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Ultrasonographic Assessment of Inferior Vena Cava Distensibility After Cardiac Arrest

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Scholarship Domain: Evidence-based Medicine

Project Type: Investigator-initiated Clinical Research

Ultrasonographic Assessment of Inferior Vena Cava Distensibility After Cardiac Arrest

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Background: Post-cardiac arrest hypotension is associated with mortality and poor neurological outcome among survivors. Increased inferior vena cava (IVC) distensibility has previously been demonstrated to be predictive of fluid responsiveness. However, the utility of measuring IVC distensibility after cardiac arrest is currently unclear.
Objective: Our objectives were to determine if increased IVC distensibility is common and associated with hypotension after cardiac arrest.
Methods**:** Prospective cohort study performed at a single academic hospital. We enrolled consecutive adult post-cardiac arrest patients who were mechanically ventilated after return of spontaneous circulation (ROSC). We performed bedside U/S during the initial 6 hours after ROSC and measured IVC distensibility. Mean arterial blood pressure (MAP) was recorded at the time of the U/S. IVC distensibility was calculated as: [maximum anterior/posterior (AP) diameter – minimum AP diameter value]/minimum AP diameter. We *a priori* defined increased IVC distensibility as ≥18% based on previous literature, and post-ROSC hypotension as MAP <70 mmHg.
Results**:** Of the 40 included patients, 14 (35%) had increased IVC distensibility. We found similar mean MAP among patients with IVC distensibility <18% vs. ≥18%, 91 mmHg (95% CI 77 - 105) vs. 98 mmHg (95% CI 83 - 112) respectively. Hypotension occurred in 24% of the entire cohort and increased IVC distensibility occurred in 22% of patients with hypotension and 36% of patients without hypotension, absolute risk difference -13% (95% CI -46 to 19).
Conclusion**:** Although IVC distensibility was common after cardiac arrest it was not associated with post-cardiac arrest hypotension.

Introduction

Over half of post-cardiac arrest patients die in the hospital and the majority of survivors are functionally dependent secondary to anoxic brain injury.[1] Finding new approaches to improve clinical outcomes among post-cardiac arrest patients is a high priority for resuscitation science. Given the complex nature of post- cardiac arrest syndrome, the etiology of post-cardiac arrest hypotension likely varies between patients. Identifying innovative clinical interventions to mitigate brain injury after ROSC is at the forefront of resuscitation research. Our group has previously demonstrated that cardiovascular instability is common and associated with poor clinical outcomes among patients successfully resuscitated from cardiac arrest.[1,2] The 2015 American Heart Association (AHA) Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care recommend avoiding and immediately reversing hypotension after ROSC.[3] However, these guidelines go on to acknowledge that targets for hemodynamic or perfusion measures (such as cardiac output, total peripheral resistance, mixed/central venous oxygen saturation) remain undefined in post-cardiac arrest patients. Thus, the ideal strategies to prevent and reverse post-cardiac arrest hypotension should incorporate bedside diagnostic testing to rapidly identify the etiology of hypotension and guide interventions (e.g. intravenous fluids vs. inotrope/vasopressor administration).

The use of focused cardiac ultrasound (FOCUS) has been well established in a variety of emergent conditions.[4] Specifically, FOCUS has been demonstrated to be useful in identifying the etiology of traumatic as well as non-traumatic hypotension. In addition, measuring the inferior vena cava (IVC) distensibility during the FOCUS exam has been demonstrated to be a predictor of fluid responsiveness[5]. Although there is evidence to support the use of US during the intra-arrest period,[6,7] the utility of US during the evaluation of post-cardiac arrest syndrome is not yet well established. Our objectives were to determine if increased IVC distensibility is common and associated with hypotension after cardiac arrest. Our overarching hypothesis is that focused cardiac ultrasound (FOCUS) can be used to identify the etiology of hypotension and guide the management of post-cardiac arrest hypotension. The first step in this line of research is to test if (1) left ventricular ejection fraction (LVEF) and (2) inferior vena cava diameter, as measured by FOCUS, are associated with post-cardiac arrest hypotension. Therefore, our specific aims are as follows:

SPECIFIC AIM 1*:* Perform a prospective cohort study to test if left ventricular ejection fraction is associated with post -cardiac arrest hypotension during the initial six hours after ROSC.

SPECIFIC AIM 2: Test if inferior vena cava (IVC) distensibility is associated with post-ROSC hypotension during the initial six hours after ROSC.

Methods

This was a prospective cohort study performed at Cooper University Hospital (CUH), a single center, urban academic hospital in Camden, NJ. CUH is the leading provider of comprehensive health services, medical education, and clinical research in southern New Jersey. The hospital serves as southern New Jersey's major tertiary referral hospital for specialized services including (among others) critical care and cardiovascular disease (Cooper Heart Institute). Of 554 total beds, CUH has 74 critical care beds and a 37-bed ED. The emergency department is a training center that cares for 75,000 patients annually and is home to the only academic emergency medicine residency program in southern New Jersey.

Recruited participants were adult post-cardiac arrest patients [both out-of-hospital (OHCA) and in-hospital arrest] who were mechanically ventilated after ROSC. Preliminary unpublished data captured within this department revealed that LVEF and IVC distensibility are associated with MAP. We previously performed FOCUS on 12 consecutive post-cardiac arrest patients and found a higher MAP among patients with a normal/hyperdynamic LVEF and IVC distensibility < 18% compared to subjects with a depressed LVEF or IVC distensibility ≥ 18%, median [interquartile range (IQR)] 109 (88-128), 73 (64-78), and 88 (80-85) mmHg respectively ($p = 0.015$ by Kruskal–Wallis test). This encouraging data solidified our decision to expand this pilot study into a larger study with an anticipated larger sample size.

Inclusion criteria: 1) age ≥ 18 years, 2) cardiac arrest, defined as a documented absence of pulse and cardiopulmonary resuscitation (CPR) initiated, 3) ROSC for at least 20 minutes, 4) not following commands immediately after ROSC, and 5) mechanically ventilated after ROSC**. Exclusion criteria** were patients defined by: 1) presumed etiology of arrest from trauma and (2) pregnancy.

Subjects were identified and recruited through the Cooper Health System's Emergency Department and the Intensive Care Unit. Our institution currently has a validated mechanism in place for real- time notification of study personnel when an OHCA patient arrives in the emergency department (ED) or when a cardiac arrest occurs in-hospital. Study personnel assessed patient eligibility and immediately enrolled patients meeting all inclusion and no exclusion criteria. The IRB at Cooper approved this study with a waiver of informed consent (IRB # 16-068).

We performed bedside FOCUS exam to estimate the left ventricular ejection fraction and record the corresponding mean arterial blood pressure (MAP) immediately after ROSC, and 24 hours after ROSC. We obtained cardiac ultrasound (subxyphoid, parasternal long axis, and apical views), to determine the LVEF, and the maximum IVC anterior/posterior (A/P) diameter on inspiration and minimum A/P diameter on expiration immediately after ROSC and at 24 hours.

An emergency medicine physician board-certified in echocardiography evaluated and standardized visual estimation of left ventricular function and IVC measurements. A video training module developed by ultrasound fellowship trained emergency medicine and critical care physicians was used to standardize visual estimation of LVEF. We performed multivariable logistic regression analysis to test the association between estimated left ventricular ejection fraction (defined as 1, hyper-dynamic; 2, normal; 3, mild/moderately depressed; 4, severely depressed) and post- ROSC hypotension [defined as MAP < 70 mmHg]. We estimated the inferior vena cava distensibility during the FOCUS exam. We calculated the IVC distensibility as: (maximum A/P diameter – minimum A/P diameter value)/minimum A/P diameter. Our primary outcome was hypotension, defined as a MAP < 70 mmHg at the time of ultrasound examination. We performed multivariable logistic regression analysis to test the association between IVC distensibility (categorized as < 18% vs. ≥ 18%) and post-ROSC hypotension (defined as MAP < 70 mmHg). We calculated odds ratios using multivariable logistic regression analyses with hypotension (MAP < 70 mmHg) as the dependent variable, and LVEF and IVC distensibility as independent variables. The model was adjusted for demographics, comorbidities, cardiac arrest variables, and post-cardiac arrest interventions that are found to have a statistically significant association with hypotension at a $p < 0.05$.

We collected demographics, data pertaining to the index cardiac arrest event, and outcomes consistent with the Utstein style for reporting cardiac arrest research, including all post-ROSC variables recommended for post -resuscitation research (see Appendix I).[8,9]

To ensure adequate power to test the two independent variables, in addition to five candidate variables, in a multivariable model, we estimated the necessary sample size for the primary outcome, based on the following assumptions: a) a predicted post-cardiac arrest hypotension rate of 50%;[2,10] and b) an estimated event (hypotension) per covariate ratio of 10:1 necessary for multivariable modeling.[11,12] To accrue 70 hypotensive subjects we estimated that a minimum of 140 total cases would be necessary, with an anticipated number of subjects to be 120.

All data were collected at the patient's bedside or from the medical record in Cooper University Hospital Medical Records Department. Focused cardiac ultrasound is routinely performed after successful resuscitation from cardiac arrest by trained emergency medicine and critical care house staff who record HIPPA compliant video clips for review by ultrasound fellowship trained emergency and critical care physicians. All images and video clips were stored on a HIPAA compliant off- site server. Patients were assigned a study number and de-identified data was copied from the chart and entered into an electronic database, Research Electronic Data Capture (REDCap), a secure, web -based application designed to support data capture for research studies.
A list was maintained matching the patient names and record numbers with study identification numbers.
All data points collected are itemized in Appendix I.

Results

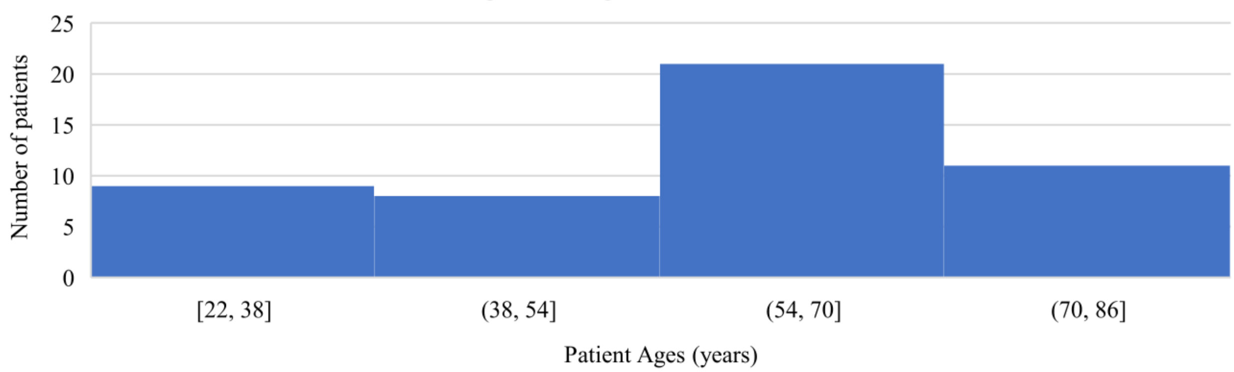
Investigators successfully collected 51 cardiac arrest patients that had achieved ROSC for greater than twenty minutes. Of these patients, 40 had interpretable US images and retrievable data, and were included in analysis for significance in the initial six hours after ROSC. Patients were excluded secondary to uninterpretable US images, images captured outside of the given timeframe, or patients with an incomplete chart. Data on the entire cohort (including data collected at the twenty four hour mark) are presented here.

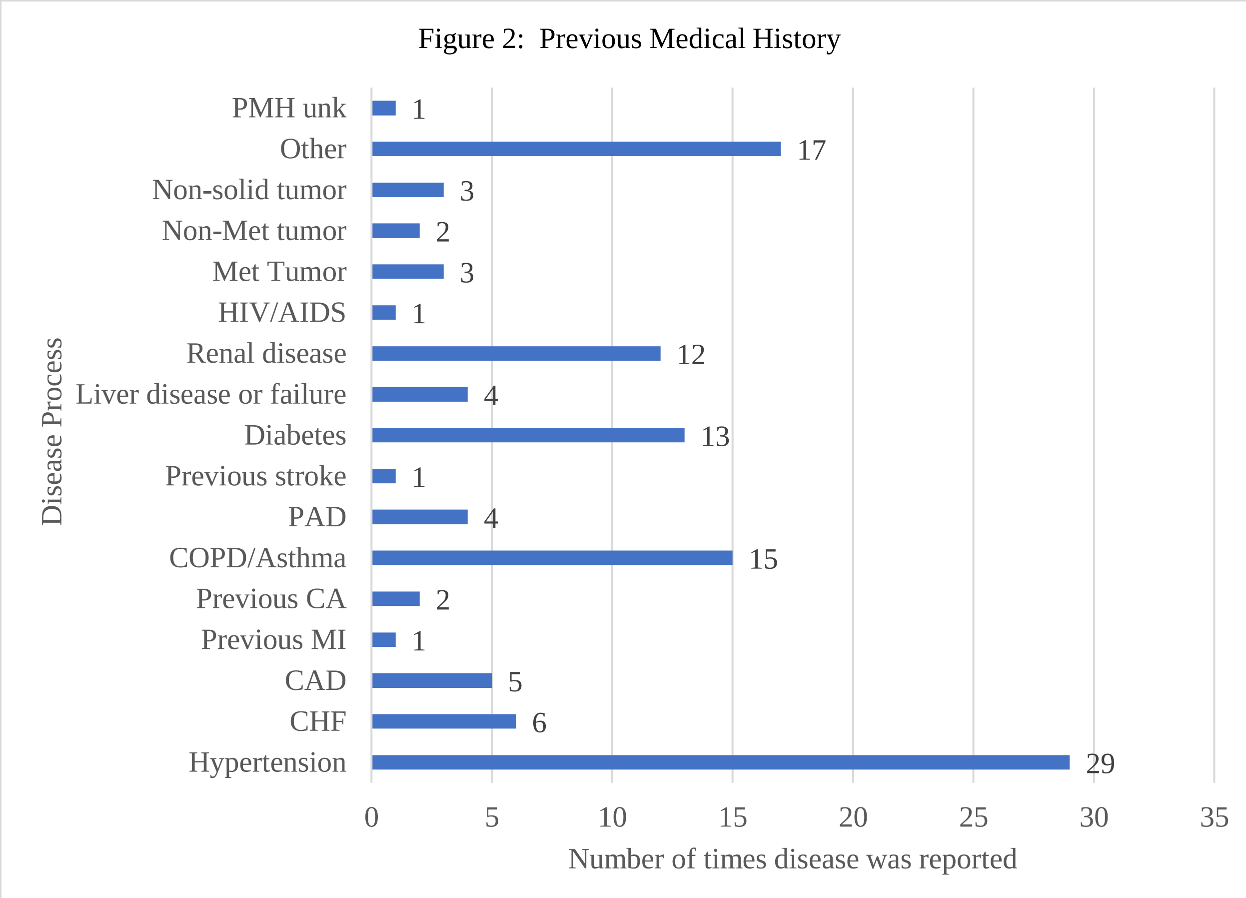
Demographics

The majority of patients enrolled were Non-Hispanic, Caucasian men who been living independently prior to arresting outside of the hospital. The average age of patients was 56.65 years, and the entire study population was 59% (29) men and 41% (20) women. 67% (33) were Non-Hispanic, 26% (13) were Hispanic, and 6% (3) were of unknown ethnicity. The majority of patients were Caucasian (69%, 34), and African American (24%, 12). Many patients had existing medical comorbidities prior to admission (Figure 2). The majority of patients had an existing diagnosis of hypertension (64.4%, 29), chronic obstructive pulmonary disease (COPD) or asthma (33.3%, 15), and/or other disease (37.8%, 17). See Table 1 and Figures 1-2.

Table 1: Patient Demographics
Age
Mean 56.65 years Median 58 years
Sex
Men 29 (59%) Women 20 (41%)
Race
Caucasian 34 (69%) African American 12 (24%) Unknown 3 (6%)
Ethnicity
Non-Hispanic 33 (67%) Hispanic 13 (26%) Unknown 3 (6%)

Figure 1: Age Distribution





Description of Cardiac Arrest and Neurological Disability

For the majority of patients, the time of arrest was known (71%, 35), and patients were living independently (77%, 37), with a favorable pre-arrest neurological status, as defined by a modified Rankin score of 0 – *No symptoms at all* (59%, 29). The majority of patients arrested outside of the hospital (59%, 29) at a general medical facility (14%, 7), or another location (12%, 6). Only 14% (7) of patients arrested either in the ED, ICU, or CCU. The majority of patients were not discharged alive (67%, 33). Of those that were discharged (n = 16), the majority went home (43%,7) with no post-arrest neurological disability (37.5%, 6) [mRS = 0 – *No symptoms at all*], or moderate-to-severe disability (43.8%, 7) [mRS = 4-5; 4 – *Moderately severe disability; unable to walk unassisted and unable to attend to own bodily needs without assistance*, 5 – *Severe disability; bedridden, incontinent, and requiring constant nursing care and attention*]. See Figure 3 and Tables 2-3.

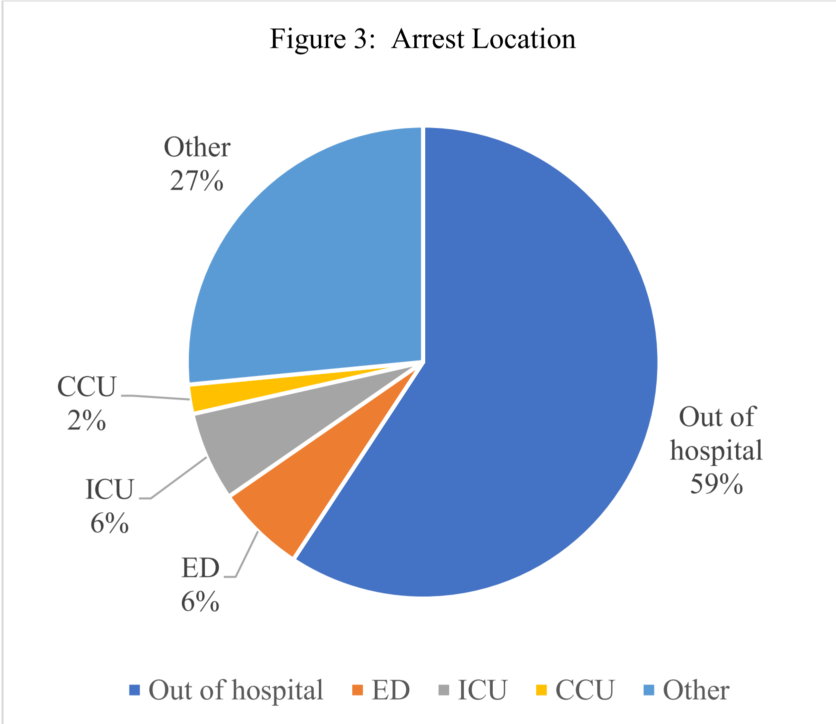


Table 2: Description of Cardiac Arrest Event
Time of arrest known (n = 49)
Yes 35, (71%) No 14, (29%)
Pre-arrest location (n = 48)
Living independently 37 (77%) Rehabilitation facility 1, (2%) Nursing home 3 (6%)
Homeless 2 (4%) Unknown 5 (10%)
Arrest Location (n = 49)
Out-of-hospital 29 (59%) GMF 7 (14%) Other 6 (12%) ED 3 (6%) ICU 3 (6%) CCU 1 (2%)
Patient discharged alive? (n = 49)
Yes 16 (32%) No 33 (67%)
Discharged (n = 16)
Home 7 (43%) Other 6 (37%) LTACH 2 (12%) Hospice 1 (6%)

Table 3: Description of Neurological disability (mRS)
Pre-arrest neurological disability (n = 42)
0 – No symptoms at all 29 (59%)
1 – No significant disability despite symptoms; able to carry out usual duties and activities 7 (14%)
2 – Slight disability; unable to carry out all previous activities but able to look after own affairs without assistance 3 (6%)
3 – Moderate disability; requiring some help, but able to walk around unassisted 1 (2%)
4 – Moderately severe disability; unable to walk unassisted and unable to attend to own bodily needs without assistance 2 (4%)
5 – Severe disability; bedridden, incontinent, and requiring constant nursing care and attention 0 (0%)
6 – Dead 0 (0%)
Post-arrest neurological disability (n = 16)
0 – No symptoms at all 6 (37.5%)
1 – No significant disability despite symptoms; able to carry out usual duties and activities 2 (12%)
2 – Slight disability; unable to carry out all previous activities but able to look after own affairs without assistance 0 (0%)
3 – Moderate disability; requiring some help, but able to walk around unassisted 1 (6%)
4 – Moderately severe disability; unable to walk unassisted and unable to attend to own bodily needs without assistance 4 (25%)
5 – Severe disability; bedridden, incontinent, and requiring constant nursing care and attention 3 (18.8%)
6 – Dead 0 (0%)

Description of Cardiac Ultrasound Findings

For the majority of patients, the initial estimated LV function (as defined by interpretable US scans captured from zero to six-hour time mark) was normal (68%, 24) where the initial RV:LV ratio was not greater than 1 in 93% (42) of patients. Initial pericardial effusion was present in only 2% (1) of the entire cohort (Table 4). IVC distensibility was calculable in 40 patients, with a minimum values of 0.0, maximum values of 600.0, an average of 48.0 with a standard deviation of 106.5 (Figure 4). In the initial cohort, MAP (n = 43), was found to be at a minimum value of 49.0, maximum value of 211.33, with a mean of 91.59 and standard deviation of 29.68 (Figure 5).

At the twenty-four-hour time mark (n = 15), it was revealed that the majority of patients had normal LV function (60%, 9). RV:LV ratio was not greater than 1 in the majority of patients (90.5%, 19), and pericardial effusion was only present in 5% (1) of the selected cohort (Table 4). IVC distensibility at twenty-four hours (n =22) revealed a minimum value of 16.1, maximum 143.8, an average of 30.0, with a standard deviation of 31.32 (Figure 6). In the twenty-four-hour cohort (n = 26), the MAP was revealed to have a minimum value of 60.33, maximum value of 171.67, a mean of 86.47, with a standard deviation of 21.67 (Figure 7).

We found similar mean MAP among patients with IVC distensibility <18% vs. ≥18%, 91 mmHg (95% CI 77 - 105) vs. 98 mmHg (95% CI 83 - 112) respectively, in the initial 6 hours post ROSC (Figure 8). Hypotension occurred in 24% of the entire cohort. Increased IVC distensibility occurred in 22% of patients with hypotension and 36% of patients without hypotension, absolute risk difference -13% (95% CI -46 to 19) (Figure 9). See Table 4 and Figures 4-9.

Table 4: Cardiac Ultrasound Findings
Initial Estimated LV Function (n = 35)
Normal 24 (68%) Mild/Moderate depression 2 (6%) Severe Depression 6 (17%)
Hyperdynamic 2 (6%) Unable to interpret 1 (3%)
Initial IVC Distensibililty (n = 40)
Min 0.00 Max 600.0 Mean 48.0 Standard Deviation 106.5
Initial MAP (n = 43)
Min 49.0 Max 211.33 Mean 91.59 Standard Deviation 29.68
Initial RV:LV ratio > 1 (n = 45)

Yes 3 (6.7%) No 42 (93%)

Initial pericardial effusion (n = 46)

Yes 1 (2%) No 45 (98%)

24 Hour Estimated LV Function (n = 15)

Normal 9 (60%) Mild/Moderate depression 1 (7%) Severe Depression 3 (20%)

Hyperdynamic 1 (7%) Unable to Interpret 1 (7%)

24 Hour IVC Distensibility (n = 22)

Min -16.1 Max 143.8 Mean 30.0 Standard Deviation 31.32

24 Hour MAP (n = 26)

Min 60.33 Max 171.67 Mean 86.47 Standard Deviation 21.67

24 Hour RV:LV ratio >1 (n = 21)

Yes 2 (9.5%) No 19 (90.5%)

24 Hour pericardial effusion (n = 21)

Yes 1 (5%) No 20 (95.5%)

Figure 4: Initial IVC Distensibility (0-6 Hour)

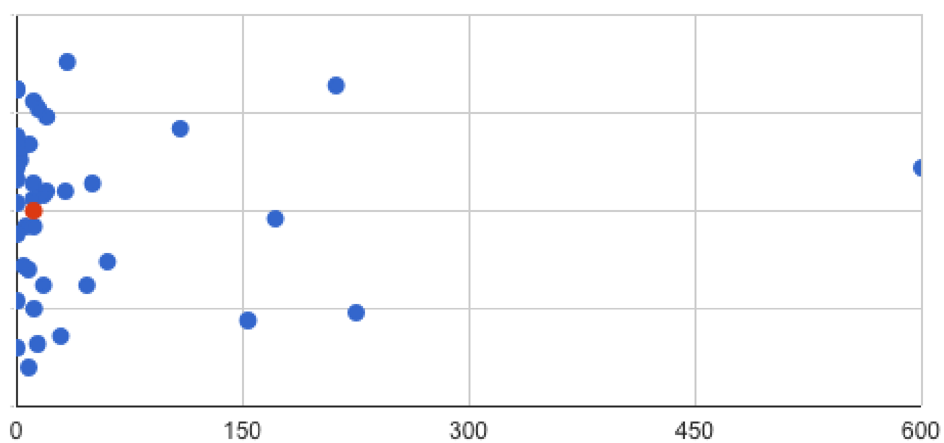


Figure 5: Initial MAP (0-6 Hour)

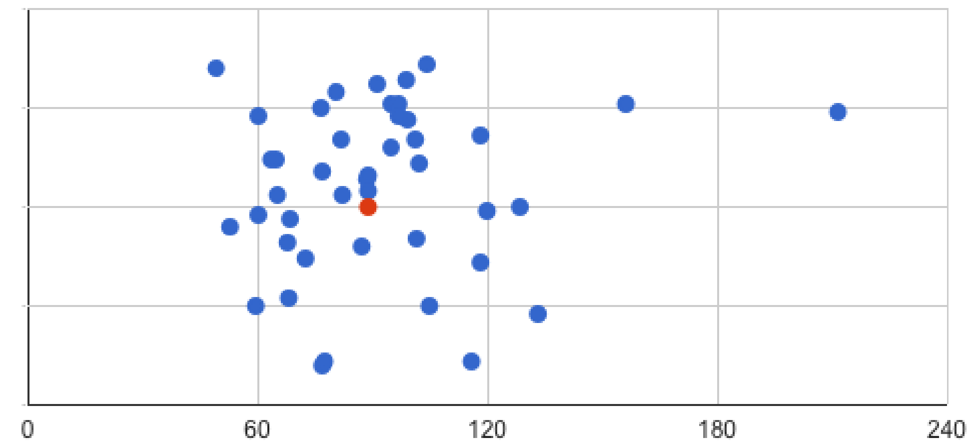


Figure 6: 24 Hour IVC Distensibility

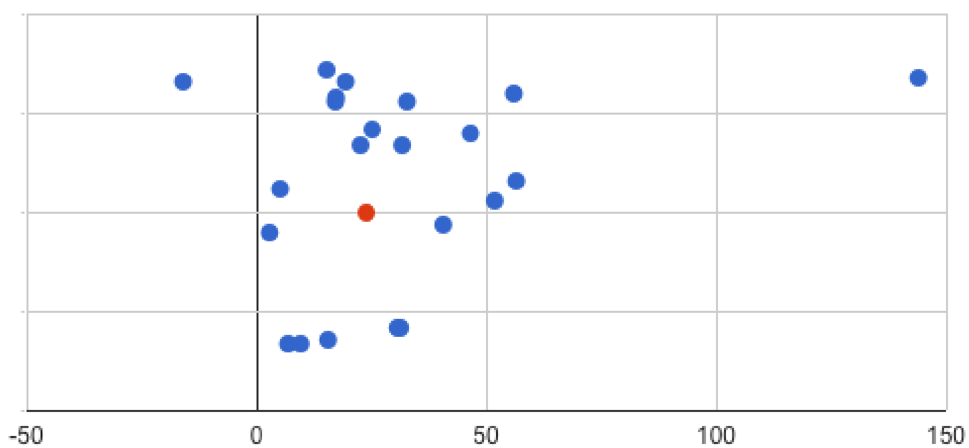
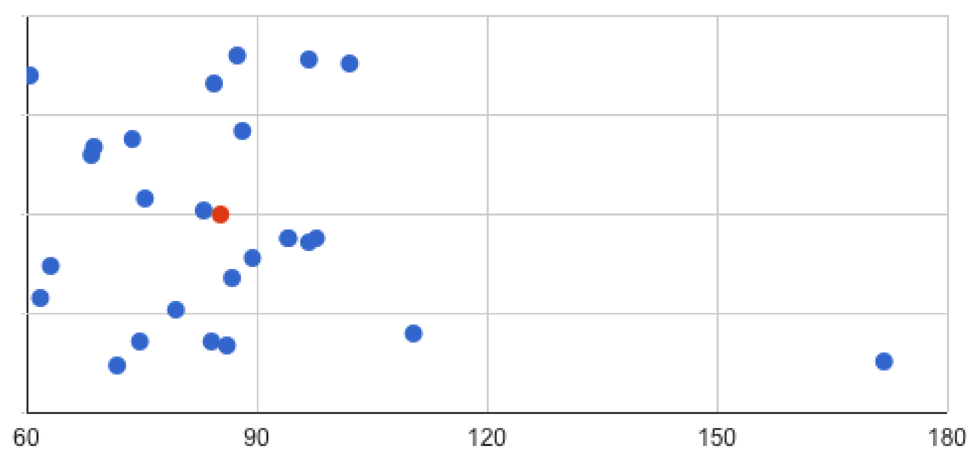
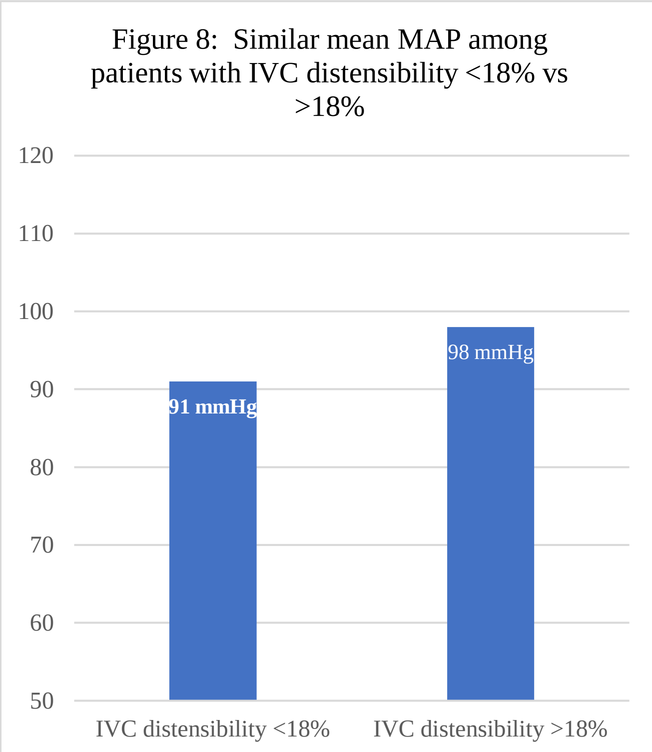
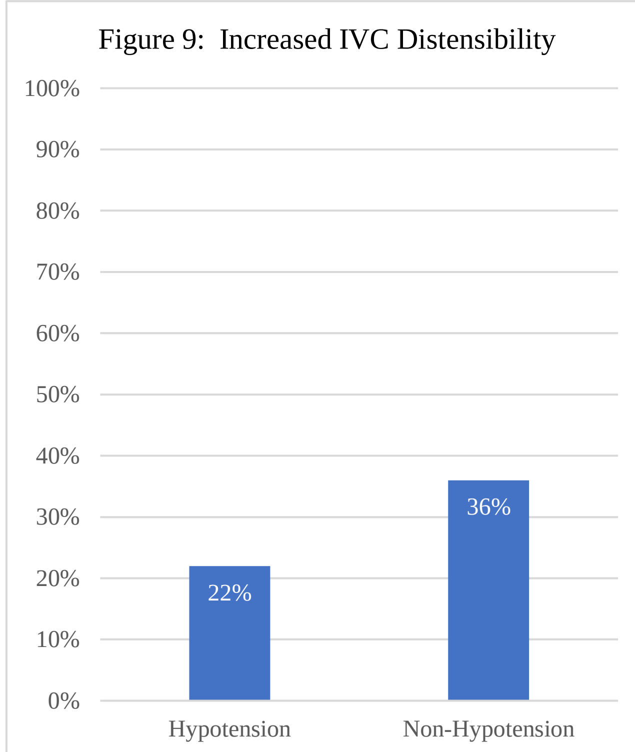


Figure 7: 24 Hour MAP







Discussion

Regulation of blood pressure in post-cardiac arrest patients is routinely performed in the emergency department as part of supportive care. Our group has previously demonstrated that early arterial hypotension is common in post-cardiac arrest syndrome and is associated with in-hospital mortality.[2] Further, our group has demonstrated that a time-weighted average MAP less than 70 mmHg during the initial six hours after ROSC is associated with poor neurological function among survivors.[1] These findings suggest reversing post-cardiac arrest hypotension may be time sensitive. However, the etiology of post-cardiac arrest hypotension likely varies between patients, and there are currently no recommended diagnostic tests to rapidly identify the etiology of post-cardiac arrest hypotension. By demonstrating an association between FOCUS findings, and post-cardiac arrest hypotension this project aimed to identify two potential therapeutic targets to prevent and reverse post- cardiac arrest hypotension. If the hypotheses are confirmed, this project would therefore identify a role for FOCUS use in future clinical trials of hemodynamic optimization to reduce neurological injury after cardiac arrest. After review of the collected data, it appears that our group was successful in identifying IVC distensibility as common after cardiac arrest, however, we were unable to disprove our null hypothesis of using IVC distensibility to identify the etiology of post-cardiac arrest hypotension.

In review of the data, it appears that IVC distensibility was common after cardiac arrest. In the initial 6 hours post ROSC, we found similar mean MAP among patients with IVC distensibility <18% vs. ≥18%, 91 mmHg (95% CI 77 - 105) vs. 98 mmHg (95% CI 83 - 112) respectively. This encouraging finding is in line with existing research that previously observed IVC distensibility in the setting of fluid responsiveness[5]. This finding drove our inquiry to further explore the presence of IVC distensibility specifically among hypotensive cardiac arrest patients. Therefore, we compared IVC distensibility among hypotensive and non-hypotensive cohorts. We found that hypotension occurred in 24% of the entire cohort. Increased IVC distensibility occurred in 22% of patients with hypotension and 36% of patients without hypotension, absolute risk difference -13% (95% CI -46 to 19). It appears here, that although IVC distensibility was common, it was not associated with cardiac arrest hypotension. Furthermore, it is interesting to find that IVC distensibility was greater in the non-hypotensive cohort. Causes for an increased IVC distensibility among non-hypotensive cardiac arrest patients, or inversely, a decreased IVC distensibility among hypotensive patients, could be multi-fold. These phenomena could reflect the use of vasopressors during post-ROSC cardiac arrest management. Use of epinephrine and norepinephrine are common vasopressor agents use in post-ROSC management. Data on concomitant vasopressor use was gathered in this study, but not specifically analyzed. Another supposition for the observed lower IVC distensibility among hypotensive patients compared to non-hypotensive patients, is the phenomenon of 'myocardial stunning' that has been documented to occur in intra- and post-arrest stages of resuscitation. Damaged myocardium secondary to resuscitation efforts may not be able to contribute to the cardiac output necessary to observe IVC distensibility, resulting in decreased observable movement of the IVC on US.

Merits

This project generates new, critically important knowledge about a fundamental element of post-cardiac arrest care. This innovative project takes a completely new approach to the concept that interventions initiated after ROSC can impact the trajectory of disease course. Although US has been utilized to guide rapid medical decision making during cardiac arrest, this project is innovative in that we are applying this hypothesis *after*

ROSC. This research generates new, critically important knowledge with the goal of broadening the diagnostic utility of FOCUS to include post-ROSC management. The first step in this line of research began with the question of determining if there is an association between FOCUS findings and post-cardiac arrest hypotension. If so, then FOCUS can be used in future studies testing if FOCUS-directed protocols to prevent and reverse post-cardiac arrest hypotension improve clinical outcomes. However, it appears that although IVC distensibility is common after cardiac arrest, it is not associated with post cardiac arrest hypotension.

Limitations

The main limitation to this project is the small sample size of the study population. With a sample size of 40 captured within the first six hours after ROSC, and the sample size of 15 at the twenty-four-hour mark, limited data and derivations could be gathered. We initially powered this study expecting a study population of 140, with an anticipated collection number of 120 patients. However, time and the complex approach towards collecting these data limited its success. Future prospective cohort studies would address these limitations, such as employing a designated on-call point person to capture and follow patients from presentation to the ED to twenty-four-hour time mark.

Another limitation to this study is rooted in the fact that data were collected from one single-center urban academic emergency department. These data may not be applicable to the general population, or other emergency departments serving different patient populations. Our patient population mainly arrested outside of the hospital, and had pre-existing, pre-arrest comorbidities. These comorbidities and the chronic medications that are required to maintain them may have confounding effects on the data collected here. Lastly, US scans were interpreted by emergency medicine physicians and an intensivist. The data gathered were subjective interpretations of these clinicians.. This type of data is inherently subject to issues of inter-rater reliability and bias.

Conclusion

Although IVC distensibility was common after cardiac arrest it was not associated with post-cardiac arrest hypotension. Future research is required to test if IVC distensibility predicts fluid responsiveness after cardiac arrest. Data presented here inform future research projects aimed at revealing an association between FOCUS findings and post-cardiac arrest hypotension.

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Appendix I

Data Points collected:

Record ID
Date/Time of Arrest
Age (age at time of arrest)
Date of admission to hospital

Gender:
Male
Female

Race:
Caucasian
African American
Asian
American Indian
Unknown
Other:

Ethnicity:
Non-Hispanic
Hispanic
Unknown

Pre-Arrest location:
Living independently
Rehab facility
Nursing home
Homeless
Unknown

Pre-arrest neurological disability (Modified Rankin Scale (mRS):
0- No symptoms at all
1- No significant disability despite symptoms; able to carry out all usual duties and activities
2- Slight disability; unable to carry out all previous activities, but able to look after own affairs without assistance
3- Moderate disability; requiring some help, but able to walk around unassisted
4- Moderately severe disability; unable to walk unassisted and unable to attend to own bodily needs without assistance
5- Severe disability; bedridden, incontinent, and requiring constant nursing care and attention
6- dead
unknown

Previous Medical History:
Hypertension
Congestive Heart Failure
Coronary Artery Disease
Previous myocardial infarction
Previous Cardiac arrest
Chronic obstructive pulmonary disease or asthma
Peripheral Vascular Disease
Dementia
Previous Stroke
Hemiplegia or paraplegia
Connective tissue disease
Peptic ulcer disease
Diabetes
Liver disease/Liver Failure
Renal disease
HIV/AIDS
Metastatic solid tumor
Non-metastatic solid tumor
Non-solid tumor
Other
Past medical history not known
Diabetes:
Without EOD
With EOD
Renal disease:
No Dialysis, creatinine >/= 2.0
Dialysis
Liver Disease:
Mild/moderate
Severe/cirrhosis
Clarify other: ____

Arrest location:
Emergency department (ED) (with CPR started pre-hospital)
ED (only)
Intensive care unit
Coronary care
General medical floor (GMF) (indicate which)
Other (clarify)
Arrest Location GMF: Indicate where ______
Arrest location: Other, specify ______

Etiology of arrest:
Cardiac
Respiratory
Hemorrhagic
Traumatic
Sepsis
Other
Unknown

Etiology, Other, clarify _____

Initial Rhythm:
Ventricular fibrillation
Ventricular tachycardia
Pulseless electrical activity
Asystole
Unknown

Intra-arrest medications administered:
Epinephrine IV
Epinephrine ET
Atropine
Lidocaine
Vasopressin
Amiodarone
Calcium
Other
Epinephrine IV: Dose administered ______
Epinephrine ET dose administered ______
Atropine: Dose administered ______
Lidocaine: Dose administered ______
Vasopressin: Dose administered ______
Amiodarone dose administered ______
Calcium: dose administered ______
Other, clarify ______
Other, dose administered ______

Date/Time of ROSC ______
(when ROSC is achieved and sustained for >=20min)

Downtime ______
(unk if time preceding CPR is unknown)

Targeted Temperature Management employed/Therapeutic Hypothermia (TH) Initiated:
Yes
No

If no, reason not initiated:
Patient returned to baseline mental status
Lack of commitment to aggressive treatment
Contraindicated
Other (specify)
Specify TH not initiated other ______

Target Temperature:
32-34
35-36
Other

Completed Therapeutic Hypothermia:
Yes
No

Did patient experience a temperature greater than 100.4 in first 72hrs post ROSC:
Yes
No

Post ROSC rhythm:
Normal sinus rhythm
Tachycardia
Bradycardia
Ventricular tachycardia
Atrial fibrillation
Atrial fibrillation w/ RVR
Other
Post ROSC rhythm other, clarify ______

Post ROSC anti-arrhythmics:
Yes
No

Initial Assessment (performed within six hours of ROSC) Initial mean arterial blood pressure (MAP) _________ (mmHg) Initial Post ROSC Vasopressors*:*
Yes
No

Vasopressors/inotropes administered:
Norepinephrine
Epinephrine
Dopamine
Vasopressin
Dobutamine
Milrinone
Phenylephrine
Initial Cumulative Vasopressor Index (CVI) ______

Amount isotonic IV Fluids received prior to initial US __________ (mL)

Initial Estimated Left Ventricular Function:
Normal
Mild/Moderate depression
Severe Depression
Hyper-dynamic
Unable to interpret

Initial Inferior Vena Cava Maximal Measurement ______

Initial Inferior Vena Cava Minimal Measurement ______

Initial distensibility ______

Initial *right ventricle: left ventricle* ratio > 1*:*

Yes
No

Initial pericardial effusion:

Yes
No

Modified Sequential Organ failure Assessment (SOFA) score – initial respiratory (PaO2/FiO2)

0 (> 400)
1 (< 400)
2 (< 300)
3 (< 200)
4 (< 100)

Coagulation (platelets x 10^3/mm^3)

0 (> 150)
1 (< 150)
2 (< 100)
3 (< 50)
4 (< 20)
Not tested

Liver (bilirubin (mg/dl))

0 (< 1.2)
1 (1.2 - 1.9)
2 (2.0 - 5.9)
3 (6.0 - 11.9)
4 (< 12.0)
Not tested

Cardiovascular

0 (no hypotension)
1 (MAP < 70 mmHg)
2 (dopamine 5 or any dobutamine)
3 (dopamine 5-15 or norepinephrine < 0.1)
4 (dopamine > 15 or norepinephrine > 0.1)
(doses given are in µg/kg/min)

Renal (creatinine (mg/dL))

0 (< 1.2)
1 (1.2 - 1.9)
2 (2.0 - 3.4)
3 (3.5 - 4.9 or < 500 ml/day urine output)
4 (> 5.0 or < 200 ml/day urine output)
Not tested

24 Hour Assessment (performed 24-30 hours after ROSC):

24 Hour MAP __________ (mmHg)
24 Hour Post ROSC
Vasopressors: Yes
No

Vasopressors/inotropes administered:

Norepinephrine
Epinephrine
Dopamine
Vasopressin
Dobutamine
Milrinone
Phenylephrine
24 Hour CVI ______

Amount isotonic IV Fluids received between 6 and 24 hour US____________ (mL)

24 Hour Estimated Left Ventricular Function:

Normal
Mild/Moderate depression
Severe Depression
Hyper-dynamic
Unable to interpret

24 Hour Inferior Vena Cava Maximal Measurement ______

24 Hour Inferior Vena Cava Minimal Measurement ______

24 hour distensibility ______

24 hour right ventricle: left ventricle ratio > 1:

Yes
No

24 hour pericardial effusion:

Yes
No

Modified SOFA score -- 24hr

Respiratory (PaO2 / FiO2)

0 (> 400)
1 (< 400)
2 (< 300)
3 (< 200)

4 (< 100)

Coagulation (platelets x 10^3/mm^3)
0 (> 150)
1 (< 150)
2 (< 100)
3 (< 50)
4 (< 20)
Not tested

Liver (bilirubin (mg/dl))
0 (< 1.2)
1 (1.2 - 1.9)
2 (2.0 - 5.9)
3 (6.0 - 11.9)
4 (< 12.0)
Not tested

Cardiovascular
0 (no hypotension)
1 (MAP < 70 mmHg)
2 (dopamine 5 or any dobutamine)
3 (dopamine 5-15 or norepinephrine < 0.1)
4 (dopamine > 15 or norepinephrine > 0.1)
(doses given are in µg/kg/min)

Renal (creatinine (mg/dL))
0 (< 1.2)
1 (1.2 - 1.9)
2 (2.0 - 3.4)
3 (3.5 - 4.9 or < 500 ml/day urine output)
4 (<5.0 or < 200 ml/day urine output)
Not tested

APACHE II
score___________________________________

CPR after ROSC:
Yes
No

DNR established:
Yes
No

Patient made comfort care:
Yes
No

Additional discharge diagnoses:
Sepsis
MI
CVA
Pneumonia
ARDS
RF
MSOF
Other
None
Additional Diagnoses, other, clarify ______
Additional Diagnoses resolved?
Yes
No

Discharged Alive:
Yes
No

Date of death
____

Cause of death
____

Date of discharge
____

Discharge location:
Home/short term rehabilitation
Nursing Home
LTACH
Hospice
Other (clarify)
Discharged to: other, clarify______

Discharge neurological disability (mRS)
0- No symptoms at all
1- No significant disability despite symptoms; able to carry out all usual duties and activities
2- Slight disability; unable to carry out all previous activities, but able to look after own affairs without assistance
3- Moderate disability; requiring some help, but able to walk around unassisted
4- Moderately severe disability; unable to walk unassisted and unable to attend to own bodily needs without assistance
5- Severe disability; bedridden, incontinent, and requiring constant nursing care and attention
6- dead

The Cooper Health System
Institutional Review Board
FWA #: 00000211

Final Approval-Administrative Letter
Expedited Initial Review

Date: June 30, 2016

To: Christopher McFadden, MD
Harry Mazurek, PhD

IRB#: **16-068**

Study#: 1

Study Title: Association between estimated left ventricular function and inferior vena cava distensibility on focused cardiac ultrasound examination and mean arterial pressure after cardiac arrest.

Principal Investigator's Name: Brian W Roberts, MD

Primary department involved in this study: The Cooper Health System - Emergency Medicine

This study has final IRB approval. It is ready for your approval.

Dr. Mazurek's signature indicates that he also approves the following external investigators for research on this project:

Julia Moon(ext), MPH, BA- Rowan Student