Petr Fila

CARDIAC SURGERY

CKTCH | Center of Cardiovascular Surgery & Transplantation

Cardiac surgery history

1896 - heart stab wound suture (Rehn)
1908 - pulmonary embolectomy – unsuccessful (Trendelenburg)
1923 - „close path“ mitral stenosis operation (Cutler,Levine)
1925 - comisurolysis of mitral valve through LA appendage (Souttar)
1938 - open arterial duct ligation (Gross)
1944 - Blalock-Taussig shunt in tetralogy of Fallot
1944 - surgery for coarctation of the aorta – resection (Crafoord)
1953 - atrial septal defetct closure – hypothemia (Lewis)
1953 - EXTRACORPOREAL CIRCULATION – ASD closure (Gibbon)
1955 - surgery for tetralogy of Fallot (Kirklin)
1960 - aortic valve replacement (Harken)
1960 - mitral valve replacement (Starr)
1962 - heart revascularization with vein grafts
1964 - heart revascularization with LITA
1967 - heart transplantation
1967 - artifitial heart (Cooley)

Cardiac surgery in hypothermia

First open heart surgery in hypothermia – ASD closure (Navrátil , Brno 1956)

Surgical approaches in cardiac surgery

Median sternotomy
Ministernotomy (aortic valve, …)

Thoracotomy
- **right side (ASD, Mi, Tri, re-do surgery)**
- **left side (open arterial duct, CoA, ao arch., decs. aorta)**

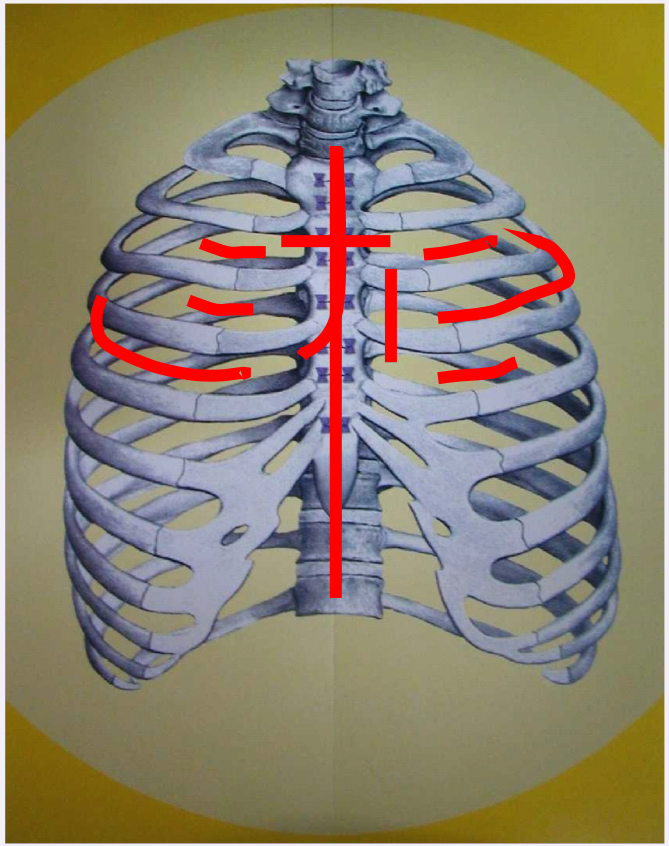
Minithoracotomy
- **left side – ischemic heart disease, open arterial duct)**
- **right side (IHD)**

Transverse sternotomy

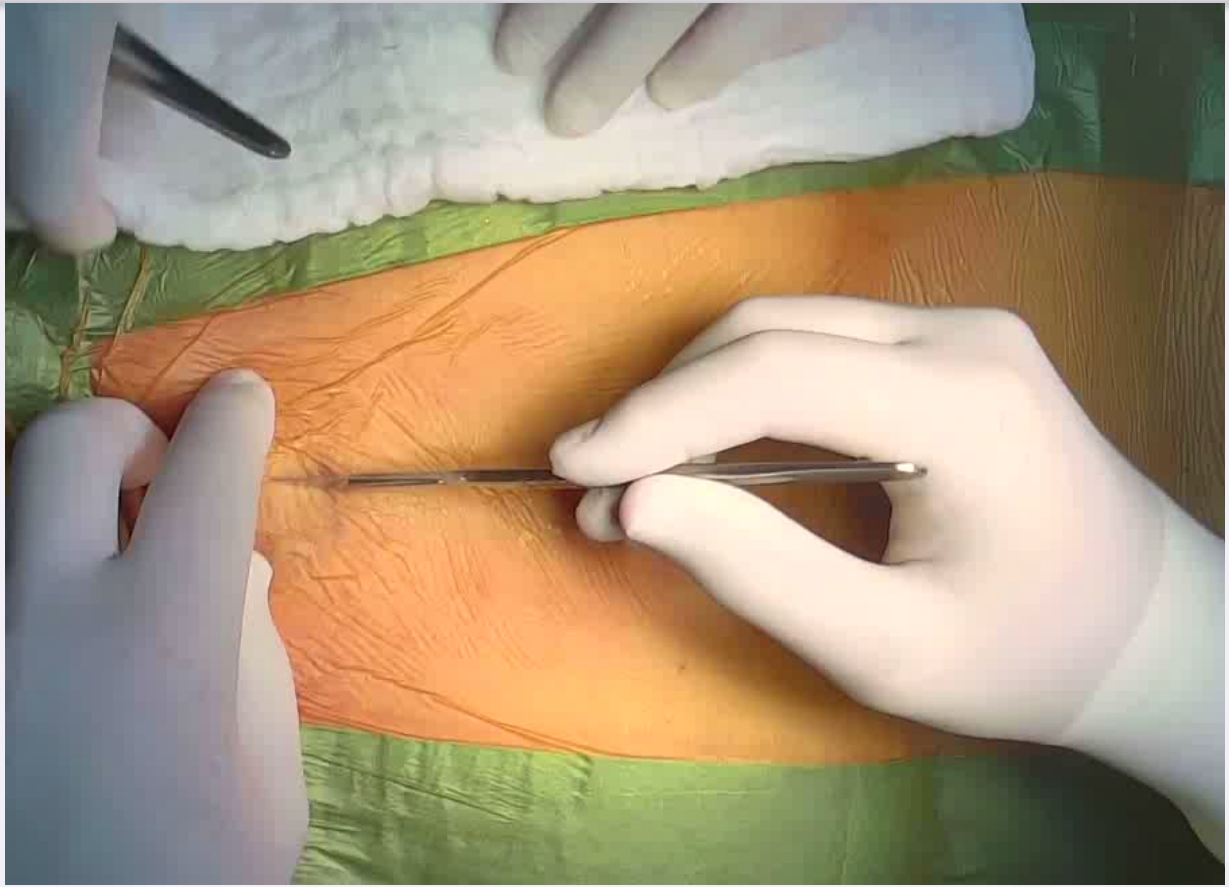
Parasternal incision

Incision in the epigastrium

Endoscopic approach (robotic)



Ministernotomy



Cardiac surgery

- **without cardiopulmonary bypass - beating heart**
  - congenital heart diseases (open arterial duct, CoA)
  - CABG
  - pericarditis
  - heart injury
  - mitral comissurotomy

- **with cardiopulmonary bypass (ECC)**

Extracorporeal circulation

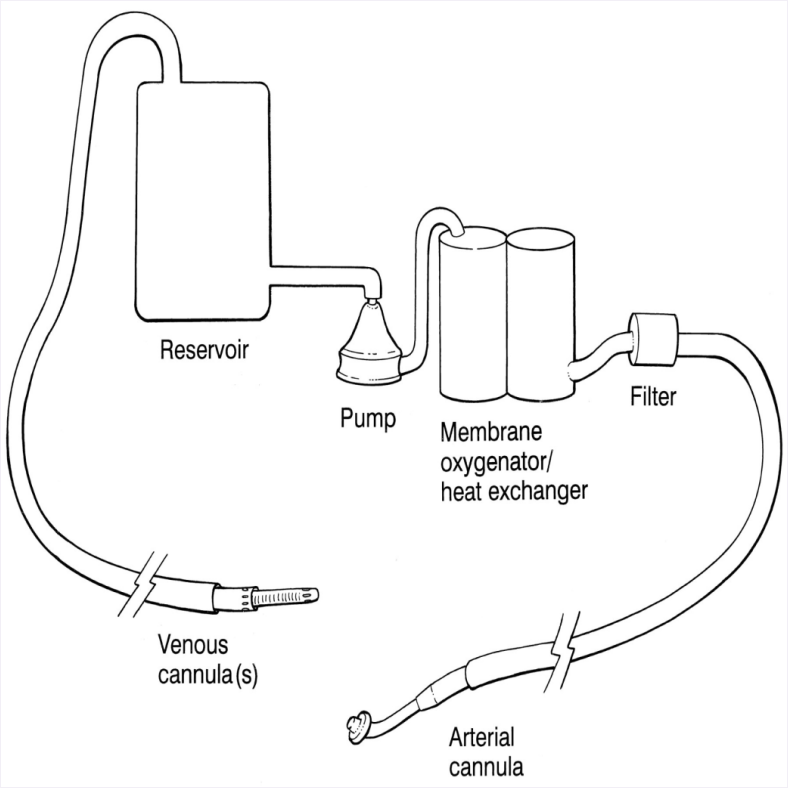
1. **Pump**

2. **Oxygenator**

3. **Heat exchanger**

Principles

- heparinization (2-3 mg/kg)
- hemodilution
- hypothermia
  normothermia

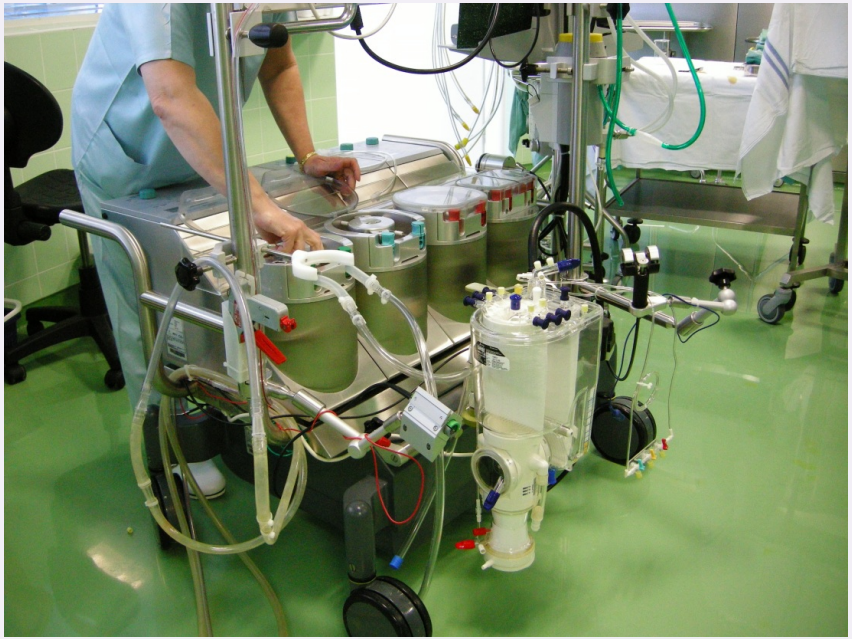


Extracorporeal circulation

First ECC in central Europe

Brno, 1958

Extracorporeal circulation nowadays



Myocardial protection

Ischemic cardiac arrest = myocyt injury

Cardioplegic solution

crystaloid x blood

warm x cold

Types of delivery

antegrade

retrograde

Heart diseases

Congenital

- without shunting
- left to right shunt
- right to left shunt
- others

Acquired

- ischemic heart diseases
- valve diseases
- aortic diseases
- tumors
- others

Surgery for congenital heart diseases - history

1938 - arterial duct ligation (Gross)
1944 - B-T shunt
1944 - coarctation of aorta (Crafoord)
1951 - closure of ASD (Dennis)
1953 - extracorporeal circulation (Gibbon)

1947 – arterial duct ligation (Bedrna)
1949 – B-T shunt, coarctation of aorta (Rapant)
1956 – ASD closure (Navrátil)
1958 – first operation with C-P bypass (Navrátil)
1961 – Tetralogy of Fallot (Navrátil)

Congenital heart diseases

0,6-1% newborns

the most often - VSD, ASD, open arterial duct

Main principles of treatment

- **critical defects - early repair**
- **others – at the preschool-age surgery**

- **radical correction**
- **palliative surgery**

Advance in congenital heart surgery

- fetal ECHO development, noninvasive diagnosis

- reduction of palliative surgery

- radical correction during first step of surgery

- catether intervention techniques development
  (BAS, ASD and VSD closure, PDA closure, coils, stents, dilation)

- post surgery mortality reduction, intensive care

Congenital heart diseases

85% of CHD live to the age of adult

50% - absolutely healthy

25% - time to time obsarvation
(possibility occurrence of residues)

25% - regular observation

if need - reintervention

Congenital heart diseases - types

Congenital
- without shunt
- left to right shunt
- right to left shunt
- others

Acquired
- ischemic heart diseases
- valve diseases
- aortic diseases
- tumors
- others

coarctation of aorta
aortic arch disorders
aortic stenosis
pulmonary stenosis

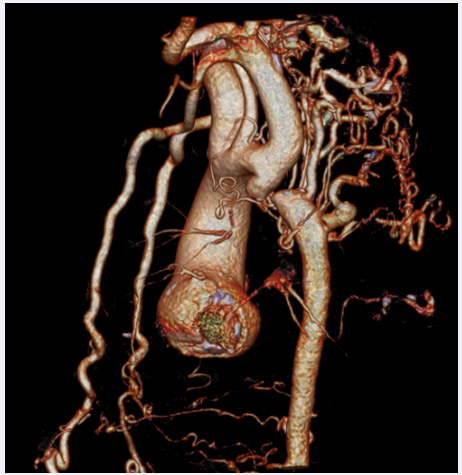
Coarctation of the aorta

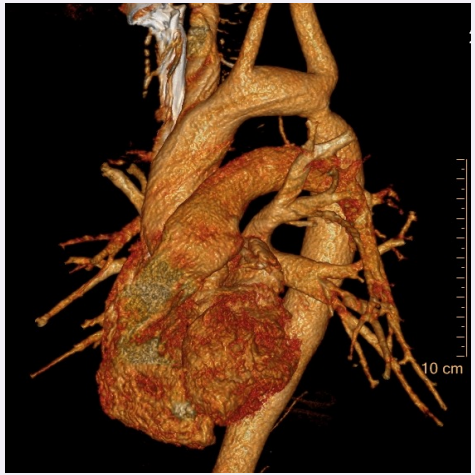
5-8 % of CHD

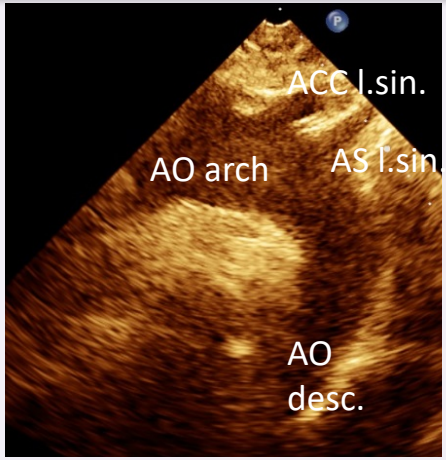
male : female 2-5:1

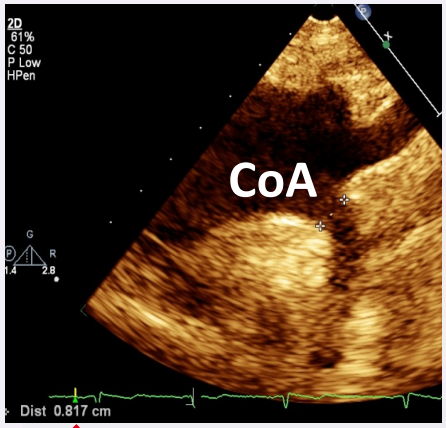
congenital narrowing of thoracic aorta after the origin of subclavian artery

- hypertensin in upper part of body



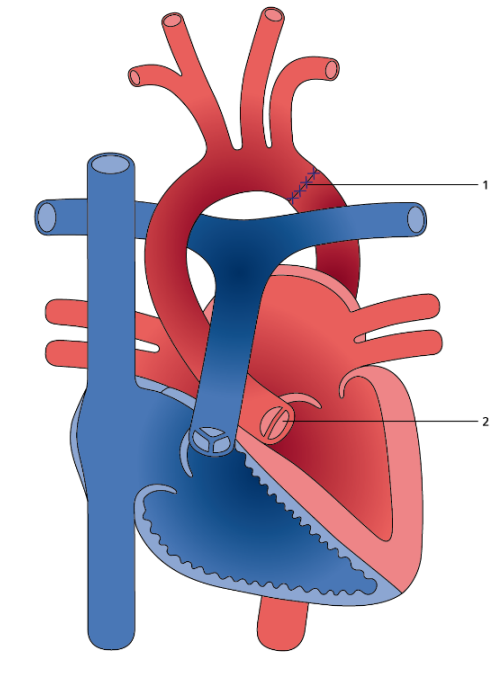




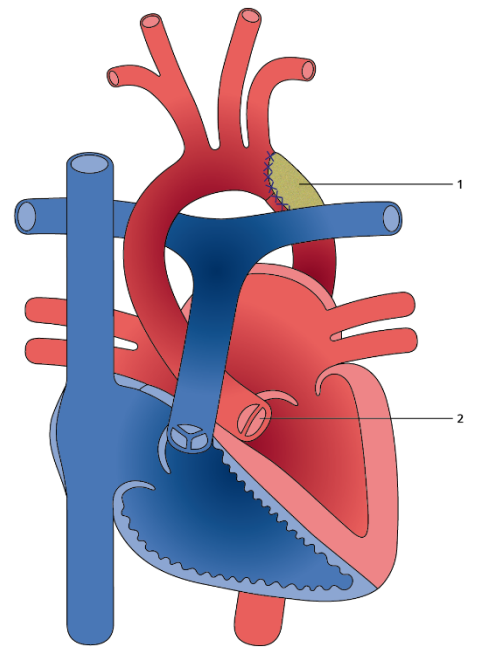


Coarctation of the aorta - surgery

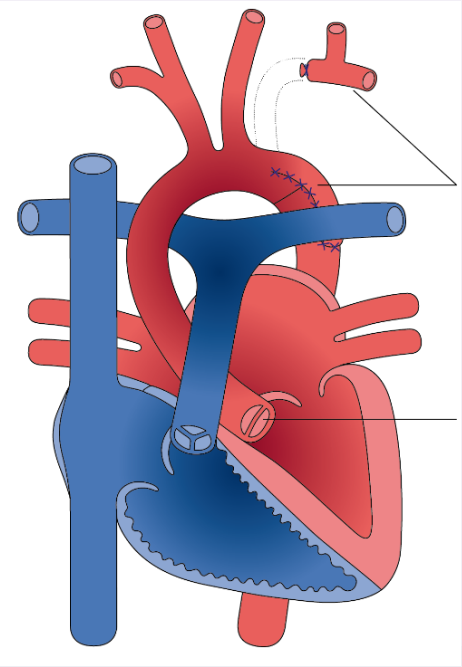
Resection + end to end anastomosis
(1945 C.Crafoord)



Reconstruction with patch - Vossschulte
(1957)

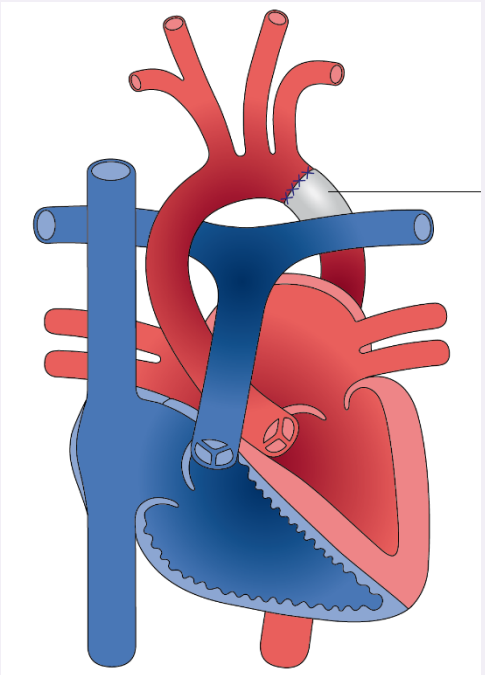


Reconstruction - Waldhausen (1966)

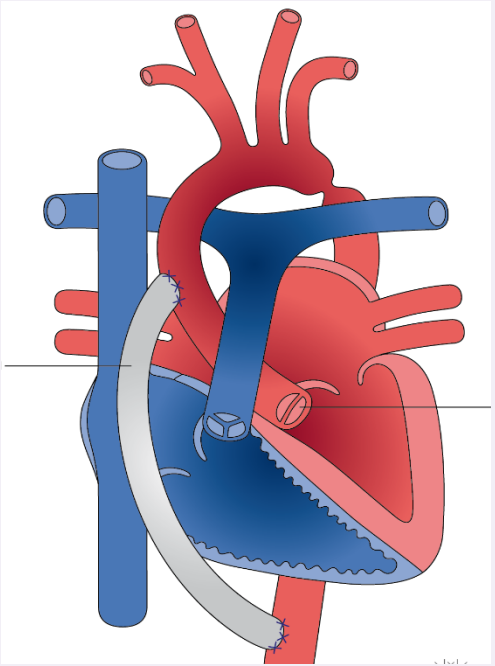


Coarctation of the aorta - surgery

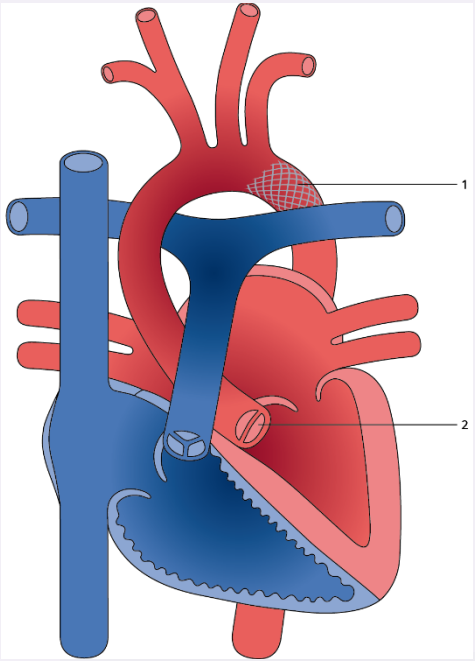
Excision + vascular prosthesis



Extraanatomic bypass

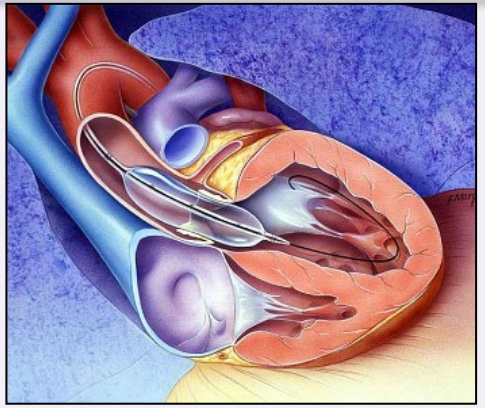


Stent/SG implantation

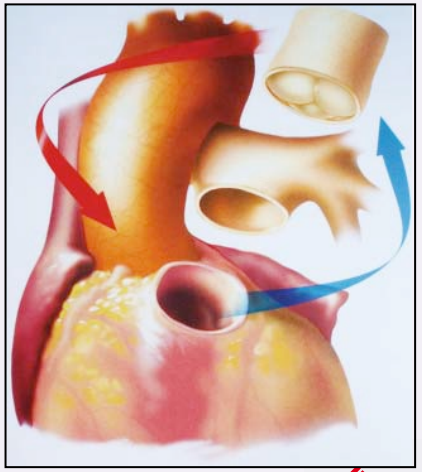


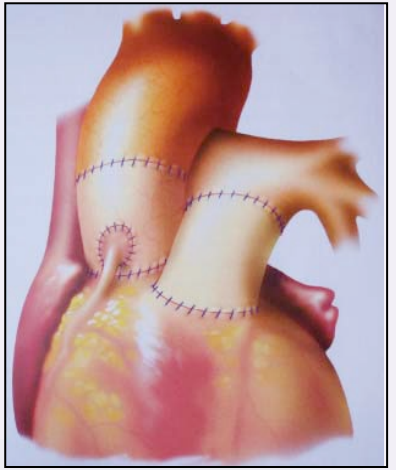
Congenital aortic valve stenosis

- subvalvular, valvular, supravalvular
- palliative treatment
- reduction of surgery
- delaying of aortic valve replacement



Therapy:
- catheter treatment,
- aortic valve sparing surgery
- aortic valve replacement
  mechanical (biological)valve
  Ross procedure





Ross operation – autograft harvesting

Congenital heart dieases

Congenital

- without shunt
- left to right shunt — increased pulmonary blood flow
  - patent ductus arteriosus
  - aortopulmonary window
  - anomalous origin of the LCA from the pulmonary artery
  - ASD
  - VSD
  - AV septal defect
    - incomplete x complete
- right to left shunt
- others

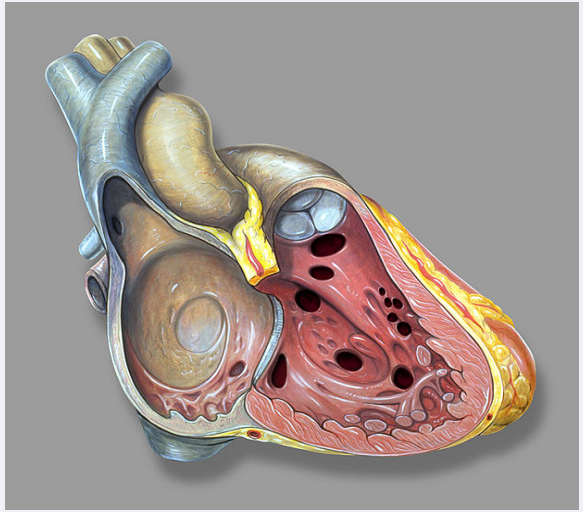
Acquired

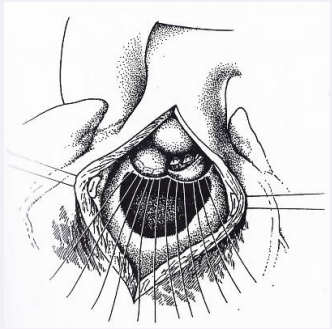
- ischemic heart diseases
- valve diseases
- aortic diseases
- tumors
- others

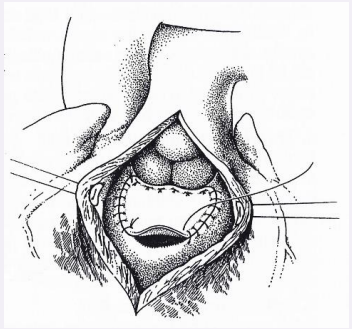
Ventricular septal defect

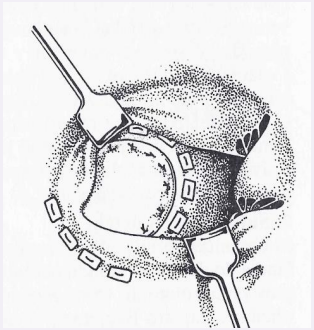
most often CHD
Isolated x with other CHD

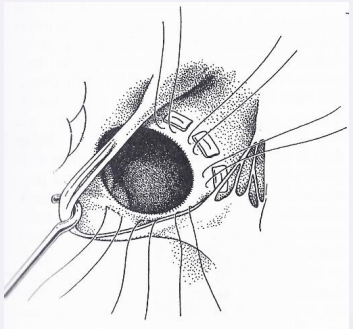
Blood circulation pathophysiology
depends on diameter and PVR

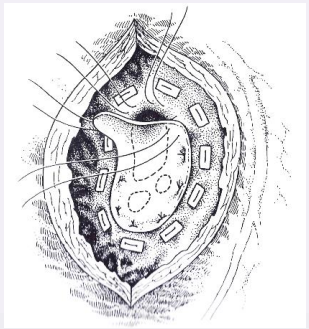












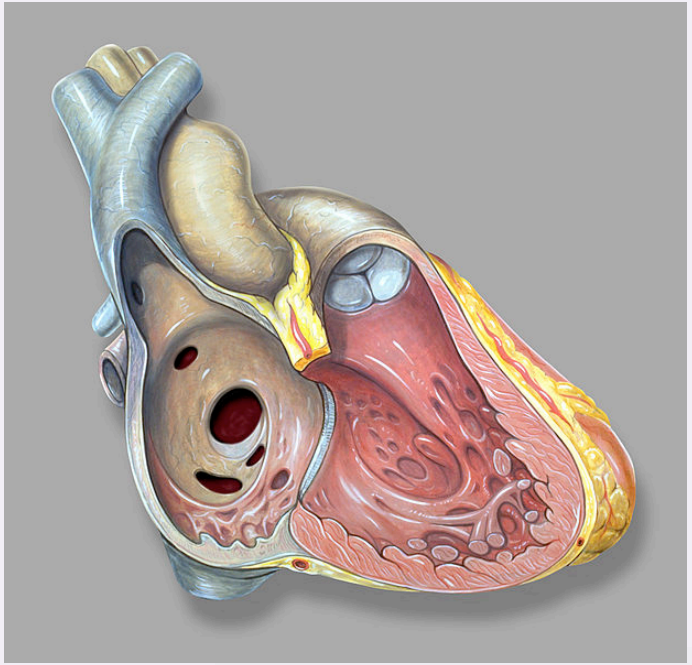
Atrial septal defect

no symptoms x large defect - weariness

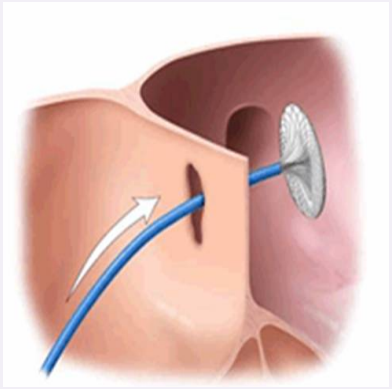
symptoms in adult – enlarging RA, RV, RV failure, arythmia

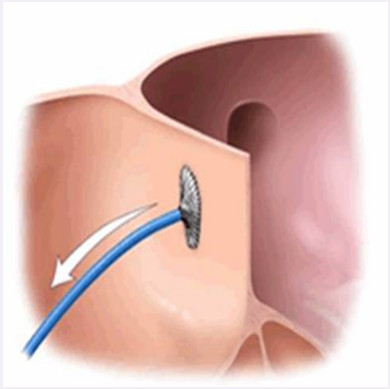
↑ CVP - paradoxical embolism

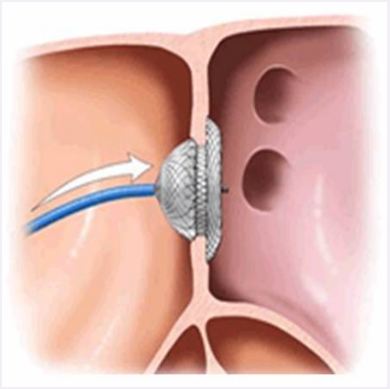
surgery x cathetrization

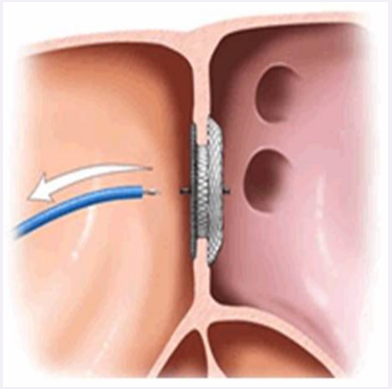


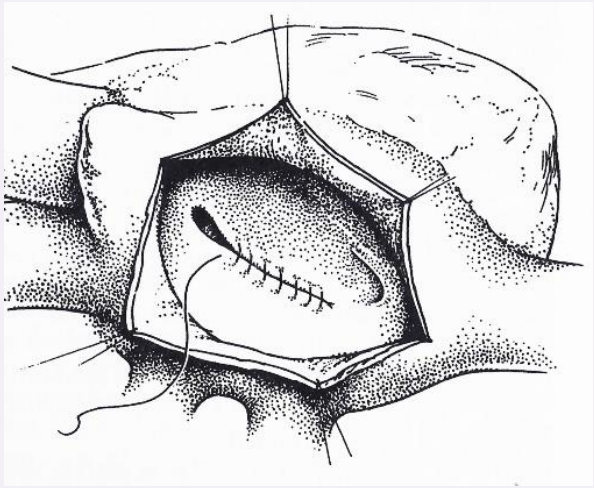
Atrial septal defect - closure

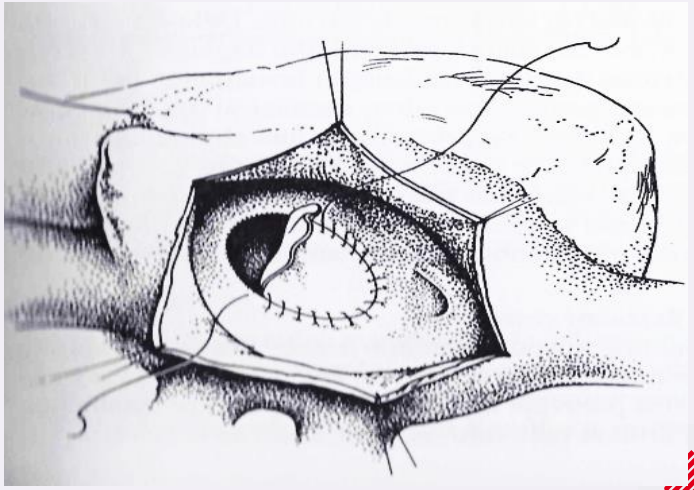








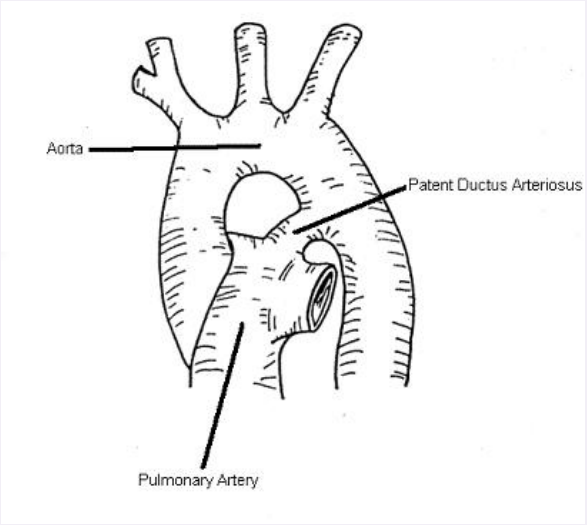


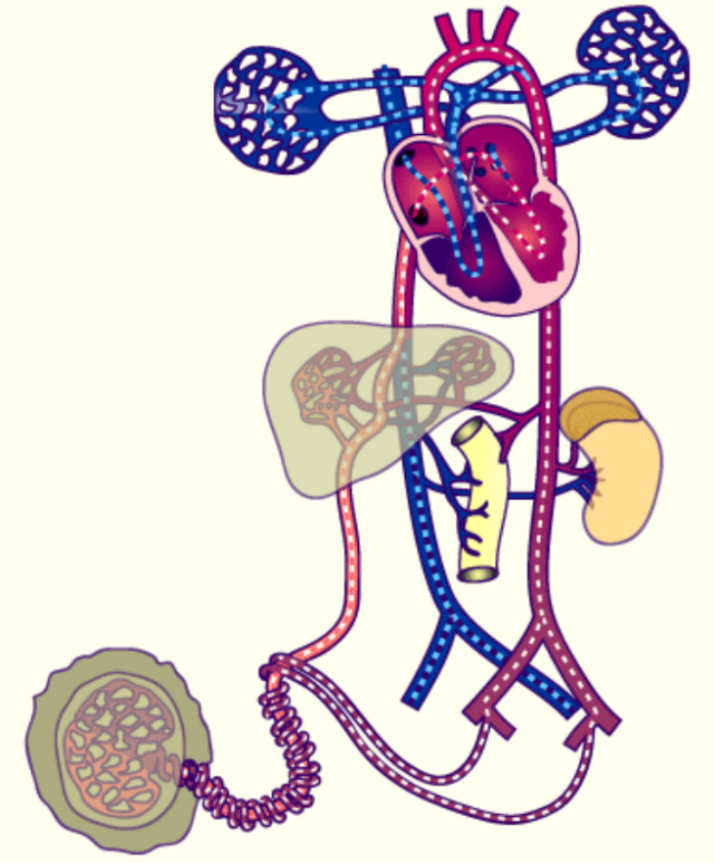


Persistent open arterial duct

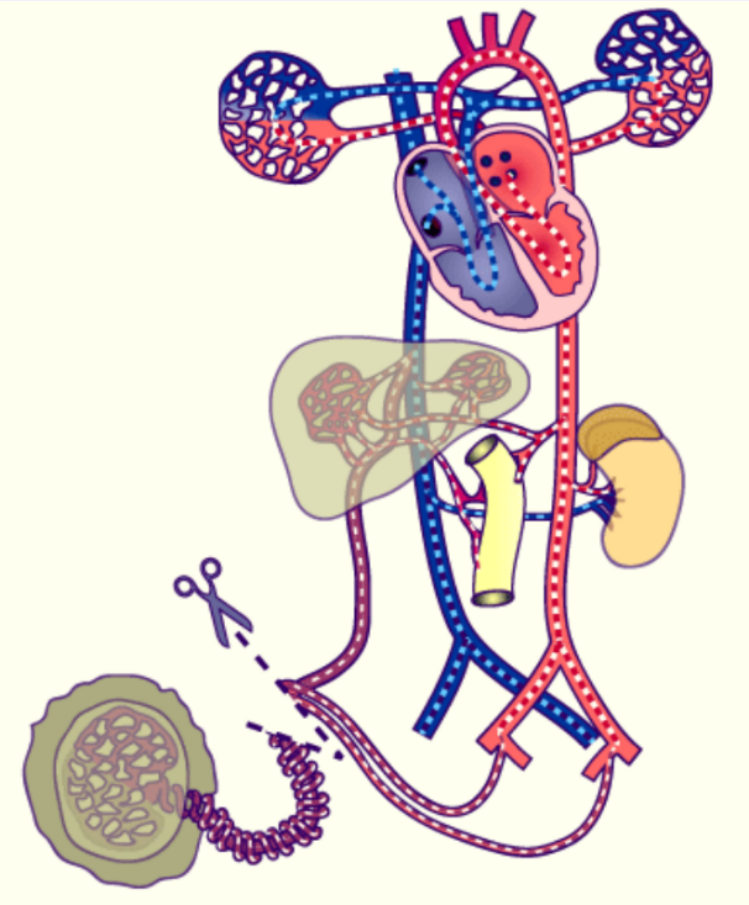
Extracardial connection
– pulmonary and systemic circulation

During fetal circulation
- ↑prostaglandins (E2, E1) → persistent connection



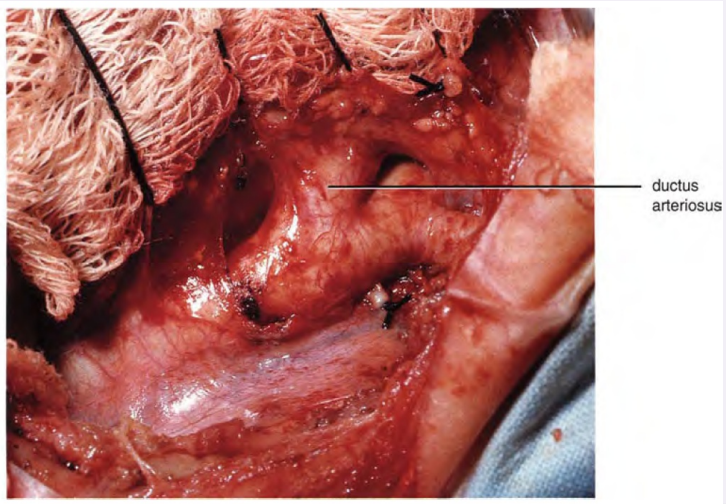


Persistent open arterial duct



After birth ↑pO2 a ↓PG
(placental removal)

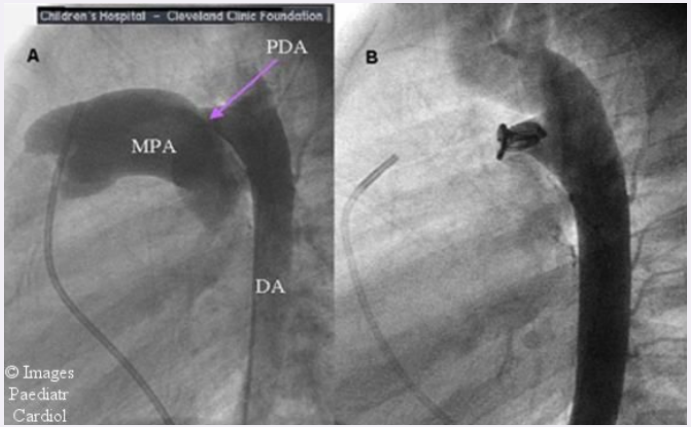
5-10% all congenital heart diseases
In prematurely born 20-30%

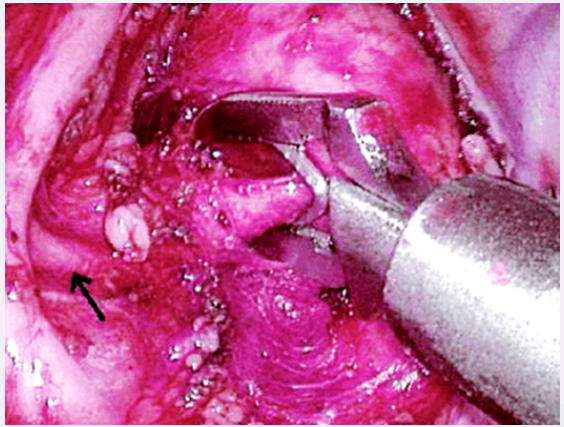


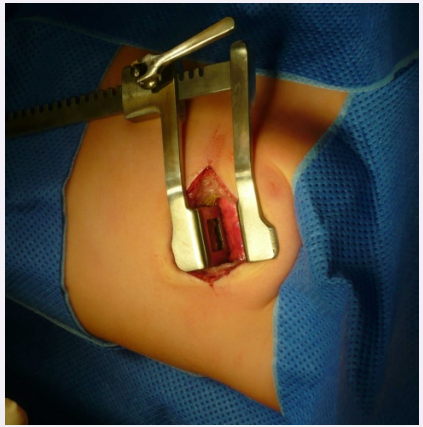
Persistent open arterial duct (persistent ductus arteriosus)

farmacotherapy - ibuprofen - PG inhibitors
cathetrization
surgery - VATS
- „open surgery“ - thoracotomy

Closing is making except for disorders, when PDA is important for survival.
- PG E1 - (pulmonary stenosis, HLHS, TGA)

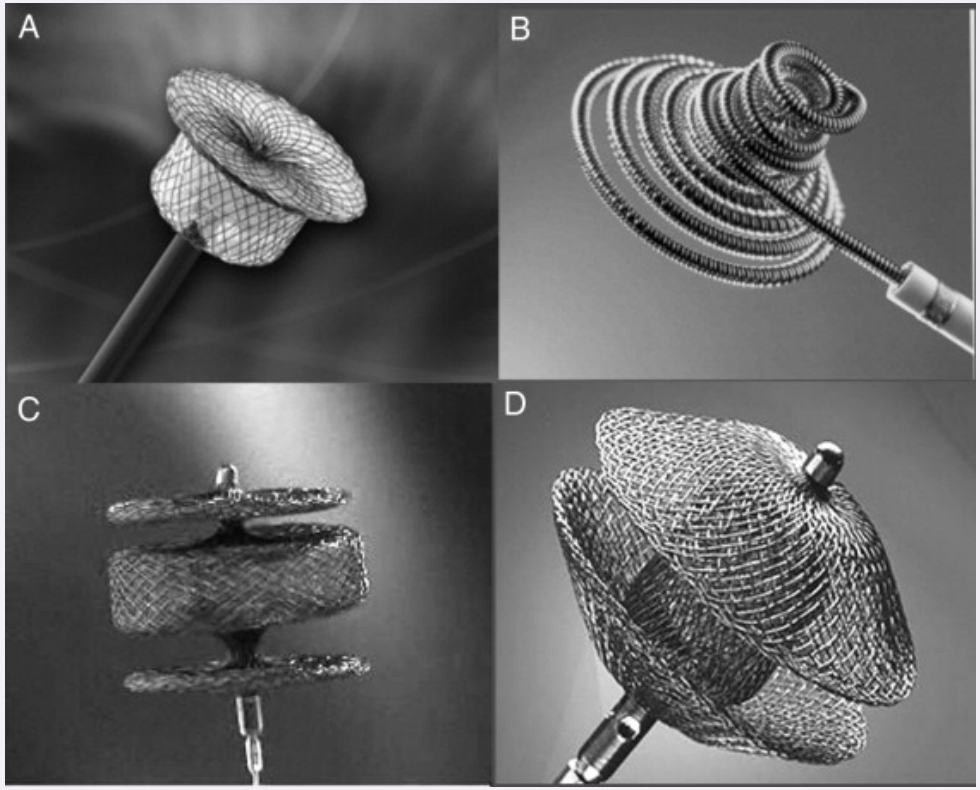


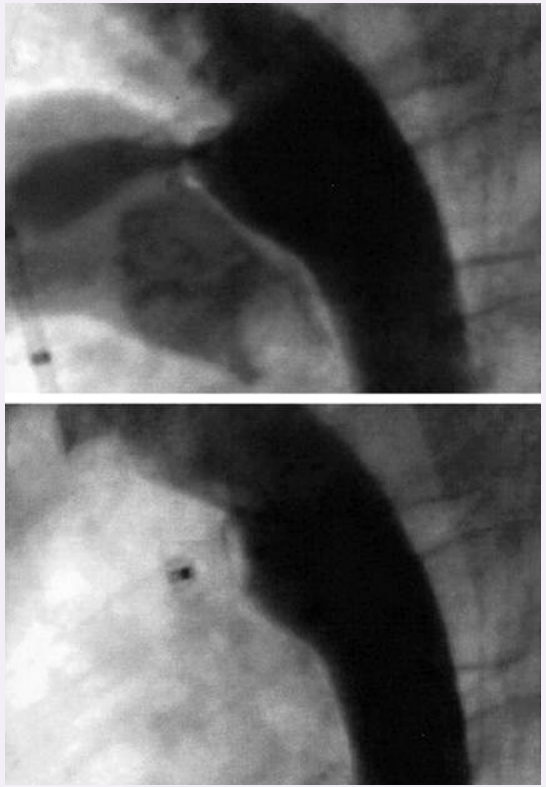




Persistent open arterial duct (persistent ductus arteriosus)

Rashkind, Amplazer, coil





Mehta SK, Younoszai A, Pietz J, Achanti BP. Pharmacological closure of the patent ductus arteriosus.Images Paediatr Cardiol 2003;14:1-15

Congenital heart diseases

Congenital

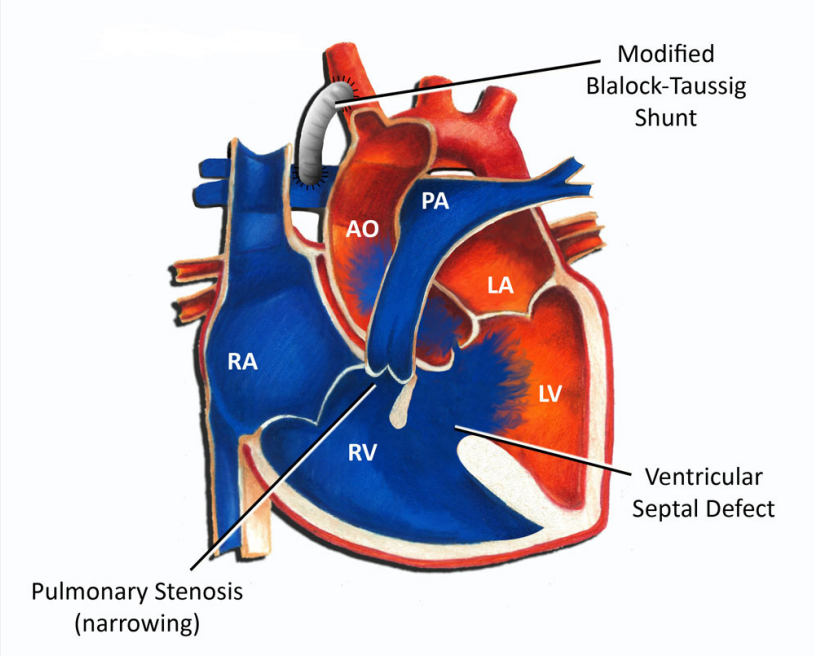
- without shun
- left to right shunt
- **right to left shunt - cyanotic**
  - **tetralogy of Fallotova**
  - **TGA**
  - **VSD with pulmonary atresia**
  - **total anomalous pulmonary venous return**
  - **truncus arteriosus**
- others

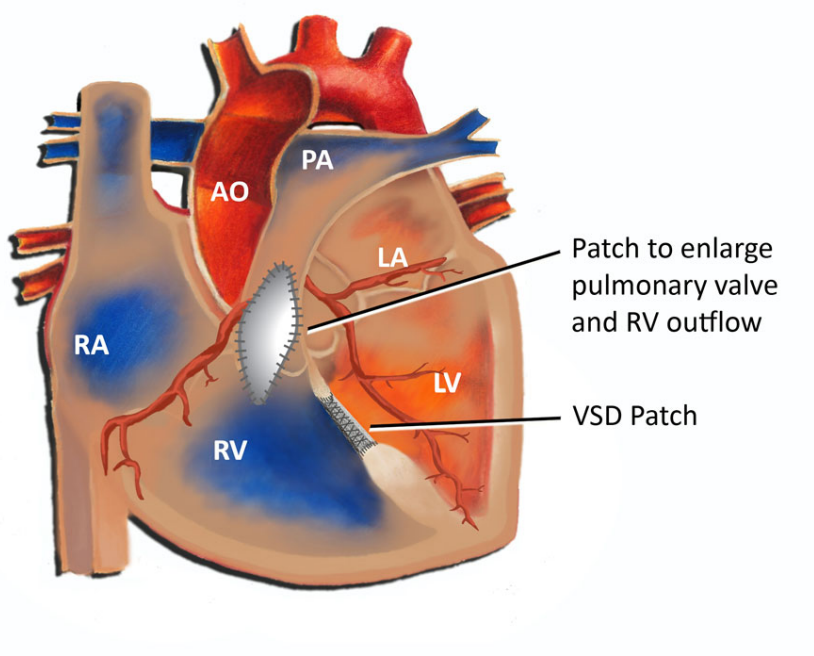
Acquired

- ischemic heart diseases
- valve diseases
- aortic diseases
- tumors
- others

Tetralogy of Fallot

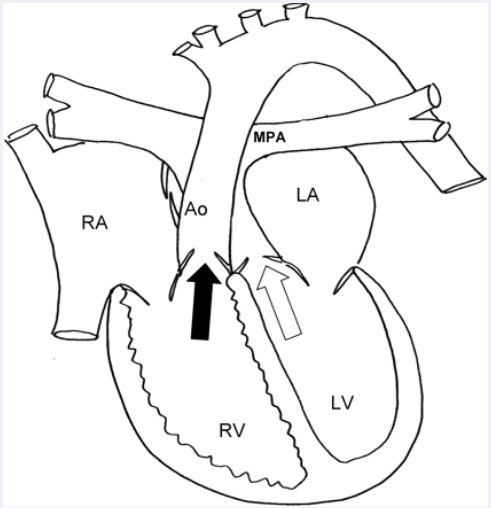
- surgery during first year
- observation
- 20% redo surgery in adult

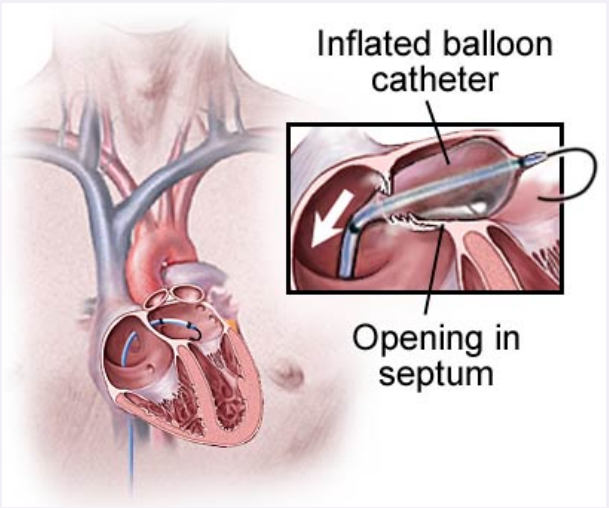




Transposition of great arteries - dTGA

1. **dextro-transposition of the great arteries** (**d-TGA**)
   - also **complete transposition of the great arteries.** The primary arteries (the aorta and the pulmonary artery) are transposed.
   - cyanotic congenital heart defect
   - this condition is described as **ventriculoarterial discordance with atrioventricular concordance**,



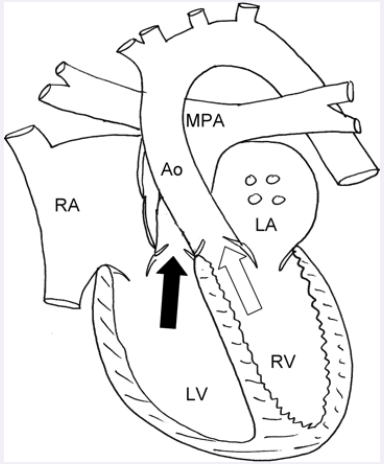


Transposition of great arteries - ccTGA

2. **levo-transposition of the great arteries** (**l-TGA**)
   also congenitally corrected transposition of the great arteries (**cc-TGA**),
   - non-cyanotic congenital heart defect (**CHD**)
   - the aorta and the pulmonary artery are transposed
   - morphological left and right ventricles are also transposed. This condition is described as **atrioventricular discordance** (**ventricular inversion**) **with ventriculoarterial discordance**.

Problem?

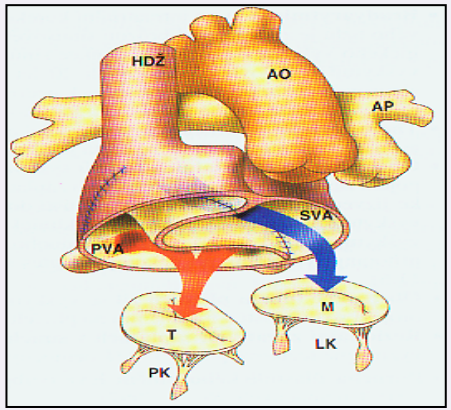
The systemic ventricle is the RV!

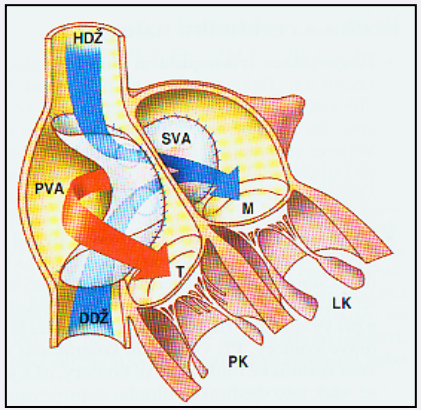


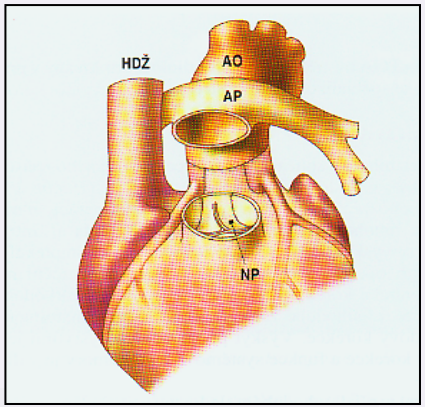
Transposition of great arteries

Follow-up…., redo surgery

- Senning, Mustard
  after 30 years - RV dysfunction, TriR, arrythmia
  → heart transplantation
- switch Jatene
  supravalvular AoS, PS; neo-aortic root dilatation;
  coronary artery stenosis





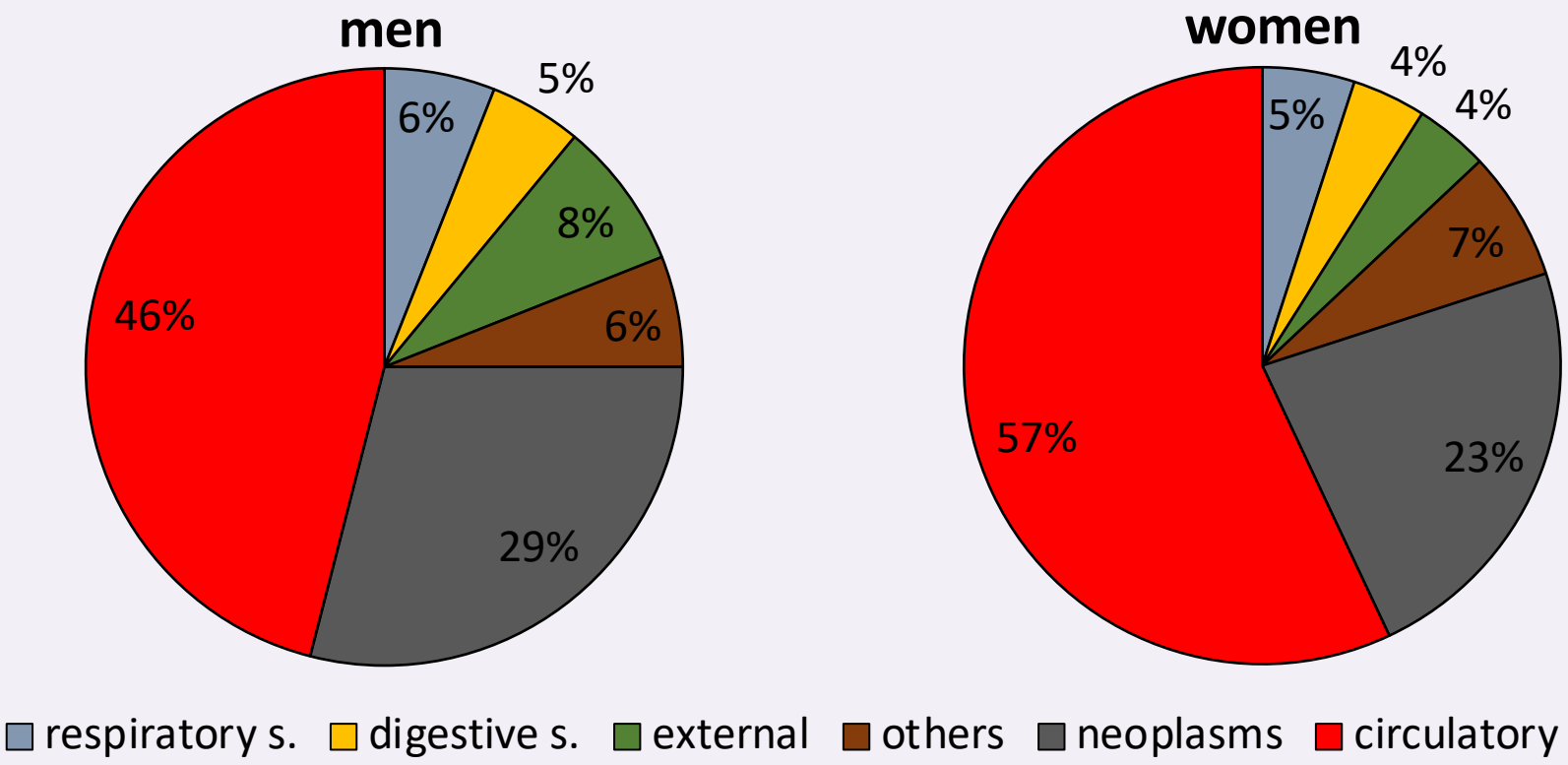


Aquired heart diseases

Congenital
- without shunting
- left to right shunt
- right to left shunt
- others

Acquired
- ischemic heart diseases
- valve diseases
- aortic diseases
- tumors
- others

Ischemic heart disease - cause of death



IHD – risk factors, signs, symptoms

- **hypertension**
- **diabetes**
- **obezity**
- **smoking**
- **hyperlipoproteinemia**
- **…**

- no symptoms
- angina pectoris
- myocardial infarction
- heart failure, sudden death

IHD - treatment

PREVENTION!!!

- drugs

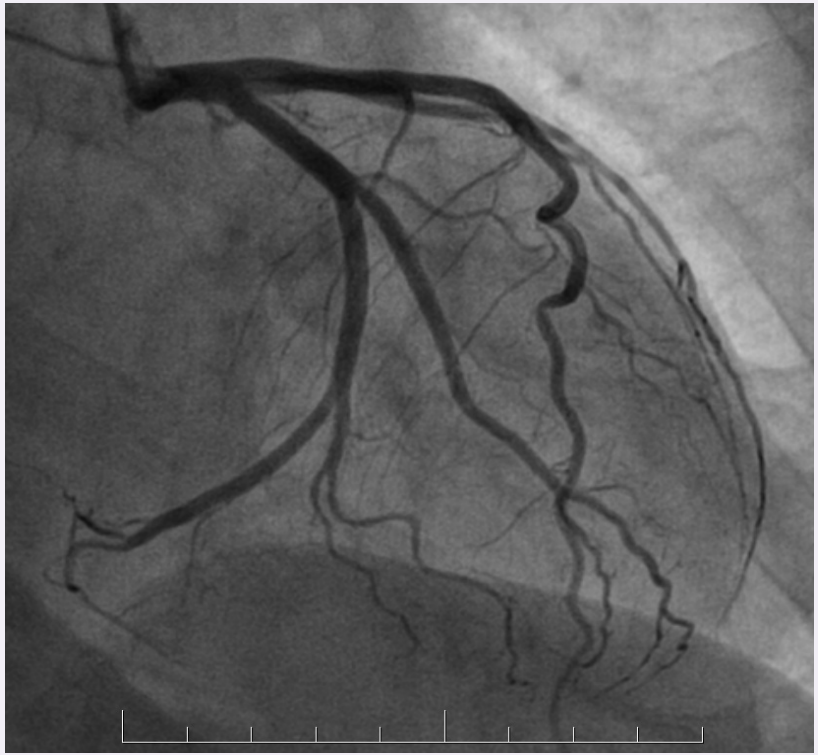
- percutaneous coronary intervention

- surgical revascularization

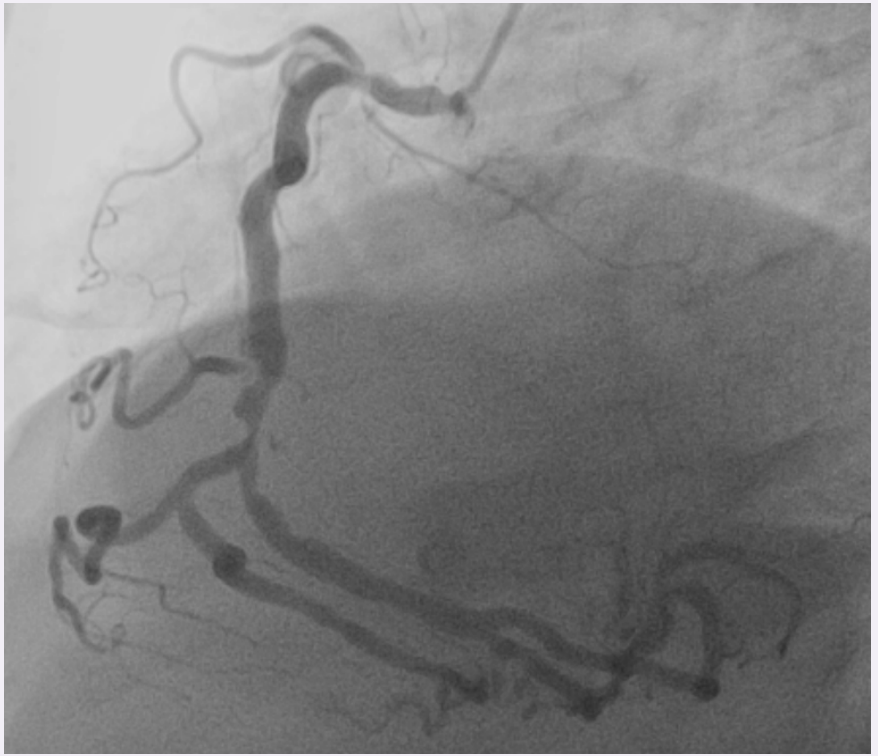
- combination

- heart transplantation

Coronary arteries



Coronarogram – ischemic heart disease



IHD – indication for surgical treatment

Clinical

- stable angina pectoris
- instable angina
- MI without possibility of intervention
- postinfarction angina

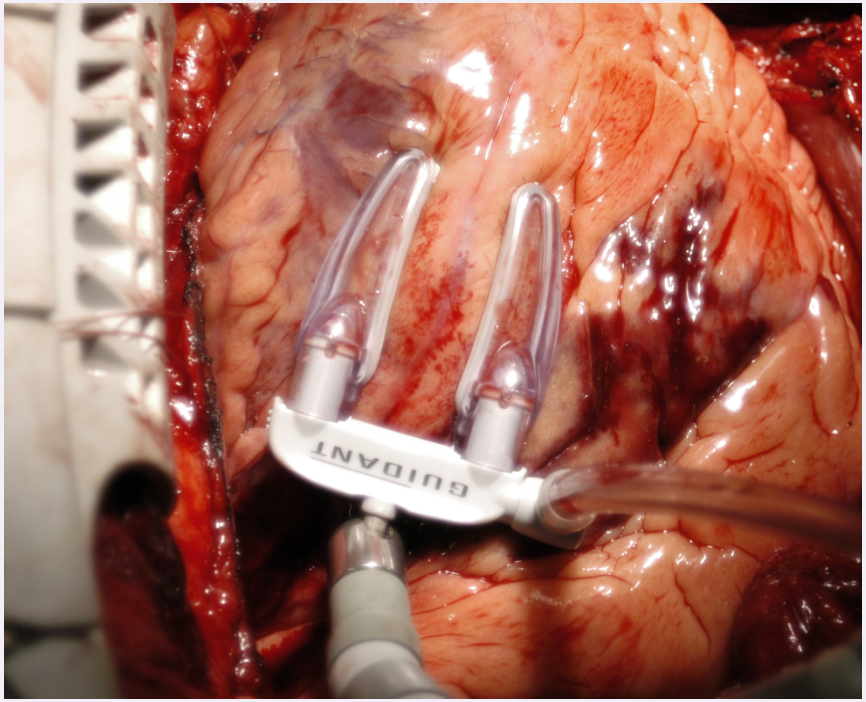
Anatomical

- number of arteries with stenosis (left main coronary artery, one, two, three arteries…)
- grade and localization of coronary artery stenosis
- possibility of surgical treatment (diffuse coronary artery disease, artery diameter, myocardial viability)

IHD – surgical treatment options

without C-P bypass – „off-pump“

with C-P bypass



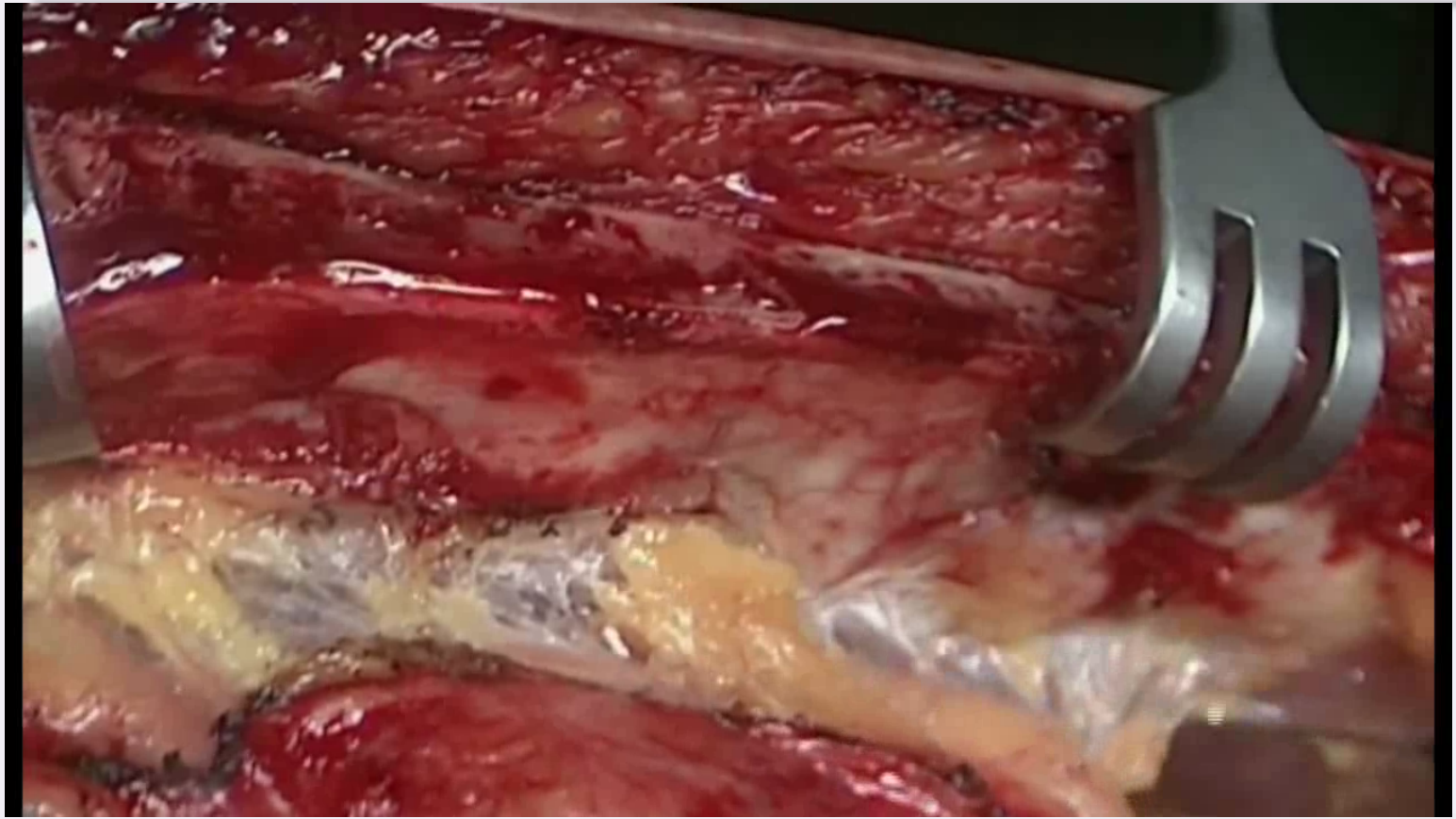
sternotomy
minithoracotomy
endoscopic
robotic

Choice of conduits for coronary artery bypass

Arterial

- LITA (a. thoracica int. l. sin) – 10 years patency 90-95%
- RITA

LIMA harvesting

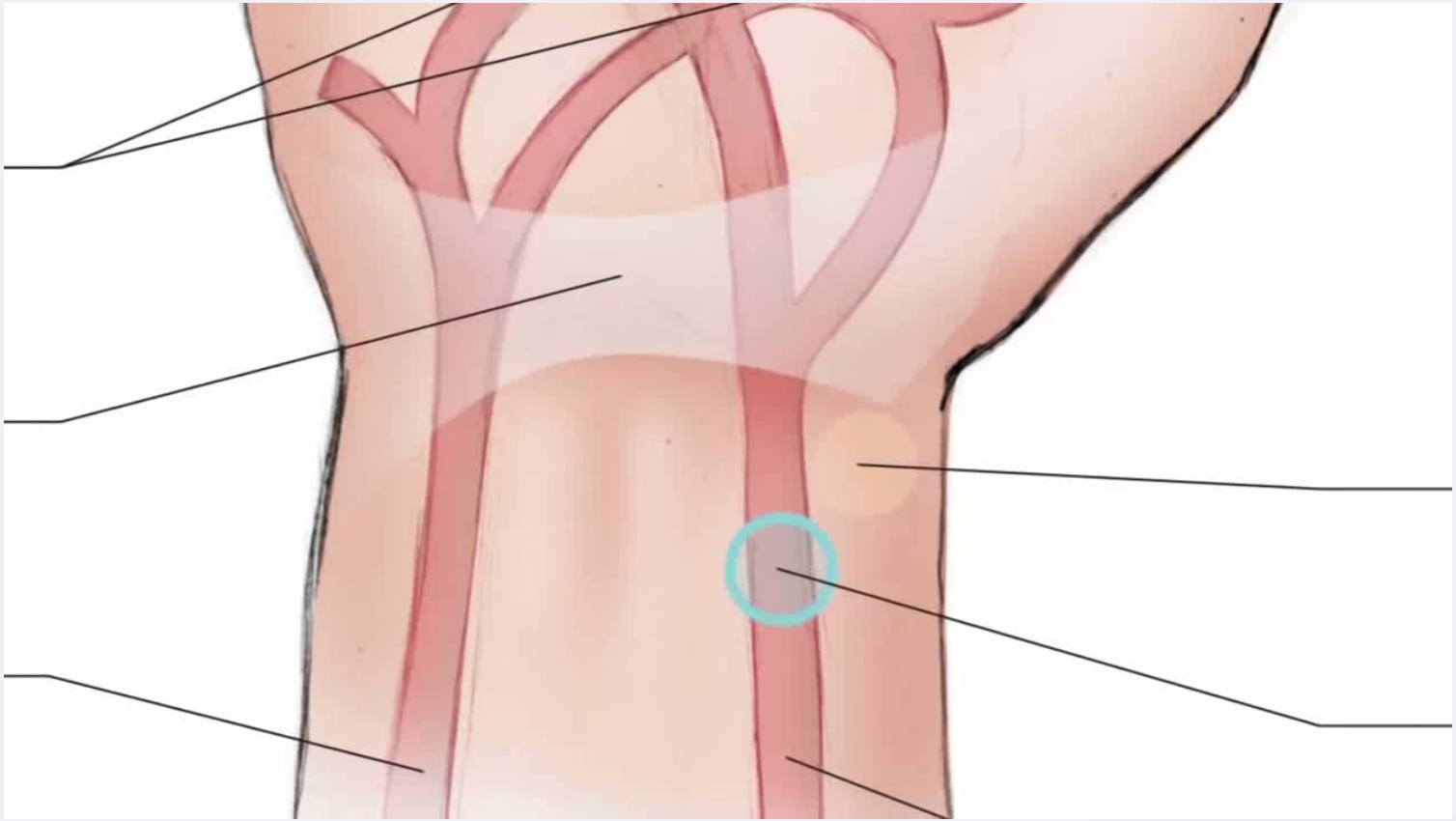


Choice of conduits for coronary artery bypass

Arterial

- LITA (a. thoracica int. l. sin) – 10 years patency 90-95%
- RITA
- radial artery

Radial artery – Allen´s test



Choice of conduits for coronary artery bypass

Arterial

- LITA (a. thoracica int. l. sin) – 10 years patency 90-95%
- RITA
- radial artery
- a. gastroepiploica dx., a. epigastrica inf.

Choice of conduits for coronary artery bypass

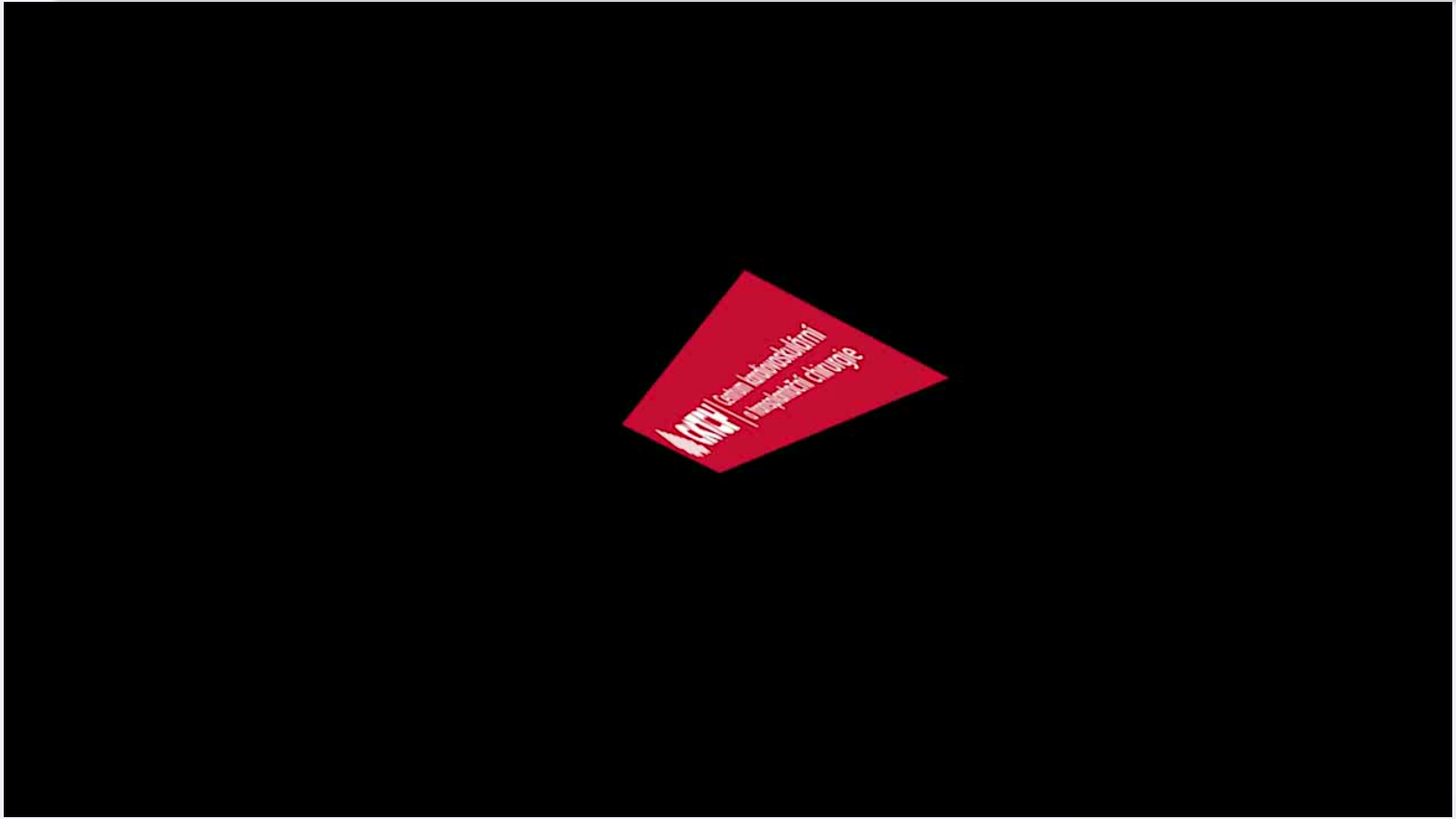
Arterial

- LITA (a. thoracica int. l. sin) – 10 years patency 90-95%
- RITA
- radial artery
- a. gastroepiploica dx., a. epigastrica inf.

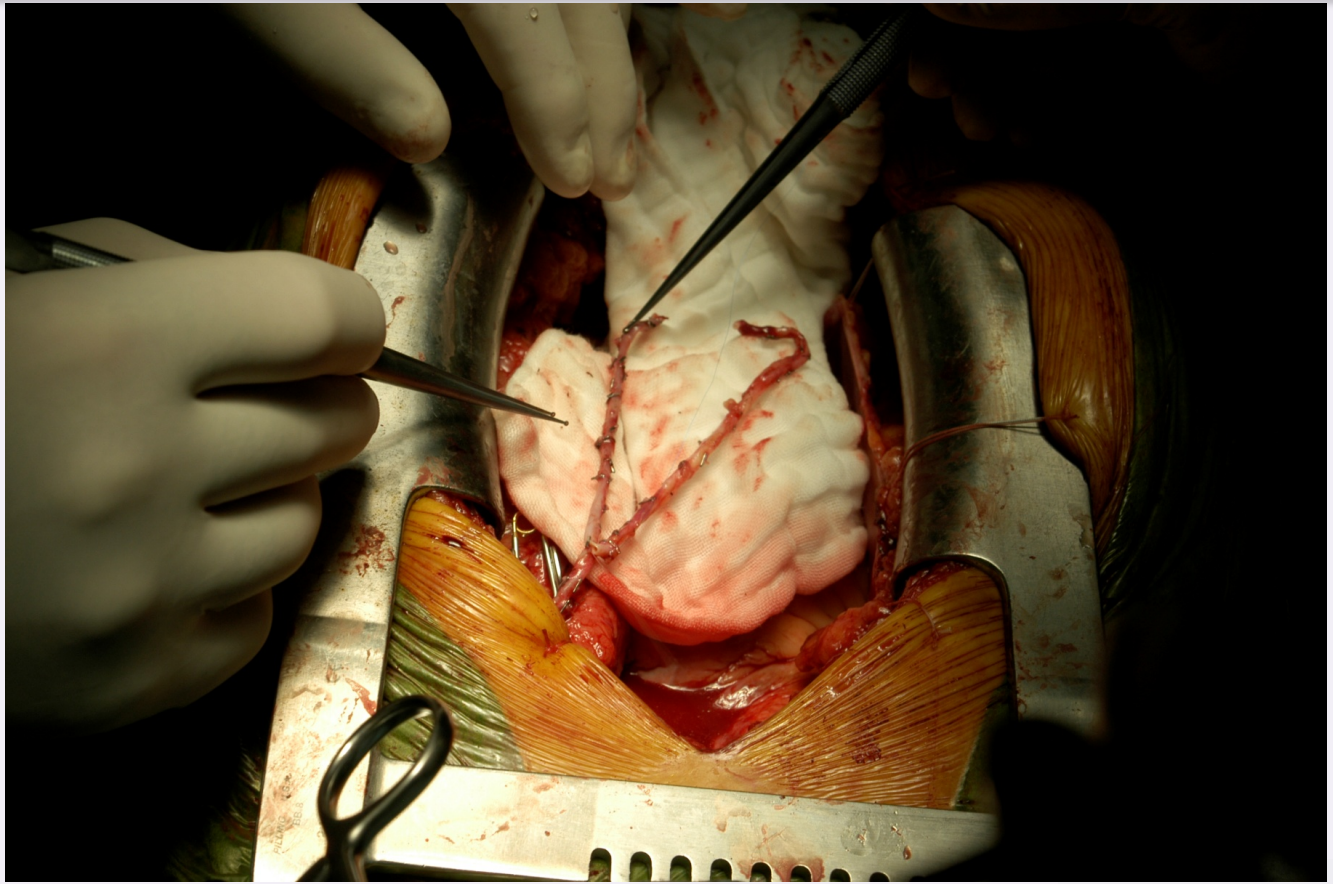
Venous

- great saphenous vein – 10 years patency 50-60%
- short saphenous vein
- brachial or cephalic veins from upper arms

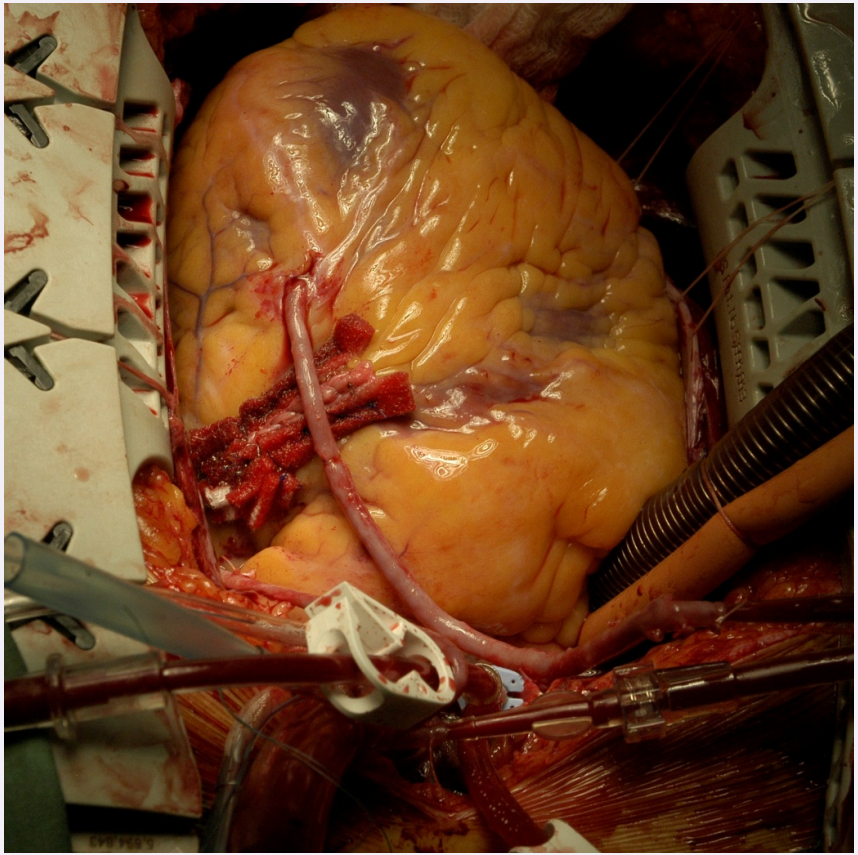
Endoscopic vein harvesting

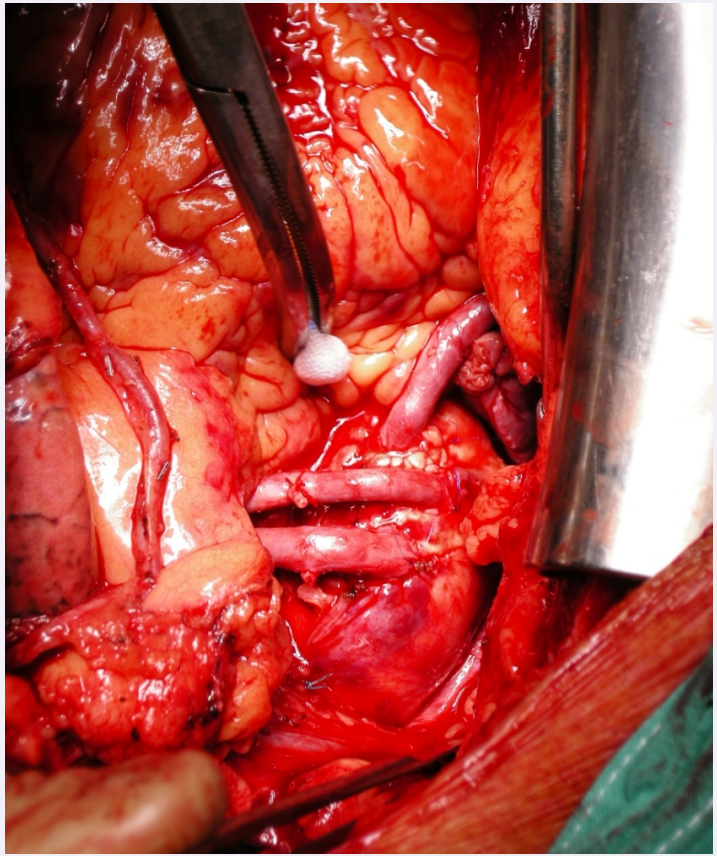


Choice of conduits for coronary artery bypass



Choice of conduits for coronary artery bypass



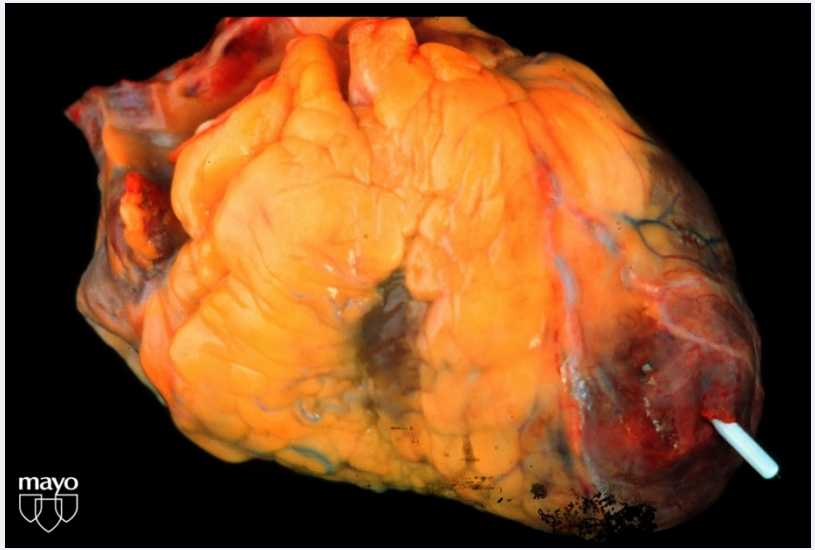


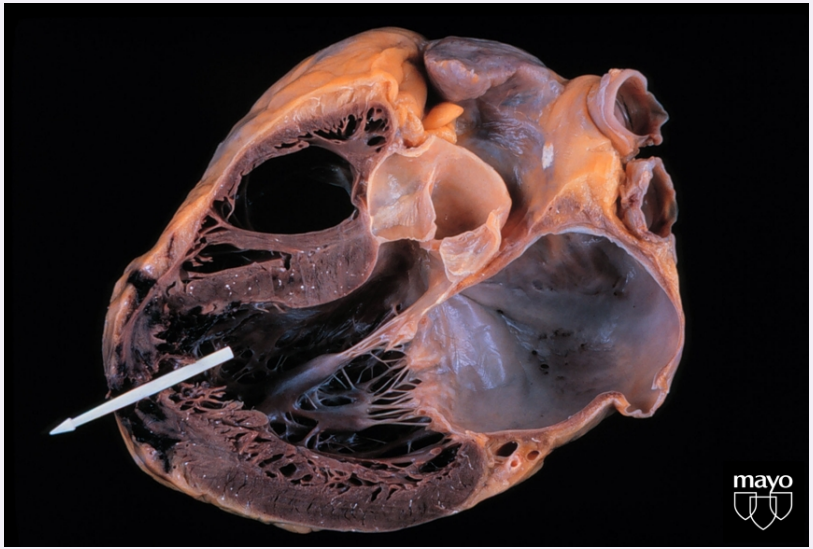
Mechanical complications of acute MI

free wall rupture

VSD

mitral regurgitation



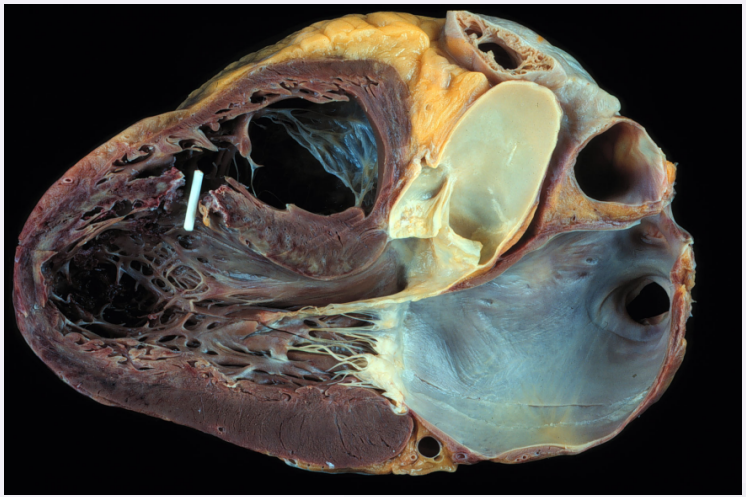


Mechanical complications of acute MI

free wall rupture

VSD

mitral regurgitation

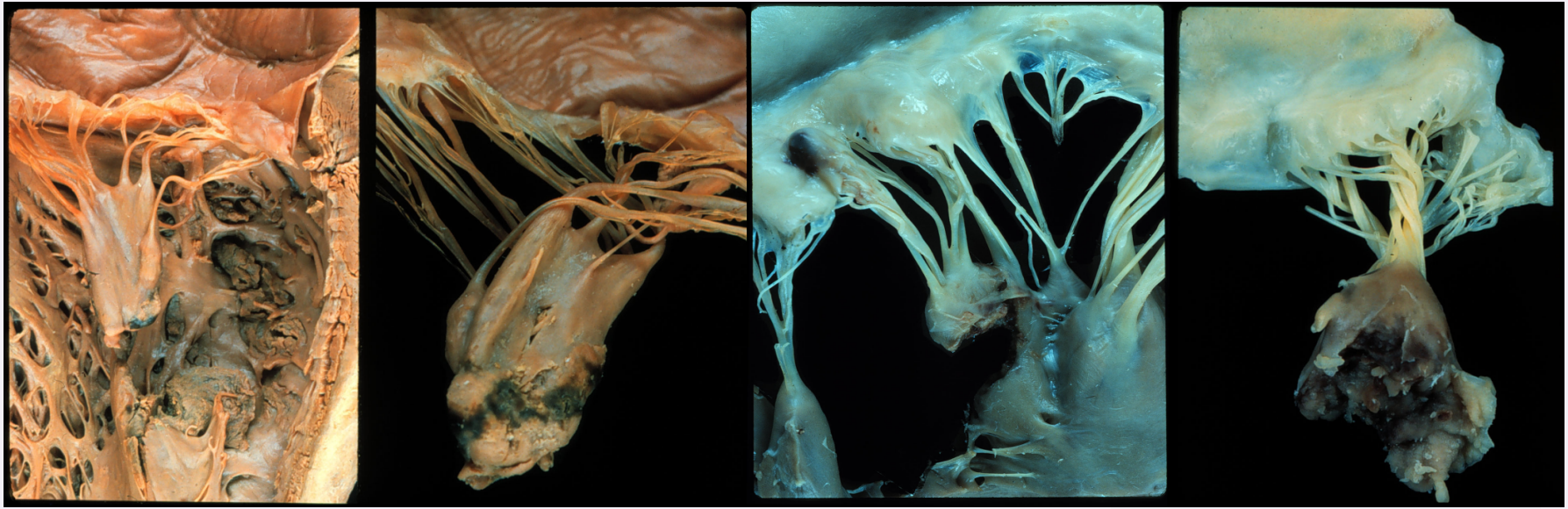


Mechanical complications of acute MI

free wall rupture

VSD

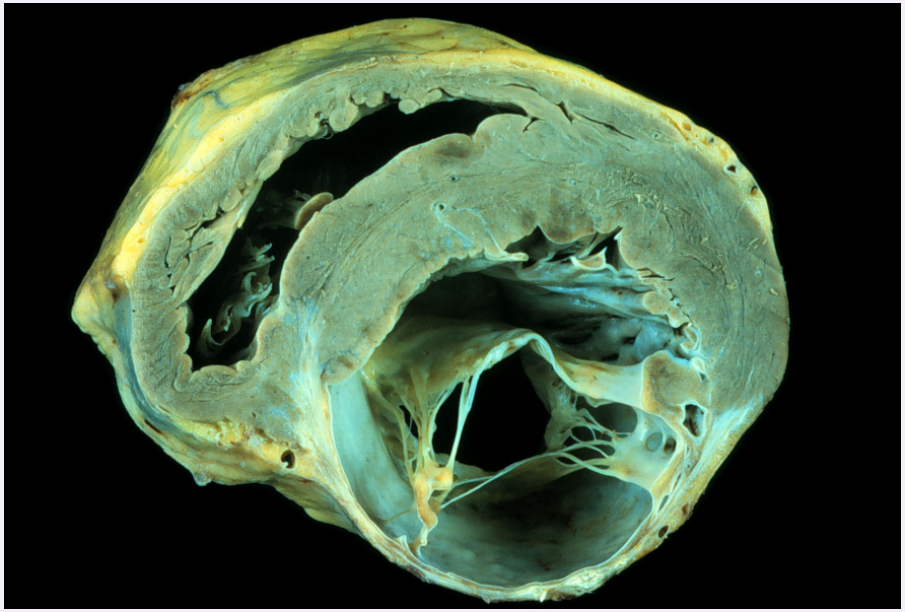
mitral regurgitation – papillary muscle rupture



Mechanical complications of acute MI

LV aneurysm

LV pseudoaneurysm



Valve diseases - history

1950 - Bailey – closed aortic valvulotomy
1952 - Hufnagel – descending thoratic aortic valve
1956 - Murray – descending thoratic aortic homograft
end of 50th – Hurley, Kirklin – open valvulotomy
1960 - Harken, Starr – AVR with aortic ball valve
1962 - Barratt-Boyes – AVR with homograft
1965 - Binet – AVR with bioprothesis
1967 – Ross procedure
1991 - David, Yacoub – aortic valve sparing surgery

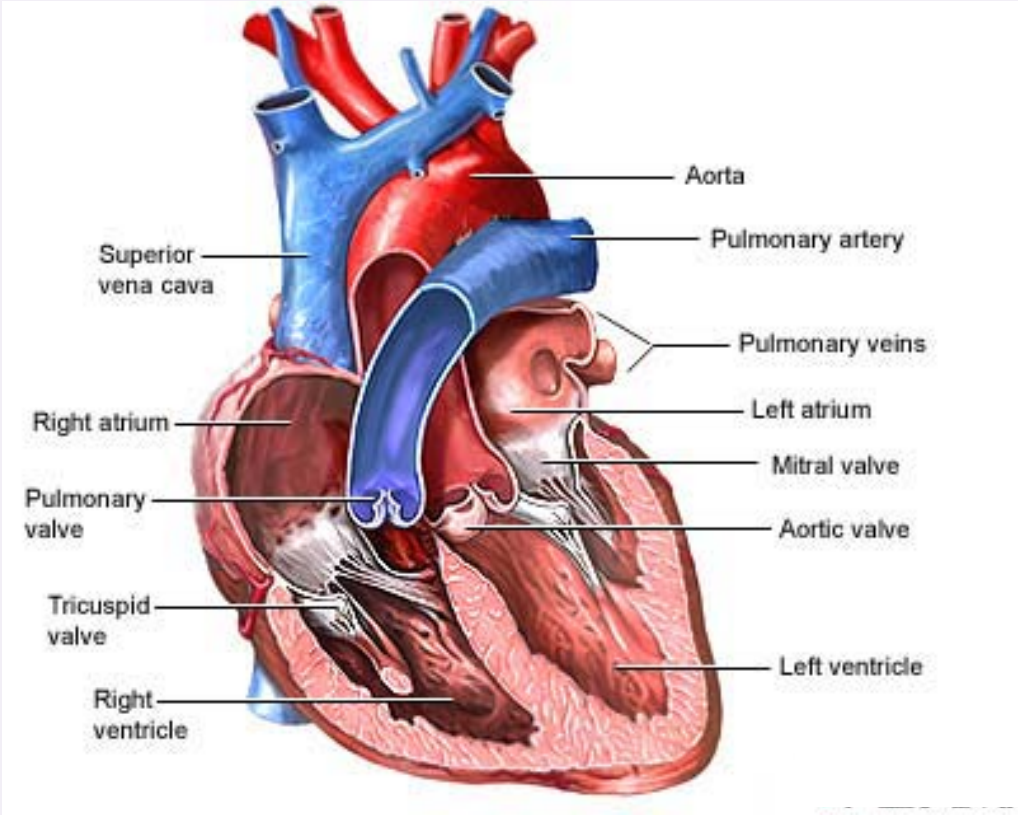
Anatomy of heart valves

Atrio-ventricular valves (Mi,Tri)

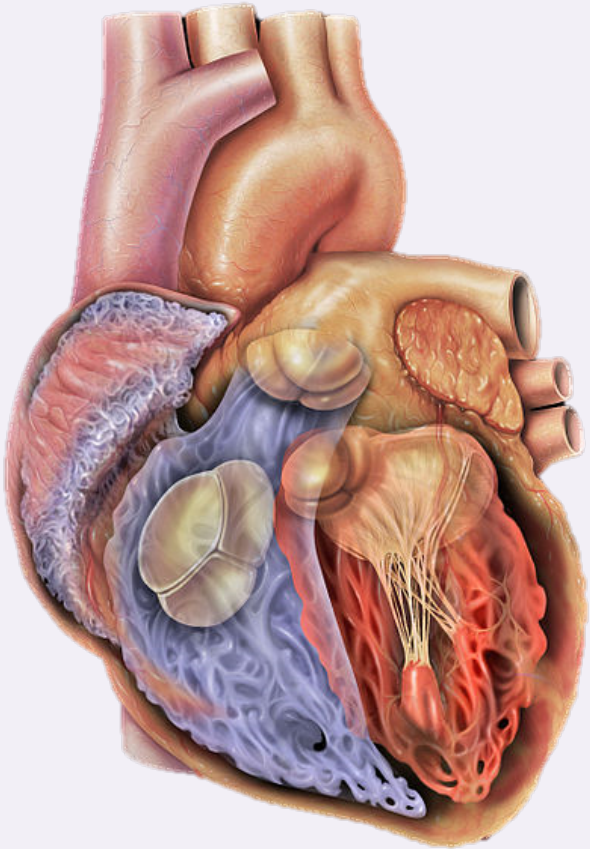
- annulus
- leaflets
- papillary muscles
- chords
- left /right ventricle

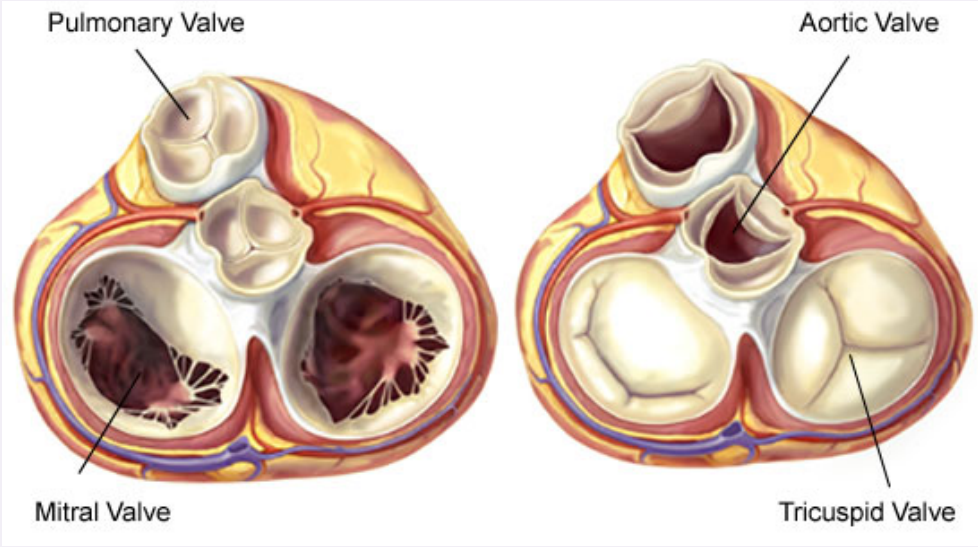
Ventriculo-arterial valves

- anulus
- leaflets
- root



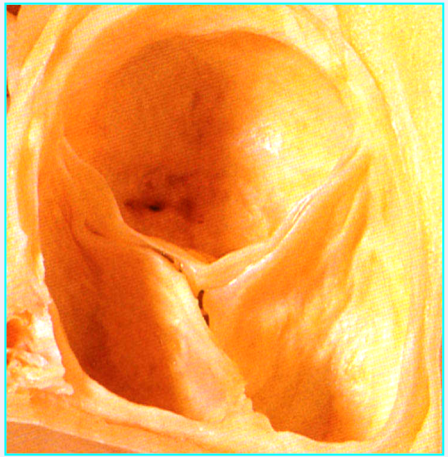
Anatomy of heart valves - localization





Aortic valve disease - stenosis

Etiology - degenerative
- congenital
- post-rheumatic



most often
AS risk factors

bicuspid - 2%
turbulent flow
aortic root dilatation!

+ Mi valve

Aortic valve disease – stenosis - pathophysiology

LV concentric hypertrophy

coronary flow reduction

↓ aortic pressure (= coronary artery perfusion pressure)

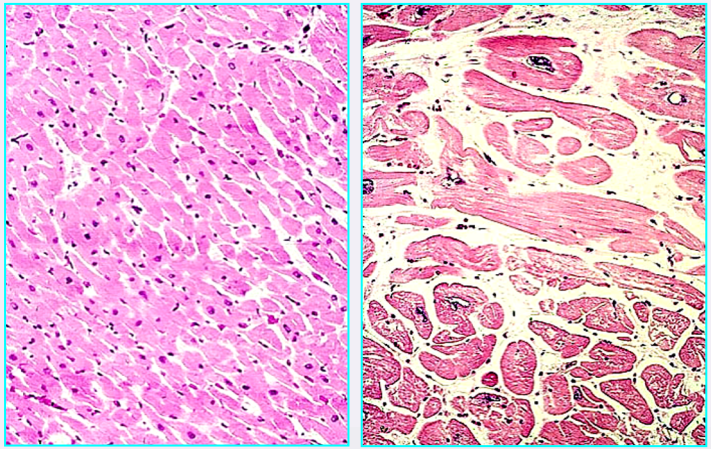
↓ diastolic time (= coronary artery perfusion time)

LV hypertrophy, ↑ AP_S , increase time of ejection → ↑ O_2 consumption

systolic/diastolic dysfunction

myocyt hypetrophy

fibrosis (collagen +15%)



Aortic valve disease – stenosis – indication for surgery (AVR)

aortic valve stenosis (on ECHO)

+ symptoms (AP, dyspnea, syncope)

⇨ surgery

– symptoms …. LV function? (↓EF, LV dilatation)

⇨ surgery

Aortic valve disease - regurgitation

acute x chronic

Etiology - post-rheumatic
- **endocarditis**
- **congenital**
- **degenerative**
- **annulus/root dilatation**

Mitral valve diseases

Stenosis **Etiology** **- post-rheumatic**

Indication for surgery - symptoms (dyspnoa)
- MV ≤ 1,5cm²
- atrial fibrilation
- PH

Regurgitation (acute, chronic)

Etiology **- myxomatous degeneration**
- post-rheumatic
- endocarditis
- ischemic

Indication for surgery - symptoms
- RV > 40ml, RF > 40%,

Tricuspid valve diseases

Stenosis

Etiology - post-rheumatic

Indication for surgery - gradient > 2-3mmHg

Regurgitation

Etiology- relative…annulus dilatation

- endocarditis

Indication for surgery - TriR grade III-IV

Heart valve surgery

1. Valve sparing – if it possible

    X risk of failure valve sparing surgery → redo surgery

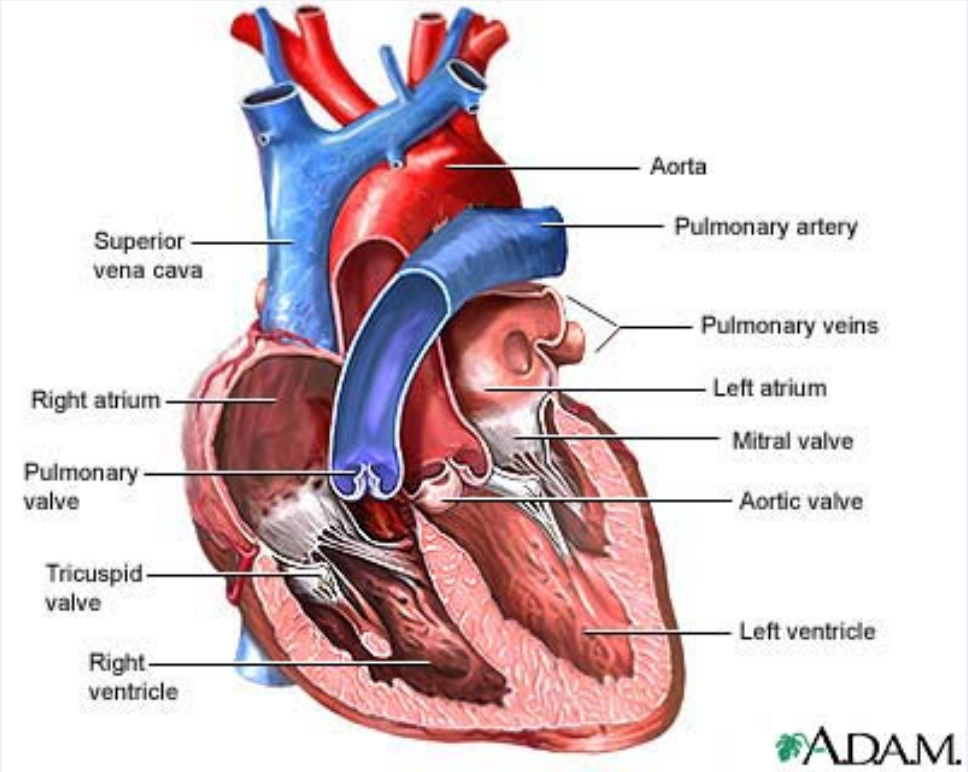
2. Valve replacement

    X risk of valve prosthesis

Anatomy of heart valves

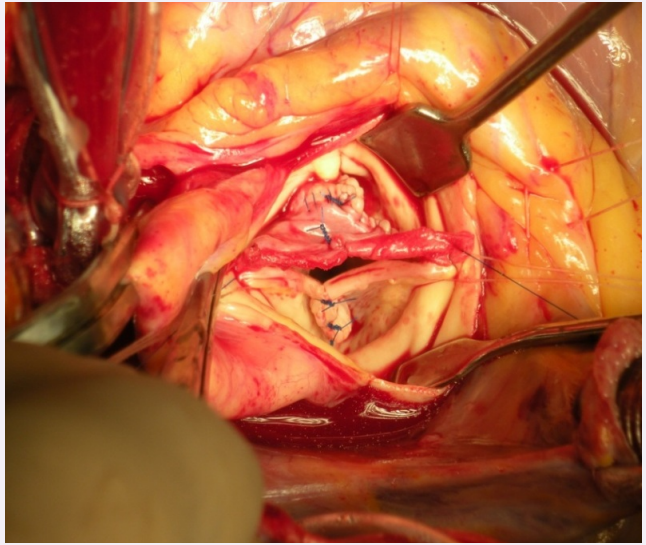
Ventriculo-arterial valves

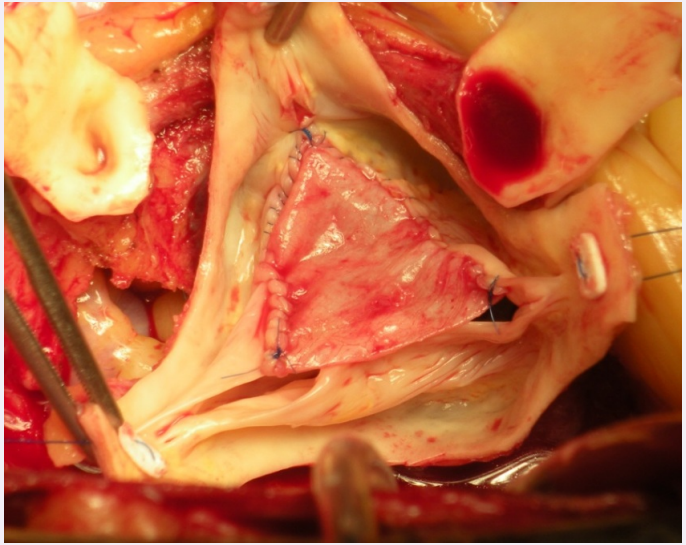
- leaflets
- anulus
- root

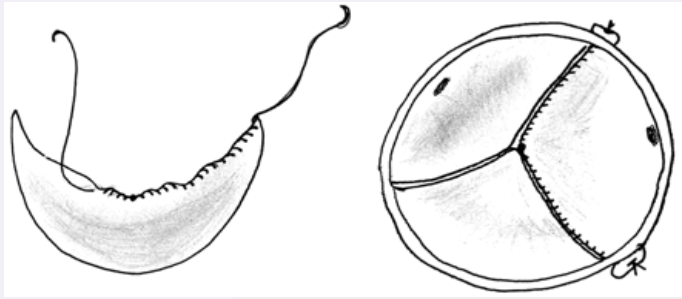


Aortic valve sparing surgery

Leaflets

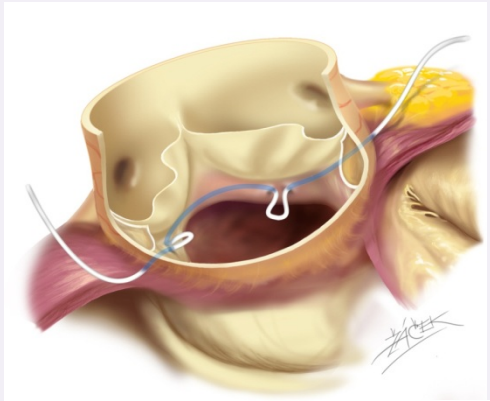


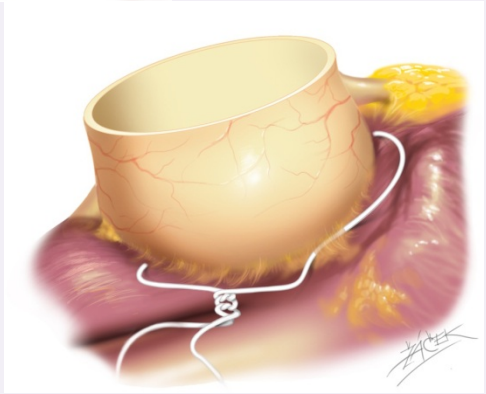




Aortic valve sparing surgery

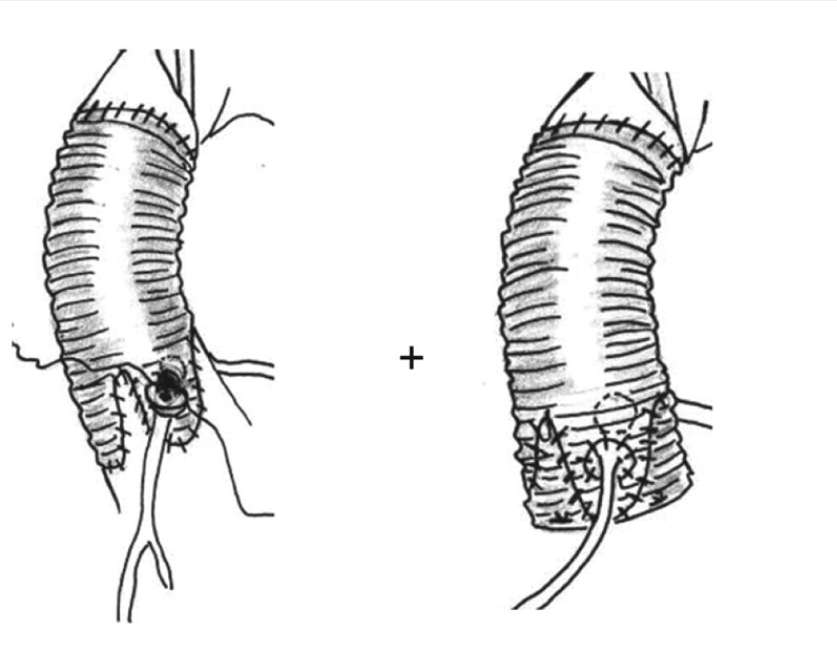
Annulus

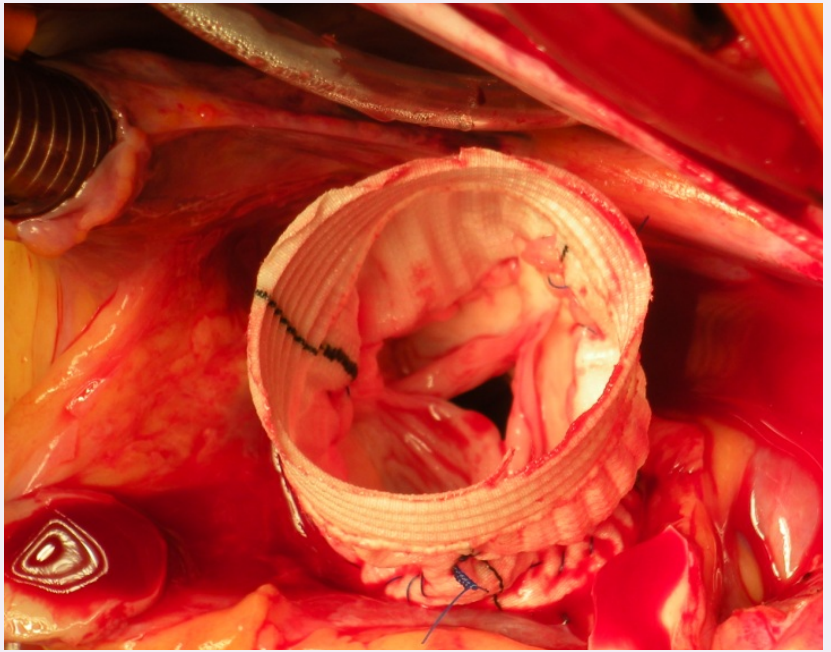




Aortic valve sparing surgery

Root

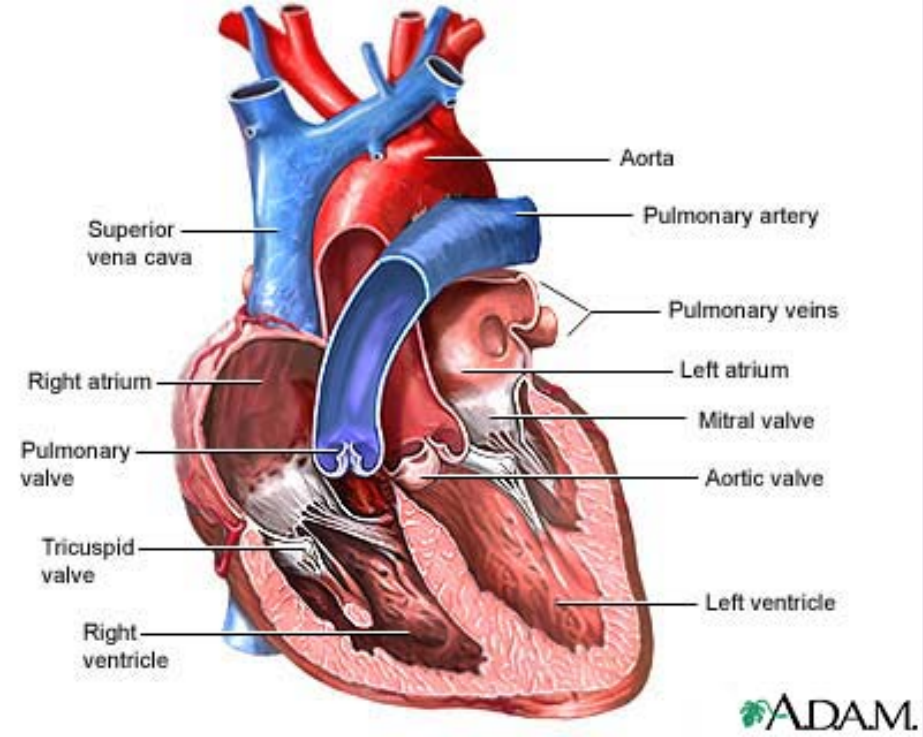




Anatomy of herat valves - localization

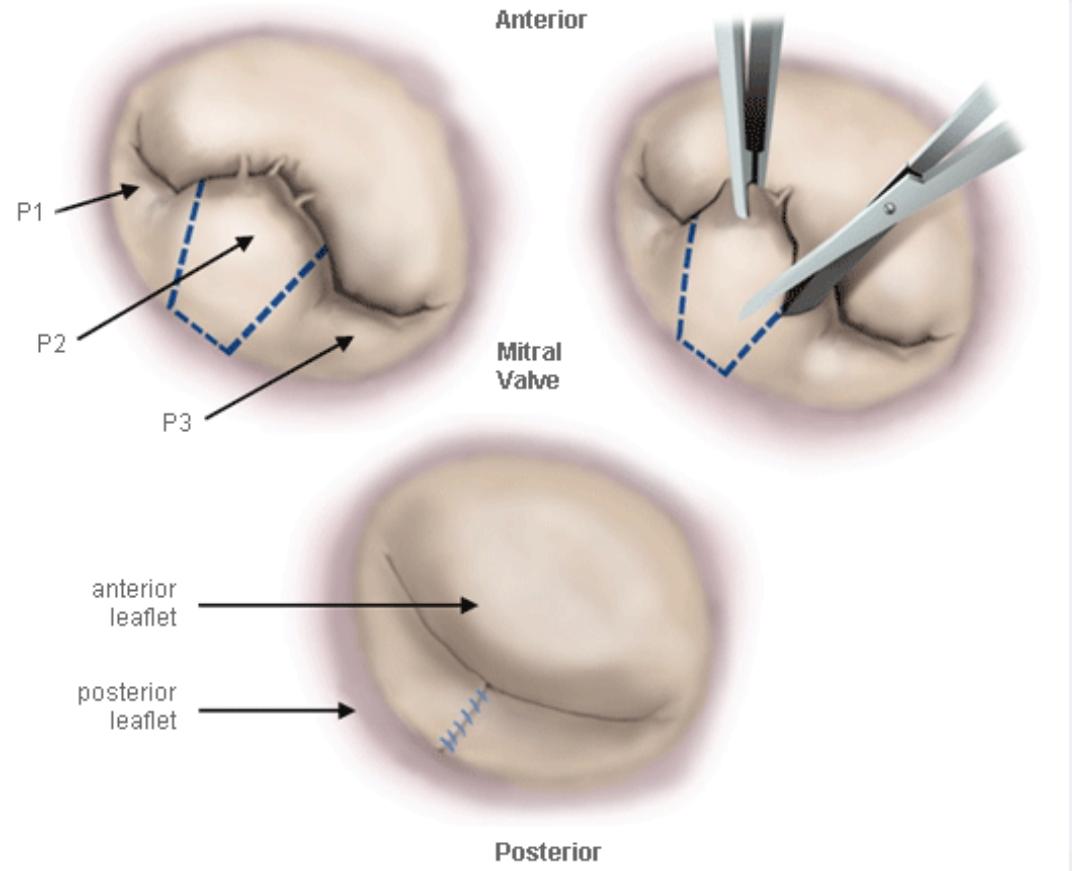
Atrio-ventricular valves (Mi,Tri)

- leaflets
- anulus
- papillary muscles
- chords
- left/right ventricle



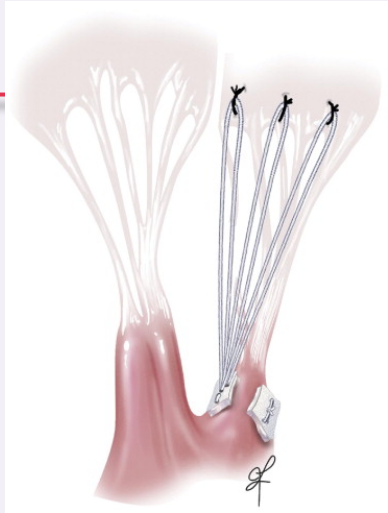
Mitral valve reconstruction surgery

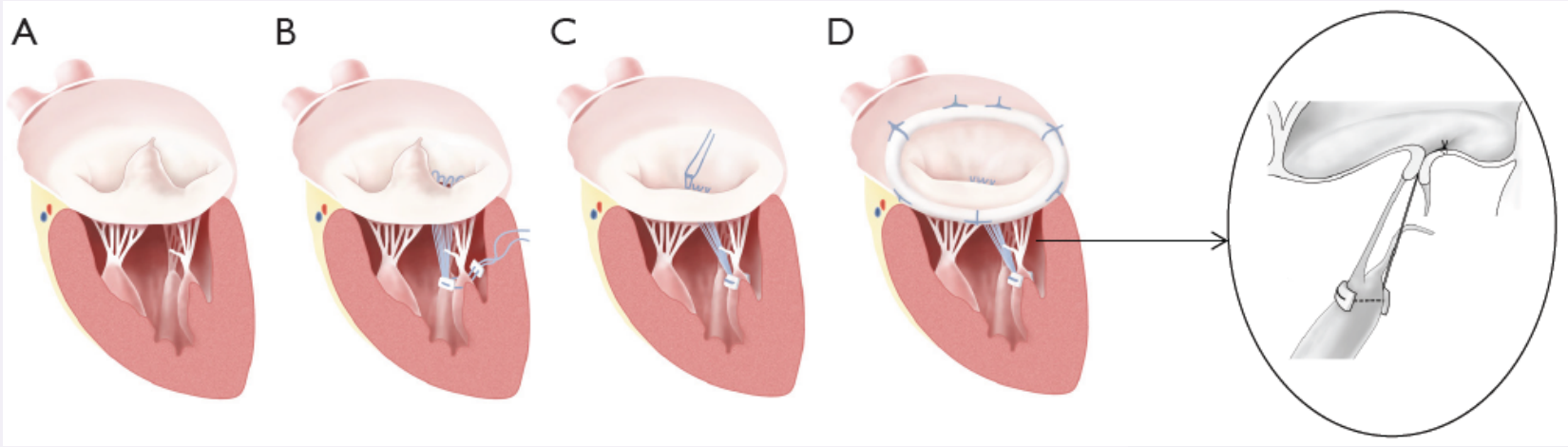
Leaflets



Mitral valve reconstruction surgery

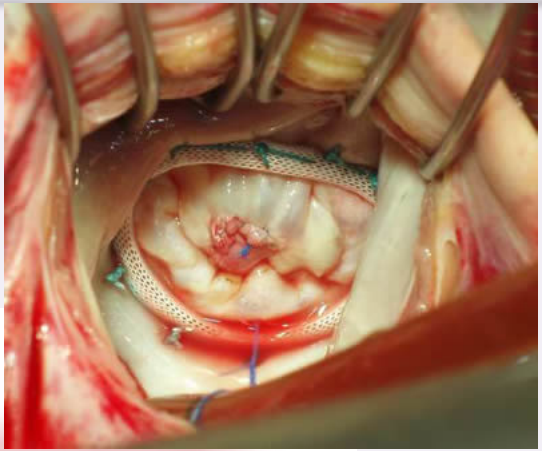
Papillary muscles
Chords

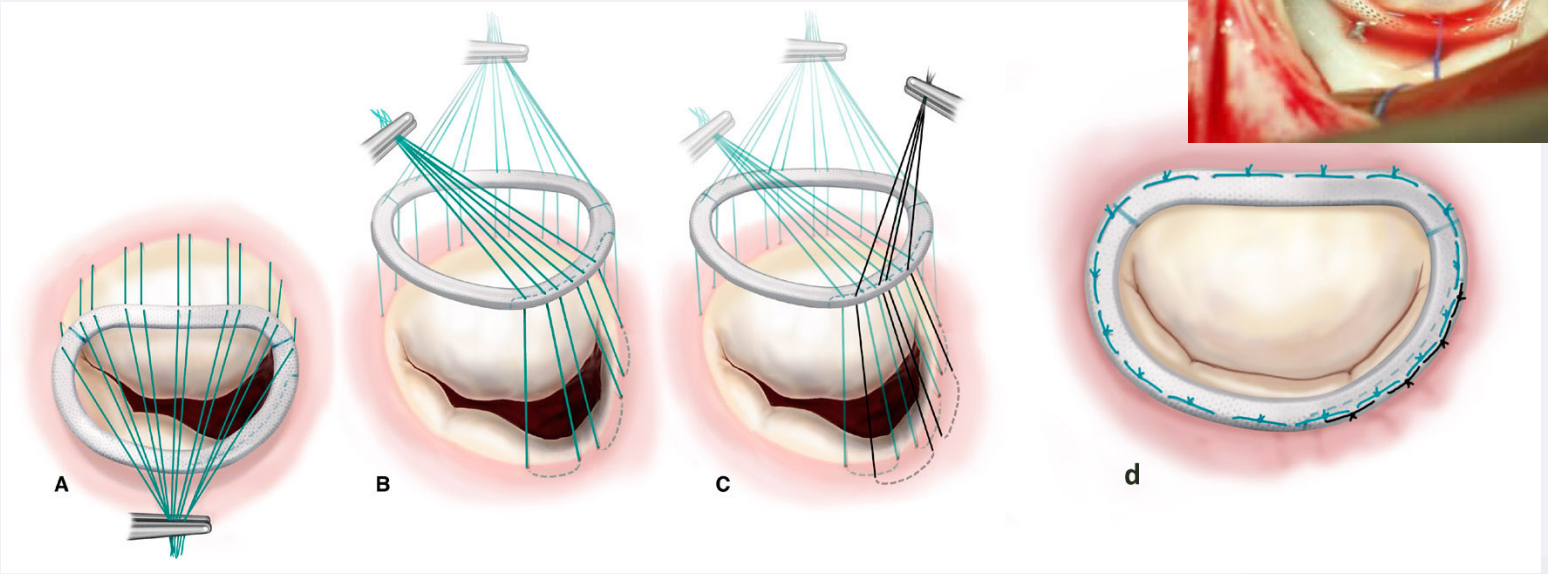




Mitral valve reconstruction surgery

Annulus



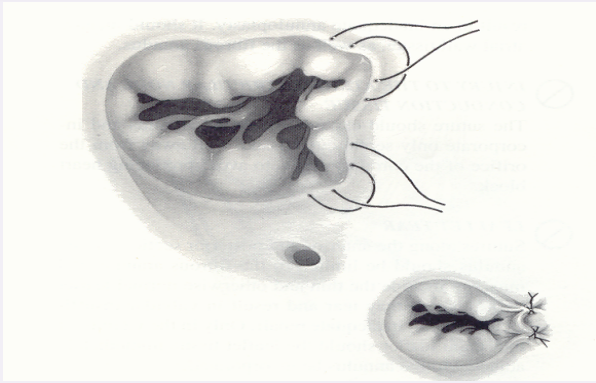


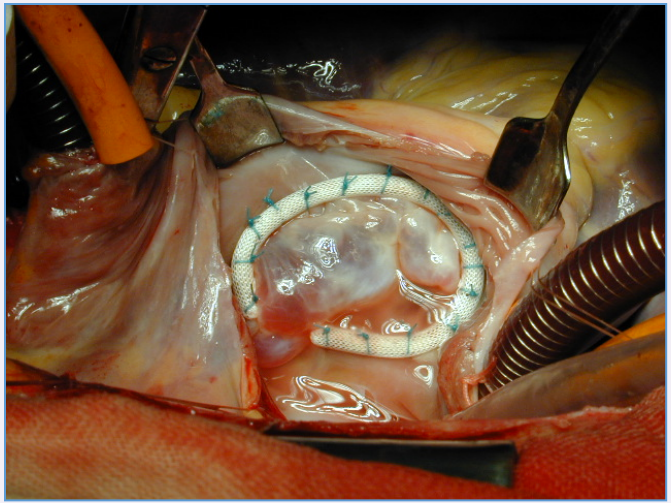
Tricuspid valve reconstruction surgery

Annulus

Leaflets

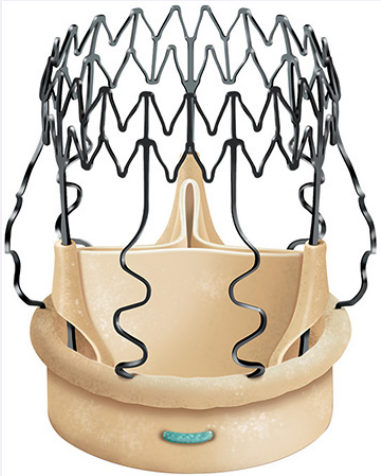
(chords)



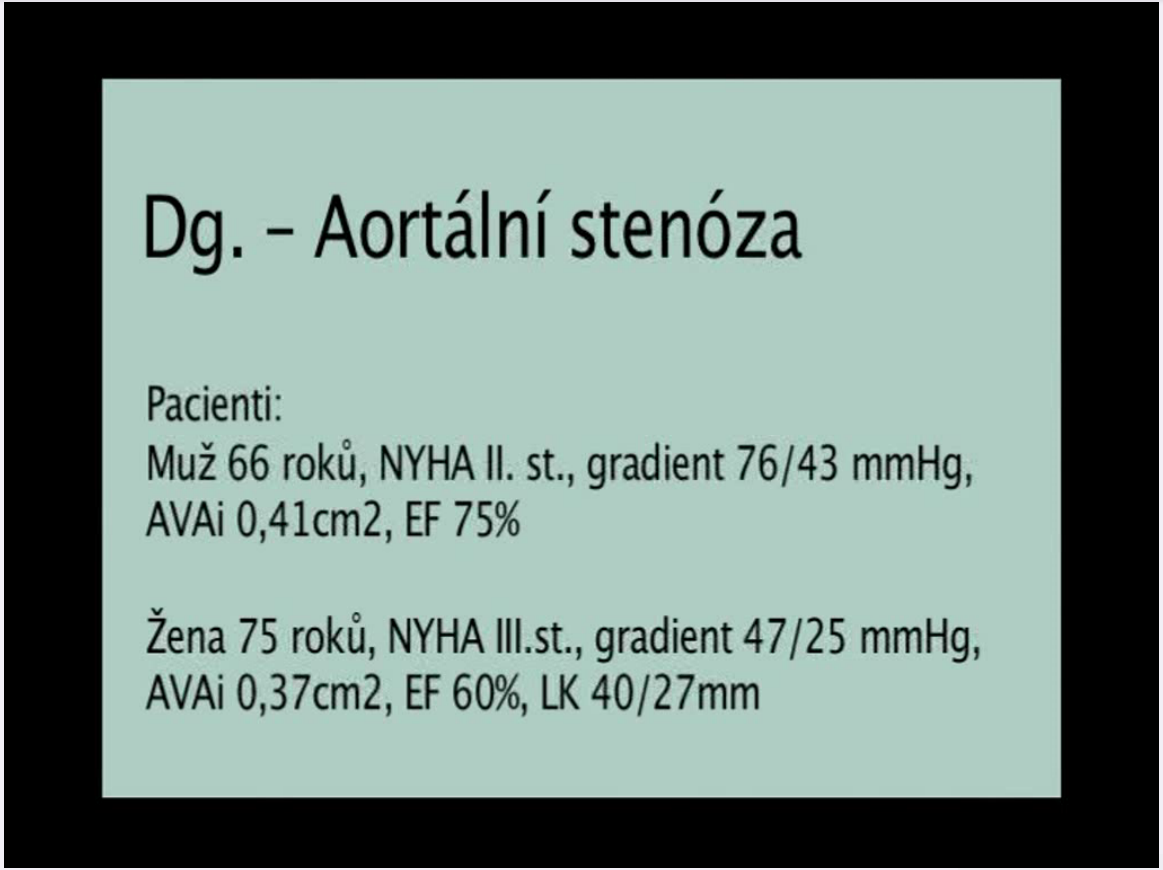


Valve replacement - mechanical

Valve replacement - biological



Aortic valve replacement - video



Aortic valve replacement – sutureless bioprosthesis

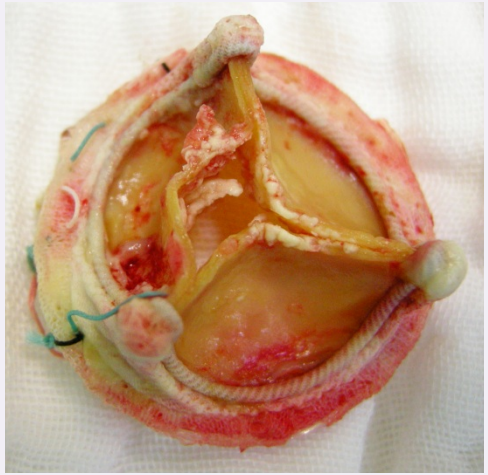
Mechanical vs. biological valves

Mechanical

- advantages - long-term durability
- disadvantages - need of anticoagulation

Biological

- advantages - no anticoagulation
- disadvantages - limited durability



Complications after valve replacement

- thrombembolism

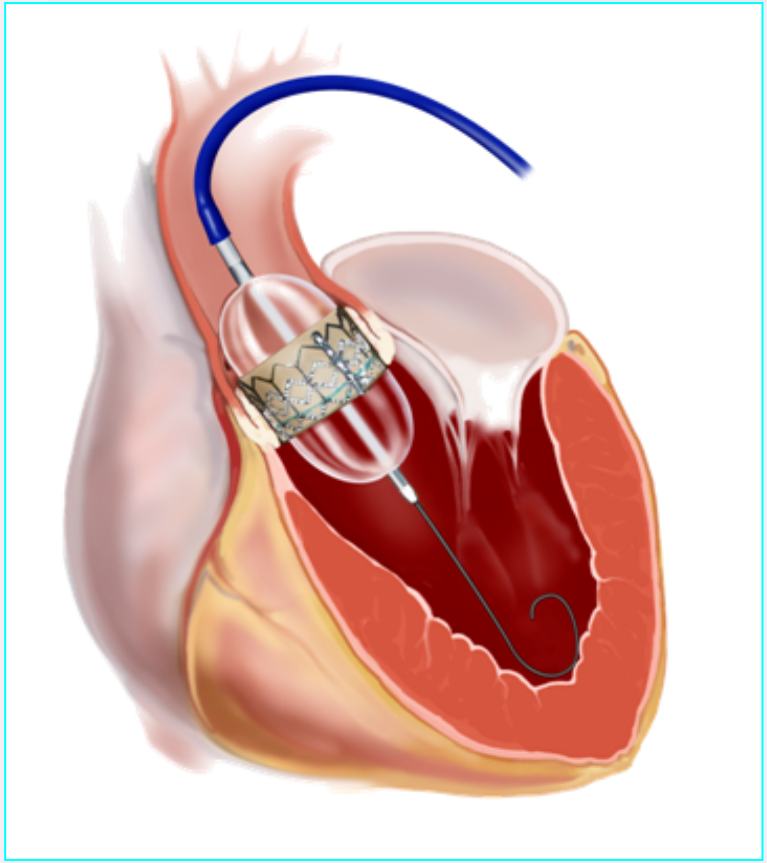
- bleeding

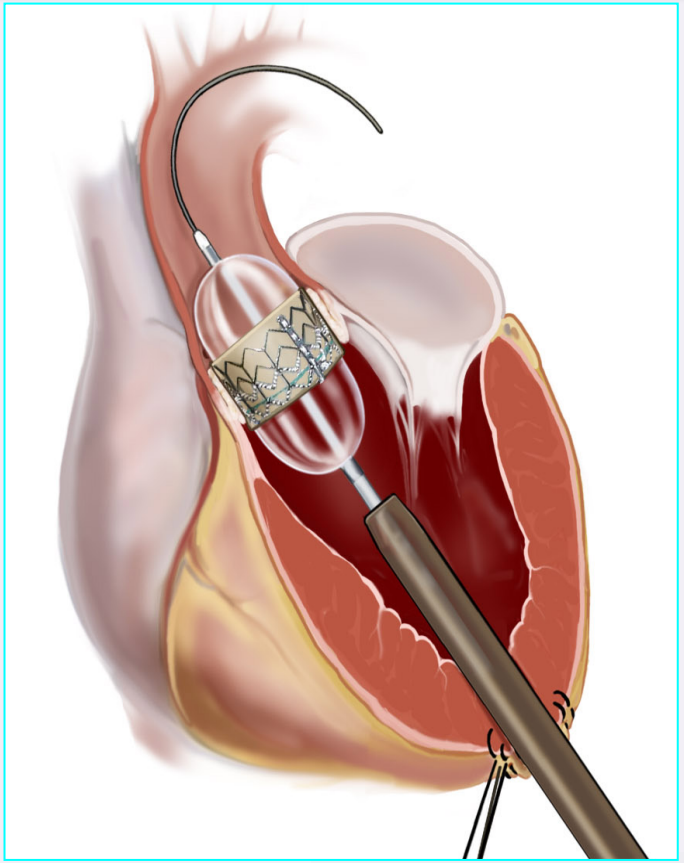
- valve dysfunction (pannus, thrombus)

- prosthetic endocarditis

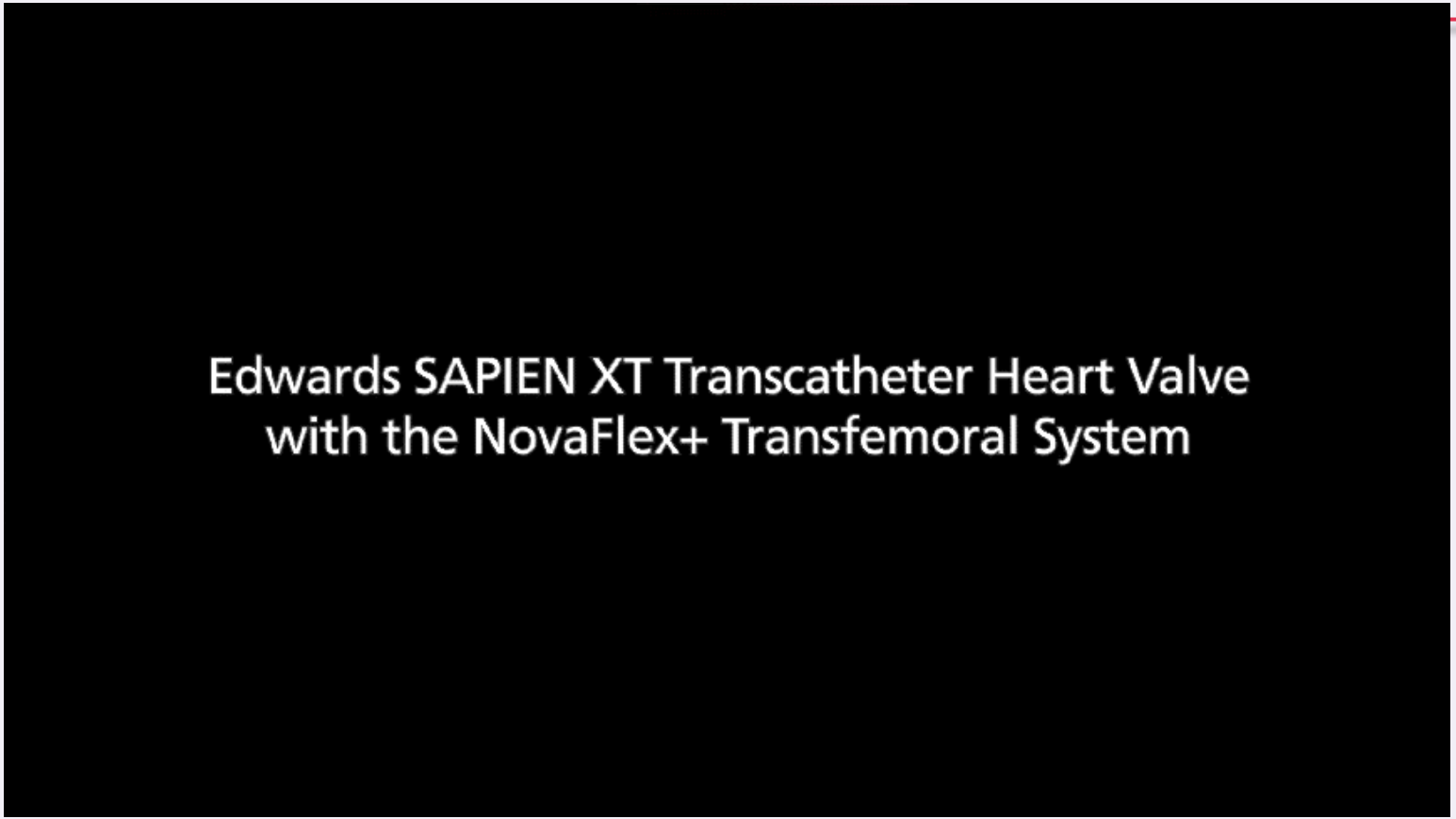
2 - 4% per year
Mortality 1% per year

TAVI – transcatheter aortic valve implantation



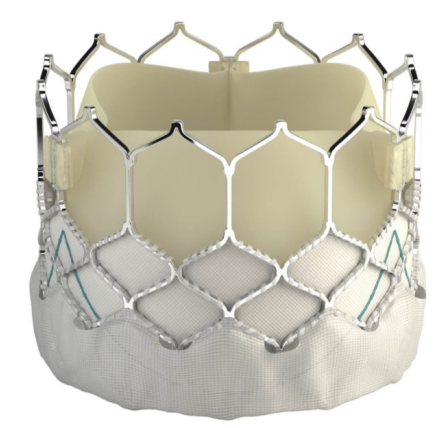


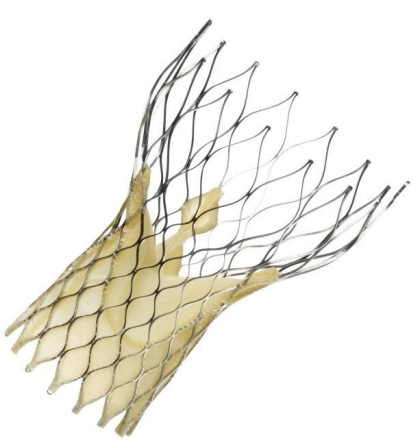
TAVI - transfemoral

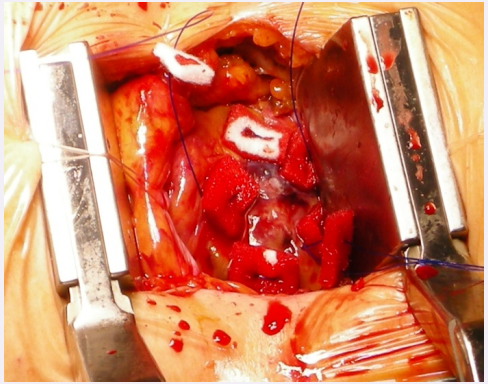


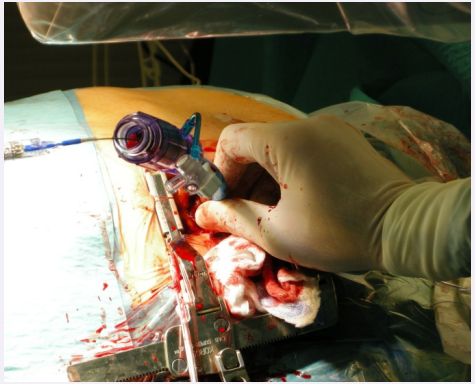
TAVI - transapical

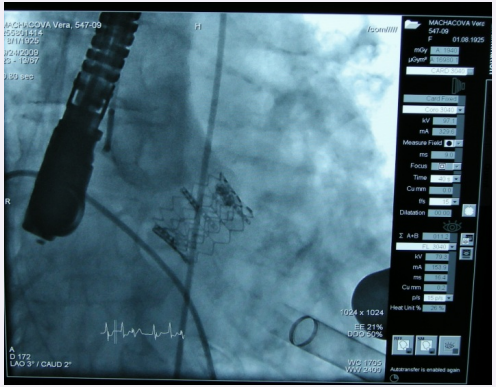
TAVI





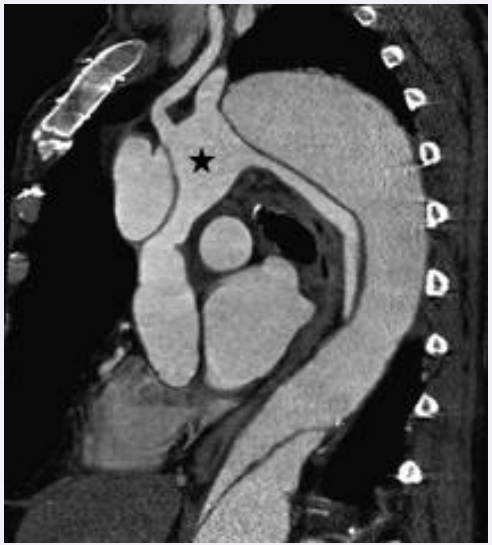


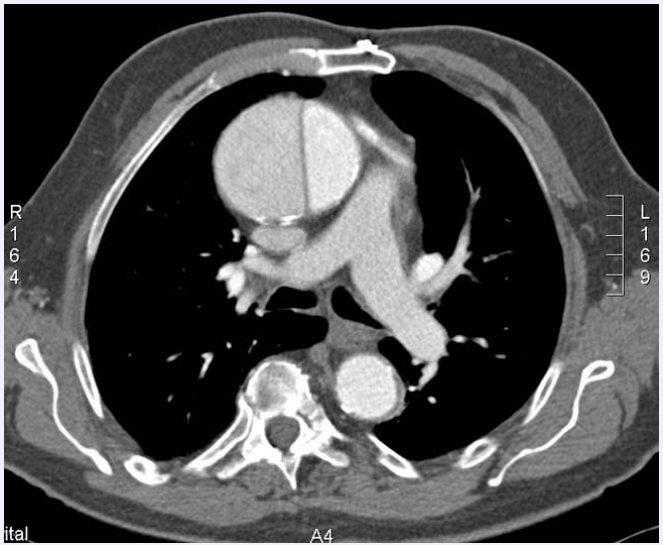


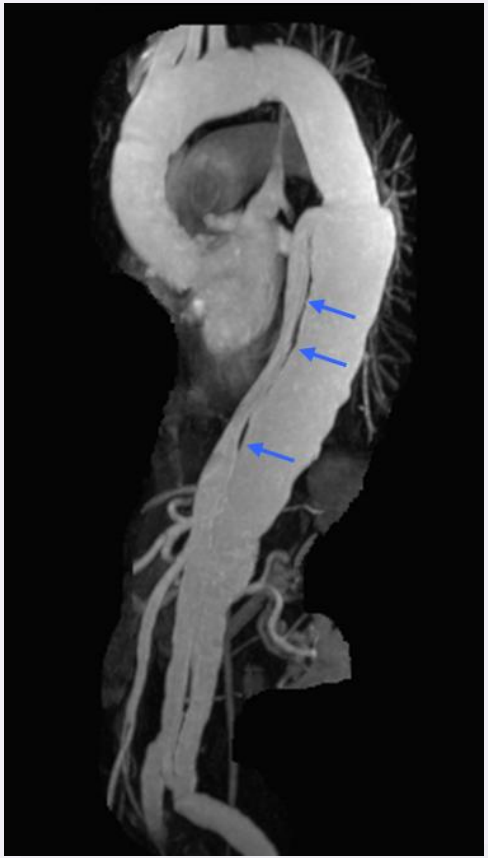


Aortic dissection

tear in the inner wall of the aorta causes
blood to flow between the layers of the
wall of the aorta and force the layers apart
→ true and false lumen
- acute (< 2 weeks)
- chronic







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Aortic dissection

Splitting tunica media

⇓

Weakening of the walls of the false lumen
Impaired flow of aortic branches

⇒ **Risk of rupture**

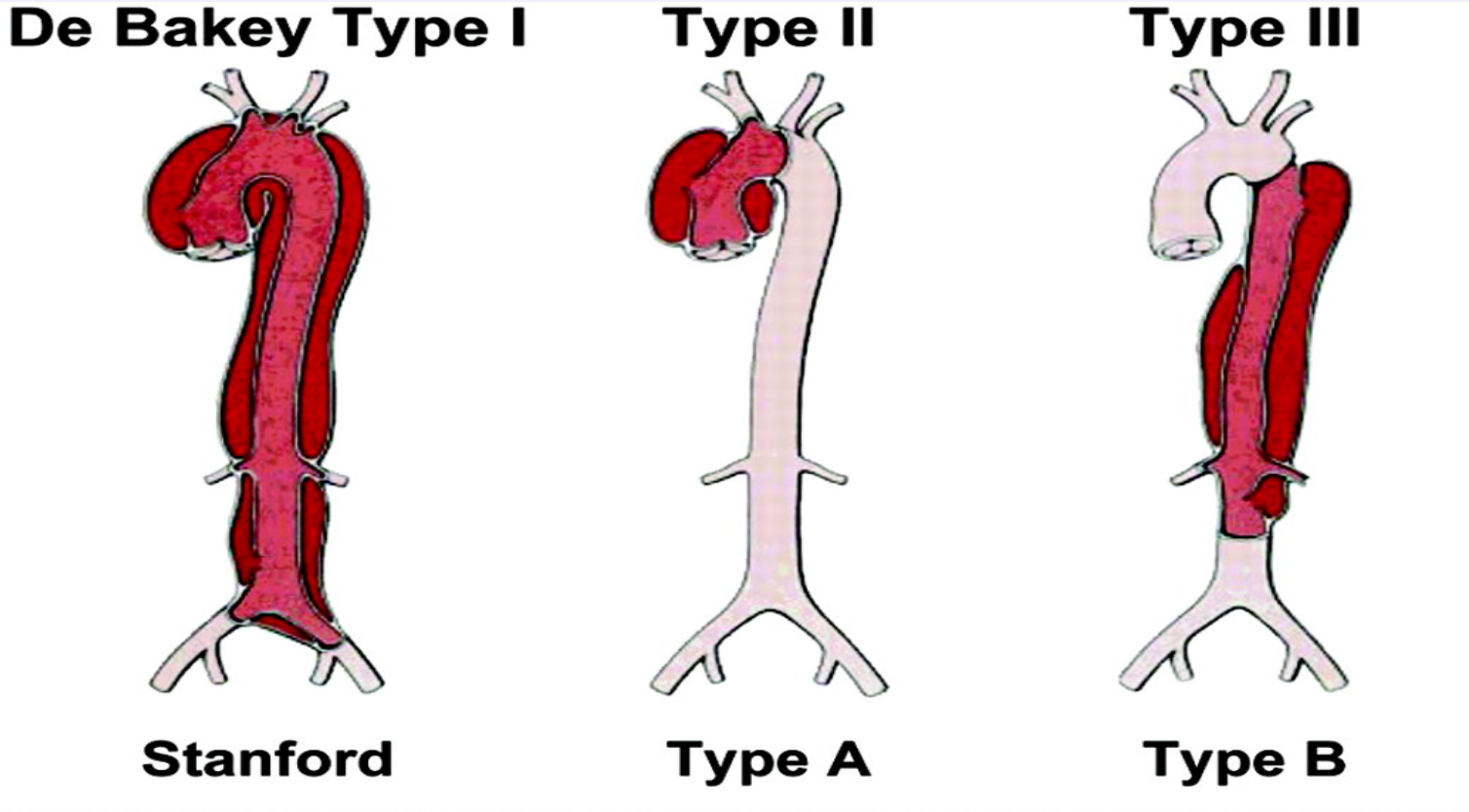
⇓

Tamponade
Malperfusion – brain, myocardial, visceral, extremity

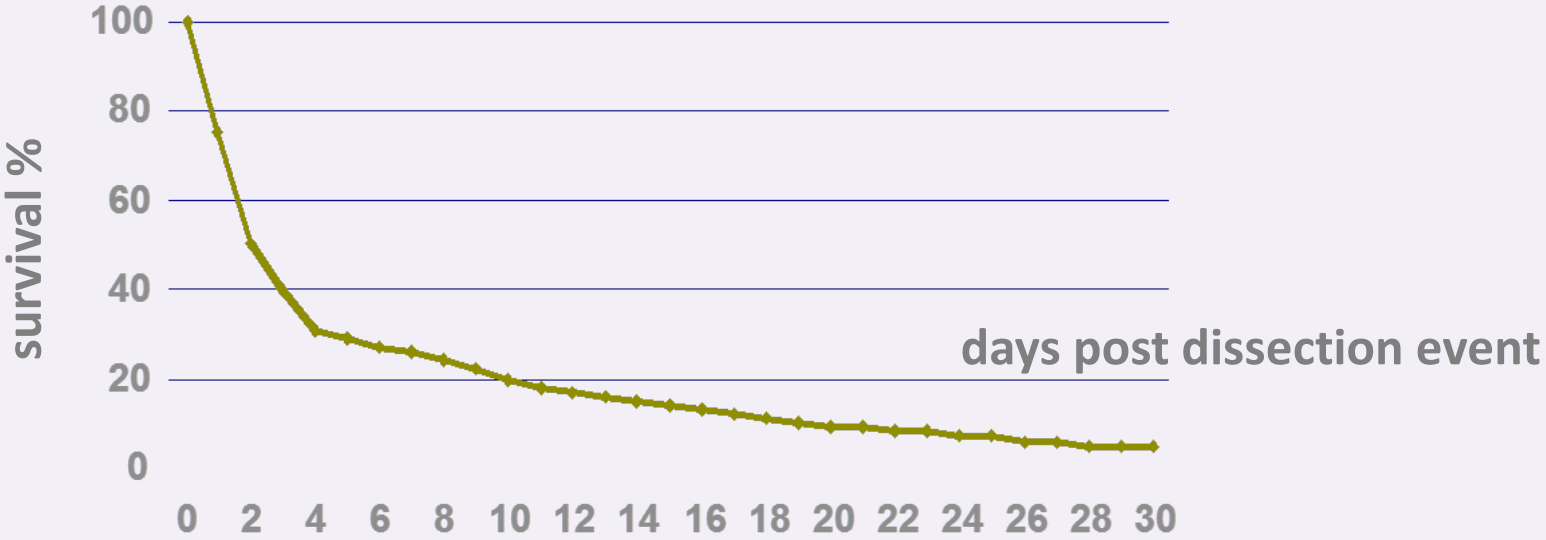
Aortic dissection

- hypertension
- connective tissue disorders (Marfan, Ehlers-Danlos, Turner)
- degenerative or inflamatory disease of aortic wall
- iatrogenic injury
- atherosclerosis
- bicuspid aortic valve
- aortic dilatation
- trauma
- polycystic kidney disease
- coarctation of the aorta
- …

Aortic dissection - classification



Survival of untreated pts with type A aortic dissection



- 50 % (36–72 %) of untreated pts with acute type A dissection die within 48 hours
- mortality rate 1 % / hour
- the survival rate without treatment at 1 month is approximately 5%
- after 3 weeks approx. 90 % †

Aortic dissection - symptoms

PAIN!!!

- pre-shock symptoms (sweating, hypotension, tachycardia)
- malperfusion (peripheral or splanchnic ischemia)

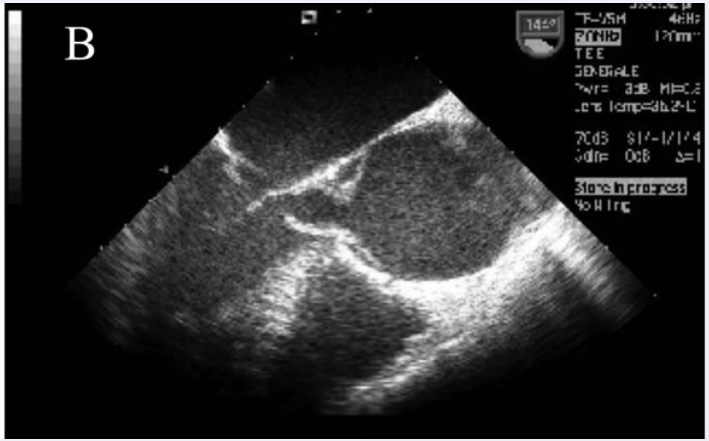
CAVE:
ALWAYS CONSIDER AORTIC DISSECTION IN CASE OF ISCHEMIC EXTREMITY !

- neurological signs (stroke)
- no another symptoms (some patients are only complaining chest pain)

Aortic dissection - diagnosis

WITHOUT DELAY !!!

ECHO
CT-angio
(MR)



Aortic dissection - therapy

Initial

analgetics

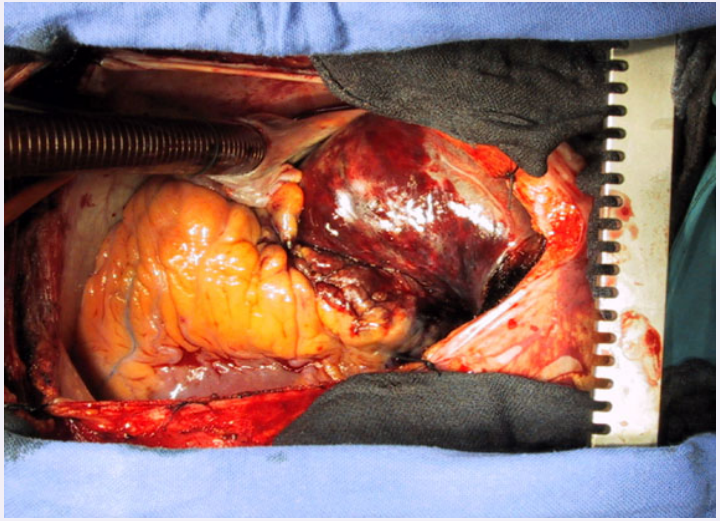
ANTIHYPERTENSIVE THERAPY (vasodilatation, betablockers)

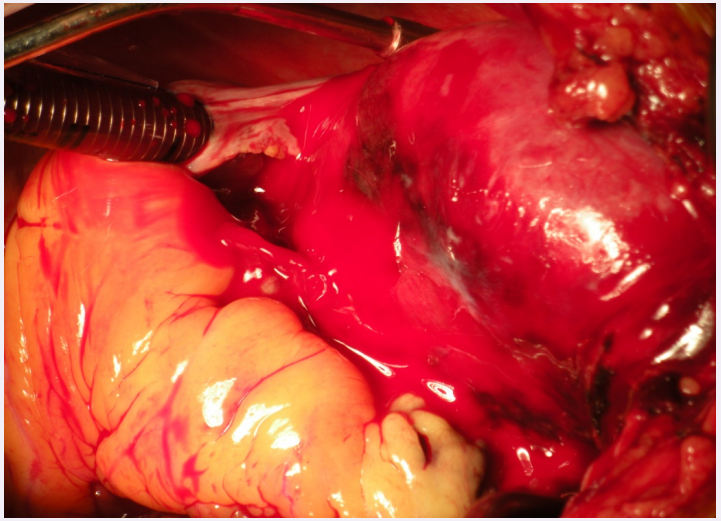
Definitive

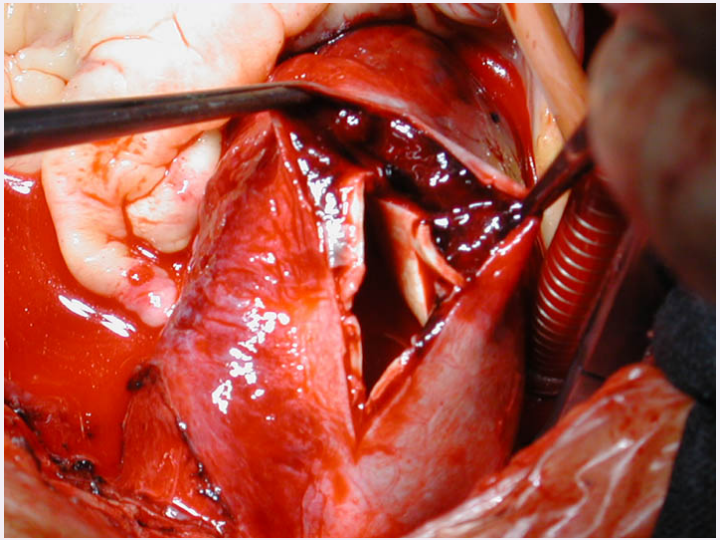
Type A - surgery

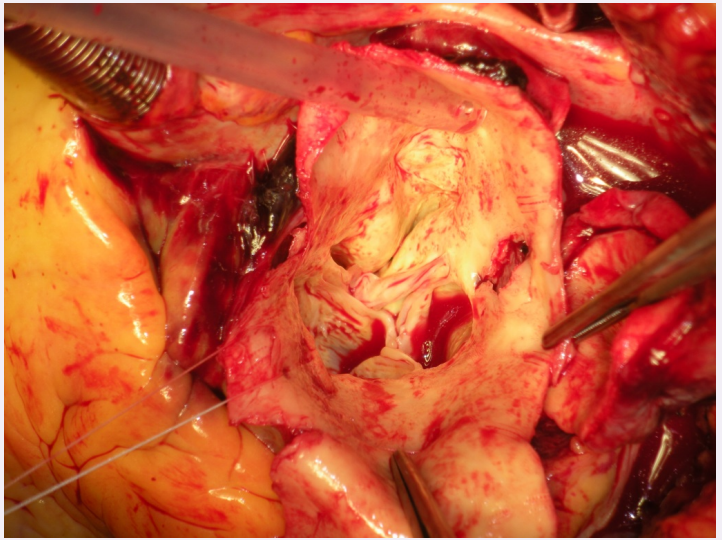
Type B - no surgery

- intervention (stentgraft) :
  - rupture
  - malperfusion
  - pain
  - progresive dilatation >10mm/30 days
  - failure of hypertension treatment management

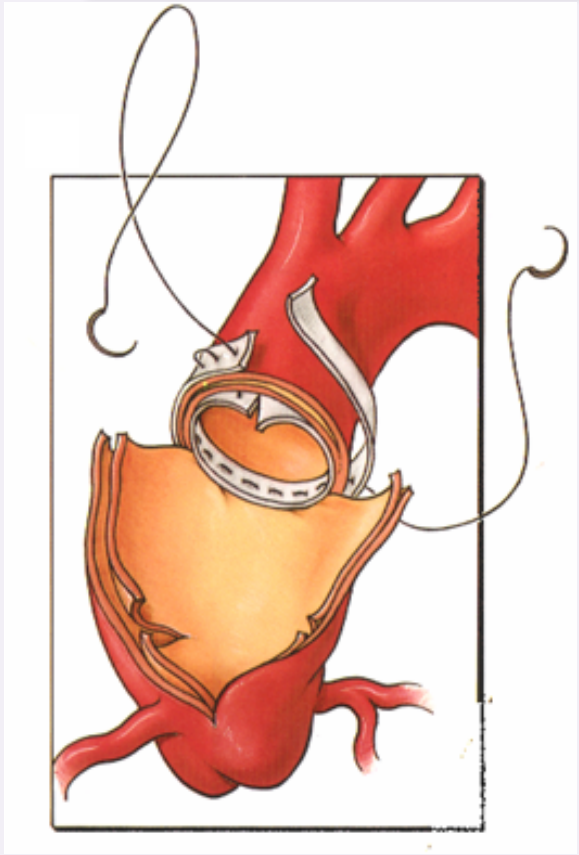


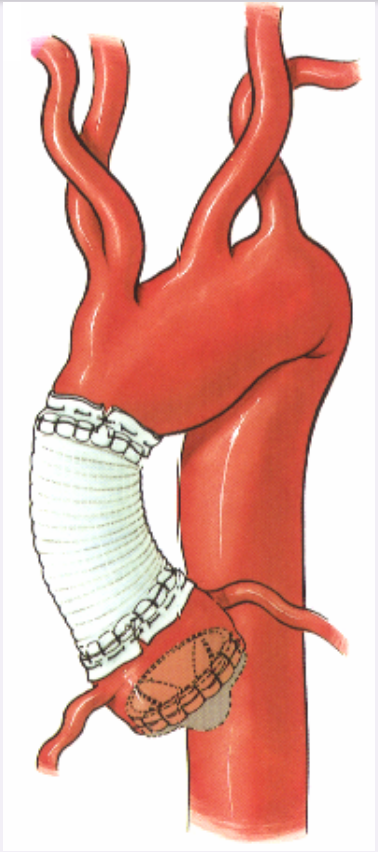


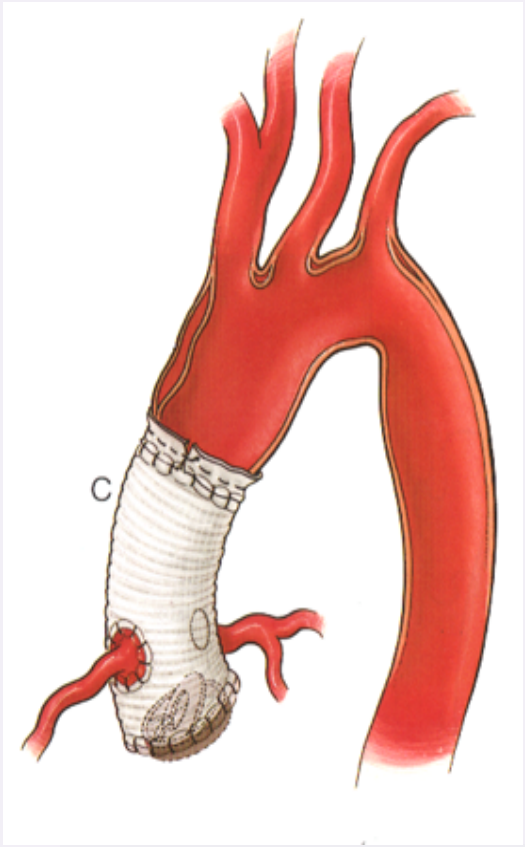




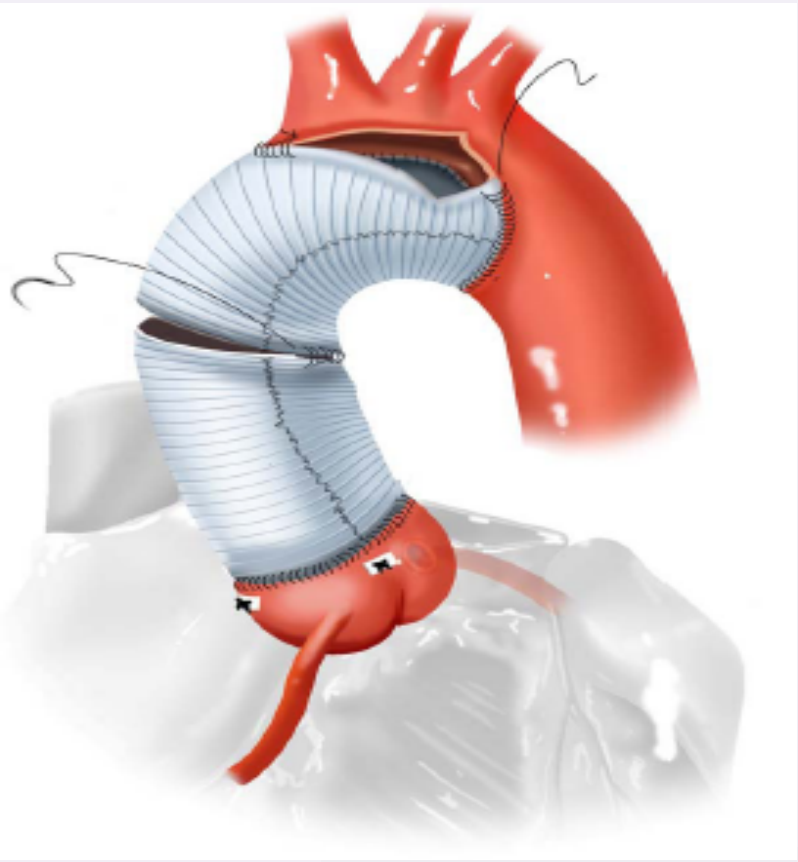
Aortic dissection - surgery



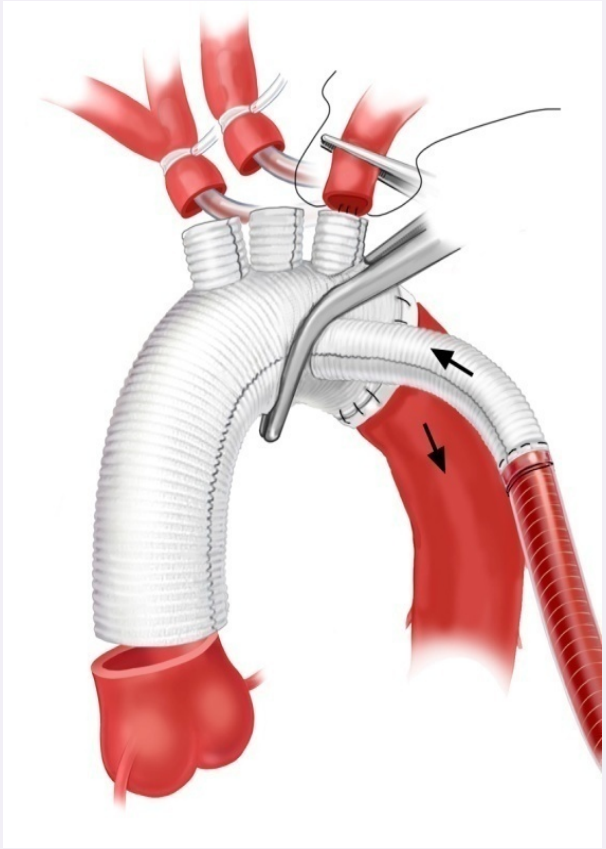


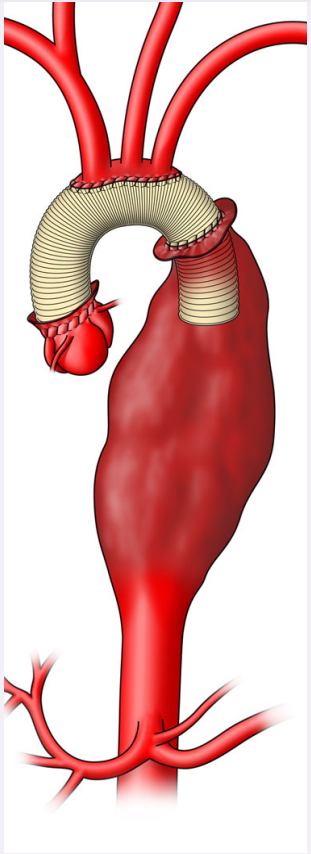


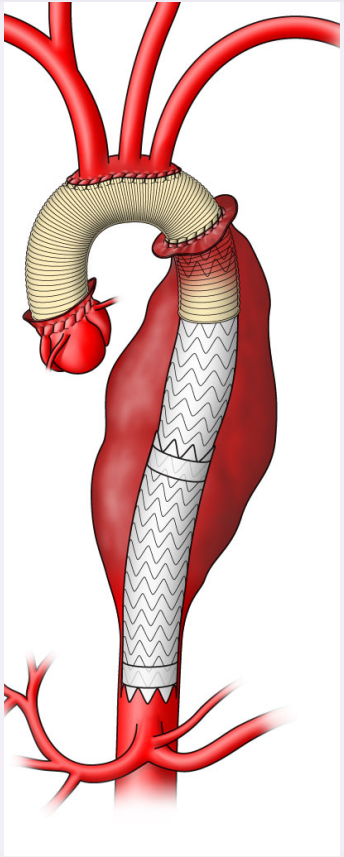
Aortic dissection - surgery



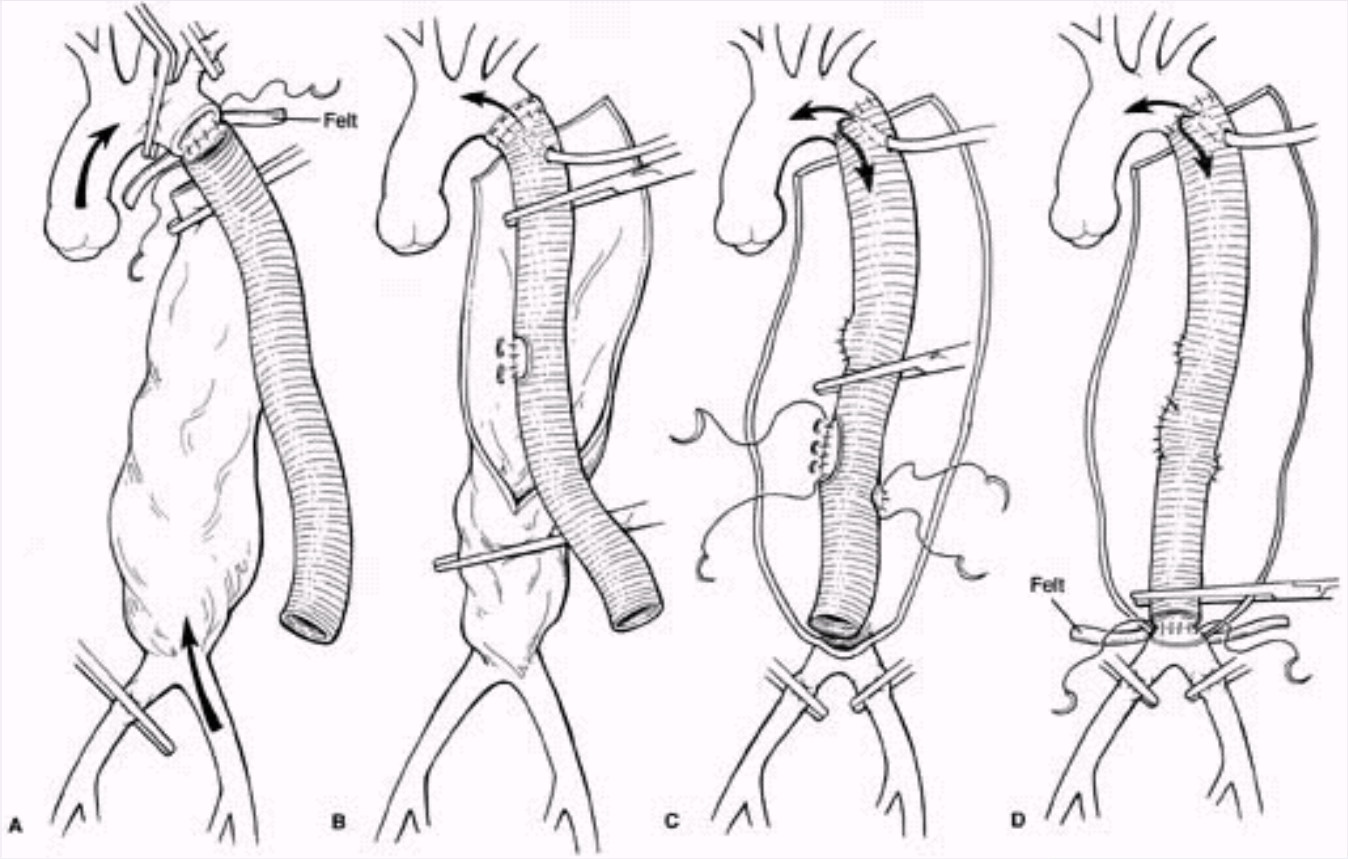
Aortic dissection - surgery



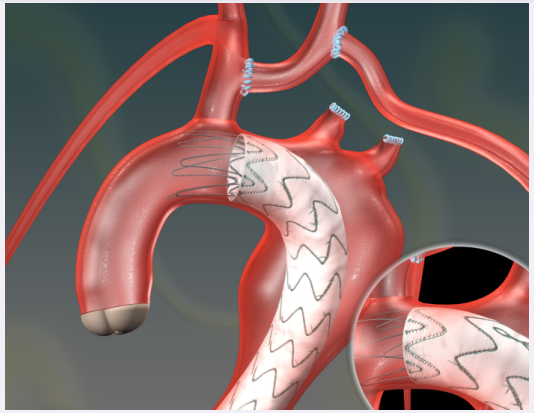




Aortic dissection type B - surgery



Endovascular therapy of aortic type B dissection



Aortic dissection therapeutic results

Prognosis without treatment

type A - within 48 hours of the event - 50% mortality

- survival rate at 1 month is approximately 5%

Surgery

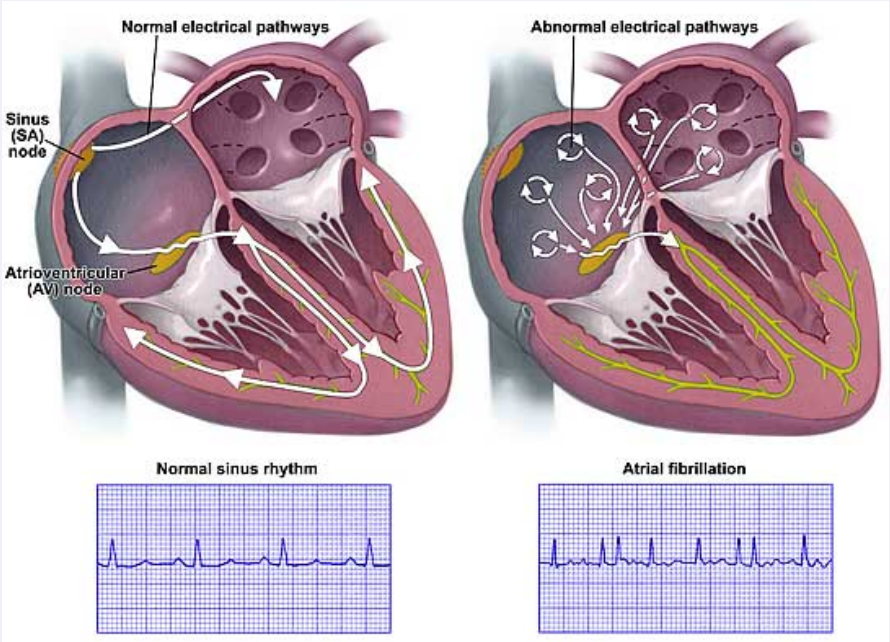
		survival	
	early mortality	1 year	5 years
Type A	10-25%	91%	75%
Type B	20-50%	93%	82%
stentgrafts	5-10%		

Conservative (no surgery) therapy

Type B	10-20%

Atrial fibrilation

- the most often SV dysrythmias
- the most serious consequences
- no mapping during surgery



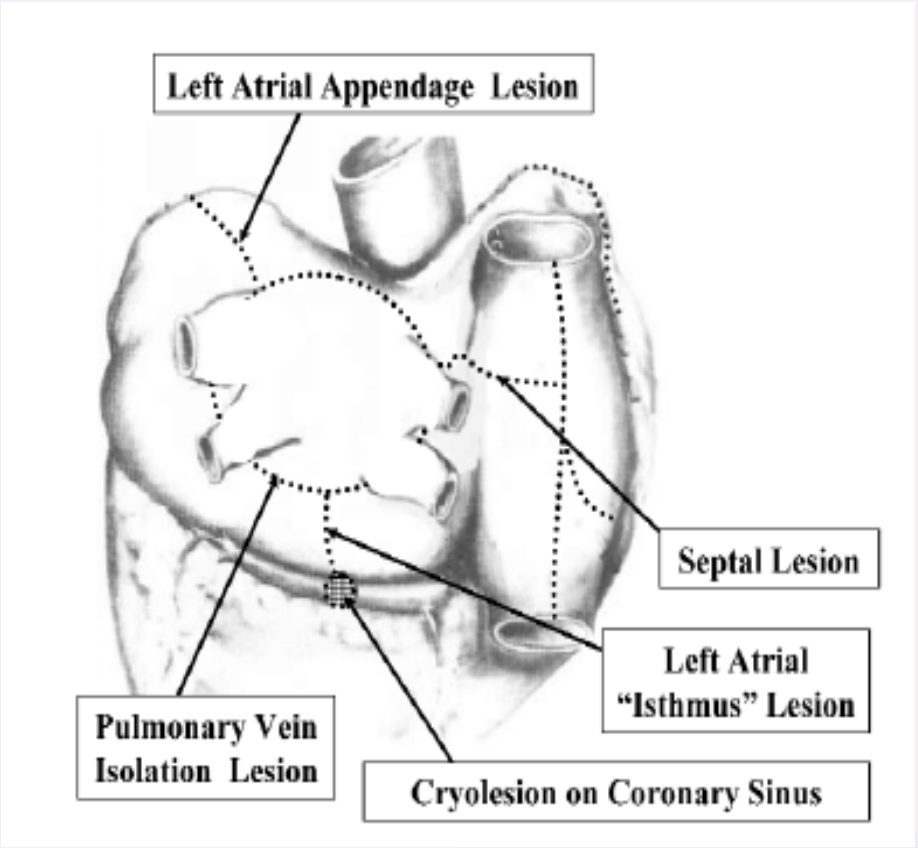
Atrial fibrilation – MAZE procedure

Lesions

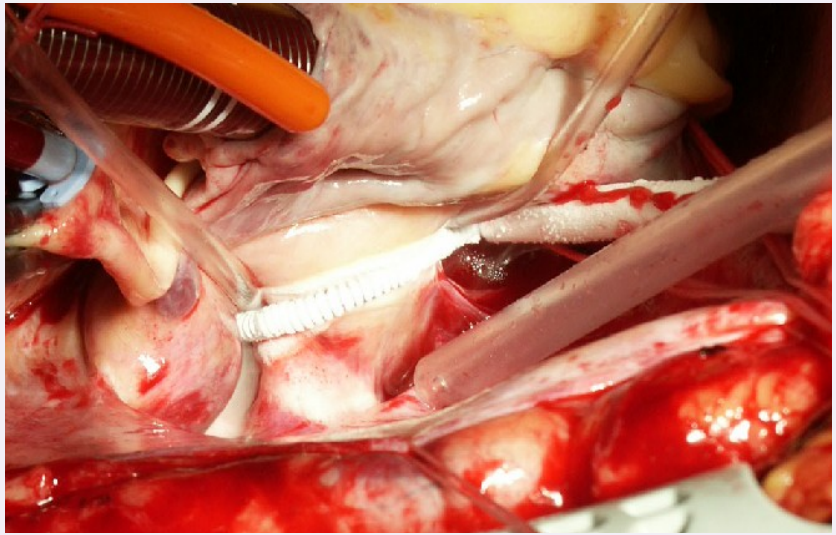
- transmural
- continual

Technique

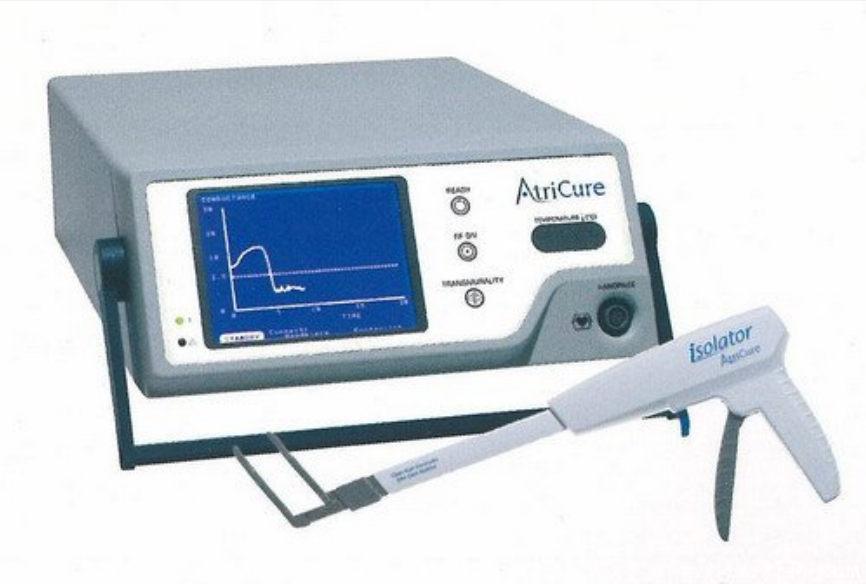
- surgical incision
- kryo
- radiofrekvency ablace

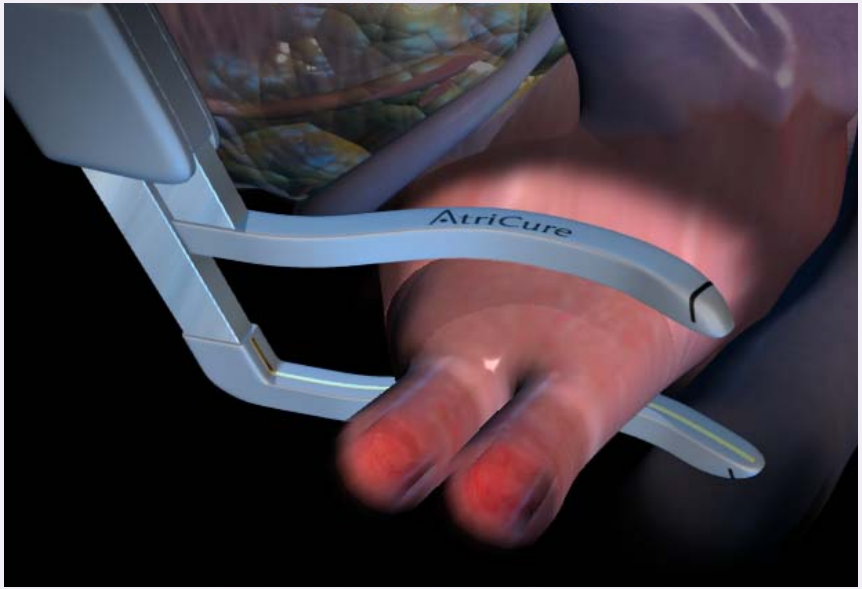


Atrial fibrilation – cryo MAZE



Atrial fibrilation – radiofrequency MAZE





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Heart transplantation

Indications

terminal heart failure
(coronary artery disease, valve disease, cardiomyopathy)

Contraindications

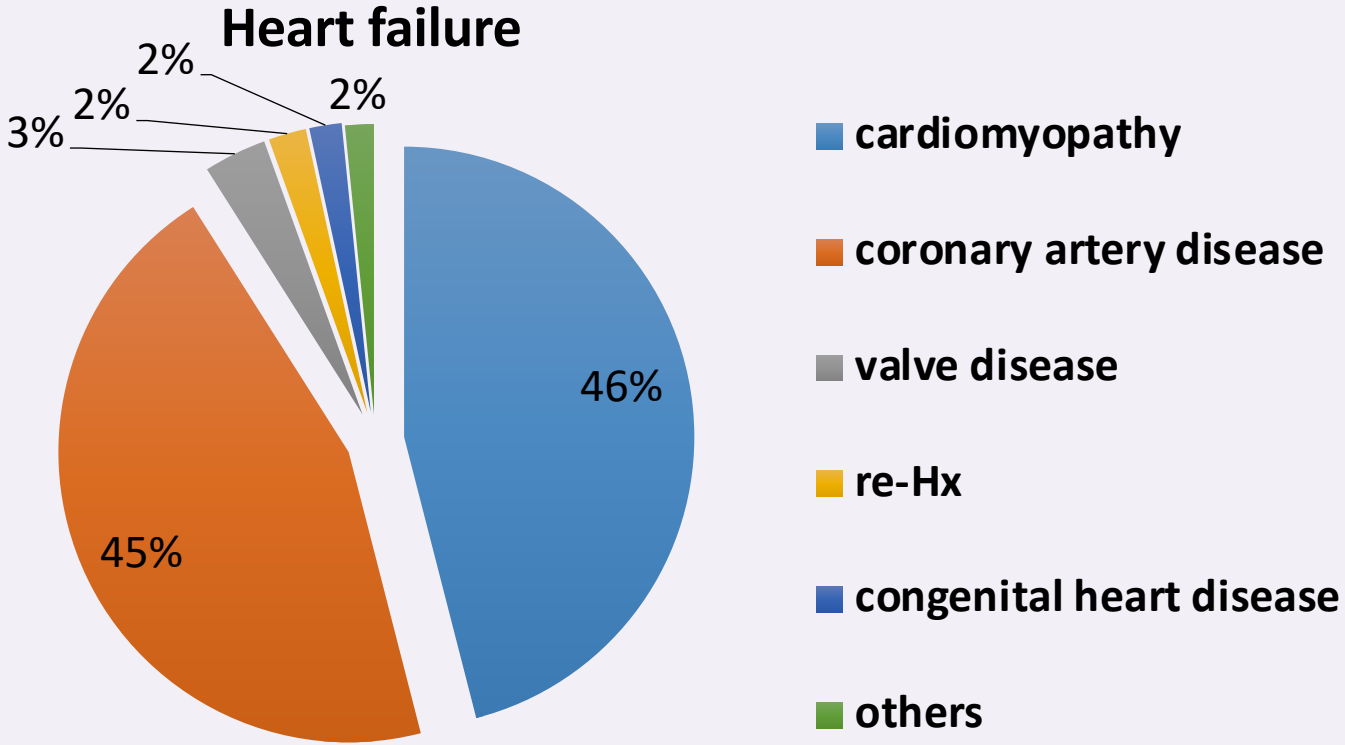
fixed pulmonary hypertension
neoplasms
HIV
active alcohol or drug abuse
age over 60 years (60-65 years – individual assessment),

Potential relative contraindications

active infection, pulmonary embolism, active peptic ulcer disease

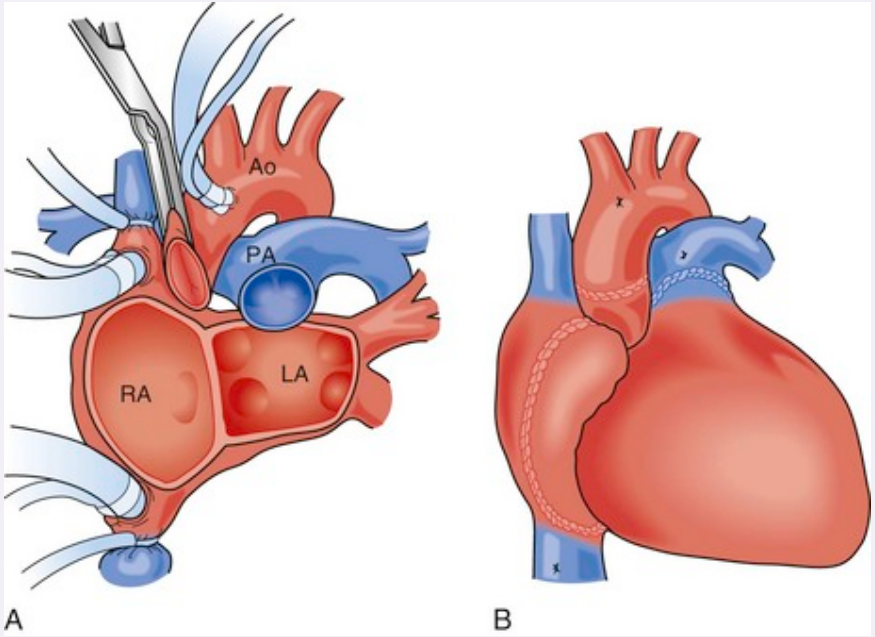
liver, kidney failure – 2 or 3 organs transplantation

Heart failure - etiology

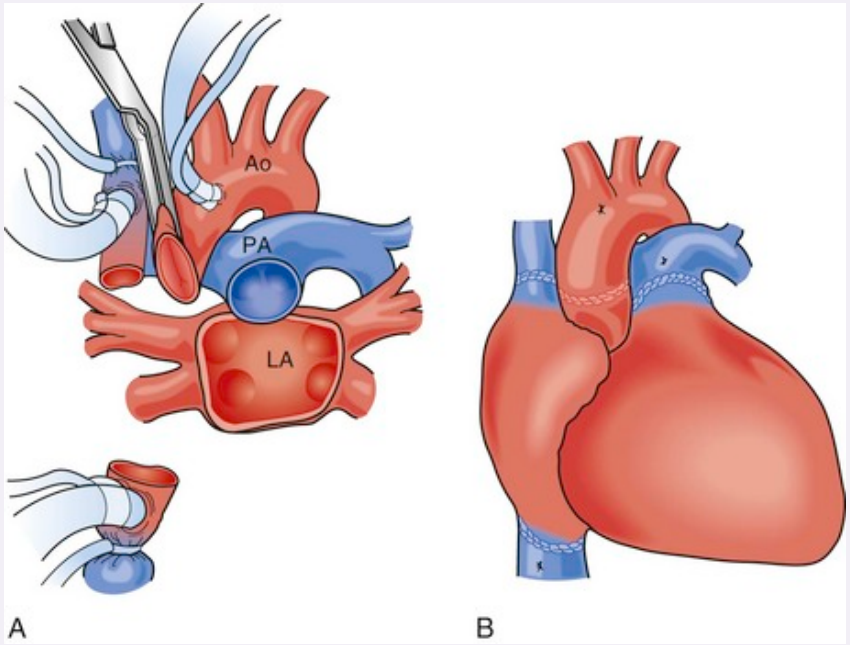


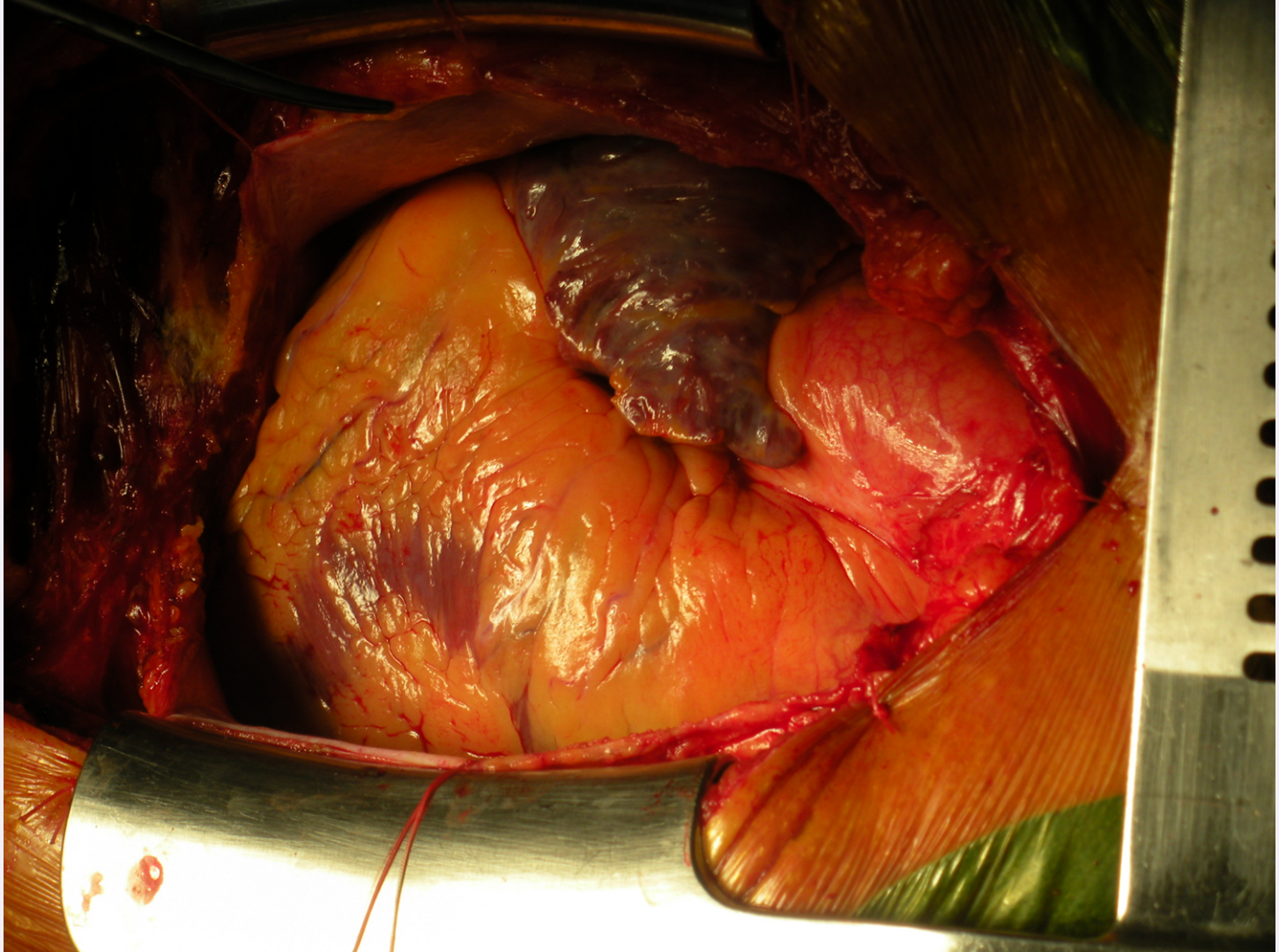
Heart transplantation - surgical technique

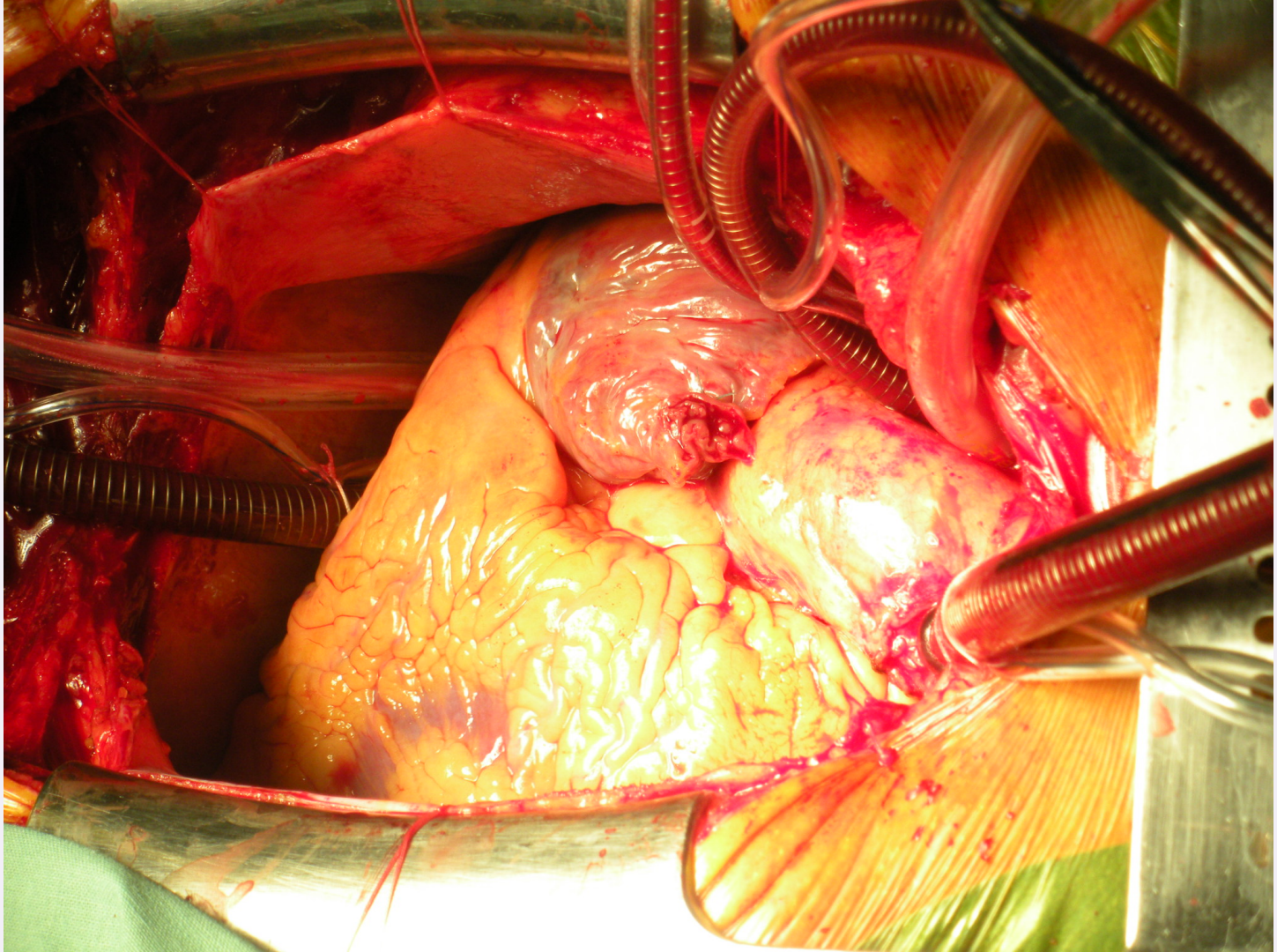
biatrial (Lower-Shumway)

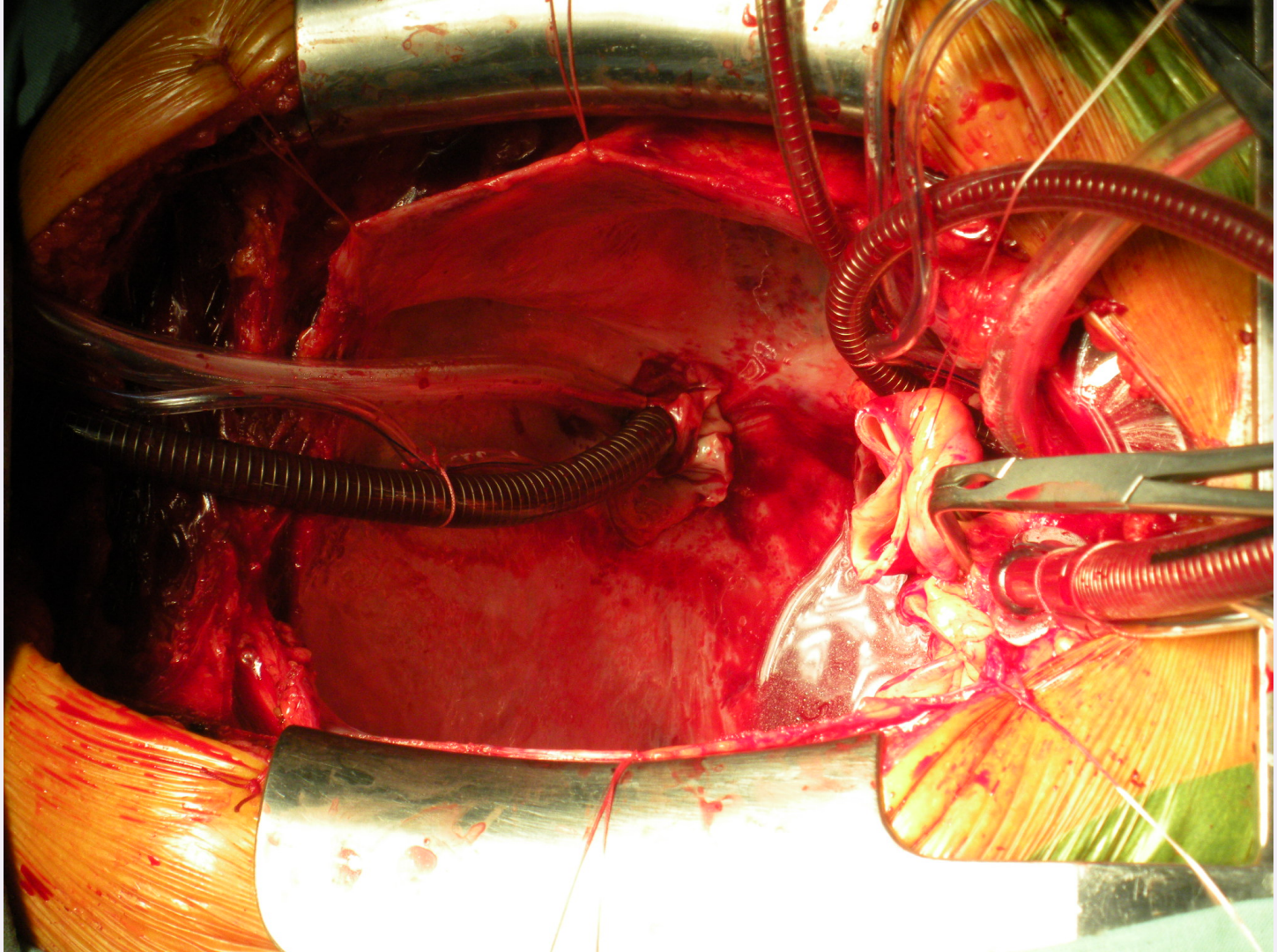


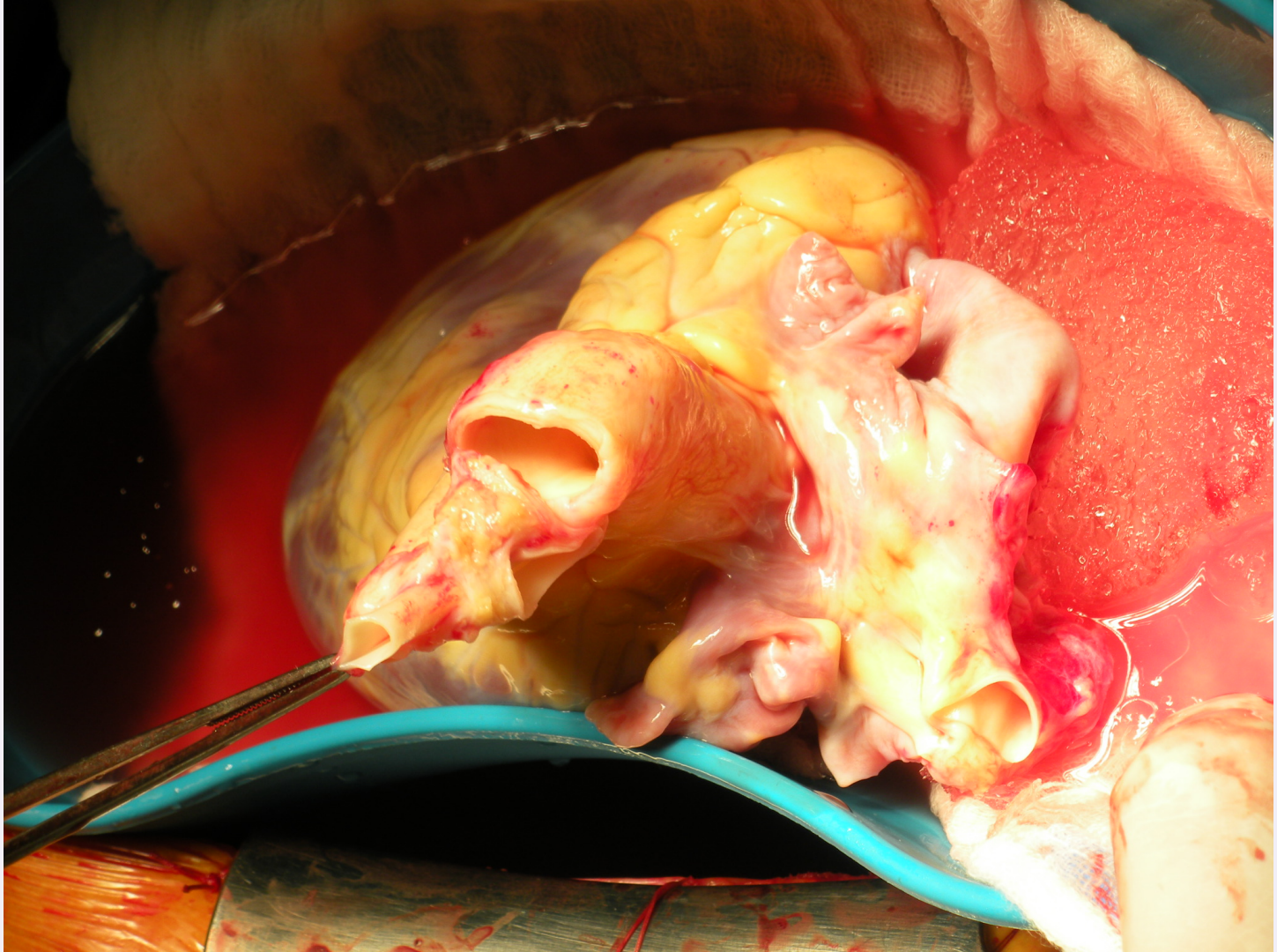
bicaval

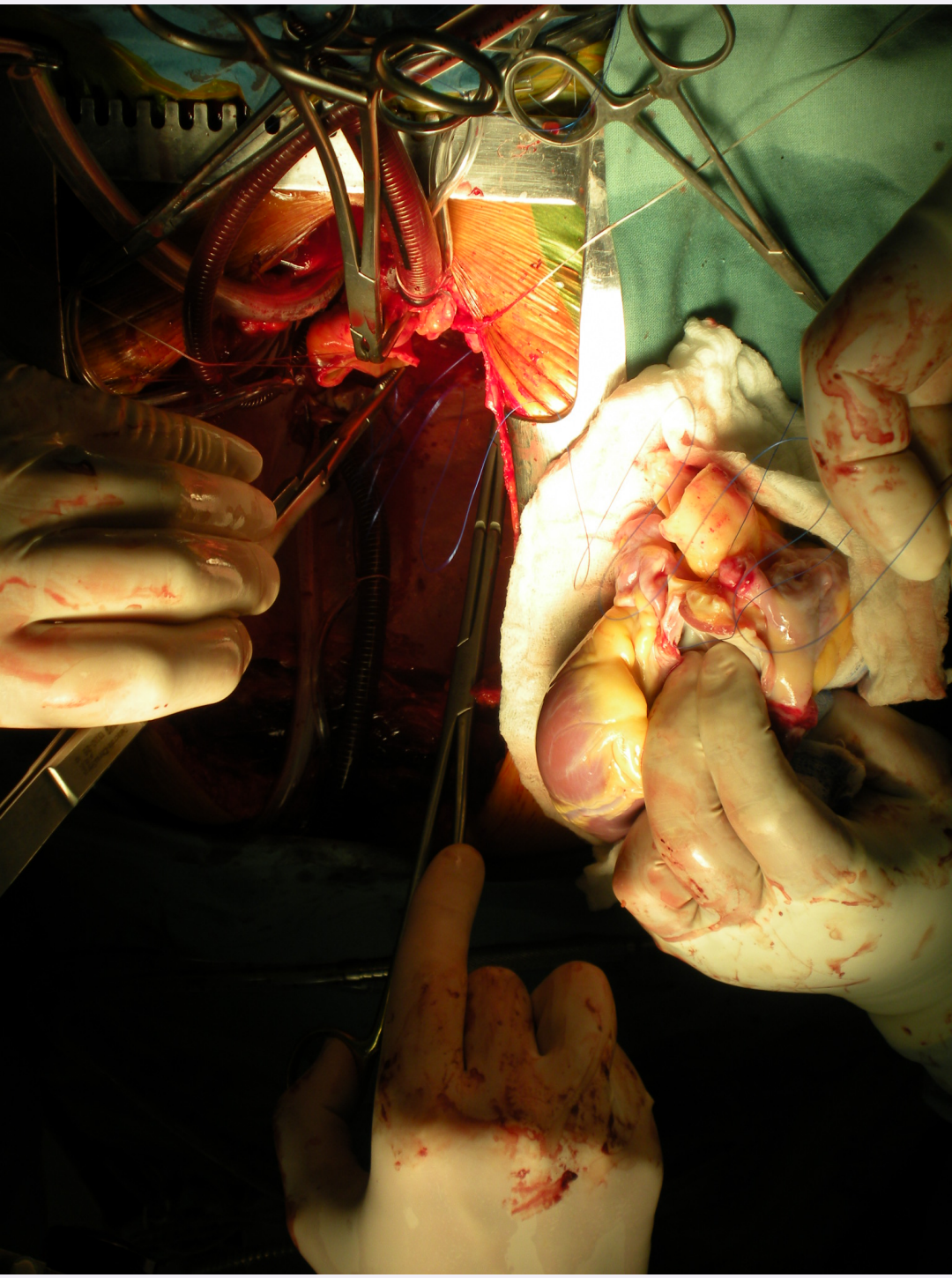


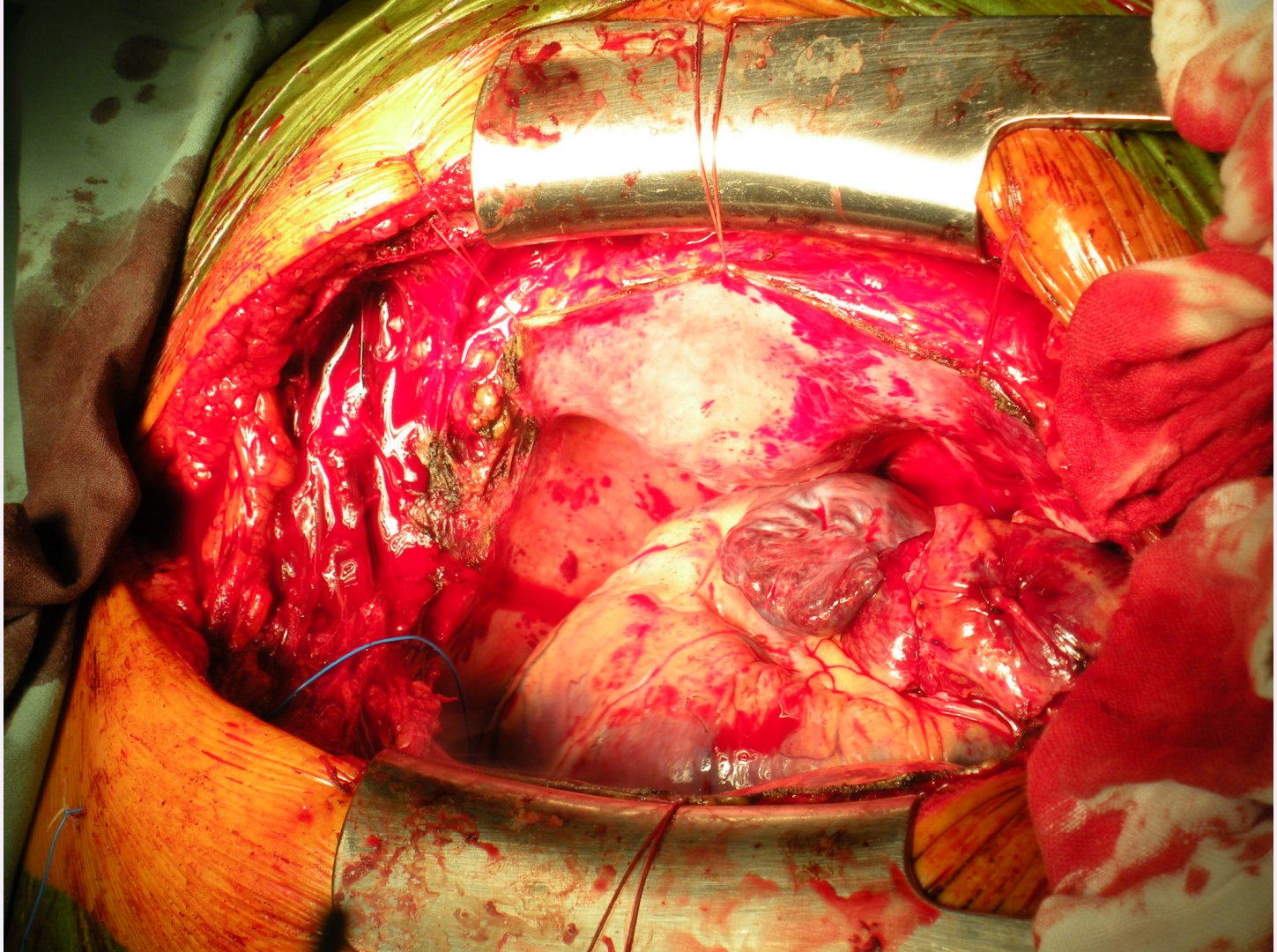


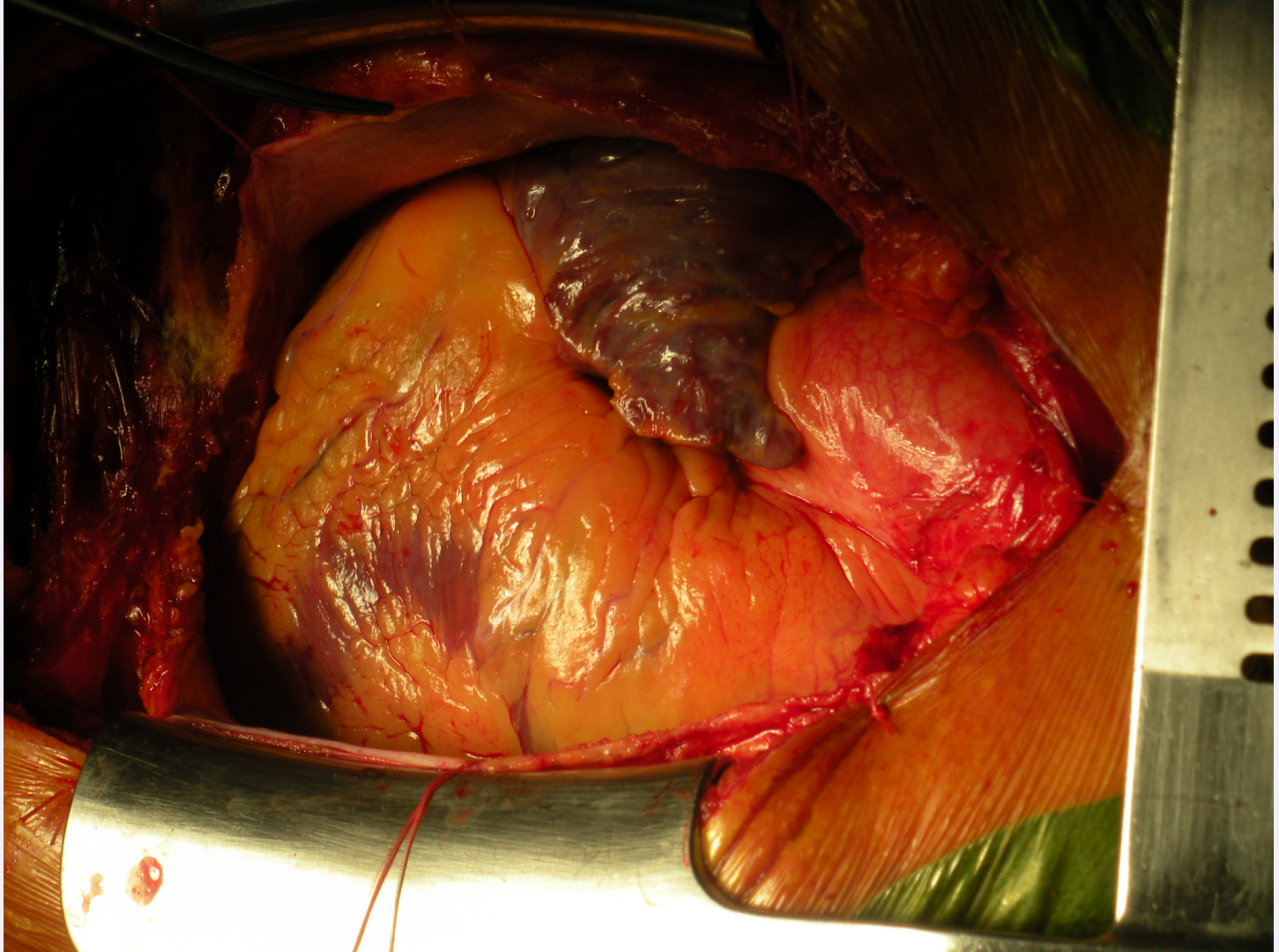












Mechanical circulatory support

Duration of support	Type of support needed	Localization	Flow
▪ **short-term** reversible damage ▪ **long-term** „brigde-to-transplantation“ ▪ **permanent** contraindications for heart transplantation	▪ **left-side** ▪ **right-side** ▪ **biventricular**	▪ **paracorporeal** ▪ **implantable**	▪ **Pulsatile** • **pneumatic** • **electromechanic** ▪ **Non-pulsatile** • **axial** • **centrifugal**

Mechanical circulatory support - indication

Postcardiotomy cardiogenic shock

unsuccessful weaning from extracorporeal circulation
malignant ventricular arrythmias
low cardiac output syndrom

Other etiology of cardiogenic shock

after acute myocardial infarction, after PCI, myocarditis…

Chronic heart failure

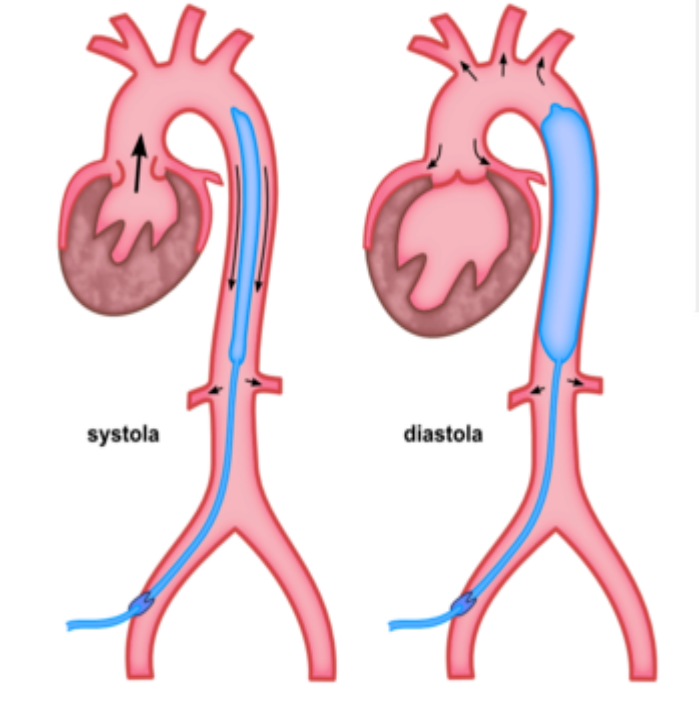
pts on waiting list for heart transplantation

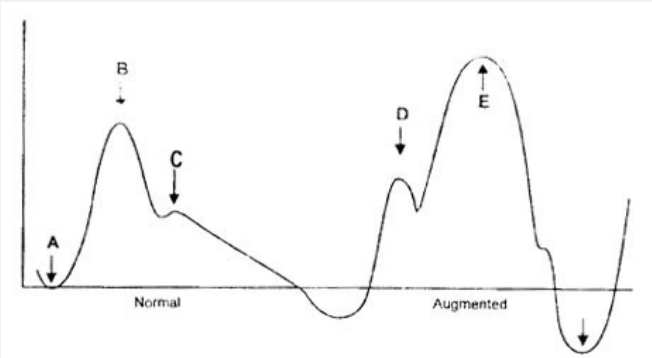
Acute rejection after HTx

Heart failure (primary graft non-function) after HTx

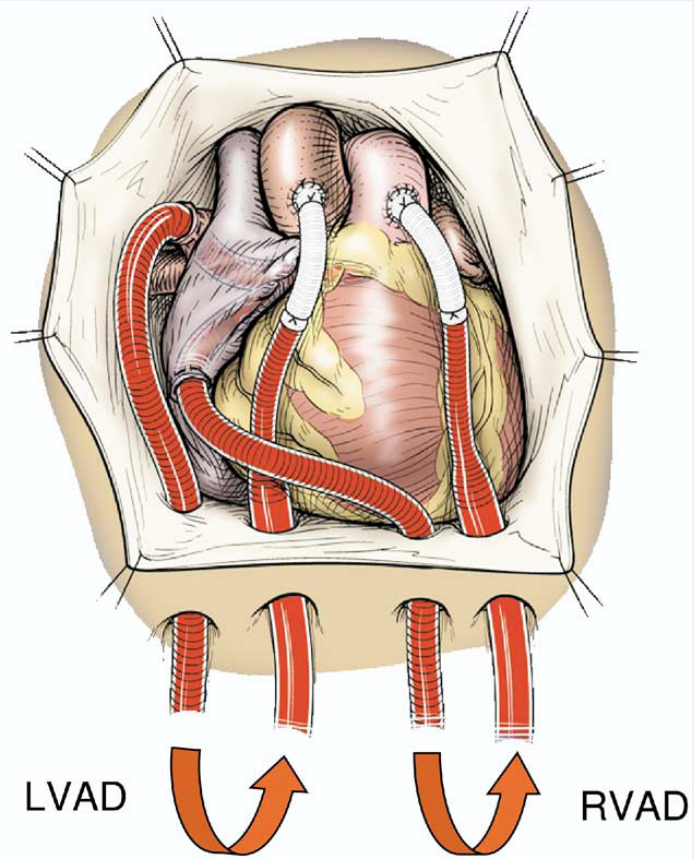
Patients with contraindications for heart transplantation

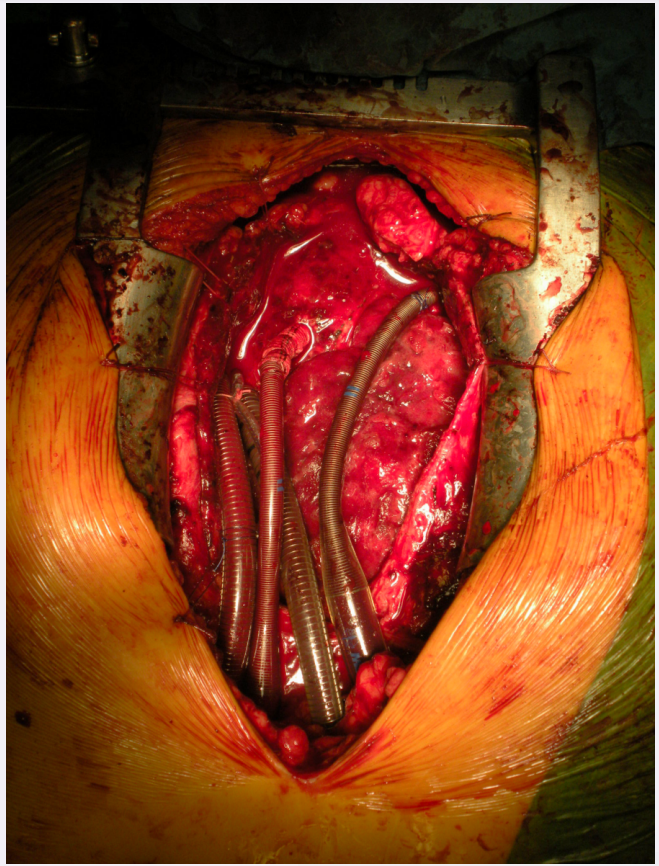
Intraaortic baloon counterpulsation





Short-term MCS - Centrimag



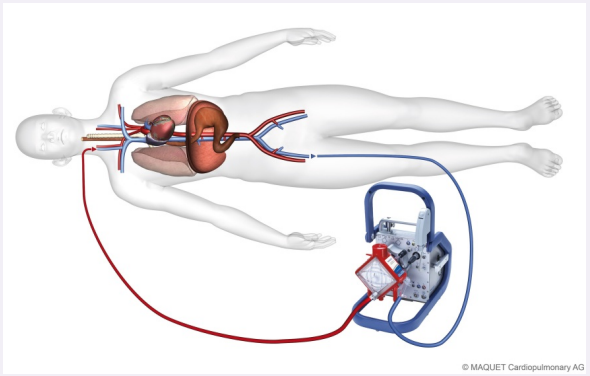


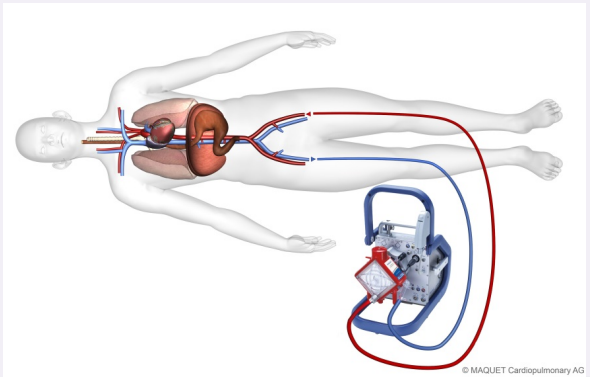
Short-term MCS - Centrimag

Short-term MCS - Centrimag

Short-term MCS - ECMO

extracorporeal membrane oxygenation





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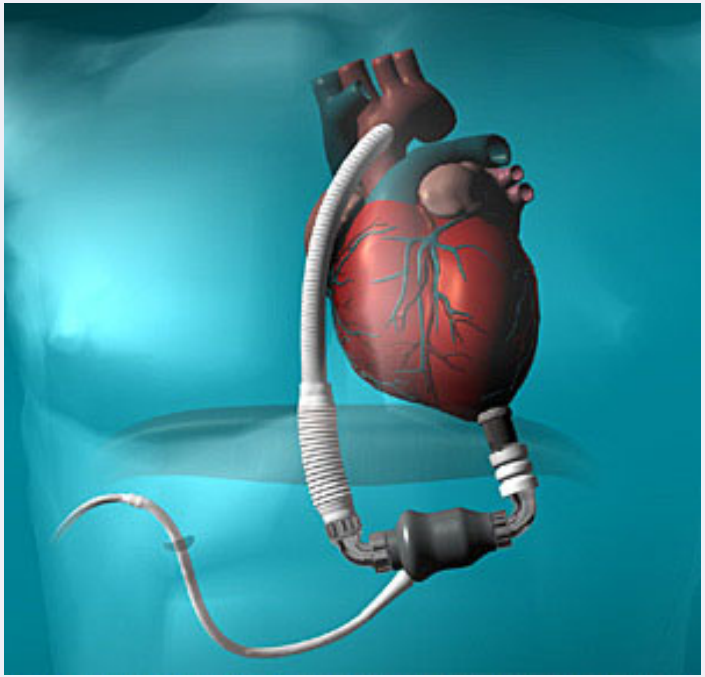
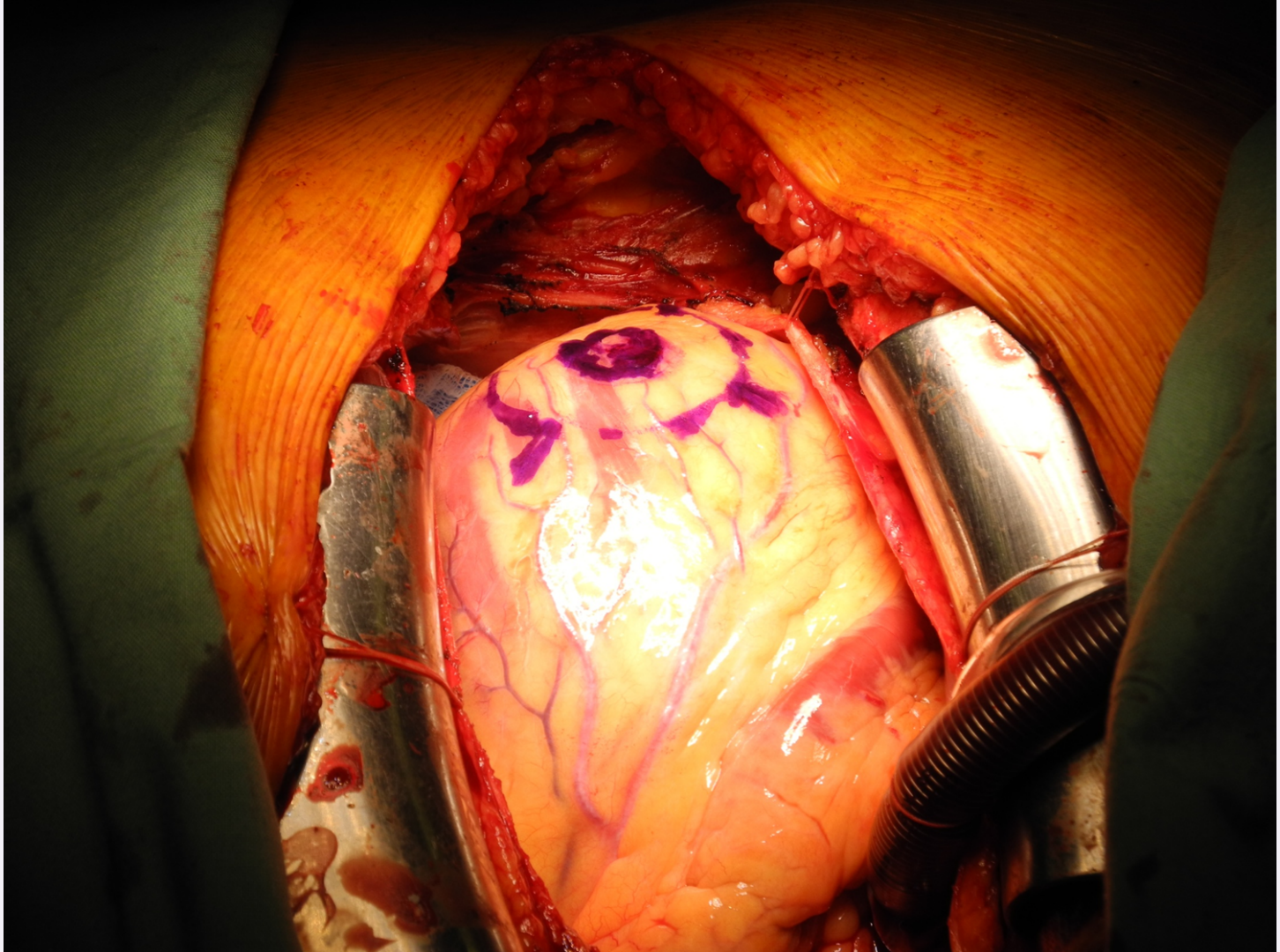
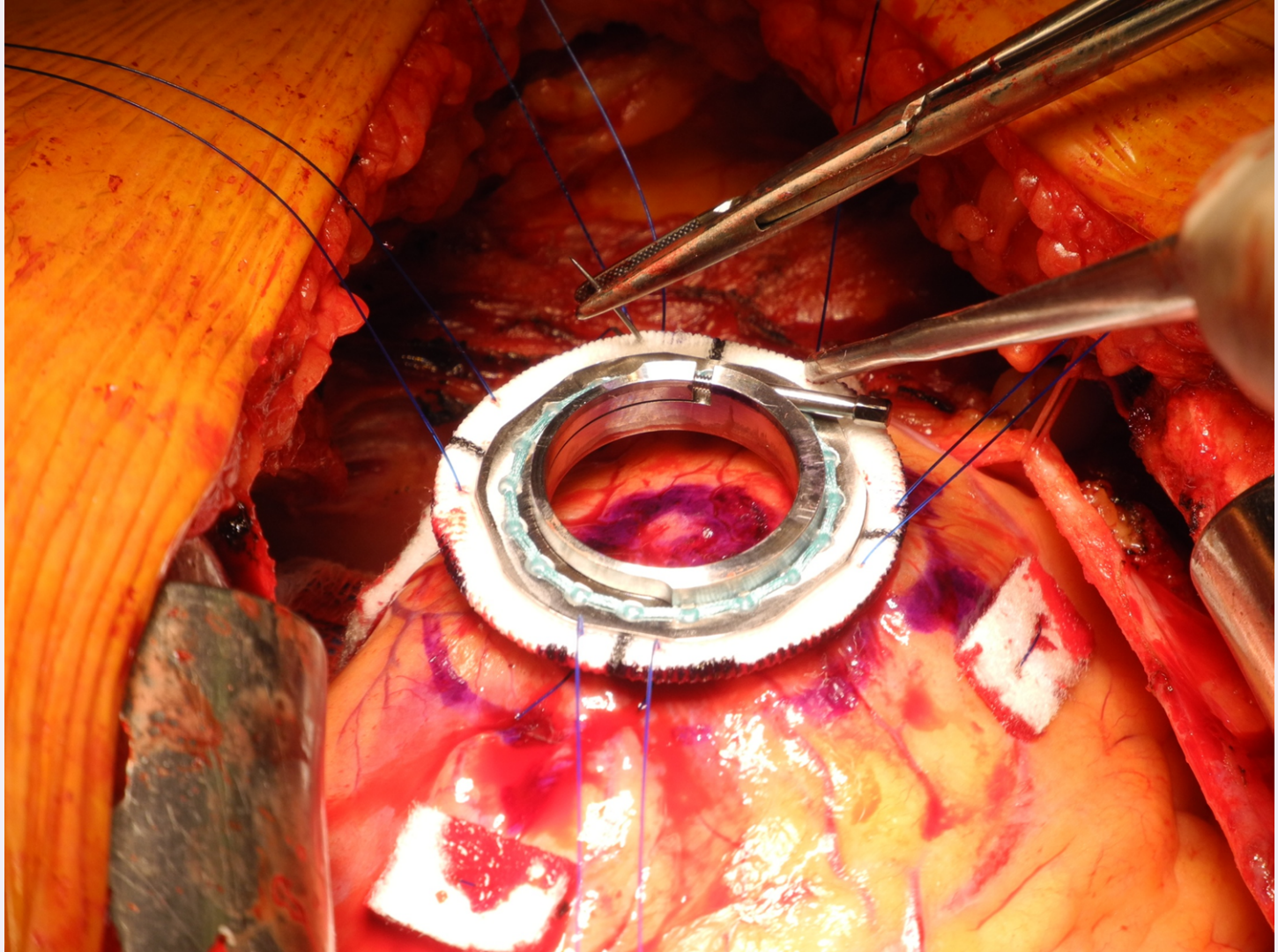
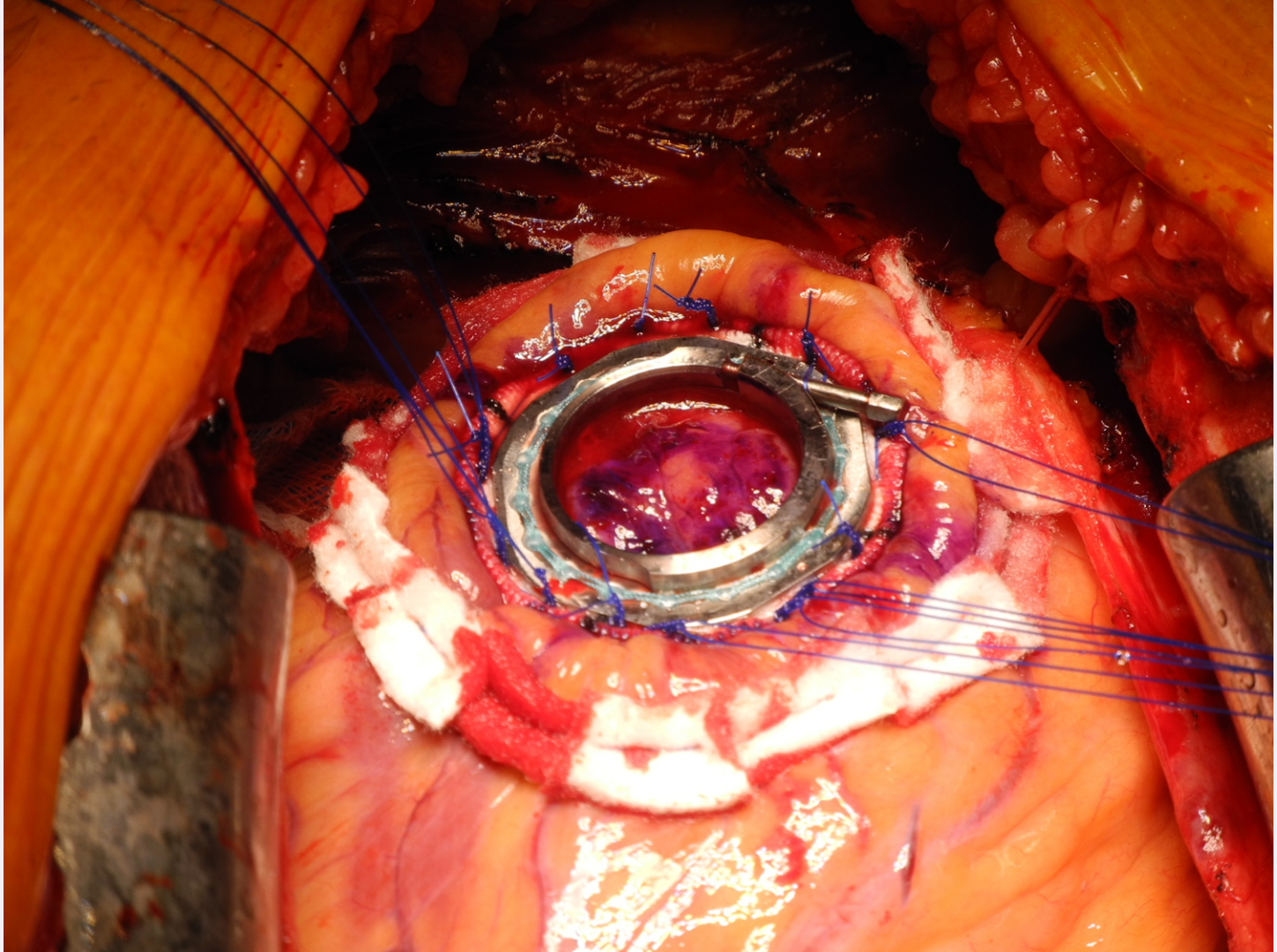
Long-term MCS – Heartmate II

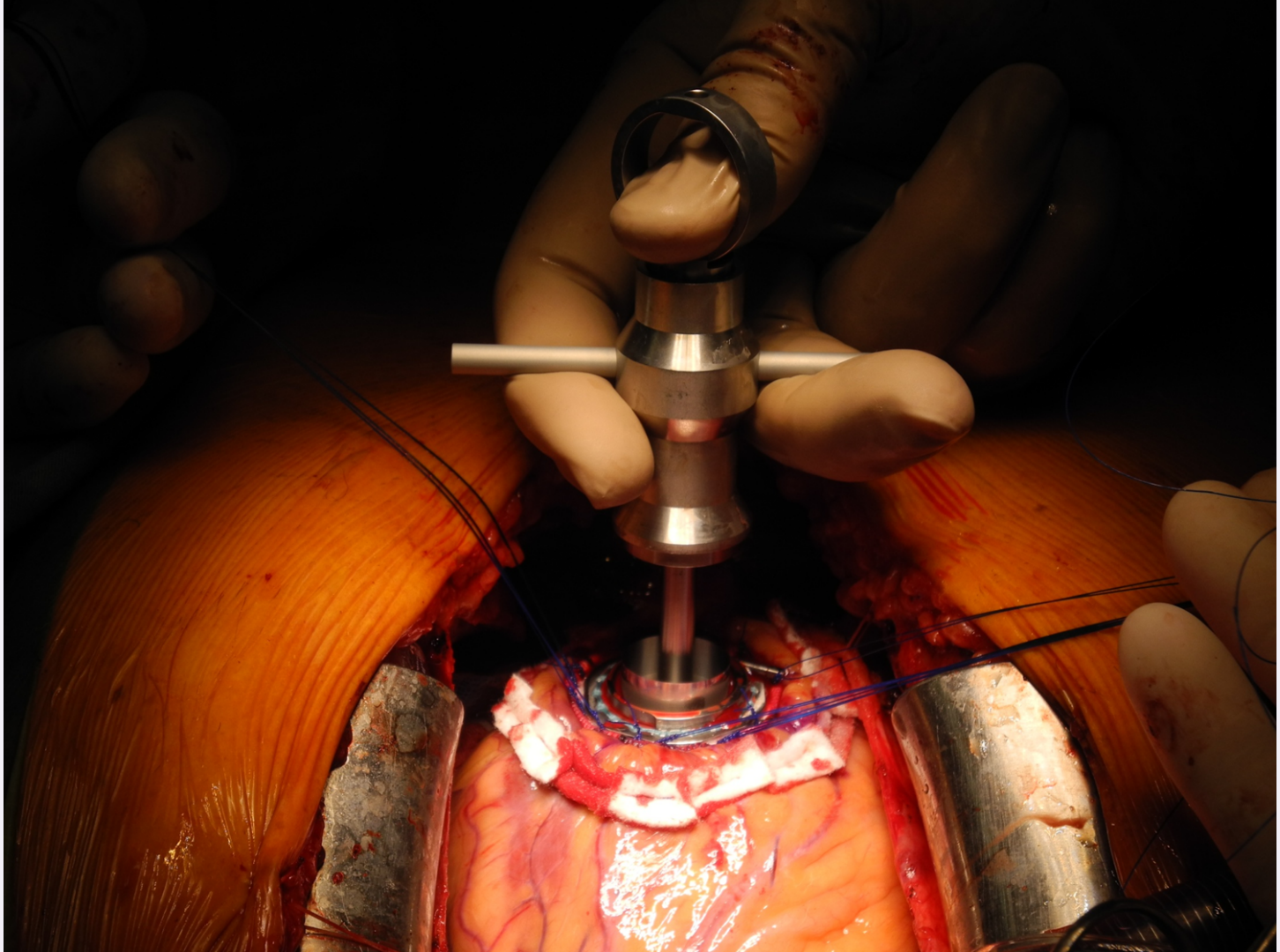


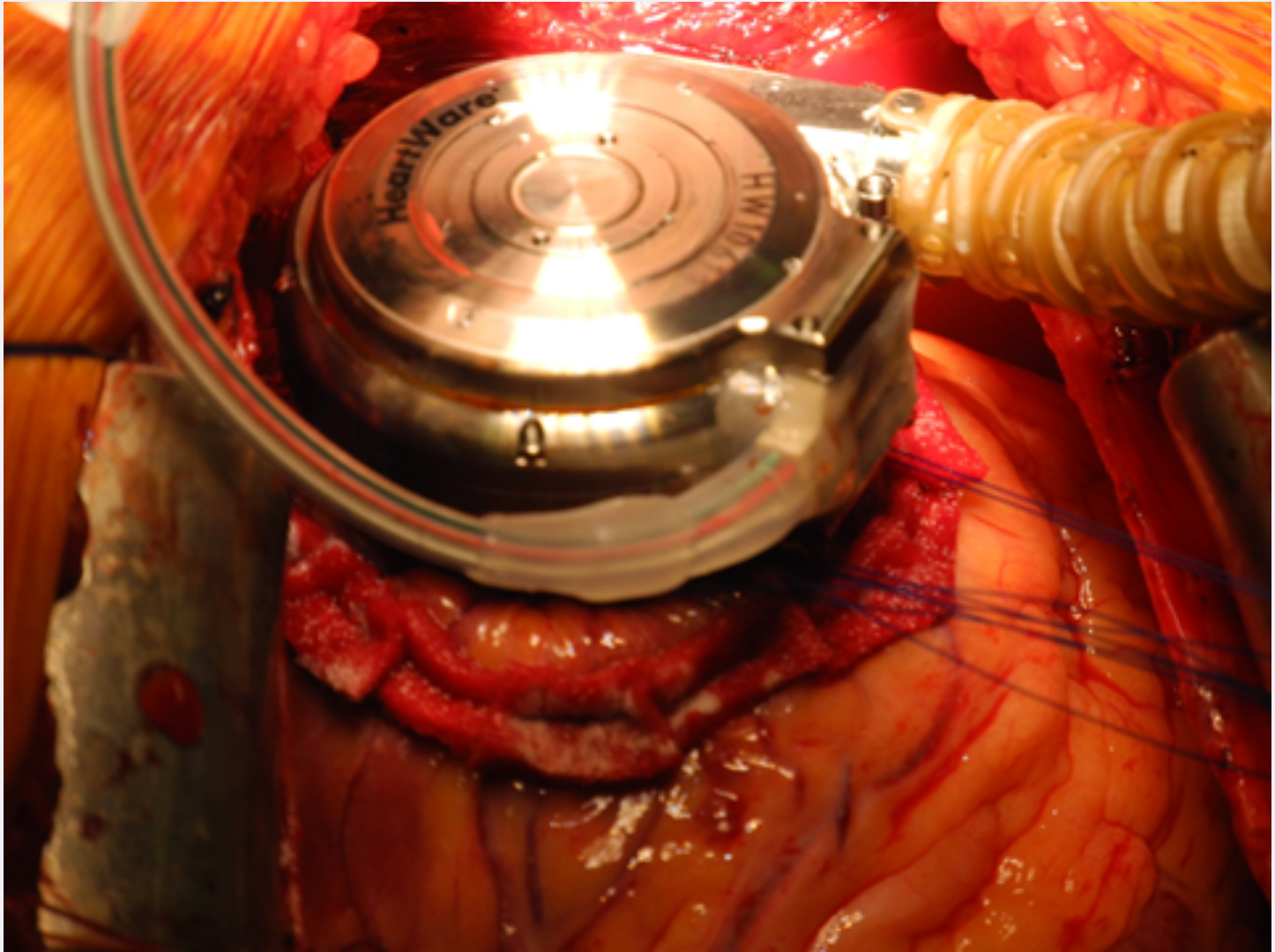
MCS - HeartWare

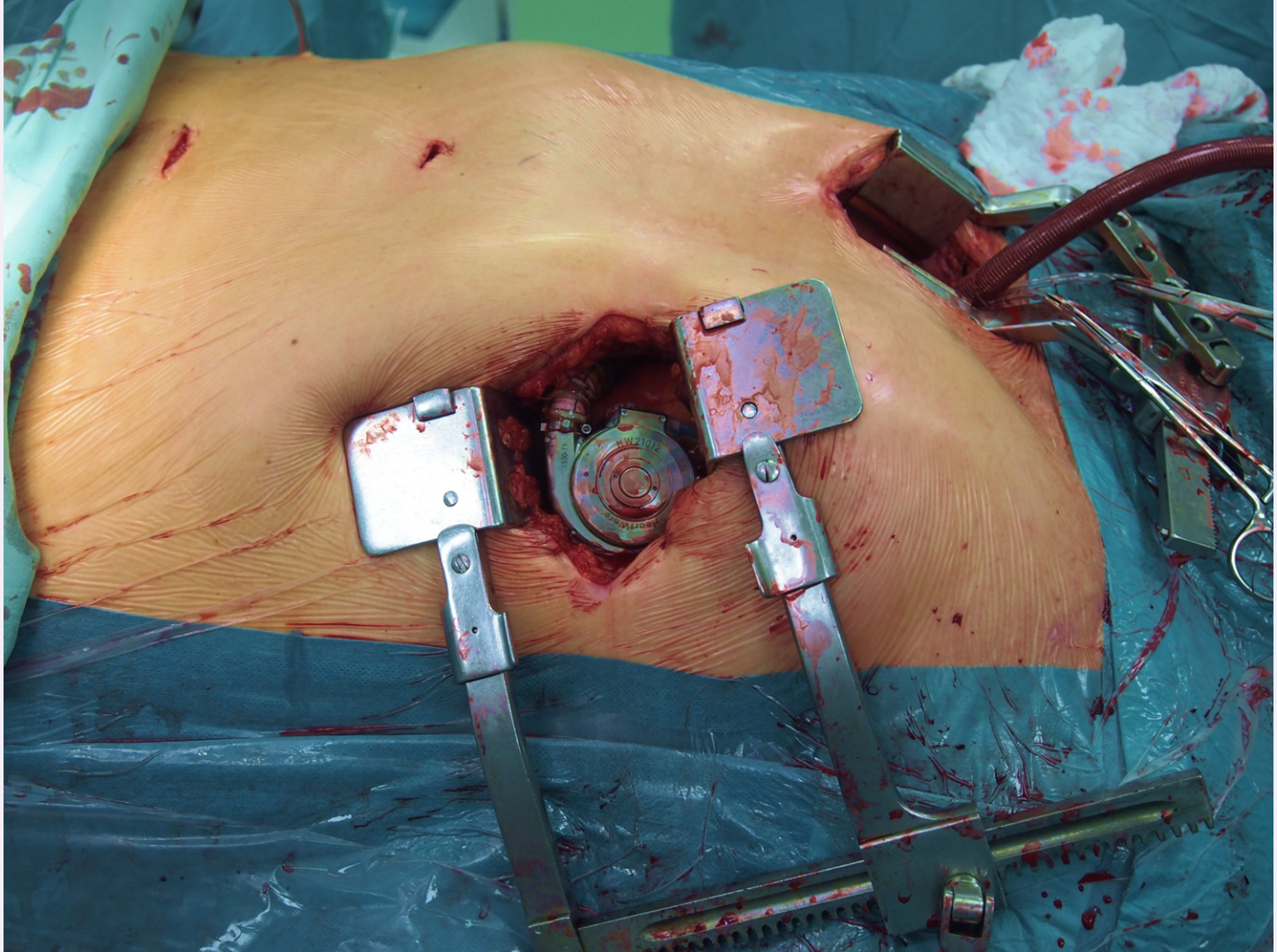


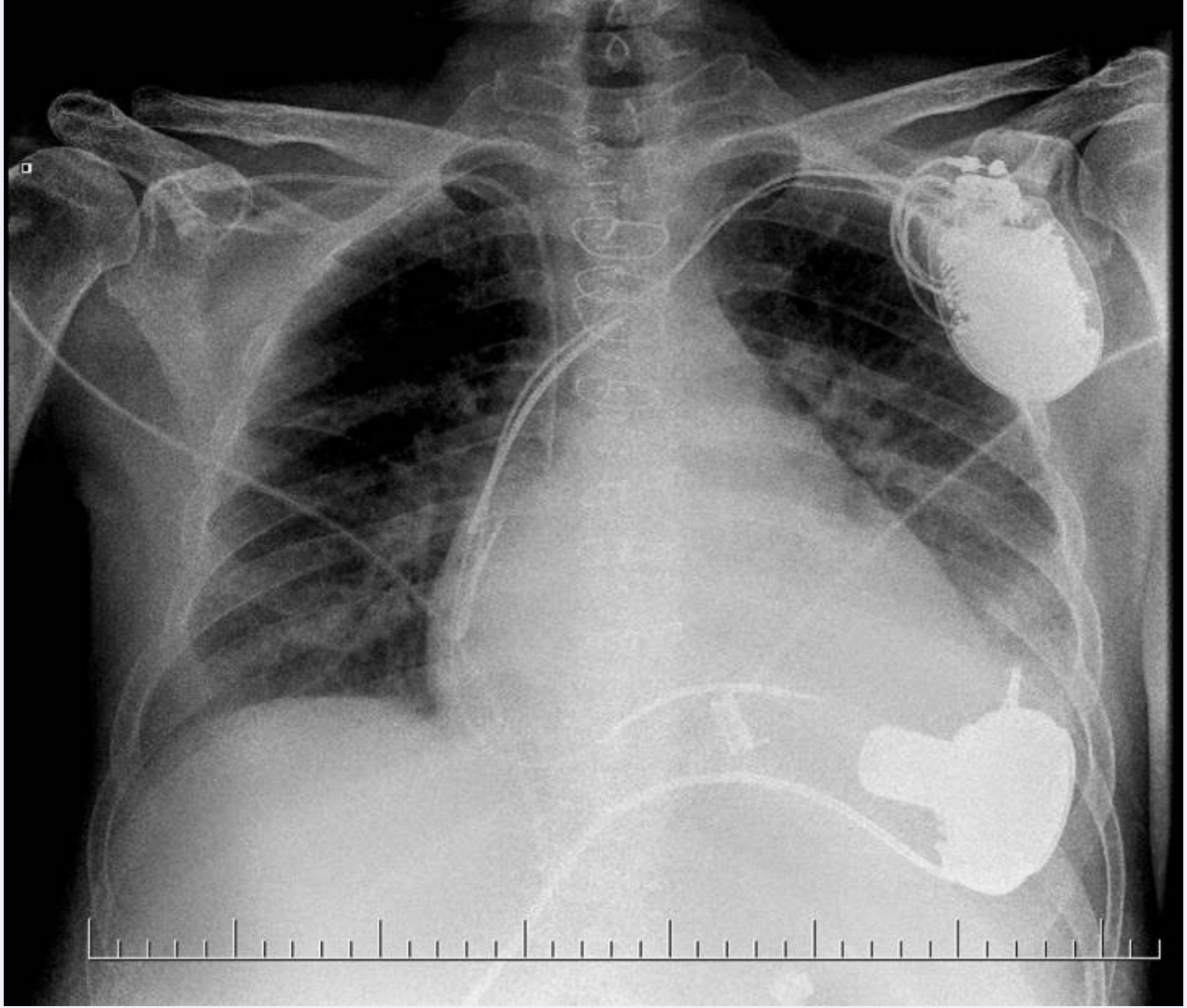




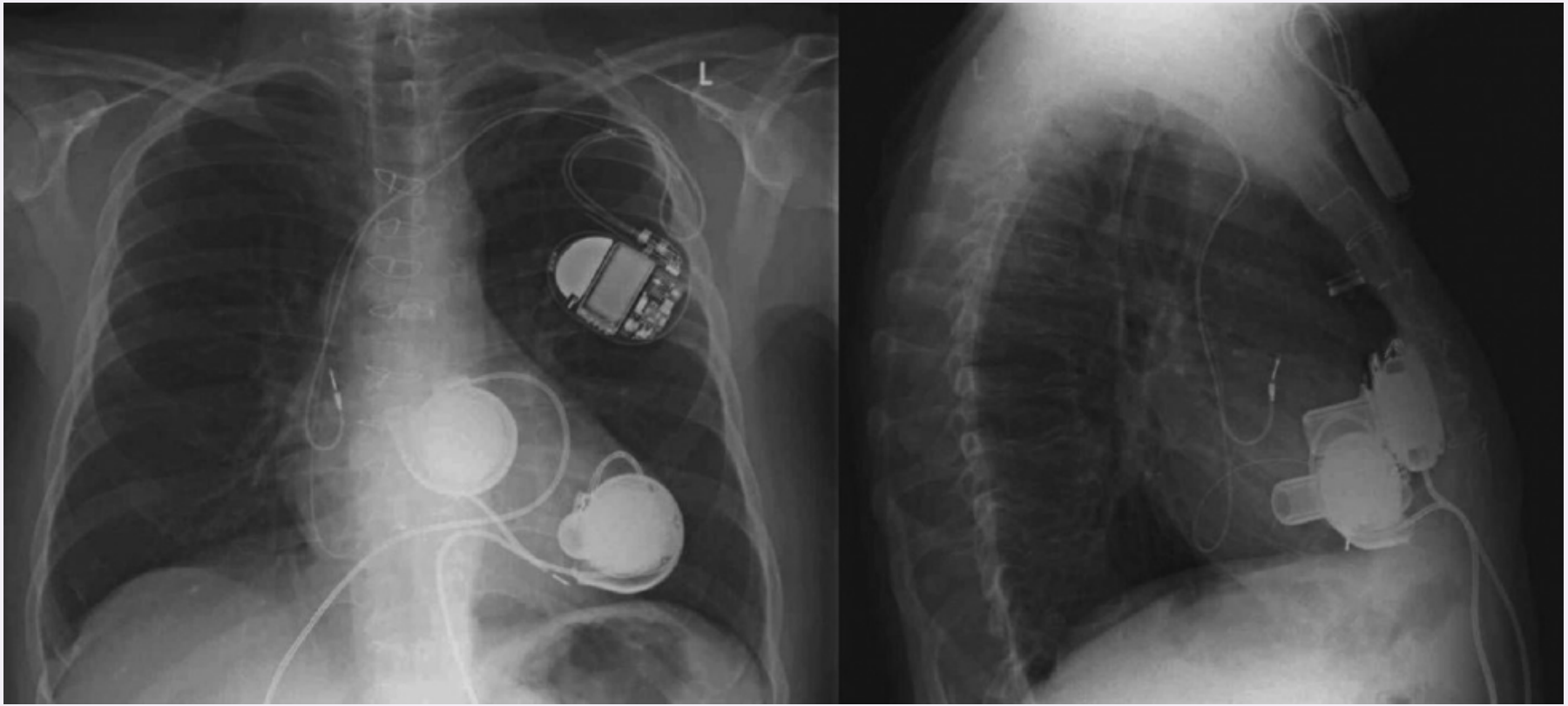



HeartWare

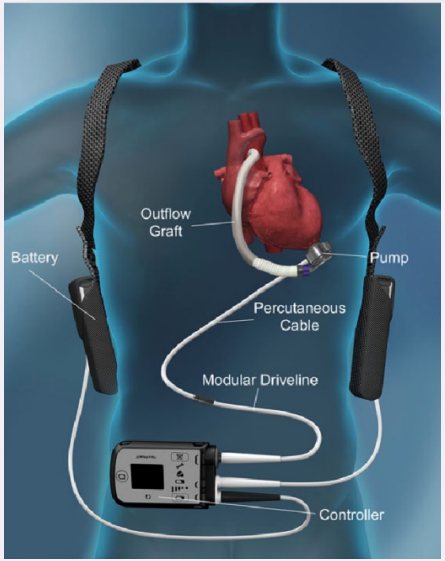


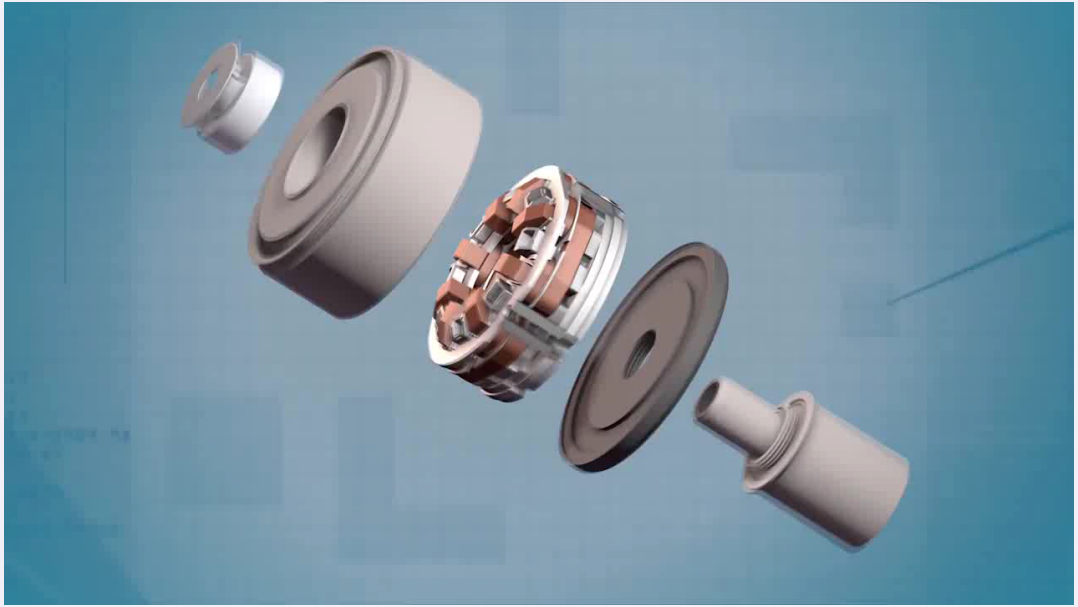


MCS – LVAD as BiVAD



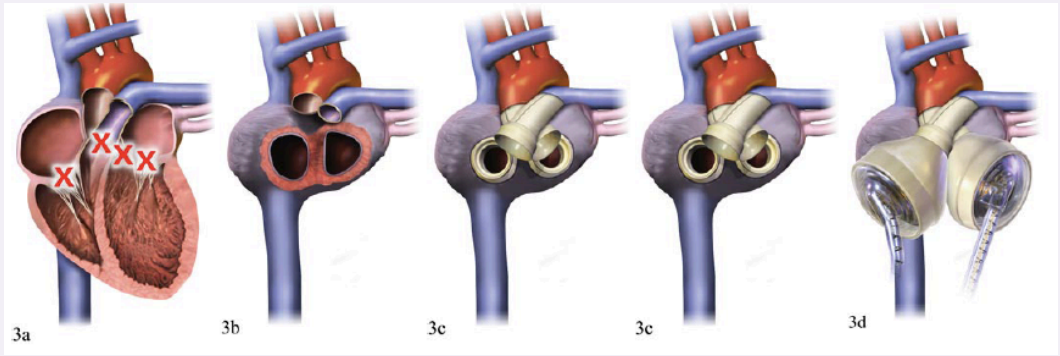
MCS – HEARTMATE 3

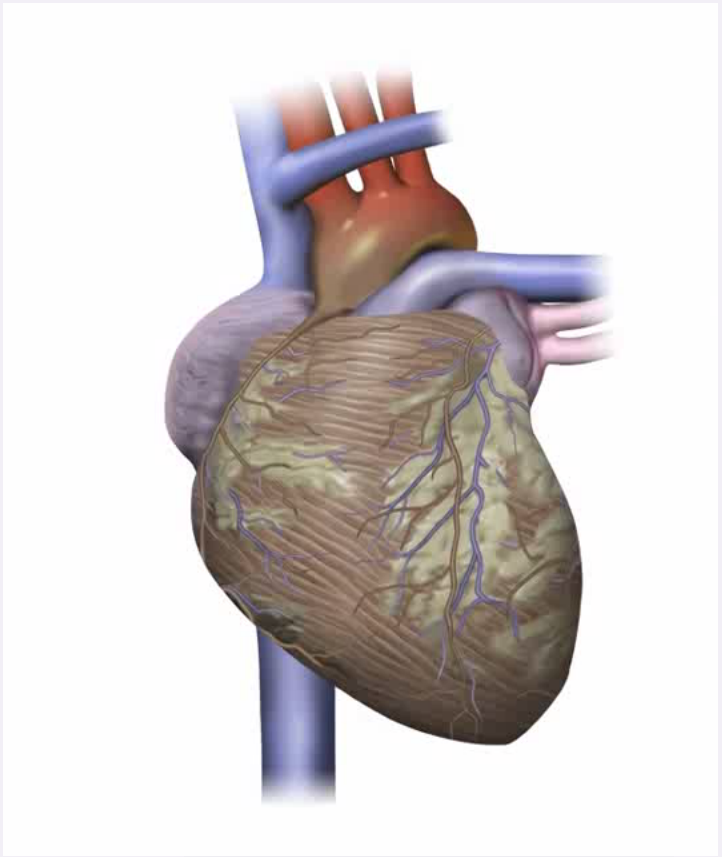




Total artificial heart - Syncardia

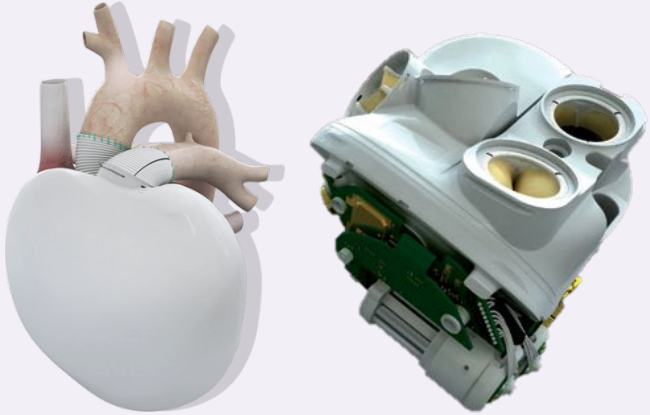
- pneumatic pump – pulsatile flow
- bridge-to-transplant
- noise

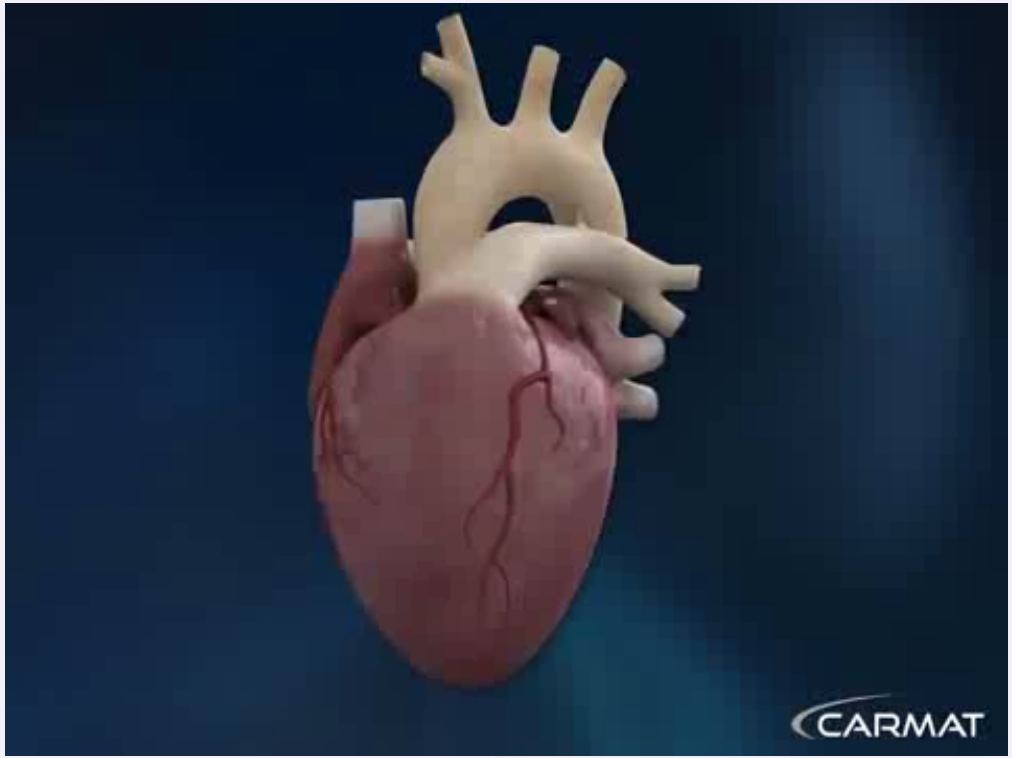




Total artificial heart - Carmat

- electrohydraulic pump, biological valves, membranes - bovine pericardium
- pulsatile flow, autoregulation





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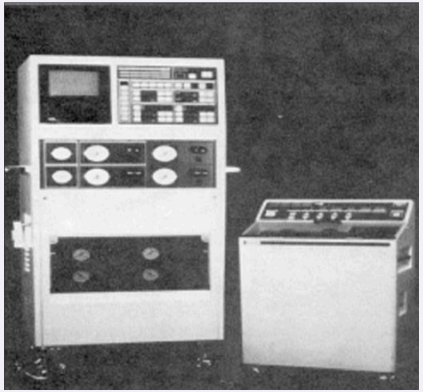
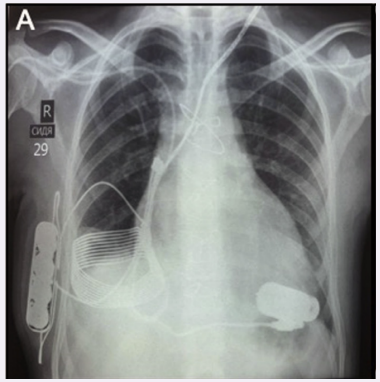
MCS - future

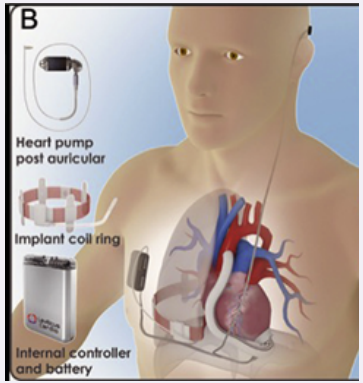
- miniaturization??? – external components
- wireless
- telemonitoring
- no anticoagulation

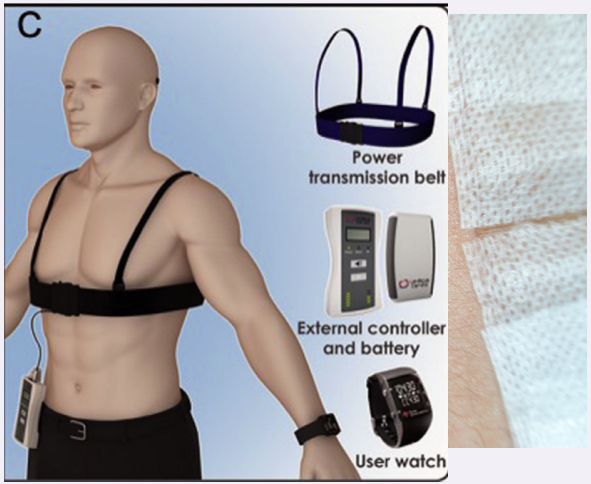
MCS – future - miniaturization

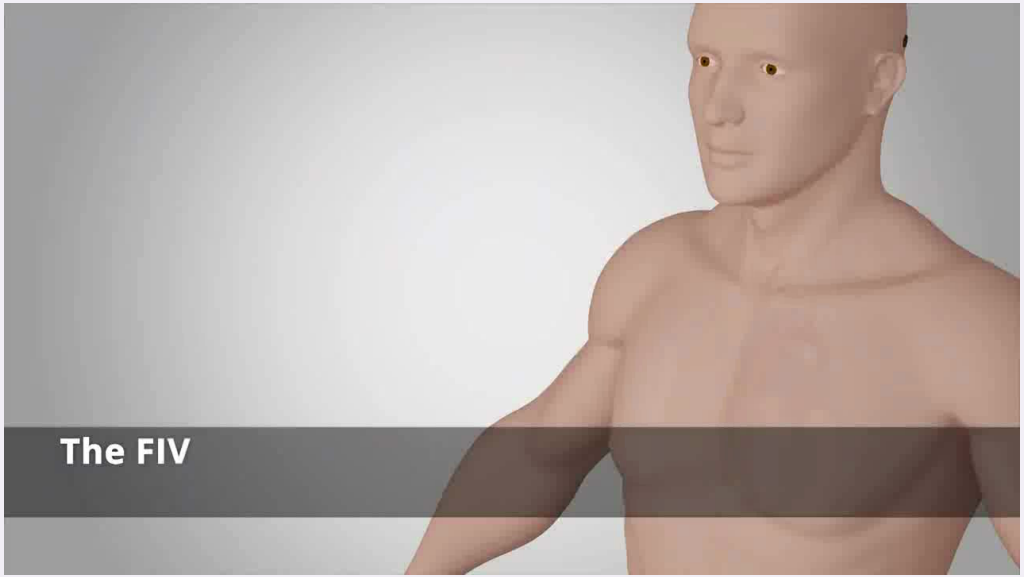


MCS – future - wireless

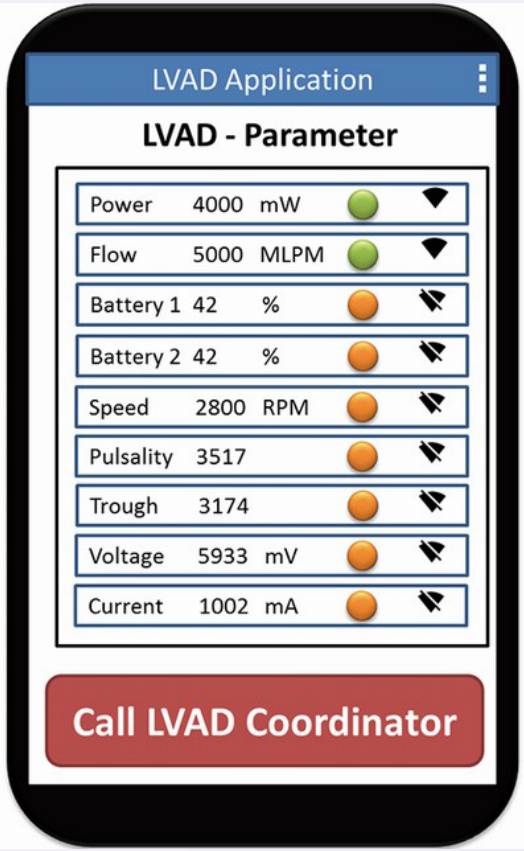








MCS – future - telemonitoring



MCS – future – no anticoagulation

Evaluation of low-intensity anti-coagulation with a fully magnetically levitated centrifugal-flow circulatory pump—the MAGENTUM 1 study

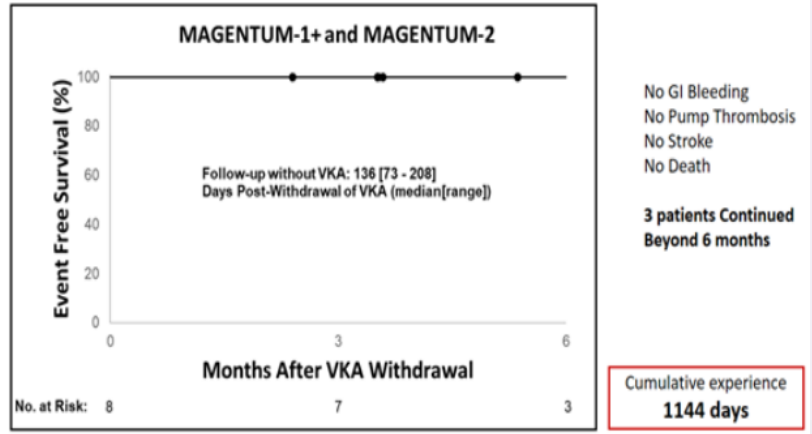
Ivan Netuka, MD, PhD[a,*], Peter Ivák, MD, PhD[a,b], Zuzana Tučanová, MD[a], Stanislav Gregor, PharmD[c], Ondrej Szárszoi, MD, PhD[a], Poornima Sood, MD[d], Daniel Crandall, PhD[d], Jessica Rimsans, PharmD, BCPS[e], Jean Marie Connors, MD[f], Mandeep R. Mehra, MD[g]

A Trial of Complete Withdrawal of Anticoagulation Therapy in the Heartmate 3 Pump

I. Netuka[1,*], P. Ivak[1], Z. Tucanova[1], S. Gregor[1], O. Szarszoi[1], J. Rimsans[2], J. Connors[2], D. Crandall[3], P. Sood[3], M. Mehra[2]

after 6 weeks - ↓ INR 1,5-1,9
n = 15
after 6 months
- no stroke, no pump thrombosis
- 1x GI bleeding

from MAGENTUM 1 study – n = 5
MAGENTUM 2 – after 6 months – complete withdrawal anticoagulation therapy



Netuka, I, et al. JHLT, 2018, 37.5: 579-586
Netuka I., et al. JHLT, 2019, 38.4: S113

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