Load Distributing Band Mechanical Chest Compression Device for Treatment of Cardiac Arrest

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Traditional CPR

- The problem with standard CPR (STD-CPR): provides only 1/3 of normal blood supply to the brain and 10-20% to the heart

- Problem of rescuer fatigue, CPR not consistent, and need to stop CPR during rescuer changes and patient transfers

With permission from Dr Sang Do Shin, Seoul National University

Load Distributing Band CPR

The AutoPulse™ (Revivant Corporation, Sunnyvale, CA) is a non-invasive Load Distributing Band device.

Distributing force over the entire chest improves the effectiveness of chest compressions.

Less harm, elimination of rescuer fatigue, more consistent, and eliminating the need to stop CPR during rescuer changes and patient transfers

Use of an Automated, Load-Distributing Band Chest Compression Device for Out-of-Hospital Cardiac Arrest Resuscitation

JAMA 2006 June 295(22): 2629-2637

Ong MEH, Ornato JP, Edwards DP, Best AM,

Ines CS, Hickey S, Williams D, Clark B, Powell R, Overton J,

Peberdy MA.

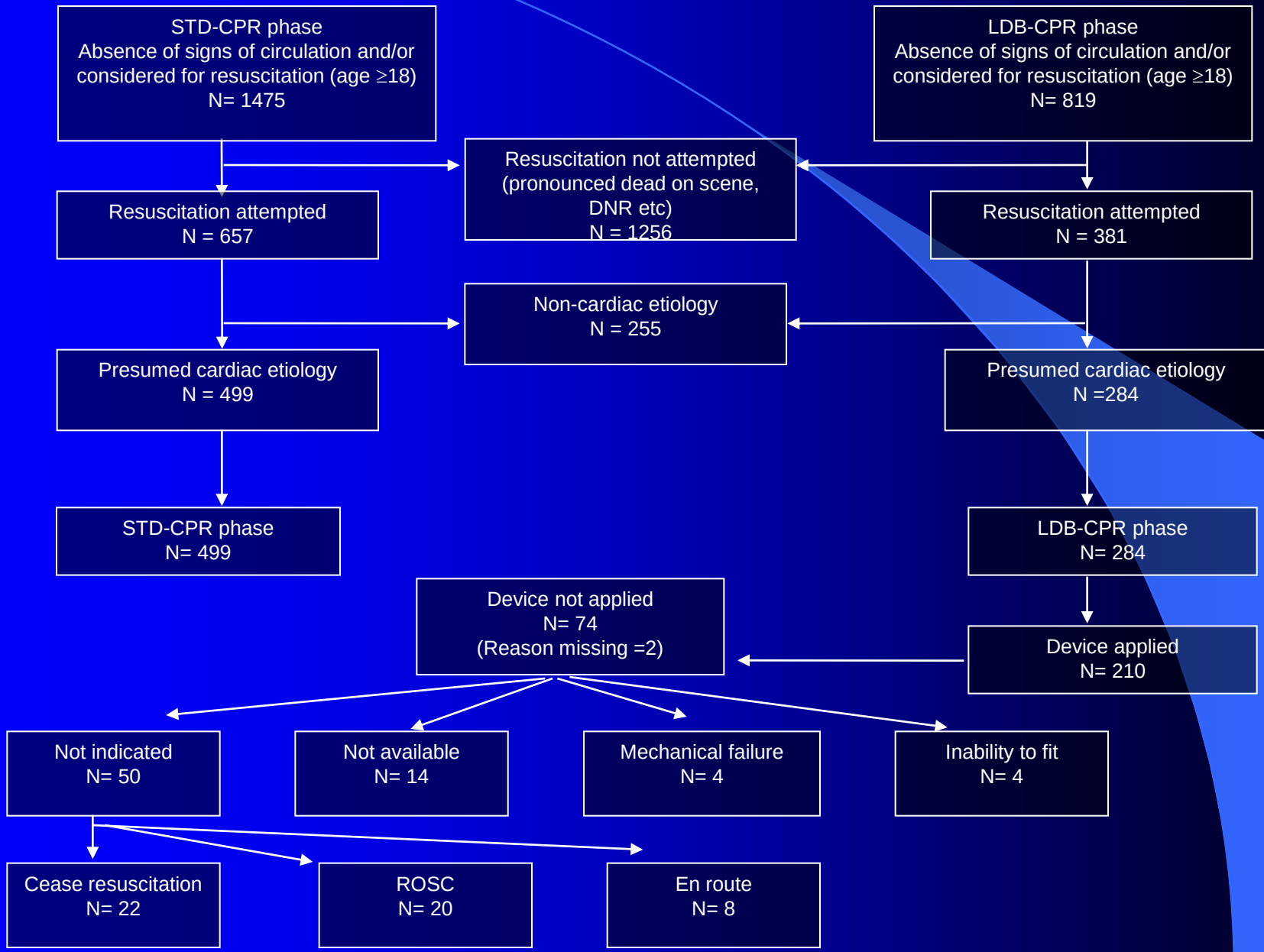
Methods

Phased, non-randomized, interventional trial

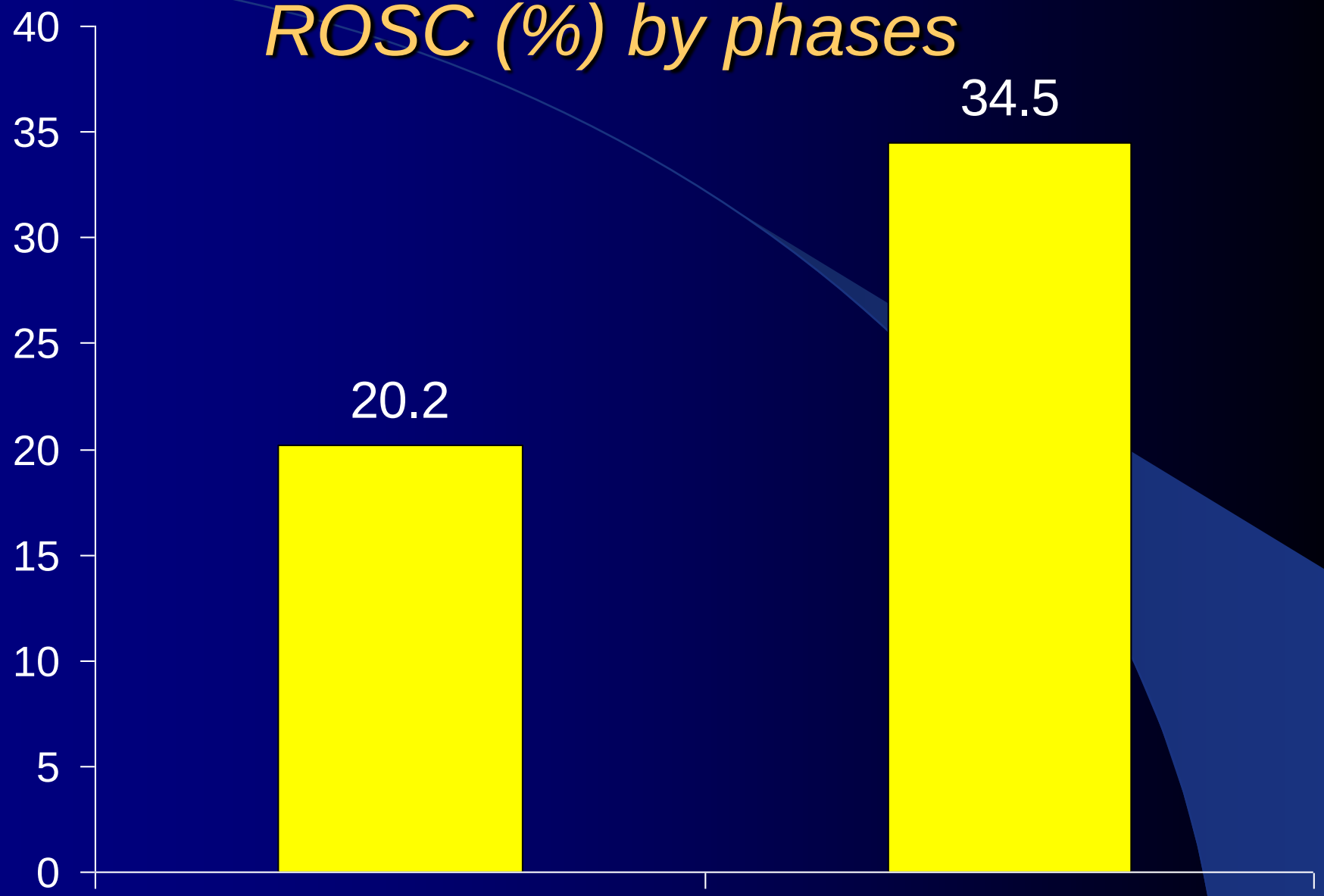
Before and after replacement of standard CPR with the LDB-CPR device in adult OHCA victims treated by paramedics in Richmond, Virginia

Richmond metropolitan area: population of approximately 200 000, representative of a mid-size North American city

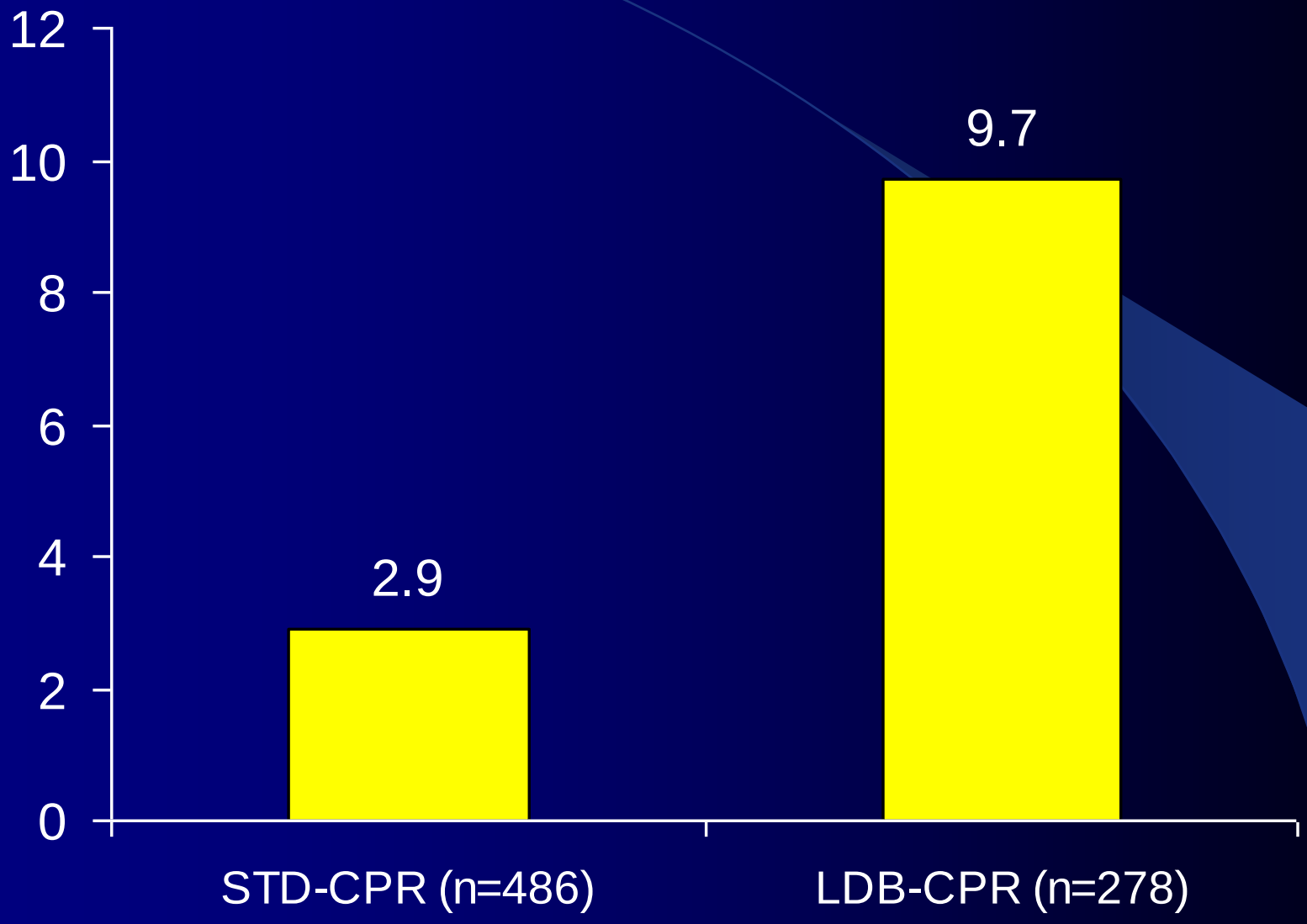
Utstein reporting template for data elements



ROSC (%) by phases



Survival to Discharge (%) by Phases



OR 3.63, 95% CI [1.90, 7.23]

CPC/OPC by Phases

	STD-CPR (n=101)	LDB-CPR (n=96)	P value
CPC 1 (%)	5 (5.6)	13 (15.1)	0.36
CPC 2 (%)	3 (3.4)	3 (3.5)	
CPC 3 (%)	2 (2.3)	2 (2.3)	
CPC 4 (%)	3 (3.4)	3 (3.5)	
CPC 5 (%)	76 (85.4)		
OPC 1 (%)	2 (2.3)	4 (4.7)	0.40
OPC 2 (%)	4 (4.5)	10 (11.6)	
OPC 3 (%)	4 (4.5)	4 (4.7)	
OPC 4 (%)	3 (3.4)	3 (3.5)	
OPC 5 (%)	76 (85.4)	65 (75.6)	

Manual chest compression vs use of an automated chest compression device during resuscitation following out-of-hospital cardiac arrest: a randomized trial.

Jama. Jun 14 2006;295(22):2620-2628.

Hallstrom A, Rea TD, Sayre MR, et al.

Table. Study Characteristics

Study Component	Hallstrom et al, 2006[12]	Ong et al, 2006[13]
Study design	Prospective, cluster randomized clinical trial	Retrospective, pre-post, observational study
Setting	EMS systems in 5 communities	Single EMS system
Primary population considered	Out-of-hospital cardiac arrest of presumed cardiac origin	Out-of-hospital cardiac arrest of presumed cardiac origin
Interventions	LDB-CPR vs manual CPR: "Quick look" rhythm check, then CPR with device applied when ready or manual CPR with randomization at first-shock evaluation	LDB-CPR vs manual CPR: Device applied "as early as possible" and CPR given before shock unless cardiac arrest witnessed
EMS response time (fire response or first vehicle)*	LDB-CPR, 5.6 min Manual CPR, 5.7 min	LDB-CPR, 4.6 min Manual CPR, 4.6 min
Mean time to LDB-CPR*	11.9 min	Not measured
Patients in VF/VT*	LDB-CPR, 31% Manual CPR, 32%	LDB-CPR, 24% Manual CPR, 21%
Time to first shock if VF/VT*	LDB-CPR, 11.8 min Manual CPR, 9.7 min	Not measured
Primary outcome*	Survival to 4 h: LDB-CPR, 26% Manual CPR, 25%	ROSC: LDB-CPR, 35% Manual CPR, 20%
Selected secondary outcomes*	Survival to hospital discharge: LDB-CPR, 6% Manual CPR, 10% Good neurological outcome (CPC score of 1 or 2): LDB-CPR, 3% Manual CPR, 8%	Survival to hospital discharge: LDB-CPR, 10% Manual CPR, 3% Good neurological outcome† (CPC score of 1 or 2): LDB-CPR, 6% Manual CPR, 2%
Primary analysis	Intention-to-treat, multivariable logistic regression modeling with clustering	Intention-to-treat, multivariable logistic regression modeling
Potential confounders	Unequal time to first shock for VF group, heterogeneity of treatment sites, interaction of treatment effect and response time, unknown quality of CPR, and potential for enrollment bias	Secular trends in outcomes, unequal advanced life support response times, unequal fraction witnessed arrests, unknown quality of manual CPR, and introduction of postresuscitation hypothermia

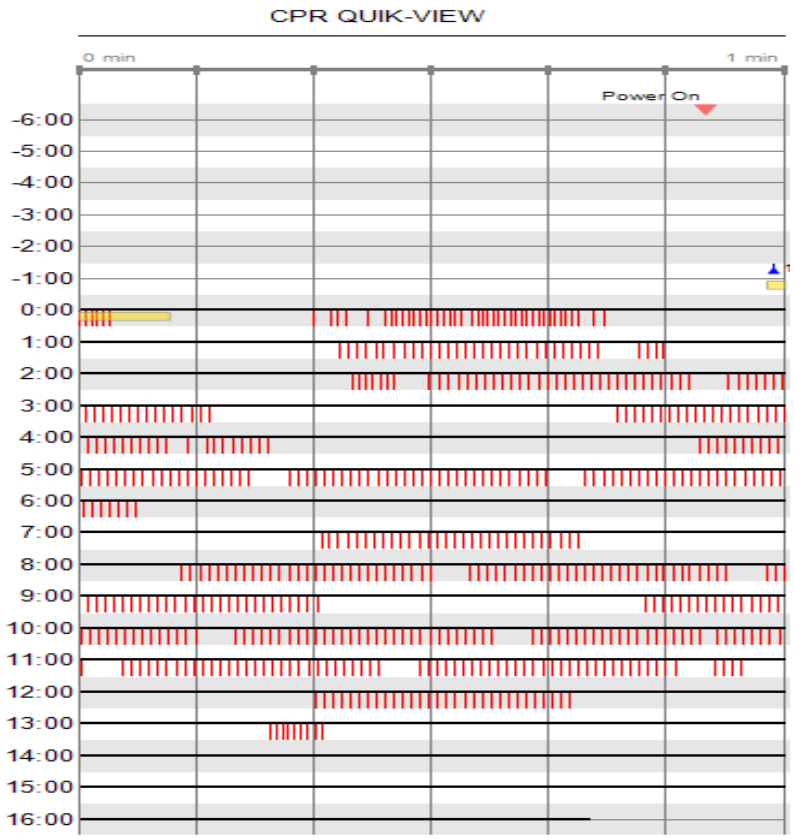
Reconciling the results

Device should not be seen as the ‘miracle’ solution to cardiac arrest

Multiple factors will affect cardiac arrest outcomes

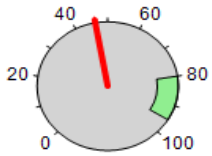
The AutoPulse™ should be seen as a possible new component of an overall resuscitation strategy

Challenge is to incorporate this in current treatment protocols seamlessly



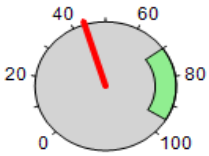
Interruptions to CPR during device deployment

CPR Ratio (/total time)



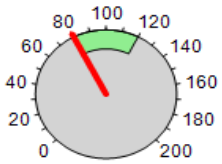
7:44 / 16:44 = 46 %

Compressions Ratio (/total time)



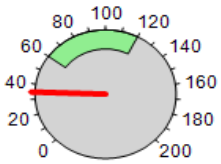
7:17 / 16:44 = 44 %

Compression Rate



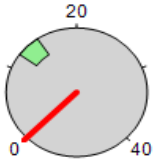
80/minute

Compressions/minute

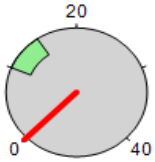


35/minute

Ventilation Rate



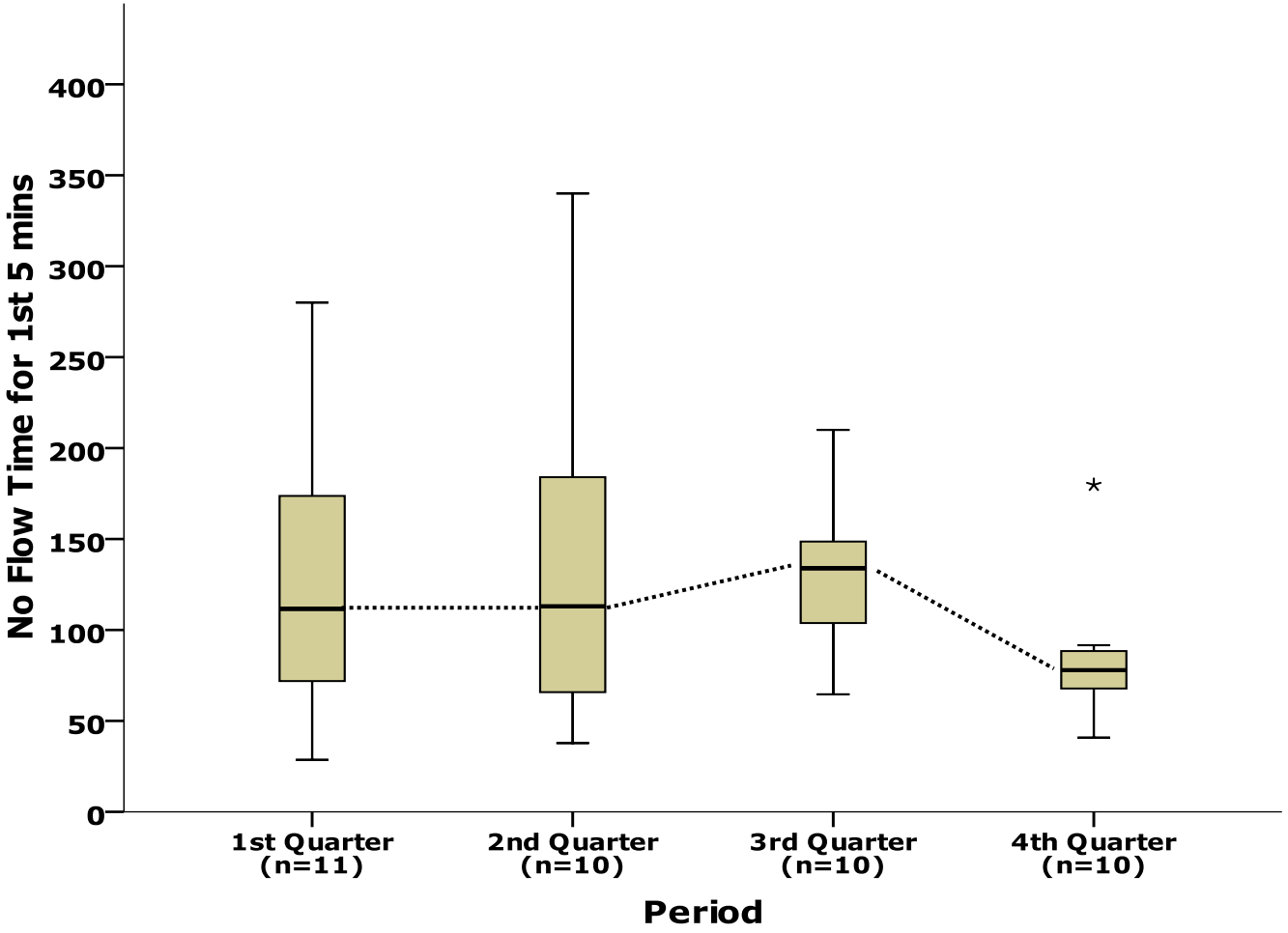
Ventilations/minute



Cardiopulmonary Resuscitation Interruptions with Use of a Load Distributing Band Device During Emergency Department Cardiac Arrest. Ann Emerg Med 2010 Sep; 56(3):233-241

Variables (n=52)	Manual CPR (n=23)	AutoPulse (n=29)	Difference	95% CI
NFT (0-5mins)	76.29 (39.92)	135.87 (75.60)	-59.58	(-92.95, -26.22)
NFR (0-5mins)	0.25 (0.13)	0.45 (0.25)	-0.20	(-0.31, -0.08)
NFT (5-10mins)	102.08 (67.36)	80.95 (44.87)	21.13	(-14.78, 57.05)
NFR (5-10mins)	0.34 (0.22)	0.27 (0.15)	0.07	(-0.05, 0.19)

Error bar of No Flow Time for 1st 5 mins of resuscitation over LDB phase of the study



Pit Crew Philosophy to Integration of AutoPulse™ into Resuscitation Protocol

- Efficient method of utilizing all available resources
- Each crew member has a defined role and position relative to patient.
- AutoPulse™ readied for application while manual compressions are being performed.

Use of an Automated, Load-Distributing Band Chest Compression Device for Cardiac Arrest Resuscitation : A Multi-Centre Clinical Trial

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Office of Clinical Sciences, Duke-NUS GMS

Results – Patients Demographics

Characteristics	*Manual CPR n=459 (%)*	*LDB-CPR n=552 (%)*	*p-value*
Mean Age (SD)	64.45 (15.8)	65.38 (15.5)	0.349
Male	311 (67.8)	361 (65.4)	0.429
Race			
Chinese	310 (57.5)	369 (66.9)	
Indian	49 (10.7)	54 (9.8)	0.461
Malay	79 (17.2)	91 (16.5)	
Others	21 (4.6)	38 (6.9)	
Medical history, n (%)			
No medical history	47 (10.2)	47 (8.5)	0.347
Heart disease	155 (33.8)	192 (34.9)	0.735
Diabetes	130 (28.3)	150 (27.2)	0.685
Hypertension	198 (43.1)	251 (45.5)	0.457
Stroke	42 (9.2)	38 (6.9)	0.184
Cancer	38 (8.3)	52 (9.4)	0.526
Respiratory disease	44 (9.6)	40 (7.3)	0.180
Renal disease	22 (4.8)	58 (10.5)	0.001
Other medical history	85 (18.5)	210 (38.0)	<0.001
Unknown medical history	81 (17.7)	103 (18.7)	0.678

Results – Patients Demographics

Characteristics	*Manual CPR n=459 (%)*	*LDB-CPR n=552 (%)*	*p-value*
Hospital			
Hospital A	186 (40.5)	293 (53.1)	<0.001
Hospital B	273 (59.5)	259 (46.9)	
Arrest location			
Prehospital	437 (95.2)	463 (83.9)	<0.001
ED	22 (4.8)	89 (16.1)	
Bystander witnessed	292 (63.6)	233 (42.2)	<0.001
EMS witnessed	41 (8.9)	23 (4.2)	0.002
Bystander CPR	110 (24.0)	50 (9.1)	<0.001
Initial rhythm			
Ventricular fibrillation	23 (5.0)	40 (7.3)	
Ventricular tachycardia	0 (0.0)	10 (1.8)	<0.001
Asystole	340 (74.0)	336 (60.9)	
Pulseless electrical activity	80 (17.4)	119 (21.6)	
Pre-hospital defibrillation	100 (21.8)	84 (15.2)	0.007
Defibrillated at ED	124 (27.0)	154 (27.9)	0.754
AutoPulse applied	-	454 (82.3)	<0.001

Results

Time of collapse to time arrived at ED

Phase (N = 600)	Mean (SD), min	IQR, min
Manual CPR (n = 392)	34:03 (16:59)	25:00, 43:00
LDB-CPR (n = 208)	33:18 (14:57)	25:00, 43:00

- Mean downtime is comparable in both phases.
- **INCLUDE** cases that are out-of-hospital arrest and **EXCLUDE** those that are in-hospital arrest.
- Collapsed downtime refers to time of collapse to time arrival at ED.

Results - Comparison of Clinical Outcomes

	Manual CPR n=459(%)	*LDB-CPR n=552(%)*	*Crude OR (95% CI)*	*Adjusted† OR (95% CI)*
Return of spontaneous circulation	103 (22.4)	195 (35.3)	1.89 (1.43,2.50)	1.60 (1.16, 2.22)
Survival to hospital admission	65 (14.2)	109 (19.8)	1.49 (1.07, 2.09)	1.23 (0.84, 1.81)
Survival to hospital discharge	6 (1.3)	18 (3.3)	2.55 (1.00, 6.47)	1.42 (0.47, 4.29)

† The model was adjusted for hospital, arrest location, bystander witnessed, EMS witnessed, initial rhythm, prehospital defibrillation and LDB-CPR applied.

Results - CPC/OPC of Survivors

Performance categories	*Manual CPR n=6 (%)*	*LDB-CPR n=16 (%)*	*p-value**
CPC 1	1 (16.7%)	12 (75%)	0.01
CPC 2	1 (16.7%)	1 (6.3%)	
CPC 3	4 (66.7%)	1 (6.3%)	
CPC 4	0 (0.00)	2 (12.5%)	
OPC 1	1 (16.7%)	10 (62.5%)	0.06
OPC 2	1 (16.7%)	2 (12.5%)	
OPC 3	4 (66.7%)	2 (12.5%)	
OPC 4	0 (0.00)	2 (12.5%)	

* Fisher's exact test was used to compare percentages
CPC= Cerebral Performance Category; OPC= Overall Performance Category

Conclusion

A resuscitation strategy using LDB-CPR in an ED environment was associated with improved neurologically intact survival to discharge in adults with non-traumatic cardiac arrest, in a setting with long arrest times.

A Multicenter Randomised Controlled Trial Comparing Shock Success With Synchronized Defibrillation (Compression Upstroke Versus Precompression) During Ongoing Mechanical Cardiopulmonary Resuscitation In The Emergency Department

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Overview

Objective

•To compare shock success during defibrillation synchronized with the upstroke of chest compression (peak upstroke), and precompression (control)

Primary Outcomes:

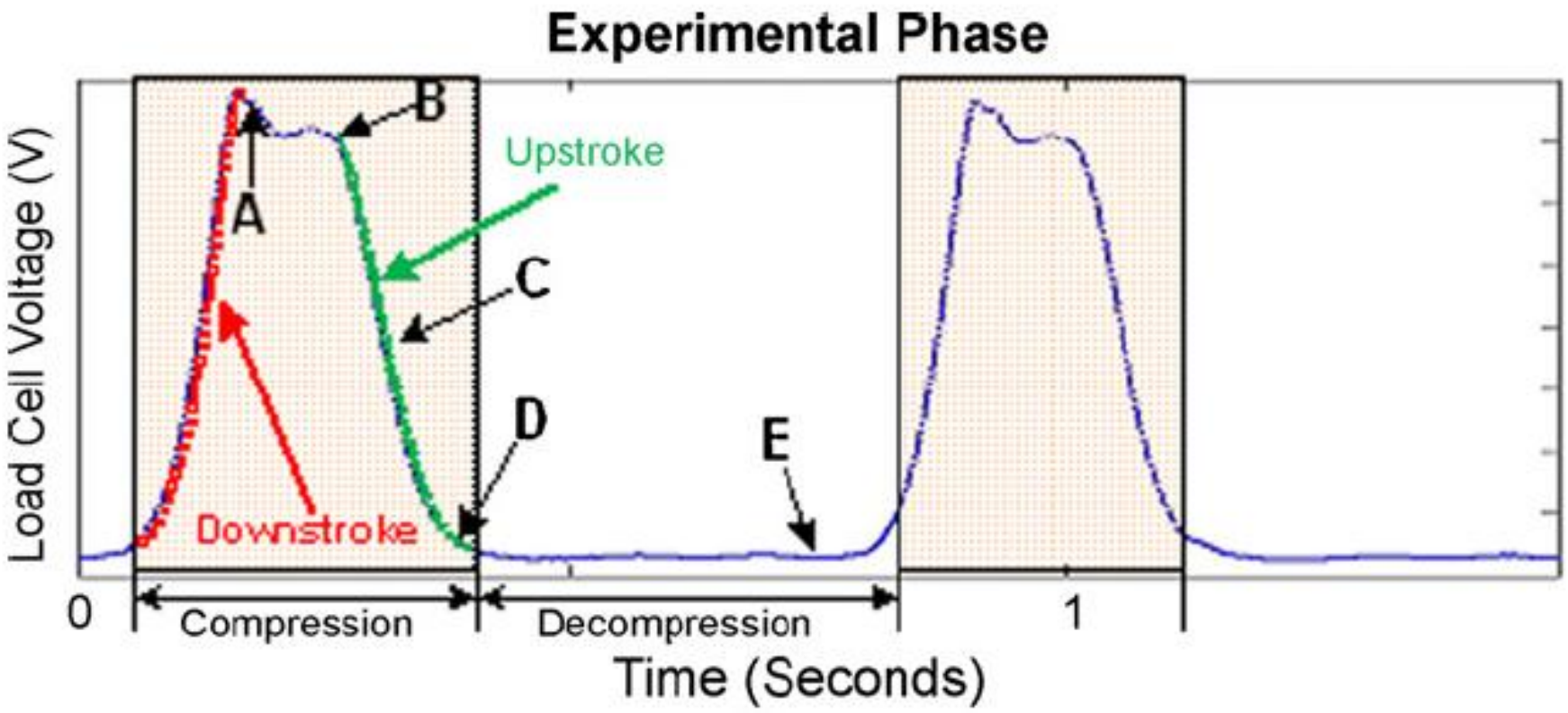
•Shock success defined as the termination of VF or pulseless VT and establishment of organised rhythm within 60 sec and requires at least 2 QRS complexes separated by no more than 5 sec

Second Outcomes:

•Termination of VF for at least 5 sec after the shock, regardless of the resulting rhythm

•ROSC
•Survival to hospital admission
•Survival to hospital discharge
•Glasgow Outcomes Score (CPC/OPC)
•European Quality of Life in 5 Dimensions (EQ-5D)

Synchronized Shocking Phases



Li Y YT, Ristagno G, Chung SP, Bisera J, Quan W, Freeman G, Weil MH, Tang W. The optimal phasic relationship between synchronized shock and mechanical chest compressions. *Resuscitation*. 2010;81(6):724-729.

Synchronized Shock Phases

Primary experiment results.

Parameters	Control	Experimental phases				
		Phase A	Phase B	Phase C	Phase D	Phase E
Success rate (%)	44.4	52.8	59.7	63.9*	68.1**	41.7
CPP (mm Hg)	27.9 ± 10.6 (25.4–30.4)	27.3 ± 10.6 (24.8–29.8)	28.0 ± 10.6 (25.5–30.5)	27.7 ± 10.1 (25.3–30.1)	28.2 ± 10.5 (25.7–30.7)	27.5 ± 10.3 (25.1–29.9)
Energy (J)	55.4 ± 11.9 (52.6–58.2)	55.8 ± 12.5 (52.9–58.7)	55.9 ± 11.8 (53.1–58.7)	56.3 ± 12.1 (53.5–59.1)	55.3 ± 12.0 (52.5–58.1)	55.4 ± 11.9 (52.6–58.2)
Peak voltage (V)	501 ± 65 (486–516)	515 ± 69 (499–531)	515 ± 66 (499–531)	514 ± 66 (498–530)	502 ± 67 (486–518)	502 ± 66 (486–518)
Peak current (A)	13.8 ± 1.6 (13.4–14.2)	13.5 ± 1.6 (13.1–13.9)	13.5 ± 1.6 (13.1–13.9)	13.5 ± 1.6 (13.1–13.9)	13.8 ± 1.6 (13.4–14.2)	13.8 ± 1.6 (13.4–14.2)
Impedance (Ω)	36.5 ± 3.7 (35.6–37.4)	38.2 ± 4.3* (37.2–39.2)	38.3 ± 4.1** (37.3–39.3)	38.2 ± 4.1* (37.2–39.2)	36.5 ± 4.2 (35.5–37.5)	36.6 ± 3.9 (35.7–37.5)
DFT (J)	65.2 ± 6.6 (63.6–66.8)	63.9 ± 9.0 (61.8–66.0)	59.7 ± 8.1 (57.8–61.2)	59.1 ± 6.8 (57.5–60.7)	57.7 ± 8.9* (55.6–59.8)	67.6 ± 6.7 (66.0–69.2)

72 shocks were applied to each phase.

* Compared with control, $p < 0.05$.

** Compared with control, $p < 0.01$.

Li Y YT, Ristagno G, Chung SP, Bisera J, Quan W, Freeman G, Weil MH, Tang W. The optimal phasic relationship between synchronized shock and mechanical chest compressions. *Resuscitation*. 2010;81(6):724-729.

Learning points

- Clinical trials in emergency situations
- Importance of device training and quality of implementation
- Co-ordination of multi-site trials (eg battery maintenance issues)
- PI initiated, industry supported trials
- Intellectual property and clinical trials agreements