

REBOA and catheter-based technology in trauma

To the Editor:

Thank you for your Current Opinion article in last month's edition of the *Journal of Trauma and Acute Care Surgery*. The renewed interest in catheter-based hemorrhage control for trauma leads to many more questions than answers. The data for the use of resuscitative endovascular balloon occlusion of the aorta (REBOA) are indeed minimal, and evidence to suggest this procedure to be beneficial for trauma is lacking. The dismal results from Gupta et al. may have been related to the use of devices unsuitable and unsafe for REBOA. The advent of endovascular surgery, after the time of the Brooklyn case series, forced industry to identify and create safer interventional devices. Vascular surgeons have been using a slightly more complex variation of REBOA for nearly two decades in patients with exsanguination from below the diaphragm in the form of ruptured abdominal aortic aneurysms. Simplifying this technique for a similar indication seems indicated as we continue to observe a high mortality rate for potentially salvageable civilian and military torso hemorrhage.

Widespread promotion of REBOA for broad use is certainly premature at this time. REBOA in the United States currently belongs in the hands of the trained acute care surgeon who is able to perform the procedure given the technological limitations and who is able to troubleshoot and understand the potentially severe complications of REBOA. Discussion about use by most non-surgeons should be limited at this time to "future consideration," after training, and once devices with improved safety profiles have been FDA approved. REBOA is performed outside the United States by emergency department physicians who have access to smaller devices. No high-level data are available to support its use; however, as is the case in Japan, acute care surgeons are not readily available, and catheter-based hemorrhage control by the emergency department physician is the only immediately available option.¹ The Japanese Association for the Surgery of Trauma (JAST) is currently enrolling patients in a multi-institutional trial to examine the role and outcomes of REBOA.

The growing interest in REBOA highlights advances in catheter-based technology for trauma as well as the expanding role of the acute care surgeon in the use of endovascular techniques. REBOA is a catheter-based, damage-control procedure that can be

performed by trained acute care surgeons. The optimal training regimen, modality, and method of skill maintenance have yet to be determined. However, acute care surgeons have been performing bedside insertions of various arterial and venous catheters for decades. REBOA is analogous to the placement of an intra-aortic balloon pump or a large femoral arterial line and does not require lengthy training to achieve competency. In Japan, emergency physicians are credentialed after performing REBOA three times during residency training.¹ "Expert" endovascular skills or lengthy training is not required. Nearly all REBOA procedures in Houston and Baltimore to date have been performed by acute care surgeons, who, by definition, are novice interventionalists. The only endovascular training completed before performing REBOA was acquired in general surgery residency and/or a 1-day course. No procedure-related deaths or major complications occurred in our earliest report,² and this trend has continued to date. Acute care surgeons are able to perform this procedure in less than 6 minutes as measured by virtual-reality simulation³ and as seen on video review of REBOA procedures performed in the resuscitation areas of our own institution. Once common femoral access is achieved, the four subsequent steps to balloon occlusion take little time. Preliminary data from the AAST AORTA trial may reveal aortic occlusion times to be similar between emergency department thoracotomy (EDT) and REBOA. This time to occlusion is likely to decrease with increasing operator experience and availability of new devices that abolish the need for an oversized sheath and an extremely long guidewire platform.

In reference to Figure 1, I would advocate consideration of REBOA in any patient with exsanguinating hemorrhage below the diaphragm, including those in full arrest and ongoing cardiopulmonary resuscitation. Open cardiac massage has not been proven to be superior to closed chest compression in traumatic arrest. During cardiopulmonary resuscitation, resuscitation and Advanced Cardiac Life Support protocols continue, and aortic occlusion is the only missing component. This may be accomplished rapidly without the morbidity of an EDT. The exact blood pressure parameters are so far ill defined, and for patients with systolic blood pressure greater than 80 mm Hg, time to definitive hemorrhage control and other institution-dependent factors may determine whether REBOA is a safe alternative. In reference to Figure 3, REBOA may be all that is required for severe pelvic

hemorrhage. If the systolic blood pressure responds appropriately to balloon occlusion, pelvic packing may not be required, and avoidance of an incision and at least one additional trip to the operating room may minimize morbidity. There have been no instances of pelvic packing after REBOA for pelvic bleeding at our own institution, even in cases where angiography and/or external fixation was not immediately available. Our anecdotal evidence also suggests that REBOA in Zone 3 may be enough inflow reduction to halt presumed venous hemorrhage. This observation is likely caused by a combination of inflow reduction, resuscitation, and fracture stabilization. Ongoing venous hemorrhage even after inflow control with REBOA may require pelvic packing in patients on anticoagulants or antiplatelet therapy.

I advocate that REBOA become another tool for the acute care surgeon to be used in combination with EDT, pelvic packing, surgical exploration, and/or angiography. Institution-dependent resources will likely play a large role in where REBOA fits into hemorrhage control. The ability to perform the procedure as well as the distance and time to the computed tomographic scan, operating room, angiography suite, or hybrid room will dictate its use. Each institution should engage in an honest appraisal of resources and expertise before the introduction of REBOA.

The answers to your salient questions will come from a combination of clinical and translational research, experience, availability of expertise, and local resources. Perhaps, the use of REBOA will decrease the number of blood products transfused; bridge a severe traumatic brain injury multitrauma patient to organ donation; avoid complications from EDT, pelvic packing, or pelvic embolization; decrease intensive care unit or hospital lengths of stay; improve hospital disposition; or increase overall survival for particular injury patterns. Studies should include a disclosure of procedure-related complications to accurately weight the risk-benefit ratio.

Again, I thank you for sharing your insight in last month's edition of the *Journal of Trauma and Acute Care Surgery* and look forward to many additional publications on the topic of REBOA in the future.

*The author is a Clinical Advisory Board Member of Pryor Medical Inc.

Megan Brenner, MD
Shock Trauma Center
University of Maryland
Baltimore, MD

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Re: REBOA and catheter-based technology in trauma

In Reply:

We appreciate Dr. Brenner's comments on our Current Opinion article.¹ As a leader in the development and dissemination of the contemporary resuscitative endovascular balloon occlusion of the aorta (REBOA) technique and a card-carrying endovascular-trained surgeon, Dr. Brenner is certainly well-qualified to assess the current state and future

potential of REBOA use in trauma. We acknowledge that the safety profile of current devices is likely superior to those used by Hughes² and Gupta et al.,³ and we agree wholeheartedly with Dr. Brenner's cautions against premature broad application and use by nonsurgeons.

Our proposed algorithm is admittedly conservative and tailored to surgeons and institutions with limited training and experience. We do disagree with Dr. Brenner's assertion that "open cardiac massage has not been proven to be superior to closed chest compression in traumatic arrest." Internal cardiac massage is at least twice as effective as external massage in maintaining cardiac output and is far superior in providing coronary and cerebral perfusion.^{4,5} Moreover, Luna et al.⁶ demonstrated that closed chest cardiopulmonary resuscitation does not augment arterial pressure in scenarios consistent with traumatic cardiopulmonary arrest (i.e., hypovolemia and pericardial tamponade). Consequently, we continue to advocate for resuscitative thoracotomy with open aortic cross-clamping and internal cardiac massage in the setting of traumatic cardiopulmonary arrest.

Dr. Brenner and her collaborators deserve credit for reinvigorating interest and refining the technique of REBOA; their efforts will undoubtedly save many lives. We look forward to a rigorous scientific study of the technique to further clarify its application.

*The authors declare no conflicts of interest.

Walter L. Biffl, MD
Charles J. Fox, MD
Ernest E. Moore, MD
Department of Surgery
Denver Health Medical Center
Denver, CO

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