

2020 BROWARD COUNTY EMS GRANT APPLICATION

"Funding to improve or expand prehospital EMS Systems"

Section I

1. Project Title: AMR Cardiac Arrest Patient Outcome Improvement

Is this a pilot project? [ ] Yes [x] No

2. Project Cost \$: 27,666.00

3. Agency Name: American Medical Response

Address: 2500 NW 29th Manor Pompano Beach, Fla

Telephone: 561-248-2331 Fax: 561-588-5199

4. Project Manager: The individual with direct knowledge of project and responsible for project implementation.

Name: Brooke Liddle

Telephone: 561-248-2331 Email: brooke.liddle@amr.net

5. Authorized Signatory: The individual authorized to sign the application on behalf of the agency or entity.

Name of Signatory: Brooke Liddle

Title of Signatory: Chief of Operations

6. Projects Impacting Direct Services to Emergency Victims: This may include, but is not limited to: vehicles, medical and rescue equipment, communications, dispatch, navigation, and other equipment that impacts on-site treatment. (Countywide projects must offer participation to all licensed EMS providers, based upon levels of service.) Attach Form A.

Countywide: [ ] Yes [ ] No

Multiple Agencies: [ ] Yes [x] No How Many? \_\_\_\_\_

Single Agency: [x] Yes [ ] No

7. Projects Impacting Indirect Services: Training of all types (public, first responders, law enforcement personnel, EMS personnel and other healthcare staff), research, and documentation. (Countywide projects must offer participation to all licensed EMS providers.) Attach Form A.

Countywide: [ ] Yes [ ] No

Multiple Agencies: [ ] Yes [x] No How Many? \_\_\_\_\_

Single Agency: [x] Yes [ ] No

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**8. Problem/Unmet Need Description:** Provide a narrative of the problem or need and the population affected by describing the present situation and management (if any) and the potential adverse consequences if not addressed.

AMR provides medical rescue services, to the seaside Town of Lauderdale-by-the-Sea, Florida, in Broward County, with an approximate population of 13,000 residents. The beach areas, often experience rip tides that can facilitate swimmer distress and result in saltwater drownings, multiple times per year. Once the victim is removed from the water, AMR responders begin resuscitation efforts on the beach, using manual chest compressions. The victim is "packaged" and carried by EMS personnel off the beach, to a waiting ALS transport ambulance. CPR compressions, are interrupted during that time. With the application of an ACCD, chest compression would be uninterrupted.

In addition, AMR responds to, treats and transports approximately thirty(30) cardiac arrest patients per year, in Lauderdale-by-the Sea. Manual resuscitation efforts, are afforded for those patients as well.

AMR has carefully evaluated our EMS operations with the goal of identifying ways to improve the level of service and patient outcome. We have determined that the purchase of Automated Chest Compression Devices (ACCDs) would enhance current treatment modalities and improve patient outcomes.

- The chest compression device performs 100 plus compressions per minute with a depth of 2 inches with the same efficiency for all patients.
- The device allows for complete chest wall recoil after each compression and provides a 50% duty cycle, which allows for equal compression and relaxation time for the chest wall.
- Improving blood flow during mechanical chest compressions will help the medic to establish an intravenous line due to the inflation of the veins making it easier for the ambulance personnel to find a vein to start the line and administer appropriate drug therapies.
- Using the device will reduce the stress and strain on the responding medics and make the transport safer as the medic can be seated to perform treatment instead of standing over the patient.
- The device provides compliant chest compressions that can be initiated within less than 20 seconds and that sustain adequate circulation and allow for continued PCI to treat the cause of the arrest, or as a bridge for other circulatory support devices such as ECMO.

(See attachment: Clinical Research Update)

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**9. EMS Improvement and Expansion to Resolve Problem or Address Needs:**

Describe proposed solutions to the problem and/or need (question #8 – problem description). State the improvements that are reasonably foreseeable and measurable. Use data, scientific, or anecdotal information to support the agency's request. Explain how the project will improve and/or expand prehospital EMS in Broward County. Be specific.

Studies have proven that the use of ACCDs is safe, effective and highly reliable. ACCDs are designed to ensure effective, quality compression will be delivered. An ACCD helps to minimize pauses during CPR as compressions can continue while other procedures, e.g. defibrillation, are being done. Consistent cardiac compression profoundly increases the chance of return of spontaneous circulation (ROSC). In addition, in the event that a life is lost, a patient's organs will be more viable for transplant due to adequate tissue perfusion.

The citizens we serve will benefit from more consistent and effective compressions, always 2 inches in depth, at a rate of at least 100 beats per minute, with full recoil of the chest and fewer interruptions, leading to increased survival. The effectiveness of emergency crews will be improved as the use of an ACCD relieves one rescuer from performing manual chest compressions allowing him/her to perform other critical tasks .

(See attachment: Rescuer Fatigue With CPR)

In the event that AMR does not receive funding to purchase ACCDs, patients suffering cardiac arrest will continue to receive limited care. We will continue with our current practice of manual chest compressions with its limitations – minimal blood circulation, interruptions in compressions to move patients, rib injuries and compromised safety.

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<p><b>10. Measurable Outcomes:</b> Outcomes should be viewed from the perspective of the project and provide for: improved conditions/service - for patients as well as EMS personnel; expanded services; new knowledge; or improved knowledge. <b>Outcomes must be measurable and attainable. (Attach additional pages, as needed.)</b></p>	
<b>A. Project</b>	AMR Cardiac Arrest Patient Outcome Improvement
<b>B. Activities</b>	Continuing compliant CPR, while minimizing rescuer fatigue and reducing risk of injury
<b>C. Outcomes</b>	Return of spontaneous circulation, survival rates and rescuer injury
<b>D. Indicators</b>	Real-time monitoring of pulse, respirations, EKG, level-of consciousness and rate/depth of chest compressions  Post resuscitation outcomes
<b>E. Data Source</b>	EMS documentation via Electronic Patient Care Reports. Hospital patient outcome reports
<b>F. Data Collection Method</b>	QA review of Patient Care Reports and hospital patient outcome reports



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**11. Project Schedule:** Please complete the table below. Insert additional rows if needed.

Months after Grant is Executed	Activity
One	Order 2 ACCDs
Two	Implement and complete training
Three	Place devices in service

**12. Supporting Research or Literature?**  Yes (Attachment A)  No  
 (Required if this is a Pilot Project.)

**13. Letters of Support or Reference?**  Yes (Attachment B)  No

**14. Budget:** Do not use brand names when listing items. Use only generic names. Round up/down to the nearest dollar. Please use the table below. Insert additional rows if needed. Do not include extended warranties.

Item	Unit Cost	Quantity	Total
Automated Chest Compression Device	\$13,833.00	2	\$27,666.00
Delivery charges, if any			
<b>Total</b>			\$27,666.00

**15. Future Expenses:** Estimate the maintenance or other required recurring expenses per unit after the first grant year (if applicable). Note: No funding will be provided for these expenses under this grant program and must be absorbed by the grant recipient(s). Discuss this issue with your agency as it may affect its budget.

Items	Cost
Stabilization straps (30)	\$2,910.00
Suction Cups 3-pack (10)	\$1,480.00
Maintenance per year	\$1,404.00

**Grant monies cannot be used to replace existing equipment.**

**BL**

Initials of authorized signatory acknowledging the individual understands this statement.

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16. **Medical Director Approval:** For all projects requiring approval from the agency's Medical Director in accordance with Chapter 401, Florida Statutes, or Chapter 64J-1, Florida Administrative Code.

**The undersigned, as Medical Director for this agency, supports and approves this project.**

Signature: Joe Nelson, DO, MS, FACOEP, FACEP  
Digitally signed by Joe Nelson, DO, MS, FACOEP, FACEP  
DN: cn=Joe Nelson, DO, MS, FACOEP, FACEP, o=ourEmergency  
Medical Services, email=jnmsn@aol.com, c=US  
Date: 2019.09.19 13:21:50 -0400

Date: 9-19-19

Printed Name: Joe Nelson, DO

17. **Partial Funding:** Will the agency accept partial funding?  
(Note: If the agency is awarded partial funding, an amendment to the outcomes and budget forms must be submitted).

Yes, the agency will accept partial funding

No, the agency will not accept partial funding

Signature: Brooke Liddle  
Digitally signed by Brooke Liddle  
Date: 2019.09.19 13:36:35 -04'00'  
(Authorized Signatory)

Printed Name: Brooke Liddle

**AGENCY NAME:** American Medical Response

**AUTHORIZED SIGNATORY:** Brooke Liddle

**DATE:** 09/19/2019

**PRINT AUTHORIZED SIGNATORY NAME:** Brooke Liddle

**TITLE:** Chief of Operations

**PROJECT MANAGER'S SIGNATURE:** Brooke Liddle  
Digitally signed by Brooke Liddle  
Date: 2019.09.19 13:37:28 -04'00'

**PRINT PROJECT MANAGER'S NAME:** Brooke Liddle

**TITLE:** Chief of Operations

**TELEPHONE:** 561-248-2331

**EMAIL:** brooke.liddle@amr.net

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**If this is a Single Agency Project, this is the last page of the application.**

**If this is a Multiple Agency/Countywide Project (excluding Countywide training projects), please continue by completing the Participating Agency Summary Sheet (Form A) and Section II for each Participating Agency.**

**Grant Application Submission Deadline:**

**TBD**

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**SECTION II**  
**(Complete for ALL "Multiple Agencies" or "Countywide" Projects,**  
**EXCLUDING Countywide Training Projects)**

**Does your agency desire to participate in the grant project?**

If No, ignore the remaining questions and return the form to the Project Manager (GRANTEE).

\_\_\_\_\_  
**Initials of authorized signatory for Participating Agency**

If Yes, complete remaining items and return to:

Project Manager (name) \_\_\_\_\_

The undersigned Participating Agency \_\_\_\_\_  
(Agency name)

agrees to enter into an ADDENDUM TO BROWARD COUNTY EMS GRANT FUNDING AGREEMENT and acknowledges that it has joined in with the \_\_\_\_\_ (GRANTEE) on a Project Application for

(Project Title and Summary) \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

as part of the BROWARD COUNTY EMS GRANT FUNDING. The Participating Agency acknowledges that, to be included as a Participating Agency under the agreement between BROWARD COUNTY and GRANTEE for BROWARD COUNTY EMS GRANT FUNDING ("Agreement"), it will be required to agree to the terms and conditions for the funding.

**1. Medical Director Approval:**

For projects requiring approval from the agency's Medical Director in accordance with Chapter 401, Florida Statutes, or Chapter 64J-1, Florida Administrative Code, the agency's Medical Director must complete the following:

**As Medical Director for above Participating Agency, I support and approve this project.**

**AUTHORIZED SIGNATURE:** \_\_\_\_\_

**PRINT NAME:** \_\_\_\_\_

**DATE:** \_\_\_\_\_

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**2. Recurring Expenses after the grant year:**

The estimate for maintenance or other required expenses per unit after the first grant year, if applicable, are listed below. These costs will be absorbed by the grant recipient(s) (including each Participating Agency) and not paid from grant funds.

Item \_\_\_\_\_ Cost \$ \_\_\_\_\_

\_\_\_\_\_ Initials of authorized signatory for \_\_\_\_\_  
(Participating Agency)

**3. State the number of items requested or Training Participants.** \_\_\_\_\_

**4. PARTICIPATING AGENCY AUTHORIZED SIGNATORY:**

\_\_\_\_\_  
DATE:

PRINT NAME: \_\_\_\_\_

TITLE: \_\_\_\_\_

**5. PARTICIPATING AGENCY PROJECT LEADER SIGNATURE:**

\_\_\_\_\_  
DATE:

PRINT NAME: \_\_\_\_\_

PARTICIPATING AGENCY PROJECT LEADER TITLE:

\_\_\_\_\_

EMAIL: \_\_\_\_\_

**6. PROJECT MANAGER (GRANTEE'S RESPONSIBLE AGENT) SIGNATURE:**

\_\_\_\_\_  
DATE:

PRINT NAME: \_\_\_\_\_

PROJECT MANAGER TITLE: \_\_\_\_\_

DATE: \_\_\_\_\_ TELEPHONE: \_\_\_\_\_

EMAIL: \_\_\_\_\_

## NEW LUCAS® 3

### Chest Compression System, version 3.1

## Data Sheet

### Setting the standard for mechanical CPR

We continue to innovate the LUCAS platform with Wi-Fi® connection to the LIFENET® System and integration into CODE-STAT™ Data Review Software. The new LUCAS 3, v3.1, allows for tailored rates to meet your protocols, alerts configured to improve compliance, Post-Event Reports to your inbox, and asset notifications by e-mail.



#### Device configuration via the LIFENET System

Wirelessly set device presets to align with your protocols

- Adjustable rate: 102, 111, 120 ± 2 compressions per minute – fixed or variable during operation
- Adjustable depth: 1.8 to 2.1 ± 0.1 inches/45 to 53 ± 2mm – fixed during operation
- Audible CPR timer: 1-15 minutes (in 1 minute increments)
- Adjustable ventilation alerts, pause length and count
- Auto-lowering of the piston (AutoFit or QuickFit)
- Pressure pad release to allow for chest rise during ventilation

#### Post-Event reporting

- Receive device Post-Event Report (PDF) via e-mail after device check-in over Wi-Fi
- Transmit reports wirelessly to any predetermined e-mail addresses (configurable in LIFENET)
- Integration with CODE-STAT 11\*

#### Asset management via LIFENET

- Asset dashboard for fleet status at latest device check-in
- Notifications of expiring and expired LUCAS batteries
- Notifications of upcoming or missed service

#### The world's most used mechanical CPR device

- Over 15 years of experience, over 24,000 devices deployed, and 200+ publications\*\*
- Unique device design: piston with suction cup designed to stabilize the compression point and follow the chest
- Used in the field all the way into the cardiac cath lab

#### Proven safe and effective, quick and easy

- Highest level of evidence showing safety and efficacy<sup>1</sup>
- Simple 1-2-3 step user interface
- Quick: A median 7 sec. interruption at transition from manual to mechanical CPR in clinical use<sup>2</sup>

#### Proven to perform. Reliably.

- Easy to maintain and own
- Compact and lightweight
- >99% operational reliability in clinical use<sup>1</sup>

\*Commercially available mid-2018

\*\*As of April 2018



## Specifications

### Device and Therapy

#### Type of chest compression

- Piston with suction cup designed to stabilize the compression point
- Factory default settings consistent with AHA and ERC Guidelines 2015

#### Compression rate

- Configurable to 102 – 111 – 120 compressions per minute, fixed, or variable during use
- Factory default setting: 102 ± 2 compressions per minute

#### Compression depth

- Configurable to a fixed value between 1.8 to 2.1 ± 0.1 inches / 45 to 53 ± 2 mm
- Factory default setting: 2.1 ± 0.1 inches / 53 ± 2 mm for nominal patients  
Note: 1.5 to 2.1 inches / 40 to 53 mm for chest height < 7.3 inches / 185 mm

#### Pressure pad during ventilation

- To allow for chest rise during ventilation the pressure pad can be configured to move up 0.4 inch / 10 mm above start position during pauses or during continuous compressions
- Factory default setting: pressure pad remains in start position

#### Compression duty cycle: 50 ± 5%

#### Compression modes (operator selectable)

- ACTIVE 30:2 mode: 30:2 (factory default setting) or 50:2 (setup option) compression to ventilation ratio
- ACTIVE Continuous mode

#### Ventilation alerts

- ACTIVE 30:2 mode: LED blinks and audible alert signals before ventilation pause
- ACTIVE Continuous mode: LED blink. Configurable to 6 to 10 alerts per minute (factory default setting: 10 alerts per minute). Audible alert configurable ON/OFF (factory default setting: OFF)

#### Ventilation pause duration

- ACTIVE 30:2 mode: configurable to 3 to 5 sec. (factory default setting: 3 sec.)
- ACTIVE Continuous mode: configurable to 0.3 to 2 sec. (factory default setting: 0.3 sec.)

### Device and Therapy (cont.)

#### Suction cup start position

- Configurable:
  - QuickFit (factory default setting): Manual lowering of the suction cup. Automatic fine-tuning will occur when locking the start position
  - AutoFit: Automatic lowering of the suction cup from its upper position down to the chest
  - Manual: Manual lowering of the suction cup to the chest. No automatic fine-tuning will occur when locking the start position

**Suction cup in ADJUST mode:** The device can be setup so that the suction cup automatically returns up from the chest when the operator pushes the ADJUST key coming from PAUSE or ACTIVE (30:2 or Continuous) modes (factory default setting: OFF)

#### Audible timers

- 1 to 15 minutes, in 1 minute increments (factory default setting: OFF)
- The timer can be setup as either CPR Timer or Continuous Timer
  - CPR Timer: the device only measures the time in uninterrupted ACTIVE (30:2 or Continuous) modes
  - Continuous Timer: the device measures the time continuously, independent of what mode the device is in

#### Safety system controls

- Automatic self-test at each Power ON
- Advanced control of delivered compression depth, rate and duty cycle, with safety alarm
- Soft Start at beginning of compressions
- Automatic adjustment of compression force to reach the set compression depth in individual chests

#### Patients eligible for treatment

- 6.7 to 11.9 inches / 17.0 to 30.3 cm chest height
- 17.7 inches / 44.9 cm maximum chest width
- No patient weight limitation

### Device post-event data and connectivity

#### Connectivity

- Wireless connectivity: Device can communicate via Bluetooth™ (factory default setting ON) and connect to configured Wi-Fi networks to receive and transmit data when not in clinical use.
- Local Bluetooth connection for setting up local Wi-Fi network, and for Post-Event Report generation and software updates (if Wi-Fi cannot be used)
- Ability to disable Bluetooth and/or Wi-Fi

#### Wi-Fi and LIFENET capabilities

- Manual or automatic data transmission (configurable): push the TRANSMIT key in range of known network (factory default setting), or setup option for automatic data transmission whenever the device is off, charging and in range of known network
- Setup options: Device functionality can be configured with setup options via secure, online platform (LIFENET) and be transmitted to the device wirelessly. A single setup profile can be applied to entire fleet or individual setup options for each device
- Post-Event Reports: Device can transmit Post-Event Reports (PDF) wirelessly and send to any predetermined e-mail addresses.
- Device readiness status: Device can transmit device readiness and battery notifications wirelessly to any predetermined e-mail addresses

**Post-Event Report contents:** Easy to read Post-Event Report (PDF) showing:

- Summary of device use: compression time, ratio, rate, count, number of pauses > 10 sec. and duration of longest compression pause
- Visual timeline showing device compressions, rate and pauses
- Event log showing user interactions, battery alerts and alarms
- Full display of device setup for quick reference
- Comprehensive post-event review in CODE-STAT 11 Data Review Software (optional)



## Device post-event data and connectivity (cont.)

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**Device readiness data:** Configurable in LIFENET to send e-mail notifications on latest device check-in status including:

- Battery nearing expiration
- Battery expired
- Failed device self-test

### Reporting software over Bluetooth

- Report Generator software (DTX, included with device purchase for download online) with ability to download, print, save and share device reports of each use (PDF format)
- The Report Generator (DTX) can be downloaded on a pc with Windows® 7, 8.1 or 10

**Device data storage:** 4GB (estimated to store more than two uses per day over the lifetime of the device, 8 years)

## Device physical specifications

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**Device dimensions when assembled (HxWxD):** 22.0 x 20.5 x 9.4 inches / 56 x 52 x 24 cm

**Device dimensions while stored in carrying case (HxWxD):** 22.8 x 13.0 x 10.2 inches / 58 x 33 x 26 cm

**Battery dimensions (HxWxD):** 5.1 x 3.5 x 2.2 inches / 13.0 x 8.8 x 5.7 cm

**Weight of the device with Battery (no straps):** 17.7 lbs / 8.0 kg

**Battery weight:** 1.3 lbs / 0.6 kg

**Back plate:** Thin and lightweight back plate (0.6 inches / 15mm and 2.5 lbs / 1.1 kg)

## Device environmental specifications

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### Operating temperature

- +32°F to +104°F / +0°C to +40°C
- -4°F / -20°C for 1 hour after storage at room temperature

**Storage temperature:** -4°F to +158°F / -20°C to +70°C

**Relative humidity:** 5% to 98%, non-condensing

**Device IP classification (IEC60529):** IP43

**Operating input voltage:** 12-28 V DC

**Atmospheric pressure:** 62-107 kPa -1253 to 13000 ft (-382 to 4000 m)

## Power specifications

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**Power source:** Proprietary battery alone or with external power supply or car power cable

**Power supply input:** 100-240VAC, 50/60Hz, 2.3A, Class II

**Power supply output:** 24VDC, 4.2A

**Car power cable:** 12-28VDC/0-10A

**Battery type:** Rechargeable Lithium-ion Polymer (LiPo)

**Battery capacity:** 3300 mAh (typical), 86 Wh

**Battery voltage (nominal):** 25.9 V

**Battery run time (nominal patient):** Battery run time 45 minutes (typical) Extended run time connecting to external power supply

## Power specifications (cont.)

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### Maximum Battery charge time:

Charged in the device using external power supply:

- Less than two hours at room temperature (+72°F / +22°C)

Charged in the external battery charger:

- Less than four hours at room temperature (+72°F / +22°C)

### Battery service life (interval for recommended replacement)

- Recommendation to replace the battery every 3 to 4 years or after 200 uses (of more than 10 minutes each time)
- End of Battery service life will be indicated by a constant yellow LED to the far right on the Battery charge indicator

**Battery IP classification (IEC60529):** IP44

### Battery charge temperature

- +32°F to +104°F / +0°C to +40°C
- (+68°F to +77°F / +20°C to +25°C preferred)

### Battery storage temperature

- -4°F to +104°F / -20°C to +40°C
- +105°F to +158°F / +41°C to +70°C ambient for less than a month

## Annotated Bibliography: Rescuer Fatigue with CPR

### OVERVIEW

Multiple studies demonstrate rescuer fatigue can affect chest compression quality and that the rescuer does not recognize when fatigue CPR affects performance.

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*Hightower D, Thomas S, Stone CK, Dunn K, March, J. "Decay in quality of closed-chest compressions over time." Ann Emerg Medicine. 1995;26:300-303.*

The ability of healthcare providers to provide adequate chest compressions deteriorates significantly after a brief period of time (one minute). They generally cannot perceive the onset of compression impairment related to fatigue. This study was done on manikins using a 15/2 compression/ventilation ratio.

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*Ochoa FJ, Ramalle-Gomara E, Lisa V, Saralegui I. "The effect of rescuer fatigue on the quality of chest compressions." Resuscitation. 1998;37:149-152.*

This study, also performed on manikins, confirmed the findings of Hightower, et al: Quality of CPR declined significantly after one minute. Time to reported fatigue was about 3 minutes. Profession, gender, weight and height did not influence the quality of compressions or the capacity to notice when fatigue affects rescuer. This study was done using a 15/2 compression/ventilation ratio.

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*Greingor JL. "Quality of cardiac massage with ratio compression-ventilation 5/1 and 15/2." Resuscitation. 2002;55:263-267.*

The quality of CPR provided by healthcare providers declined significantly after the first minute with a 15/2 ratio compared with 5/1 ratio. This suggests that CPR with a higher compression/ventilation ratio is more tiring. Insufficient compression depth was the most frequent error in both ratios. This study was done using manikins.

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*Ashton A, McCluskey A, Gwinnutt CL, Keenan AM. "Effect of rescuer fatigue on performance of continuous external chest compressions over 3 min." Resuscitation. 2002;55:151-155.*

Healthcare providers performed two consecutive 3-minute periods of continuous compressions separated by a 30-second time interval on manikins. The total number of compressions was maintained (100/min) over both periods of CPR, but the number of satisfactory chest compressions performed decreased to 82 the first minute to only 27 by the sixth minute. Seven subjects were unable to complete a second 3-minute interval due to exhaustion.

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*Wik L, Kramer-Johansen J, Mykelbust H, et al. "Quality of cardiopulmonary resuscitation during out-of-hospital cardiac arrest." JAMA. 2005;293:363-365.*

Measured quality of CPR performed by ambulance personnel on patients in cardiac arrest to assess adherence to 2000 CPR guidelines (15:2 ratio). Only 28% of compressions met the guidelines for depth; most compressions were too shallow.

(over)

The compression part of the duty cycle was 42% instead of the recommended 50%. Chest compressions were not given 38% of the time.

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*Abella BS, Alvarado JP, Mykelbust H, et al. "Quality of cardiopulmonary resuscitation during in-hospital cardiac arrest." JAMA. 2005;293:305-310.*

The quality of CPR was inconsistent and often did not meet CPR Guidelines (2000), even when performed by well-trained hospital staff on patients in cardiac arrest. Chest compression rates were less, compression depth was too shallow, and ventilation rates were high.

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*Abella BS, Sandbo N, Vassilatos P, et al. "Chest compression rates during cardiopulmonary resuscitation are suboptimal: a prospective study during in-hospital cardiac arrest." Circulation. 2005;111:428-434.*

Chest compression rates provided by trained healthcare providers in the hospital setting were below the AHA Guidelines (2000) recommended rate and suboptimal compression rates correlated with poor return of spontaneous circulation.



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# Clinical Research Update

## Evidence-based use of mechanical CPR

### State of the science

Mechanical CPR (mCPR) is a rapidly evolving area of resuscitative science with a growing volume of published data comparing mCPR to manual CPR. Changes to clinical practice should be based on each study's level of evidence and awareness of common limitations associated with cardiac arrest studies focused on survival outcomes.

### Level of evidence

Some study designs have a higher level of scientific evidence than others. Prospective randomized controlled trials (RCT) provide the highest level of clinical evidence. Observational registry studies provide a lower level of evidence due to several known limitations.

Prospective randomized controlled study	Observational registry study
<b>Advantages</b> <ul style="list-style-type: none"> <li>Highest quality of evidence available<sup>1</sup></li> <li>Low potential for bias</li> <li>One treatment is directly compared to another</li> </ul>	<b>Advantages</b> <ul style="list-style-type: none"> <li>Low cost</li> <li>Easier to execute</li> <li>Can help with QA/QI and benchmarking</li> </ul>
<b>Limitations</b> <ul style="list-style-type: none"> <li>High cost</li> <li>Strict documentation of patient and treatment data</li> <li>Results may not be generalizable</li> </ul>	<b>Limitations</b> <ul style="list-style-type: none"> <li>Low to moderate quality of evidence</li> <li>Limited data and control of documentation<sup>1</sup></li> <li>High potential for bias</li> </ul>

While some observational registries indicate that the use of mCPR may result in worse survival outcomes than manual CPR<sup>2-6</sup>, large prospective RCTs, which provide a higher level of evidence, have shown that mCPR using the LUCAS device is equivalent to high-quality manual CPR.<sup>7</sup> RCT results should be taken with a higher priority than observational registry results.

### Bundled resuscitation treatments

- Resuscitations involve many combinations of treatments (e.g. mCPR, defibrillation, impedance threshold device, ACLS drugs, targeted temperature management, various ventilation methods).
- For an individual treatment to show a statistical benefit in survival, its contribution margin must be overwhelming.
- Even high level of evidence research is challenged by this.

### Missing clinical data

- Observational registries are often absent of crucial clinical information from resuscitation cases (e.g. CPR pause times, device application time, number of defibrillation shocks).
- These missing data points may also contribute to inconsistent outcome results.

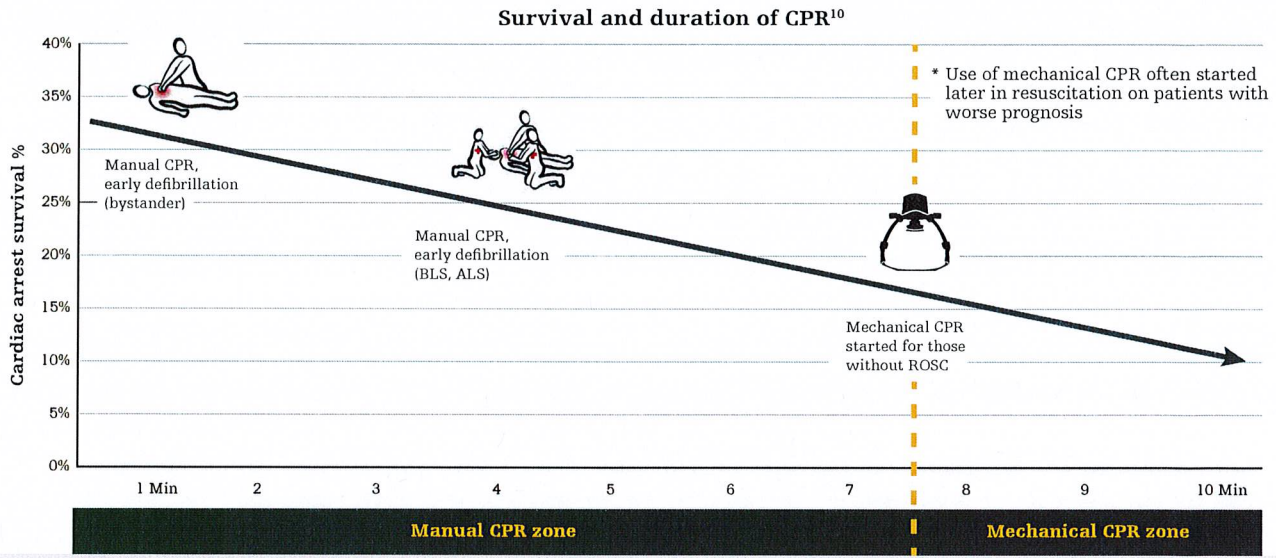
### Resuscitation time bias

The timing of interventions can also introduce “resuscitation time bias” in cardiac resuscitation studies.<sup>8</sup>

- Interventions given later in resuscitations (e.g. mCPR, epi) tend to be given to patients who are less likely to survive, with or without the intervention (Figure A).
- This can bias outcomes in favor of the non-intervention group. The early survivors will accrue into the non-intervention group, whereas the more difficult patients will transition into the intervention group.
- This makes it difficult to compare early interventions (e.g. manual CPR) with later interventions (e.g. mCPR) in non-randomized populations from registry data.



For survival outcome to be as good in patients receiving mCPR as in the patients who respond on manual CPR alone, mCPR would have to dramatically improve the chances of survival. Even if mCPR doubled survival, it would still appear inferior to manual CPR in observational registry data.<sup>9</sup>



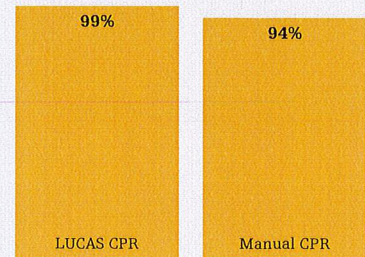
**Figure A.** Illustration showing the likelihood of survival from cardiac arrest declines over time. When mCPR is used, it's often late in resuscitation efforts on patients with worse prognosis of survival vs. the early survivors who only received manual CPR.

### LUCAS® Chest Compression System

Headlines in the scientific media and conclusion statements in published registries should be interpreted with caution. These can misrepresent the actual benefits of mCPR. In addition, RCTs should be prioritized over observational registries. The LINC trial is an RCT that represents the best available level of evidence for use of LUCAS.<sup>7</sup> These results demonstrated that:

- LUCAS was safe and effective
- survival in the LUCAS group was equivalent to high quality manual CPR
- among survivors, six-month neurological outcomes in the LUCAS group trended slightly better vs. manual CPR\*

\*Among survivors, good neurological outcomes at 6 month (GPC of 1-2)



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## LUCAS<sup>®</sup> CHEST COMPRESSION SYSTEM

### Selected Bibliography Summaries

April 2016

#### Prehospital Studies

##### Studies with Control Groups

Rubertsson S, Lindgren E, Smekal D, et al. Per-protocol and pre-defined population analysis of the LINC study. *Resuscitation*. 2015;96:92-99. This study performed two pre-defined sub-group analyses within the large randomized controlled European LINC trial to evaluate if the results supported the previously reported intention to treat (ITT) analysis; the rationale being to see if results were consistent when excluding possible protocol violations and factors with estimated dismal influence on both treatment interventions tested in the randomized ITT groups (n = 2589). These sub-groups were predefined in an effort to reduce bias and the negative effects of subgroup analyses decided upon after the completion of the study. The pre-protocol group (n = 2370) excluded patients that violated the inclusion/exclusion criteria or did not get the actual treatment to which they were randomized. The pre-defined group (n = 1133) excluded patients in which the time from dispatch to arrival at the scene exceeded 12 minutes, non-witnessed cardiac arrests and in cases where the LUCAS device was not immediately brought to the scene. Patient 4-hour survival was 23.8% in the mechanical-CPR group versus 23.5% in the manual-CPR group in the per-protocol population and 31% versus 33.9% in the pre-defined group. There was no difference in any of the second outcome variables analyzed. 6 month survival with CPC score 1 (best neurological outcome) was 8.3% in the mechanical CPR group vs. 6.8% in the manual CPR group (p = 0.19) in the per protocol population, and 12.2% vs. 10.3% (p = 0.35) in the predefined population, respectively. In summary, the results from these pre-defined sub-group analyses were consistent with the previously published ITT analysis.

Tranberg T, Lassen J, Kaltoft A, et al. Quality of cardiopulmonary resuscitation in out-of-hospital cardiac arrest before and after introduction of a mechanical chest compression device, LUCAS-2; a prospective, observational study. *Scand J Trauma Resusc Emerg Med*. 2015;23:37. This Danish study analyzed CPR quality metrics in 155 of 696 OHCA patients who were treated with manual compressions followed by LUCAS compressions treated between April 2011 to February 2013. CPR quality was evaluated using transthoracic impedance measurements collected by the LIFEPAK 12 defibrillator. Median total CPR duration was 21 min. In the cases with both manual and LUCAS CPR, the episode with the LUCAS compressions was significantly longer than the time with manual CPR (13 mins vs. 5 mins; p < 0.001), reflecting the LUCAS device being used in selected prolonged resuscitation attempts. The no-flow fraction was significantly lower during LUCAS CPR than during manual CPR (16% vs. 35%; p < 0.001). No differences were found in pre- and post-shock no-flow time throughout manual and LUCAS CPR. Contrary to manual CPR, the average compression rate with the LUCAS device was in conformity with the current Guidelines (102/min vs. 124/min, p < 0.001). The authors reported an overall 9% survival of the patients treated with the combination of the LUCAS device and manual CPR, which included six patients where PCI was performed during ongoing LUCAS CPR, and two patients who were taken into the hospital during ongoing LUCAS CPR and treated with cardiopulmonary support. The latter two were reported alive at 30 days follow up with minimal neurological sequelae. In summary, chest compressions provided by the LUCAS device improved CPR quality by significantly reducing the no-flow fraction and by improving the quality of chest compression compared with manual CPR during OHCA resuscitation.

Levy M, Yost D, Walker R, et al. A quality improvement initiative to optimize use of a mechanical chest compression device within a high-performance CPR approach to out-of-hospital cardiac arrest. *Resuscitation*. 2015;92:32-37.

This U.S. report describes a quality improvement initiative undertaken by the Anchorage Fire Department to reduce LUCAS device application time in OHCA patients and to optimize the overall CPR process. Updated high-performance CPR training was rolled out which included: lectures, online tests, mock drills and in-person debriefing and review of downloaded CPR data from defibrillator/monitors after each event. A protocol change was instituted to require completion of two full cycles of manual CPR before transition to mechanical CPR to ensure those patients with the potential for early ROSC received 4 min of minimally interrupted manual chest compressions before device application. A new LUCAS application method took advantage of existing protocol-specified CPR interruptions, to allow for placement of the device's back plate under the patient, and feeding



the device's support legs through the arms of the provider performing manual compressions without interfering with the continuity of manual compressions. Crews were instructed to immediately resume manual compressions upon experiencing any device difficulties. CODE-STAT™ CPR quality data from the year before (2012), during and after the initiative (2013) were evaluated. Compared to OHCA cases from 2012 (n = 61), median duration of the pause prior to first mechanical compression for cases from 2013 (n = 71) decreased from 21 to 7 sec (p < 0.001), while median chest compression fraction increased from 0.90 to 0.95 (p < 0.001). Median duration of the longest pause decreased from 25 to 13 sec (p < 0.001), while the proportion of cases where the longest pause was for mechanical CPR application decreased from 74% to 31% (p < 0.001). In summary, significant increases in compression fraction and significant decreases in duration of the longest pause strongly suggest a large improvement in LUCAS device application efficiency when implementing an overall high-performance CPR process.

Esibov A, Barville I, Chapman F, et al. Mechanical chest compressions improved aspects of CPR in the LINC trial. *Resuscitation*. 2015;91:116-121.

This analysis compared chest compression fraction (CCF) and perishock pauses in a subset of patients (N: 206) enrolled in two of the six sites of the European multicenter randomized controlled LINC trial comparing the LUCAS device vs. manual CPR in OHCA. Using electronic downloads of continuous ECG and impedance data from LIFEPAK 12 monitor defibrillators, the authors analyzed CCF over the first 10 min of recorded data as well as perishock pauses for shocks. The LUCAS device was applied and started within 5 min of the beginning of recorded signals in 89% of the LUCAS cases. Median CCF was 0.79 in the manual treatment group and 0.84 in the LUCAS treatment group (p < 0.001). Beginning with the minute following the LUCAS device deployment, the median CCF over the next 10 min was 0.91 in the LUCAS group. The median perishock pause was 10 sec for manual CPR and 0 sec when using the LUCAS device (p < 0.001). During LUCAS use, 70.9% of shocks were delivered without pausing compressions. In conclusion, good chest compression fractions were achieved in both groups, indicating high-quality CPR in both groups. Furthermore, patients treated with the LUCAS protocol had a significantly higher CCF, and shorter perishock pauses, compared to patients treated with conventional CPR.

Kamrud J, Boland L, Frazee C, et al. Use of transthoracic impedance data to evaluate intra-arrest chest compression quality before and after placement of a mechanical chest compression system. *Prehosp Emerg Care*. 2015;19(1):Abstract 131.

This U.S. retrospective analysis was conducted in all OHCA patients treated with the LUCAS device by a single ambulance service in Minnesota in 2013. Transthoracic impedance (TTI) data from 269 events obtained from CODESTAT data review software were used to compare chest compression quality metrics between the manual vs mechanical compression phases. The mean (range) duration of the manual phases was 3:37 min. and 23:39 min. for the mechanical phases. Mean compression fraction was significantly higher during mechanical versus manual compressions (89% vs 75%; p<0.0001). Compression rate was also better aligned with the recommended 100 compressions/min during mechanical compressions, with mean compression rates of 102/min and 121/min (p<0.0001) in the mechanical and manual phases, respectively. On average, the first mechanical compression was delivered 4 min 15 sec after the start of TTI recording, with a median device application pause of 26 sec. In summary, these data demonstrate the use of a mechanical chest compression device can improve compression fraction and increase compliance with compression rate guidelines. Based on these findings, this system will emphasize earlier device placement with minimal pauses for application.

Perkins G, Lall R, Quinn T, et al. Mechanical versus manual chest compression for out-of-hospital cardiac arrest (PARAMEDIC): a pragmatic, cluster randomised controlled trial. *Lancet*. 2015;385(9972):947-955.

This large cluster randomized prehospital UK study examined whether the "pragmatic" introduction of the LUCAS 2 device into front-line emergency response vehicles would improve OHCA survival compared to conventional manual CPR. The study was conducted from April 15, 2010 to June 10, 2013 at four UK ambulance services. Clusters consisted of ambulance service vehicles, which were randomly assigned (1:2) to use the LUCAS device or to perform manual compressions, meaning every third vehicle carried a LUCAS device. Patients received manual (N: 2819) or LUCAS CPR (N: 1652) according to the first trial vehicle to arrive on scene. In the LUCAS group, 60% of patients actually received mechanical chest compression, the rest got manual CPR. The primary endpoint, thirty-day survival, was similar between the LUCAS treatment group (6%) and in the manual CPR group (7%) (adjusted odds ratio 0.86, 95% CI 0.64-1.15). No serious adverse events were noted in any of the groups. In the LUCAS group three patients had chest bruising, two had chest lacerations, and two had blood in mouth. Fifteen device incidents occurred during operational use. In summary, there was no evidence of improvement in 30-day survival with LUCAS 2 device compared with manual compressions, but it was noted that actual use of the LUCAS device in the LUCAS group was low.

Villadiego Sanchez J, Borja Padilla J, del Valle Fernandez P, et al. Comparison of survival in cardiorespiratory arrest patients receiving conventional manual or external mechanical chest compression. *Resuscitation*. 2014;85S:S48. APO74.

This Spanish prospective observational cohort study from 2012 compared survival rates in 169 OHCA patients receiving manual CPR (N: 108) or LUCAS CPR (N: 61). Survival to hospital arrival was achieved in 29.5% of the LUCAS group vs. 24.1% of the manual CPR group (no significant differences). Survival to hospital discharge was achieved in 13.3% of the LUCAS group vs. 14.8% of the Manual CPR group (no significant differences). In summary, prehospital use of the LUCAS device did not result in statistically significant survival to hospital arrival or discharge in patients treated with automatic or manual CPR.



Rubertsson S, Lindgren E, Smekal D, et al. Mechanical chest compressions and simultaneous defibrillation vs conventional cardiopulmonary resuscitation in out-of-hospital cardiac arrest. The LINC randomized trial. *JAMA*. 2013;311(1):53-61.

This European large randomized control multicenter LINC trial hypothesized that a 3 minute algorithm of mechanical chest compressions delivered by the LUCAS device with defibrillation during ongoing chest compressions would improve 4-hour survival in patients as compared to guideline-based manual CPR in OHCA. From Jan. 2008 to Aug. 2012, 2,589 patients were randomized to either LUCAS CPR (N:1300) or manual CPR (N:1289) at six sites in Europe. Surviving patients were evaluated for neurological outcome using a CPC score 1-2 as good outcome. Survival at 4 hours was 23.6% with LUCAS CPR and 23.7% with manual CPR ( $p > .99$ ). Survival with good neurological outcome was 7.5% vs 6.4% at intensive care unit discharge, 8.3% vs 7.8%, at hospital discharge, 8.1% vs 7.3%, at 1 month, and in 8.5% vs 7.6% at 6 months with LUCAS CPR and Manual CPR, respectively, and without statistical significance. The proportion of survivors with CPC 1-2 in the LUCAS and manual CPR groups was 99% vs. 94% respectively at 6 months. The numbers of serious adverse events and device-related adverse events were low, the LUCAS device showed a high reliability of 99.4% during the four years the study was conducted. After randomization, 3.5% of the patients randomized to mechanical CPR did not fit the device; 2.3% were too big and 1.2% too small, suggesting the device can be expected to fit about 95% of cardiac arrest patients. In conclusion, there was no significant difference in 4-hour survival between patients treated with the LUCAS device and the 3 minute algorithm or those treated with guideline-adherent manual CPR. The vast majority of survivors in both groups had good neurological outcomes by 6 months.

Satterlee P, Boland L, Johnson P, et al. Implementation of a mechanical chest compression device as standard equipment in a large metropolitan ambulance service. *J Emerg Med*. 2013;45(4):562-569.

This U.S. retrospective OHCA case series describes the results after implementing the LUCAS device for routine use across a large ambulance service during the initial 2 years of use (during 2008-2010). 38 devices were deployed in a 70-vehicle, 400-provider ambulance service within 3 months in Minnesota. The LUCAS device was used in 85% (498 of the 572 cases where LUCAS usage data were available). Primary reasons for not using the LUCAS device were; short resuscitation times due to early ROSC or early declaration of death (8%), patient too large for the device (2.3%), patient too small for the device (0.9%). Overall ROSC rates were 35% of LUCAS-treated arrests and 41% of non-device-treated, respectively ( $p = 0.31$ ). When removing short resuscitation attempts of less than 5 min, ROSC rates were 26% among LUCAS-treated arrests and 24% among non-device treated arrests, respectively ( $p = 0.78$ ). User feedback was positive with 9.1 out of max 10 for perceived device efficacy and 8.9 for overall ease of operation. In conclusion, the LUCAS device fit most patients and was well received by prehospital providers. Resuscitation of limited duration due to early death or early ROSC frequently precluded device use, and this has important implications for evaluating the association between device use and ROSC in observational settings.

Axelsson C, Herrera M, Fredriksson M, et al. Implementation of mechanical chest compression in out-of-hospital cardiac arrest in an emergency medical service system. *Am J Emerg Med*. 2013;31(8):1196-1200.

This is a Swedish retrospective analysis of the survival of consecutive OHCA patients before (period 1, N: 1,218 patients) and after implementing the LUCAS device (period 2, N: 1,183 patients) in the EMS organization. In period 2, survival improved significantly over period 1; patients admitted to hospital alive increased from 25.4% to 31.9% ( $p < 0.0001$ ), survival at 1 month increased from 7.1% to 10.7% ( $p = 0.002$ ). Bystander CPR, crew-witnessed cases and post-resuscitation care increased, whereas the rates of VF declined and the response times as well as the delay to defibrillation increased. The LUCAS device was used in 60% of OHCA, manual CPR alone in 40%. Survival rates of patients who were actually treated with the LUCAS device were significantly lower than those who received only manual CPR during period 2; admission to hospital 28.6% vs. 36.1% ( $p = 0.008$ ), survival to 1 month 5.6% vs. 17.6% ( $p < 0.0001$ ). There were significant differences between the groups that likely influenced the difference in outcomes. Patients treated with the LUCAS device appeared to be a higher risk group with a lower chance of survival; there were significantly fewer crew-witnessed cardiac arrests treated with LUCAS vs manual CPR (13% vs. 22%) (data indicated crew-witnessed arrests had three times higher chance of survival), and the LUCAS patients were significantly more likely to have got adrenalin (95% vs. 53%) (data indicated patients who got adrenalin had a significantly lower chance to survive and generally had a longer time to defibrillation compared to those who only got manual CPR). The main reason for not having mechanical compression was probably early ROSC as the treatment protocol called for the LUCAS device to be applied first after manual CPR and defibrillator. In summary, due to many changes in care over the time periods, the authors could not conclude the LUCAS device was the contributor to the significantly increased survival. The LUCAS device did provide benefits to the staff's working environment and it appeared to be used in more difficult patients with a lower chance of survival.

Maule Y. The aid of mechanical CPR; better compressions, but more importantly – more compressions... (translated from French language; Assistance Cardiaque Externe; Masser mieux, mais surtout masser plus...). *Urgence Pratique*. 2011;106:47-48.

This is a Belgian retrospective study that compared compression ratios (the amount of time compressions were being delivered compared to the total CPR time) of the LUCAS chest compression system to that of manual compression. CODE-STAT™ 7.0 Data Review software was used to analyze the data. Two cohorts, consisting of 200 recordings each of non-traumatic CPR, were randomly created. Total duration of CPR was 41 minutes, 20 seconds ( $\pm 5$  min., 15 sec.). The average compression ratio for cases using the LUCAS device was 93% ( $\pm 4\%$ ). The compression ratio for cases using manual compressions was 69% ( $\pm 6\%$ ). The author concludes that based on these ratios, mechanical chest compression devices, regardless of the type, allows for optimization of compression times during CPR.



## LUCAS Bibliography

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Carmona Jiménez F, Padró P, García A, et al. Cerebral flow improvement during CPR with LUCAS, measured by Doppler. *Resuscitation*. 2011; 82S1: 30. AP090. (This study is also published in a longer version, in Spanish language with English abstract, in *Emergencias* 2012;24:47-49.)

This is a Spanish prospective study which compared the middle cerebral artery flow (measured by Doppler at 5-6 cm) during manual chest compressions and then during LUCAS 2 chest compressions in six prehospital cardiac arrest patients. In three patients no data could be recorded due to early ROSC or no flow due to subarachnoid hemorrhage. In three patients the median flow during manual chest compressions was  $31.6 \pm 8.32$  cm/s which increased to  $50.6 \pm 17.12$  cm/s during LUCAS compressions. The authors mention that normal flow for a healthy person is 60-80 cm/s. The authors concluded that the LUCAS device seems to improve cerebral flow compared to manual CPR.

Saussy J, Elder J, Flores C, et al. Optimization of cardiopulmonary resuscitation with an impedance threshold device, automated compression cardiopulmonary resuscitation and post-resuscitation in-the-field hypothermia improved short-term outcomes following cardiac arrest. *Circulation*. 2010;122:A256. (Poster on file at *Physio-Control*.)

This a retrospective prehospital study from New Orleans EMS system comparing the results after implementing the LUCAS device 1(V2), the impedance threshold device (ITD) and post-ROSC in-field hypothermia (N: 180) in December 2009 to end of September 2010, with historical data (N: 374). Stable ROSC increased to 36% (38/106) compared to 21% (78/374) ( $p < 0.002$ ). 69% (58/84) of the patients in which EtCO<sub>2</sub> was measured had an increased EtCO<sub>2</sub> value, and in 36% (30/84) this increase was over 10mm. EtCO<sub>2</sub> is a surrogate for circulation. There were no major adverse events. The authors concluded that the implementation of the devices was feasible, safe and resulted in a 71% increase of stable ROSC.

Axelsson C, Karlsson T, Axelsson Å, et al. Mechanical active compression-decompression cardiopulmonary resuscitation (ACD-CPR) versus manual CPR according to pressure of end tidal carbon dioxide (PETCO<sub>2</sub>) during CPR in out-of-hospital cardiac arrest (OHCA). *Resuscitation*. 2009;80(10):1099-1103.

This prospective, cluster randomized Swedish study of 126 prehospital cardiac arrest patients showed that the LUCAS device 1(V1) (N:64) created significantly higher PETCO<sub>2</sub> values compared to manual CPR (N:62) with an average value of 3.26 vs. 2.69 kPa,  $p = 0.04$ . There were no differences in survival, probably due to the fact that the study inclusion was late, about 20 minutes after the cardiac arrest occurred, and the patients constituted a high risk group with a very low overall survival. PETCO<sub>2</sub> is a practical, non-invasive method that correlates well with circulation, such as pulmonary blood flow and cardiac output, and is known to be an almost immediate indicator for return of spontaneous circulation. PETCO<sub>2</sub> has also been used as an indicator for rescuer fatigue.

Olasveengen T, Wik L, Steen P. Quality of cardiopulmonary resuscitation before and during transport in out-of-hospital cardiac arrest. *Resuscitation*. 2008;76:185-190.

This is a Norwegian retrospective, observational study of CPR hands-off ratio on scene compared to during transport while treating prehospital cardiac arrest patients who received manual CPR (N: 36) or who got LUCAS 1(V1) CPR (N:7). With manual CPR the hands-off ratio increased from  $0.19 \pm 0.09$  on-scene to  $0.27 \pm 0.15$  ( $p = 0.002$ ) during transport. Quality was significantly better with mechanical rather than manual CPR with no difference in hands-off ratio on scene ( $0.10 \pm 0.06$ ) vs. during transport ( $0.08 \pm 0.06$ ) ( $p = 0.248$ ). The hands-off ratio over the entire episode of approx. 33 to 40 minutes was  $0.22 \pm 0.09$  with manual CPR and  $0.09 \pm 0.06$  with LUCAS CPR.

Maule Y. Mechanical external chest compression: a new adjuvant technology in cardiopulmonary resuscitation. (Translated from French language :L'assistance cardiaque externe: nouvelle approche dans la RCP.) *Urgences & Accueil*. 2007;29:4-7.

This publication describes the implementation and early results of LUCAS 1(V1) CPR at the Brugmann University Hospital in Belgium. 150 consecutive out-of-hospital cardiac arrest patients receiving LUCAS CPR (N: 123) or manual CPR (N: 27) were analyzed and compared to historical data on manual CPR (N: 140). The ROSC data with LUCAS (57.7%) was more than double as high compared to both the contemporary manual group (25.9%) as well as the historical manual group (22.2%). LUCAS CPR improved the physiological values of the patients; e.g. systolic blood pressure could be measured during LUCAS CPR which is hardly ever possible during manual CPR, SaO<sub>2</sub> readings were around 95%, patients showed signs of life again (moving, etc.) while they were still in VF or had a heart rhythm that produced no blood flow. In addition, the LUCAS device created an option to transport patients with effective CPR and freed up resources to focus other lifesaving tasks.

Axelsson C, Nestin J, Svensson L, et al. Clinical consequences of the introduction of mechanical chest compression in the EMS system for treatment of out-of-hospital cardiac arrest – a pilot study. *Resuscitation*. 2006;71:47-55.

This was the first cluster-controlled pilot study (N: 328) on LUCAS 1(V1) CPR vs. manual CPR in the out-of-hospital setting in Sweden. The LUCAS device was placed in the second tier and applied very late in the resuscitation process (18 minutes after collapse). The results on ROSC (both groups: 51%), hospitalized alive (38% in LUCAS and 37% in manual group n.s.) and discharged alive (8% vs. 10% n.s.) were the same in both groups. The majority of the survivors had CPC score 1 or 2 in both groups with no significant difference between the groups. During training, the LUCAS device was applied with CPR hands-off time of less than 20 seconds. The device proved to be impact resistant and dependable. Resuscitation efforts were facilitated by freeing the hands of the rescuer from chest compression. For the same reasons, safety increased during transport in a moving ambulance. The LUCAS device fit on >98% of the patients.



## Patient Series

Beesems S, Hardig B, Nilsson A, et al. Force and depth of mechanical chest compressions and their relation to chest height and gender in an out-of-hospital setting. *Resuscitation*. 2015;91:67-72.

This analysis reviews chest wall dimensions and mechanics data stored in the LUCAS 2 device during chest compressions on 95 Dutch OHCA patients. Cases were included only if the suction cup was placed correctly, there was no realigned during the first 5 min of chest compressions, and if no other anomaly in device use was noted. All patients received manual CPR prior to the application of the device. The mean chest height was 232 mm for males and 209 mm for females ( $P < 0.001$ ). The LUCAS device was found to deliver the compression depth according to its specifications (53 mm depth in patients with chest height  $>185$  mm). The mean force required to achieve the compression depth of 53 mm ranged between 219 and 568 Newton with a mean of 410 Newton. No correlation was found between chest height and force required to reach 53 mm depth, nor gender and force. In summary, there was a large variation of the required force to achieve a compression depth of 53 mm in individual patients.

Pietsch U, Lischke V, Pietsch C. Benefit of mechanical chest compression devices in mountain HEMS: lessons learned from 1 year of experience and evaluation. *Air Med J*. 2014;33(6):299-301.

This Swiss study used and evaluated 2 mechanical chest compression devices in the alpine helicopter emergency services (HEMS). Seven rescues with ongoing CPR (3 with the LUCAS device; 4 with the AutoPulse® device) were performed in remote alpine terrain. These devices functioned properly and were easily applied even in difficult mountainous terrain. A previous study regarding helicopter rescue already proved the use of the LUCAS device lead to increased CPR quality and reduced hands-off time compared with manual chest compressions (Putzer, 2013). In summary, CPR under special circumstances like deep hypothermia, in which a prolonged CPR is essential, the use of the LUCAS or AutoPulse device was easy even in difficult alpine terrain which requires special rescue missions like winch or multi evacuation and rescue system evacuation.

Boyce L, Vliet Vlieland T, Bosch J, et al. High survival rate of 43% in out-of-hospital cardiac arrest patients in an optimised chain of survival. *Neth Heart J*. 2015;23(1):20-25.

This Dutch study describes short term and 1 year survival after OHCA in a system using LUCAS chest compression system. 242 consecutive OHCA patients were admitted to the emergency department between April 2011 and December 2012. Follow-up took place in July 2014. 76% of the patients had a cardiac origin, and 52 % had a shockable rhythm. In 74 % of patients, the cardiac arrest was witnessed, 76 % received bystander CPR and in 39 % an automatic external defibrillator (AED) was used. Of the 168 hospitalized patients, 144 underwent therapeutic procedures. A total of 105 patients survived until hospital discharge. Younger age, cardiac arrest in public area, witnessed cardiac arrest, cardiac origin with a shockable rhythm, the use of an AED, shorter time until return of spontaneous circulation, Glasgow Coma Scale (GCS)  $\geq 13$  during transport and longer length of hospital stay were associated with survival. Seventy two (69 %) survivors were alive at 1 year after the cardiac arrest. In summary, a survival rate of 43% after hospital admission of OHCA is achievable. Witnessed cardiac arrest, cardiac cause of arrest, initial cardiac rhythm and GCS  $\geq 13$  were associated with higher survival.

Walker R, Esibov A, Chapman F. Impact of shock timing during mechanical CPR on defibrillation efficacy. *Circulation*. 2014;130. Abstract 152.

This is a retrospective analysis of electronic defibrillator recordings from the Amsterdam Resuscitation Study (ARREST), a Dutch prospective out-of-hospital cardiac arrest registry, to investigate if shock efficacy (defined as absence of VF at five sec after the shock) varied if delivered during a pause of chest compressions vs during ongoing mechanical chest compressions, and, in the latter case, if the shock efficacy varied during the chest compression cycle. 153 cases using the LUCAS device and having at least one shock delivered after LUCAS device initiations were included. After LUCAS compressions were started, 509 shocks at 360 J occurred; VF termination outcome could be determined for 460 of these. There was no statistical difference in VF termination efficacy if the first eligible shock was delivered during a pause in mechanical compressions compared to if it was delivered during ongoing compressions (87% VF termination during a pause, and 85% during ongoing LUCAS compressions;  $p=0.74$ ). For all eligible shocks, VF termination efficacy was 83.9% and 79.1% ( $p = 0.20$ ) in the pause group vs ongoing compression group, respectively. For shocks delivered during mechanical chest compressions, there were no statistically significant differences in VF termination rate if the shock was delivered during four different stages of chest compression duty cycle, starting with piston upstroke phase : 89%, 80%, 69%, 80% ( $p = 0.12$ ). For shocks during a pause, VF termination rate did not differ for preshock pauses  $\leq 5$  sec (82.4%) vs.  $>5$  sec (84.8%;  $p = 0.63$ ). In summary, shocks can be delivered during ongoing LUCAS compressions without reducing defibrillation efficacy. The exact shock timing during the LUCAS device compression cycle did not significantly alter shock efficacy. VF termination rate was not affected by pre-shock pause duration during LUCAS compressions.