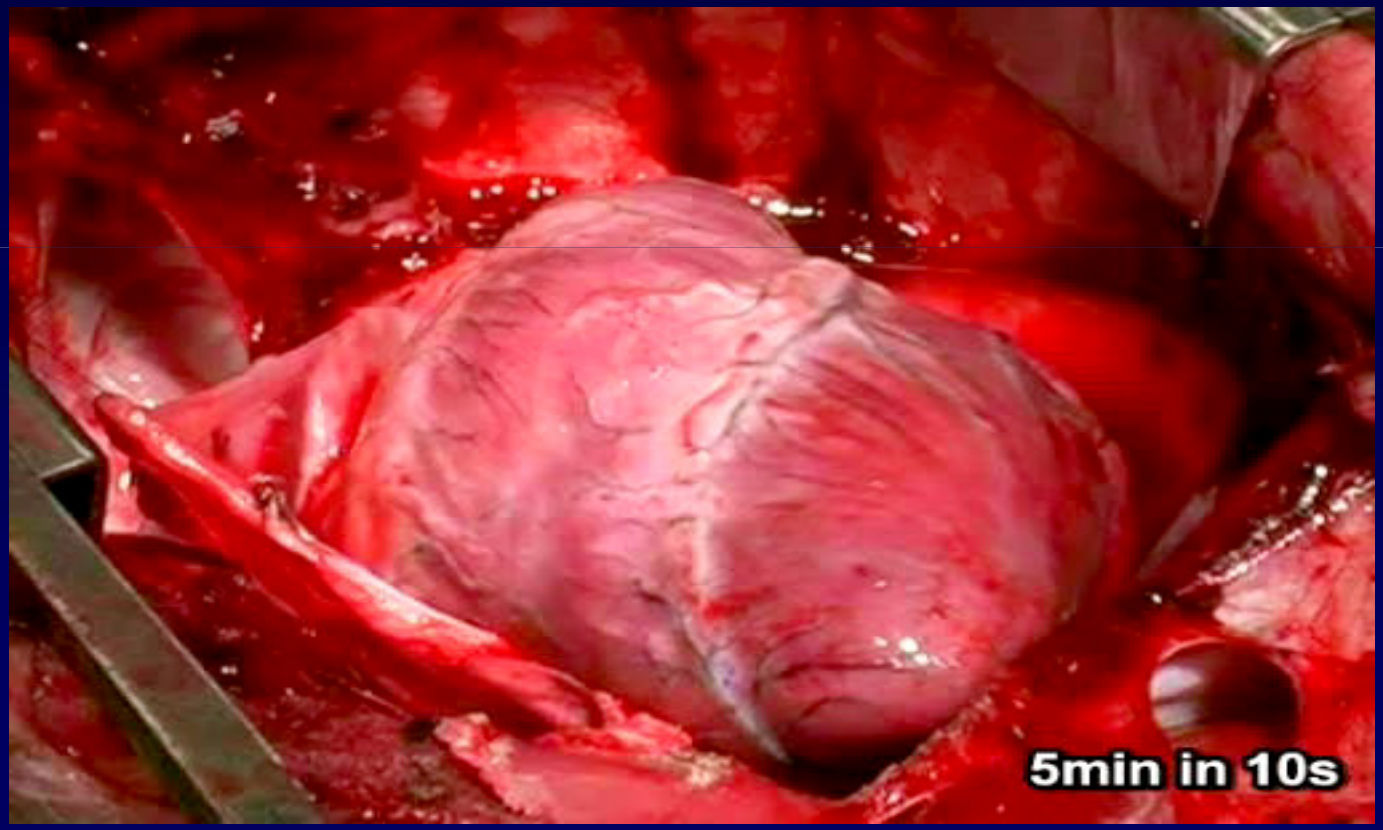
Reanimatie en Mechanische hulpmiddelen voor thoraxcompressies: stand van zaken

Hans E. Luijten

Afdeling cardiologie, HaGa, Reinier de Graaf Gasthuis, Delft



Geinduceerd VF in de big. Steen S et al, Resuscitation 2003; 58: 257.

Stellingen WES Symposium 2010

1. Wie heeft er persoonlijke ervaring met het gebruik van mechanische CPR pre- dan wel in-hospitaal?

2. Wie denkt dat gebruik van mechanische CPR lijdt tot een betere overleving en/of neurologische uitkomst bij patiënten?

Epidemiology Cardiac Death in the EU

- 280 Milion inhabitants
- 1.5 Milion cardiovascular deaths / year
- 700,000 deaths / year due to CAD
- 350,000 sudden cardiac deaths / year

CPR anno 2010

- Afgelopen 40jr is de overleving na CA, ondanks AED, BLS training en richtlijn verbeteringen laag gebleven: 5 tot 10%! Slechts 2.5-7.5/100pts overleven met goede neurologische uitkomst!
- Optimale manuele CPR is ***moeilijk***: vaak te ondiep, te traag en met onderbrekingen > 50% van de tijd! Dit zal ik laten zien.
- Kwaliteit van manuele CPR neemt > 1min significant af bij leken én professionals!

Overleving na Cardiaal Arrest

Adult Survival Rates to Hospital Discharge After Inpatient and Outpatient Arrest

	Inpatient[71]	Outpatient*[64,72,73]
Location	United States, Canada	United States, Canada, England, Norway, Sweden
Dates included	1/00–3/04	2/98–6/02 3/02–10/03 1/99–12/00
Total No. (% survival)	36 902 (17.6)	5234 (6.4)
% VF or VT (% survival)	22.7 (36.0)	33.2 (16.1)
% Pulseless electric activity (% survival)	32.4 (11.2)	24.7 (2.7)
% Asystole (% survival)	35.3 (10.6)	39.0 (0.9)
% Unknown rhythm	9.6	3.0

Summary of results from 4 large studies of arrest survival,[64,71-73] showing proportions of presenting cardiac rhythm and percentage survival to hospital discharge, divided by location of arrest. Ventricular fibrillation (VF) and ventricular tachycardia (VT) are proportionally more common in the outpatient than the inpatient setting, as is asystole, whereas the reverse is true for pulseless electric activity. Survival rates to hospital discharge show an increased likelihood of survival for all rhythms when the arrest occurred in hospital setting.

*Outpatient data are pooled from the 3 studies cited.

Table. Adult Survival Rates to Hospital Discharge After Inpatient and Outpatient Arrest
From: Cooper: Circulation, Volume 114(25).December 19/26, 2006.2839-2849

Laag overlevingspercentage bij cardiaal arrest!

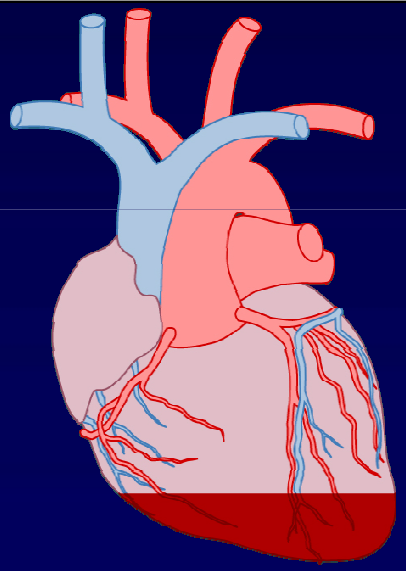
Cooper JA et al, Circulation 2006; 114: 2844

ERC ALS Guidelines 2005

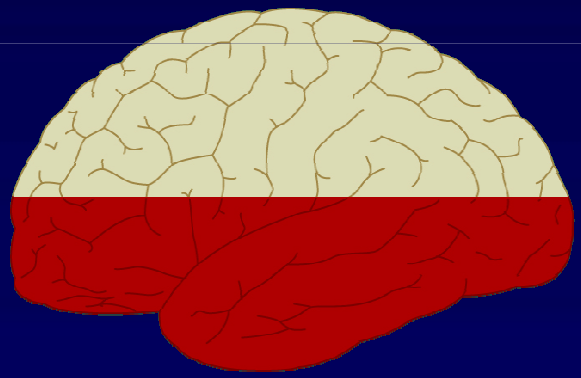
- CPR cardiac compressions 100/min
- Minimal hands-off time
- 4-5 cm deep
- Ventilations 10-12/min

Manuele CPR : Perfusie (Kern)

Manuele CPR geeft (minimale) bloeddoorstroming naar het hart en brein



10% - 20% van de normale “flow”



30% - 40% van de normale “flow”

Kern KB, *Bailliere’s Clinical Anaesthesiology* 2000; 14(3): 591-609.

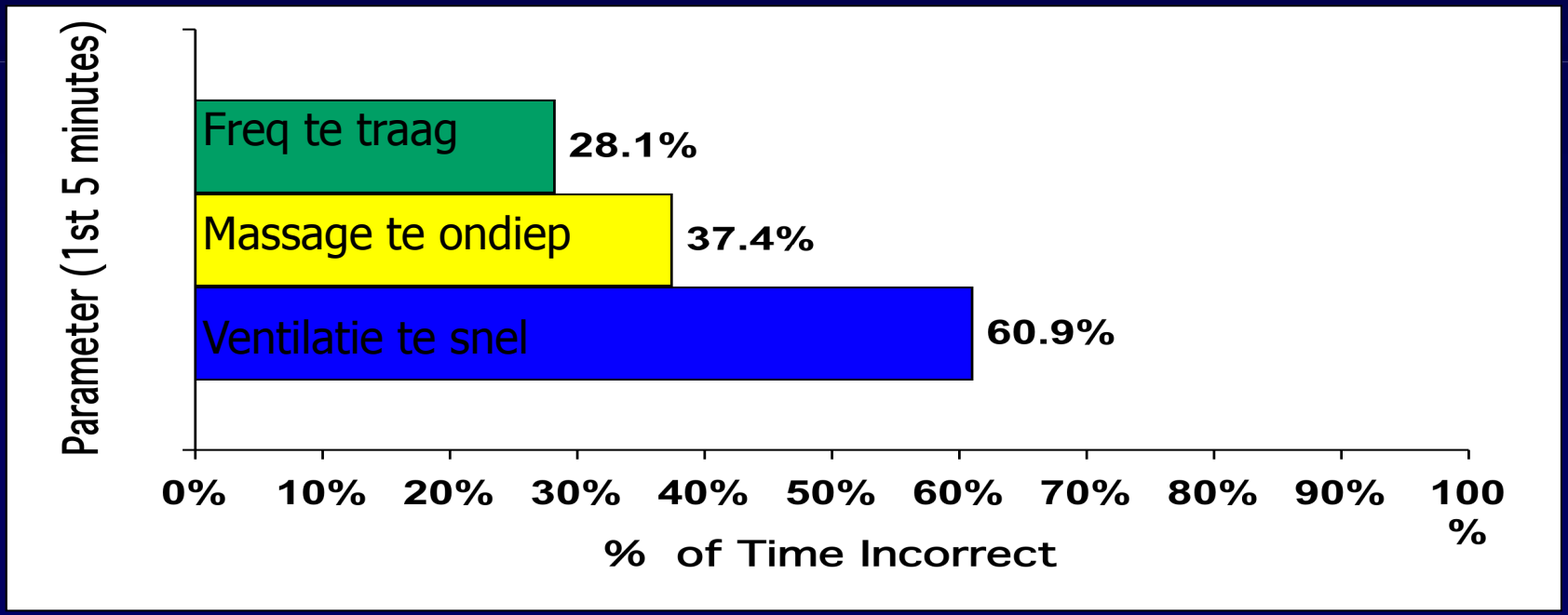
CPR in het ziekenhuis
Abella et al Circ 2005

- Data van 97 in-hospitale cardiale arresten
- Compressies < 80/m in 36.9%
  < 70/m in 21.7%
- Frequentere thoraxcompressies correleren significant met ROSC

Abella BS et al, *JAMA* 2005; 293: 305-310.

CPR : Kwaliteit (Abella et al.)

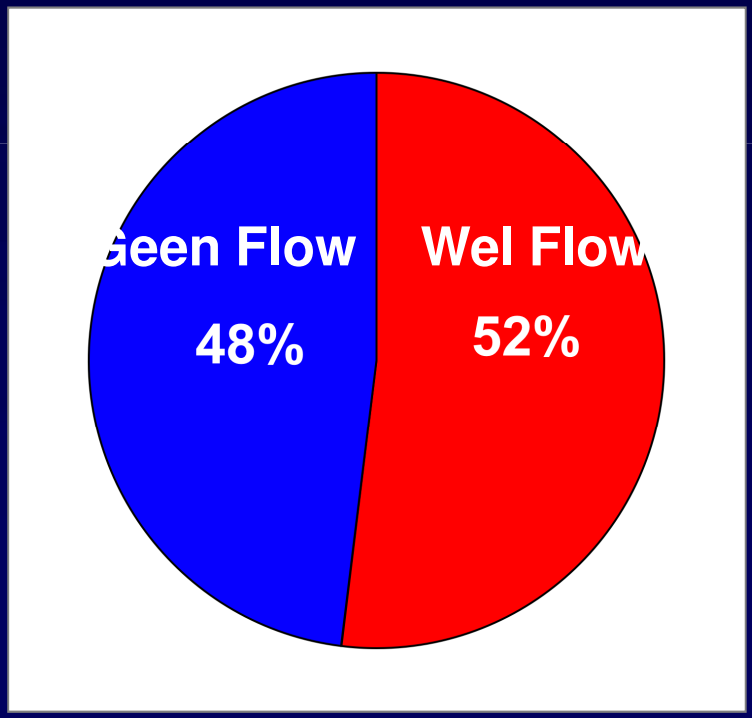
"…kwaliteit van multipele parameters van CPR was inconsistent en vaak niet conform gepubliceerde richtlijn aanbevelingen…."



Abella BS et al, *JAMA* 2005; 293: 305-310.

CPR prehospitaal – Wik et al JAMA 2005

"..thoraxcompressies werden niet gegeven de helft van de tijd, en de meeste compressies waren te ondiep.."



Wik L et al, *JAMA*. 2005; 23: 299-304.

Abella et al

Suggested practical solutions to help improve poor CPR quality:

1) Mechanical devices: set rate and depth

2) Audio feedback during manual CPR from "smart defibrillators". F.e. Q-CPR (Philips)

Potentiële voordelen mechanische hulpmiddelen voor thoraxcompressies bij reanimatie

- Intrathoracale druk ↑ ⇒ ABP opbouw die aanzienlijk hoger kan zijn dan wat manueel wordt geobserveerd
- Continue hartmassage van constante kwaliteit en zonder vermoeibaarheid zolang krachtbron functioneert
- Case reports en haemodynamische metingen (dieren en humaan) suggereren een goed effect

Mechanische hulpmiddelen thoraxcompressies bij reanimatie

AutoPulse: fabrikant Revivant/Zoll

- Electrisch aangedreven band om de thorax
- 80 +/-5 x per min aangespannen zodat borstomvang circumferentieel afneemt en intrathoracale druk stijgt
- 20% anteroposterior borstcompressie m.b.v. sensor

Lucas: fabrikant Jolife/Medtronic

- Pneumatisch aangedreven
- Bestaat uit zuignap die op borstbeen drukt

AutoPulse LDB CPR

10 Kg (19kg met 1 batterij+1 reserve), circa 30min bedrijfstijd op 1 batterij

AutoPulse LDB CPR

- Wat is de AutoPulse?
  - Load-distributing band mechanisch thorax compressie-apparaat.
- Wat doet de AutoPulse?
  - Compressies 80+/-5 per min, thoraxcompressie=20% reductie in AP dimensie borst, 30:2 of continue modus
- Patiënt parameters
  - Borstomvang 76-130cm, max gewicht 130kg, niet traumatisch CA
- Betere klinische uitkomst?

AutoPulse Mechanical CPR

Improved hemodynamic performance with a novel chest compression device during treatment of in-hospital cardiac arrest

A-CPR

M-CPR

CPP

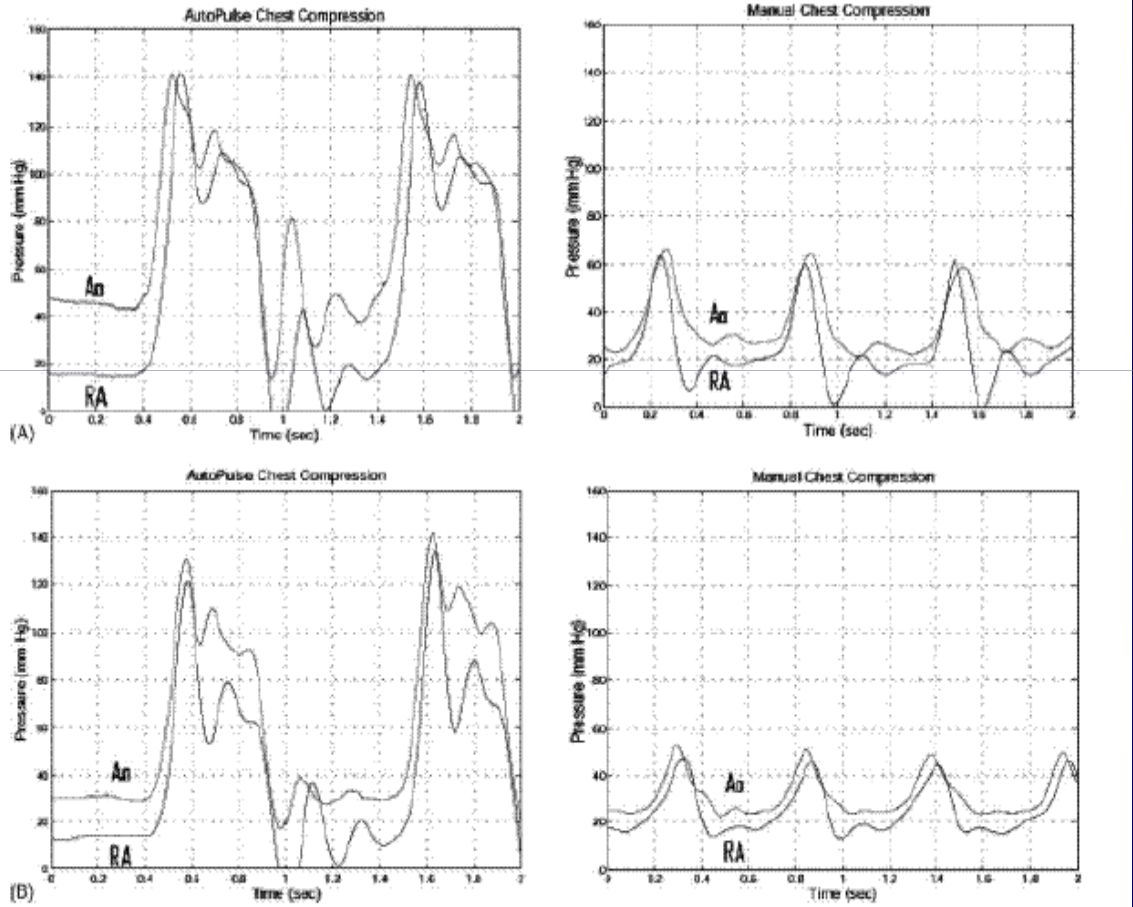


Fig. 2. Phasic vascular pressure traces during manual and A-CPR in two patients (A, B) reproduced from digital recordings. Record A shows one of the largest changes observed in aortic pressure and the diastolic aortic and right atrial pressure difference (coronary perfusion pressure) produced by A-CPR when compared to manual CPR. Record B shows a patient where the diastolic aortic and right atrium differences are near the mean values observed in this study.

Timerman Resuscitation 2003; 61: 273-80

Manual Chest Compression vs Use of an Automated Chest Compression Device During Resuscitation Following Out-of-Hospital Cardiac Arrest

A Randomized Trial

- Following 1st planned monitoring DSMB terminated enrollment

- No difference in primary end point of survival to 4 hours

Device design or implementation strategies require further evaluation

Hallstrom JAMA 2006; 295: 2620-8

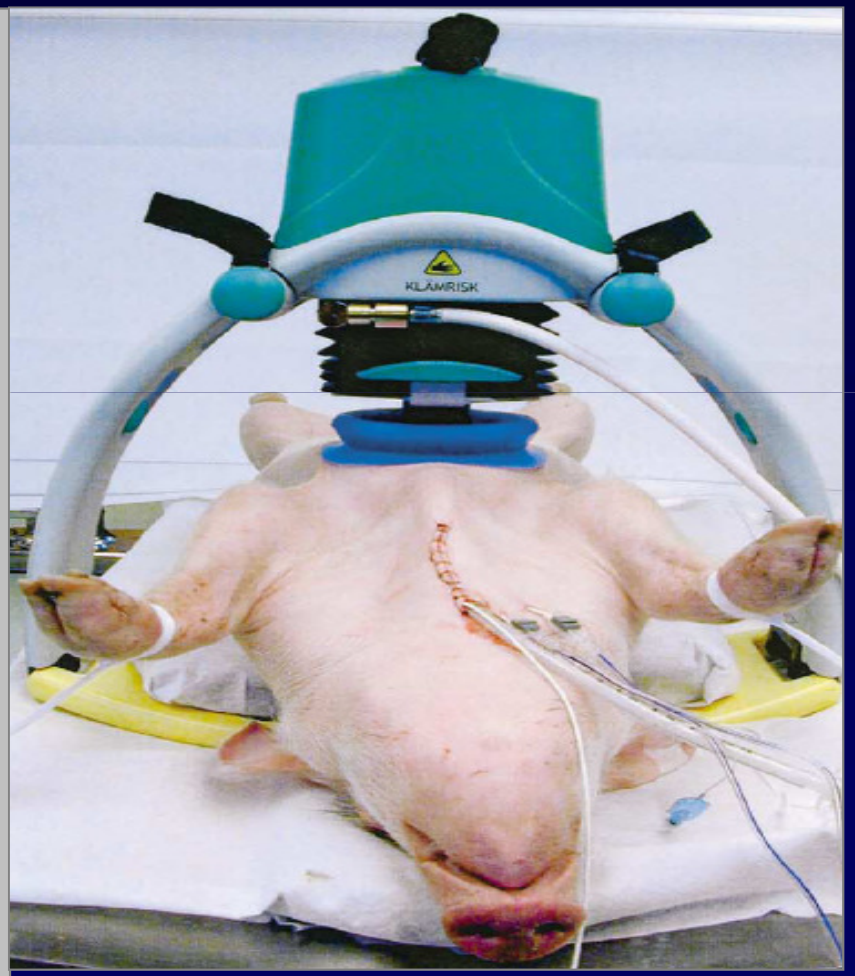
Lucas

- 6.5 kg exclusief zuurstoftank en draagtas
- Pneumatisch aangedreven
- 100 compr/min max 5cm diep
- Actieve decompressie
- Zuurstofverbruik 70 liter/min
- Zuurstoftank (O_2 of perslucht) of zuurstofaansluiting in ziekenhuis met 4-6 bar druk
- 7L fles gaat circa 30min mee

Dierexperimenteel onderzoek

- Gerandomiseerde studie in biggen met geïnduceerd VF
- ↑ CO, carotisflow, $etCO_2$ en CPP met Lucas-CPR vs M-CPR

→Lucas geeft een betere circulatie tijdens VF dan manuele CPR



Steen et al, Resuscitation 2002; 55: 289-99

Lucas (1)
Lund University Cardiac Assist System

- 2002 Stig Steen, Zweden
- 2006 Ambulancedienst Hollands Midden
- LUMC op cathkamer tijdens CPR
- Op perslucht aangedreven hartmassage-apparaat; Lucas 2 is batterij aangedreven
- 100/m compressie, zgn actieve decompressie: “zuig/perspomp”
- Defibrillatie TIJDENS massage

LUCAS (2)

- Scholing, aanpassing LPA 7 protocol en werkplekmanagement
- Max 3 sec ritmecheck per 2 min, intubatie TIJDENS massage
- Geen onderbreking CPR tijdens transfer
- 280 pts 2007-7, ROSC 37,3%
- 20 min persisterend asystolie >>> stop reanimatie prehospitaal
- Trismus (kaakklem) bij aantal reanimaties

LUCAS (3)

- CO_2 capno GEEN graadmeter meer voor besluit om te stoppen
- “wandelen” van de LUCAS >>> fixatie “straps”
- Soms (s)trekken, grimassen, afweerbewegingen tijdens CPR >>> esketamine
- LUCAS massages maken coronaire angiografie en/of PCI TIJDENS reanimatie mogelijk

Mechanische thoraxcompressies: conclusies uit klinische studies

- Onvoldoende bewijs voor de effectiviteit van de AutoPulse en geen bewijs voor de effectiviteit van de Lucas uit gerandomiseerd humaan onderzoek
- Niet goed te verklaren waarom de 3 humane AutoPulse studies zulke verschillen in uitkomst laten zien

Epidemiology Cardiac Arrest

Background:

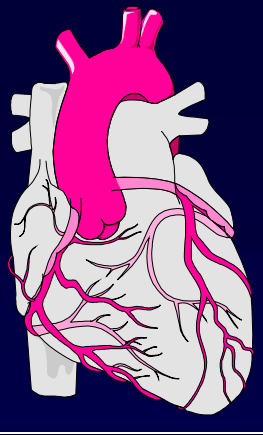
1. Acute myocardial infarction (AMI) / pulmonary embolism (PE) in 50 - 70% underlying cause of cardiac arrest

2. Following AMI in 10 - 20% CPR

Silfvast T. J Int Med 229:331-335, 1991
Spaulding CM et al., N Engl J Med 336:1629—1633, 1997

Findings in the coronary arteries after sudden cardiac death

(postmortem angiography)

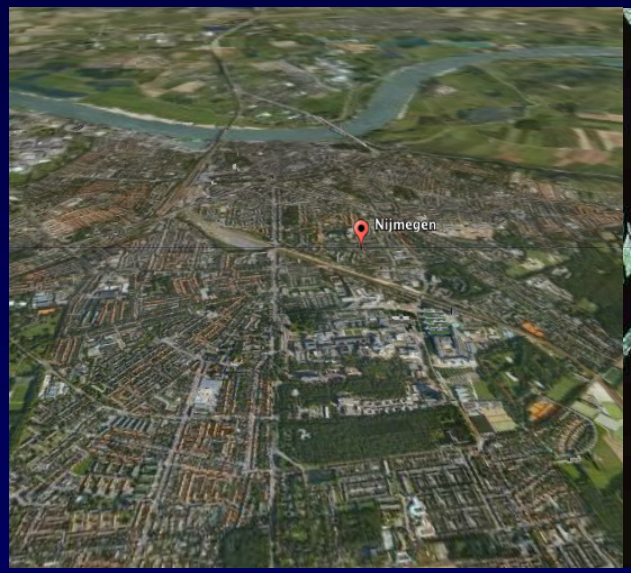


	n	Coronary thrombi	In addition	Control
Davies et al *(NEJM 1984)*	100	74% (115 total)	21% plaque rupture	78 dead pat., 0 thrombi
Frink et al *(Br Heart J 1988)*	24	100% (35 total)	74% micro-emboli	12 dead pat., 0 thrombi

- *DeWood et al* (*Cardiovasc Clinic 1987*)
  - 70% of patients with sudden cardiac death (SCD) show coronary thrombi after resuscitation
- *Zipes, Wellens* *(Circulation 1998)*
  - Thrombi, plaque rupture > 50% after SCD
  - Coronary thrombi in 40-86% of all survivors after cardiac arrest (of cardiac aetiology)

PCI during ongoing CPR

Hans E. Luijten



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Background (1)

- Cardiac arrest is a lethal disease, with a 5-10% chance of survival in Out-Of-Hospital-Arrest (OOHA)

- Optimal treatment should address the underlying cause, this is often Acute Coronary Thrombosis

Background (2)

- Ongoing manual CPR in cases without Return Of Spontaneous Circulation (ROSC) precludes effective PCI

- Mechanical CPR with the *AutoPulse®* adequately supports perfusion of heart and brain, buying time to effectively treat underlying cause of the cardiac arrest

Objectives

- Primary PCI in cases of Out-Of-Hospital-Arrest of Presumed Cardiac Etiology (OOHA-PCE) with a high suspicion of a “fresh” ST Elevation MI (STEMI)
- Pre- and/or In-Hospital treatment with *AutoPulse®* CPR (A-CPR) in consecutive cases with cardiac arrest
- Primary PCI of infarct related artery (IRA) during or immediately after CPR with or without ROSC to test feasibility and determine possible survival benefit

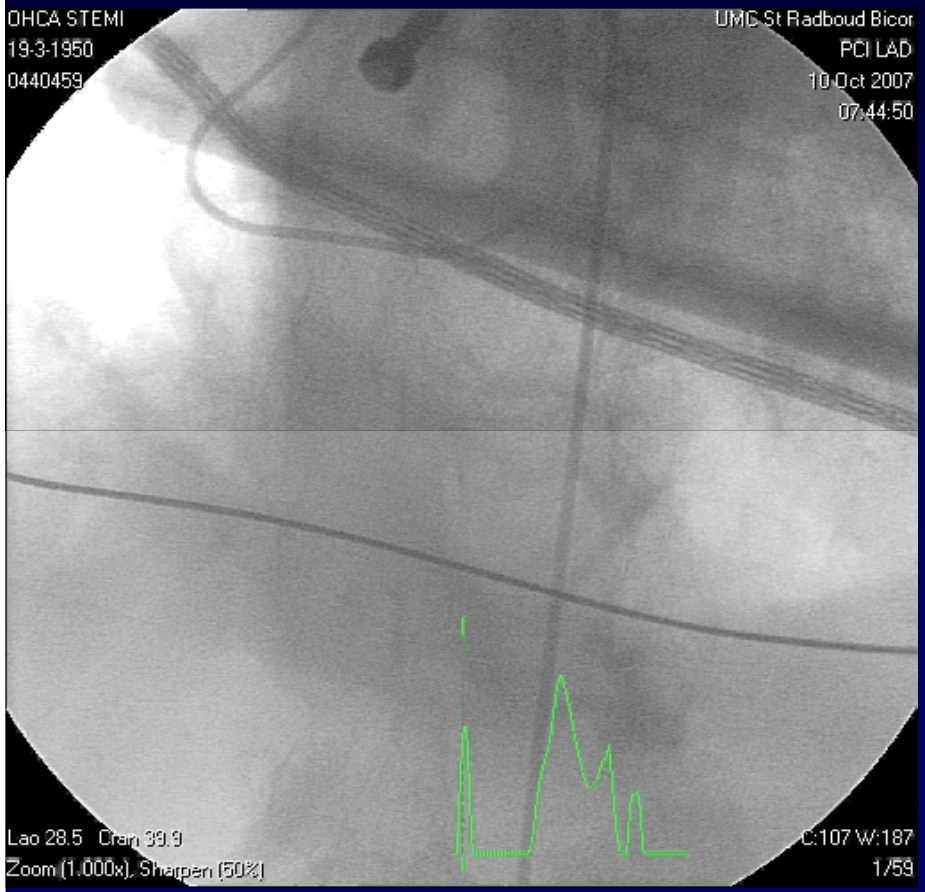
Methods (1)

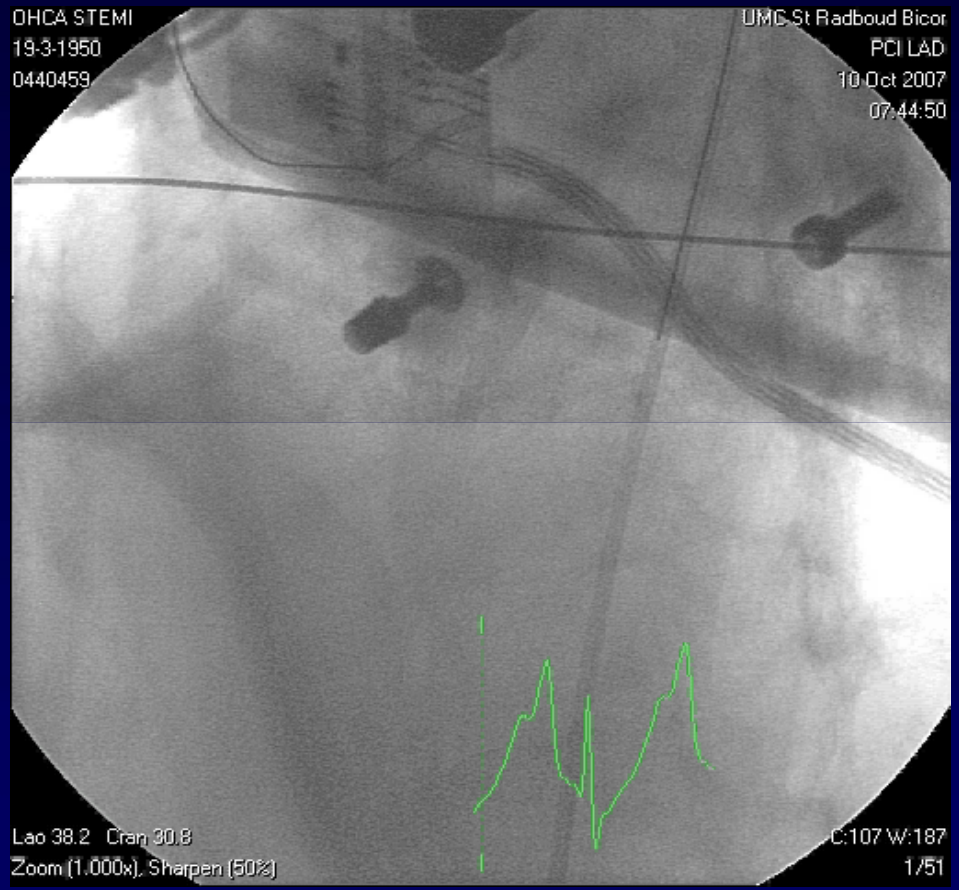
- Consecutive OOHA-PCE cases with or without ROSC
- Prospective nonrandomized case series: first reported results
- Start January 2007, ongoing registry in high volume PCI center (1400/year)
- Start of A-CPR in pre-hospital phase by EMS or in Emergency Department

Methods

- *AutoPulse®* on board in all 17 ALS ambulances
- Extensive pit crew *AutoPulse®* deployment training of emergency medical service (EMS), Emergency Department and cathlab personnel
- A-CPR before and/or during acute coronary angiography for presumed fresh ST Elevation Myocardial Infarction

Cathlab Case – PCI tijdens AutoPulse





Patient Population (1)

- 16 cases, 11 male, age mean 59.94, median 60, range 34 – 80 yrs
- 1st documented rhythm:
  8 VF, 6 PEA, 2 bradycardia

Patient Population (2)

- Anterior STEMI 9/16
- Inferior STEMI 2/16
- Massive pulmonary embolism 1/16 (autopsy dx)
- Severe aortic valve stenosis 1/16 (autopsy dx)
- Hypovolemic shock 1/16
- Cardiogenic shock without STEMI 2/16

Patient Population & Results

Age	Sex	1st rhythm	PCI vessel	Diagnosis	Survival	1st pH	Lactate	IABP	AP pre/C
57	F	VF / OOHA	LAD 2VD	Ant STEMI	> 475 d	6.98	2.6	+	+/+
46	F	VF / OOHA	LAD 1VD	Ant STEMI	> 185 d	6.75	2.5	+	-/+
71	M	Asystole	Uns (PAD)	Ant STEMI	0	6.91	23.3	-	-/+
34	M	VF > PEA	LM	Ant STEMI	0	6.84	22.8	+	+/+
72	M	VF	0 VD	Severe AS	0	7.25	8.3	-	-/+
61	M	Asystole	none	Pulm Emb	0	---	---	-	+/+
52	M	VF	LAD+RCA	Ant STEMI	0	7.03	10.0	-	+/+
72	M	PEA brady	3 VD	IPL STEMI	0	6.92	---	-	-/+
62	M	VF	LM-LAD	Ant STEMI	0	6.62	24.8	-	+/+

Results (1)

- Survival 4/16 = 25%
- STEMI 11/16, 9/11 anterior infarct
- Successful PCI 9/11 STEMI cases
- Endotracheal intubation 14/16

Results (2)

Characteristics Non-survivors (12/16):

pH < 7.1 and/or lactate > 8

all died the same day

Results (3)

Characteristics Survivors (4/16):

Anterior STEMI, age < 60, successful PCI
during (3/4) and/or after A-CPR (2/4)
pH > 6.74, lactate < 3.0
1 or 2VD
Therapeutic hypothermia 3/4 post-PCI
Good neurological outcome

Conclusions (1)

- Ongoing CPR is NOT a contra-indication for acute coronary angiography and/or PCI
- *AutoPulse®*-CPR allows the performance of primary PCI of IRA in cases without ROSC with a high success and relatively high survival rate

Conclusions (2)

- *AutoPulse®*-CPR generates high Aortic BP not attainable with manual CPR
- Low pH < 7.1 and/or high 1st lactate level > 8 after OOHA appear highly predictive of non-survival

Recommendation

Newly proposed paradigm

1. Scoop and run to cathlab for shock refractory VF/pulseless VT in cases with a non-traumatic arrest and a high suspicion of an acute STEMI

2. *Train and implement mechanical CPR in the resuscitation chain of survival in OOHA-STEMI*

CIRC Trial

Study Device: AutoPulse® Resuscitation System Model 100

Category	Specifications
Chest Displacement	Equal to 20% reduction in anterior-posterior chest depth
Physiological Duty Cycle	50 ± 5%
Compression Rate	80 ± 5 compressions per minute
Compression Modes (user selectable)	• 15 : 2 (15 compressions with two 1.5 second ventilation pauses) • 30 : 2 (30 compressions with two 1.5 second ventilation pauses) • Continuous compression
Ventilation Pause (15:2 and 30:2 modes)	Two pauses of 1.5 seconds each

CIRC – Circulation Improving Resuscitation Care Trial

Inclusion Criteria

Patients aged 18 years or more (or local age of consent) who suffer non-traumatic arrest of presumed cardiac etiology in an out-of-hospital setting and who do not meet any of the exclusion criteria below.

Exclusion Criteria

Patients must not fulfill any of the following exclusion criteria (See Section 4.2):

- Wards of the state
- Prisoner
- Traumatic arrest (blunt, penetrating, burns)
- Arrest due to exsanguinations, strangulation, smoke inhalation, drug overdose, electrocution, hanging, drowning
- Known or clinically apparent pregnancy
- Do Not Attempt to Resuscitate (DNAR) orders
- Apparent patient weight more than 225 kg (500 lbs)
- CPR device other than AutoPulse
- Patients who are reached after 16 minutes after the time of emergency call (911). This exclusion is determined at the time of CRF abstraction, not during treatment of the patient.

CIRC – Trial Objectives and Endpoints

2.1 Primary Objective

The primary objective is to determine if AutoPulse integrated CPR (A-CPR) is superior or equivalent to manual CPR (M-CPR), in terms of the number of patients who survive to hospital discharge after OOHCA-PCE.

2.2 Primary Endpoint

The primary endpoint is OOHCA-PCE patient survival to hospital discharge.

2.3 Secondary Objectives

To compare A-CPR to M-CPR in terms of the following outcomes:

- the number of patients with sustained return of spontaneous circulation (ROSC)
- the number of patients who survive to twenty-four hours (from time of emergency call/911)
- the number of patients with neurologically intact outcomes at discharge

2.4 Secondary Endpoints

- Survival to sustained ROSC
- Survival to twenty-four (24) hours (from time of emergency (911) call)
- Survival to hospital discharge with a Modified Rankin Score ≤ 3
- Process Outcomes:
- The total number of defibrillation shocks
- The duration of pulselessness (from emergency call (911) to ROSC)
- Hands-on interval or other measures of CPR quality
- Measures of survival to neurological intactness at time of hospital discharge
- Modified Rankin Scale
- CPC score

LINC Studie

- OHCA manuele CPR versus Lucas-CPR met defibrillatie TIJDENS thoraxcompressie
- Randomisatie, multicenter, Utrecht, Zweden en Engeland
- Primaire eindpunt: overleving 4u na ROSC
- Sec eindpunten: ROSC, overleving in ZkH, 1 en 6M, neurologische uitkomst
- Studie loopt momenteel

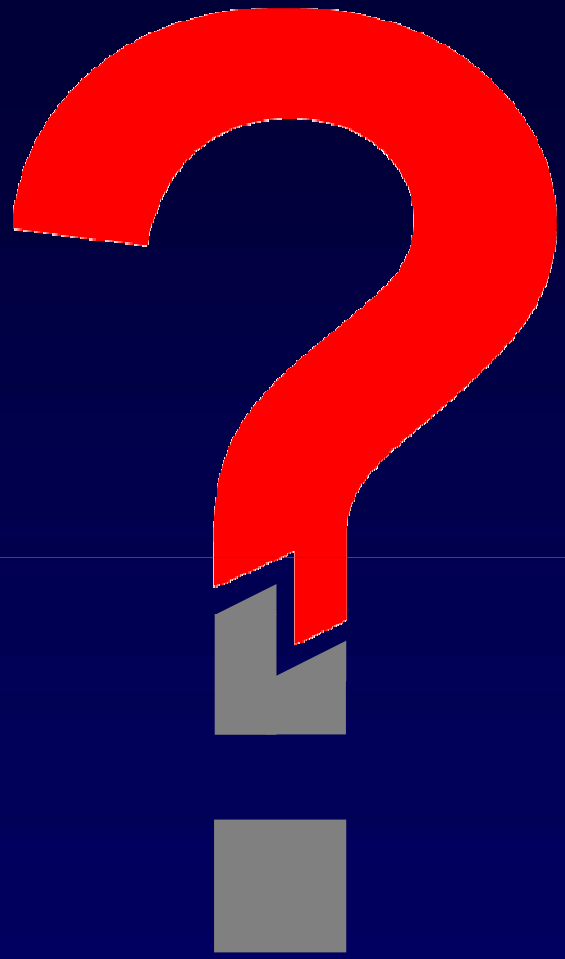
NRR Advies: Mechanische CPR - I

- Er is nog reserve over de uiteindelijke waarde van de mechanische compressieapparatuur
- De NRR moedigt nieuwe wetenschappelijke studies aan om een beter beeld te krijgen van potentiële nut van deze apparatuur
- Er wordt nog geen uitspraak gedaan over een aanbeveling, bij gebrek aan gegevens die verbeterde overleving tot ontslag konden aantonen

NRR Advies: Mechanische CPR - II

- Prehospitale invoering op grotere schaal baseren op gerandomiseerd klinisch onderzoek met aangetoond betere uitkomst voor de patiënt

- Of mechanische thoraxcompressie binnen het ziekenhuis wel zinvol is, valt niet te beoordelen omdat daar geen enkele klinische studie over is uitgevoerd



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