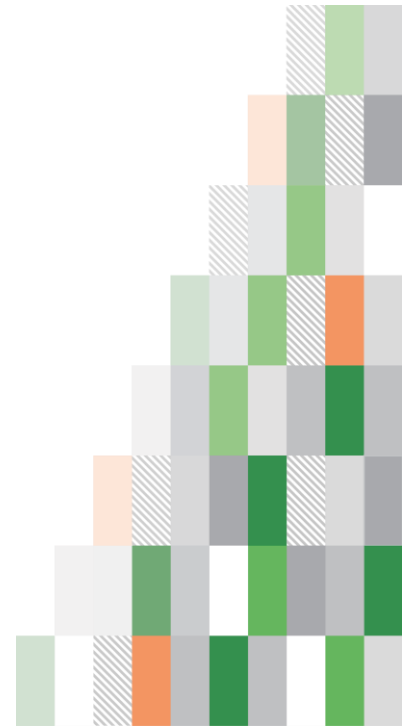


RISE OF THE MACHINES

Hype or hope im kardiogenen Schock

FM Fruhwald, Kardiologie Graz



Baustelle Radiologie-Neubau

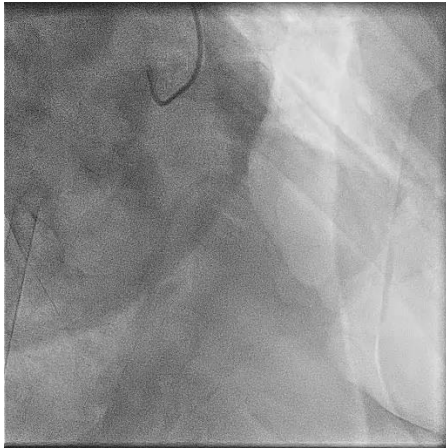
Anamnese

Übernahme vom NEF unter laufender Reanimation direkt ins Herzkatheterlabor. Beobachteter HKL Stillstand - primär Kammerflimmern, nach 1x Defibrillation pulslose elektrische Aktivität.

Kohlenhydrat-Stw			
Glukose (Vollblut)	501 ;PC/+++	mg/dL	70-100
Kohlenhydrat-Stw: Messgr. d. Glykolyse			
Laktat (Vollblut)	14.4 ;PC/+		
Blutgase/Säure-Basenh.: Eingabewerte			
FiO2, arteriell	1.00 ;PC		
Blutgase/Säure-Basenh., art			
Temperatur, arteriell	37.0 ;PC	°C	
pO2, arteriell	58.6 ;PC/-	mm Hg	71.0-104.0
pH, arteriell	6.857 ;PC/--		7.35-7.45
H+ Konzentration, arteriell	139.1 ;PC	nmol/L	12.0-16.0
pCO2, arteriell	72.3 ;PC/+	mm Hg	35.0-46.0
HCO3, aktuell, arteriell	12.8 ;PC/-	mmol/L	21.0-26.0
HCO3, Standard, arteriell	9.0 ;PC/-	mmol/L	22.0-26.0
Anionenlücke, arteriell	20.3 ;PC	mmol/L	-
BE, tatsächlich, arteriell	-21.0 ;PC/-	mmol/L	- 2.0-3.0
BE, Standard, arteriell	-20.8 ;PC/-	mmol/L	- 2.0-3.0
O2 Sättigung, arteriell	65.1 ;PC/-	%	95.0-98.5
Alveo-arterieller O2 Gradient	553.3 ;PC	mm Hg	
pO2/FiO2, arteriell	59 ;PC	mm Hg	
pO2 in Alveolarluft	611.9 ;PC	mm Hg	
arteriell alveoläre pO2-Ratio	9.6 ;PC	%	
Hb-Derivate, art			
Hämoglobin, arteriell	11.3 ;PC/-	g/dL	13.0-17.5
Hämatokrit, arteriell	34.7 ;PC/-	%	40.0-50.0

1. BGA 12h30





Schleuse eingeführt in die Arteria femoralis rechts Einführschleuse 6F 11cm Schleuse eingeführt in die Arteria femoralis rechts ECMO Schleuse eingeführt in die Vena femoralis rechts ECMO - Amplatz Torq/Vue Delivery System Schleuse eingeführt in die Arteria femoralis rechts anterior Einführschleuse 6 F. - Amplatz Torq/Vue Delivery System	Heparin 5000E i.a. Natriumbicarbonat (8,4%) L-Adrenalin 1mg L-Adrenalin 1mg Natriumbicarbonat (8,4%) L-Adrenalin 1mg Humanalbumin 100ml Aspirin 150 mg iv Kengrexal Bolus 13 ml iv Kengrexal Infusomat 17 ml/h Curzel 2000 mg iv Humanalbumin 100ml Heparin 5000E i.a. Elomel isoton 500 ml iv Heparin 3000 IE iA Elomel isoton 1000 ml iv Dobutamin Perfusor 250g 5ml/h Heparin 5000 IE iA Elomel isoton 1500 ml iv
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Material bei Diagnostik	Material bei Intervention
Einführschleuse 6F 11cm JR 4 6F JL 4,0 6F D35° 150cm Amplatz Torq/Vue Delivery System Amplatz Torq/Vue Delivery System	ECMO Zubehör lt. SOP XBC 3,0 6F Abbott Turm Trac 0,014"/190 cm Abbott Turm Trac 0,014"/190 cm Abbott Whisper Extra Support NC Ballon 2,5 x 15mm Asahi Sion blue 190cm Asahi Suoh 03 Mikrokatheter SuperCross 90 Asahi Suoh 03 Abbott Turm Trac 0,014"/190 cm Sapph. Ballon 1,0 / 10mm Guide Liner 6F Führungskatheter Mikrokatheter Turmpike LP Sapph. Ballon 0,85 / 10mm Abbott Balance Heavyweight Sapph. Ballon 0,85 / 10mm NC Ballon 2,0 15mm Neon 1,0 8mm Sapph. Ballon 1, 10mm NC Ballon 2,0/15mm NC Ballon 0,85/10mm

Intervention:

LAD	
Sapph. Ballon 1,0 / 10mm	PTCA Ballon gedehnt @ 16atm für 19sek
Sapph. Ballon 0,85 / 10mm	PTCA Ballon gedehnt @ 16 atm für 10 sek
Sapph. Ballon 0,85 / 10mm	PTCA Ballon gedehnt @ 16atm für 16 sek
NC Ballon 2,0 15mm	PTCA Ballon gedehnt @ 16atm für 54 sek
Neon 1,0 8mm	PTCA Ballon gedehnt @ 20atm für 52 sek
Sapph. Ballon 1, 10mm	PTCA Ballon gedehnt @ atm für sek
NC Ballon 2,0/15mm	PTCA Ballon gedehnt @ 16 atm für 60 sek
NC Ballon 0,85/10mm	



UNTERSUCHUNGEN:

Koronarangiographie, Cardiac Assist Device Ecmo, PCI akut, PTCA Eingefäß, PTCA mehrfach, Rekanalisationversuch, Strahlendosis: 194 Gy/cm²

INDIKATION(EN):

Laufende CPR, beobachteter HKS, primär VF, anschl. PEA, unter CPR ad HKL

DIAGNOSEN:

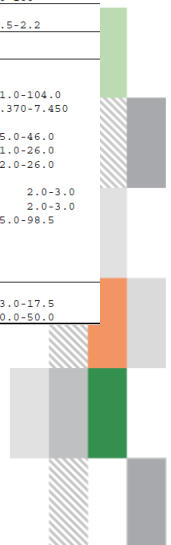
Koronare 3-Gefäß-Erkrankung
Diffus sklerosierte Koronargefäße
LM mit 30 % iger Stenose im proximalen Drittel.
LAD mit 90 % iger Stenose proximal am Abgang.
LAD mit 99 % iger Stenose im mittleren Drittel, massiv verkalkt.
CX mit 99 % iger Stenose proximal am Abgang, subtotal langstreckig verkalkt.
RCA mit 75 % iger Stenose im mittleren Drittel.

BGA 15h17

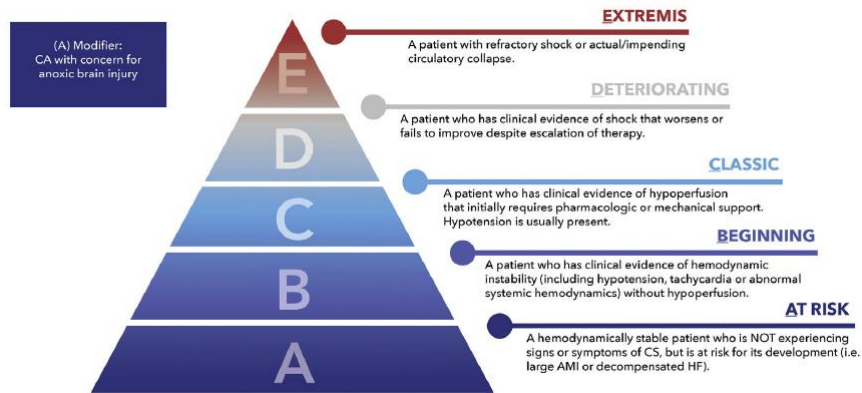


Kohlenhydrat-Stw				
Glukose (Vollblut)	330 ;PC/+++	mg/dL		70-100
Rohlenhydrat-Stw-Messgr.d.Glykolyse	15.0 ;PC/+	mmol/L		0.5-2.2
Laktat (Vollblut)				
Blutgase/Säure-Basenh.:Eingabewerte				
PO2, arteriell	0.85 ;PC			
Blutgase/Säure-Basenh.,art				
Temperatur, arteriell	37.0 ;PC	°C		
PO2, arteriell	488.0 ;PC/+	mm Hg		71.0-104.0
pH, arteriell	7.266 ;PC/+			7.370-7.450
H+ Konzentration, arteriell	54.2 ;PC	nmol/L		
PCO2, arteriell	37.6 ;PC	mm Hg		35.0-46.0
HCO3, aktuell, arteriell	17.1 ;PC/-	mmol/L		21.0-26.0
HCO3, Standard, arteriell	17.0 ;PC/-	mmol/L		22.0-26.0
Anionenlücke, arteriell	21.2 ;PC	mmol/L		
BE, tatsächlich, arteriell	-9.0 ;PC/-	mmol/L		- 2.0-3.0
BE, Standard, arteriell	-9.9 ;PC/+	mmol/L		- 2.0-3.0
O2 Sättigung, arteriell	99.9 ;PC/+	%		95.0-98.5
Alveol-arterieller O2 Gradient	54.2 ;PC	mm Hg		
PO2/FIO2, arteriell	574 ;PC	mm Hg		
PO2 in Alveolarluft	542.4 ;PC	mm Hg		
arteriell alveoläre PO2-Ratio	90.0 ;PC	%		
Hb-Derivate,art				
Hämoglobin, arteriell	5.5 ;PC/---	g/dL		13.0-17.5
Hämatokrit, arteriell	16.8 ;PC/-	%		40.0-50.0

Direkt nach der Übernahme komplikationslose Anlage einer VAecmo (eCPR). Nach initialer Kreislaufstabilisierung Coronarangiographie, Labor und USKG zum Ausschluss potentiell reversibler Ursachen. Intensivmedizinische Optimierung des Elektrolyt und Säure/Basen Haushalts sowie Volumsoptimierung. In der CAG komplexer 3 Gefäß KHK mit massiver Kalzifizierung und subtotaler Stenosierung in mehreren Gefäßgebieten. Revaskularisationsversuch LAD wird nach Ausschöpfen der techn. Möglichkeiten abgebrochen (TIMI III).
Im weiteren Verlauf trotz max. intensivmedizinischer Maßnahmen inkl. mechanischer Herzkreislaufunterstützung zunehmende hämodynamische Instabilität. Herr verstirbt im therapierefraktären kardiogenen Schock.



Kardiogener Schock = Kardiogener Schock?



SCAI = Society for Cardiovascular Angiography and Interventions



Naidu S, JACC 2022

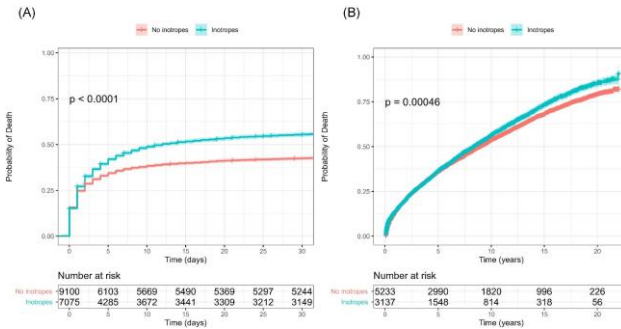
Inotropika bei CS

- ▶ SWEDEHEART-Register 2000-2022
 - ▶ N=702 799
- ▶ AMI-Patienten
 - ▶ N=302 847
- ▶ Kardiogener Schock
 - ▶ N=16 214 (60% männlich)
- ▶ Inotropika vs keine Inotropika
 - ▶ N=9118 vs 7096
 - (Inotropika=Noradrenalin, Dobutamin, Dopamin, Milrinon etc)



Petursson P, EHJ CV Pharmacotherapy 2025

Inotropika bei CS



Subgroup	No.inotropes	Inotropes	HR (95% CI)	P-value
All Patients	9118	7096	1.81 (1.71 - 1.92)	0.001
Age				
≤70	3038	2638	2.33 (2.06 - 2.64)	
>70	6080	4458	1.54 (1.41 - 1.68)	
Sex				0.843
Man	5315	4511	1.75 (1.60 - 1.92)	
Woman	3803	3803	1.78 (1.59 - 1.99)	
Diabetes				0.458
Yes	2351	1096	1.67 (1.44 - 1.94)	
No	8568	4079	1.78 (1.64 - 1.93)	
Diagnosis				0.018
ACS	7259	6252	1.70 (1.58 - 1.84)	
Other	1859	844	2.16 (1.80 - 2.59)	
University Hospital				0.304
Yes	2841	2380	1.67 (1.48 - 1.89)	
No	6277	4716	1.81 (1.66 - 1.97)	
MI				0.001
Yes	6671	2447	1.53 (1.05 - 2.25)	
No	6025	1071	2.13 (1.42 - 3.21)	
Angiography				0.001
Yes	3852	5496	1.50 (1.02 - 2.20)	
No	4252	2844	2.12 (1.44 - 3.13)	
PCI				0.001
Yes	2839	3643	1.44 (0.98 - 2.12)	
No	6279	3453	2.15 (1.46 - 3.16)	
Revascularization				0.001
Yes	3400	3636	1.45 (0.99 - 3.02)	
No	6257	2861	2.06 (1.40 - 3.02)	

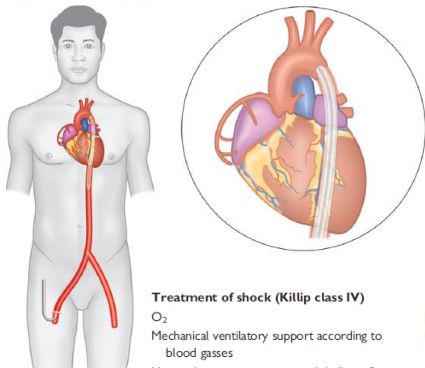
Es gibt keine Patientengruppe im CS, die von Katecholaminen langfristig profitieren

Petursson P, EHJ CV Pharmacotherapy 2025



IABP

Intra-aortic balloon pump



Treatment of shock (Killip class IV)

O ₂	I	C
Mechanical ventilatory support according to blood gases	I	C
Haemodynamic assessment with balloon floating catheter	IIb	C
Inotropic agents: dopamine and dobutamine	IIb	B
Intra-aortic balloon pump	I	C
LV assist devices	IIa	C
Early revascularization	I	B

- ▶ Helium-gefüllter Ballon
 - ▶ Puls-synchrones Aufblasen in der Diastole
 - ▶ Ablassen in der Systole
- ▶ Durch Verdrängung des Blutes in die Peripherie wird der Auswurf in der Systole erleichtert
- ▶ Viele Jahre Klasse 1-Empfehlung bei CS post AMI

Van de Werf, EHJ 2008, Wong ASK, Ann Transl Med 2020



IABP bei CS

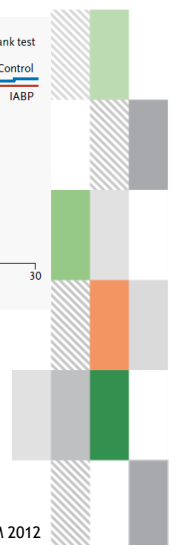
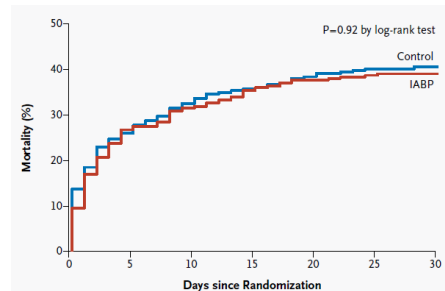
- ▶ IABP-SHOCK II
 - ▶ Infarkt mit CS
 - ▶ N=600
- ▶ IABP-Implantation vor oder sofort nach PCI
 - ▶ 1:1-getriggter Support der IABP
- ▶ Full-support durch IABP so lange, bis ein RRs von >90mmHg für 30min ohne Katecholamine möglich war
- ▶ Primärer Endpunkt
 - ▶ 30 Tage Mortalität



Thiele H, NEJM 2012

IABP bei CS

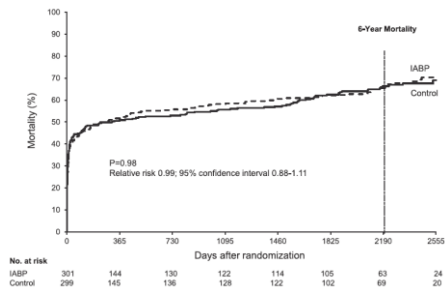
Variable	IABP (N=301)	Control (N=299)
Sign of impaired organ perfusion — no./total no. (%)		
Altered mental status	215/300 (71.7)	232/299 (77.6)
Cold, clammy skin and extremities	257/300 (85.7)	245/299 (81.9)
Oliguria	90/300 (30.0)	99/299 (33.1)
Serum lactate >2.0 mmol/liter	226/300 (75.3)	218/298 (73.2)
Serum lactate — mmol/liter		
Median	3.6	4.7
Interquartile range	2.1–7.2	2.3–8.2
Fibrinolysis <24 hr before randomization — no. (%)	28 (9.3)	20 (6.7)
Resuscitation before randomization — no. (%)	127 (42.2)	143 (47.8)
Myocardial infarction — no./total no. (%)		
Non-ST-segment elevation	96/300 (32.0)	81/298 (27.2)
ST-segment elevation	200/300 (66.7)	212/298 (71.1)
Anterior	136/298 (45.6)	116/296 (39.2)
Systolic blood pressure — mm Hg		
Median	89	90
Interquartile range	79–107	80–109
Diastolic blood pressure — mm Hg		
Median	55	55
Interquartile range	46–67	45–65
Mean blood pressure — mm Hg†		
Median	69	68
Interquartile range	59–80	59–80
Use of catecholamines at randomization — no./total no. (%)	270/301 (89.7)	268/298 (89.9)



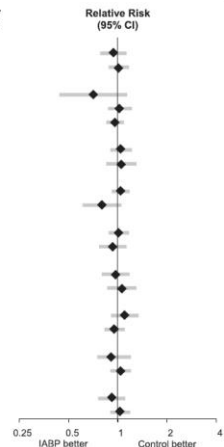
Thiele H, NEJM 2012

IABP bei CS

- ▶ 6-Jahres-FUP
 - ▶ 591 von 600 Patienten
- ▶ Kein Unterschied im outcome



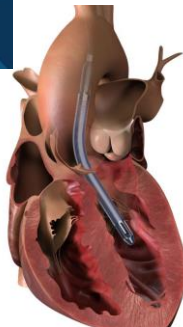
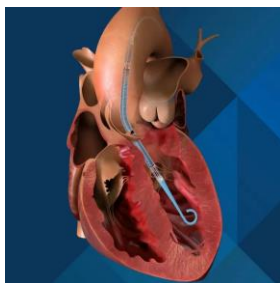
Baseline Variable	6-Year Mortality n (%)		Relative Risk (95% CI)	P-Value for Interaction
	IABP	Control		
Female	67 (69.1)	64 (73.6)	0.94 (0.78-1.13)	0.51
Male	130 (65.0)	133 (64.3)	1.01 (0.88-1.17)	
Age <50 years	70 (41.7)	20 (58.8)	0.71 (0.44-1.14)	0.32
Age 50-75 years	347 (61.4)	108 (59.7)	1.02 (0.87-1.22)	
Age >75 years	174 (84.2)	69 (87.3)	0.96 (0.85-1.09)	
Diabetes	194 (71.2)	73 (81.1)	1.04 (0.90-1.22)	0.10
No diabetes	393 (63.5)	124 (60.8)	1.05 (0.85-1.30)	
History of hypertension	408 (72.5)	137 (69.5)	1.04 (0.92-1.18)	0.08
No history of hypertension	178 (49.4)	60 (61.9)	0.80 (0.61-1.05)	
STEMILBBB	412 (66.0)	138 (65.1)	1.01 (0.88-1.17)	0.48
NSTEMI	179 (67.0)	59 (72.0)	0.93 (0.77-1.13)	
Anterior STEMI	215 (65.2)	69 (67.0)	0.97 (0.80-1.18)	0.56
Non-anterior STEMI	197 (67.1)	69 (63.3)	1.06 (0.86-1.30)	
Previous infarction	130 (80.3)	43 (72.9)	1.10 (0.91-1.34)	0.22
No previous infarction	460 (62.2)	154 (65.5)	0.95 (0.83-1.10)	
Hypothermia	222 (62.5)	81 (68.6)	0.91 (0.75-1.20)	0.28
No hypothermia	369 (68.4)	116 (65.9)	1.04 (0.90-1.20)	
Blood pressure <80 mmHg	160 (54.7)	63 (75.9)	0.92 (0.76-1.11)	0.35
Blood pressure ≥80 mmHg	425 (65.4)	132 (63.5)	1.03 (0.90-1.19)	



Thiele H, Circulation 2019



Impella



- ▶ Mikroaxial-Pumpe fördert Blut aus dem LV in die Ao ascendens
- ▶ Impella CP
 - ▶ A. femoralis
 - ▶ Gestochen (14F)
 - ▶ HMV 4l/min
 - ▶ 46.000 U/min
- ▶ Impella 5.5
 - ▶ A. subclavia/axillaris
 - ▶ Via Gefäßprothese (chirurgisch 23F)
 - ▶ HMV 5,5l/min
 - ▶ 33.000 U/min

Attinger-Toller A, Front in CV Medicine 2022



Impella bei CS

- ▶ DanGer Shock
 - ▶ STEMI mit CS
 - ▶ N=355
- ▶ Impella CP vs SOC
 - ▶ PCI und Vasopressoren
- ▶ Impella auf Maximum für mind 48h
- ▶ Eskalation auf "große" Impella u/o ECMO in beiden Gruppen möglich
 - ▶ Primärer Endpunkt
 - ▶ 180 Tage Mortalität



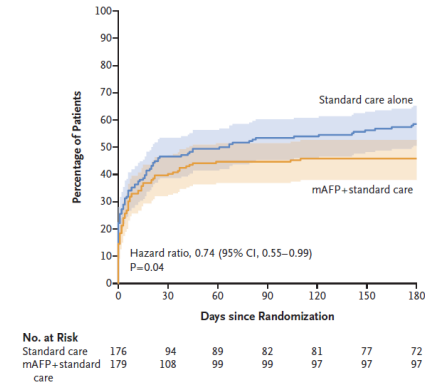
Möller JE, NEJM 2024

Impella bei CS



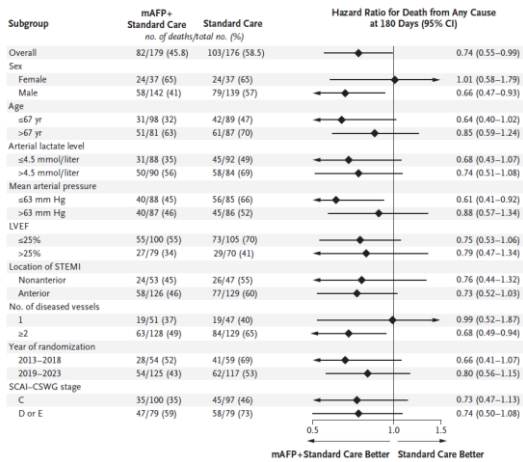
Characteristic	Microaxial Flow Pump plus Standard Care (N=179)	Standard Care Alone (N=176)
Median age (IQR) — yr	67 (58–76)	69 (61–76)
Male sex — no. (%)	142 (79.3)	139 (79.0)
Medical history — no. (%)		
Hypertension	89 (49.7)	94 (53.4)
Diabetes	33 (18.4)	47 (26.7)
Myocardial infarction	29 (16.2)	28 (15.9)
Heart failure	16 (8.9)	17 (9.7)
Chronic kidney disease	17 (9.5)	18 (10.2)
Median systolic blood pressure (IQR) — mm Hg	84 (72–91)	82 (72–91)
Median of the mean arterial blood pressure (IQR) — mm Hg	63 (55–72)	64 (55–73)
Median heart rate (IQR) — beats/min	94 (77–110)	95 (76–111)
Median arterial lactate level (IQR) — mmol/liter	4.6 (3.4–7.1)	4.5 (3.2–6.9)
Median left ventricular ejection fraction (IQR) — %	25 (20–31)	25 (15–30)
Resuscitation before randomization — no. (%)	39 (21.8)	33 (18.8)
Intubation before randomization — no. (%)	35 (19.6)	28 (15.9)
Transfer from outside hospital — no. (%)	51 (28.5)	48 (27.3)
Anterior myocardial infarction — no. (%)	126 (70.4)	129 (73.3)
SCAI-CSWG stage at admission — no. (%)†		
C	100 (55.9)	97 (55.1)
D	51 (28.5)	50 (28.4)
E	28 (15.6)	29 (16.5)

A Death from Any Cause



Möller JE, NEJM 2024

Impella bei CS



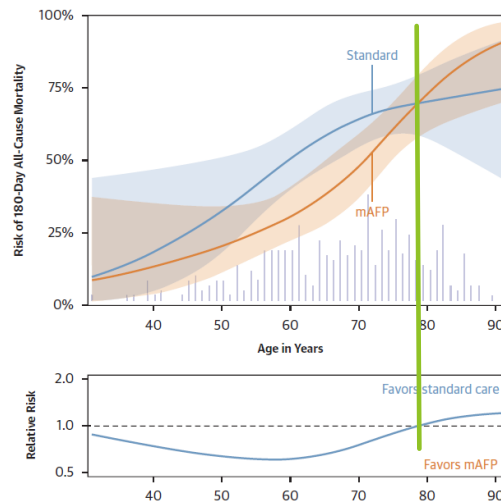
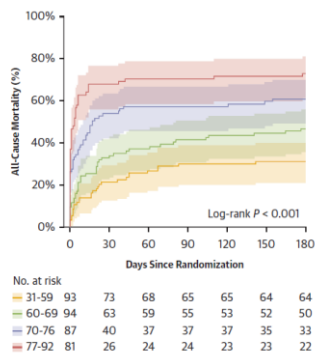
Management	Microaxial Flow Pump plus Standard Care (N=179)	Standard Care Alone (N=176)
Revascularization		
PCI — no. (%)	171 (95.5)	172 (97.7)
Non-culprit vessel PCI — no./no. of patients with multivessel disease (%)	59/127 (46.5)	55/129 (42.6)
Immediate CABG — no. (%)	1 (0.6)	4 (2.3)
Median time from admission to balloon inflation (IQR) — min	58 (36-114)	45 (31-81)
Mechanical circulatory support		
Placement of Impella CP device — no. (%)†	170 (95.0)	3 (1.7)
Randomization occurred before PCI and microaxial flow pump placed before PCI — no./total no. (%)	84/99 (84.8)	3/3 (100)
Median time from randomization to placement of microaxial flow pump (IQR) — min	14 (8-29)	15 (8-31)
Median duration of microaxial flow pump support (IQR) — hr	59 (30-87)	60 (31-92)
Mechanical hemolysis — no./total no. (%)‡	21/170 (12.4)	1/3 (33.3)
Device malfunction — no./total no. (%)‡	2/170 (1.2)	1/3 (33.3)
Successful weaning from microaxial flow pump — no./total no. (%)	138/170 (81.2)	1/3 (33.3)
Escalation to additional mechanical circulatory support		
Placement of Impella 5.0 device — no. (%)	7 (3.9)	5 (2.8)
Placement of Impella CP for venting during venoarterial ECMO therapy — no. (%)	0	4 (2.3)
Placement of Impella 2.5 device — no. (%)	0	1 (0.6)
Placement of Impella RP device — no. (%)	0	0
Venoarterial ECMO — no. (%)	21 (11.7)	33 (18.8)
Median time from randomization to placement of venoarterial ECMO (IQR) — hr	14 (4-54)	2 (1-5)
Placement of permanent LVAD — no. (%)	10 (5.6)	4 (2.3)
Any escalation to additional mechanical circulatory support — no. (%)	28 (15.6)§	37 (21.0)¶
Intensive care management		
Mechanical ventilation — no. (%)	133 (74.3)	116 (65.9)
Median duration of mechanical ventilation (IQR) — days	5 (2-10)	3 (1-10)
Medication use — no. (%)		
Any vasopressor	159 (88.8)	146 (83.0)

Möller JE, NEJM 2024



Impella für alle?

- ▶ Subanalyse der Impella-Gruppe
- ▶ Patientenalter und outcome

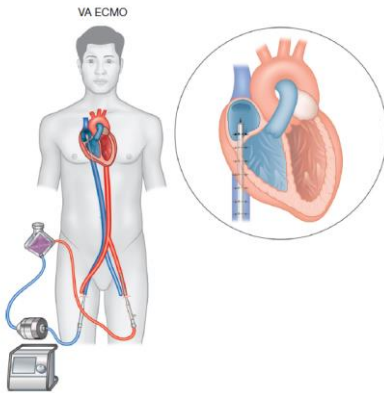


Ab 77 Jahren ist die Mortalität mit Impella höher als ohne

Klein A, JACC 2025



VA-ECMO



- ▶ VA-ECMO funktioniert wie HLM
 - ▶ Venöse Kanüle holt Blut aus der VCI zum Oxygenator
 - ▶ Arterielle Kanüle transportiert Blut vom Oxygenator in das arterielle System
- ▶ Zentrale Kanülierung
 - ▶ Antegrader Fluss in der Aorta descendens
- ▶ Femorale Kanülierung
 - ▶ Tw. retrograder Fluss in der Aorta descendens
- ▶ Artefizieller Kreislauf mit Ersatz von Herz- und Lungenfunktion



Wong ASK, Ann Transl Med 2020

VA-ECMO bei eCPR

- ▶ INCEPTION
 - ▶ 160 Patienten mit OHCA und bystander CPR (kein ROSC nach mindestens 15min)
 - ▶ 70 Patienten → VA-ECMO
 - ▶ 64 Patienten → konventionelle CPR
- ▶ Prim. Outcome
 - ▶ Cerebral performance category 1 oder 2 (=gute Neurologie) nach 30 Tagen



Suverein MM, NEJM 2023

VA-ECMO bei eCPR



Characteristic	Extracorporeal CPR (N=70)	Conventional CPR (N=64)	Outcome	Extracorporeal CPR (N=70)	Conventional CPR (N=64)	Odds Ratio (95% CI)†
Age — yr	54±12	57±10	Initiation of extracorporeal CPR — no. (%)	52 (74)	3 (5)	0.02 (0.0 to 0.6)
Male sex — no. (%)	63 (90)	57 (89)	Cannulation and circulation successful	46 (66)	3 (5)	
Primary shockable rhythm — no. (%)	69 (99)	63 (98)	Cannulation or circulation failed	6 (9)	0	
Arrest occurred at home — no. (%)	31 (44)	24 (38)	Patient died before ICU admission	2 (3)	0	
Witnessed arrest — no. (%)	68 (97)	63 (98)	No initiation of extracorporeal CPR — no. (%)	18 (26)	61 (95)	58.7 (16.4 to 210.7)
CPR started ≤5 min after arrest — no. (%)	69 (99)	61 (95)	Logistic failure	3 (4)	0	
Total no. of defibrillations	8±5	9±6	Cessation of treatment	2 (3)	NA	
Transport distance — no. of patients (km)	68 (17±10)	63 (16±11)	Stable ROSC	13 (19)	NA	
Cause of arrest — no. (%)			Randomly assigned to conventional CPR	NA	61 (100)	
Acute myocardial infarction	51 (73)	52 (81)	ROSC — no./total no. (%)	18/70 (26)	20/64 (31)	1.3 (0.6 to 2.8)
Secondary arrhythmia	11 (16)	11 (17)	ROSC before emergency department arrival	10/18 (56)	9/20 (45)	
Pulmonary embolus	1 (1)	0	ROSC after emergency department arrival	8/18 (44)	11/20 (55)	
Metabolic or electrolyte	1 (1)	0	Intermittent ROSC during resuscitation — no. (%)	27 (39)	22 (34)	0.8 (0.4 to 1.7)
Neurologic	0	1 (2)	Extracorporeal CPR performed in emergency department (vs. cardiac catheterization laboratory) — no. (%)	39 (56)	1 (2)	1.5 (0.1 to 18.0)
Intoxication	1 (1)	0	PCI — no. (%)	34 (49)	14 (22)	0.3 (0.2 to 0.6)
Other†	5 (7)	0	Admitted to ICU — no. (%)	57 (81)	23 (36)	0.1 (0.1 to 0.3)
			Decannulation			
			No. of patients	45	2‡	NA
			Median interval from arrest to decannulation (IQR) — hr	26 (9–53)	NA	NA

Suvrein MM, NEJM 2023

VA-ECMO bei eCPR



Death after ICU admission	Extracorporeal CPR (N=70)	Conventional CPR (N=64)	Odds Ratio (95% CI)
No. of patients	44	10	
Interval from arrest to death — days	3±6	5±6	-1.5 (-5.8 to 2.8)
Survived to ICU discharge — no. (%)	14 (20)	15 (23)	1.2 (0.5 to 2.8)
Survived to hospital discharge — no. (%)	14 (20)	13 (20)	1.0 (0.4 to 2.4)
Discontinued treatment — no./total no. (%)	56/70 (80)	51/64 (80)	1.0 (0.4 to 2.3)
Neurologically unfavorable	24/56 (43)	4/51 (8)	
Multiple organ failure	15/56 (27)	7/51 (14)	
Cannulation or ECLS failure	8/56 (14)	0	
No more treatment options	5/56 (9)	40/51 (78)	
Other	4/56 (7)	0	

Outcome	Extracorporeal CPR (N=70)	Conventional CPR (N=63)†	Odds Ratio (95% CI)	P Value	Risk Ratio (95% CI)
Primary outcome: 30-day survival with favorable neurologic outcome — no./total no. (%)	14/70 (20)	10/62 (16)‡	1.4 (0.5–3.5)	0.52	1.05 (0.97–1.13)
Secondary outcomes — no./total no. (%)					
3-month survival with favorable neurologic outcome	12/68 (18)	9/63 (14)	1.5 (0.6–3.8)		
6-month survival with favorable neurologic outcome	14/70 (20)	10/63 (16)	1.3 (0.5–3.3)		

Suvrein MM, NEJM 2023

VA-ECMO bei CS



- ▶ ECLS-SHOCK
 - ▶ MI mit CS und geplanter PCI
 - ▶ ECLS oder medikamentöse SOC
- ▶ 420 Patienten
 - ▶ 209 ECLS
 - ▶ 208 SOC
- ▶ Prim. Endpunkt
 - ▶ Gesamtmortalität nach 30 Tagen

- ▶ Einschluss bei
 - ▶ RR <90mmHg oder Katecholamine für RR >90
 - ▶ SCAI C/D/E
 - ▶ Laktat >3
- ▶ Kein Einschluss bei
 - ▶ CPR >45min
- ▶ ECLS-Einbau beim HK/vor PCI inkl. antegraden Beinperfusion



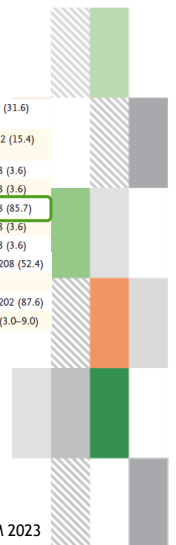
Thiele H, NEJM 2023

VA-ECMO bei CS



Characteristic	ECLS (N=209)	Control (N=208)
Median age (IQR) — yr	62 (56-69)	63 (57-71)
Male sex — no. (%)	170 (81.3)	169 (81.2)
Median body-mass index (IQR)†	27 (25-30)	28 (25-31)
Cardiovascular risk factors — no./total no. (%)		
Current smoking	74/204 (36.3)	71/206 (34.5)
Hypertension	118/207 (57.0)	115/206 (55.8)
Hypercholesterolemia	55/207 (26.6)	74/206 (35.9)
Diabetes mellitus	70/208 (33.7)	60/206 (29.1)
Cardiovascular history — no./total no. (%)		
Myocardial infarction	23/208 (11.1)	31/206 (15.0)
PCI	27/208 (13.0)	43/206 (20.9)
CABG	5/208 (2.4)	6/207 (2.9)
Stroke	20/208 (9.6)	11/207 (5.3)
Peripheral-artery disease	21/208 (10.1)	16/206 (7.8)
Signs of impaired organ perfusion — no. (%)		
Altered mental status	200 (95.7)	198 (95.2)
Cold, clammy skin and limbs	202 (96.7)	204 (98.1)
Oliguria	150 (71.8)	150 (72.1)
Median blood pressure (IQR) — mm Hg		
Systolic	95 (80-120)	97 (80-120)
Diastolic	61 (50-73)	60 (50-71)
Median heart rate (IQR) — beats/min	90 (75-110)	95 (71-110)
ST-segment elevation myocardial infarction — no./total no. (%)	135/204 (66.2)	141/207 (68.1)
Fibrinolysis <24 hr before randomization — no./total no. (%)	6/208 (2.9)	9/208 (4.3)
Resuscitation before randomization — no. (%)	162 (77.5)	162 (77.9)
Median time until return of spontaneous circulation during longest continuous resuscitation (IQR) — min	20 (10-25)	20 (12-28)
SCAI shock stage — no. (%)‡		
C	104 (49.8)	111 (53.4)
D	38 (18.2)	18 (8.7)
E	67 (32.1)	79 (38.0)

Active left ventricular unloading during ECLS therapy — no./total no. (%)	11/191 (5.8)	6/19 (31.6)
Other mechanical circulatory support in patients without ECLS — no./total no. (%)	0/17	28/182 (15.4)
Intraaortic balloon pump	—	1/28 (3.6)
Impella 2.5	—	1/28 (3.6)
Impella CP	—	24/28 (85.7)
Impella 5.0	—	1/28 (3.6)
Impella 5.5	—	1/28 (3.6)
Target temperature management — no./total no. (%)	82/209 (39.2)	109/208 (52.4)
Invasive mechanical ventilation		
Patients — no./total no. (%)	183/203 (90.1)	177/202 (87.6)
Median duration (IQR) — days	7.0 (4.0-12.0)	5.0 (3.0-9.0)

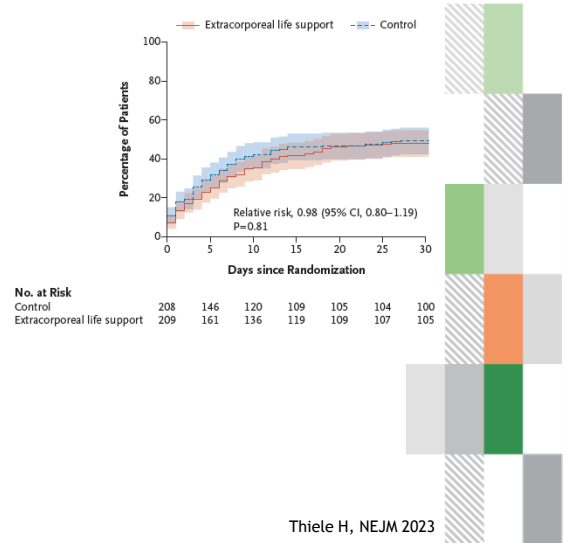


Thiele H, NEJM 2023

VA-ECMO bei CS



Outcome	ECLS (N=209)	Control (N=208)	Effect Size (95% CI)*
Primary outcome			
Death from any cause — no. (%)	100 (47.8)	102 (49.0)	Relative risk, 0.98 (0.80 to 1.19)
Secondary outcomes			
Renal-replacement therapy — no. (%)	17 (8.1)	29 (13.9)	Relative risk, 0.58 (0.33 to 1.03)
Repeat revascularization — no. (%)	18 (8.6)	22 (10.6)	Relative risk, 0.81 (0.45 to 1.47)†
Myocardial reinfarction — no. (%)	2 (1.0)	2 (1.0)	Relative risk, 1.00 (0.07 to 12.72)†
Rehospitalization for congestive heart failure — no. (%)	3 (1.4)	2 (1.0)	Relative risk, 1.49 (0.24 to 13.61)†
Poor neurologic outcome, CPC 3 or 4 — no./total no. (%)‡	27/109 (24.8)	24/106 (22.6)	Relative risk, 1.03 (0.88 to 1.19)
Median duration of invasive mechanical ventilation (IQR) — days	7.0 (4.0 to 12.0)	5.0 (3.0 to 9.0)	HLE, 1 (0 to 2)
Median time until hemodynamic stabilization (IQR) — days	3.1 (1.2 to 6.6)	3.1 (1.2 to 5.4)	HLE, 0.27 (-0.41 to 1.14)
Median duration of catecholamine therapy (IQR) — days	5.0 (2.5 to 8.0)	4.0 (2.0 to 7.0)	HLE, 1 (0 to 1)
Median duration of intensive care treatment (IQR) — days	10.0 (4.0 to 16.0)	8.0 (4.0 to 13.0)	HLE, 1 (0 to 3)
Median duration of hospital stay (IQR) — days	12.0 (5.0 to 20.0)	10.0 (3.0 to 19.0)	HLE, 2 (0 to 4)
Safety outcomes			
Peripheral ischemic vascular complications warranting surgical or interventional therapy — no. (%)	23 (11.0)	8 (3.8)	Relative risk, 2.86 (1.31 to 6.25)
Stroke or systemic embolization — no. (%)	8 (3.8)	6 (2.9)	Relative risk, 1.33 (0.47 to 3.76)
Moderate or severe bleeding — no. (%)§	49 (23.4)	20 (9.6)	Relative risk, 2.44 (1.50 to 3.95)



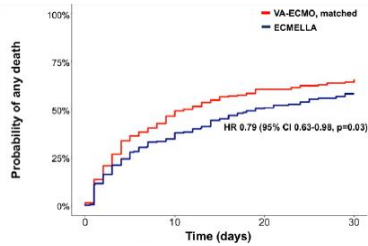
ECMELLA bei CS



- ▶ STOP-SHOCK Register (2013-2019)
 - ▶ VA-ECMO plus Impella (2.5/CP/5.5) beim CS
 - ▶ 686 Patienten mit CS in 16 Zentren
 - ▶ 255 ECMELLA-Patienten vs 255 propensity matched VA-ECMO-Patienten
 - ▶ 63% Infarkt-Patienten, davon 95% mit PCI versorgt
 - ▶ 67% St.p. CPR
 - ▶ Prim. Endpunkt: 30 Tage-Mortalität



ECMELLA bei CS



ECMELLA-Gruppe hat

- doppelt so viele schwere Blutungen (18 vs 38%)
- Signifikant mehr Interventionsbedürftige Ischämien (12 vs 22%)
- Signifikant höhere Dialyserate (39 vs 59%)

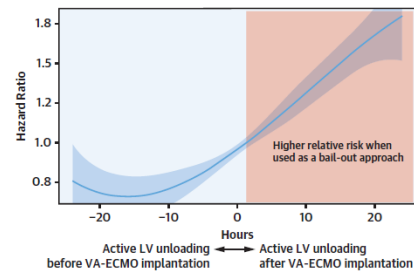
30-day mortality					
Variable	N	ECMELLA	VA-ECMO	HR (95% CI)	p-interaction
Age					
<52 years	167	41.4% (36/87)	46.3% (37/80)	0.81 (0.52-1.29)	NS
52-62 years	173	59.3% (48/81)	68.5% (63/92)	0.75 (0.52-1.09)	
>62 years	170	70.1% (61/87)	74.7% (62/83)	0.80 (0.66-1.14)	
Sex					0.19
Female	120	46.7% (29/60)	63.3% (38/60)	0.59 (0.38-0.96)	
Male	390	60.3% (117/195)	63.8% (124/195)	0.85 (0.66-1.10)	
Cause of CS					0.84
AMI	321	56.8% (90/159)	61.7% (100/162)	0.80 (0.60-1.06)	
Non-ischemic	187	57.3% (59/96)	66.7% (62/91)	0.78 (0.53-1.10)	
Prior cardiac arrest					0.14
Yes	341	59.4% (101/170)	70.2% (120/171)	0.69 (0.53-0.90)	
No	169	51.8% (44/85)	50.0% (42/84)	1.01 (0.66-1.55)	
eCPR					0.39
Yes	172	70.2% (59/84)	73.9% (65/88)	0.60 (0.41-0.89)	
No	338	50.3% (86/171)	58.1% (87/167)	0.74 (0.55-0.99)	
Lactate					NS
<5 mmol/l	190	44.3% (31/70)	43.8% (35/80)	0.99 (0.61-1.60)	
5-10.8 mmol/l	159	61.0% (47/77)	76.8% (63/82)	0.68 (0.47-0.98)	
>10.8 mmol/l	138	67.2% (43/64)	74.3% (55/74)	0.66 (0.44-0.98)	
SAVE score					NS
≥6	130	47.8% (33/69)	59.0% (36/61)	0.70 (0.44-1.12)	
<6	143	57.3% (43/75)	63.2% (43/68)	0.85 (0.56-1.30)	
<11	112	75.0% (48/64)	81.3% (39/48)	0.70 (0.46-1.06)	
SAPS II					NS
<52	134	43.7% (31/71)	61.9% (39/63)	0.58 (0.36-0.92)	
52-76	151	59.2% (42/71)	60.0% (48/80)	0.90 (0.59-1.36)	
>76	137	72.0% (59/82)	74.6% (39/51)	0.85 (0.57-1.27)	
Overall	510	56.9% (145/255)	63.5% (162/255)	0.79 (0.63-0.98)	0.03

Schrage B, Circulation 2020

ECMELLA bei CS



- ▶ 421 Patienten mit VA-ECMO beim CS
 - ▶ Impella-Implantation early/delayed (2h) in Relation zur ECMO-Implantation
 - ▶ 18 Zentren in 4 Ländern
 - ▶ Mortalität nach 30 Tagen war signifikant geringer in der Impella-first-Gruppe
 - ▶ HR 0.64 (95%CI 0.46-0.88, p<0,01)



UNLOAD-ECMO-Studie wird diesen Ansatz prospektiv randomisiert untersuchen

Schrage B, JACC-HF 2023

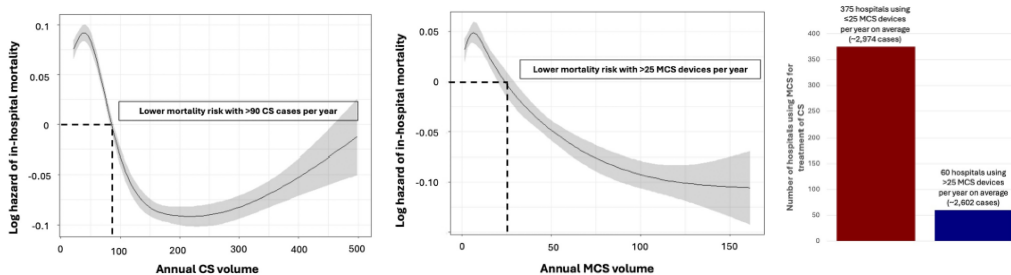
Ist case-load der Schlüssel zum Erfolg?

- ▶ 2017-2021
 - ▶ 220.223 CS-Patienten in 1232 Krankenhäusern in DE
 - ▶ 435 KH's haben MCS (IABP, Impella, VA-ECMO)
- ▶ Wie hängen case-load und outcome zusammen?



Dettling A, EJHF 2025

Ist case-load der Schlüssel zum Erfolg?



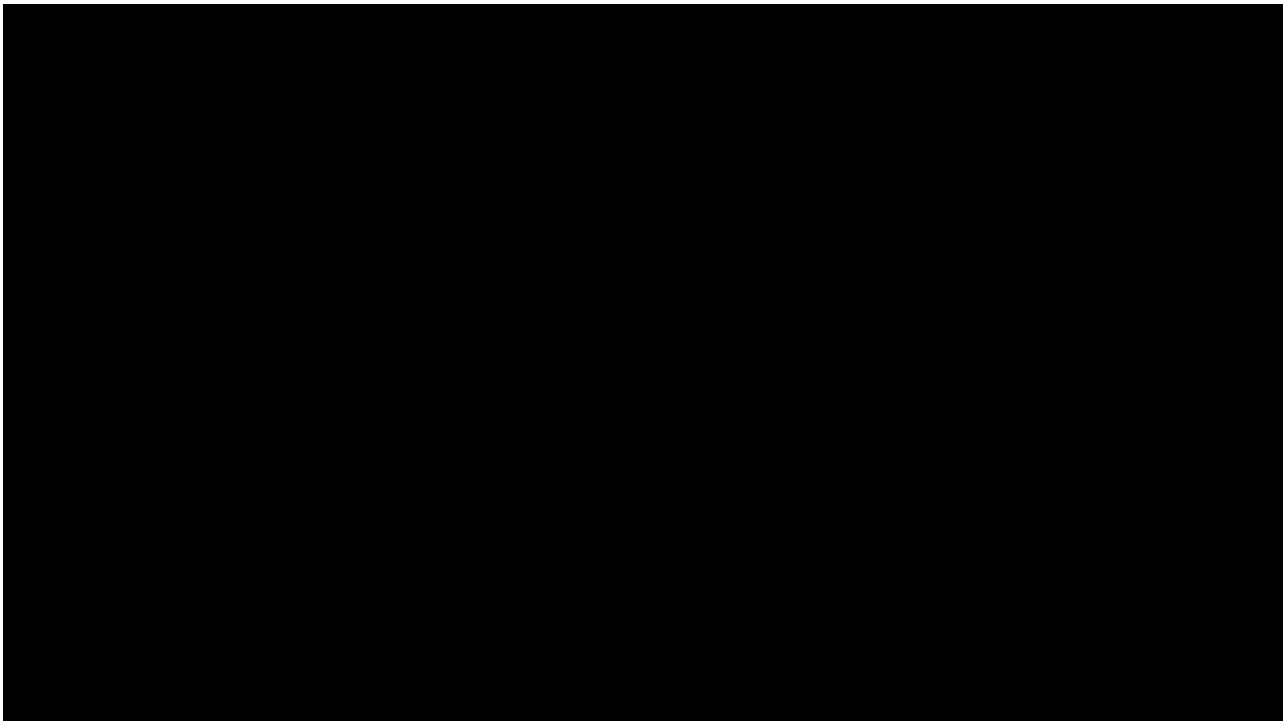
- ▶ In KH's mit hoher case-load eines CS (>90/y) ist das Mortalitätsrisiko geringer
- ▶ In KH's mit hoher Expertise an MCS (>25/y) ist das Outcome besser



Dettling A, EJHF 2025

Rise of the machines in CS ?

- ▶ IABP
 - ▶ nein
 - ▶ Impella
 - ▶ Ja, bei Infarkt und Schock
 - ▶ V.a. bei Pat. <77 Jahren
 - ▶ VA-ECMO
 - ▶ eCPR ?
 - ▶ CS post Infarkt ?
 - ▶ ECMELLA
 - ▶ ECMO als upgrade der Impella oder vice versa
 - ▶ Künftiger Standard ?
- ▶ ABER
- ▶ Alles steht und fällt mit der zahlenmäßigen Erfahrung des Behandlungsteams



Rise of the machines in CS ?

- ▶ IABP
 - ▶ nein
- ▶ Impella
 - ▶ Ja, bei Infarkt und Schock
 - ▶ V.a. bei Pat. <77 Jahren
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