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REBOA – Interest is Widespread but Need for Training Persists

Jason M Samuels, MD*,

Department of Surgery, University of Colorado Anschutz, 12636 East 17th Ave, Room 5401, Aurora, CO, 80045.

Kaiwen Sun, MD,

Department of Surgery, University of Nebraska Medical Center, 983280 Nebraska Medical Center Omaha, NE 68198-3280.

Ernest E Moore, MD,

Department of Surgery, Denver Health Medical Center, 777 Bannock St, 80204 Denver, CO, United States.

Julia R Coleman, MD,

Department of Surgery, University of Colorado Anschutz, 12636 East 17th Ave, Room 5401, Aurora, CO, 80045.

Charles J. Fox, MD,

Department of Surgery, Denver Health Medical Center, 777 Bannock St, 80204 Denver, CO, United States.

Mitchell J Cohen, MD,

Department of Surgery, Denver Health Medical Center, 777 Bannock St, 80204 Denver, CO, United States.

Angela Sauaia, M.D. Ph.D.,

Department of Public Health and Surgery, University of Colorado Denver, 655 Broadway #365, Denver, Co 80203.

Jason N MacTaggart, MD

Department of Surgery, University of Nebraska Medical Center, 983280 Nebraska Medical Center Omaha, NE 68198-3280.

Abstract

Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) was first described in the 1950s, but early attempts at REBOA faced several technical challenges. Subsequent advances in endovascular technologies led to renewed interest in employing REBOA for management of

* **Corresponding Author:** 12636 East 17th Ave, Room 5401, Aurora, CO 80045, Phone Number: (214) 289-1373, Jason.Samuels@cuanschutz.edu.

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hemorrhagic shock. However, REBOA usage remains infrequent, and indications for REBOA implementation remain unclear. We evaluated current opinions of trauma surgeons toward the use of REBOA for control of trauma-related hemorrhage and other causes of hemorrhagic shock. We hypothesize, that despite heightened interest in REBOA, implementation remains limited. A 25-question survey was thus created to query institutional and surgeon-specific training and practice patterns related to REBOA usage. The anonymized survey was distributed via email to a national trauma surgeon database and responses were recorded online. 992 subjects were invited to participate, of whom 31% (n=311) responded. Of these, 89% reported to be a trauma or acute care surgeon at a Level I trauma center, 50% reported practicing for 20 years. Two-thirds (68%) reported REBOA use at their institution, and the majority (59%) employed REBOA at least once. However, most (78%) performed 5 REBOA placements last year. Respondents supported REBOA usage in non-trauma causes of shock including gastrointestinal bleeding (60%), post-partum hemorrhage (83%), and ruptured abdominal aortic aneurysm (69%). A significant minority (20.3%) reported either only slight confidence or no confidence in their ability to deploy REBOA, and thus 21% reported being 'very interested' in attending a REBOA skills course. We thus conclude that REBOA has gained wide interest among trauma surgeons. However, placement remains infrequent with most providers placing a few annually. Educational courses are needed to disseminate the necessary skills for REBOA utilization.

Keywords

REBOA; Trauma; Endovascular Trauma; Aortic Occlusion; Hemorrhagic Shock

Introduction

Resuscitative endovascular balloon occlusion of the aorta (REBOA) was first employed during the Korean war as a method for rapid hemorrhage control.(1) Subsequent early attempts faced numerous challenges primarily due to limited catheter technologies and late application during profound shock. With advances in catheter materials and construction, ease of use has increased and complications following REBOA have diminished. Recent studies using modern catheters through 7-French sheaths report vascular complication rates ranging from 0 – 5%.(2–8) Additionally, contemporary studies suggest REBOA improves mortality compared to resuscitative thoracotomy in trauma patients with subdiaphragmatic hemorrhagic shock.(4, 8, 9) However, REBOA has not clearly demonstrated benefit in all populations, as Brenner et al. found no benefit when comparing REBOA to resuscitative thoracotomy in patients requiring CPR pre-hospital or after arrival.(8) Other studies have raised concerns with overzealous REBOA utilization citing the lack of adequate control groups and persistently high mortality.(10, 11) One possible explanation for conflicting data on REBOA's efficacy may lie with the difficulty in identifying the appropriate clinical setting for REBOA (i.e. a pulseless patient who would otherwise undergo resuscitative thoracotomy or a trauma patient in hemorrhagic shock requiring advanced resuscitative measures). Thus far, data analysis, experience, and expert opinion have not yet converged on the optimal indications for REBOA. As a result, usage remains sporadic, with Trauma Quality Improvement Project (TQIP) reporting centers placing REBOA less than 10 times

per year on average, and the vast majority (>90%) of TQIP centers not using REBOA at all. (12)

Another potential explanation for the lack of widespread implementation and infrequent use of REBOA is individual provider unfamiliarity with the REBOA procedure.(13) Several skills courses have been developed to disseminate the techniques necessary for REBOA.(14, 15) Courses such as the Endovascular Skills for Trauma and Resuscitative Surgery (ESTARS), Basic Endovascular Skills for Trauma (BEST), and Advanced Endovascular Strategies for Trauma Surgeon courses provide both didactic lectures and hands-on training to ensure the appropriate skillset and knowledge for successful REBOA implementation.(14, 15) Understanding barriers to attending such courses and identifying which skills are sought by learners will improve the utility of these courses and increase the efficiency and rapidity of dissemination of standardized REBOA skills and knowledge.

The aim of this study is to evaluate the opinions of trauma providers across the United States regarding REBOA application, including comfort performing REBOA, frequency of utilization, and clinical indications for REBOA. Additionally, this study evaluates insight into learner preferences and barriers to attending REBOA skills courses. We hypothesize that while interest in REBOA is widespread among trauma providers, comfort with the endovascular skills necessary for REBOA implementation is limited.

Methods

This is a purposive, confidential survey of members of a national trauma and acute care surgery society, the American Association for the Surgery of Trauma (AAST). This study was approved as exempt by the institutional review board (IRB# 416–16-EX). We developed a 25-question survey to gauge interest in, comfort with, frequency of, and indications for REBOA usage, as well as interest in REBOA skills courses (Supplemental Material). Specifically, we ascertained basic demographic and career details, including surgeon's specialty, practice location, and experience with REBOA usage. To determine practice patterns, we queried use of several procedures related to trauma resuscitation including the use of emergency department thoracotomies (EDT), central line placements, and REBOA. Subjects were also asked questions regarding opinions toward REBOA usage, including which provider specialties should be performing REBOA. Knowledge and comfort level related to REBOA skills were assessed with a scale from 1– 10, with 1 being “not at all interested or important” and 10 being “very interested or very important.” Questions regarding which skills should be included in a skills course had the following Likert scale options: “not necessary”, “good but not critical to include”, “critically important”, and “no preference”. The survey was disseminated to the membership of the AAST, using their “listserv” by email. Three reminders were sent to maximize response rates. The survey was completed online at [surveymonkey.com](https://www.surveymonkey.com) (San Mateo, CA).

Data were analyzed using Graphpad version 8.0 (San Diego, Ca). Continuous variables are reported as mean and standard deviation when normally distributed or median with interquartile range when not normally distributed.

Results

Respondents

Overall, 992 subjects were surveyed with a response rate of 31.4% (n=311). Among responders, 89% identified their specialty as trauma/acute care surgeons, 6.3% as general surgeons, 1.7% as surgical critical care providers, and 2.3% as vascular surgeons (Table 1). Over half (50.7%) reported being in practice for over twenty years, and about one-third (34%) reported practicing for 11–20 years (Table 1). Only four respondents (1.3%) stated they had practiced for 5 years or less. 87% reported practicing at an ACS or state-verified level I trauma center, and 84% reported working in a city with a population over 250,000 persons. Only one respondent reported working in a rural community (population < 50,000 residents).

Practice Patterns

Among the respondents, most (245, 79%) reported doing an EDT in the past year, but placement was infrequent with close to half (43%) having placed only 1–3 EDTs in the preceding year (Table 2). Regarding other trauma care procedures, 65% of respondents reported 7 or more central or arterial line placements in the past year.

When evaluating REBOA usage, the majority of respondents reported that REBOA was used in their institution (Table 2). Over three-fourths stated their hospital was equipped to use REBOA if necessary, and nearly all respondents felt their hospital was equipped to manage patients in the event that REBOA was deployed. A majority of respondents reported using REBOA at some point in their career. However, REBOA implementation remains limited, with over three-fourths of respondents reporting they had personally placed a REBOA five times or fewer over the last year. Ten (5.6%) respondents reported placing REBOA greater than 10 times over the past year. Over forty percent of respondents reported REBOA usage at their institution for non-trauma patients such as acute gastrointestinal hemorrhage or postpartum hemorrhage. REBOA usage also differed by years in practice, with a greater percentage of respondents practicing for 10 years or less reporting REBOA use at least once compared to respondents in practice for over 10 years (72% vs 55%, $p=0.0479$).

Opinions on REBOA Usage

Most respondents (89.8% of 295) felt REBOA was indicated in non-compressible truncal hemorrhage. The majority also felt REBOA should be deployed in non-trauma causes of shock including gastrointestinal bleeding, post-partum hemorrhage, and ruptured abdominal aortic aneurysm (Figure 1). Regarding whom should perform REBOA, all but one respondent (99.7%) believed REBOA should be placed by surgeons, while a minority believed emergency physicians (11.8%) and interventional radiologists (10%) also should be able to use REBOA. Free text comments for this question included statements like “*depends on the situation*” or “*anyone qualified if a surgeon not immediately available*” (Table 3).

Interest in REBOA Skills Courses

Though the majority reported being “fairly confident” or “very confident” in their ability to deploy REBOA (Table 4), interest in attending REBOA training courses to learn about or

refresh one's skills was high, with 21% reporting the highest interest and 39% reporting an interest of seven or higher. Respondents reported a slightly lower interest in attending such a course if traveling over 150 miles was required, with only 17% reporting the highest interest, and only 33% reporting an interest of 7 or more. Skills that respondents felt were most necessary were cut-down and percutaneous access of the femoral artery (Table 4). Of respondents, 70% expressed interest in an additional half-day of training focused on vascular access techniques including catheter usage and wire control. Lastly, respondents felt a course would be best with either a physical mannequin or cadaver (Table 4). Respondents cited several potential barriers to attending a skills course including cost of course (62% of respondents), time away from practice (56% of respondents), and travel distance (49% of respondents). Only 14% of respondents reported inability to implement REBOA or lack of institutional support as a barrier to attending a course.

Discussion

Although almost 90% of respondents thought REBOA was indicated for non-compressible hemorrhage and a majority reported some personal and institutional experience with the procedure, only a third of respondents were "very confident" in their skills to deploy REBOA. Furthermore, despite most of those surveyed practicing primarily at urban, level I trauma centers, over 40% of respondents had never performed REBOA. Of the almost 60% of respondents that had ever performed REBOA, the frequency of use was low, with almost 95% performing the procedure less than monthly, and many reporting performing only a few in the preceding year. This is congruent with others who have found usage of REBOA remains limited.(12) In addition, over one-third of respondents expressed an insufficient degree of confidence with REBOA placement, and an equal proportion of respondents reported a significant interest in attending a REBOA skills course. Though data continue to accumulate regarding optimal indications for REBOA, these responses suggest that one potential explanation for infrequent REBOA implementation is the significant proportion of providers who lack the necessary confidence for its use. This supports the development of more training opportunities to disseminate and maintain endovascular knowledge and techniques for trauma surgeons.

A recent joint American College of Surgeons and American College of Emergency Physicians consensus statement supported the use of REBOA for traumatic hemorrhagic shock,(16) and this was reaffirmed a year later despite the lack of high quality evidence.(12) Other committee statements have supported REBOA for traumatic hemorrhagic shock as well, including the Joint Trauma System, the Western Trauma Association and the World Society of Emergency Surgery.(17–19) Most recently, a consensus paper by Borger van der Burg et al. determined that REBOA was indicated for several causes of severe hemorrhage including traumatic injuries, ruptured abdominal aortic aneurysm, severe post-partum hemorrhage, and severe gastrointestinal bleeding.(20) As higher-quality clinical data accumulate supporting REBOA, our survey data suggest that these guidelines reflect a sentiment shared by a significant proportion of trauma surgeons that REBOA should be considered and implemented into algorithms for the management of hemorrhagic shock.

Similar to resuscitative thoracotomy, the frequent use of REBOA will likely remain limited to a small number of the very highest volume centers. Only 6% of respondents performed greater than ten resuscitative thoracotomies during the preceding year, with almost the same proportion performing greater than ten REBOA procedures over the same time period. This finding might be of some reassurance that there is not over exuberant use of REBOA across the country. However, with 30% of respondents practicing at institutions not offering the procedure while the vast majority of respondents believe REBOA to be beneficial, there appears a discordance. This likely reflects two factors: 1) a lack of practice guidelines based on high-quality evidence that define the clinical situations in which REBOA should be used, and 2) the inability to acquire and maintain the knowledge and skills necessary for REBOA implementation.

Despite substantial clinical experience in trauma surgery, nearly 40% of respondents to our survey expressed an interest in attending a skills course to develop or improve their comfort with REBOA. However, respondents cited several barriers to attending skills courses including time away from practice and unwillingness to travel to a course. Multiple courses are now available which aim to educate trauma and critical care practitioners on the performance of REBOA and management of patients with the catheters. These include the Basic Endovascular Skills for trauma (BEST) course (15), the Endovascular Skills for Trauma and Resuscitative Surgery (ESTARS) course, and the Advanced Endovascular Strategies for Trauma Surgeons course.(14) The BEST course previously demonstrated the power of such REBOA skills courses. In the 2014 report by Brenner *et al.*, the authors reported rapid improvement in the time to REBOA deployment for learners in just six trials of guided practice.(15) However, the model used to demonstrate this improvement did not include the percutaneous or open arterial access portion of the procedure and did not assess longer-term skill and knowledge retention, reducing relevance to actual clinical care. Our survey demonstrates a strong desire for both percutaneous ultrasound-guided and open surgical arterial access skill training to increase comfort level with REBOA. The BEST course does teach femoral access using a cadaver model, but the lack of realistic femoral artery access modeling is a major limitation of mannequin and virtual reality-based training approaches. While respondents to this survey said mannequins were critical to an educational training program, training models with cadavers such as that designed by Nesbitt et al. or swine models like that from Borger et al. appear more relevant to the actual clinical setting.(21, 22)

Though this study is, to our knowledge, the largest sampling of views related to REBOA utilization to date, across a broad range of centers and communities, it has several limitations. First, the survey was restricted to trauma providers and thus does not reflect opinions of the broader medical profession. Additionally, it is conceivable that there was a sampling bias, with respondents reflecting strong opinions either for or against REBOA, and not necessarily demonstrating the opinions of all trauma providers. Similarly, the majority of respondents were senior trauma providers with over 10 years of experience. A survey of more junior respondents may reflect different opinions or greater comfort with endovascular techniques for hemorrhage control. Finally, the survey assessed self-reported REBOA usage, rather than actual documented REBOA usage rates, and our survey data cannot identify

whether low usage rates are due to lack of clear indications, lack of necessary skills, or some other unmeasured factors not queried by this survey.

Conclusion

In summary, REBOA is widely supported in this national survey of trauma care providers for traumatic and non-traumatic causes of hemorrhagic shock; however, REBOA implementation appears to lag behind interest. Sporadic REBOA usage may be due to a lack of dissemination of skills necessary for placement or due to a dearth of clear clinical indications for use. Additional endovascular training to improve and maintain familiarity with the indications, technical skills, and complications associated with REBOA are needed.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1:
Percent of respondents who felt REBOA was indicated in non-trauma causes of hemorrhagic shock.

Table 1:

Demographics of respondents

Demographics		Responses (%)
What is your primary specialty?		
N= 311	General Surgery	19 (6.1)
	Trauma	121 (38.9)
	Surgical Critical Care	5 (1.6)
	Acute Care Surgery (trauma/surgical critical care/emergency general surgery)	148 (47.6)
	Vascular	7 (2.3)
	Interventional Radiology	0
	Emergency Medicine	1 (0.3)
	Obstetrics and Gynecology	0
	Other	16 (5.1)
How many years have you been in practice?		
N=310	0–5	4 (1.3)
	6–10	41 (13.2)
	11–20	108 (34.8)
	>20	157 (50.7)
Do you practice in a level I trauma center?		
N=308	Yes	269 (87.3)
	No	38 (12.3)
	Unsure	1 (0.32)
Which population size best describes where your practice is located?		
N=309	< 50,000	1 (0.32)
	50,000 – 250,000	49 (15.9)
	> 250,000	259 (83.8)
If your institution had to transfer a patient, how far away would the transfer site be?		
N=310	We would not transfer	251 (81.0)
	< 10 miles	13 (4.2)
	10–50 miles	22 (7.1)
	> 50 miles	24 (7.7)

Table 2:

Usage of hemorrhage controlling procedures including REBOA among respondents.

Questions		Responses (%)
How many emergency department thoracotomies have you yourself performed in the past year?		
N=310	0	65 (21.0)
	1–3	136 (43.9)
	4–6	66 (21.3)
	7–10	24 (7.7)
	> 10	19 (6.1)
How many central lines and arterial access procedures have you personally performed in the past year?		
N=310	0	20 (6.5)
	1–3	39 (12.6)
	4–6	48 (15.5)
	7–10	28 (9.0)
	>10	175 (56.5)
Is REBOA performed at your institution		
N=310	Yes	212 (68.4)
	No	93 (30.0)
	Unsure	5 (1.6)
Is your hospital equipped to perform REBOA		
N=310	Yes	243 (78.4)
	No	58 (18.7)
	Unsure	9 (2.9)
Is REBOA a procedure that you have performed at some point in your career?		
N=302	Yes	178 (58.9)
	No	124 (41.1)
How many REBOA placements have you personally done in the last year?		
N=176	0–5	138 (78.4)
	6–10	28 (15.9)
	11–20	6 (3.4)
	21–50	4 (2.3)
	> 50	0 (0)
Has REBOA been utilized at your institution for non-trauma related needs		
N=302	Yes	127 (42.1)
	No	151 (50)
	Unsure	24 (8.0)

Table 3:

Comments on who should place REBOA.

Response
"Both ED and surgery should be trained in placement"
"In some settings, Emergency MDs if immediate transfer or therapy available"
"Depends on where being performed"
"Vascular surgeon"
"Anyone properly trained if surgeon immediately available"
"IR help occasionally necessary"
"Depends on training but should be a physician"
"Pediatric Cardiologists"
"Anyone qualified"

Table 4:

Familiarity with REBOA placement and opinions towards skills courses.

How confident are you in your skills to deploy REBOA					
				Responses (%)	
N=302	Not at all confident			37 (12.3)	
	Slightly Confident			24 (8.0)	
	Somewhat Confident			55 (18.2)	
	Fairly Confident			84 (27.8)	
	Very Confident			102 (33.8)	
Please select the importance of including the following procedures in a REBOA class					
		Responses (%)			
N=303		Not necessary	Good to include but not critical	Critically Important	No preference
	Percutaneous access w/ ultrasound	18 (5.9)	69 (22.8)	206 (68.0)	10 (3.3)
	Femoral Artery Cutdown	30 (10.0)	93 (30.9)	170 (2.7)	8 (2.7)
	Focused Assessment with sonography for trauma (FAST)	111 (37.1)	83 (27.8)	92 (30.8)	13 (4.4)
	Angiography (pelvic, splenic)	88 (29.1)	138 (45.7)	65 (3.6)	11 (3.6)
	Embolization	116 (38.5)	120 (39.9)	55 (3.3)	10 (3.3)
Please select the importance of including the following procedures in a REBOA class					
		Responses (%)			
N=302		Not necessary	Good to include but not critical	Critically Important	
	Live Tissue (Pig)	67 (22.5)	157 (52.7)	74 (24.8)	
	Cadaver	38 (12.7)	167 (55.9)	94 (31.4)	
	Physical Model or Mannequin Simulator	17 (5.7)	127 (42.6)	154 (51.7)	
	Computerized Simulator	56 (18.7)	194 (64.7)	50 (16.7)	