Systems Improving Outcomes from OHCA

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CI: Patents licensed to Zoll and Stryker

CONGRESSO NAZIONALE IRC 2023

Italian Resuscitation Conference 2023

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LA RIVOLUZIONE DEI SISTEMI

Systems Improving Outcomes from OHCA Agenda

- What is system?
- Chain of Survival, with sub groups
- CPR Guidelines
- Public Access Defibs
- Defibrillation
- How to perform CPR
- Physiology driven CPR
- Example of a rare system (used in not so rare patients)

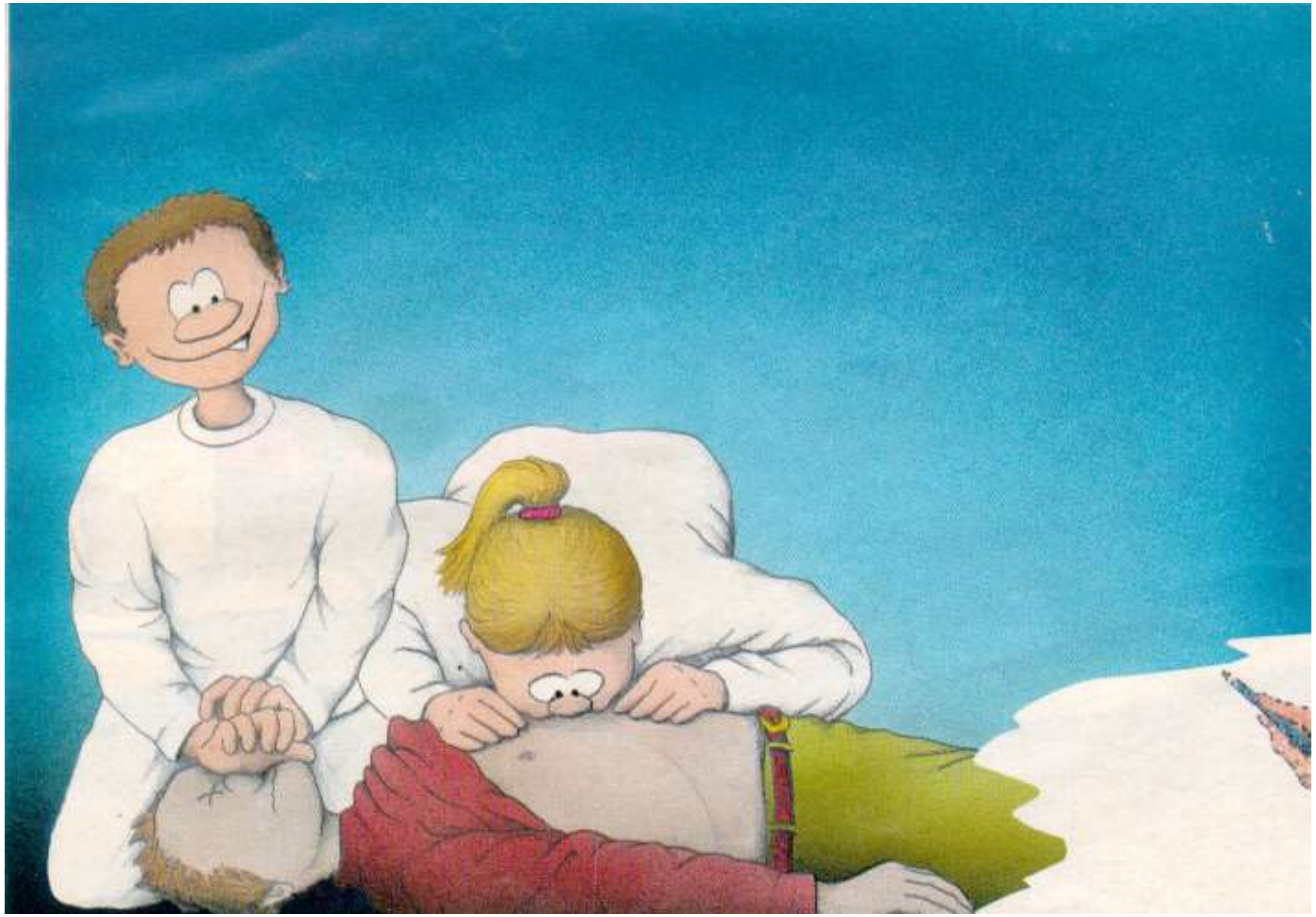
What Is System?

- An entity consisting of grouped components that are connected (interdependent) according to a specific plan to achieve a certain outcome. *Un'entità costituita da componenti raggruppati che sono collegati (interdipendenti) secondo un piano specifico per ottenere un determinato risultato.*
- A system is created to give a predetermined outcome which has a priority over the outcome of each subsystem. *Un sistema viene creato per fornire un risultato predeterminato che ha priorità rispetto al risultato di ciascun sottosistema.*

Google translate – does it work??

The ultimate system is the Chain of Survival
This is the Gold Standard

Guidelines are constantly under debate
Cardiac Arrest patients' reaction to the Guidelines



E il paziente ha parlato

"Grazie per avermi salvato la vita!"

Public-access defibrillation and survival after out-of-hospital cardiac arrest

A P Hallstrom 1, J P Ornato, M Weisfeldt et al.
N Engl J Med 2004 12;351(7):637-46.
doi: 10.1056/NEJMoa040566

A Landmark study documenting the positive outcome effect of the Public-Access Defibrillation (PAD) system

Characteristics and Survival of OHCA

	CPR only (n=107)	CPR plus AED (n=128)	P Value Unadjusted	P Value Adjusted
Volunteer response activated, no (%)	57 (53.8)	89 (69.5)	0.06	
Bystander CPR, no (%)	62 (62.0)	81 (64.8)	0.55	
Intervall call to EMS and arrival of EMS, min	5.6 ± 3.4	5.7 ± 3.3	0.63	
Shock delivered with non-EMS AED	2 (1.9)	44 (34.4)	<0.001	
VF/VT as first rhythm, no (%)	43 (47.3)	71 (57.7)	0.63	
Patients admitted to hospital, no (%)	29 (27.1)	50 (39.1)	0.07	
Survivors of definite arrest, no	15	30	0.03	0.03
Survivors of definite or uncertain arrest, no	16	31		0.03
CPC of survivors of definite arrest, no (%)			0.09	
Normal	10 (71.4)	22 (73.3)		
Mildly impaired	3 (21.4)	5 (17.7)		
Moderately impaired	1 (7.1)	3 (10.0)		

Pre-shock pause impact on shock success

- We included 2807 of 2969 M-cc and 1715 of 1791 LDB-cc shocks (total 4522).
- Median pre-shock time was 4 seconds (IQR 3-16) for M-cc, and 0 seconds (IQR 0-6) for LDB-cc.

	Shock success, M-cc	Shock success, LDB-cc
Initial VF/VT first shock[a, b]		
Pre-shock pause		
<10 sec	282 (83%)	33 (85%)
10-19 sec	108 (86%)	23 (84%)
20-29 sec	84 (90%)	13 (93%)
≥ 30 sec	41 (87%)	7 (100%)
All initial rhythms, all shocks[c, d]		
Pre-shock pause		
<10 sec	1480 (80%)	201 (78%)
10-19 sec	367 (83%)	163 (80%)
20-29 sec	290 (87%)	90 (87%)
≥ 30 sec	147 (85%)	62 (89%)

- **Conclusion:**

Different pre-shock pauses did not affect shock success for M-cc or LDB-cc. However, the impact on ROSC and neurologic outcome requires further investigation.

Olsen JA et al. Ress 2013.

Shock through compressions, TOF

	Shock success, LDB compressions
Initial VF/VT first shock	130 (78%)
All initial rhythms, all shocks	861 (79%)

Which is lower than the 80-90% success we achieved when chest compressions were paused

Will this be influenced by where in the compression-decompression cycle the shock hit?

Olsen JA et al. Ress 2013.

Resuscitation 103 (2016) 99–105

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Resuscitation

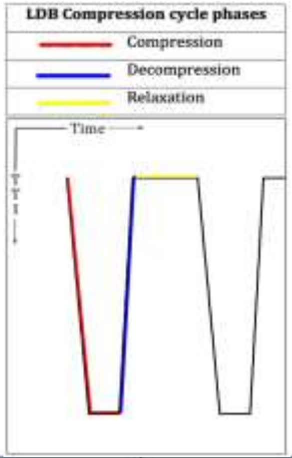
journal homepage: www.elsevier.com/locate/resuscitation

EUROPEAN RESUSCITATION COUNCIL

Clinical paper

Defibrillation success during different phases of the mechanical chest compression cycle☆

Mikkel T. Steinberg[a,b,*], Jan-Aage Olsen[a,b], Cathrine Brunborg[c], David Persse[d], Fritz Sterz[e], Michael Lozano Jr[f], Mark Westfall[g,h], David T. Travis[f], E. Brooke Lerner[i], Lars Wik[b]



First shock	TOF (%)	Unadjusted OR (95% CI)	P-value	Adjusted OR (95% CI)	P-value
Control group	69/80 (86)				
Compression	41/57 (72)	0.41 (0.17-0.97)	0.04	0.42 (0.17-1.00*)	0.05**
Decompression	18/23 (78)	0.57 (0.18-1.87)	0.36	0.56 (0.17-1.83)	0.34
Relaxation	29/39 (74)	0.46 (0.18.1.20)	0.12	0.50 (0.19-1.32)	0.16
Up to three shocks	**TOF (%)**	**Unadjusted OR (95% CI)**	**P-value**	**Adjusted OR (95% CI)**	**P-value**
Control group	216/263 (82)				
Compression	119/168 (71)	0.55 (0.34-0.89)	0.02	0.56 (0.34-0.91)	0.02
Decompression	45/58 (78)	0.70 (0.35-1.39)	0.31	0.71 (0.36-1.39)	0.32
Relaxation	103/138 (75)	0.67 (0.40-1.14)	0.14	0.66 (0.38-1.13)	0.13

*Exact OR 95% CI upper limit=0.995

**Exact p=0.049

- LDB compr. Cycles in phases
- Shock categorized according to which phase it impacted the chest compression cycle.
- Control were those where LDB was stopped prior to shock

Pads position, effect of shocks

Of 989 shocked patients, 917 (93%) received 3074 indicated shocks.

	Sternal Apical	Anterior Posterior	OR, 95% CI	p
Patients w/shockable initial rhythm	269 (57%)	277 (63%)		=0.05
Initial rhytm shock success	797/993 (80.3%)	859/1069 (80.4%)	0.99, 0.80-1.24	=0.96
Successful shocks	1163/1436 (81%)	1303/1638 (79.5%)	1.10, 0.92-1.31	=0.32
Median number of shocks	3 (IQR 1-4)	3 (IQR 1-5)		

Conclusion: There was no significant difference in shock success rate between sternal-apical and anterior-posterior defibrillator pads positioning during manual CPR of OHCA patients.

Olsen JA et al. Ress 2013.

Effect of escalating vs fixed energy defifrillation

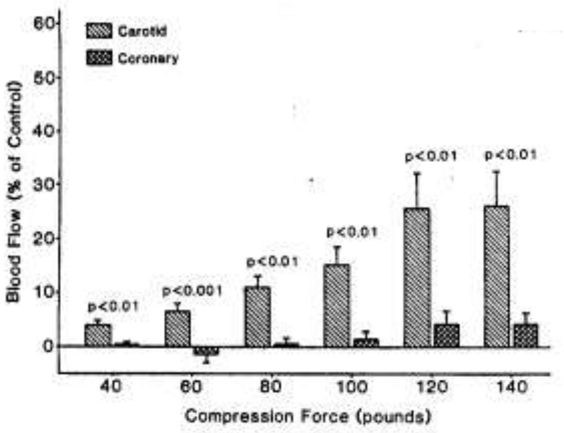
	Escalating energy 200-360J, n=411	Fixed energy 360J, n=914	OR, 95% CI	p
Number of shocks	1157	2662		
Successful shocks	963 (83.2%)	2178 (81.8%)	0.91, 0.76-1.09	=0.29
Pat w/initial VF/VT, 1 shock success	237/274 (86.5%)	409/492 (83.1%)	0.77, 0.51-1.17	=0.22
Median number of shocks	2 (IQR 1-4)	2 (IQR 1-4)		
Fixed, survival			Unadjusted 0.83, 0.62-1.12	=0.23
			Adjusted 1.10, 0.78-1.54	=0.61

Conclusion: No difference in individual shock success between defibrillation strategies. and no difference in patient survival to hospital discharge between the fixed versus escalating defibrillation strategies.

Olsen JA et al. Ress 2013.

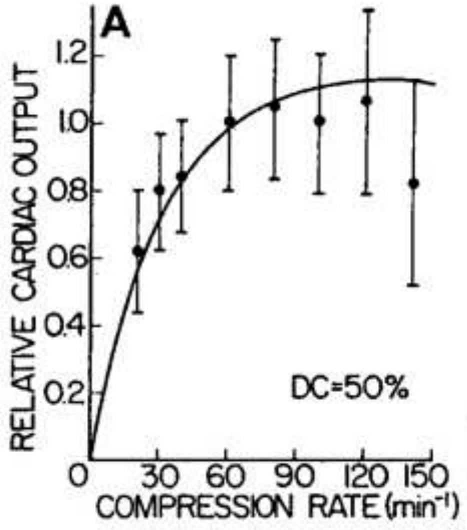
We “know” how CPR must be done to delay the process of death:

Compressions with appropriate depth:



Ditchey *et al* Circulation 1982

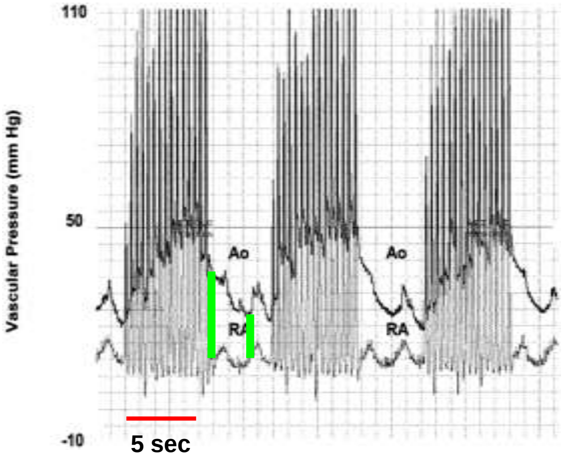
Compressions with appropriate rate



Fitzgerald *et al* Am J Physiol 1981

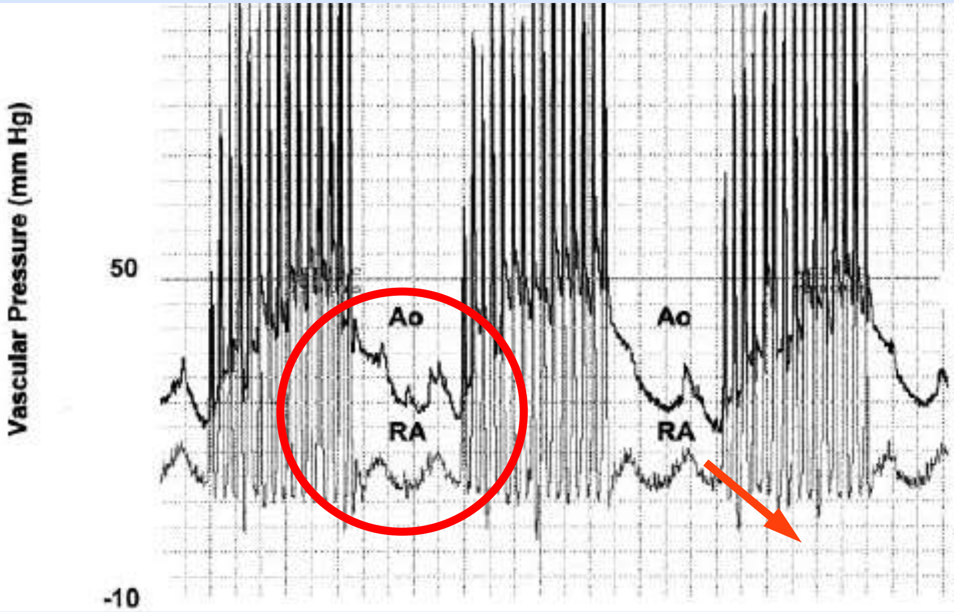
And without pauses…

Berg RA *et al* Circulation 2001



Effects of Compression Interruptions in pigs

Rapid Reduction in Coronary Perfusion Pressures



15 animals in each group, 3 minutes VF, 15 minutes CPR,
Either Continuous compressions or Interruptions for 50% of time

Interruptions → 24 hour survival ↓12% to 2%

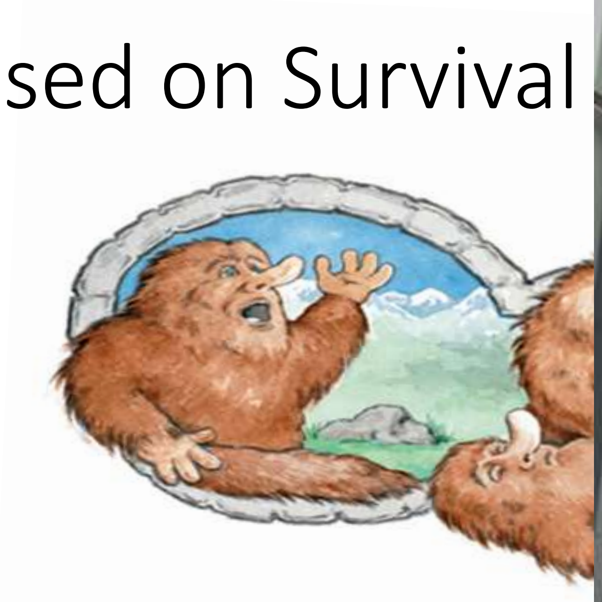
Decreased Survival with Interruptions

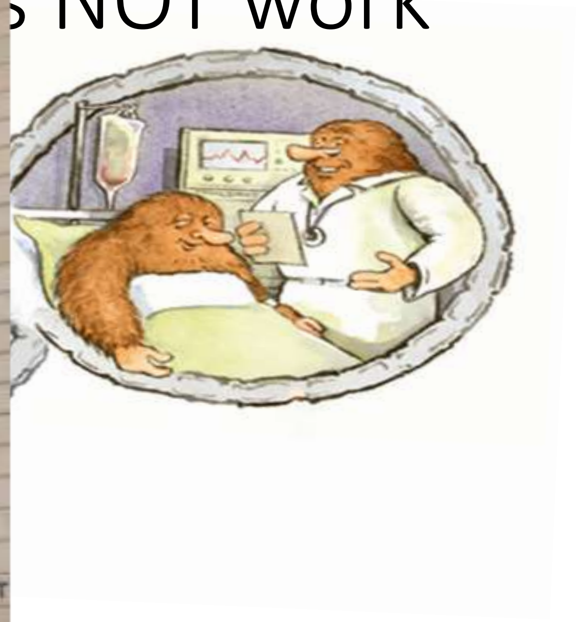
This is one of the evidences that argue not to do CC pauses and consequently support continuous CC.
We have explored this clinically and present an abstract at RESS/AHA next month.
Our findings are interesting and is based on Intra Arterial Blood Pressure during CC

Kern et al, Circulation, 105 (2002) 645-649

The Chain of Su

Based on Survival … s NOT work



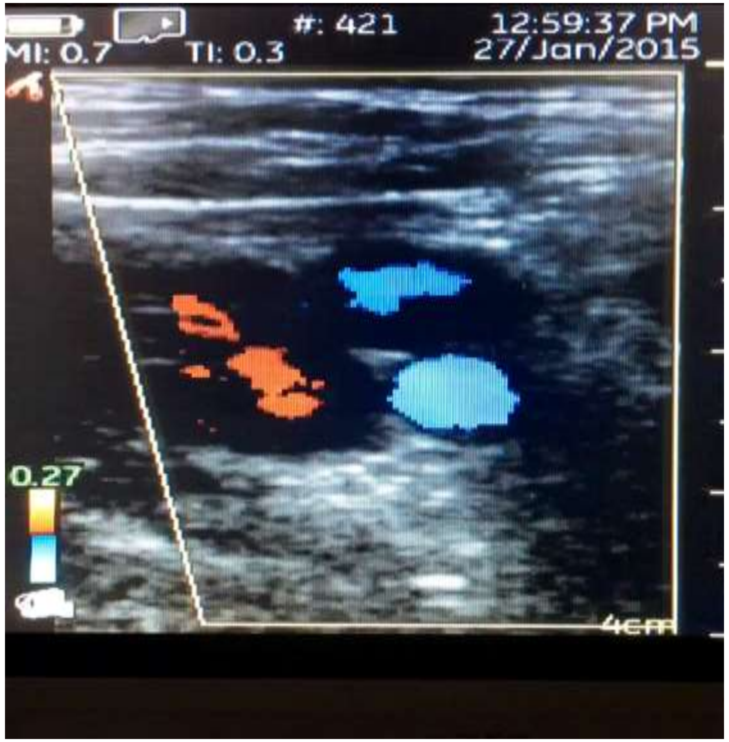


- A theoretical unrealistic
- Works fine if you are bli … rate like a robot
- HCWs step into the cha … t accordingly
- But they do not know th … rch for objective measurements like phys

Our Street Laboratory

I recommende radial canulation with US guidance

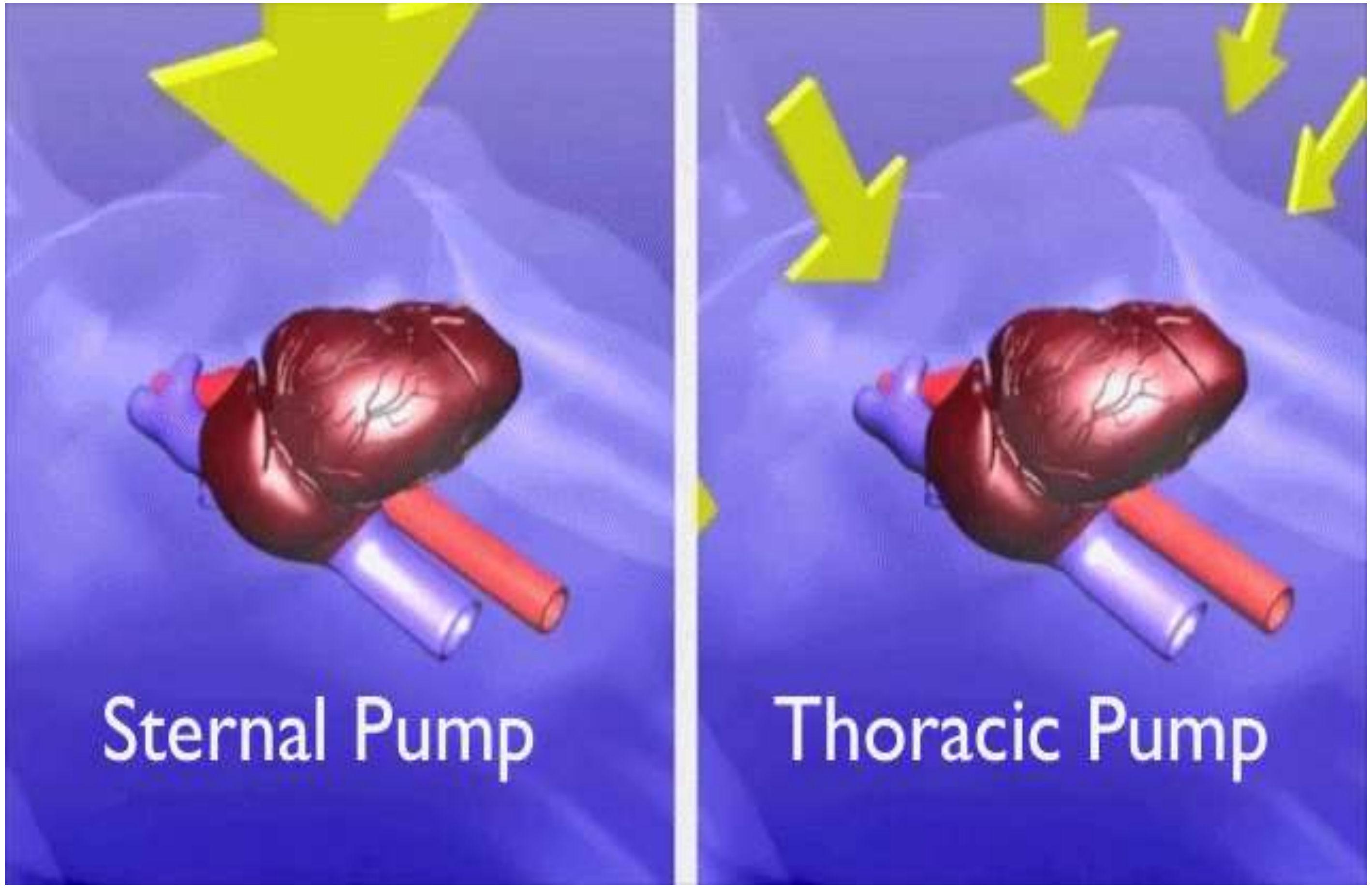
Optimize how you stabilize (tape) the arm, put something under the wrist. Let someone hold the probe



1/3 of femoral canulations are in the vein. Rotate hip laterally

Physiology based CPR

- $EtCO_2$
- Intra arterial blood pressure
- Cerebral oxymetry
- Ballistocardiography



- End-tidal CO_2
  - Independently associated with survival
  - First sign of ROSC was a rise in end-tidal CO_2.
    - Salen P, et al. Acad Emerg Med 2001; 8:610-615.
    - Grmec S, et al. Resuscitation 2007; oi:10.1016/j.resuscitation.2006.07.012.
- $ETCO_2$ detected changes in
  - CC performance
  - cardiac rhythm

White RD, Ann Emerg Med 1994

- CC pauses will decrease $ETCO_2$ to 0

Ornato JP. Annals of Emerg Med 1993

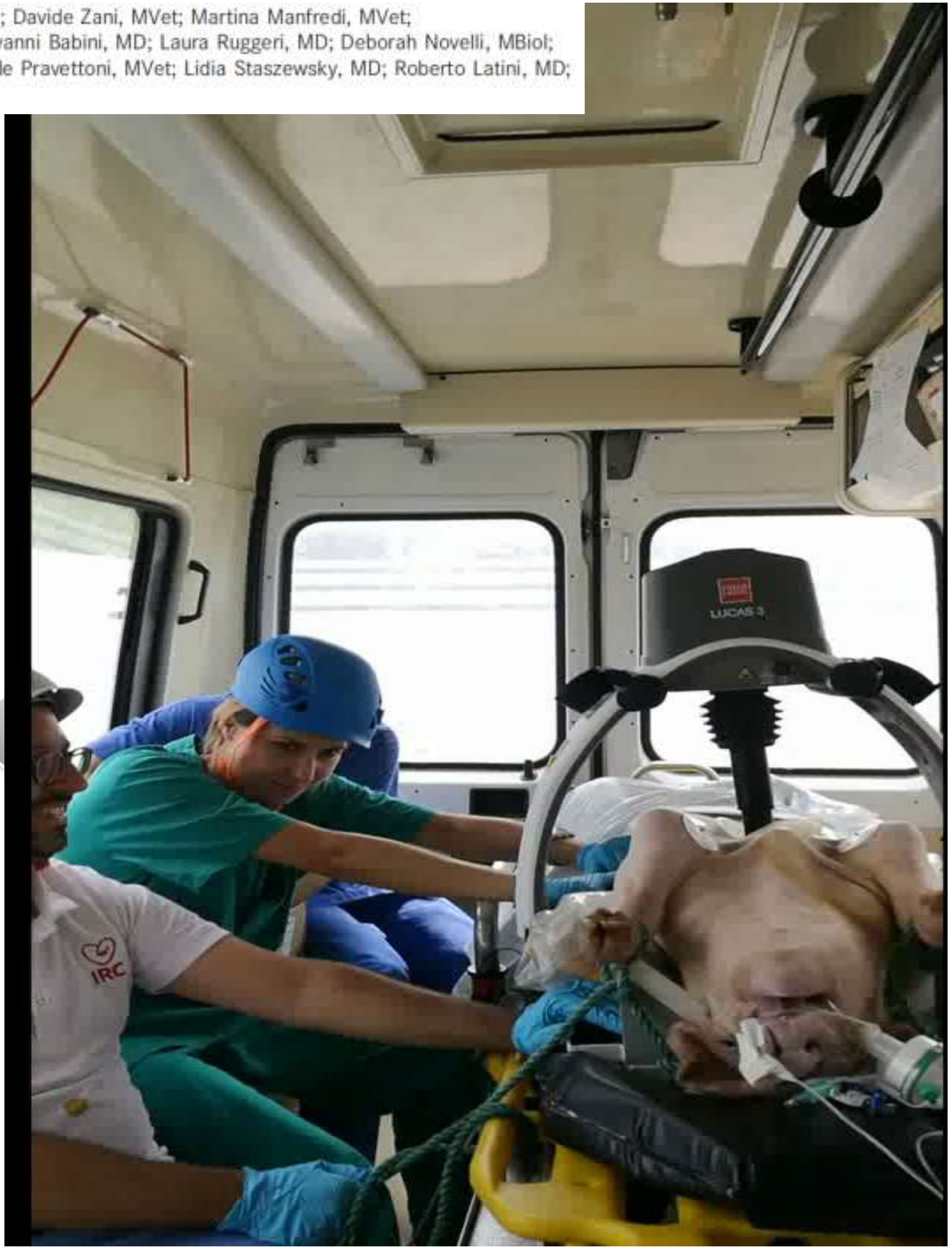
Physiology driven CPR based on personalized treatment

- Physiology measurements achieved will support initiating different care modalities based on objective physiologic measurements and not on dictation of what to do according to minutes resuscitated
- We have a toolbox with different technologies that will help us to change from algorithm guided to
    - physiology driven CPR and post ROSC treatment

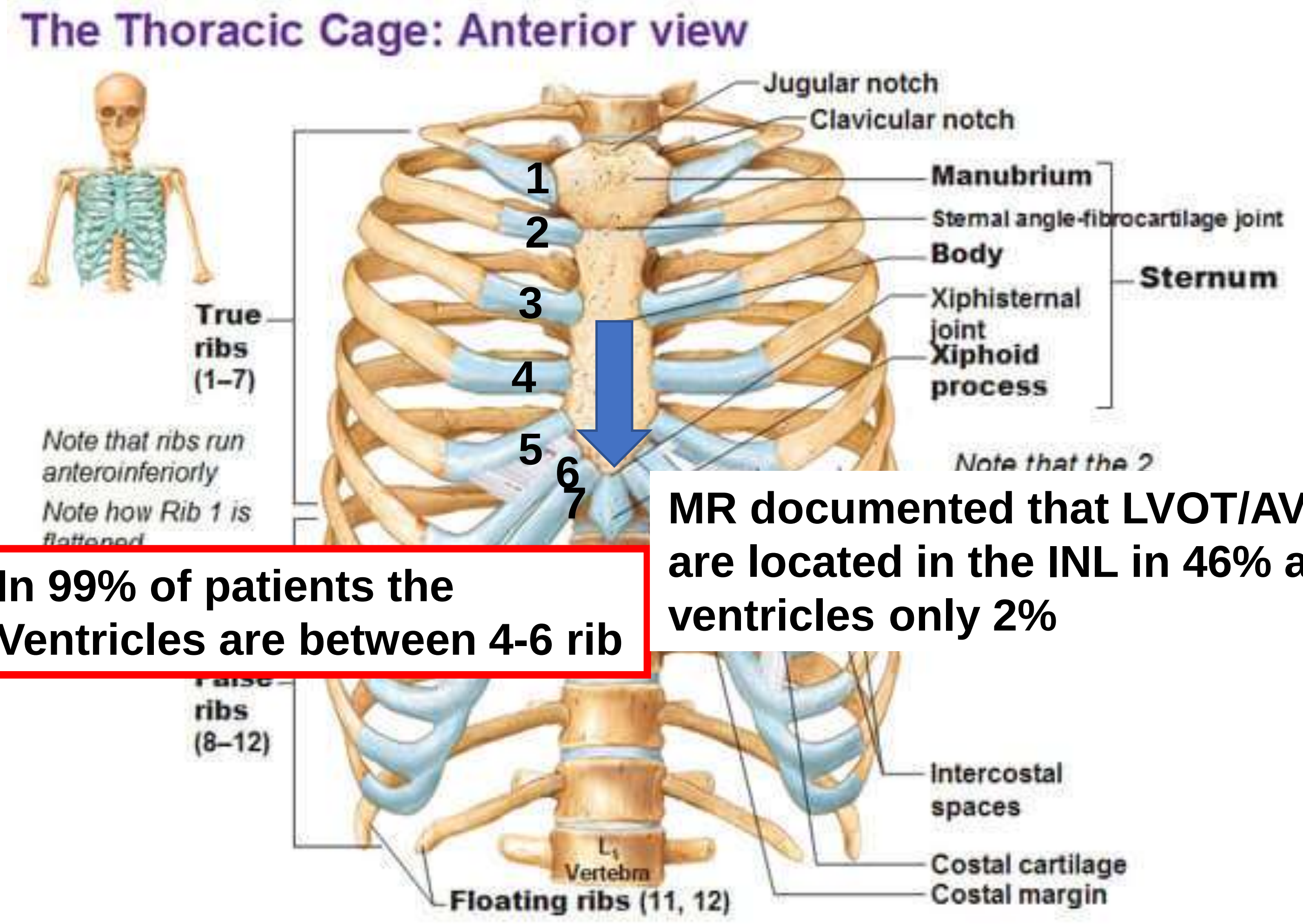
- Change to individual physiology-based treatment.
- It is wrong that one size (Guideline) fits all.
- We may reach that goal by the following:
  - How to put in invasive arterial catheter
  - How to understand the measurement values and curves during CPR and ROSC
  - How to use it as Physiology driven CPR and guidance
- I will also talk about Ballistocardiography. Is it Future?
  - How to deploy
  - How to use it
  - What future may bring




Aurora Magliocca, MD; Davide Olivari, MBiol; Daria De Giorgio, MBiol; Davide Zani, MVet; Martina Manfredi, MVet; Antonio Boccardo, MVet; Alberto Cucino, MD; Giulia Sala, MVet; Giovanni Babini, MD; Laura Ruggeri, MD; Deborah Novelli, MBiol; Markus B Skrifvars, MD, PhD; Bjarne Madsen Hardig, RN, PhD; Davide Pravettoni, MVet; Lidia Staszewsky, MD; Roberto Latini, MD; Angelo Belloli, MVet; Giuseppe Ristagno, MD, PhD



Does it matter where on the chest you push?



In 99% of patients the Ventricles are between 4-6 rib

MR documented that LVOT/AV/AR are located in the INL in 46% and ventricles only 2%

If you follow Guidelines and administer 1 mg of Epi, This is what happens when you monitore the effect by invasive arterial line measurements


180
3: ART (mmHg)
0
150
3: P1 (mmHg)
0
120
3: P1 (mmHg)
0
60
3: P1 (mmHg)
0
60
3: P1 (mmHg)
0
120
3: P1 (mmHg)
0
120
3: P1 (mmHg)
0
150
3: ART (mmHg)
0
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120
3: ART (mmHg)
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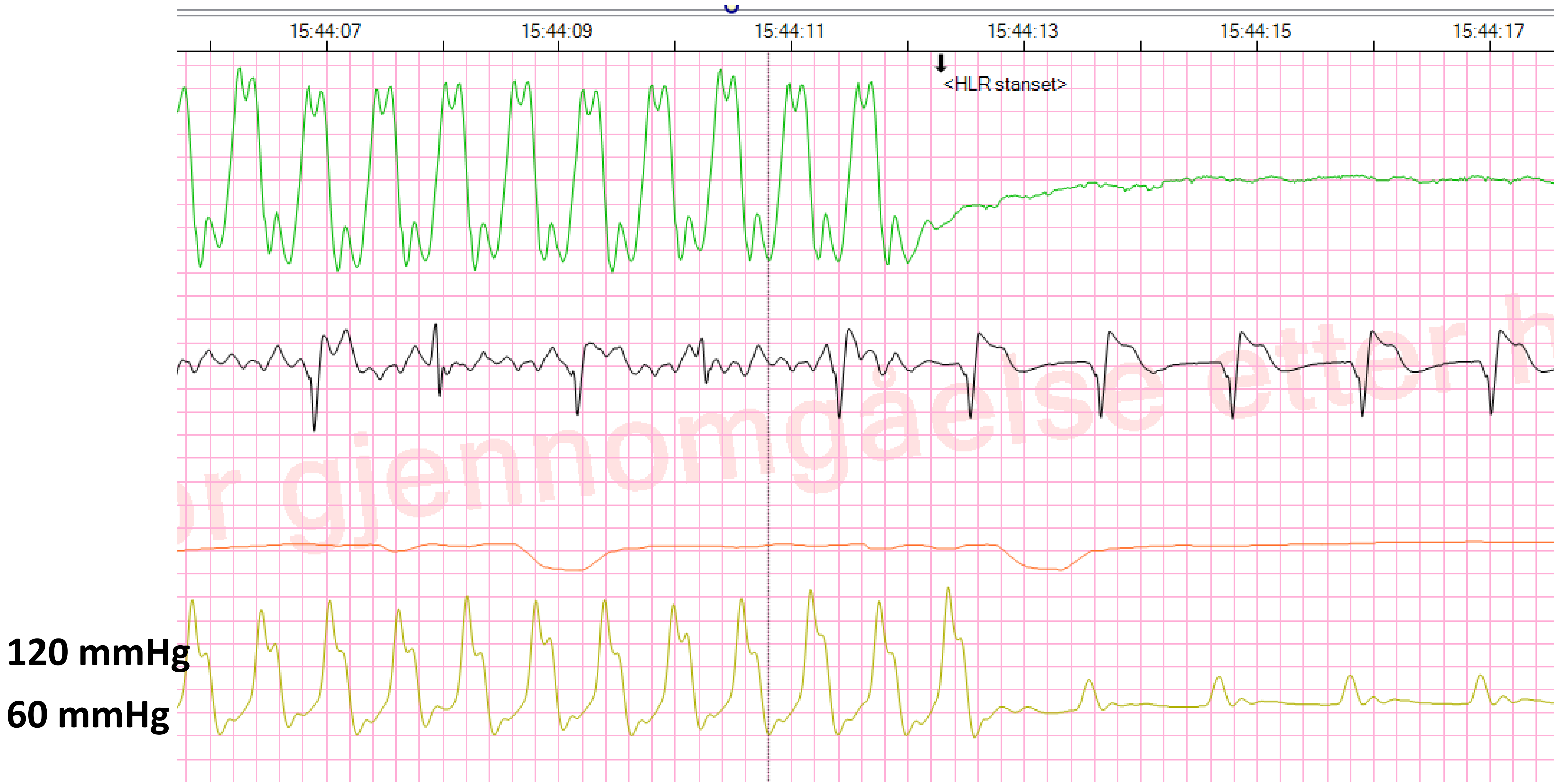
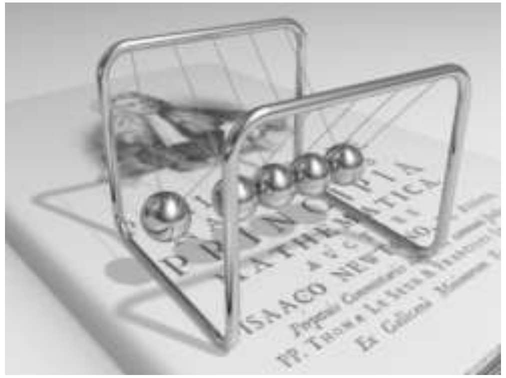

15:44:07
15:44:09
15:44:11
15:44:13
15:44:15
15:44:17
<HLR stanset>
120 mmHg
60 mmHg

System in the future?

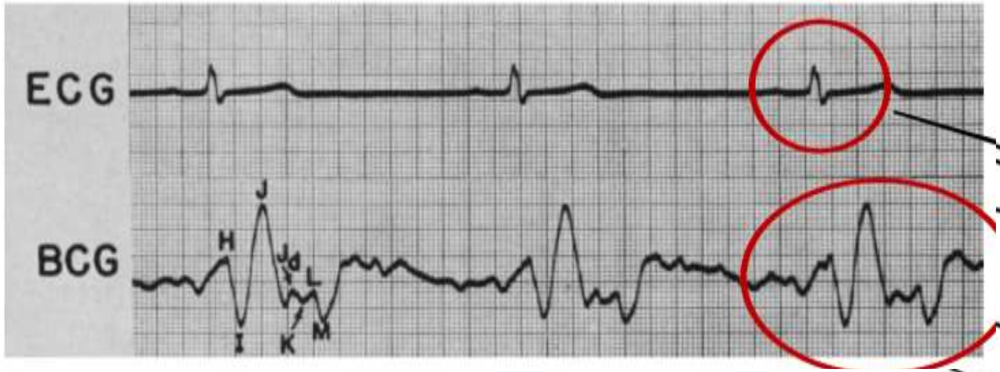
Ballistocardiology

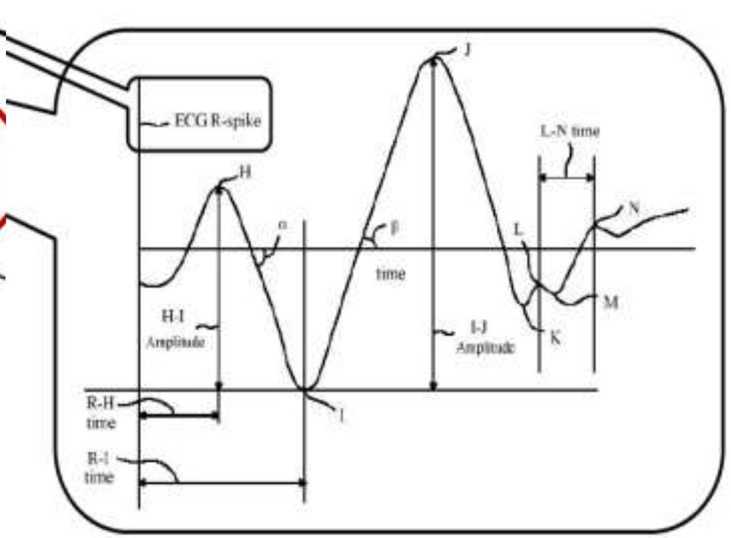


The motion of the blood is primarily in the length direction of the human being

As the heart pumps two mechanical effects can be measured

- Motion of the heart causing a recoil effect on the chest
- Motion of the blood causing a recoil effect in whole body





BCG is the mechanical response of the electrical EKG signal

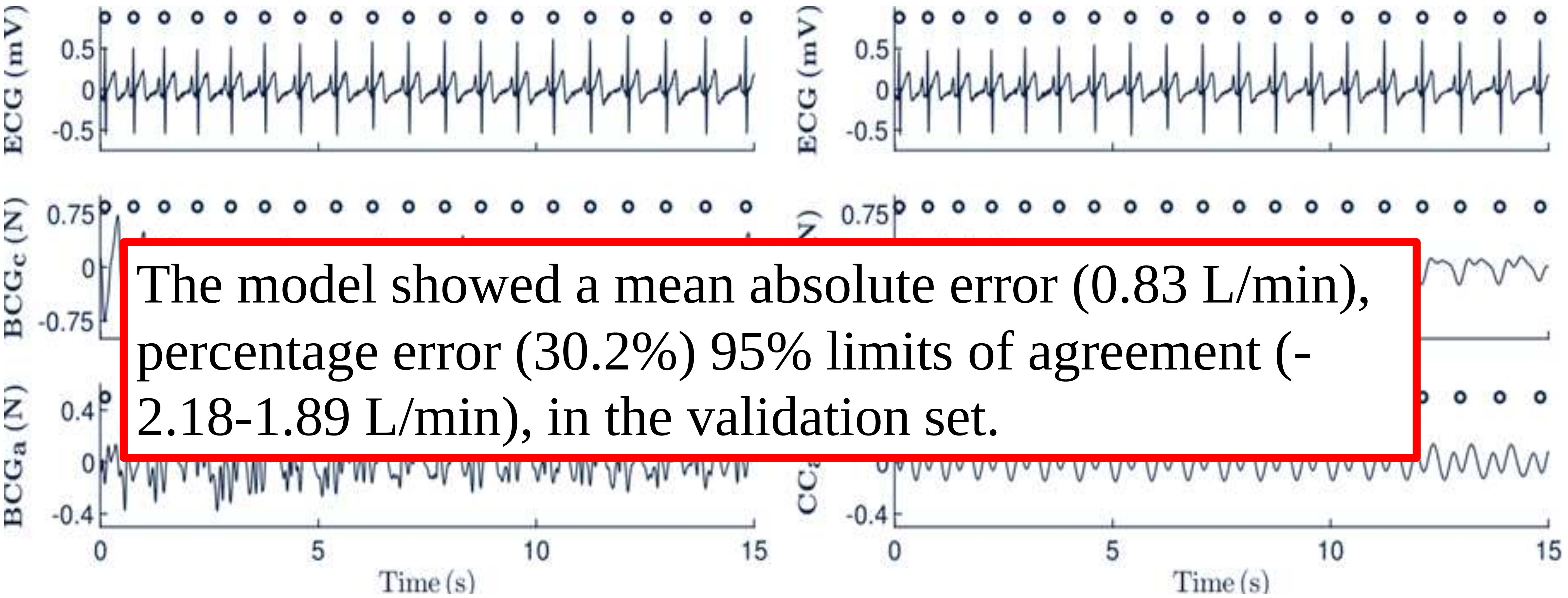
H-I-J-M ~ blood flowing up-down-up in the body

The delay and details of the shape of the BCG signal can reveal cardiac dysfunction

J-peaks can be used to measure Heart Rate (HR) and Heart Rate Variability (HRV) in a similar way as the R-peaks in the ECG

The first use of BCG in emergency Medicine, drowning, ROSC

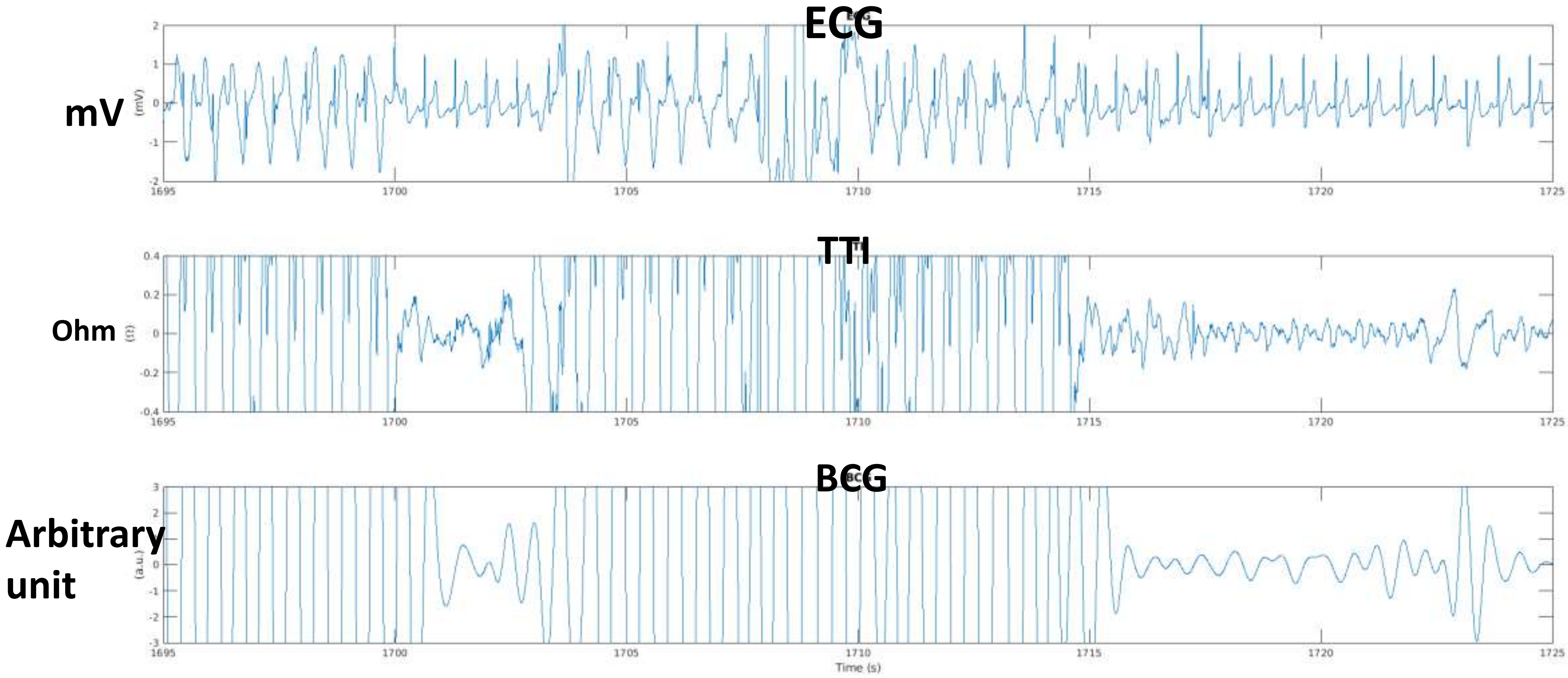
Preprosessed signal | **Adaptively Filtered signal**



The model showed a mean absolute error (0.83 L/min), percentage error (30.2%) 95% limits of agreement (-2.18-1.89 L/min), in the validation set.

Figure 1. Adaptive filtering of BCG signals to extract the circulatory-related component. Preprocessed ECG, BCGc and BCGa are represented from top to bottom in the left panel. While adaptively filtered (using a recursive least square (RLS) algorithm) ECG and circulatory-related components of the BCGc (CCc) and BCGa (CCa) are depicted from top to bottom in the right panel. Dark blue circles represent the instants of the QRS complexes.

BCG piezoelectric sensor during CPR and ROSC



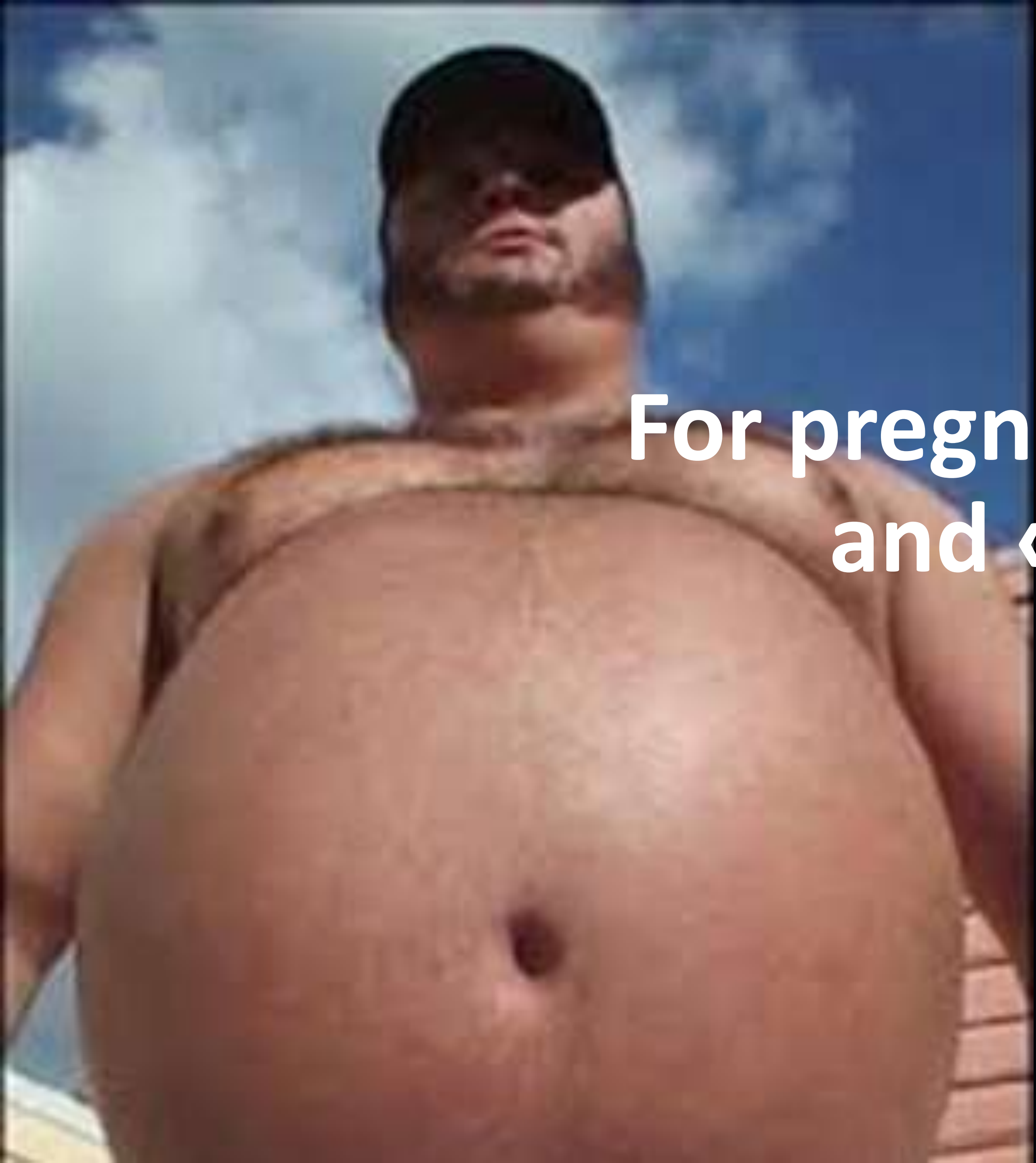









For pregnant women and «men»



THANK YOU
FOR LISTENING
AND THE
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