luzerner kantonsspital
LUZERN SURSEE WOLHUSEN

Cardiology Division – Heart Center, Luzerner Kantonsspital

LUCCA 3.0 – Impella® Workshop

MCSD indications for high-risk interventions and shock management
– When would you use an Impella® device …?

PD Dr. Adrian Attinger, MD & PD Dr. Matthias Bossard, MD
Senior Consultants Interventional Cardiology

Lucerne, February 22, 2024

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• WHAT'S YOUR EXPERIENCE WITH THE IMPELLA™ DEVICE?

Who has experience with mechanical circulatory support devices?

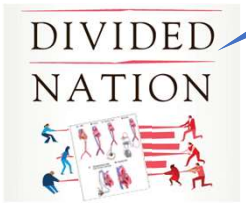
Who has experience with the Impella® device?

2

• OUR EXPERIENCE WITH THE IMPELLA™ DEVICE

Are there only pVAD / Impella enthusiasts in Lucerne?

NO!!!

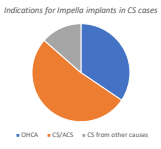


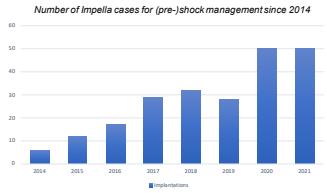
VS.

3

• OUR EXPERIENCE WITH THE IMPELLA™ DEVICE

Cardiogenic shock and heart failure management using the Impella™ device
– Cardiology Division – LUKS: Almost one decade of experience





- **Indications for use of the Impella™ device in Lucerne:**
  1. (pre-)shock & OHCA (approx. 80%)
  2. Heart failure & high-risk PCI
  3. Bridge to recovery/ HTX/ LVAD

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Does my patient require mechanical support using an Impella™ device?
– First things first: Patients that may benefit from support

Scenarios, which may require MCSDs

Decision for Impella Support

Complex (cardiac) procedure
- High-risk PCI
- OPCAB
- Post-CS
- VT ablation
- …

Cardiogenic shock

Heart failure
- Bridge-to-recovery
- Bridge-to-decision

5

Which patients are eligible for an Impella™ device?
– Balance the risk and benefits of pVADs?

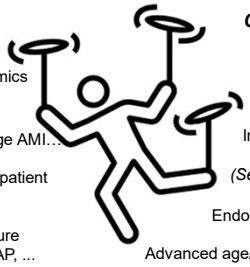
PRO:

(Cardiogenic) shock:
Deteriorating hemodynamics

At risk for shock:
Post-cardiac surgery, large AMI…

(Advanced) heart failure patient
- Awaiting HTX, LVAD,…

Complex cardiac procedure
- PCI, VT ablation, OPCAP, ...



CONs:

"Hostile" aorta, severe PAD

Mechanical aortic valve

Intracardiac thrombus

(Severe AS/ AR)

Endocarditis *(VSD / ASD)*

(Active bleeding)

Advanced age/ frailty

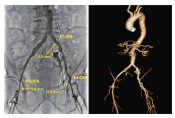
6

Assess your patient for eligibility
– Use your clinical judgement, echocardiography (and fluoroscopy)…

What is your patient's will?

Use echocardiography

Assess the vascular status



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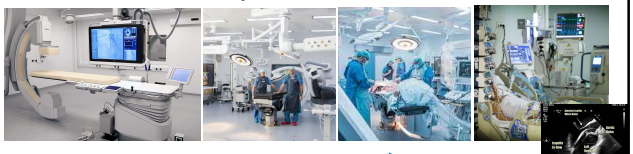
The (optimal) Impella implantation setting
– It doesn't need much to implant the device ;-)

Cath lab | **Hybrid OR** | **OR** | **CCU/ ICU**



Fluoroscopic guidance

TOE guidance for implant

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Mechanical circulatory support devices…
– It's getting boring…

Educative cases:
Let's discuss!

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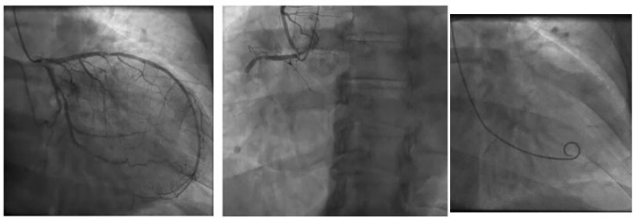
A case example
– The acute heart failure patient…

45 y/o male, SOB NYHA IV, *acute heart failure (LVEF 20%)*



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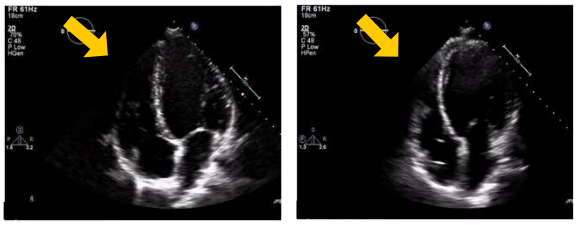
Why do we need "protection" or "support" for PCI
– Protected PCI?!

Who needs support?



Normal heart function

Severely depressed LV function

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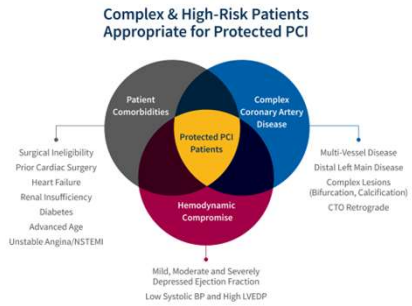
Case selection for protected PCI



12

A case example
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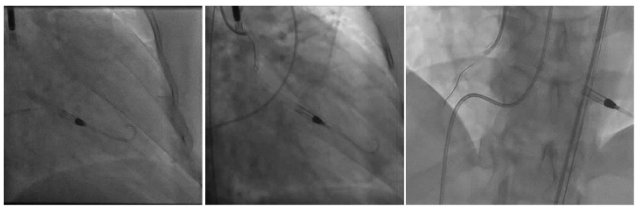

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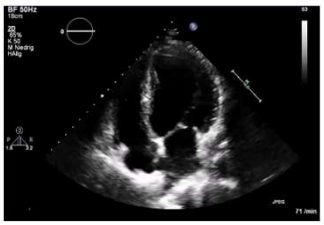
A case example
– The acute heart failure patient…

1.5 years later…

1. No more SOB (NYHA I).
2. Normal daily functioning
3. Recovery of heart function



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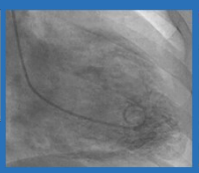
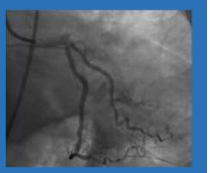
▪ A CONTEMPORARY STEMI CASE…

60 y/o female with diabetes & anterior STEMI

Acute anterior STEMI

Chest pain started approx. 2h ago!
Door-to-balloon time: 15´





No previous MI – BP 110/80mmHg; HR 90pbm – Cold clammy; Lactate 1.8mmol/L

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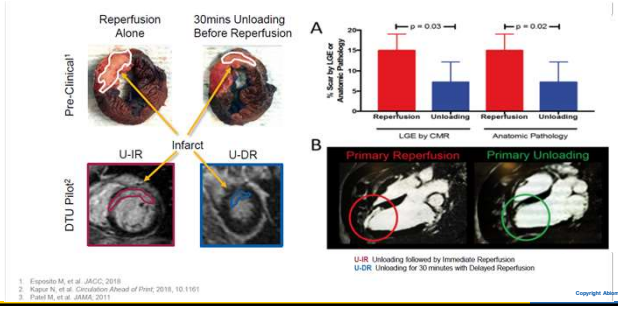
▪ VENTRICULAR UNLOADING IN STEMI
– SUCCESSFUL TRANSLATION FROM PRE-CLINICAL SCIENCE TO PATIENTS



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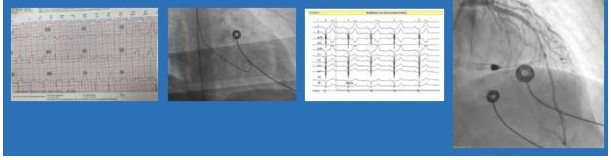
▪ MY STEMI-DTU TRIAL EXPERIENCE – IS IT FEASIBLE?

63 y/o gentleman with acute anterior STEMI

No previous MI – No comorbidities – BP 105/70mmHg; HR 60pbm – No evident shock

LUKS STEMI DTU Trial Case



Chest pain approx. 1.5h ago!
Door-to-unloading time: 20´

➡

Chest pain free after 5´!
ST-resolution!

➡

PCI to LAD - 10´

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The tale of a young patient with refractory VF
– 37 y/o male with chest pain & VF

- **Previously healthy; smoker**
- **Chest pain → Witnessed cardiac arrest; VF**
  - Down time 0'; professional CPR in the field 40'
  - Refractory VF; >15x defibrillation
  - Cath lab transfer (with AutoPulse®)
  - Profound shock (SCAI E); Lactate 24mmol/L

What's next?

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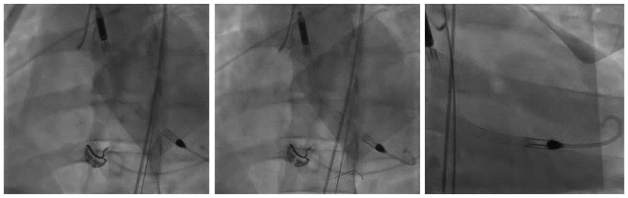
The tale of a young patient with refractory VF
– Inferior STEMI with VF



eCPR with Impella?!

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The tale of a young patient with refractory VF
– Further course…

- **Collateral damage:**
  - Abdominal compartment syndrome → Urgent laparotomy
  - Compartment syndrome of all 4 extremities
  - AKI → Hemofilter required
  - DIC / bleeding
  - Critical illness polyneuropathy
  - Prolonged weaning..
  - But evidence for neurological recovery…
- Multiple surgical interventions …
- Impella support for 48h → Surgical removal

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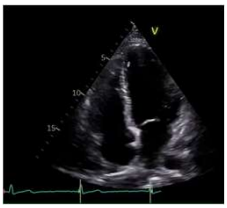
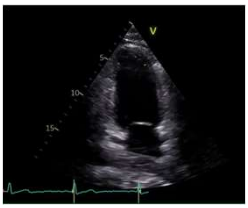
The tale of a young patient with refractory VF
– Further course… (part 2)

- **Course of recovery:**
  - Neuro-rehab for CIP
  - Dialysis stopped
  - Recovery of LV-function

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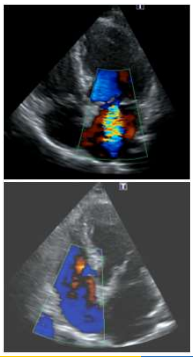
Case vignette

76y/o female

- *Severe MR* – myxomatous degeneration of MV, posterior prolapse
  - Progressive SOB (NYHA II-III)
  - Paroxysmal Afib
  - Normal LVEF, normal coronaries
  - sPAP at rest 35mmHg; exertion >50mmHg

Heart team decision: ***Surgical MVR***



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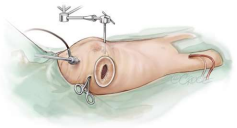
The surgical procedure
– Minimal invasive MVR using anterolateral thoracic access

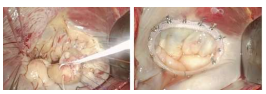
The surgical procedure:

- Anterolateral access
- Implantation of Physio™ II ring, neochordae x1
- Closure of clefts and indentures
- *Anatomically challenging, but successful procedure!*



Procedure recordings:

- Procedure duration: 6:53h
- Bypass time: 111´
- Aortic cross clamp time: 225´
- Reperfusion time 64´
- Hypothermia 28°C



Kastengren et al. Minimally invasive mitral valve surgery is associated with a low rate of complications. JIM Volume266, Issue6| December 2019, Pages 614-626

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Further course: Rapid deterioration
– „Things are about getting worse...“

- **Upon arrival on ICU:**
  - Hemodynamically unstable
  - Sliding demand of catecholamines
  - Rapid Afib, LVEF 10%
  - PEA → Resuscitation

This patient needs urgent ***SUPPORT****!*

What´s next?

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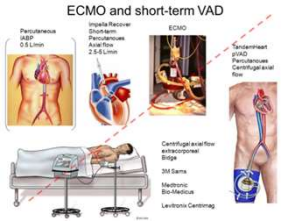
Postcardiotomy shock (PCS) requiring hemodynamic support
– Which device helps us most?

What´s next?
What are the options?



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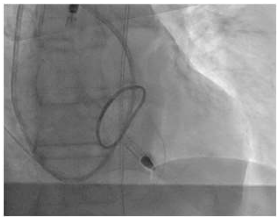
Our case – Emergecy management
– „Taking the evacuation route“



- **Urgent angiogram**
- **Transfemoral implantation of Impella™ CP**

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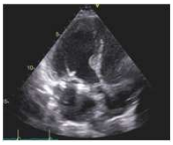
Our case – How did the patient do in hospital?
– Did things smoothen out?

- *LV unloading with Impella™ device: 5 days*
- Recurrent rapid Afib requiring ECV
- Surgical site bleeding/ hemothorax
- ICU/ IMC discharge after 13 days
- In hospital stay: 24 days
- At discharge: LVEF 25%, mild MR



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Our case – Long-term follow-up
– Three years later...

- Prior to hospital discharge: LVEF 30%
- 2 months after MVR: LVEF 40%
- 3 years lafter: LVEF 50-55%, mild-moderate MR
- Patient is fine and active (NYHA I)

Aim: *Patients should not just survive; we should also aim for myocardial protection & recovery!*

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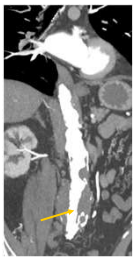
Case vignette: Severe PAD, CAD and AS
– A hostile trias

76 y/o male patient
- RCA and LCX occluded; LAD 80%
- LVEF 35-40%
- Severe AS (mean 36mmHg)
- Severe PAD
- Post-EVAR: Thrombus formation
- SOB (NYHA III)



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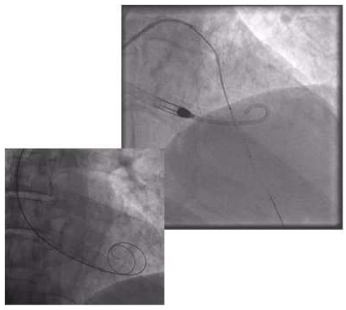
Case vignette: Severe PAD, CAD and AS
– A hostile trias

Management:
→ Left axillary access
- Surgical cutdown / sheath insertion (14F)
- BAV using TrueFlow™ Balloon (18mm)
- Impella CP Smart Assist advancement
- Single access / 6F sheath for guider
- LAD PCI (1xDES)
- Surgical device removal / access closure



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Why do we need alternative access routes for Impella implantation?
– There is no one size fits all!

Possible factors requiring alternative access:

- Peripheral artery disease (PAD)
- Aortic ulcers or thrombi
- Tortuosity of the femoral/ iliac arteries
- Elongation of the aorta
- (Post-EVAR)
- Morbid obesity (BMI >35-40kg/m^2)
- Prolonged support requirement expected (e.g. >1 week)
- …

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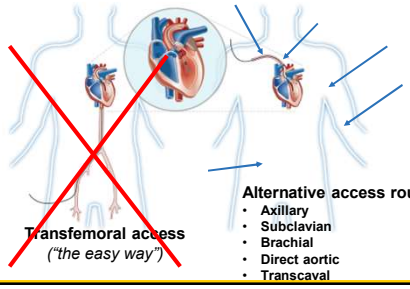
Alternative access routes for Impella implantation
– What options do we have?



Transfemoral access
("the easy way")

Alternative access routes:
- **Axillary**
- **Subclavian**
- **Brachial**
- **Direct aortic**
- **Transcaval**

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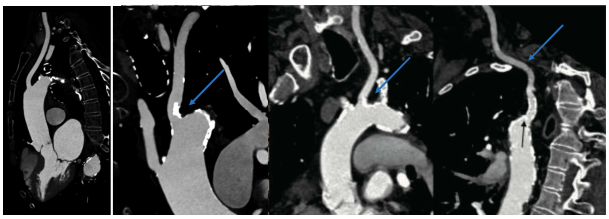
Factors prohibing transaxillary/-subclavian access for Impella implantation
– Atherosclerosis along the subclavian artery



LIMA-LAD-Graft

Cardiovascular Diagnosis and Therapy, Vol 10, No 1 February 2020

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Implantation of an Impella device requires team effort
– Get everybody involved

Teamwork!

Train your staff!

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Questions?
– Get involved… ☺

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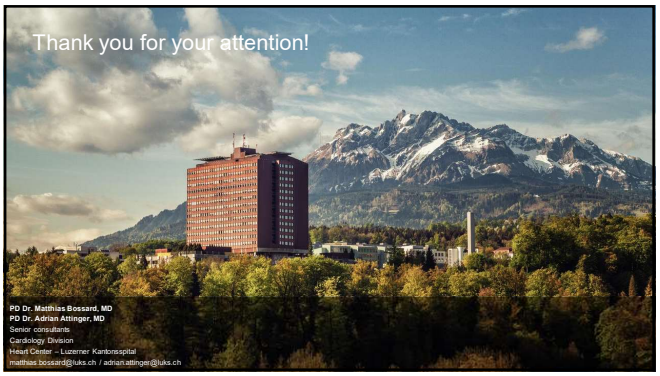

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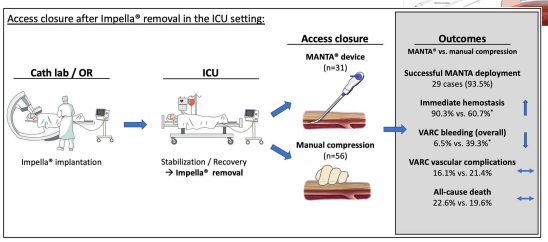
Access closure following Impella support
– It´s so simple ;-)



Cucull et al. Scientific Reports | (2022) 12:14060

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A challenging scenario: Morbid obese patient in need for MCSD support
– Which route should I take?

71 y/o male patient
- 3-v-CAD, LM steno
- LVEF 30%
- T2DM
- BMI 48kg/m²
- Poor mobility due to osteoarthritis

Which access route would you choose?

Surgical turndown:
→ Heart team decision: Protected PCI with Impella

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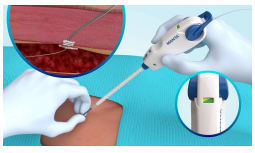
A challenging scenario: Morbid obese patient in need for MCSD support
– How it went…

Percutaneous Impella implant
- US-guidance for puncture
- PCI of LM, LAD, LCX
- **Planned access closure using MANTA™ device**



MANTA™ device does not seal puncture site
→ 8-10cm tissue in-between

Massive bleeding → Crossover using balloon occlusion does not seal access site

Urgent surgical repair necessary

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- WIESO BRAUCHT ES BEI EINER PCI "PROTECTION" ODER "SUPPORT"?

2 Szenarien:
Patient mit schlechter Herzfunktion & komplexer KHK

"Quick & Dirty" – Minimalistische PCI

PCI mit Pumpen-Unterstützung

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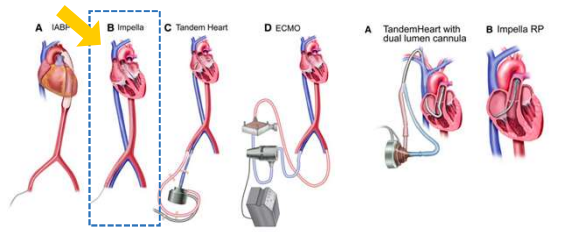
- MECHANISCHE KREISLAUFUNTERSTÜTZUNG?

«**Herzpumpen**», die den Kreislauf unterstützen → Was haben wir für Optionen?



Linksventrikuläre Unterstützung | **Rechtsventrikuläre Unterstützung**

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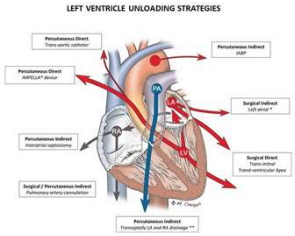
VENTRICULAR UNLOADING FOR MYOCARDIAL ISCHEMIA – NOT A NEW CONCEPT!



Reduction of the Oxygen Utilization of the Heart by Left Heart Bypass

By Clarence Dennis, M.D., Ph.D., David P. Hall, M.D., Juan R. Moreno, M.D., and Åke Senning, M.D.

Originally published
1 Mar 1962 https://doi.org/10.1161/01.RES.10.3.298
Circulation Research. 1962;10:298–305

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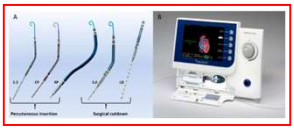
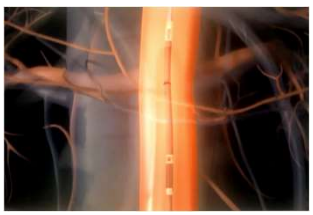
- PROTECTED PCI MIT IMPELLA – THE CONSEQUENTIAL CHOICE?

Impella: Eine «**Herzkreislaufunterstützungspumpe**», die direkt ins Herz gelegt wird
Wie geht das? Macht das Sinn?





Impella: Katheter und Konsole

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Copyright Abiomed

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- PROTECTED PCI MIT IMPELLA – THE CONSEQUENTIAL CHOICE?

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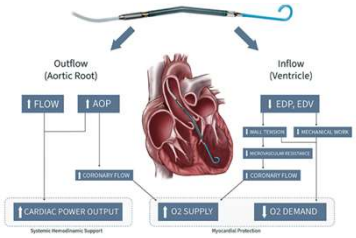

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- WIE GEHEN WIR VOR BEI DER PROTECTED PCI?

Planung und Vorbereitung sind essentiell!

1. *Aktenstudium und Aufklärung!* (Begleiterkrankungen & Patientenwünsche sind zentral)
2. *Abklärung und Früherkennung von Problemen* (mit Labor, Ultraschall, CT uvm.)
3. *Teamwork* → Unterstützung durch andere Fachdisziplinen (Anästhesie, IPS, Herzchirurgie, Gefässchirurgie, uvm.)
4. *Material* → Ultraschall, Impella, (ECMO), Drähte, Ballone, Rotablator, Imaging uvm.

Teamwork!

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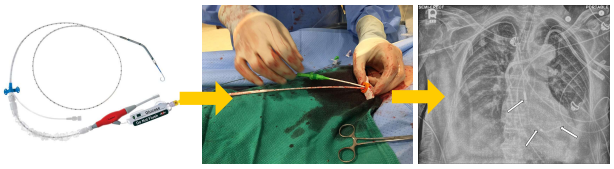
- WIE GEHEN WIR VOR BEI DER PROTECTED PCI?

Planung und Vorbereitung sind essentiell!



Teamwork!

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- EIN FALLBEISPIEL…

45 jähriger Patient mit schwerer Atemnot und schlechter Herzfunktion:
Wie weiter?

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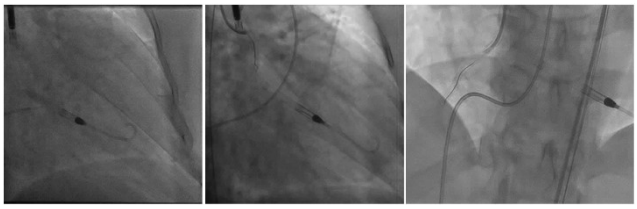
- EIN FALLBEISPIEL…

45 jähriger Patient mit schwerer Atemnot und schlechter Herzfunktion:
Was wir gemacht haben…



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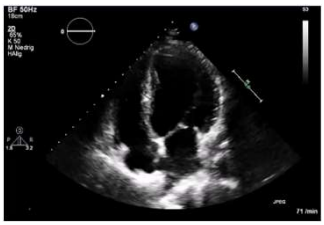
- EIN FALLBEISPIEL…

45 jähriger Patient mit schwerer Atemnot und schlechter Herzfunktion:
Wie ging es weiter?

Knapp 1 Jahr später:

1. Keine Atemnot mehr.
2. Normale Belastbarkeit
3. Erholung der Herzfunktion!



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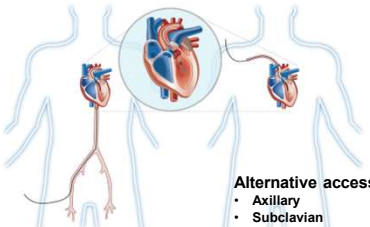
Access site selection
– Anticipate support duration



Transfemoral access
("the easy way")

Alternative access routes:
- **Axillary**
- **Subclavian**
- **Brachial**
- **Direct aortic**
- **(Transcaval)**

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Toolbox for a (regular) Impella™ implantation
– What do we need?

Access tools:

Needle and sheaths

Ultrasound with vascular

Impella accessoires:

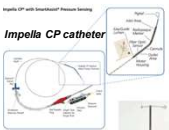
Impella CP with SmartAssist Introducer Kit

Impella Axillary Insertion Kit

Dextrose Solution

Placement Guidewire

The Impella device & control unit



Impella CP catheter

Purge Cassette

Controller unit

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Setting up the Impella™ device
– Connect all the wires and tubes correctly

Set-up Configuration of the Automated Impella Controller, Impella CP with SmartAssist C

https://www.fda.gov/media/140767/download

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Implantation of an Impella device requires team effort
– Get everybody involved

Teamwork! **Train your staff!**

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Questions?
– Get everybody involved…

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A challenging scenario: Morbid obese patient in need for MCSD support
– Which route should I take?

71 y/o male patient
- 3-v-CAD, LM steno
- LVEF 30%
- T2DM
- BMI 46kg/m^2
- Poor mobility due to osteoarthritis

Which access route would you choose?

Surgical turndown:
→ Heart team decision: Protected PCI with Impella

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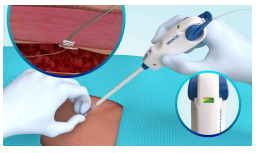
A challenging scenario: Morbid obese patient in need for MCSD support
– How it went…

Percutaneous Impella implant
- US-guidance for puncture
- PCI of LM, LAD, LCX
- **Planned access closure using MANTA™ device**



MANTA™ device does not seal puncture site
→ 8-10cm tissue in-between

Massive bleeding → Crossover using balloon occlusion does not seal access site

Urgent surgical repair necessary

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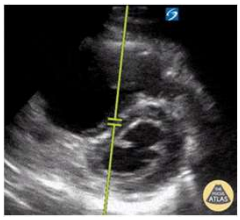
Right heart failure & MCSD
– A complex state, which needs to be recognized rapidly

Definition of RHF

CI <2.2 l/min/m² despite continuous infusion of high dose inotropes[a] and any of the following:
- CVP > 15 mmHg or
- CVP/PCWP > 0.63 or
- Moderate to severe global RV dysfunction on echocardiography defined as one of the following criteria:
  - Global RV hypokinesis
  - TAPSE score of ≤14 mm
  - RV diameter at basis >42 mm
  - RV short axis (or mid-cavity) diameter >35 mm



https://www.thepocusatlas.com/right-ventricular-dysfunction

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Right heart failure & MCSD
– Clinical signs and biochemical markers of RV failure

Clinical signs	Biochemical markers
Hypoxaemia	Increased lactate levels
Signs of systemic congestion	Elevated natriuretic peptides (BNP or NT-proBNP)
Jugular venous distension, hepatojugular reflux	Elevated cardiac troponin I or T
Peripheral oedema, pericardial effusion, congestive hepato/splenomegaly, ascites, anasarca*	Abnormal liver biochemistry (e.g. elevated transaminases, bilirubin, prolonged prothrombin time)
Signs of right ventricular dysfunction	Abnormal renal function (blood urea nitrogen, creatinine)
Third heart sound, systolic murmur of tricuspid regurgitation, hepatic pulse, signs of concomitant left ventricular dysfunction	D-dimer levels†
Paradoxical pulse	
Signs of low cardiac output state	
Hypotension, tachycardia, cool extremities, central nervous system abnormalities, oliguria	

Harjola1 et al; European Journal of Heart Failure (2016) 18, 226–241

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Right heart failure & MCSD
– Causes of acute RV failure

Acute left ventricular failure
Right ventricular ischaemia/infarction
Acute pulmonary embolism
Exacerbation of chronic lung disease and/or hypoxia
Acute lung injury or respiratory distress syndrome
Sepsis
Chronic pulmonary hypertension (groups 1–5)
Pericardial disease (tamponade)
Arrhythmias (supraventricular or ventricular tachycardia)
Congenital heart disease (e.g. atrial or ventricular septal defect, Ebstein's anomaly)
Valvulopathies (e.g. tricuspid valve regurgitation, pulmonary valve stenosis)
Cardiomyopathies (e.g. arrhythmogenic right ventricular dysplasia, familial, idiopathic)
Myocarditis or other inflammatory diseases
Cardiac surgery (e.g. cardiac transplant or left ventricular assist device implantation)
Haematological disorders (e.g. acute chest syndrome in sickle cell disease)

Harjola1 et al; European Journal of Heart Failure (2016) 18, 226–241

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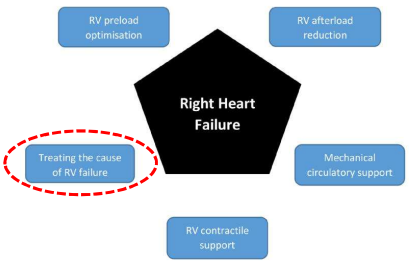
Principles of managing right heart failure.
– The 5 cornerstones of management



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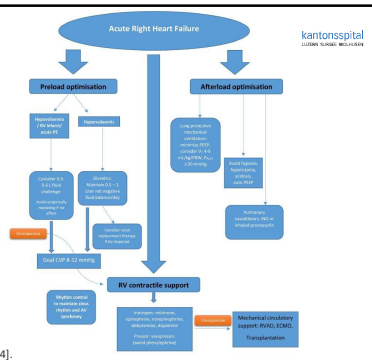
Management of isolated acute right heart failure.



Modified from Hadad et al [23] and Lahm et al [24].

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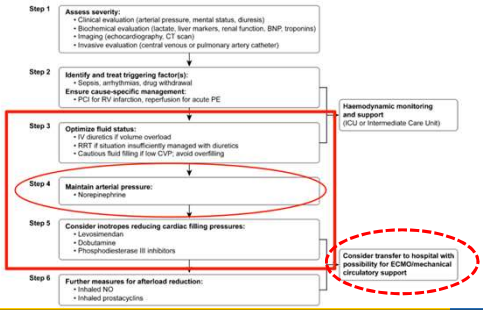
Management of acute RV failure
– A stepwise approach



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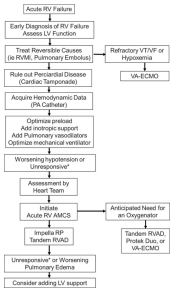
Mechanical circulatory support devices in RV failure
– A proposed algorithm



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Mechanical circulatory support devices for RV failure
– Currently available devices

Device	Mechanism/Configuration	Advantages	Disadvantages	Optimal Use
ProtekDuo RVAD (LivaNova)	• Centrifugal flow, extracorporeal • Percutaneously implanted (coaxial dual-lumen cannula) RA/RVOT to PA blood flow	• Percutaneously deployed • Single access site • Blood flow up to 4–5 l/min	• May cause SVC syndrome with larger cannula size	RV failure following durable LVAD implantation
Impella RP (Abiomed)	• Microaxial-flow • Percutaneously implanted • RA/IVC to PA blood flow	• Percutaneously deployed • Single access site • Blood flow up to 4-5 l/min	• Obligate femoral venous access • Risk of thrombosis at lower levels of anticoagulation	RV infarct or RV failure following durable LVAD implantation
Surgical CentriMag RVAD (Abbott)	• Centrifugal flow, extracorporeal • Surgically implanted • RA/RV*/SVC/IVC to PA blood flow	• Blood flow up to 7 l/min • Lower rate of red blood cell destruction	• Surgical implantation	In combination with CentriMag LVAD use
Veno-arterial ECMO	• Centrifugal flow, extra-corporeal • Percutaneously or surgically implanted • RA/IVC/SVC to aorta blood flow	• Percutaneous deployment possible • Emergent/bedside deployment • Blood flow up to 3–5 l/min	• Increases LV afterload • Systemic arterial embolic events • Risk of limb ischaemia	Massive pulmonary embolus or decompensated pulmonary hypertension
HeartMate 3 (Abbott)	• Centrifugal flow • Surgically implanted • RA/RV to PA blood flow	• Fully implantable device (i.e. dischargeable) • Blood flow up to 4–6 l/min	• Surgical implantation	In combination with durable LVAD implantation for dischargeable patient

IVC = inferior vena cava; LVAD = left ventricular assist device; PA = pulmonary artery; RA = right atrium; RV = right ventricle; SVC = superior vena cava.

Dell'Aquila et al. Cardiac Failure Review 2022;8:e14. doi.org/10.15420/cfr.2021.11

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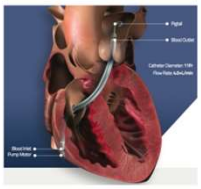
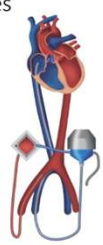
Right Ventricular Support Devices





Current and Emerging Strategies for RV Shock Management in the Setting of RV Infarct - American College of Cardiology (acc.org)

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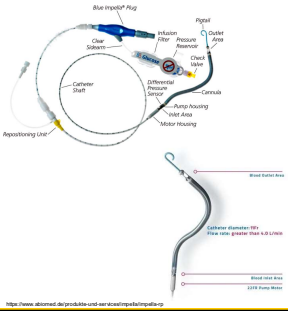
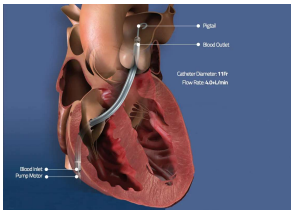
Impella™ RP for acute RV failure
– Unloading the RV





https://www.abiomed.de/produkte-und-services/impella/impella-rp

66

Impella™ RP for acute RV failure
– Patient selection

Clinical conditions in which the Impella RP is not recommended
Active infection with positive blood cultures
RA, RV or PA thrombus
Mechanical valves in the right heart*
Unrepaired ASD, PFO, or aortic dissection
PA conduit
Anatomic abnormalities precluding insertion
Moderate to severe pulmonary valve stenosis or insufficiency
Severe pulmonary hypertension (PAPs > 60mmHg)
Documented DVT and/or presence of IVC filter
Patients on right-sided support or ECMO
Allergy or intolerance to contrast
HIT or sickle cell disease

Attinger et al. Front. Cardiovasc. Med., 23 March 2022
Sec. Coronary Artery Disease | https://doi.org/10.3389/fcvm.2022.854870

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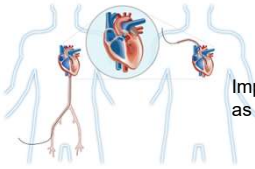
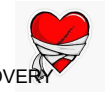
Impella™ devices as a bridge to …
– pVADs as an option to bridge a potentially fatal scenario



Impella™ devices as bridge to:

RECOVERY



HTX
(L)VAD

Harjola1 et al. European Journal of Heart Failure (2016) 18, 226–241

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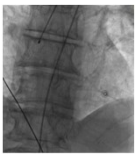
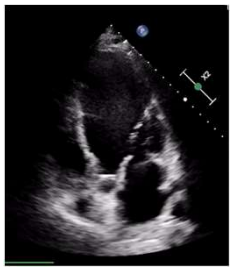
Case vignette: Patient with end-stage heart failure in his early seventies
– How far should we go?

72 y/o male patient
- Ischemic heart disease
- Cardiogenic shock 2014: LM occlusion
- Multiple coronary interventions
- ICD-implant 2014
- Rather stable for 7 years
- **2021:** Electric storm → Cardiogenic shock





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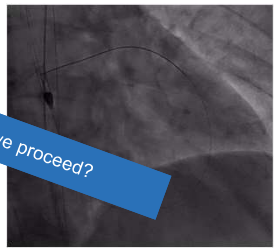
Case vignette: Patient with end-stage heart failure in his early seventies
– How far should we go?

72 y/o male patient
- End-stage HF – electric storm & CS

Meds:
- Amiodarone / sedation
- No effect!

Further course:
- pVAD Support → VT ablation
- Futile VT ablation
- Decision for LVAD implant
- Patient is at home (1.5y later)

How should we proceed?



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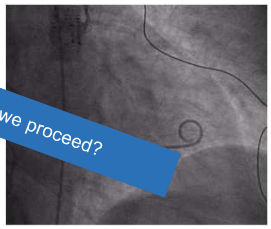
Case vignette: Late presentation of a STEMI
– Chest pain for >12hours and now things start to spiral

70 y/o female patient
- Ongoing chest pain f hours
- Anterior Q-Waves a
- Normal BP (!)
- Lactate 2.2mmol/L, clammy

How should we proceed?



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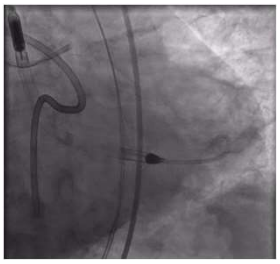
Case vignette: Late presentation of a STEMI
– Chest pain for >12hours and now things start to spiral

70 y/o female patient
- Cardiogenic shock secondary to MI
- Mechanical support first: Impella CP implantation
- Severe 3-V-CAD (incl. LM disease, occluded LAD)

- Proceedings:
  - Futile PCI attempt to LAD
  - Cardiac tamponade due to LAD perforation ☹
  - PCI of LM/ LCX
  - Transfer to ICU



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Case vignette: Late presentation of a STEMI
– Shock management using Impella – All fine?!

70 y/o female shock patient
- Profound shock – Catecholamines required
- «Insufficient support»

What options do we have?
ECMO? IABP? Impella 5.0/ 5.5?

- Proceedings:
  - Upsize Impella → 5.0 / transsubclavian access
  - 7 days support with Impella 5.0
  - Surgical removal → Transfer to community hospital
  - Hospital discharge after 21 days
  - 3 months FU → LVEF 35-40%; NYHA I-II

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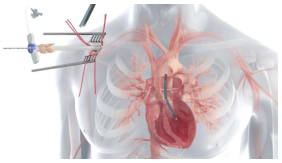
Impella™ devices as a bridge to …
– pVADs as an option to bridge a potentially fatal scenario

- Globally increasing number of patients suffering from advanced heart failure
- No. of patients requiring HTX for end-stage HF is growing
- Global organ shortage!
- pVADs (namely Impella™ devices) as bridge to recovery/ decision!

Impella 5.5
With Smart Assist



https://www.heartrecovery.com/products-and-services/impella/impella-55-with-smartassist

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Conclusions

- The term “stable” CAD should be avoided
- Nonmodifiable and modifiable determine the risk for adverse events in CAD patients.
- Novel antithrombotic regimens, lipid-lowering and inflammation-modifying agents reduce ischemic events.
- Plaque-characterization is important for risk stratification.

https://panet.ahrq.gov/webmmicase/168/Coming-Undone-Failure-of-Closure-Device

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