Quality of cardiopulmonary resuscitation when directing the area of maximal compression by transesophageal echocardiography during cardiac arrest in swine (sus scrofa).

Background: There have been no studies to determine ideal location of chest compressions during CPR, and standard hand placement is often not directly over the heart; chest compressions are often over the ascending thoracic aorta. Hypothesis: Chest compressions located over left ventricle (LV) will result in improved CPP or ROSC in a swine model of cardiac arrest. Methods: Transthoracic echo was used to mark the location of the aortic root and center of LV on animals (n=26) which were randomized to chest compressions in one of two locations. After 10mins of VFib, BLS with mechanical CPR was performed for 10mins followed by ACLS for an additional 10mins. During BLS the area of maximal compression was verified using TEE. CPP was recorded every 2mins. Results: CPP was higher in the LV group at mins 24 (p=0.003), 28 (p=0.049), and 30 (p=0.002) which were during ACLS. 9 of the LV group (69%) achieved ROSC compared to 0 of the aortic root group (p=0.001). Conclusion: In our swine model, chest compressions performed directly over LV resulted in an increase in CPP during ACLS and a greater proportion of animals with ROSC.
1. Protocol Number: FWH20110158A

2. Type of Research: Animal Research

3. Title: Quality of cardiopulmonary resuscitation when directing the area of maximal compression by transesophageal echocardiography during cardiac arrest in swine (sus scrofa).

4. Principal Investigator (PI):

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<th>Rank</th>
<th>Date of IACUC Training</th>
<th>Branch of Service/ Corps</th>
<th>Staff Resident/ Fellow</th>
<th>Department/ Office Symbol</th>
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<tr>
<td>Kenton Anderson</td>
<td>O-3</td>
<td>June 2011</td>
<td>USAF</td>
<td>Staff</td>
<td>59 EMDS/SGOE D</td>
<td><a href="mailto:kentonlanders@gmail.com">kentonlanders@gmail.com</a></td>
<td>WP: 292-3408</td>
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5. Purpose:
The purpose of this study is to evaluate how performing chest compressions directly over the left ventricle of the heart affects the quality of CPR. Quality of CPR will be determined by measuring the coronary perfusion pressure (CPP) during cardiac arrest while compressions are performed in the traditional location on the chest as compared to compressions that are located directly over the left ventricle as directed by TEE.

6. Results:
Our group identified that by guiding chest compressions over the left ventricle using transthoracic echocardiography (TTE), there was a significant increase in coronary perfusion pressure (CPP) during advanced cardiac life support (ACLS) as well as an increase in the number of animals with return of spontaneous circulation (ROSC). Our findings suggest that compression of the left ventricle may be the most important determining factor in whether a victim survives cardiac arrest. We verified the location of these compressions using transesophageal echocardiography (TEE) during CPR.

Figure 1. CPP trends: Standard CPR vs. Left Ventricle CPR

Figure 2. Difference in ROSC between Standard CPR and Left Ventricle CPR

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<th>Standard CPR</th>
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<td>ROSC (%)</td>
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P < 0.001
7. **How may your findings benefit the Air Force?**

Our findings demonstrate that chest compressions directed over the left ventricle result in a significant increase in coronary perfusion pressure and return of spontaneous circulation. These findings alone suggest that we may be able to increase the survival of cardiac arrest victims both in the military and civilian arenas. We have subsequently received a grant for a continuation study in traumatic cardiac arrest. To date, we have only enrolled one animal into the left ventricle group in the traumatic arrest study, and it had return of spontaneous circulation which is encouraging. The rate of return of spontaneous circulation in traumatic arrest is very low, and if we are able to demonstrate that compressions over the left ventricle in traumatic arrest is able to increase survival, there may be hope of increasing the survival of our airmen on the battlefield.

8. **Number of Animals**

Projected Enrollment of Animals at the Beginning of Study:   30

Actual Number of Animals Enrolled:   36

9. **Status of Animals Entered Into the Protocol:**  
The animals entered into the study have been in general good health. We requested additional technique development animals at the beginning of the study because I consulted with several experts in the field and based on my observation of the CPR techniques they have used I felt we needed more animals to refine our technique.

10. **Status of Funds:**  
Our study was funded by the AF SGR. We are under budget and all funds have been allocated for.

11. **Reason for Closure:**  
Objectives of the study were met

12. **Specific Problems:**  
The study went well and we did not encounter any specific problems.

13. **Publications and Presentations:**  
**Presentations:**  
Poster presentation at MHSRS, Ft. Lauderdale, FL, August 2013
Poster presentation at AHA, Dallas, TX, November 2013

These Presentations and Publications have not been cleared by 59 CRD and Public Affairs. –Submitting Forms 3039 with this report.

**Publications:**  
These Presentations and Publications have/ have not (choose one) been cleared by 59 CRD and Public Affairs.

14. **Exceptional Achievements:**  
This study was selected for oral presentation at MHSRS this year as well as presentation at the American Heart Association Scientific Sessions.

15. **Signature of Principal Investigator:**

____________________
KENTON ANDERSON, Maj, USAF, MC  
Director, Emergency Ultrasound  
Department of Emergency Medicine – WHASC & SAMMC  
kentonlanderson@gmail.com  
210-292-7331
# PROCESSING OF PROFESSIONAL PUBLICATIONS/PRESENTATIONS

**TO:** CLINICAL RESEARCH SQUADRON/MSR  
**FROM:** (Name/Office symbol)  
**PROTOCOL NUMBER:**

1. **TITLE OF MATERIAL TO BE PUBLISHED OR PRESENTED**

2. **MATERIAL IS FOR** (please check the appropriate box or boxes)  
   - [ ] PUBLICATION/JOURNAL (List intended publication/journal)
   - [ ] PUBLISHED ABSTRACT (List intended journal)
   - [ ] BOOK CHAPTER OR BOOK (Indicate intended publisher, name, city, country)
   - [ ] POSTER (To be demonstrated at meeting / Name of Meeting, City, State, and Date of Meeting)
   - [ ] PLATFORM PRESENTATION (At civilian institutions / Name of Meeting, City, State and Date of Meeting)
   - [ ] OTHER (Describe; Name of Meeting, City, State and Date of Meeting)

**POINT OF CONTACT**

3. **WHO IS THE PRIMARY POINT OF CONTACT AT WHASC?** (Last, First, M.I.)  
   **DUTY PHONE/PAGER No.**

**AUTHORSHIP AND CO-AUTHORS(S)** (List in the order they will appear)

<table>
<thead>
<tr>
<th>LAST NAME, FIRST NAME AND MIDDLE INITIAL</th>
<th>GRADE/RANK</th>
<th>SQUADRON/GROUP/OFFICE SYMBOL</th>
<th>INSTITUTION (If not 59 MDW)</th>
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I CERTIFY THAT ANY HUMAN OR ANIMAL EXPERIMENTAL STUDIES WERE PERFORMED AND COMPLETED IN STRICT ACCORDANCE WITH CURRENT DIRECTIVES AFI 40-402 OR MWI 41-34. I HAVE READ THE FINAL VERSION OF THE ATTACHED MATERIAL AND CERTIFY THAT IT IS AN ACCURATE COPY OF THE FINAL MANUSCRIPT.

**AUTHOR’S SIGNATURE**  
**DATE**

**COMMANDER’S SIGNATURE**  
**DATE**

WHASC FORM 3039, 20020315  
(MSR)  
PREVIOUS EDITION IS OBSOLETE
### 1st Indorsement

**To:** CLINICAL RESEARCH SQUADRON/MSR  
1. **Date In**  
2. **Assigned File Number**

3. **Date Reviewed**

4. **Author Contacted for Recommended or Necessary Changes**  
   - **Yes** (if yes, give date)  
   - **No**

5. **Comments**

☐ **Approved**

**Signature and Title of Reviewer**  
**Date**

### 2nd Indorsement

**To:** OFFICE OF PUBLIC AFFAIRS (PA)  
1. **Date In**  
2. **Date Out**

3. **Comments**

☐ **Approved (In compliance with security and policy review directives)**

**Signature and Title of Reviewer**  
**Date**

### 3rd Indorsement

**To:** MSR  
1. **Date In**

2. **Senior Author Notified by Phone of Approval**  
   - **Yes**  
   - **No**  
   - **Could Not Be Reached**  
   - **Left Message**

3. **Date Written Notice of Approval and Clearance Mailed to Author**

4. **Comments**

WHASC FORM 3039 (REVERSE) 20020315
Ultrasound guided Chest Compressions over the Left Ventricle During Cardiopulmonary Resuscitation Increases Coronary Perfusion Pressure and Return of Spontaneous Circulation in a Swine Model of Cardiac Arrest

Anderson KL¹, Castaneda M², Boudreau S², Vargas T², Zarzabal L², Sontgerath J¹, Bebarta VS¹

¹Dept of Emergency Med, San Antonio Military Medical Center, San Antonio, TX; ²CREST Program, Wilford Hall Ambulatory Surgical Center, Lackland AFB, TX

Background

Cardiac arrest is the sudden, abrupt loss of heart function. There are approximately 350,000 adult victims in the US and Canada annually, and cardiac arrest is a leading cause of death in many countries¹.

In the civilian setting the most common cause of cardiac arrest is coronary heart disease. On the military battlefield the most common cause of cardiac arrest is trauma.

The quality of chest compressions during CPR is a major determinant of successful resuscitation, however, the survival rate among resuscitated cardiac arrest victims is still low (<15%).

Standard chest compressions are not usually over the left ventricle².

Chest compressions located directly over the left ventricle may improve measures of successful resuscitation.

Objective

Primary Outcome:
Chest compressions directly over the left ventricle will result in an increased coronary perfusion pressure (CPP) when compared to chest compressions at the aortic root.

Secondary Outcome:
Chest compressions directly over the left ventricle will result in an increased return of spontaneous circulation (ROSC) when compared to chest compressions at the aortic root.

Methods

26 swine (25-32kg) were randomized to either standard (aortic root) compression site or left ventricle compression site

Millar catheters placed in RIJ and aorta (via LFA) • CPP = DBP (aortic) – DBP (R atrium)

Each animal was secured in a V-shaped trough

The location of the aortic root and the middle of the left ventricle were marked using TTE (area of maximal compression was later verified with TEE during BLS)

Thumper device was lowered over randomization position

VF was induced using a 3 sec, 60Hz, 100mA AC current applied across the precordium • Indicated by time zero

ETT was disconnected from the ventilator

Animals remained in VF for 10mins without intervention • BLS was initiated at 10mins • ACLS was initiated at 20mins

CPP was measured over the duration of the experiment

ROSC was defined as a regular cardiac rhythm with SBP>60 for 1min

Results

Figure 1. CPP at baseline, during VF arrest, BLS, and ACLS. *= statistically significant

Table 1. Difference in ROSC between Standard and Left Ventricle groups. p<0.001

Conclusions

We detected an increase in CPP during ACLS when chest compressions are performed over the left ventricle

Animals with compressions over the left ventricle were also more likely to have ROSC.

References

Date: 22 Jan 14
TO: Capt Kenton Anderson/SG03D
Your Final Report was reviewed by the WHASC IACUC during the 15 Jan 14 meeting. The Committee's decision is provided below:

FWH20110158A "Quality of cardiopulmonary resuscitation when directing the area of maximal compression by transesophageal echocardiography during cardiac arrest in swine (sus scrofa).", PI: Capt Kenton Anderson/SG03D
(Reason Closed: Objectives of the study were met)

The committee voted that this item be approved as written. A reminder will be sent to the PI regarding PA clearance.
FOLLOW-UP: Closed

Name of Official MARIA E. DOMINGUEZ
Title/Office Symbol/Phone Protocol Support/SGVUS/2-6095
Signature _______________________________ Info Copy To