Contre-pulsion intra-aortique (CPIA): ses principes, ses indications

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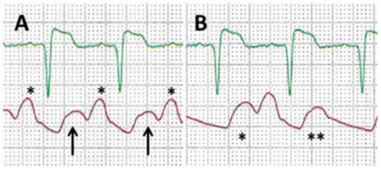
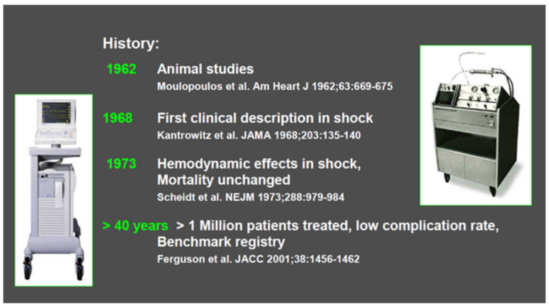
Définition

- Dispositif temporaire de soutien circulatoire mis en place de manière invasive par voie fémorale, via un désilet 8F, dans l'aorte descendante sous contrôle scopique.
- 1ère application clinique en 1968 pour un diagnostic de choc cardiogénique (Dr Kantrowitz)



Histoire



History:

1962 Animal studies
Moulopoulos et al. Am Heart J 1962;63:669-675

1968 First clinical description in shock
Kantrowitz et al. JAMA 1968;203:135-140

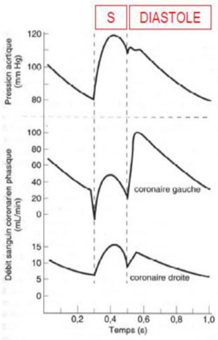
1973 Hemodynamic effects in shock, Mortality unchanged
Scheidt et al. NEJM 1973;288:979-984

> 40 years > 1 Million patients treated, low complication rate, Benchmark registry
Ferguson et al. JACC 2001;38:1456-1462

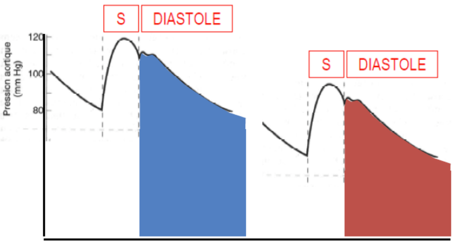
- La perfusion d'une coronaire se fait

en diastole

et surtout pour l'artère coronaire gauche

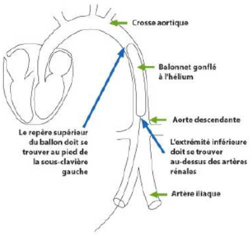


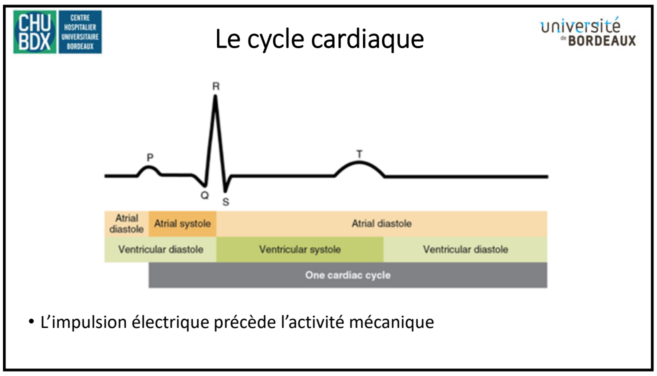
Choc cardiogénique



Fonctionnement

- Ballon en Silicone de 30 ou 40 cc (++)
- Hélium
- Synchronisation sur l'ECG pour
  - Se gonfler en début de diastole
  - Se dégonfler (de manière active) avant le début de la systole

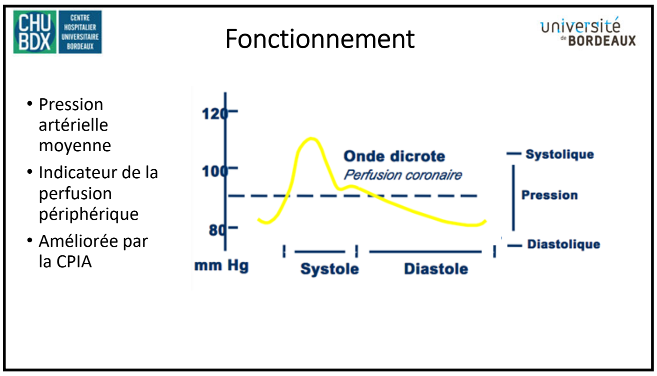

Crosse aortique
Balonnet gonflé à l'hélium
Aorte descendante
Le repère supérieur du ballon doit se trouver au pied de la sous-clavière gauche
L'extrémité inférieure doit se trouver au-dessus des artères rénales
Artère iliaque



Le cycle cardiaque

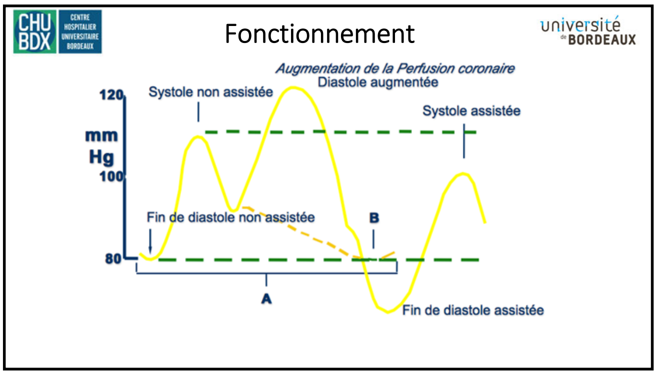
R
P
T
Q
S
Atrial diastole
Atrial systole
Atrial diastole
Ventricular diastole
Ventricular systole
Ventricular diastole
One cardiac cycle

- L'impulsion électrique précède l'activité mécanique

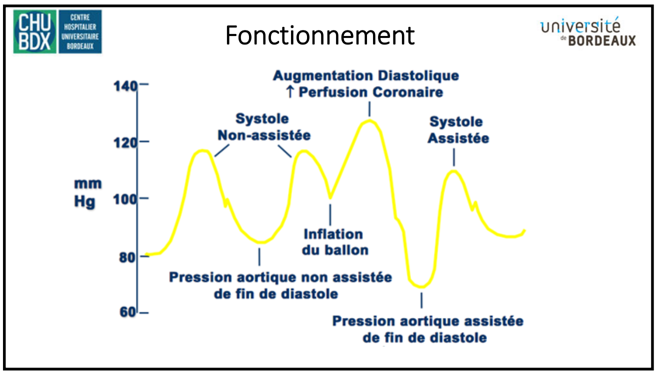


Fonctionnement

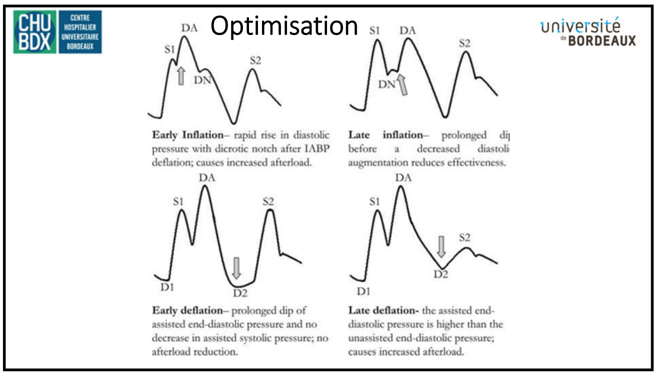
- Pression artérielle moyenne
- Indicateur de la perfusion périphérique
- Améliorée par la CPIA



Fonctionnement



Fonctionnement



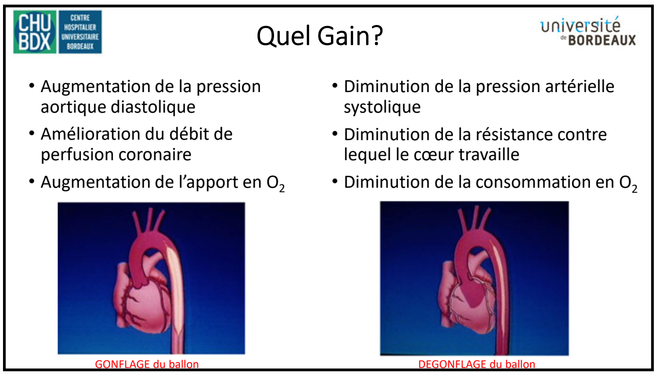
Optimisation

Early Inflation– rapid rise in diastolic pressure with dicrotic notch after IABP deflation; causes increased afterload.

Late inflation– prolonged di before a decreased diastoli augmentation reduces effectiveness.

Early deflation– prolonged dip of assisted end-diastolic pressure and no decrease in assisted systolic pressure; no afterload reduction.

Late deflation- the assisted end-diastolic pressure is higher than the unassisted end-diastolic pressure; causes increased afterload.



Quel Gain?

- Augmentation de la pression aortique diastolique
- Amélioration du débit de perfusion coronaire
- Augmentation de l'apport en O_2

- Diminution de la pression artérielle systolique
- Diminution de la résistance contre lequel le cœur travaille
- Diminution de la consommation en O_2

GONFLAGE du ballon

DEGONFLAGE du ballon

Quel Gain?

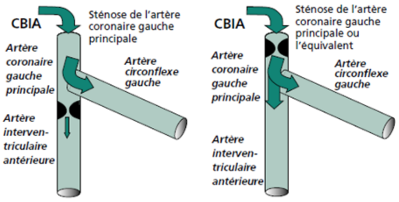
- Cela dépend
  - de la fréquence cardiaque
  - du volume du ballon

30cc
40cc
40cc
50cc
50cc
50cc

  - de la sténose coronaire

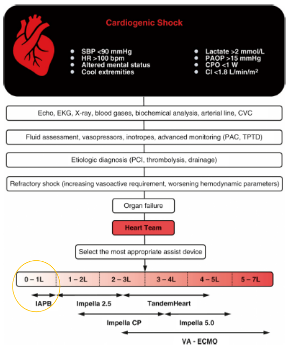
Le problème de la sténose coronaire

- Il faut l'enlever


CBIA
Sténose de l'artère coronaire gauche principale
Artère coronaire gauche principale
Artère circonflexe gauche
Artère interven-triculaire antérieure
CBIA
Sténose de l'artère coronaire gauche principale ou l'équivalent
Artère coronaire gauche principale
Artère circonflexe gauche
Artère interven-triculaire antérieure

- par angioplastie ou par pontage aorto-coronarien

Quel Gain?


Cardiogenic Shock
SBP <90 mmHg
HR >100 bpm
Altered mental status
Cool extremities
Lactate >2 mmol/L
PAOP >15 mmHg
CPO <1 W
CI <1.8 L/min/m²
Echo, EKG, X-ray, blood gases, biochemical analysis, arterial line, CVC
Fluid assessment, vasopressors, inotropes, advanced monitoring (PAC, TPTD)
Etiologic diagnosis (PCI, thrombolysis, drainage)
Refractory shock (increasing vasoactive requirement, worsening hemodynamic parameters)
Organ failure
Heart Team
Select the most appropriate assist device
0 – 1L
1 – 2L
2 – 3L
3 – 4L
4 – 5L
5 – 7L
IAPB
Impella 2.5
TandemHeart
Impella CP
Impella 5.0
VA - ECMO

Augmentation du débit cardiaque d'environ 0.5 L/min

Hajjar LA et al. Crit Care 2019;23:76

Les indications

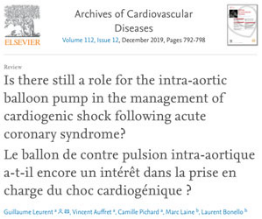
- Choc cardiogénique dans un contexte de syndrome coronarien aigu
  - lésion isolée de l'IVA proximale (atteinte mono-tronculaire)
  - « Pré-choc »: patient « limite / borderline » sur le plan hémodynamique avec faible dose concomitante d'amines vasopressives
- Angioplastie protégée / « High risk PCI »
- Infarctus du ventricule droit

Gerbaud E et al. Arch Cardiovasc Dis 2020; 113:276-284

Les indications

- ➢ Réduire la post-charge du ventricule gauche
- ➢ Augmenter le volume d'éjection systolique effectif en diminuant le shunt G>D ou en diminuant le volume régurgitant mitral

- Pré-chirurgie cardiaque
  - pontages aorto-coronariens (tronc commun)
  - insuffisance mitrale
  - communication interventriculaire
- Période « post-opératoire » de chirurgie cardiaque
- Décharge ECMO



Archives of Cardiovascular Diseases
Volume 112, Issue 12, December 2019, Pages 792-798

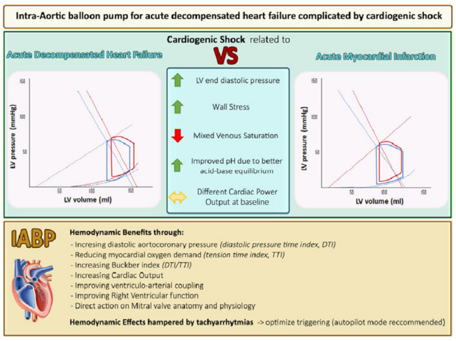
Review

Is there still a role for the intra-aortic balloon pump in the management of cardiogenic shock following acute coronary syndrome?

Le ballon de contre pulsion intra-aortique a-t-il encore un intérêt dans la prise en charge du choc cardiogénique ?

Guillaume Leurent [a], Vincent Auffret [a], Camille Pichard [a], Marc Laine [b], Laurent Bonello [b]

Leurent G et al. Arch Cardiovasc Dis 2019; 112:792-798



Intra-Aortic balloon pump for acute decompensated heart failure complicated by cardiogenic shock

Cardiogenic Shock related to

Acute Decompensated Heart Failure VS Acute Myocardial Infarction

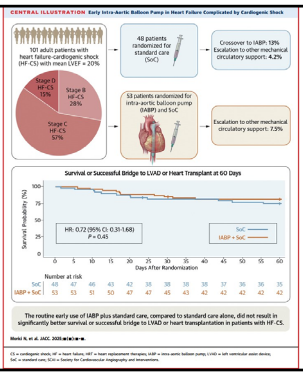
LV pressure (mmHg)
LV volume (ml)
150
100
50
50
100
150
LV end diastolic pressure
Wall Stress
Mixed Venous Saturation
Improved pH due to better acid-base equilibrium
Different Cardiac Power Output at baseline
IABP

Hemodynamic Benefits through:
- Incresing diastolic aortocoronary pressure *(diastolic pressure time index, DTI)*
- Reducing myocardial oxygen demand *(tension time index, TTI)*
- Increasing Buckber index *(DTI/TTI)*
- Increasing Cardiac Output
- Improving ventriculo-arterial coupling
- Improving Right Ventricular function
- Direct action on Mitral valve anatomy and physiology

Hemodynamic Effects hampered by tachyarrhytmias -> optimize triggering (autopilot mode reccommended)

Morici N et al. J Cardiac Failure 2022; 28:1202-1216
Brown MA et al. J Am Heart Assoc. 2021 Aug 3; 10(15): e019376.

Altshock-2 trial was stopped because of futility



CENTRAL ILLUSTRATION Early Intra-Aortic Balloon Pump in Heart Failure Complicated by Cardiogenic Shock

101 adult patients with heart failure-cardiogenic shock (HF-CS) with mean LVEF = 20%

48 patients randomized for standard care (SoC) → Crossover to IABP: 13% Escalation to other mechanical circulatory support: 4.2%

53 patients randomized for intra-aortic balloon pump (IABP) and SoC → Escalation to other mechanical circulatory support: 7.5%

Survival or Successful Bridge to LVAD or Heart Transplant at 60 Days

Number at risk

	0	5	10	15	20	25	30	35	40	45	50	55	60
SoC	48	47	46	43	42	38	38	38	38	37	36	36	35
IABP + SoC	53	53	51	50	47	47	45	43	42	42	42	42	42

The routine early use of IABP plus standard care, compared to standard care alone, did not result in significantly better survival or successful bridge to LVAD or heart transplantation in patients with HF-CS.

Morici N, et al. JACC. 2025;■(■):■-■.

CS = cardiogenic shock; HF = heart failure; HRT = heart replacement therapies; IABP = intra-aortic balloon pump; LVAD = left ventricular assist device; SoC = standard care; SCAI = Society for Cardiovascular Angiography and Interventions.

Les contre-indications

- Insuffisance aortique
- Syndrome douloureux aortique, dissection, hématome de paroi, anévrysme aortique…
- Accès artériel membre inférieur insuffisant
- « Relative »: Les tachycardies

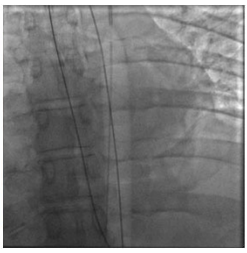
Les recommandations dans le STEMI

Intra-aortic balloon pumping should be considered in patients with haemodynamic instability/cardiogenic shock due to mechanical complications.	IIa	C
Short-term mechanical support^{c} may be considered in patients in refractory shock.	IIb	C
Routine intra-aortic balloon pumping is not indicated.[177,437]	III	B

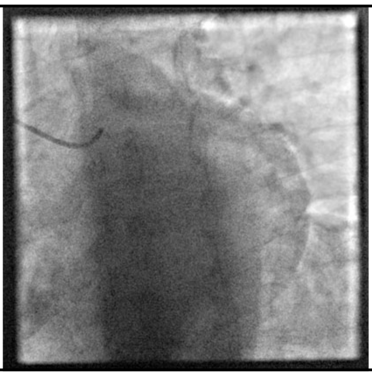
^{C} Percutaneous cardiac support devices, ECLS, and ECMO

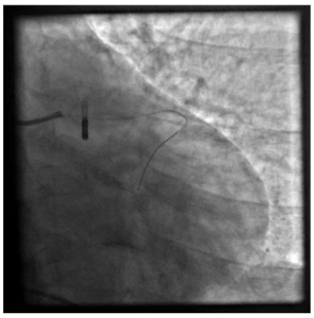
Ibanez S et al. Eur Heart J 2018; 39:119-177

Images de BPCIA

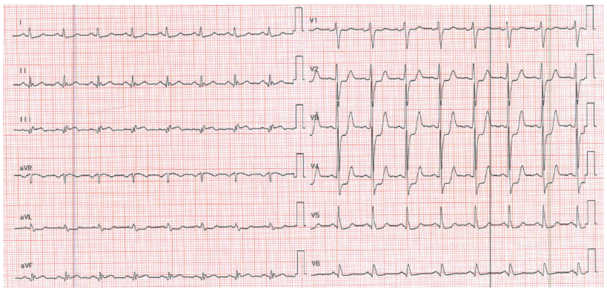


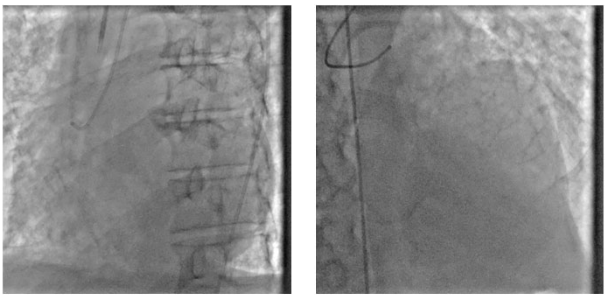
Héparinothérapie IVSE durant l'utilisation avec un objectif d'héparinémie / Activité anti Xa (HNF): 0,3-0,4 UI/mL

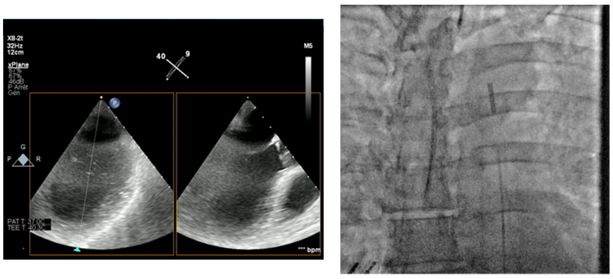




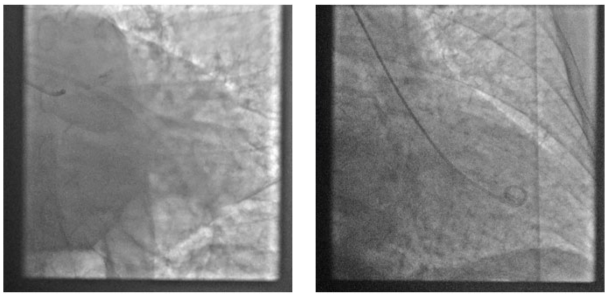
Infarctus inférieur tardif

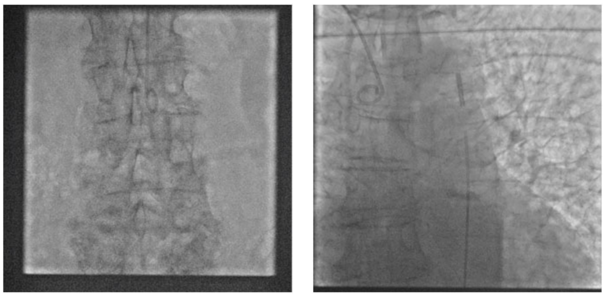

I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6




X8-2t
32Hz
12cm
xPlane
67%
46dB
P Arrêt
Gén
40
9
M5
G
P
R
PAT T: 37.0C
TEE T: 40.2C
bpm

Rupture partielle de pilier





Surveillance

- Surveillance
  - clinique: point de ponction, membre inférieur, transit, diurèse
  - biologique: anticoagulation, hémoglobine, plaquettes, lactates artériels
  - radiologique: radiographie pulmonaire de face

- Les Traitements
  - anticoagulation
  - anxiolytiques

- La console
  - pas d’arrêt prolongé
  - optimisation de l’inflation
  - présence de fuites
  - niveau d’hélium

Effets secondaires

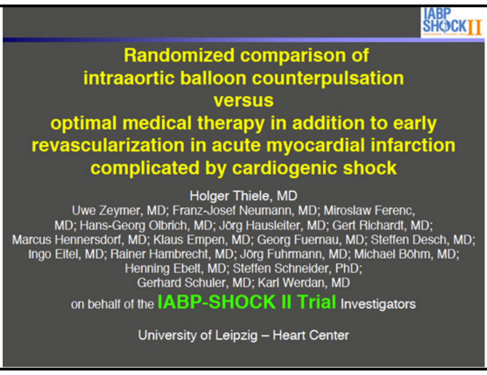
- Thrombopénie
- Thrombose artérielle
- Hypoperfusion rénale, mésentérique, ou du membre inférieur

⚠ douleur abdominale chez le (la) patient(e) porteur d'une CPIA

Sevrage et retrait

⚠ Dispositif transitoire! A enlever dès que possible!

- Sevrage progressif
(1 inflation tous les 2 cycles cardiaques puis 1 inflation tous les 4 cycles cardiaques)
- Arrêt de l'héparinothérapie 1 heure avant
- Soit préclosing à la pose
- Soit compression manuelle fémorale (30 minutes) sous couvert d'antalgiques

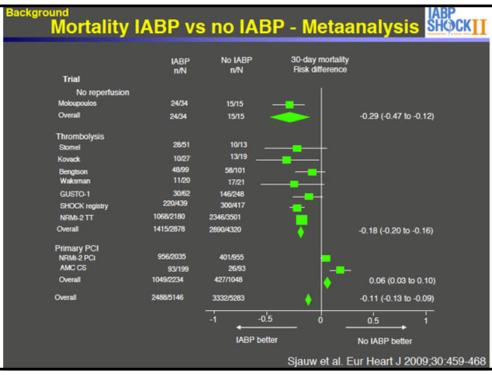


Randomized comparison of intraaortic balloon counterpulsation versus optimal medical therapy in addition to early revascularization in acute myocardial infarction complicated by cardiogenic shock

Holger Thiele, MD
Uwe Zeymer, MD; Franz-Josef Neumann, MD; Miroslaw Ferenc, MD; Hans-Georg Olbrich, MD; Jörg Hausleiter, MD; Gert Richardt, MD; Marcus Hennersdorf, MD; Klaus Empen, MD; Georg Fuernau, MD; Steffen Desch, MD; Ingo Eitel, MD; Rainer Hambrecht, MD; Jörg Fuhrmann, MD; Michael Böhm, MD; Henning Ebelt, MD; Steffen Schneider, PhD; Gerhard Schuler, MD; Karl Werdan, MD

on behalf of the **IABP-SHOCK II Trial** Investigators

University of Leipzig – Heart Center



Background

Mortality IABP vs no IABP - Metaanalysis

Trial	IABP n/N	No IABP n/N	30-day mortality Risk difference
No reperfusion			
Moloupoulos	24/34	15/15	
Overall	24/34	15/15	-0.29 (-0.47 to -0.12)
Thrombolysis			
Stomel	28/51	10/13	
Kovack	10/27	13/19	
Bengtson	48/99	58/101	
Waksman	11/20	17/21	
GUSTO-1	30/62	146/248	
SHOCK registry	220/439	300/417	
NRMI-2 TT	1068/2180	2346/3501	
Overall	1415/2878	2890/4320	-0.18 (-0.20 to -0.16)
Primary PCI			
NRMI-2 PCI	956/2035	401/955	
AMC CS	93/199	26/93	
Overall	1049/2234	427/1048	0.06 (0.03 to 0.10)
Overall	2488/5146	3332/5283	-0.11 (-0.13 to -0.09)

Sjauw et al. Eur Heart J 2009;30:459-468

Methods

Study Sites and Organisation

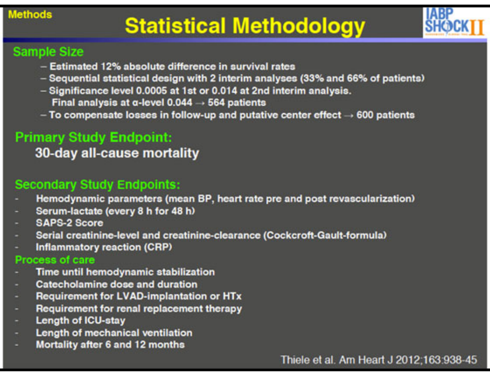
Schleswig-Holstein
Mecklenburg-Vorpommern
Bremen
Hamburg
Brandenburg
Niedersachsen
Berlin
Sachsen-Anhalt
Nordrhein-Westfalen
Sachsen
Thüringen
Hessen
Rheinland-Pfalz
Saarland
Bayern
Baden-Württemberg

DSMB:
Kurt Huber
Ferenc Follath
Bernhard Maisch
Johannes Haerting

Steering committee:
Holger Thiele
Karl Werdan
Uwe Zeymer
Gerhard Schuler

Support + Patronage:

Deutsche Gesellschaft für Kardiologie - Herz- und Kreislaufforschung e.V. German Cardiac Society
Deutsche Herzstiftung
ALKK
DFG Deutsche Forschungsgemeinschaft



Methods

Statistical Methodology

Sample Size

- Estimated 12% absolute difference in survival rates
- Sequential statistical design with 2 interim analyses (33% and 66% of patients)
- Significance level 0.0005 at 1st or 0.014 at 2nd interim analysis.
  Final analysis at α-level 0.044 → 564 patients
- To compensate losses in follow-up and putative center effect → 600 patients

Primary Study Endpoint:

30-day all-cause mortality

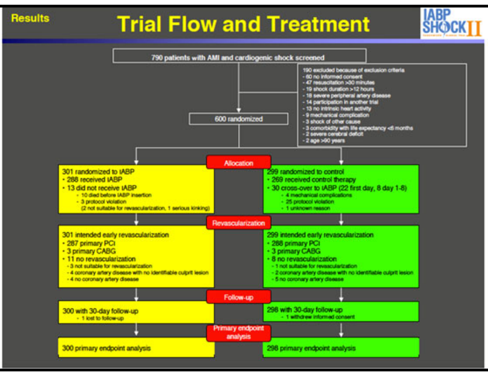
Secondary Study Endpoints:

- Hemodynamic parameters (mean BP, heart rate pre and post revascularization)
- Serum-lactate (every 8 h for 48 h)
- SAPS-2 Score
- Serial creatinine-level and creatinine-clearance (Cockcroft-Gault-formula)
- Inflammatory reaction (CRP)

Process of care

- Time until hemodynamic stabilization
- Catecholamine dose and duration
- Requirement for LVAD-implantation or HTx
- Requirement for renal replacement therapy
- Length of ICU-stay
- Length of mechanical ventilation
- Mortality after 6 and 12 months

Thiele et al. Am Heart J 2012;163:938-45



Results

Trial Flow and Treatment

790 patients with AMI and cardiogenic shock screened

190 excluded because of exclusion criteria
- 60 no informed consent
- 47 resuscitation >30 minutes
- 19 shock duration >12 hours
- 18 severe peripheral artery disease
- 14 participation in another trial
- 13 no intrinsic heart activity
- 9 mechanical complication
- 3 shock of other cause
- 3 comorbidity with life expectancy <6 months
- 2 severe cerebral deficit
- 2 age >90 years

600 randomized

Allocation

301 randomized to IABP
- 288 received IABP
- 13 did not receive IABP
  - 10 died before IABP insertion
  - 3 protocol violation (2 not suitable for revascularization, 1 serious kinking)

299 randomized to control
- 269 received control therapy
- 30 cross-over to IABP (22 first day, 8 day 1-8)
  - 4 mechanical complications
  - 25 protocol violation
  - 1 unknown reason

Revascularization

301 intended early revascularization
- 287 primary PCI
- 3 primary CABG
- 11 no revascularization
  - 3 not suitable for revascularization
  - 4 coronary artery disease with no identifiable culprit lesion
  - 4 no coronary artery disease

299 intended early revascularization
- 288 primary PCI
- 3 primary CABG
- 8 no revascularization
  - 1 not suitable for revascularization
  - 2 coronary artery disease with no identifiable culprit lesion
  - 5 no coronary artery disease

Follow-up

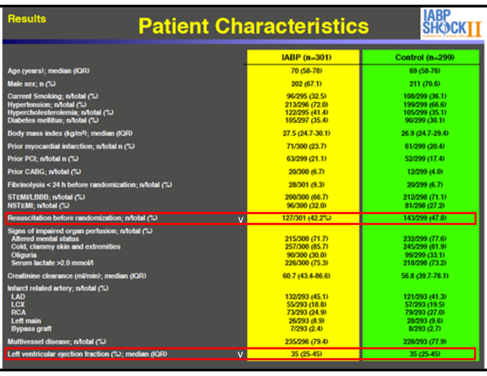
300 with 30-day follow-up
- 1 lost to follow-up

298 with 30-day follow-up
- 1 withdrew informed consent

Primary endpoint analysis

300 primary endpoint analysis

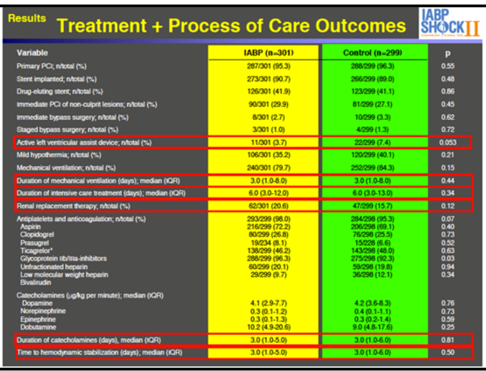
298 primary endpoint analysis



Results

Patient Characteristics

	IABP (n=301)	Control (n=299)
Age (years); median (IQR)	70 (58-78)	69 (58-76)
Male sex; n (%)	202 (67.1)	211 (70.6)
Current Smoking; n/total (%)	96/295 (32.5)	108/299 (36.1)
Hypertension; n/total (%)	213/296 (72.0)	199/299 (66.6)
Hypercholesterolemia; n/total (%)	122/295 (41.4)	105/299 (35.1)
Diabetes mellitus; n/total (%)	105/297 (35.4)	90/299 (30.1)
Body mass index (kg/m²); median (IQR)	27.5 (24.7-30.1)	26.9 (24.7-29.4)
Prior myocardial infarction; n/total n (%)	71/300 (23.7)	61/299 (20.4)
Prior PCI; n/total n (%)	63/299 (21.1)	52/299 (17.4)
Prior CABG; n/total (%)	20/300 (6.7)	12/299 (4.0)
Fibrinolysis < 24 h before randomization; n/total (%)	28/301 (9.3)	20/299 (6.7)
STEMI/LBBB; n/total (%)	200/300 (66.7)	212/298 (71.1)
NSTEMI; n/total (%)	96/300 (32.0)	81/298 (27.2)
Resuscitation before randomization; n/total (%) V	127/301 (42.2%)	143/299 (47.8)
Signs of impaired organ perfusion; n/total (%)		
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/l	226/300 (75.3)	218/298 (73.2)
Creatinine clearance (ml/min); median (IQR)	60.7 (43.4-86.6)	56.8 (39.7-78.1)
Infarct related artery; n/total (%)		
LAD	132/293 (45.1)	121/293 (41.3)
LCX	55/293 (18.8)	57/293 (19.5)
RCA	73/293 (24.9)	79/293 (27.0)
Left main	26/293 (8.9)	28/293 (9.6)
Bypass graft	7/293 (2.4)	8/293 (2.7)
Multivessel disease; n/total (%)	235/296 (79.4)	228/293 (77.9)
Left ventricular ejection fraction (%); median (IQR) V	35 (25-45)	35 (25-45)



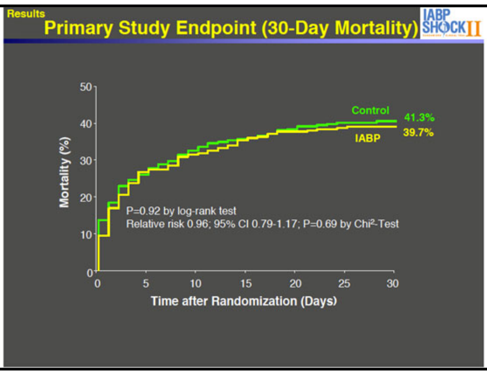
Results

Treatment + Process of Care Outcomes

Variable	IABP (n=301)	Control (n=299)	p
Primary PCI; n/total (%)	287/301 (95.3)	288/299 (96.3)	0.55
Stent implanted; n/total (%)	273/301 (90.7)	266/299 (89.0)	0.48
Drug-eluting stent; n/total (%)	126/301 (41.9)	123/299 (41.1)	0.86
Immediate PCI of non-culprit lesions; n/total (%)	90/301 (29.9)	81/299 (27.1)	0.45
Immediate bypass surgery; n/total (%)	8/301 (2.7)	10/299 (3.3)	0.62
Staged bypass surgery; n/total (%)	3/301 (1.0)	4/299 (1.3)	0.72
Active left ventricular assist device; n/total (%)	11/301 (3.7)	22/299 (7.4)	0.053
Mild hypothermia; n/total (%)	106/301 (35.2)	120/299 (40.1)	0.21
Mechanical ventilation; n/total (%)	240/301 (79.7)	252/299 (84.3)	0.15
Duration of mechanical ventilation (days); median (IQR)	3.0 (1.0-8.0)	3.0 (1.0-8.0)	0.44
Duration of intensive care treatment (days); median (IQR)	6.0 (3.0-12.0)	6.0 (3.0-13.0)	0.34
Renal replacement therapy; n/total (%)	62/301 (20.6)	47/299 (15.7)	0.12
Antiplatelets and anticoagulation; n/total (%)	293/299 (98.0)	284/298 (95.3)	0.07
Aspirin	216/299 (72.2)	206/298 (69.1)	0.40
Clopidogrel	80/299 (26.8)	76/298 (25.5)	0.73
Prasugrel	19/234 (8.1)	15/228 (6.6)	0.52
Ticagrelor*	138/299 (46.2)	143/298 (48.0)	0.63
Glycoprotein IIb/IIIa-inhibitors	288/299 (96.3)	275/298 (92.3)	0.03
Unfractionated heparin	60/299 (20.1)	59/298 (19.8)	0.94
Low molecular weight heparin	29/299 (9.7)	36/298 (12.1)	0.34
Bivalirudin			
Catecholamines (µg/kg per minute); median (IQR)			
Dopamine	4.1 (2.9-7.7)	4.2 (3.6-8.3)	0.76
Norepinephrine	0.3 (0.1-1.2)	0.4 (0.1-1.1)	0.73
Epinephrine	0.3 (0.1-1.3)	0.3 (0.2-1.4)	0.59
Dobutamine	10.2 (4.9-20.6)	9.0 (4.8-17.6)	0.25
Duration of catecholamines (days), median (IQR)	3.0 (1.0-5.0)	3.0 (1.0-6.0)	0.81
Time to hemodynamic stabilization (days); median (IQR)	3.0 (1.0-5.0)	3.0 (1.0-6.0)	0.50

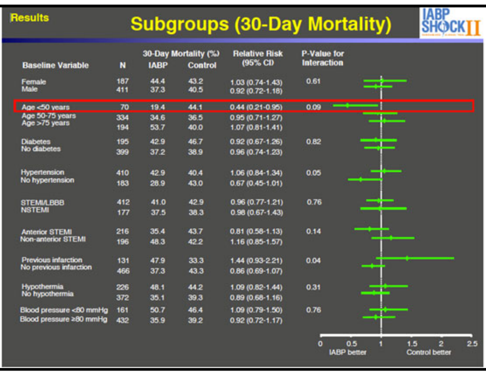
Results

Primary Study Endpoint (30-Day Mortality)



P=0.92 by log-rank test

Relative risk 0.96; 95% CI 0.79-1.17; P=0.69 by Chi²-Test



Results

Subgroups (30-Day Mortality)

Baseline Variable	N	30-Day Mortality (%)		Relative Risk (95% CI)	P-Value for Interaction
		IABP	Control		
Female	187	44.4	43.2	1.03 (0.74-1.43)	0.61
Male	411	37.3	40.5	0.92 (0.72-1.18)	
Age <50 years	70	19.4	44.1	0.44 (0.21-0.95)	0.09
Age 50-75 years	334	34.6	36.5	0.95 (0.71-1.27)	
Age >75 years	194	53.7	40.0	1.07 (0.81-1.41)	
Diabetes	195	42.9	46.7	0.92 (0.67-1.26)	0.82
No diabetes	399	37.2	38.9	0.96 (0.74-1.23)	
Hypertension	410	42.9	40.4	1.06 (0.84-1.34)	0.05
No hypertension	183	28.9	43.0	0.67 (0.45-1.01)	
STEMI/LBBB	412	41.0	42.9	0.96 (0.77-1.21)	0.76
NSTEMI	177	37.5	38.3	0.98 (0.67-1.43)	
Anterior STEMI	216	35.4	43.7	0.81 (0.58-1.13)	0.14
Non-anterior STEMI	196	48.3	42.2	1.16 (0.85-1.57)	
Previous infarction	131	47.9	33.3	1.44 (0.93-2.21)	0.04
No previous infarction	466	37.3	43.3	0.86 (0.69-1.07)	
Hypothermia	226	48.1	44.2	1.09 (0.82-1.44)	0.31
No hypothermia	372	35.1	39.3	0.89 (0.68-1.16)	
Blood pressure <80 mmHg	161	50.7	46.4	1.09 (0.79-1.50)	0.76
Blood pressure ≥80 mmHg	432	35.9	39.2	0.92 (0.72-1.17)	

Summary + Conclusions

- IABP support in cardiogenic shock is safe without significant inherent complications.
- However, IABP support did not reduce 30-day mortality in this large, randomized, multicenter trial in cardiogenic shock patients complicating myocardial infarction undergoing early revascularization.
- The primary study endpoint results are supported by a lack of benefit in secondary endpoints.

Conclusion

- Encore largement utilisé quand pas d'autre système disponible !

- Garde un « potentiel intérêt » dans certaines indications
  - Patient jeune, IVA proximale, « pré-choc »

  - Complications mécaniques de l'infarctus

  - Pré ou post- chirurgie cardiaque