



Resuscitative Endovascular Balloon Occlusion of the Aorta Improves Cardiac Compression Fraction Versus Resuscitative Thoracotomy in Patients in Traumatic Arrest

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Study objective: Resuscitative endovascular balloon occlusion of the aorta (REBOA) is emerging as an alternative to resuscitative thoracotomy for proximal aortic control in select patients with exsanguinating hemorrhage below the diaphragm. The purpose of this study is to compare interruptions in closed chest compression or open chest cardiac massage during REBOA versus resuscitative thoracotomy.

Methods: From May 2014 to December 2016, patients in arrest who received aortic occlusion with REBOA or resuscitative thoracotomy were included. Total cardiac compression time was defined as the total time that closed chest compression was performed for REBOA patients and the total time that closed chest compression (before resuscitative thoracotomy) and open chest cardiac massage (after thoracotomy) were performed for resuscitative thoracotomy patients. Cardiac compression fraction was defined as the time compressions occurred during the entire resuscitation phase. All resuscitations were captured by multiview, time-stamped videography.

Results: Fifty patients with aortic occlusion after arrest were enrolled: 22 REBOA and 28 resuscitative thoracotomy. Most were men (86%) (median age 30.2 years, interquartile range [IQR] 24.9 to 42.3; median Injury Severity Score 27, IQR 16 to 42; neither differed between groups). The median duration of total cardiac compression time was 945 seconds (IQR 697 to 1,357) for REBOA versus 496 seconds (IQR 375 to 933) for resuscitative thoracotomy. During initial resuscitation, compressions occurred 86.5% of the time (SD 9.7%) during resuscitation with REBOA versus 35.7% of the time (SD 16.4%) in patients receiving resuscitative thoracotomy. Cardiac compression fraction improved after open cross clamp in resuscitative thoracotomy patients to 73.2% of the time (SD 18.0%) but remained significantly less than the same period for REBOA (86.7%; SD 9.4%). Mean cardiac compression fraction for REBOA was significantly improved over that for resuscitative thoracotomy (86.2% [SD 9.1%] versus 55.3 [SD 17.1%]; mean difference 31.0%; 95% confidence interval for difference 22.7% to 39.23%; $P < .001$). Median pause in resuscitation related to procedural tasks was 0 seconds (IQR 0 to 13) for REBOA and 148 seconds (IQR 118 to 223) in resuscitative thoracotomy.

Conclusion: Total duration of interruptions of cardiac compressions is shorter for patients receiving REBOA versus resuscitative thoracotomy before and during resuscitation with aortic occlusion. Markers for perfusion during resuscitation must be examined to understand the effects of cardiac compressions and aortic occlusion on patients in arrest because of hemorrhagic shock. [Ann Emerg Med. 2018;72:354-360.]

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INTRODUCTION

Background and Importance

There is increasing evidence that resuscitative endovascular balloon occlusion of the aorta (REBOA) is a feasible alternative to resuscitative thoracotomy with aortic cross clamping for patients without severe intrathoracic hemorrhage.¹ Resuscitative aortic occlusion has been

shown to improve cerebral and coronary blood flow during cardiopulmonary resuscitation (CPR).²⁻⁴ In the setting of medical arrest, the quality of CPR, as measured by the cardiac compression fraction, may improve outcomes after CPR,⁵ but recently several studies have showed that the timing of initial compressions may affect these outcomes.⁶ Recent evidence demonstrates that REBOA is associated

Editor's Capsule Summary

What is already known on this topic

During traumatic cardiac arrest, aortic occlusion can stop exsanguination and divert blood flow to the heart and brain. Open thoracotomy and resuscitative endovascular balloon occlusion of the aorta (REBOA) are alternative methods to achieve aortic occlusion that have had little direct comparison.

What question this study addressed

This observational study compared interruptions in chest or cardiac compressions during traumatic cardiac arrest from 22 REBOA and 28 thoracotomy cases.

What this study adds to our knowledge

Aortic occlusion is completed approximately 2 minutes earlier with thoracotomy, but interruptions in chest compressions were substantially reduced by REBOA.

How this is relevant to clinical practice

Although slightly slower for achieving aortic occlusion in this cohort, REBOA produces fewer interruptions in other ongoing procedures compared with open thoracotomy.

with performance times similar to those of resuscitative thoracotomy with respect to time to aortic occlusion.⁷ However, to our knowledge the time required for each procedure and its effect on resuscitation, specifically the cardiac compression fraction, have yet to be examined.

Goals of This Investigation

The purpose of this study was to use real-time videography linked with a high-fidelity, continuous-vital-sign-measurement system during resuscitation of all trauma patients arriving in arrest to a high-volume urban tertiary care trauma center. We hypothesized that REBOA patients would have higher cardiac compression fraction compared with patients receiving resuscitative thoracotomy. The outcomes of this study were chosen to represent resuscitation timing and mechanics only because comparison of patient-oriented outcomes in these 2 biased and heterogeneous cohorts is not meaningful.

MATERIALS AND METHODS

Study Design and Setting

The University of Maryland School of Medicine Institutional Review Board approved this prospective,

observational study for data collection on May 1, 2014, through December 31, 2016. The R Adams Cowley Shock Trauma Center is a primary adult resource center in Baltimore, MD.

Selection of Participants

We included patients if they arrived to the trauma resuscitation unit in cardiac arrest or developed cardiac arrest shortly after arrival, and underwent either REBOA or resuscitative thoracotomy with aortic cross clamping. Indications for REBOA followed our institutional protocol whereby patients in arrest from hemorrhage below the diaphragm received REBOA,⁸ whereas those in arrest from intrathoracic hemorrhage received resuscitative thoracotomy as a standard of diagnosing and potentially treating intrathoracic hemorrhage. This protocol follows Advanced Trauma Life Support (ATLS) guidelines: chest radiograph and extended focused assessment with sonography for trauma to determine source of suspected exsanguination. If clinicians suspected a supradiaphragmatic source according to those results, then the patient received resuscitative thoracotomy; otherwise, a source below the diaphragm was likely and the patient received REBOA. We excluded patients if they were younger than 18 years, received both procedures, or did not receive videographic recording of adequate quality or continuous vital signs measurements.

Interventions

All patients arriving to the University of Maryland Shock Trauma Center are recorded by 24-hour, multiview, real-time videography. We synchronized these recordings with simultaneous time stamping. We identified patients by procedure type and resuscitation videos downloaded for review. Two physician reviewers who were not blinded to the study outcomes, but were blinded to each other's results, reviewed the videos independently. A senior physician evaluated all results and discrepancies. Each reviewer recorded events according to a predetermined list of significant resuscitation events.

Methods of Measurement and Outcome Measures

We assigned timing points based on patient arrival, time of aortic occlusion by balloon or open cross clamp, return of spontaneous circulation as determined by return of measurable blood pressure, and cessation of efforts. We began at admission and ended at official time of death or a period of return of spontaneous circulation that resulted in the clinician's decision to transfer the patient out of the video-study area to further diagnostic or treatment modalities. We calculated cardiac compression fraction as the

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