Cardiac anesthesia and intensive care

Dr. Kiss Rudolf

Cardiac procedures - anesthesia

- Cardiac surgical procedures:
  - coronaries, valves, septal defects
  - aorta
  - pericardial diseases (fluid, tumor)
  - Transplant, assist devices
  - congenital diseases
- Anesthesia – intensive therapy:
  - Patient safety
  - Ensure the conditions for surgical procedure

Anesthesia

- Patient's state – possible complications
  - Monitoring
  - Induction of anesthesia
  - Transfusion, bleeding
  - Other complications

Anesthesia - Monitoring

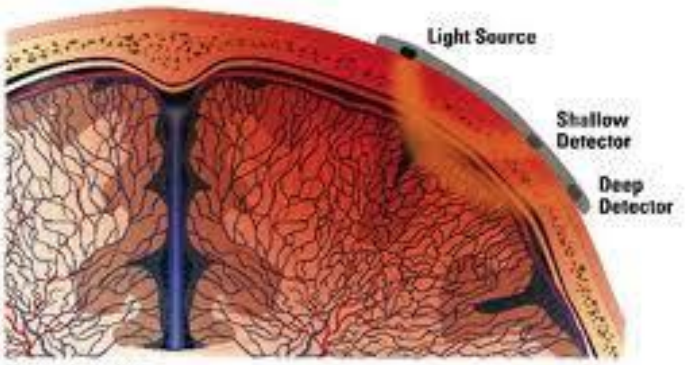
- Basic monitoring:
  - ECG,
  - Invasive BP,
  - CVP (central venous line),
  - SpO_2,
  - Urine output
  - Temperature
  - (+ large-bore periferal venous line)

- Transoesophageal echocardiography (TOE or TEE)
- Invasive haemodynamic monitor:
  - Swan-Ganz catheter
  - PiCCO (Pulse Conture Cardiac Output)
- **N**ear **I**nfra**R**ed **S**pectroscopy, **BiS**pectral index

Near **I**nfra**R**ed **S**pectroscopy

Medtronic.com

Wemed1.com



Procrna.com

Cerebral oximetry

BiSpectral index

En.wikipedia.org

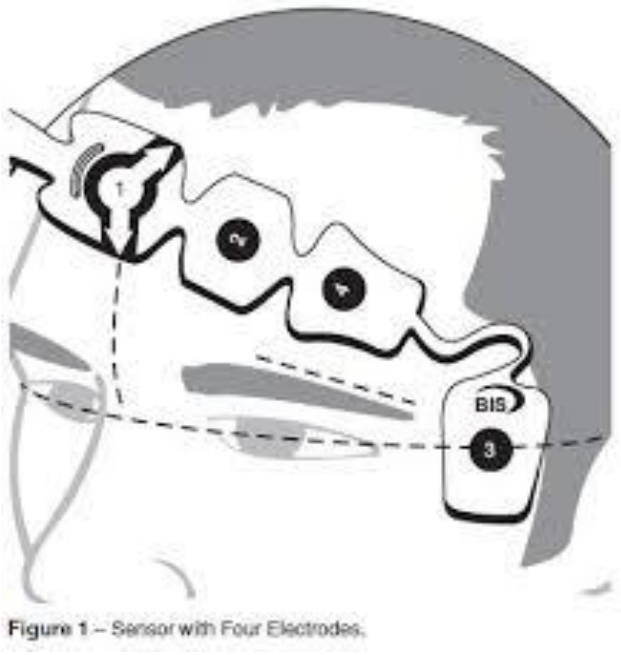
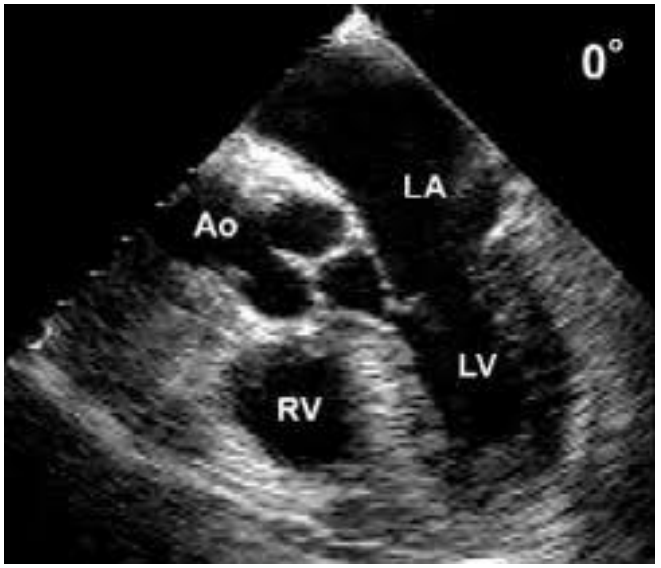


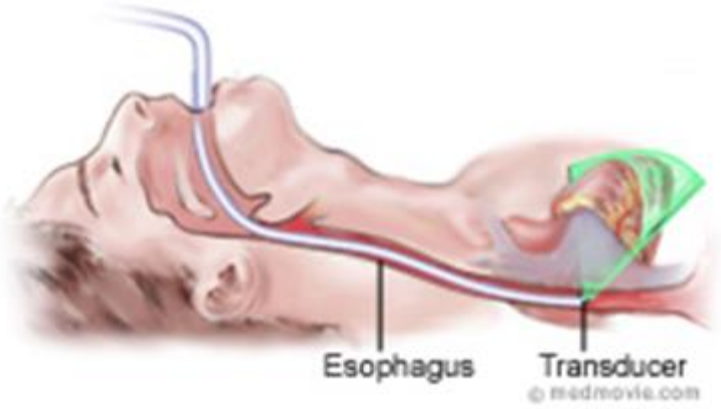
Figure 1 – Sensor with Four Electrodes.

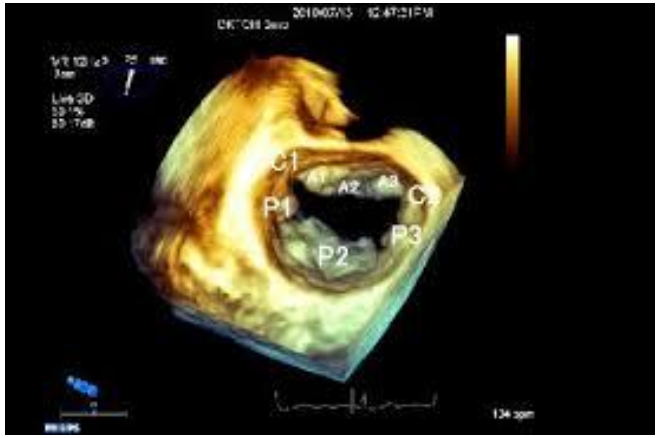
Doctorig.blogspot.com

EEG-based „depth of anesthesia”

Transoesophageal echocardiography



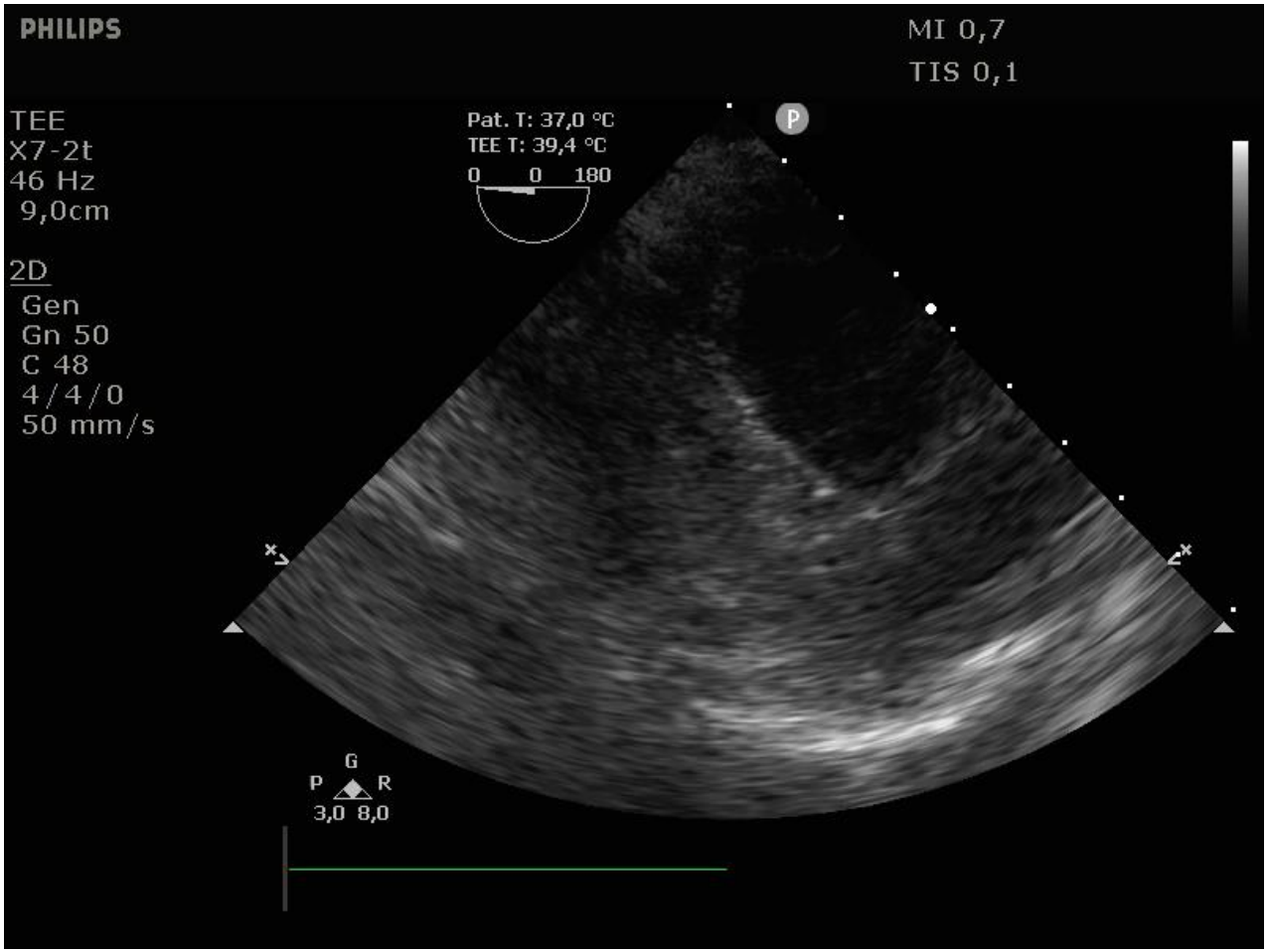




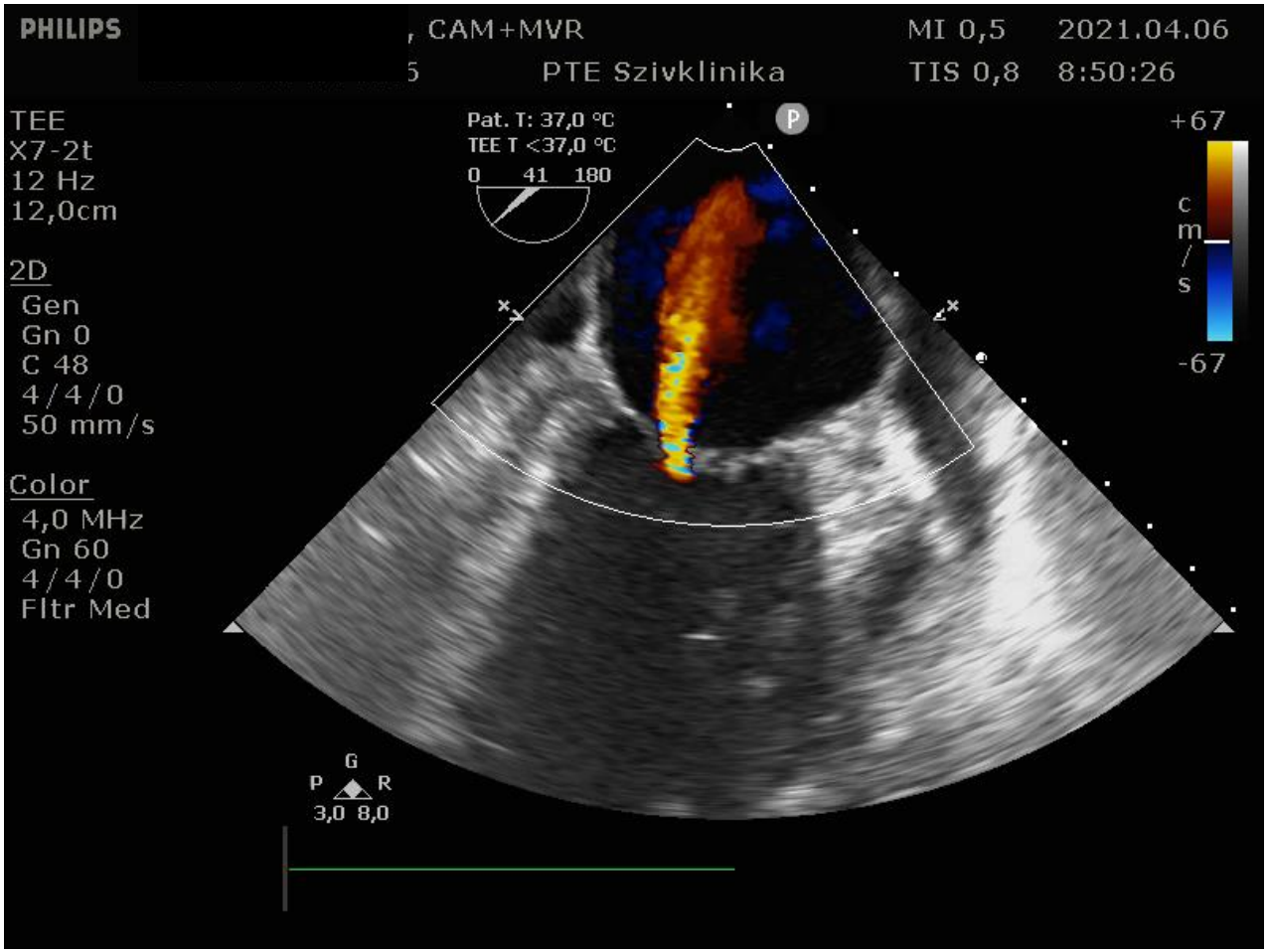
Transoesophageal echocardiography

- Questions after induction:
  - Wall motion abnormality
  - Valves – regurgitation, stenosis
    - Significant?
  - Atrial septum defect
  - Ascending aorta – plaque
- Valvuloplasty – planing, control
- Heart function after CPB

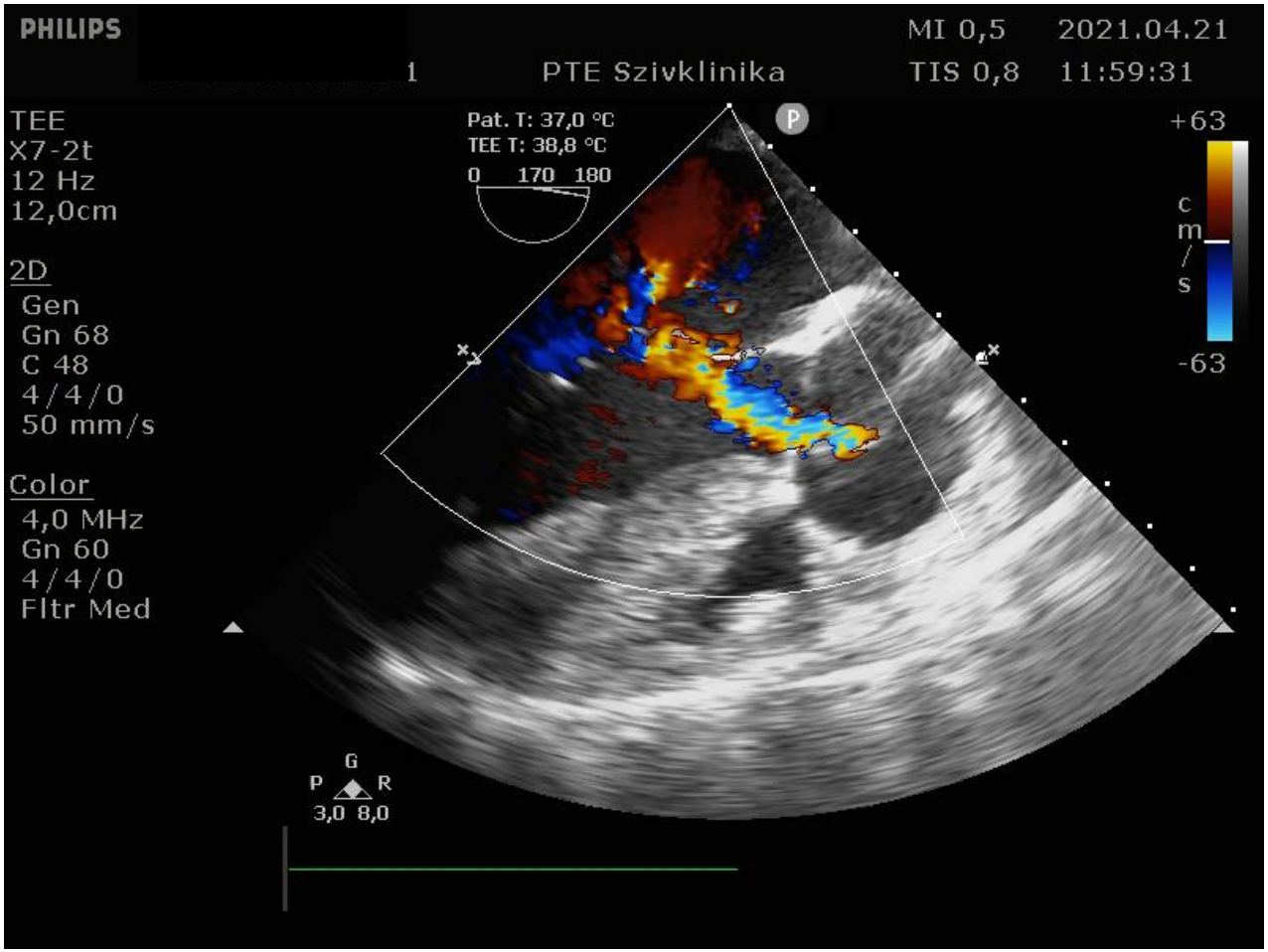
Transoesophageal echocardiography



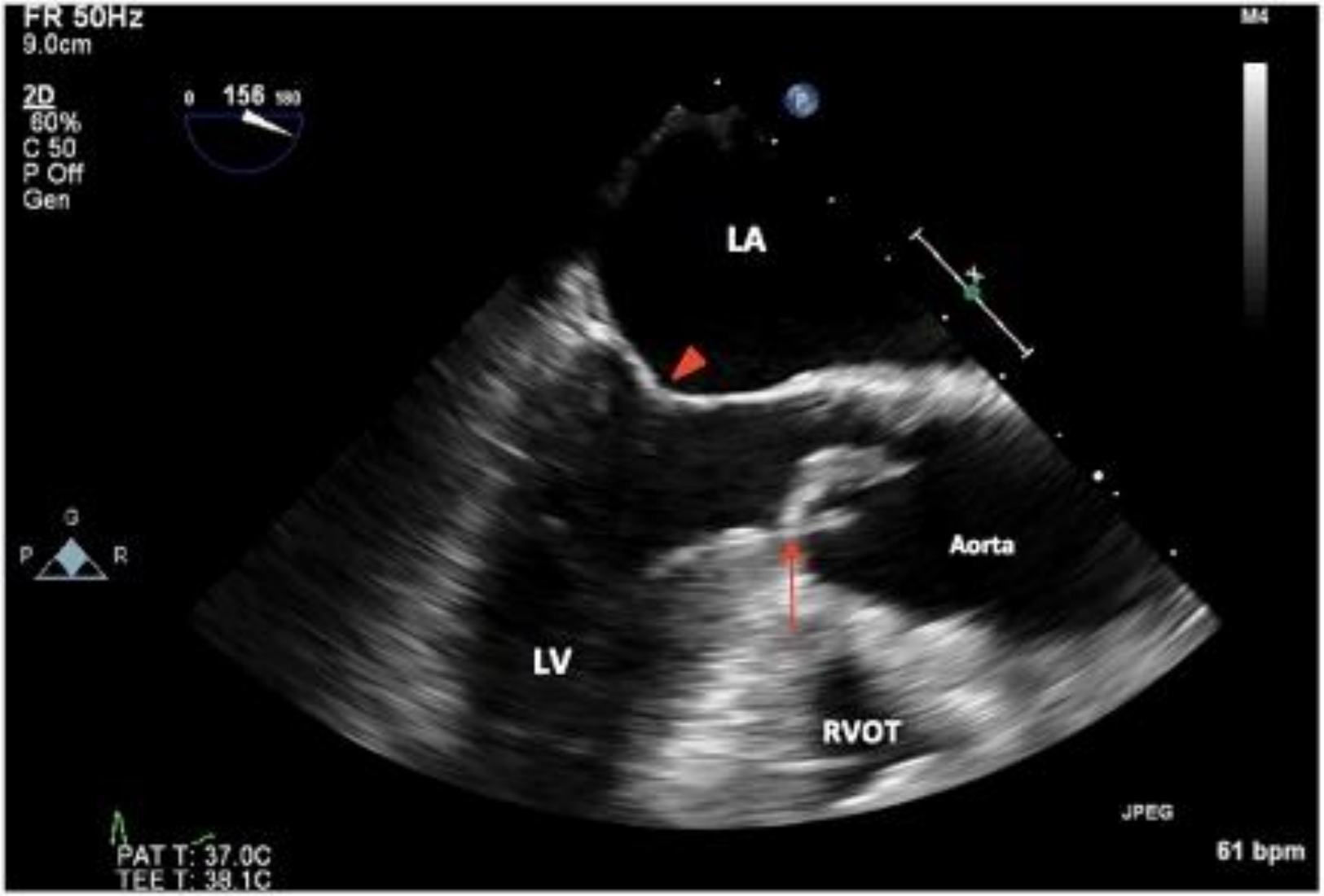
Transoesophageal echocardiography



Transoesophageal echocardiography

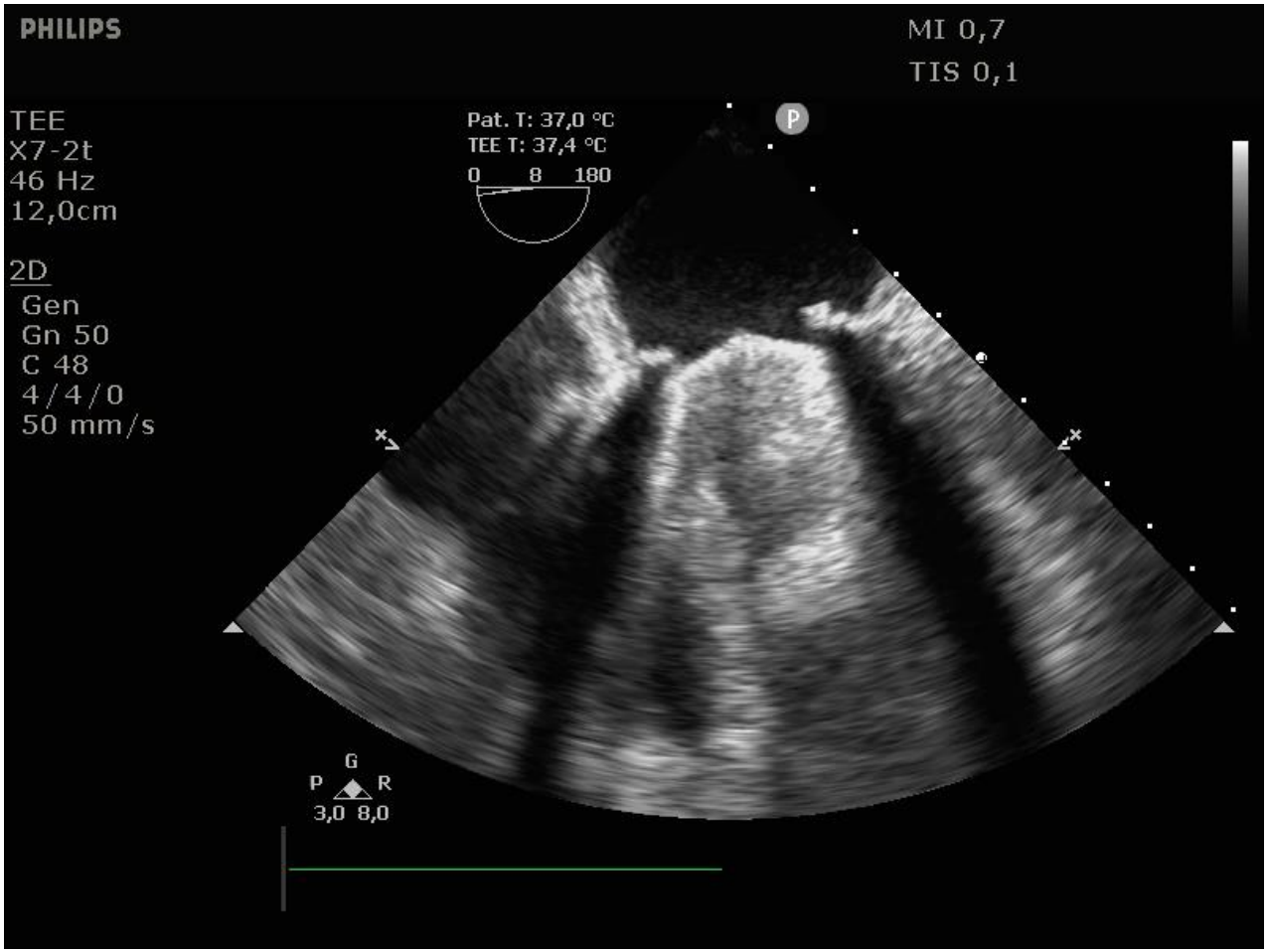


Transoesophageal echocardiography

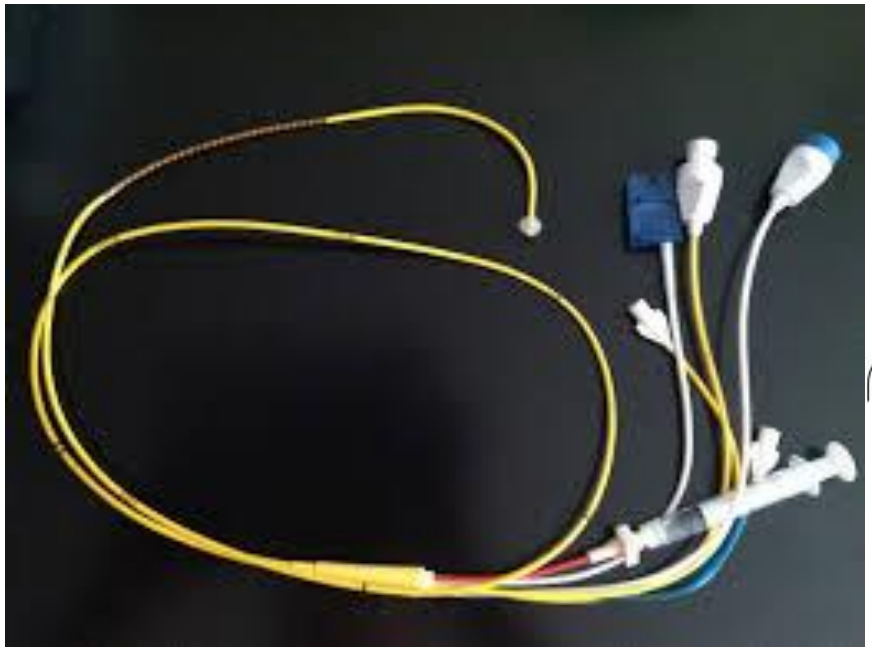


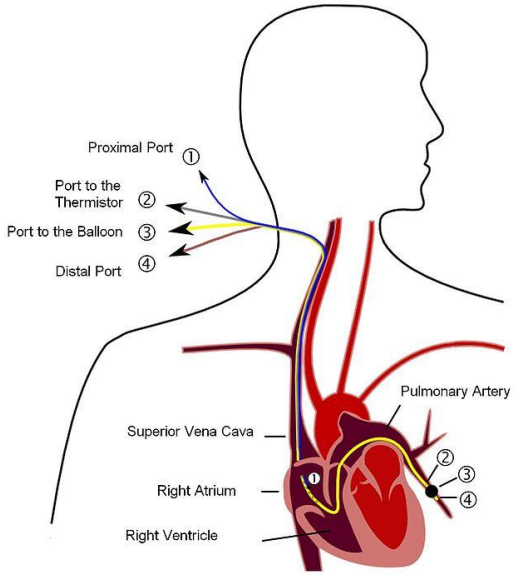
Frontiersin.org

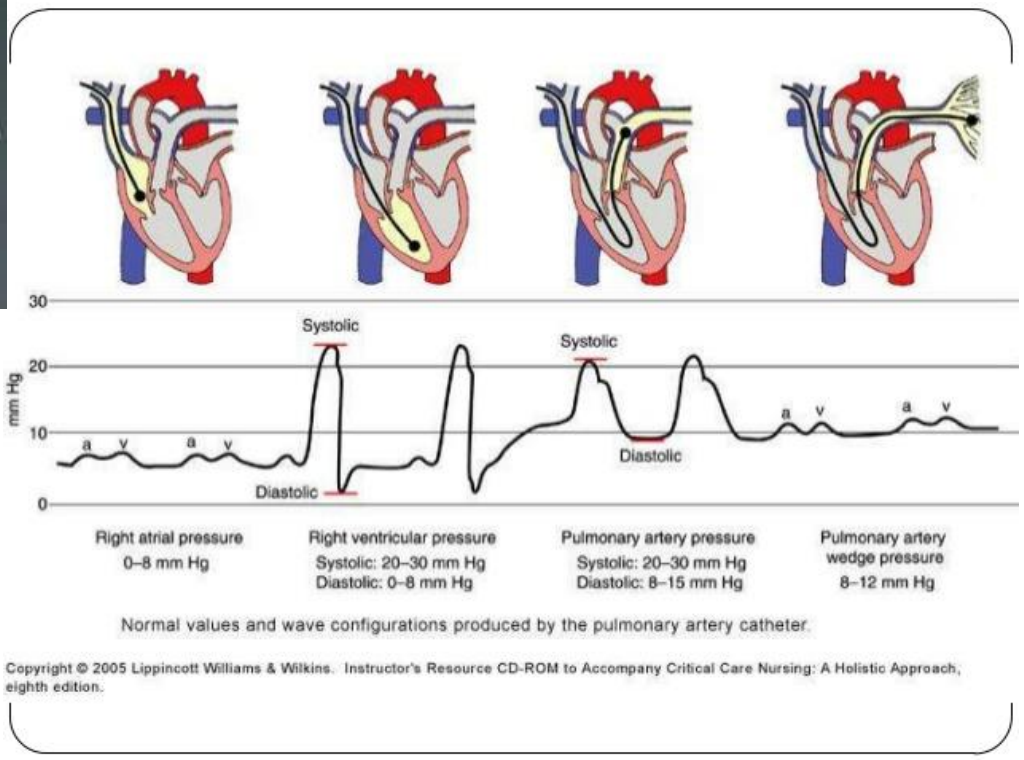
Transoesophageal echocardiography



Swan-Ganz catheter



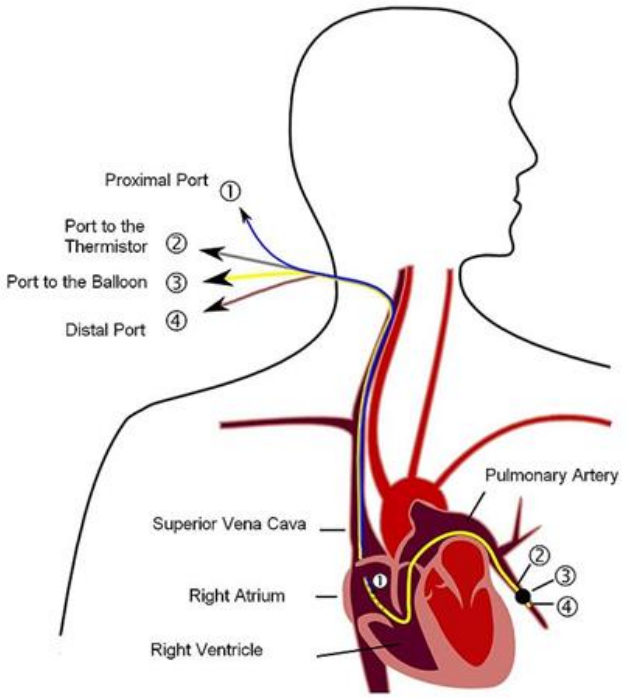




Catheter in the pulmonary artery via right heart

- Pressures : pulmonary art pressure, pulm capillary wedge press.
- Thermodilution measurement: cardiac output, vascular resistance (SVR)

Swan-Ganz catheter

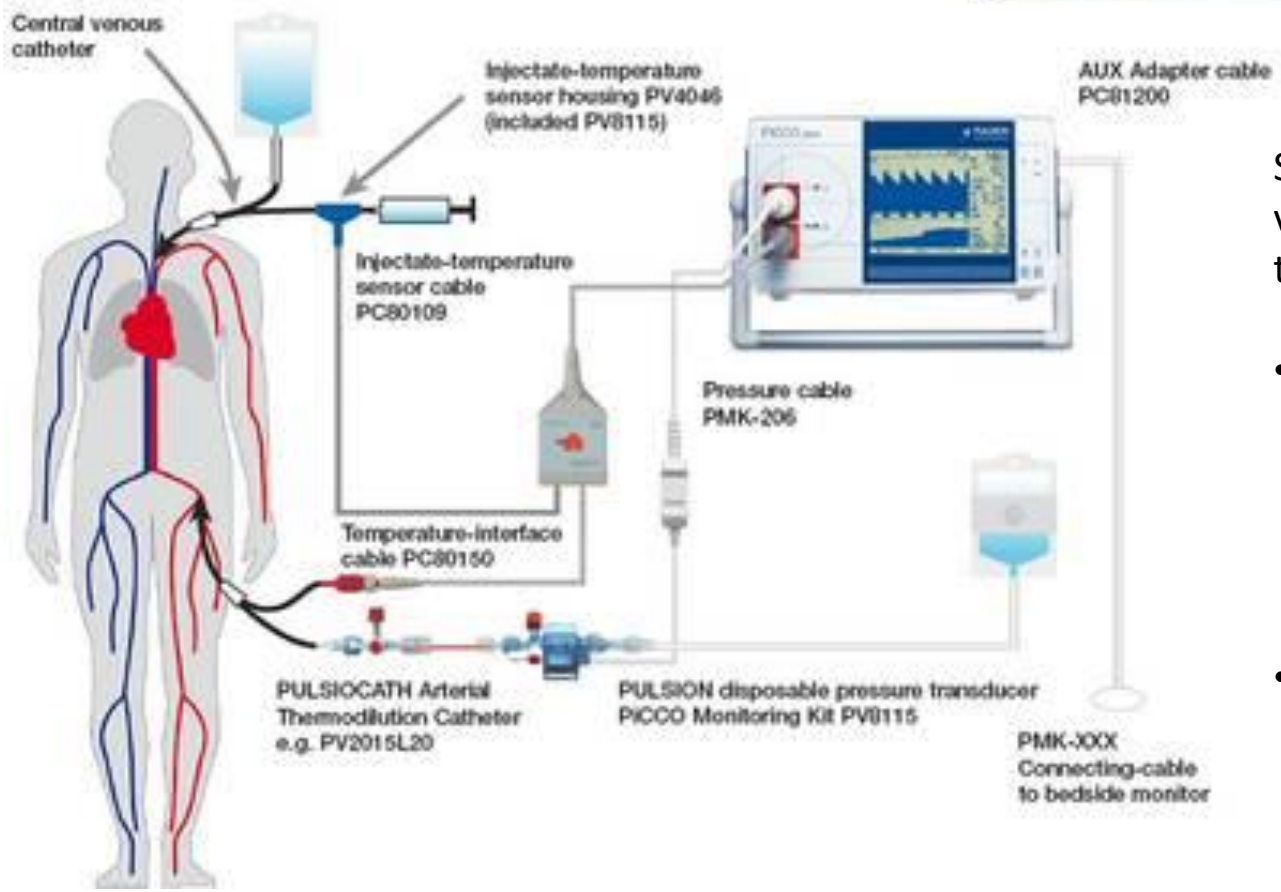


Swan-Ganz catheter

- Weaning from CPB
  - RV failure
    - Inotrop (↑ contractility) - dobutamin, PDE3 inhibitors, levosimendan
    - Inhaled NO (↓ afterload)

PiCCO

Continous pulse contour cardiac output measurement



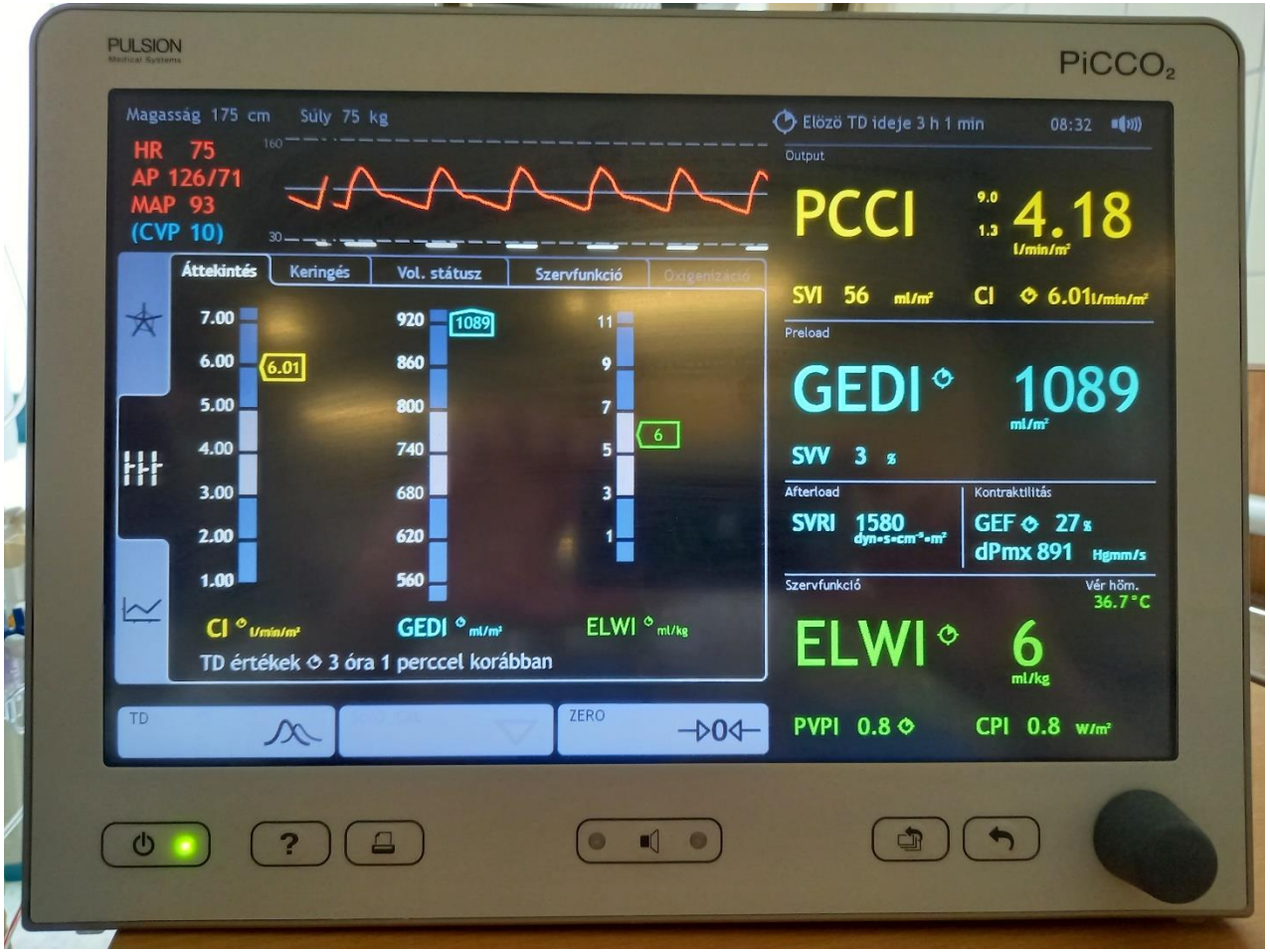
Spec. arterial catheter + central venous line (transpulmonary technic):

- Thermodilution measurement – volumes, cardiac output, SVR, others

↓

- Continuous cardiac output, SVR, others

PiCCO



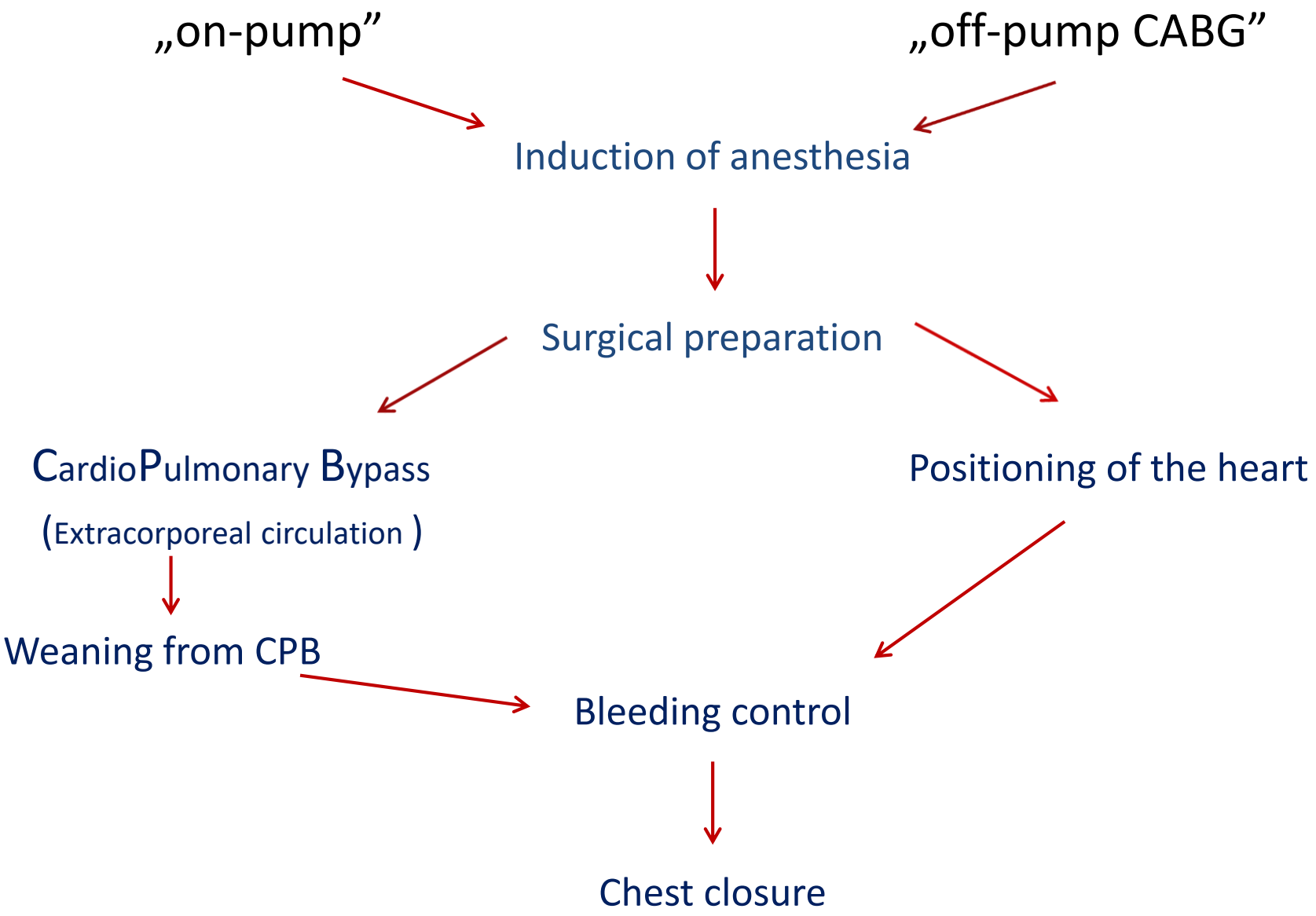
Spec. arterial catheter + central venous line (transpulmonary technic):

- Thermodilution measurement – volumes, cardiac output, SVR, others

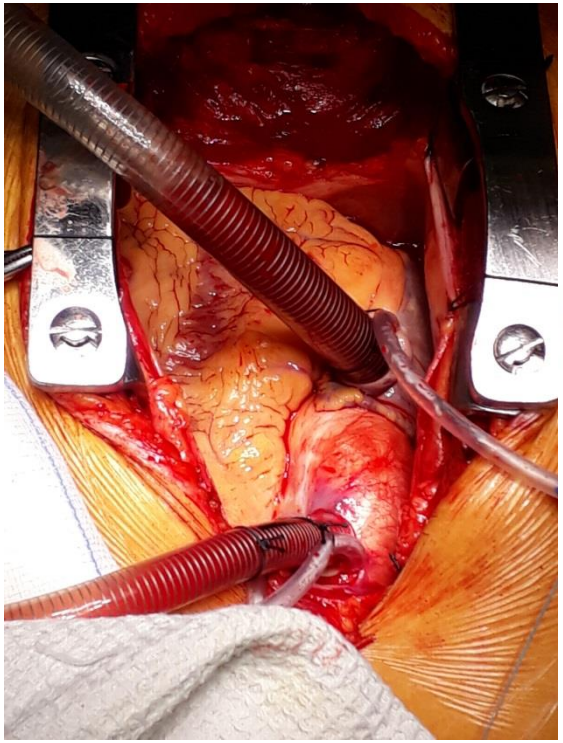
↓

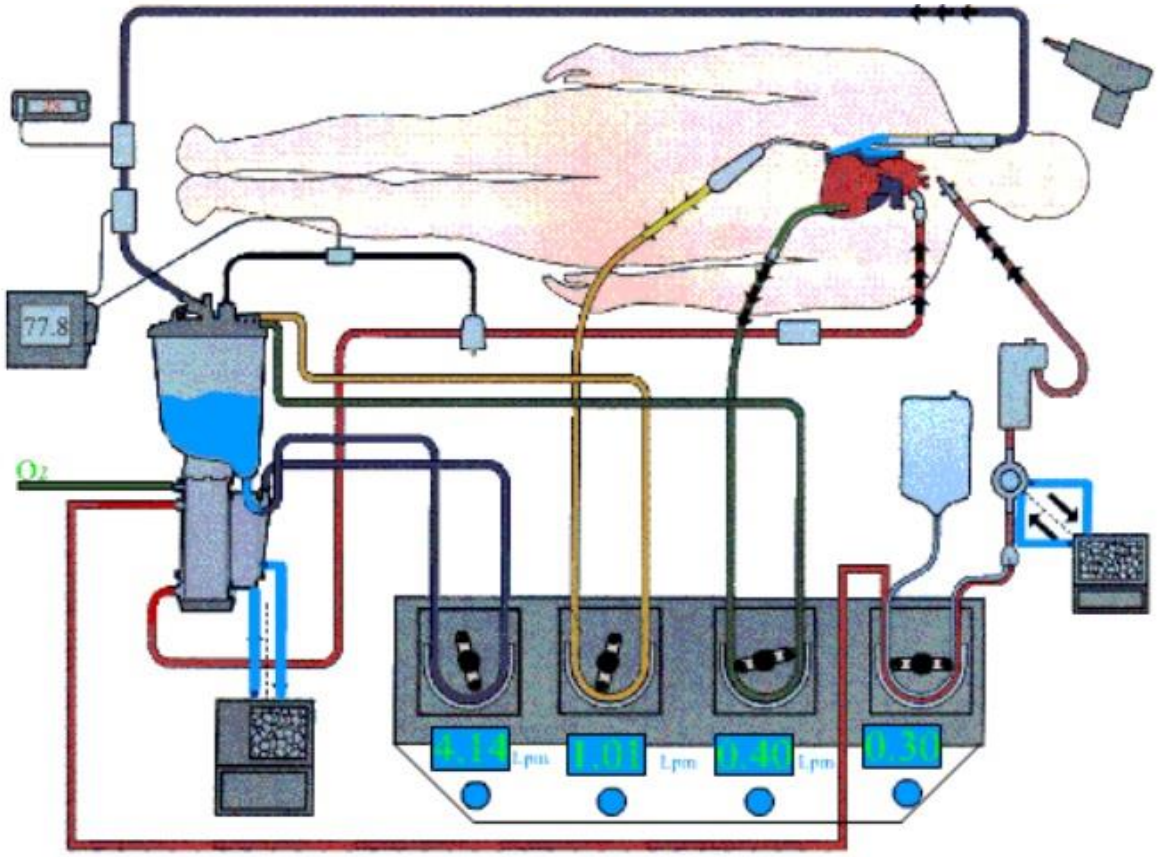
- Continuous cardiac output, SVR, others

Procedure


„on-pump”
„off-pump CABG”
Induction of anesthesia
Surgical preparation
CardioPulmonary Bypass
(Extracorporeal circulation)
Positioning of the heart
Weaning from CPB
Bleeding control
Chest closure

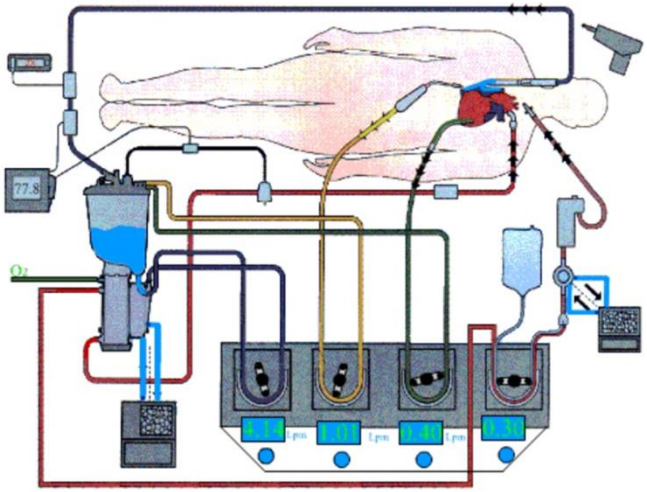
CPB



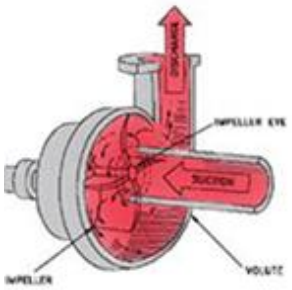


CPB

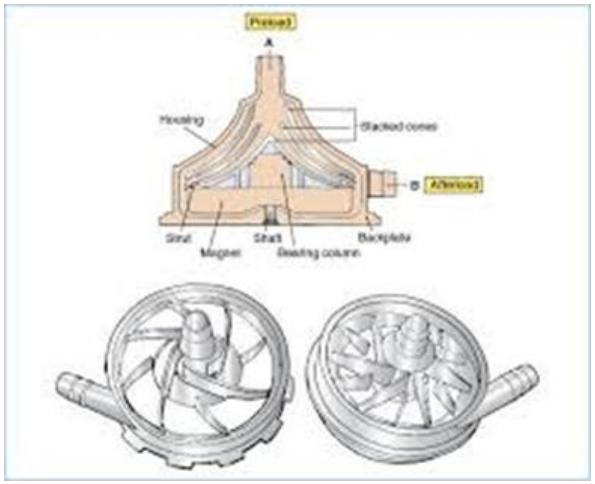
Ultrasonic Flow Sensor



CPB

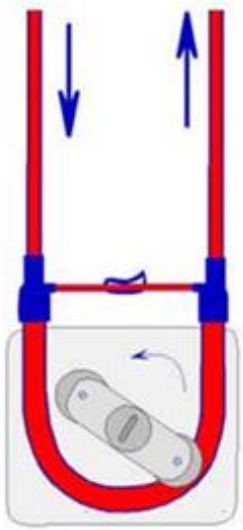


Centrifugal Pump



- More biocompatibility (usable for longer period – days)
- Afterload dependent
- Not usable for suction during the procedure

- Usable for hours
- Afterload independent
- Cheaper than centrifugal pump
- Not for circulation support only



Roller Pump

Anesthesia – cardiopulmonary bypass

- Continuous or pulsatile flow - Counted cardiac output

- Prime (fluid in the CPB machine)
- Cardioplegic solution

} Haemodilution

↓

- Activation of thrombocytes
- Heparine (300 IU/kg)

→ Coagulopathy

- Activation of inflammatory system
- Activation of complement cascade

} Systemic Inflammatory Response Syndrome (SIRS)

↓

„Normal" laboratory-parameter changes (WBC, CRP, PCT) after procedure

Systemic Inflammatory Response Syndrome

- The response of the body to infectious and non-infectious insults
- This inflammatory state affects the whole body
  - Pro- and anti-inflammatory processes
  - Complement-system activation
  - Changes in blood cloting
- Metabolic changes
  - Insulin-resistance
  - Catabolic processes

What can we see…

- Eleveated withe blood cell count
- Fever (elevated body temperature):
  - Endogen pyrogens
  - There is no conection between the postop 1. day fever and infection
- Elevated CRP and PCT
  - C-Reactive Protein:
    - The liver produces, IL-6 trigger – connects to the surfice of „dying” cells causing complement activation
    - Non-specific inflammatory protein
  - Procalcitonin:
    - Produced by the parafollicularis cells of thyroid gland and the neuroendokrin cells of gut and lungs
    - Elevated level in bacterial infections

Becsült GFR (EPI)	86		ml/p/1.73m2	
LDH	927	U H	U/l	240-480
GOT	55	U H	U/l	<44
GPT	12		U/l	<50
Kreatin-kináz	587	U H	U/l	<170
PTR idõ	12,80	U H	sec	9,40-12,50
Protrombin ráta	1,08	U	.	0,90-1,15
Protrombin INR	1,09	U	.	0,90-1,15
Trombin idõ	16,6	U	sec	11,0-17,0
Trombin idõ ráta	1,11		.	0,80-1,20
APTI	30,8		sec	25,0-37,0
APTI ráta	1,07		.	
Fibrinogén	2,78		g/l	2,00-4,00
Vérkép automatával:				
Fehérvérsejt	24,890	U H	Giga/l	4,000-10,000
Minõségi vérkép (kenetellenõrzés):				
Neutrofil karéjozott #	19,2		%	
Neutrofil Stab #	75,8		%	
Limfocita #	0,5		%	
Monocita #	4,5		%	
Eozinofil #	0,0		%	
Bazofil #	0,0		%	
Szétesett sejt #	3,5		/100FVS	
Vörösvértest	4,10	D	T/l	3,90-5,30
Hemoglobin	123	D	g/l	120-157
Hematokrit #	35,7	D	%	34,1-44,9
MCV	87,1		fl	80,0-95,0
MCH	30,0		pg	26,0-33,0
MCHC	345		g/l	310-360
RDW	13,7		%CV	11,6-14,4
Trombocita	107,0	D L	Giga/l	140,0-440,0
MPV	11,80		fl	9,40-12,40
Nagyméretû trombocita #	37,5		%	19,5-43,8
Magvas vvt #	0,0		%	0,0
Magvas vvt (abs) #	0,000		Giga/l	0,000-0,015

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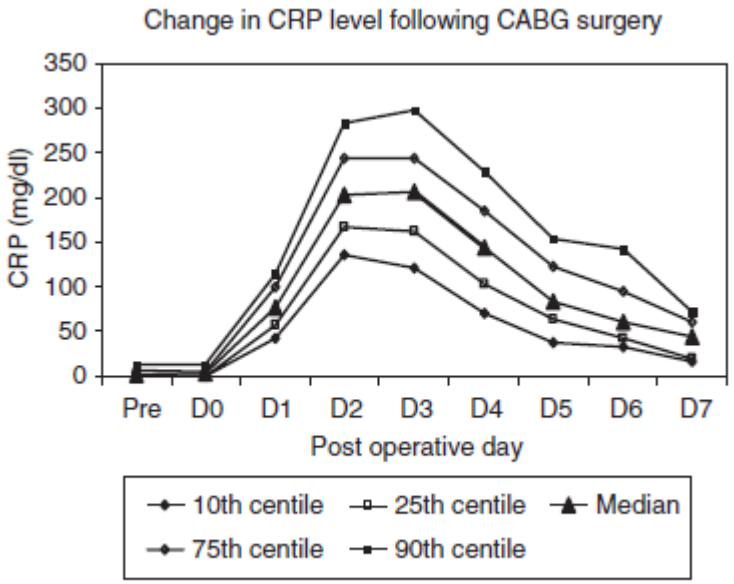
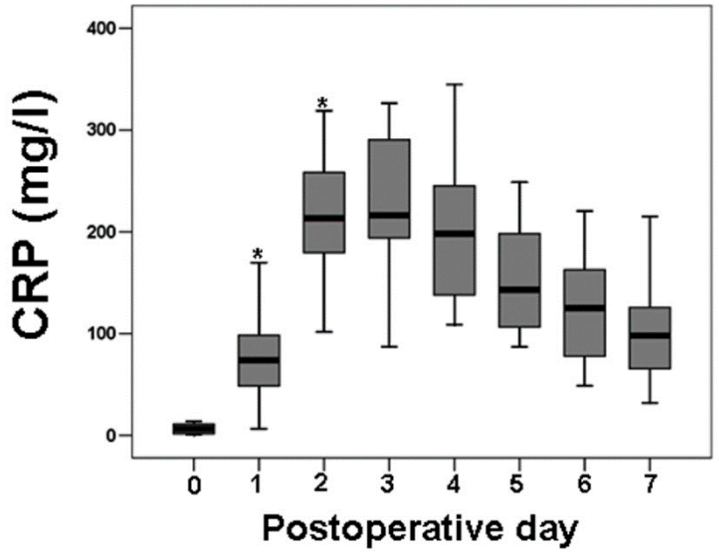
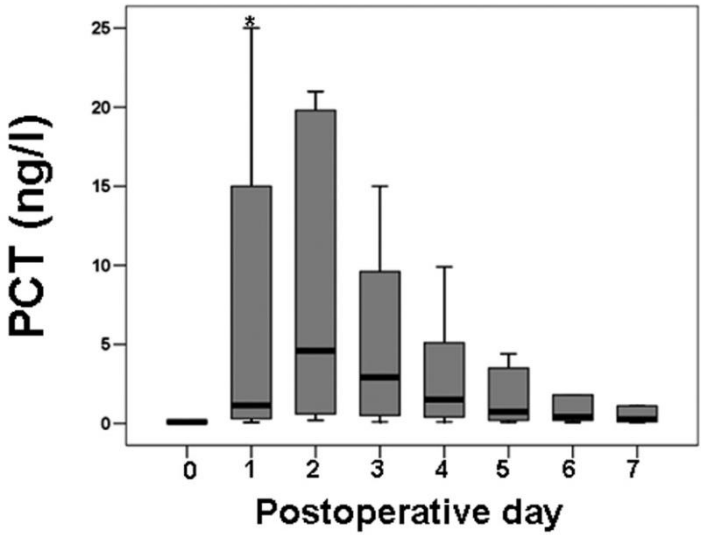
CRP and PCT



C-reactive protein levels following cardiac surgery in adults
J. Ayala, A. Smith, D. Farrar





Delannoy *et al.* Effect of cardiopulmonary bypass on activated partial thromboplastin time waveform analysis, serum procalcitonin and C-reactive protein concentrations Critical Care Vol 13 No 6

Anesthesia – weaning from CPB

To rebuild the patient's normal circulation

- Normalisation of metabolic state
- Normalisation of bodytemperature
- Normalisation of heart rhythm – defibrillation, pacemaker

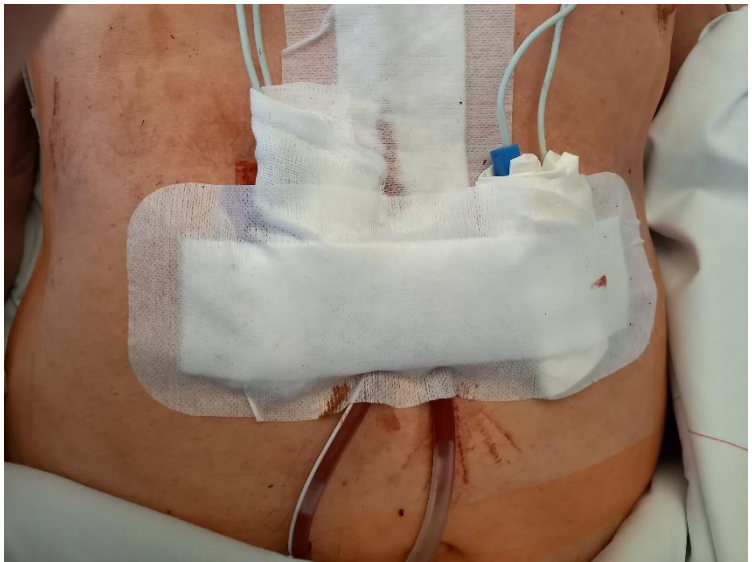
- Gradual loading - heart takes over the pump function – pump stops

- Loading of reservoir content
  - Blood pressure control
  - Right and left ventricle function


V Fib/
V Tachy
APN EKG
II
Monitor szűrő
1 mV
V Fib / V Tachy
Art
160
CVP
60
80
30
0
Pleth
NIBP
Mandzsetta választ.
SYS
DIA
Hőm.
°C
Nincs szenzor
T1
T2
36.5
EKG
54
(4)

Temporary pacemaker

- „Pull out” electrode – thin temporary electrode
  - Ventrice – always
  - Atrial
    - AAI – frequency
    - DDD – AV block
  - Postop atrial fibrillation cardioversion



Temporary pacemaker

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  - Blood pressure control
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Anesthesia – postbypass period

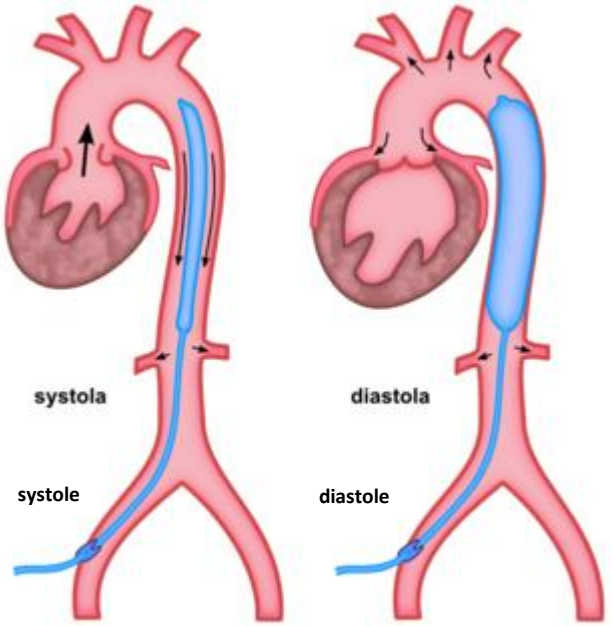
Haemodynamic stability, bleeding control

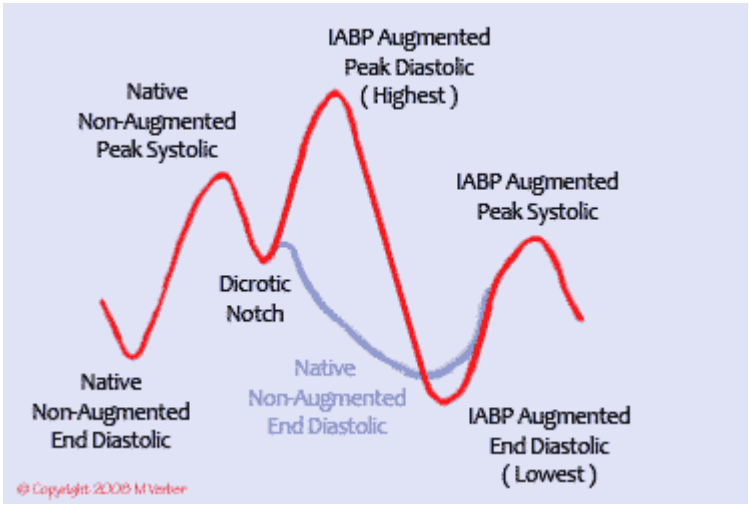
- Inotrope, vasoconstrictor
  - Low systemic vascular resistance after CPB, protamine effect
    - Vasoconstrictor: noradrenalin, phenylephrine, epinephrine
  - Left or/and right heart failure
    - Inotrope: dobutamine, milrinone, levosimendan
    - Mechanical support: IABP, ECMO

Invasive hemodynamic monitoring, TEE

Anesthesia – Mechanical circulatory support

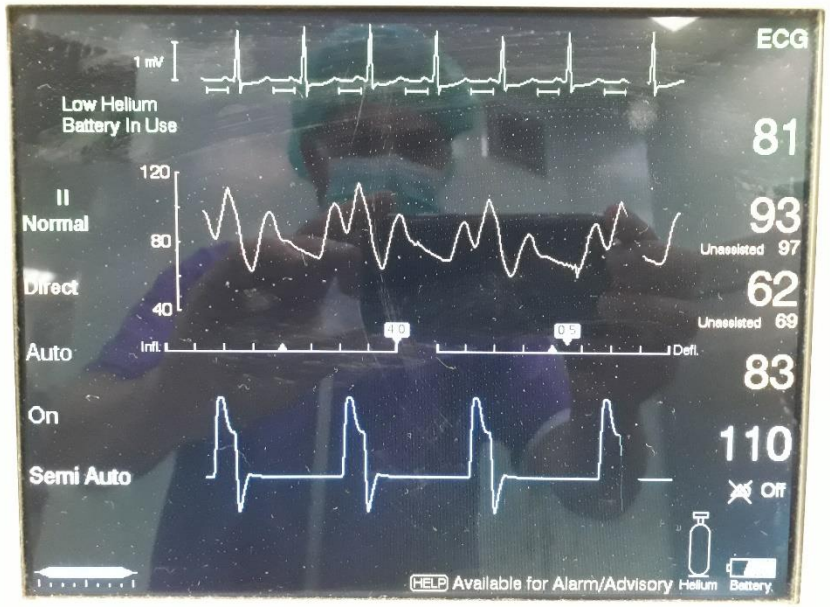
- IntraAortic Balloon Pump
  - makes „extra” pulse wave toward coronaries and brain
  - Improves the coronary and brain circulation
  - Just 0,5l „extra caridac output”

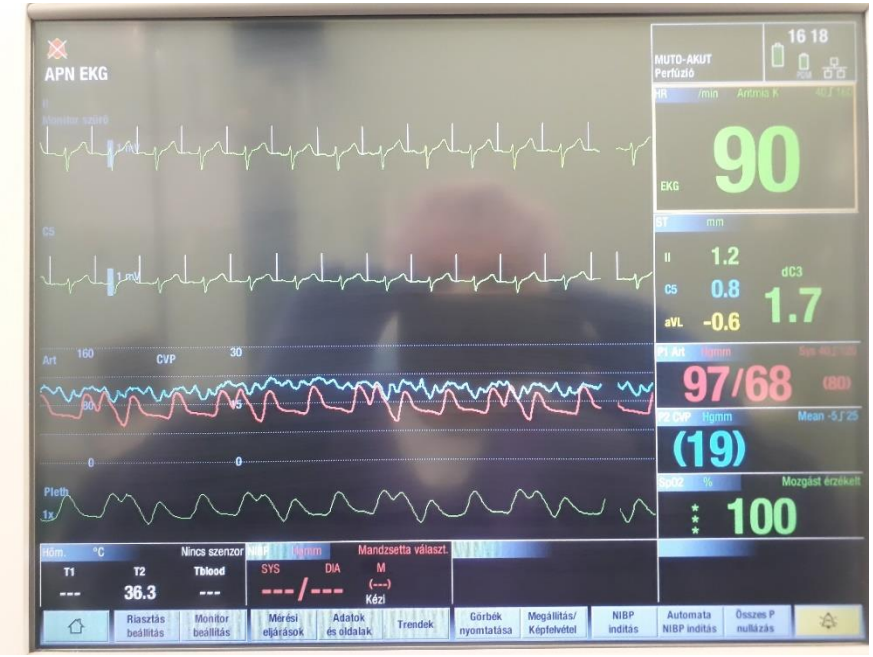


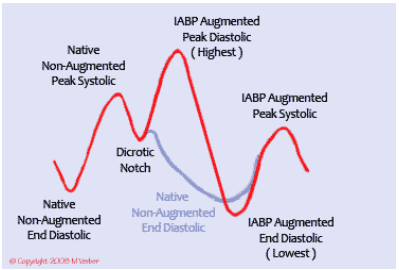


- Contraindications:
  - Severe aortic valve insufficientia
  - Aortic dissection
  - Severe aortoiliac occlusive disease

IntraAortic Balloon Pump

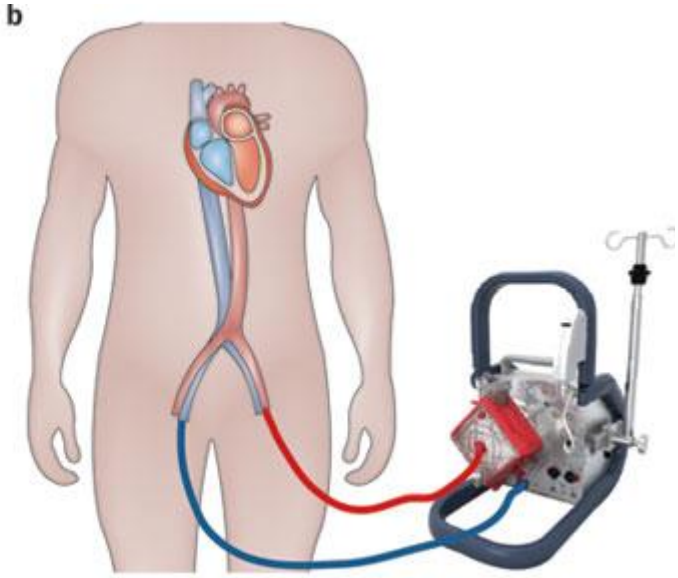


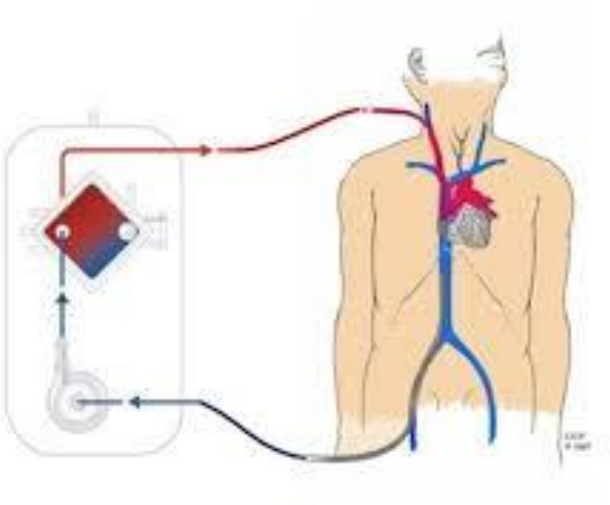




Anesthesia – Mechanical circulatory support

- ExtraCorporeal Membrane Oxygenation (ExtraCorporeal Life Support)
  - Similar to CPB used during operation
  - Veno-Arterial ECMO

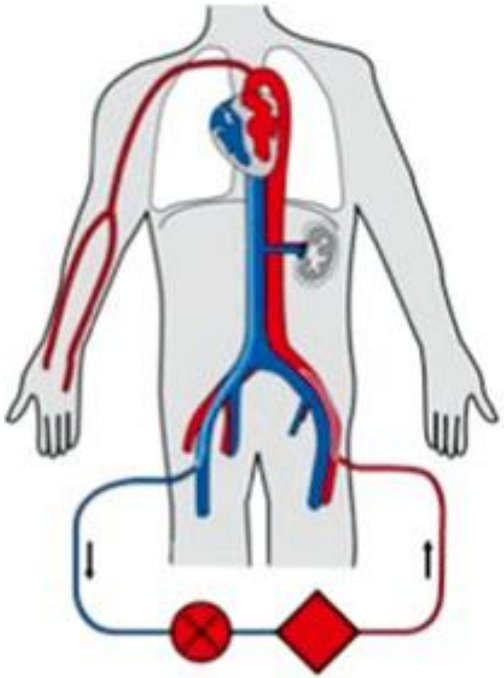




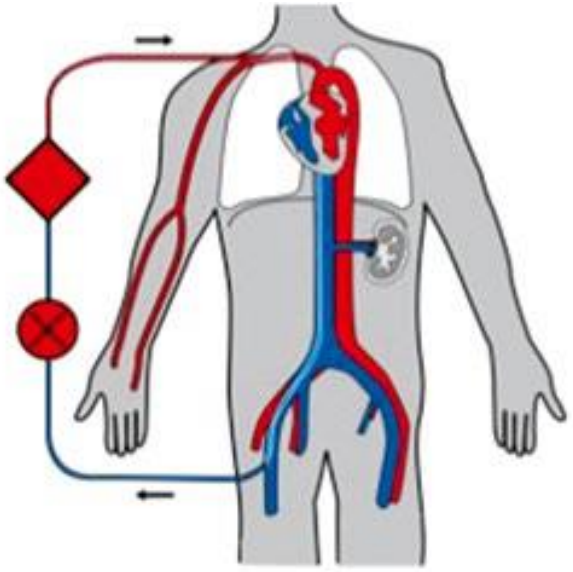
ExtraCorporeal Membrane Oxygenation

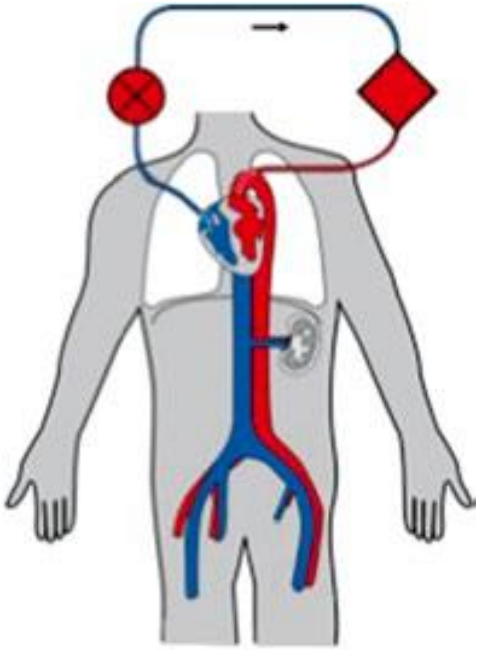
(ExtraCorporeal Life Support)

VA-ECMO



Periferal canulation





Central canulation

Blood pump: BP Memebrane lung: ML

ECMO – Extracorporeal life support in adults - Springer

ExtraCorporeal Membrane Oxygenation
(ExtraCorporeal Life Support)

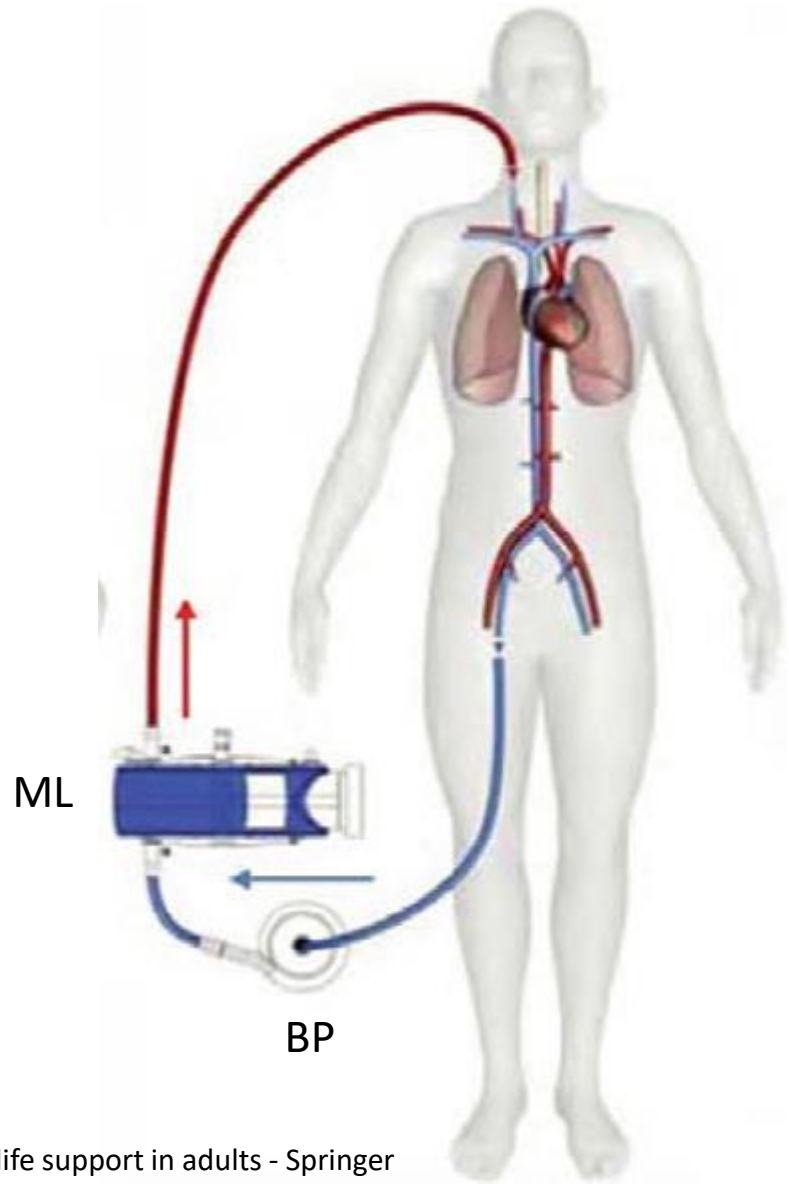
- Anticoagulation
  - Heparine – ACT or aPTT control
- Canulation – organ perfusion
- Bleeding control
- Canulation site infection
- Patient moving

ExtraCorporeal Membrane Oxygenation

(ExtraCorporeal Life Support)

VV-ECMO

- CO_2 removal
- Oxygenation



ECMO – Extracorporeal life support in adults - Springer

Anesthesia – postbypass period

Haemodynamic stability, bleeding control

- Fliud management
  - I.v. fliuds, transfusion

- Transfusion
  - Pocked red blood cell, FFP, Tct
  - Factor concentrates (Prothombin Complex Concentrate, Fibrinogen Concentrate, Activated factor VII concentrate)
- Protamine (1:1 Heparine)

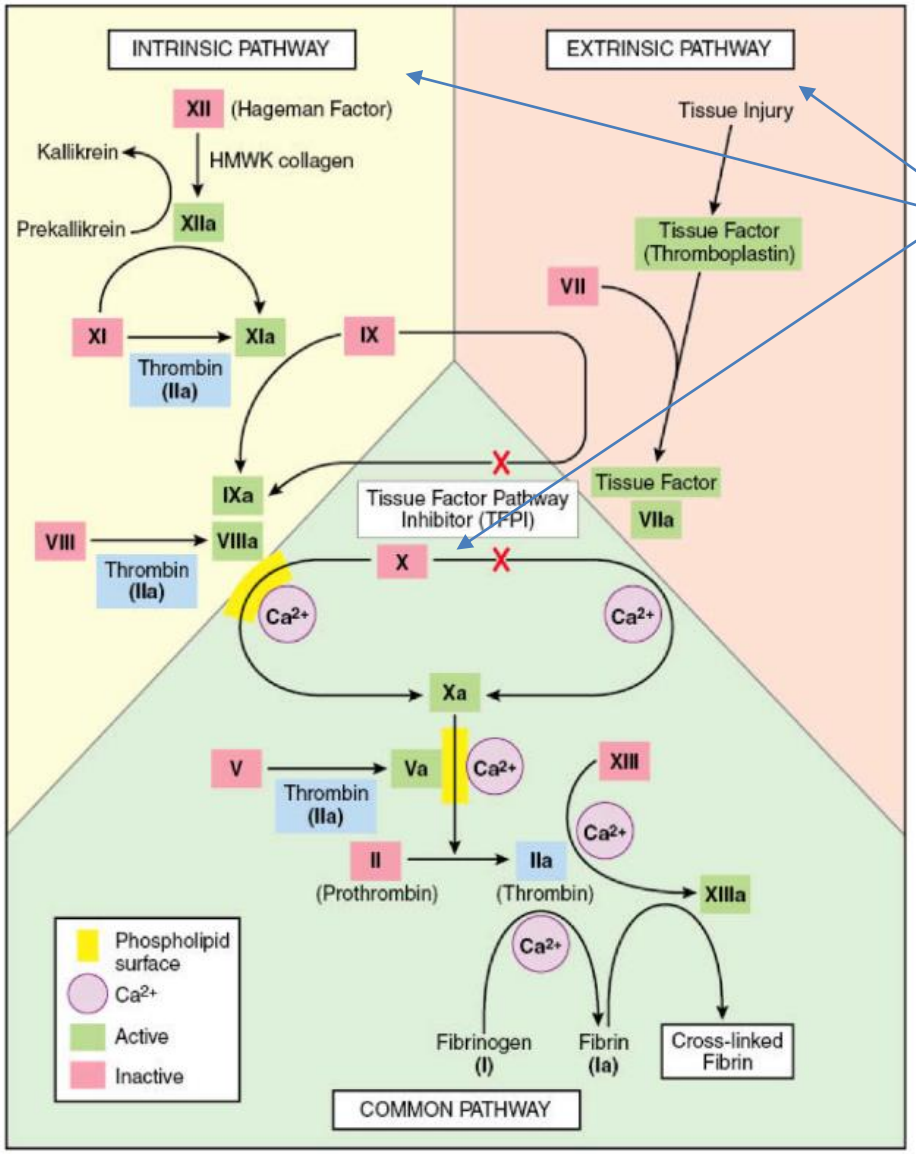
Point of Care tests
(Blood gas, Activated Clotting Time, Thrombelastography)
Laboratory tests

- Tranexamic acid – continuous infusion from start of the procedure
- Aprotinin

What should wee give?

(VIIa ?)

Ca^{2+}



PCC: II, VII, IX, X

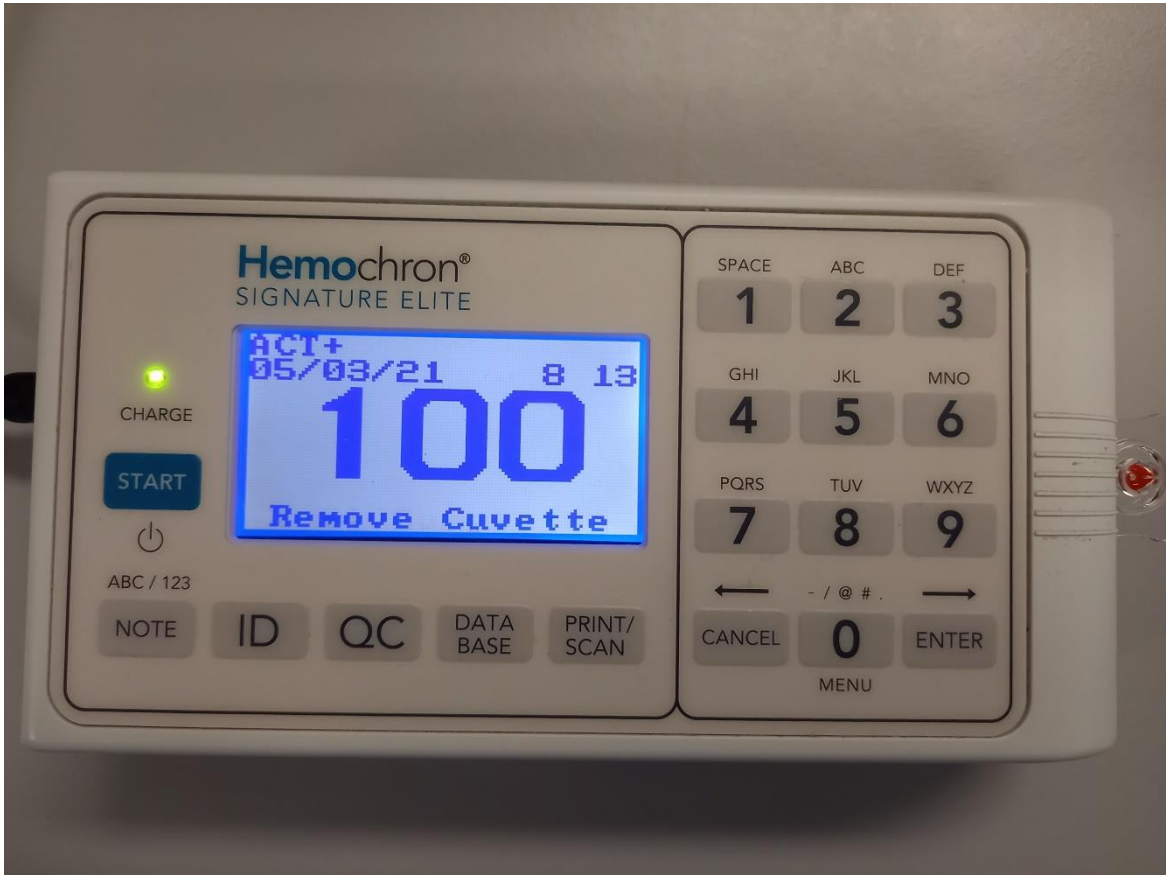
CLS Behring

Fibrinogen

Tct

Point of care blood cloting tests

- Activated Cloting Time
  - Monitoring of high-dose heparine-effect
  - 300-400 IU/kg → >480s (400s) for CPB, >350s for OPCAB



Point of care blood cloting tests

- Thrombelastography (TEG) (-metry)
  - Small blood sample
  - Diferent reagents – diferent parts of blood cloting

ACTIVE-TIP TECHNOLOGY:
The pipette-tip contains test specific dry reagents.

All reagent handling is eliminated.

EX-test	Rapid overview of the coagulation process
FIB-test	Detection of functional fibrinogen under dual platelet inhibition
AP-test	Inhibition of fibrinolysis facilitating the detection of hyperfibrinolytic activity (in combination with EX-test)
IN-test	Intrinsic screening test, sensitive to heparin and coagulation factors e.g. FVIII
HI-test	IN-test with heparin neutralisation to ascertain residual coagulation activity
TPA-test	Activation of fibrinolysis for the detection of antifibrinolytic therapies
RVV-test	Screening test for DOACs (e.g. rivaroxaban)
ECA-test	Screening specific for direct thrombin antagonists

ClotPro brochure

Point of care blood cloting tests

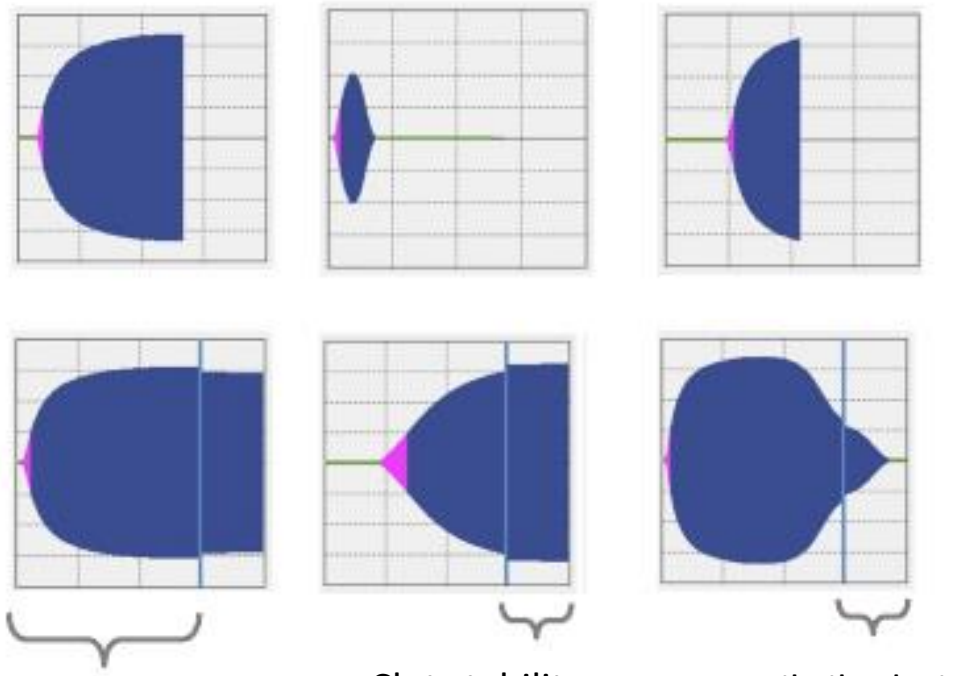
- Thrombelastometry

Clot.pro

Point of care blood cloting tests

Maximum 40 min measurement (usual presentation)

Longer than 40 min measurement (the first 30 and the last 10 min)



Start of coagulation
Clot formation

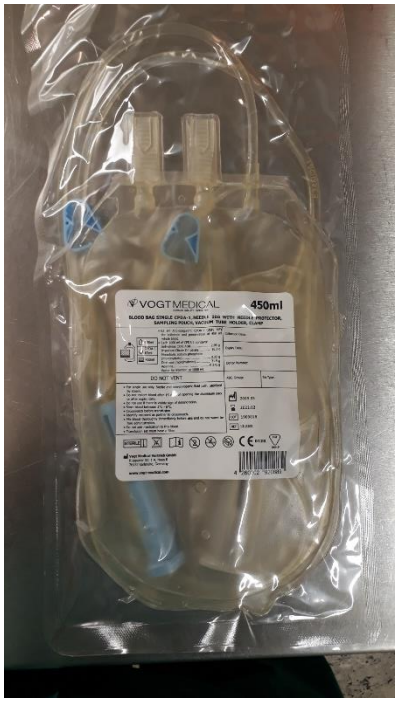
Clot stability

Fibrilnolysis

Clot.pro

Decrease of transfusion, cell salvage

- Intraoperative haemodilution: htc 40% or higher - collect blood at the beginig of the procedure, volume replacement with i.v. fluid

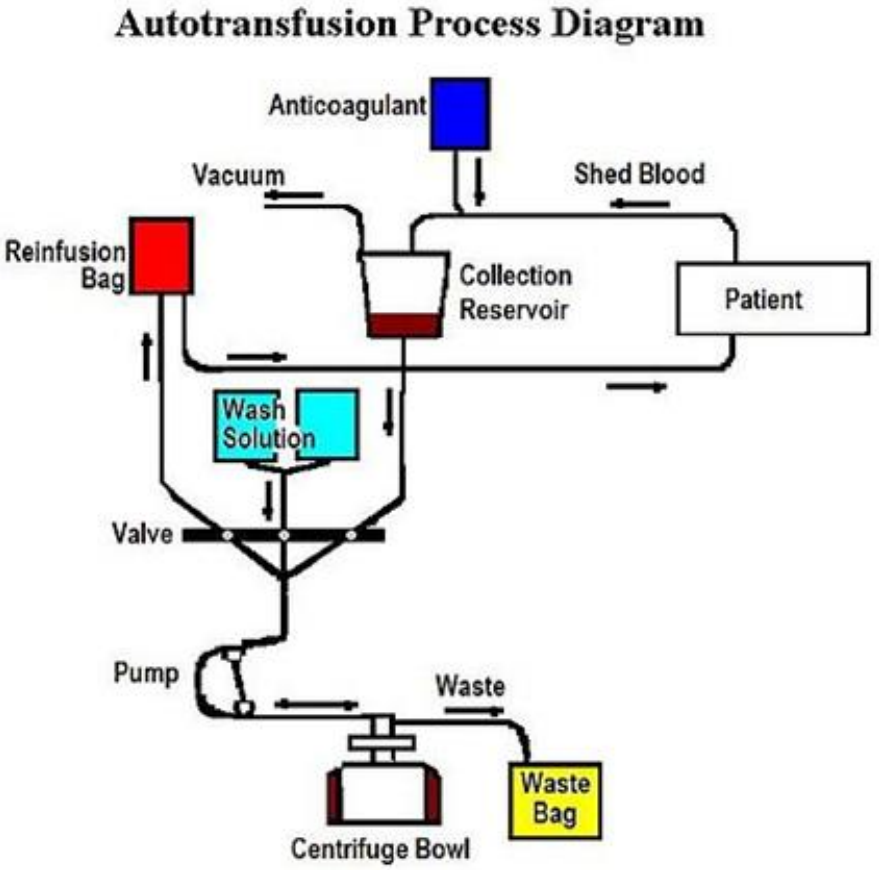


- Cell salvage technics:
  - Suction into the CPB
  - Cell-saver

Decrease of transfusion, cell salvage

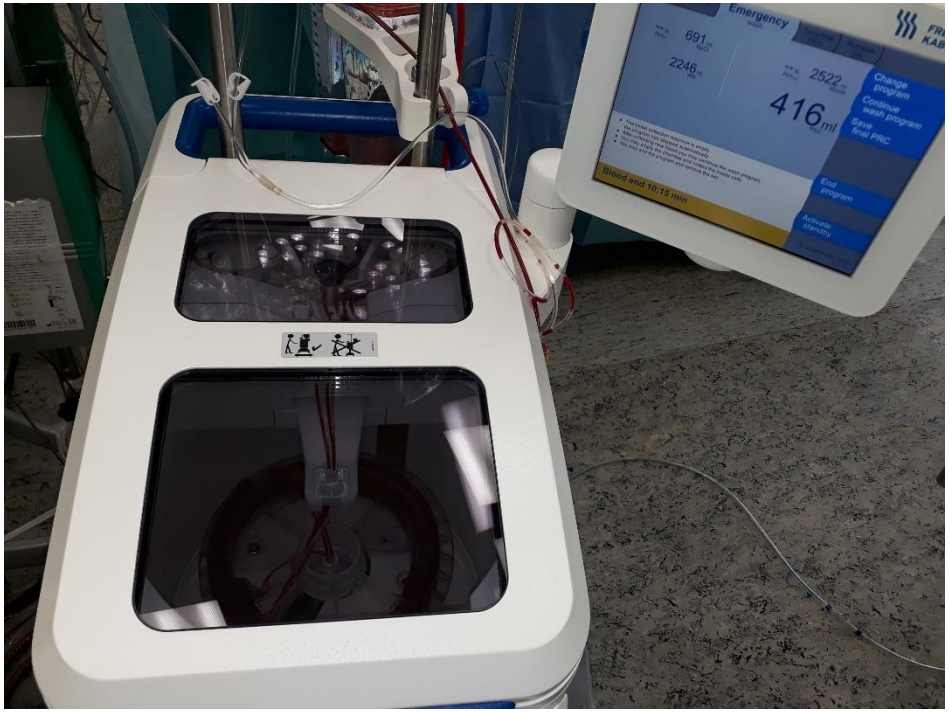
- Cell salvage technics:
  - Suction into the CPB
  - Cell-saver

The shed blood from the operative filed, mixed with heparinised saline, goes into the reservoir and after centriuge it is collected in a bag and reinfused.



Cell-saver


FRESENIUS KABI
Emergency
691
2246
2522
416
Change program
Continue wash program
Spun final PRC
End program
Activate standby
Blood end 10:15 min


Emergency
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2522
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Change program
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End program
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Blood end 10:15 min

Postoperative Intensive Care

Patient usually is not wakened and extubated in the operating theatre

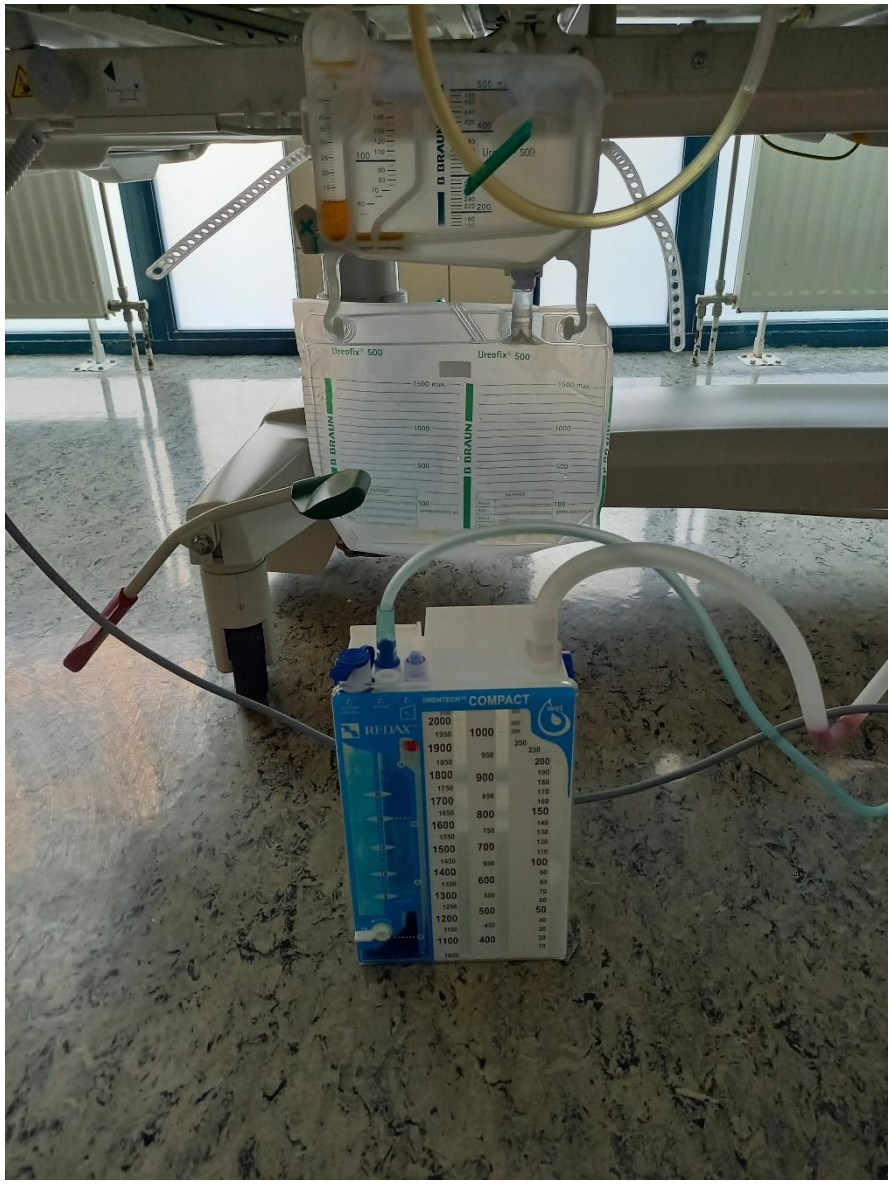
- Tasks on ICU:
  - To ensure haemodynamic stability
  - Bleeding control
  - Weaning from mechanical ventilation
  - Pain management
  - Physiotherapy

Postoperative Intensive Care

- To ensure haemodynamic stability:
  - Monitoring
  - Fluid therapy
  - Metabolic stability
  - Reduction of catecholamine dose

- Bleeding control
  - Hourly check – severe > 100 -200ml/h (bodyweight!)
  - Medical therapy (as above)
  - Surgery - reoperation

Postoperative Intensive Care

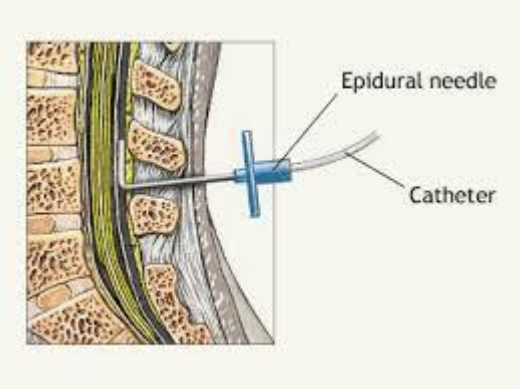


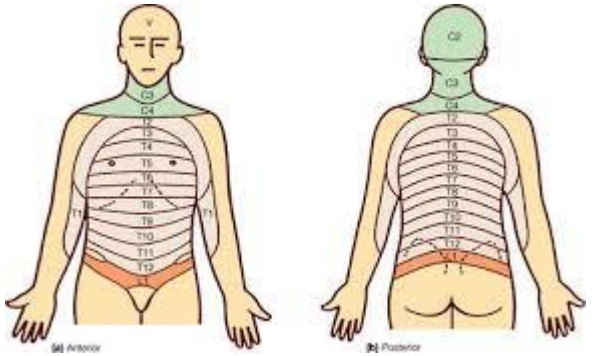
Postoperative Intensive Care

- Pain management
  - Opioids: morphine, sufentanyl
    - Nausea – dehydrobensperidol, ondansetron
    - Drowsiness
  - NSAIDs: diclofenac, Ibuprophen,…
    - Kidney function ?
    - Bleeding ?
  - Paracetamol
  - Tramadol
    - nausea
- Traditional method: i.v. opioid base and NSAID and/or paracetamol
- Multimodal therapy – without opioids

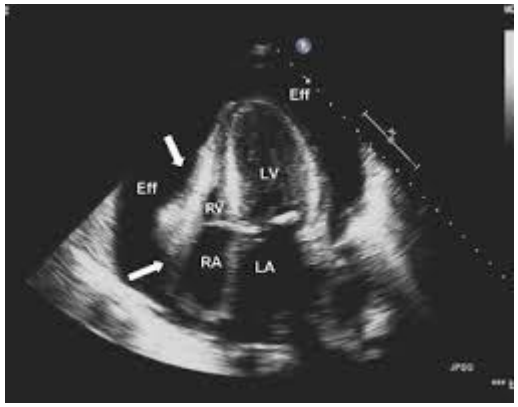
Postoperative Intensive Care

- Pain management
  - I.V.:
    - Continuous infusion
    - I.V. infusion
    - Patient Controlled Analgesia – special pump
  - Per os
  - Epidural catheter (sympathic tone↓ ↔ local effect, antithrombotic th?)



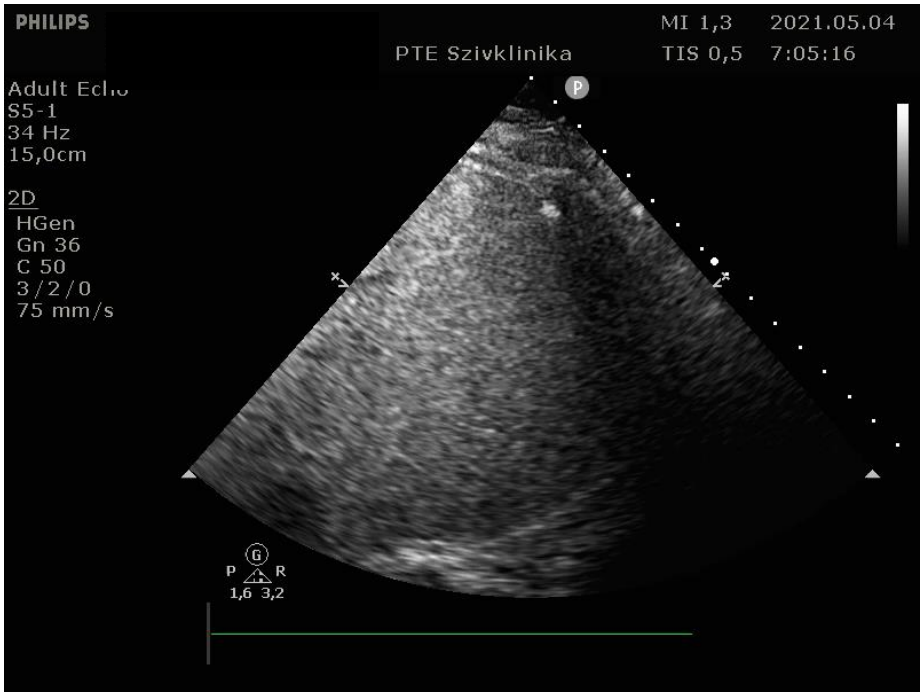


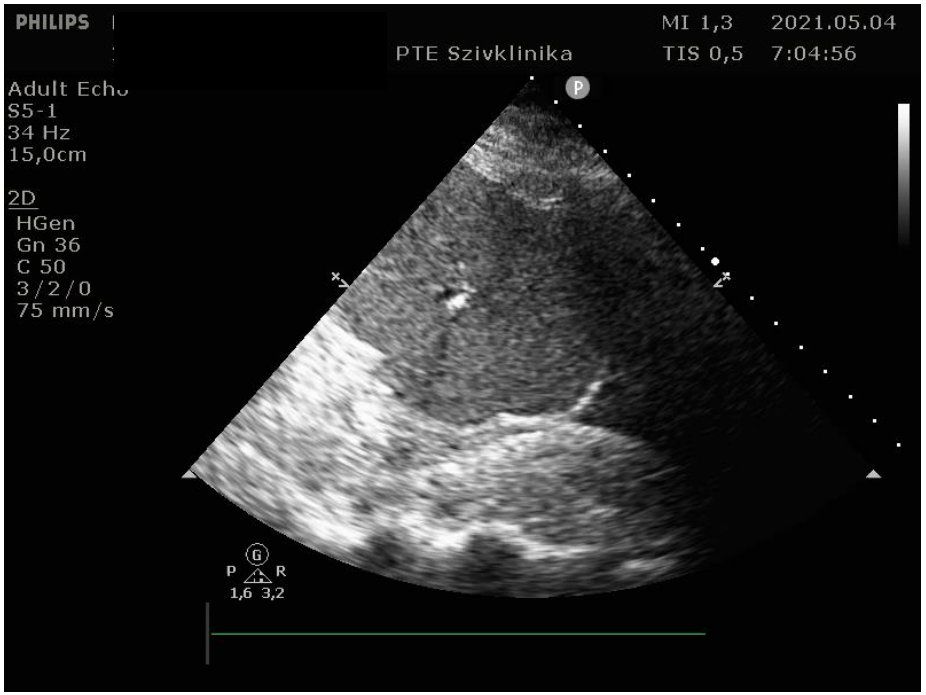
Postoperative Intensive Care - Complications



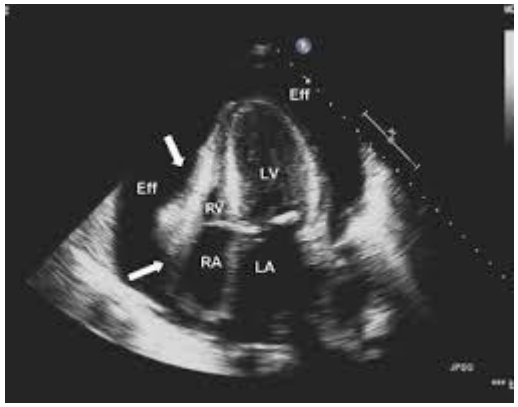
- Bleeding
- Pericardial tamponade – haemodynamic instability, RR↓, Urine output↓, CVP↑ - operation
- Kidney function↓ - diuretics, Haemodialysis
- Breathing problems – phrenic nerve injury – physiotherapy, stimulation, non-invasive ventilatory support
- Atrial fibrillation (40% after cardiac surgery) – ions, ß-blocker, amiodarone

Postoperative Intensive Care - Complications





Postoperative Intensive Care - Complications



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