit)은 관류가 부전됨으로 인해 전반적인 조직 산증의 간접적 측정으로 제공할 수 있다. 이것은 외상성 출혈성 쇼크환자에 대한 사망률의 독립적인 예측인자로 사용되어질 수 있다.

단순 두 개강내 손상은 쇼크의 원인이 아니므로 두부손상의 환자에서는 두개강내 손상보다 다른 원인을 찾아야 한다. 간결한 신경학적 검진은 의식의 정도, 눈운동과 동공반응, 최상의 운동기능, 그리고 감각의 정도등으로 결정할 수 있다. 이런 정보는 뇌관류의 평가에 유용하고 신경학적 장애의 전개와 회복의 예측에 도움이 된다.

척수손상은 교감신경 긴장도의 소실을 일으켜 저혈압을 발생시킬 수 있으며, 신경성 쇼크의 전형적인 양상은 빈맥과 피부혈관 수축이 없는 저혈압이다. 척수손상환자는 몸통손상을 동반하는 경우가 많으므로 신경성 쇼크이거나 의심되는 환자는 저혈량에 대한 치료가 우선이고, 기관관류의 회복을 위한 수액소생술의 실패는 지속되는 출혈이나 신경성 쇼크를 추정할 수 있다.

손상후 즉각적인 감염으로 인한 쇼크는 흔하지 않지만, 응급실 도착시간이 지연되면 발생할 수 있고, 패혈성 쇼크는 복부관통상 환자에서 발생할 수 있다. 초기 패혈증 쇼크의 환자는 정상 순환 혈액량, 보통의 빈맥, 따뜻함, 분홍색 피부, 수축기압은 거의 정상 그리고 넓은 맥압을 보인다.

출혈은 순환혈액량의 급성 감소로써 정의 되어진다. 임상적인 징후를 기준으로 출혈량을 짐작할 수 있는데 수액투여, 수혈요법을 제시하고 있지만 이는 단순히 분류에 따르기보다는 환자의 초기 치료반응을 따라 결정하는 게 좋다(표 3).

표 3. 환자의 초기 징후에 따른 예상 실혈량

	Class I	Class II	Class III	Class IV
실혈량(ml)*	~750	750-1500	1500-2000	>2000
실혈량 비율(%)	~15%	15-30%	30-40%	>40%
백박(회/분)	<100	100-120	120-140	>140
혈압	정상	정상	감소	감소
맥압(mmHg)	정상 또는 증가	감소	감소	감소
호흡수(회/분)	14-20	20-30	30-40	>35
소변량(ml/h)	>30	20-30	5-15	거의 없음
의식	명료, 약간 불안	불안	불안, 혼돈(confused)	혼돈, 기면(lethargic)
수액, 수혈	정질액	정질액	정질액, 혈액	정질액, 혈액

*실혈량은 몸무게 70Kg의 성인 남성을 기준으로 함

Class I 출혈은 원래 건강한 사람이라면 이정도의 출혈에서 수혈은 필요하지 않다.

Class II출혈은 정질액 소생술이 요구되어지는 비합병성 출혈로서 초기에 적극적인 수액소생술이 시작되어야 하고 환자의 상태에 따라 수혈이 필요할 수도 있다. Class III는 최소한 정질액뿐만 아니라 상황에 따라 수혈이 필요한 합병성 출혈이다. 환자는 부적절한 순환과 관련된 모든 증상을 보인다. 이런 환자는 수액소생술에 대한 반응과 환자의 말초 장기의 순환, 산소화 정도에 따라 수혈을 결정해야 한다. 그리고 Class IV는 아주 위험한 상황으로 초기부터 적극적인 치료가 이루어지지 않으면 환자가 수분내에 사망할 수도 있다.

손상의 첫 1시간 사망률과 이환율이 매우 높고 외상의 골든타임(golden time of trauma)라고 하여 외상후 첫 1시간 이내에 가장 많은 사망이 발생하는데 손상의 첫 1시간동안의 처치가 환자의 이환율과 사망률 모두를 최소화할 수 있긴 때문에 매우 중요하다.

손상후 첫 24시간 이내에 발생하는 조기 사망은 50%이상에서 조절되지 않는 대량출혈로 인해 나타나고, 그 나머지는 치명적인 외상성 뇌손상으로 인해 나타난다,

혈역학적 보조와 수액치료가 조기 및 후기 결과 모두에 의미있게 영향을 줄 것이다. 생명을 위협하는 다발성 손상은 전형적으로 외상성 뇌 또는 척수손상, 주요골절, 복부 또는 흉부 장기 파열, 또는 심각한 연조직창상으로 구성되어진다.

출혈성쇼크의 빈도는 골반골과 대퇴골골절, 간, 비장, 또는 시잔손상과 흉복부 대혈관손상후에 가장 높게 나타난다.

쇼크처치의 일차적인 목표는 순환용적(circulatory volume)을 회복하고, 출혈을 없애며, 조직산소전달을 개선하는 것이다. 쇼크의 진단과 치료는 거의 동시에 시행되어야만 하는데 대부분의 외상환자에 대해, 쇼크상태가 다른 원인을 가진다는 명확한 증거가 없다면, 환자는 저혈량 쇼크를 갖는다는 것처럼 치료를 시작해야 한다. 따라서 수액소생술은 혈압이 하강하거나 측정되지 않을 때 시행하지 말고, 실혈의 초기 징후와 증상이 분명하거나 의심될 때 시작해야 한다.

정맥이 확보되면 혈액형과 교차시험(crossmatching), 독성연구및 모든 가임기여성에서 임신반응검사를 시행하고 이때 더불어 동맥혈 검사를 시행한다.

초기소생술에 사용되는 수액은 Lactated Ringer's solution 과 생리식염수와 같은 가온된 등장성 전해질 용액이다. 이런 유형의 수액은 일시적으로 혈관내 용적 확장을 제공하고, 간질공간(interstitial space)과 세포내공간(intracellular space)으로의 체액소실에 대처하여 혈관용적을 더 안정화 시킨다. 처음에 가온된 수액을 가능한한 빠르게 일시 주사(bolus injection)하는데 상용량(usual dose)은 성인에서 1-2 L, 소아에서는 20 mL/Kg이다.

2008년 개정판 ATLS는 혈괴파괴(clot disruption)에 대한 잠재성으로 인해 출혈을 가지는 관통손상에 지연성 적극적인 수액소생술을 제한했다. 이개념은 재출혈을 피하기 위해 더 낮아진 혈압을 수용하는 것으로 허용된 저혈압(permissive hypotension) 개념이고 출혈의 완전한 수술적 조절전에 소생술 전략으로 받아들여져 왔다. 저혈압성 소생술 또는 허용된 저혈압(hypotensive resuscitation or permissive hypotension)은 외상환자에서 적극적인 수액소생술이 미리형성된 응고물을 떼어냄으로 인해 출혈을 더 조장하여 재출혈과 더욱 혈액소실을 일으킬 수 있다는 사상에서 전개되었다. 이개념은 출혈이 조절될 때까지 제한된 용량보충(volume replacement)을 포함하는 것으로 이 기간동안 빈약한 종말 기관관류가 견딘다는 개념이다. 또한 소생술에 있어서 혈액제제의 일상적인 사용을 주장하지 않았지만, 외상의 응고장애를 치료하기 위한 혈액제제의 조기 사용과 정질액의 제한된 사용에 의해 희석된 응고장애를 방지하는 것을 주장한다.

쇼크를 진단하는데 사용되어지는 부적절한 관류의 징후와 증상으로는 환자의 반응이 유용한 결정요인이고, 정상혈압, 맥압 그리고 맥박수의 환원은 관류가 정상으로 돌아왔다고 추정되는 징후이다. 그러나 이들 관찰은 기관관류에 관한 정보를 주지는 않는다. 소변배출량은 신관류의 의미있는 예민한 자료이다. 만일 이뇨제의 투여에 의해 수정되지 않는다면 정상소변량은 적절한 신관류를 의미한다. 이런 이유에 대해, 소변배출은 소생술의 주된 모니터와 환자반응의 하나이다. 적절한 소생수액 공급은 성인에서 소변배출이 약 0.5 mL/kg/hr, 소아에서 1 mL/kg/hr이다. 1세 이하의 소아에서는 2 mL/kg/hr을 유지해야 한다.

초기 저혈량 쇼크환자는 빈호흡으로 인해 호흡성 알칼리증을 보인다. 호흡성 알칼리증은 쇼크의 초기단계의 경한 대사성 산증이 따르고 이것은 치료가 요구되지 않는다. 대사성 산증은 쇼크가 오래가거나 심한 경우 발생할 수 있다. 대사성 산증은 불충분한 조직관류와 젖산의 생성을 일으키는 혐기성 대사에 의해 발생한다. 불충분한 소생술 또는 지속되는 혈액소실에 의해 지속적인 산증이 흔히 일어나고, 정상 체온인 쇼크환자에서 이런 지속적인 산증은 수액, 혈액으로 치료하고, 출혈을 조절하기 위해 수술적 중재술이 고려되어야 한다.

염기결핍과 젖산은 쇼크의 존재와 중증도를 결정하는데 유용할 수 있다. 중탄산나트륨은 저혈량 쇼크로 인한 이차적인 대사성 산증을 치료하는데 보편적으로 사용하지는 않는다.

처음 수액 소생술에 대한 환자의 반응은 순차적인 치료를 결정하는 열쇠가 되는데 처음 소생술에 대한 반응을 관찰하는 것은 측정된 것보다 많은 혈액소실을 갖는 환자와 내부출혈의 수술적 조절을 요하는 지속적인 출혈을 갖는 환자를 찾아내려는 것이다. 수술방에서의 소생술은 외과의사에 의해 출혈을 직접 조절하는 것과 혈관내 용적(혈관내 유효 혈액량)의 회복을 동시에 수행할 수 있다. 추가로 수술은 처음 상태가 혈액 소실의 양과 불균형인 환자에서 불필요한 수혈이나 과수혈의 가능성을 제한다.

초기 수액치료의 반응이 중요한데, 처음 수액투여에 대한 환자 반응을 세가지로 나눌 수 있고 이에 대한 활력후와 치료지침이 표 4에 나와있다.

표 4. 초기 수액 소생술에 대한 반응*

	신속한 반응	일시적 반응	미약한 반응, 무반응
활력징후	정상으로 회복	일시적 회복 후 다시 혈압감소, 맥박 증가	비정상
예상 실혈량	적음(10%-20%)	보통, 지속되는 실혈(20-40%)	대량실혈(>40%)
추가 수액 투여 필요성	낮음	높음	높음
수혈 필요성	낮음	중간~높음	즉시 필요
혈액준비	혈액형, 교차시험	혈액형	RH-O
수술적 치료 필요성	있음	높음	아주 높음
외과의를 초기에 호출	필요함	필요함	필요함

*성인에서 2000mL의 등장성 정질액, 소아에서 20mL/kg의 링거젖산수액 투여후

수혈의 주된 목적은 혈관내 용적의 산소이동 능력을 보존하기 위한 것이다. 수액 소생술 자체는 정질액으로 시행되어질 수 있는데 간질과 세포내 용적 보상(interstitial and intracellular volume restitution)에 기여하는 장점이 있다. 교차시험(crossmatching)을 하고 type-specific blood로 투여하는데, 만일, type-specific blood를 이용할 수 없는 상황인 경우는 type O packed cell을 사용할 수 있고, 감작이나 추후 합병증을 예방하기 위해 가임기 여성에서는 Rh-형 세포(Rh-negative cells)가 선호되어진다.

농축적혈구(packed red cells), 신선동결혈장(FFP)및 혈소판의 가장 좋은 비율은 논쟁의 여지가 남아있지만, 1:1:1 비율이 회복을 개선시키고 사망률을 감소시킨다.

저체온증은 예방되어야만 하고, 만일 환자가 병원에 도착시 저체온증을 가지고 있다면 바꿔야 한다. 응급실에서 혈액 가온기(blood warmers)의 사용은 바람직하다. 많은 양의 정질액을 투여받는 환자에서 저체온증을 예방하기 위해 가장 효과적인 방법은 그 수액을 사용하기 전에 39°C (102.2°F)에 수액을 가온하는 것이다. 이것은 가온기에서 정질액을 저장하여 시행할 수 있거나 전자레인지의 사용으로 시행할 수 있다. 혈액부산물은 전자레인지에서 가온할 수 없지만 그들은 정맥수액가온기를 이용하여 도관을 가온할 수 있다.

Damage control resuscitation(DCR)과 지혈성 소생술(hemostatic resuscitation)은 최근에 개발된 개념으로써, 출혈성쇼크와 즉각적인 생명위협 손상을 갖는 환자에게 최적화된 소생 접근과 수혈접근을 하는 방법이다. 심한 외상손상을 받은 환자에서 목표는 의인성 소생술 손상을 최소화하고, 존재하는 외상성 쇼크와 응고장애의 악화를 예방하며, 결정적인 지혈을 얻기위한 것이 DCR의 목표이다. 한번 이것이 도달되면, 다음 즉각적인 목표는 빠르게 쇼크, 저응고, 혈관내 용적 결핍을 반전시키고, 적절한 산소 전달과 심박출량을 유지하는 것이다.

외상성 응고장애가 발생하는 환자는 흔히 대량수혈을 요구하는데, 성인에서 대량수혈은 입원 24시간 이내에 적혈구를 10units 이상 받는 경우로 정의한다. 대량수혈은 높은 사망률을 갖는다. 대량수혈의 예측은 사망률이 높기 때문에 향후 연구를 위한 우리의 가장 집중적인 과업중의 하나이고, 적절한 대량수혈 가이드라인의 빠른 완성은 생존을 개선 시킬 것으로 보인다. 예측 공식은 전형적으로 혈압, 심박수, 염기결핍, INR, 그리고 혈색소수치, 그리고 외상환자에서 FAST 등을 포함한다. 이 예측 모델을 사용하는 일차적인 장점은 DCR 전략을 요구하게 될 환자를 입원시키는 것을 즉각적으로 결정하는 능력을 증대하는 것이다. 가끔은 심한 손상과 심각한 저혈압을 가지는 환자가 대량수혈이 필요할 것이라는 것이 명백하지만, 보상성 쇼크 상태에 있을 수 있는 심각한 내부출혈을 가진 환자는 명백하지 않을 수 있다. 이런 환자에서 빠르게 적용할 예측 도구가 가장 가치가 있을 수 있다

DCR의 한 부분인 허용된 저혈압(permissive hypotension)은 혈전형성을 촉진하기 위해 정상보다 약간 낮게 혈압을 허용하여 종말기관으로 충분한 관류를 유지하도록 하는 것으로 요약되어질 수 있다. 지혈성 소생술은 적혈구, 혈장과 혈소판의 비율을 1:1:1로 사용하는 것을 주장하는 것으로, 조기에 많은 양의 정질액과 농축적혈구 사용대신에 혈장과 혈소판-함유 제제로 실혈을 보충함으로써 희석성 응고장애의 악화를 최소화하는 것을 의미한다. 여기에 응고인자와 섬유소원-함유제제의 적절한 사용도 포함한다. 대부분의 혈액수혈을 받는 환자들은 칼슘보충이 필요 없다. 과도한 칼슘보충은 해롭다.

체온은 초기 평가기동안 모니터해야 하는 중요한 활력징후이고 식도 또는 방광 체온이 중심체온의 정확한 임상 측정이다. 알콜의 영향하에 있는 외상 환자와 매우 추운기온에 노출된 외상환자는 혈관이완의 결과로써 저체온증을 더 잘 갖는다.

적절한 외부가온 장치, 가온램프, 열모자, 가온된 호흡가스 그리고 가온된 정맥수액과 혈액을 이용한 환경에서의 급속재가온은 일반적으로 저혈압과 저체온증을 교정할 것이다.

39℃으로 가온된 정질액으로 복막 또는 흉강의 세척술과 같은 중심재가온이나 심폐기를 이용한 중심재가온은 때때로 적응된다. 저체온증은 예방에 의해 가장 잘 치료된다.

소생을 위한 개흉술을 흉부외상에 의한 심정지의 경우 일부 적응증이 되는 경우에는 개흉심장마사지(open cardiac massage)를 시행할 수 있다. 흉부자상을 입은 환자이면서 응급실에서 "생명징후(sign of life)"가 관찰된 경우가 적응증에 해당한다(표 5).

표 5. 개흉심장마사지

손상형태	
둔상	맥박, 혈압, 자발 호흡이 있는 상태로 응급실이나 외상센터에 도착한 환자에서 심정지가 목격된 경우
심장의 관통상	① 응급실이나 외상센터에서 심정지가 목격되었거나, ② 병원밖에서 심폐소생술을 받은 시간이 5분 미만이면서 생명의 이차적인 징후가 있는 경우(예: 동공반사, 자발운동, 형태를 갖춘 심전도)
심장 이외의 흉부 관통상	① 응급실이나 외상센터에서 심정지가 목격되었거나, ② 병원밖에서 심폐소생술을 받은 시간이 15분 미만이면서 생명의 이차적인 징후가 있는 경우(예: 동공반사, 자발운동, 형태를 갖춘 심전도)

또한 고형장기 손상, 축혈관의 파열, 골반고리를 포함하는 골반골 골절과 같은 비압박성 몸통출혈(noncompressible torso hemorrhage)로 인한 출혈성 쇼크와 심각한 복강출혈을 갖는 환자에서 소생술적 개흉술(resuscitative thoracotomy)에 의한 대동맥겸자(aortic clamping)과 소생술적 혈관내 풍선 폐쇄(resuscitative endovascular balloon occlusion of the aorta: REBOA)를 시행하여 초기에 환자의 상태를 안정하게 유지하는데 도움이 될 수 있다.

이러한 대동맥 겸자와 REBOA는 대동맥 근위부압력을 보조하여 관상동맥 혈류, 심박출량, 중심동맥압, 경동맥 혈류, 그리고 뇌의 부분적 산소압 등의 증가를 일으키고, 또한 출혈을 최소화하여 소생술과 출혈부위의 수술적인 복구(surgical repair)를 용이하게 할 수 있다.

골반골골절에 의한 저혈량 쇼크가 발생한 경우 신속한 지혈이 필요한데 골반골 골절의 경우 직접 압박에 의한 지혈은 불가능하고 혈관조영술을 이용한 지혈방법(embolization)이 사용된다. 동맥출혈의 경우에는 동맥조영술을 통한 색전술로 80%이상에서 지혈할 수 있다. 하지만, 혈관조영술을 통한 색전술로 모든 골반강 내 출혈을 지혈시킬 수는 없다. 골반강내 정맥이 광범위하게 서로 연결되어 있고 정맥판막이 없는 해부학적 특성으로 인해 정맥출혈을 지혈하는 방법으로 유용하지 않고, 골절된 뼈에서 나오는 출혈도 지혈할 수 없다. 골반골 골절환자에서 혈관조영술은 일반적으로 환자가 혈역학적으로 불안정하거나 골반 혹은 후복막강에 큰 혈종이 있는 경우 또는 CT상 조영제의 혈관 밖 유출(contrast blush)가 관찰되는 경우 적응이 되지만, CT상 이러한 소견이 없는 경우에도 임상적으로 골반강 출혈이 의심되는 경우에는 실시할 수 있다.

외상초음파상 음성이면서 골반강내 출혈을 시사하는 소견(예로 전후 압박에 의한 손상, open-book 손상)이 있는 혈역학적으로 불안정한 환자의 경우에는 외압박이나 외고정술 및 혈관조영술을 먼저 고려한다.

따라서 초기 응급실에서는 보존적인 치료를 시행할 수 밖에 없다. 이러한 보존적 치료법으로 추가적인 혈관손상과 골절 손상을 최소화하기 위해 골반골 고정법을 할 수 있는데 pelvic sling을 권장하고 있는데 이는 다양한 형태로 시행할 수 있고 불안정한 골반골 골절 또는 그로 인한 심한 출혈이 있는 경우에는 일시적으로 사용할 수 있다. 하지만 MAST(military anti-shock trausers: MAST)의 경우는 사용을 제한한다. 대부분의 골반골 골절 손상은 복부 손상과 동반되며 이는 MAST 적용에 금기에 해당되며 실제로 MAST의 사용이 골반골 골절에 의한 출혈을 막는다는 연구 결과도 없다.

Conclusion

다발성 외상은 손상 첫 1시간 내에 사망할 확률이 높을 정도로 생명을 위협하는 손상이 많고 많은 환자에서 쇼크가 발생한다. 따라서 외상으로 인한 쇼크는 대부분이 저혈량증이고 즉각적인 출혈조절과 수액 또는 혈액보충을 해야 하는데 쇼크의 진단과 치료는 거의 동시에 발생해야만 한다. triad of trauma를 빠른 시간내에 회복시키기 위해 생리적 원칙에 기초를 두고 출혈을 중지시키며 체액소실을 보충하고 응고장애를 예방하기 위해 적절한 수액과 혈액제제의 사용을 고려하고 저체온증을 교정하는 것이 필요할 것이다.

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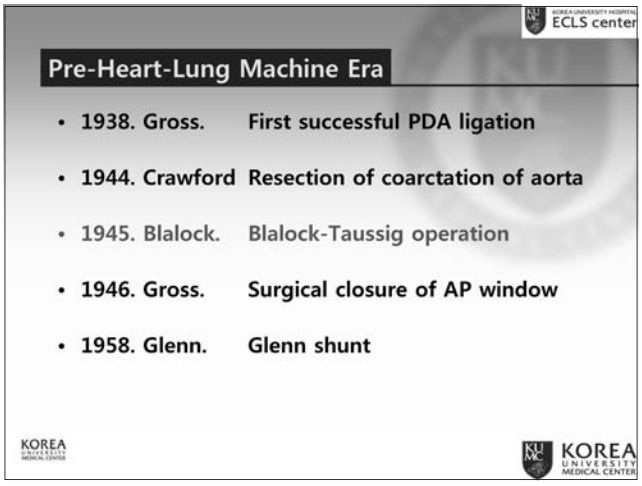
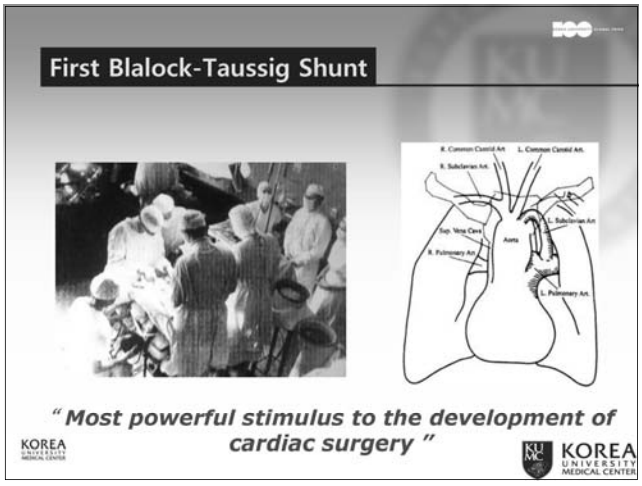
ECMO: Past, Present and Future

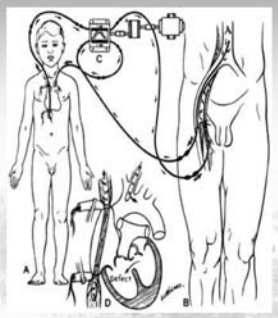
Department of Thoracic and Cardiovascular Surgery, Organ Transplantation Center, Korea Artificial Organ Center, Anam-Hospital, Korea University Medical Center, Seoul

Jae-Seung Jung, M.D., Ph.D.





Controlled Cross-circulation



- 1954. Lillehei
  First surgical closure of VSD under controlled cross-circulation
- Used in 45 patients between 1954 to 1955
- VSD
  TOF
  AVSD

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Development of CPB

ECLS center

• 1951. Dodrill.	Mitral valve surgery under left heart bypass
• 1952. Dodrill.	Relief of PS under right heart bypass
• 1953. Lewis.	ASD closure under surface cooling
• 1953. Gibbon.	ASD closure by heart-lung machine
• 1954. Lillihei.	VSD closure under controlled cross-circulation
• 1954. Kirklin.	Establishment of CPB with oxygenator in cardiac surgery

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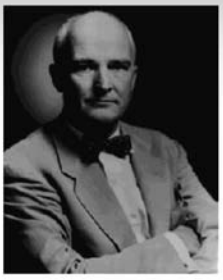
J. Gibbon and Heart-lung Machine



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ECMO의 역사

KOREA UNIVERSITY MEDICAL CENTER

ECLS center

ECMO – the beginnings

John and Mary. Gibbon – 1930s begins work on extracorporal circulatory techniques, which eventually led to development of the heart and lung machine

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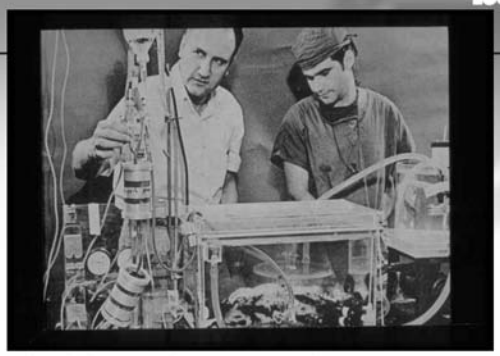
Early Animal experiments

Dr. R. Bartlett

Phil Drinker PhD, 1968 → First trial of Membrane Oxygenator



Ted Kolobow and Warren Zapol 1969

→ membrane lung for CO2 removal

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ECMO – the beginnings

- 1971 – first reports of bedside CPB used for long-term support *
- Prior to 1970s, attempts at long-term extracorporal support limited by gas-exchange devices ("oxygenators"), which did not separate the gas from the blood and led to hemolysis, thrombocytopenia, coagulopathy if used for hours at a time → bubble oxygenator

*Kolobow T, Spragg RG, Pierce JE, Zapol WM. Extended term (16 days) partial extracorporeal blood gas exchange with the spiral membrane lung unanesthetized lambs. *Trans Am Soc Artif Intern Organs* 1971; 17:350-354

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First successful ECMO patient, 1971

Auto Bicycle TA
→ Traumatic thoracic aortic rupture
→ Post Op ARDS

J Donald Hill MD and Maury Bramson BME, Santa Barbara, Ca, 1971. (Courtesy of Robert Bartlett, MD)

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ECMO – the evolution

1975, Bartlett et al. successfully apply bedside CPB to treat a newborn with meconium aspiration, marking the beginning of ECMO in critical care

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ECMO History

Esperanza, Age 1 day 1975

VA ECMO due to Meconium Aspiration

Slide courtesy of Dr. R. Bartlett

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ECLS center

ECMO History

Esperanza, age 21

Slide courtesy of Dr. R. Bartlett

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Reprinted from THE LANCET *August 9, 1980, pp. 292-294*

TREATMENT OF ACUTE RESPIRATORY FAILURE WITH LOW-FREQUENCY POSITIVE-PRESSURE VENTILATION AND EXTRACORPOREAL REMOVAL OF CO_2

L. GATTINONI* A. AGOSTONI†
A. PESENTI* A. PELIZZOLA*
G. P. ROSSI* M. LANGER*
S. VESCONI* L. UZIEL†
U. FOX‡ F. LONGONI‡
T. KOLOBOW§ G. DAMIA*

**Istituto di Anestesiologia e Rianimazione, †Istituto di Clinica Medica VII, and ‡Istituto di Clinica Chirurgica III, Università di Milano; and §National Institutes of Health, Bethesda, Maryland, U.S.A.*

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Low-Frequency Positive-Pressure Ventilation With Extracorporeal CO_2 Removal in Severe Acute Respiratory Failure

Luciano Gattinoni, MD; Antonio Pesenti, MD; Daniele Mascheroni, MD; Roberto Marcolin, MD; Roberto Fumagalli, MD; Francesca Rossi, MD; Gaetano Iapichino, MD; Giuliano Romagnoli, MD; Lji Uziel, MD; Angelo Agostoni, MD; Theodor Kolobow, MD; Giorgio Damia, MD

Gattinoni et al., *JAMA*, 1986; 256, 881-886

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Vol. XXXIV Trans Am Soc Artif Intern Organs 1988

Registry Reports

National Experience with Extracorporeal Membrane Oxygenation for Newborn Respiratory Failure

Data from 715 Cases

JOHN M. TOOMASIAN, SANDY M. SNEDECOR, RICHARD G. CORNELL, ROBERT E. CILLEY, AND ROBERT H. BARTLETT

Original ECMO Registry Report 1988

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ELSO CHARTER MEETING

Ann Arbor, Michigan
October 1, 2, 3, 1989

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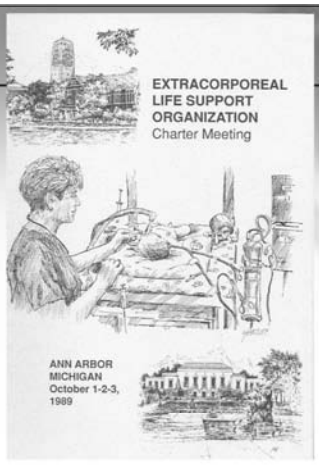

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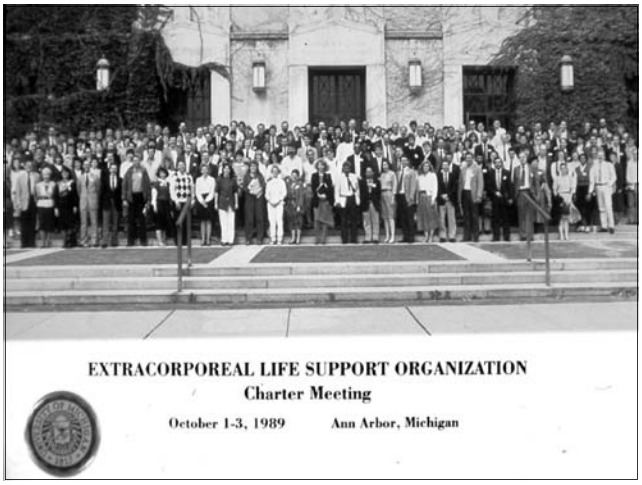
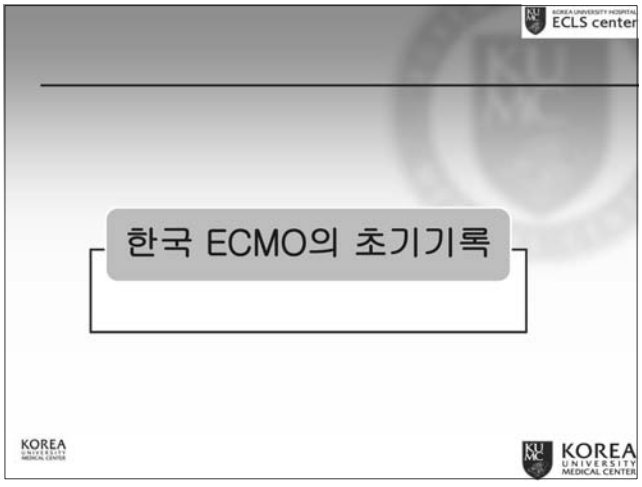
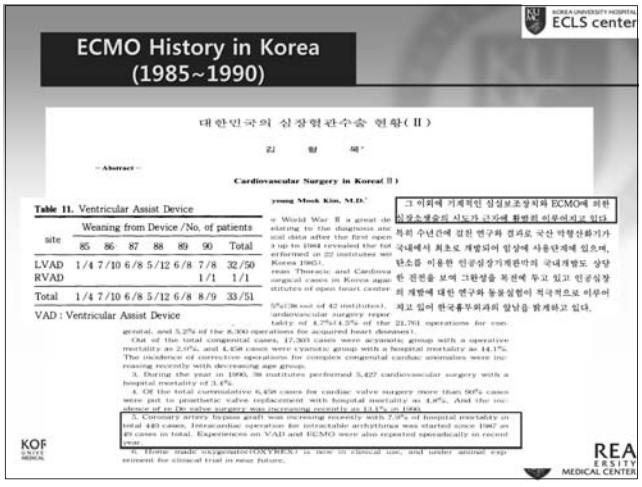
EXTRACORPOREAL LIFE SUPPORT ORGANIZATION
ELSO
Established 1989
KOREA UNIVERSITY MEDICAL CENTER


EXTRACORPOREAL LIFE SUPPORT ORGANIZATION
Charter Meeting
October 1-3, 1989 Ann Arbor, Michigan


ECLS center
한국 ECMO의 초기기록
KOREA UNIVERSITY MEDICAL CENTER


ECLS center
ECMO History in Korea
(1985~1990)
대한민국의 심장혈관수술 현황(Ⅱ)
Cardiovascular Surgery in Korea(Ⅱ)
Table 11. Ventricular Assist Device
VAD : Ventricular Assist Device
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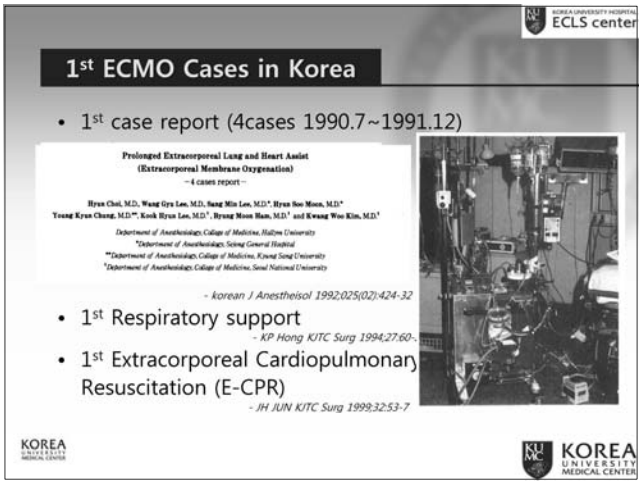
ECLS center
1st ECMO Cases in Korea
• 1st case report (4cases 1990.7~1991.12)
Prolonged Extracorporeal Lung and Heart Assist
(Extracorporeal Membrane Oxygenation)
- korean J Anestheisol 1992;025(02):424-32
• 1st Respiratory support
- KP Hong KJTC Surg 1994;27:60-
• 1st Extracorporeal Cardiopulmonary Resuscitation (E-CPR)
- JH JUN KJTC Surg 1999;32:53-7
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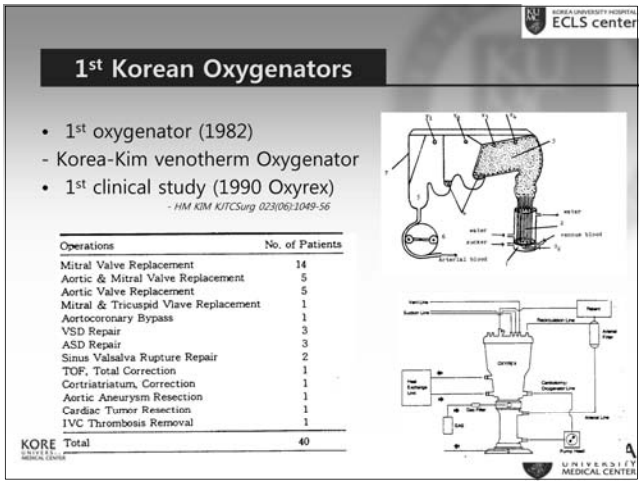
ECLS center
1st Korean Oxygenators
• 1st oxygenator (1982)
- Korea-Kim venotherm Oxygenator
• 1st clinical study (1990 Oxyrex)
- HM KIM KJTCSurg 023(06):1049-56
Operations No. of Patients
Mitral Valve Replacement 14
Aortic & Mitral Valve Replacement 5
Aortic Valve Replacement 5
Mitral & Tricuspid Vlave Replacement 1
Aortocoronary Bypass 1
VSD Repair 3
ASD Repair 3
Sinus Valsalva Rupture Repair 2
TOF, Total Correction 1
Cortriatriatum, Correction 1
Aortic Aneurysm Resection 1
Cardiac Tumor Resection 1
IVC Thrombosis Removal 1
Total 40
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ECLS center

Present

KOREA UNIVERSITY MEDICAL CENTER

Sep. 15~18, 2014 25th Anniversary ELSO, Ann Arbor, MI

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ECLS center

ECLS Registry Report
International Summary
July, 2015

Extracorporeal Life Support Organization
2800 Plymouth Road
Building 300, Room 303
Ann Arbor, MI 48109

Overall Outcomes

	Total Patients	Survived ECLS		Survived to DC or Transfer	
Neonatal					
Respiratory	28,271	23,791	84%	20,978	74%
Cardiac	6,046	3,750	62%	2,497	41%
ECPR	1,188	766	64%	489	41%
Pediatric					
Respiratory	6,929	4,579	66%	3,979	57%
Cardiac	7,668	5,084	66%	3,878	51%
ECPR	2,583	1,432	55%	1,070	41%
Adult					
Respiratory	7,922	5,209	66%	4,576	58%
Cardiac	6,522	3,661	56%	2,708	42%
ECPR	1,985	791	40%	589	30%
Total	69,114	49,063	71%	40,764	59%

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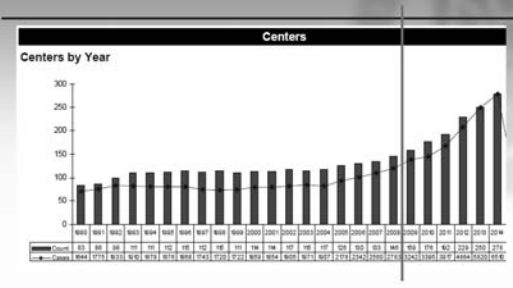

After 2008 → Abruptly increased Adult ECMO cases
- ECMO was effective in cardiac originated arrest
- CESAR trial : ECMO was effective for Severe Lung failure

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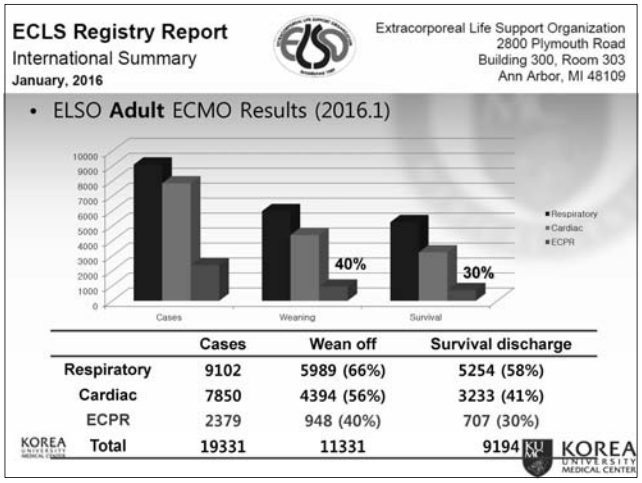
ECLS Registry Report
International Summary
January, 2016
Extracorporeal Life Support Organization
2800 Plymouth Road
Building 300, Room 303
Ann Arbor, MI 48109
• ELSO Adult ECMO Results (2016.1)
40%
30%
Respiratory
Cardiac
ECPR
Cases
Weaning
Survival
Cases Wean off Survival discharge
Respiratory 9102 5989 (66%) 5254 (58%)
Cardiac 7850 4394 (56%) 3233 (41%)
ECPR 2379 948 (40%) 707 (30%)
Total 19331 11331 9194
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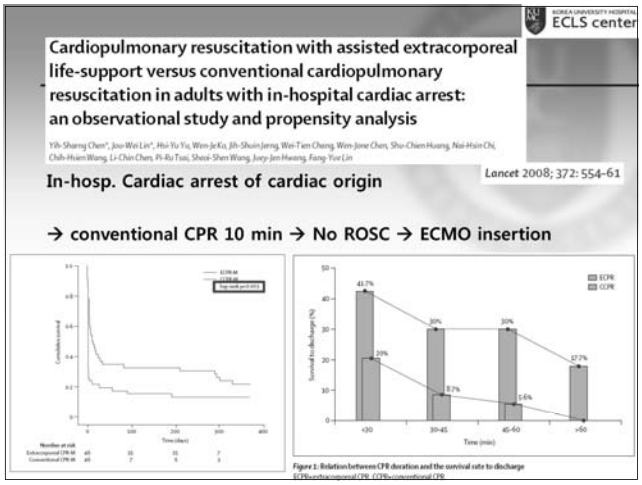
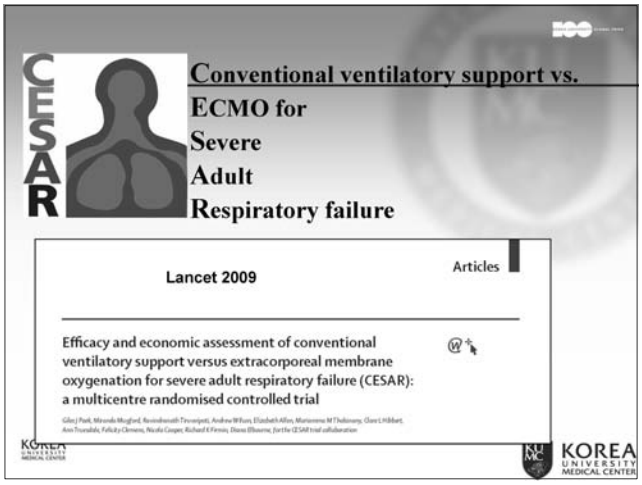

ECLS center
Cardiopulmonary resuscitation with assisted extracorporeal life-support versus conventional cardiopulmonary resuscitation in adults with in-hospital cardiac arrest: an observational study and propensity analysis
Lancet 2008; 372: 554-61
In-hosp. Cardiac arrest of cardiac origin
→ conventional CPR 10 min → No ROSC → ECMO insertion


CESAR
Conventional ventilatory support vs. ECMO for Severe Adult Respiratory failure
Lancet 2009
Articles
Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): a multicentre randomised controlled trial
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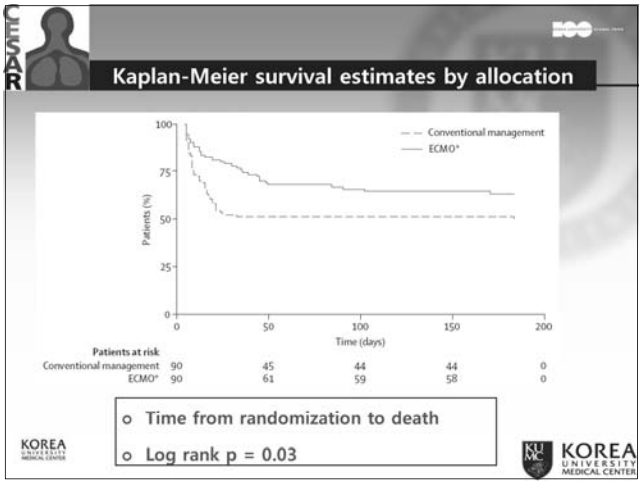
Kaplan-Meier survival estimates by allocation
Conventional management
ECMO*
Patients (%)
Time (days)
Patients at risk
Conventional management 90 45 44 44 0
ECMO* 90 61 59 58 0
Time from randomization to death
Log rank p = 0.03
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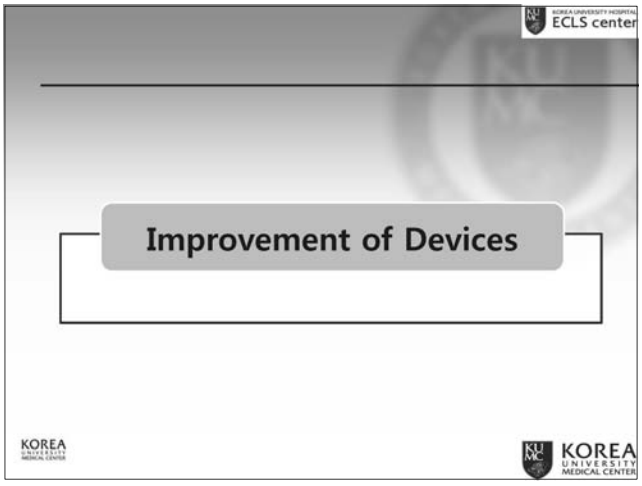
ECLS center
Improvement of Devices
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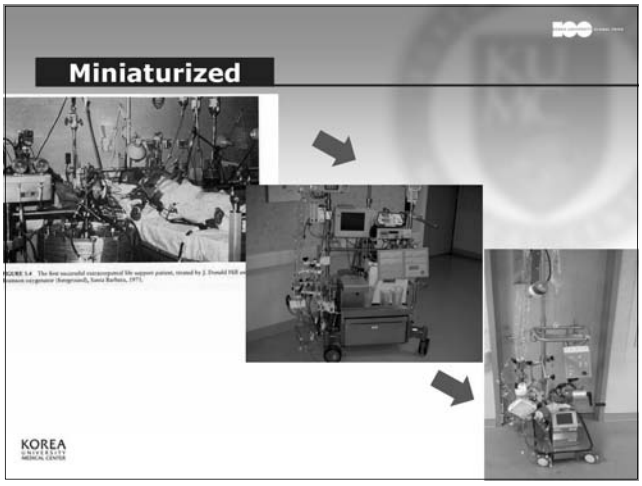
Miniaturized
KOREA UNIVERSITY MEDICAL CENTER


Minituarization
2004
2011
Courtesy by Prof. C. Schmid
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Versatility
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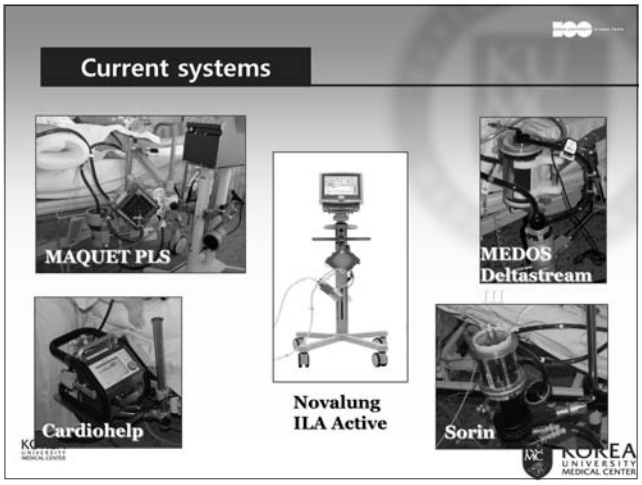
Current systems
MAQUET PLS
Cardiohelp
Novalung
ILA Active
MEDOS
Deltastream
Sorin
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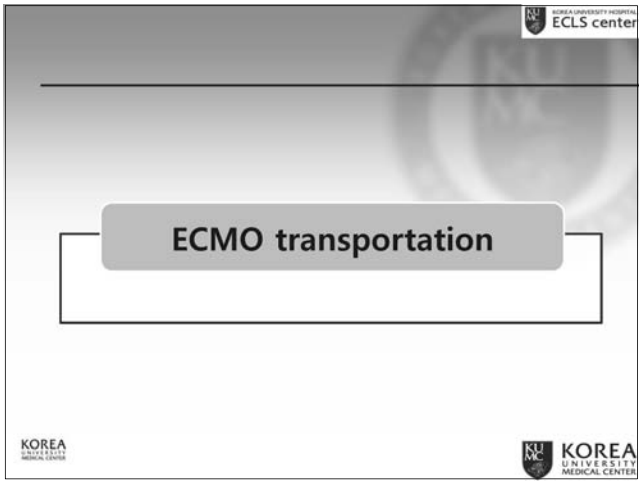
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ECMO transportation
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Transport vehicle
• Hospital helicopter
• Medical air service
• Military equipment
Courtesy by Prof. C. Schmid
KOREA UNIVERSITY MEDICAL CENTER

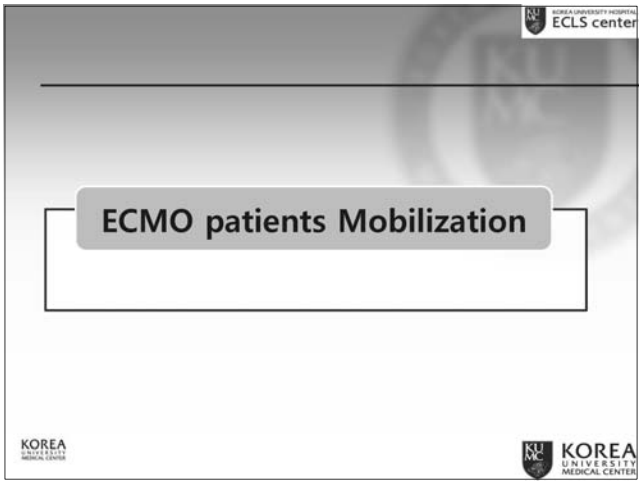

ECMO transport in Norway
Transportation of critically ill patients on extracorporeal membrane oxygenation
K Wagner, GK Sangolt, I Rinnan, HM Karlsen, JE Nilsen, T Strand, LB Stenseth and JL Svennevig
KOREA UNIVERSITY MEDICAL CENTER


ECMO transport in Sweden
Transports on ECMO
KOREA UNIVERSITY MEDICAL CENTER


ECMO transport in Korea
Courtesy by Dr. YH Cho
KOREA UNIVERSITY MEDICAL CENTER


ECMO transport in Germany
D-HDRH
NOTARZT
Team: anesthesiologist + cardiac surgeon + perfusionist
Courtesy by Prof. C. Schmid
KOREA UNIVERSITY MEDICAL CENTER


ECMO Devices for transport
Courtesy by Prof. C. Schmid
KOREA UNIVERSITY MEDICAL CENTER


ECLS center
ECMO patients Mobilization
KOREA UNIVERSITY MEDICAL CENTER


Patient mobilization in Korea
(Samsung Medical Center)
A
B
C
D
ASAIO J. 61(5):564-568, 2015.
KOREA UNIVERSITY MEDICAL CENTER


Patient mobilization in Germanry
(Regensburg Univ. Hosp)
Courtesy by Prof. C. Schmid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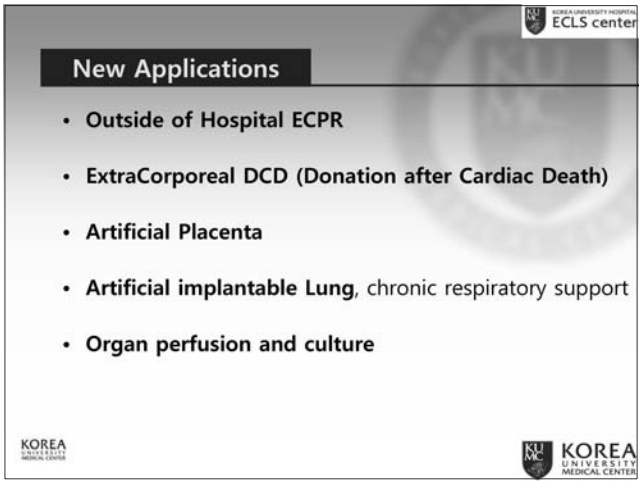
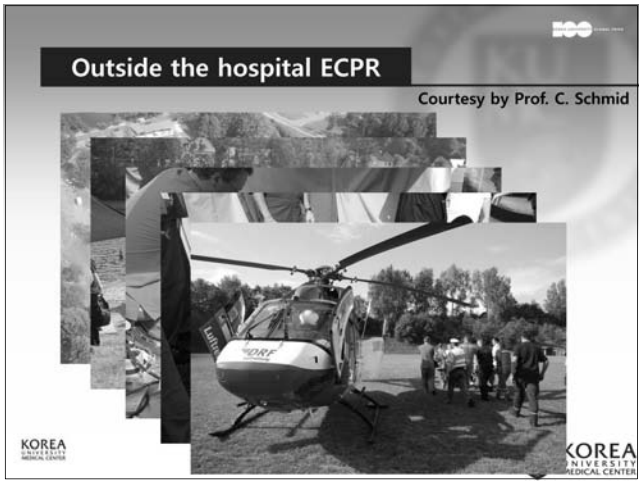
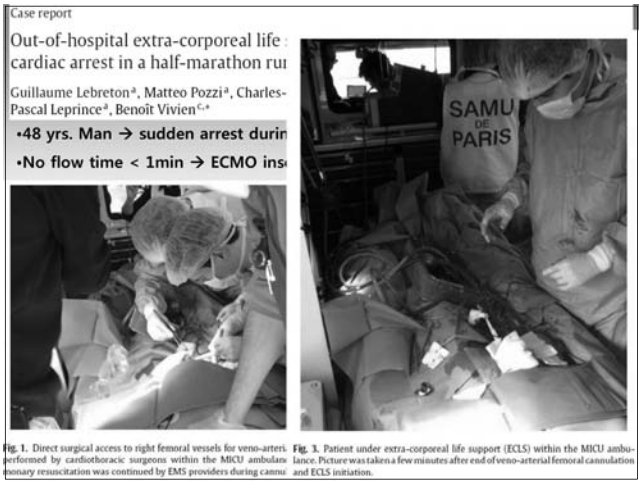
Future


ECLS center
New Applications
• Outside of Hospital ECPR
• ExtraCorporeal DCD (Donation after Cardiac Death)
• Artificial Placenta
• Artificial implantable Lung, chronic respiratory support
• Organ perfusion and culture

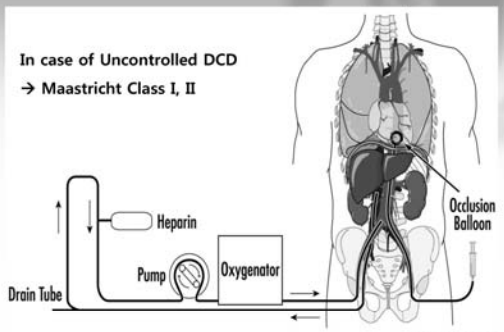

Outside the hospital ECPR
Courtesy by Prof. C. Schmid


UMAC, Paris Marathon, 2010...


Case report
Out-of-hospital extra-corporeal life
cardiac arrest in a half-marathon ru
Guillaume Lebreton[a], Matteo Pozzi[a], Charles-
Pascal Leprince[a], Benoît Vivien[c,*]
•48 yrs. Man → sudden arrest durin
•No flow time < 1min → ECMO ins
SAMU DE PARIS
Fig. 1. Direct surgical access to right femoral vessels for veno-arteri
performed by cardiothoracic surgeons within the MICU ambulan
monary resuscitation was continued by EMS providers during cannu
Fig. 3. Patient under extra-corporeal life support (ECLS) within the MICU ambu-
lance. Picture was taken a few minutes after end of veno-arterial femoral cannulation
and ECLS initiation.

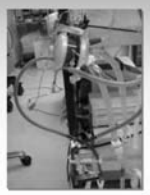
EDCD - Normothermic Perfusion by ECMO

In case of Uncontrolled DCD
→ Maastricht Class I, II



From : S. Pelletier, MD, U of Michigan

Artificial Placenta



- Maintaining fetal circulation, low pO_2, and fetal environment
- No mechanical ventilation
- Simulated breathing with fluid filled lungs
- VV-ECLS with inflow via umbilical vein and outflow via jugular vein

Brian Gray MD and Margie
Premature fetal lamb, artificial placenta 3 days, 3 days post placenta

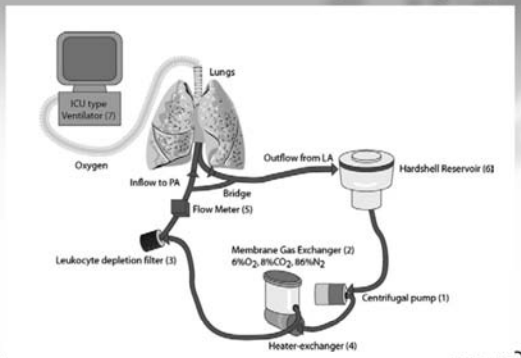
Is it possible in the future?

Artificial lung

- **Oxygenator only**
- Transthoracic a/v lines to PA and LA
- Ambulatory lung assist

Courtesy by Prof. C. Schmid

Ex Situ Perfusion of DCD Organ (Lung)



Ex Situ Perfusion of DCD Organ (Lung)

Ex Situ Perfusion of DCD Organ (Heart)

Functional evalu… …liac death donor
hearts using a co… …usion technique:
Potential for exp… …ation

Satoru Osaki, MD, PhD, M… …hahab A. Akhter, MD, and
Takushi Kohmoto, MD, Ph… g 2014;148:1123-30

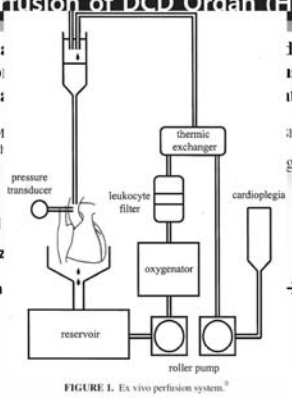


FIGURE 1. Ex vivo perfusion system.[9]

- 10 Discarded
  → coronary dz
- Resuscitation → WIT < 40min

Ex Situ Perfusion of DCD Organ (Heart)

Devices and techniques

Imagine !!!

- **Very Low flow CO2 removal devices**
- **Advanced Cannula → no complication, no anticoagulation**
- **Special Oxygenator** for
  → Bioartificial Liver, Sepsis, CRRT modules
- **Nonthrombogenic surfaces coating techniques for oxygenator**

New Definition of Sepsis

서울대학교 의과대학 흉부외과학교실

이 현 주

대한흉부심장혈관외과학회 제9차 전공의 연수교육

인　　쇄 : 2016년 5월 20일

발　　행 : 2016년 5월 26일

발 행 인 : 박　창　권

발 행 처 : 대한흉부심장혈관외과학회

100-371 서울시 중구 만리재로33길 21
LIG서울역리가 101동 401호
Tel: 02-3482-7869, Fax: 02-3482-7868
E-mail: society@ktcs.or.kr

편집제작 : (주)더 위드인

121-801 서울시 마포구 만리재로 93
(공덕동 108-1) 비퍼스B/D 2F
Tel: 02-6959-5333, Fax: 070-8677-6333
E-mail: with@thewithin.co.kr