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ORIGINAL ARTICLE

Resuscitative endovascular balloon occlusion of the aorta: simulation improves performance but may require interval training to prevent skill degradation

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Abstract

Purpose Surgical trainees are exposed to less procedures with increasing need for simulation. Resuscitative endovascular balloon occlusion of the aorta (REBOA) has become increasingly implemented for hemorrhage control, yet most courses are catered to faculty level with little data on trainees. We propose that routine training in this critical procedure will improve trainee performance over time.

Methods This is a prospective, observational study at a level I trauma center involving a monthly trauma procedural program. Early in the month, trainees received hands-on REBOA training; at the end, trainees underwent standardized, class-based evaluation on a perfused trainer. Score percentages were recorded (0–100%). Endpoints included early, mid and late performance (2–12 months). Paired T-test and Pearson's coefficient were used to evaluate differences and strength of association between time between training and performance.

Results 25 trainees participated with 5 and 11 repeat learners in the PGY-2 and PGY-3 classes, respectively. Median early performance score was 62.5% (IQR 56–81) for PGY-2s and 91.6% (IQR 75–100) in PGY-3s. Pearson's coefficient between time between and training and score demonstrated a weak correlation in the PGY-2s ($r^2 = -0.13$), but was more pronounced in the PGY-3s ($r^2 = -0.44$) with an inflection point at 5 months.

Conclusions Routine REBOA training in trainees is associated with improvement in performance within a short period of time. Skill degradation was most pronounced in trainees who did not receive training for more than 5 months. Trainees can be successfully trained in REBOA; however, this should be done at shorter intervals to prevent skill degradation.

Keywords Resuscitative endovascular balloon occlusion of the aorta · Simulation · Surgical training

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Background

Non-compressible torso hemorrhage (NCTH) remains a significant source of morbidity and mortality for severely injured trauma patients. Historically, resuscitative thoracotomy (RT) has been an adjunct in the management of NCTH. Over the past decade, Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) has gained popularity. REBOA has been used in both civilian and military trauma settings; several studies, however, have shown REBOA to have a conflicting impact on patient outcomes [1–3]. Implementation and widespread use of REBOA may be limited due to access and lack of training and familiarity with the device [2, 3]. The majority of training and courses are geared to the fellow or attending level with little data on effect on resident trainee performance. Studies have previously explored the utility in simulation and training programs utilizing REBOA with improvement in skills, with little exploration in retention over time [4], although recent evidence suggests that skill degradation does occur [5]. We hypothesize that a monthly REBOA training curriculum with training and assessment will help improve performance of our resident trainees over time with little effect in skill degradation.

Methods

We performed a prospective, observational study at a single level I trauma center within a large surgical residency program; this study was approved by our institutional research council. A monthly trauma procedural and simulation program was implemented in November 2018 to train surgical residents at all post-graduate (PG) 1–5 levels. This monthly curriculum provided training on common procedures and ended with a team-based simulation that assessed the residents in a high-fidelity environment. Surgical trainees (PGY-1–5) received hands-on training on several procedures at the beginning of the month, including vascular access, tube thoracostomy, resuscitative thoracotomy and endovascular balloon occlusion of the aorta (REBOA). At the end of the month, all trainees underwent a combination of both a focused procedural evaluation and simulation. PGY-2–5s were assessed specifically on REBOA on a proprietary, perfused trainer (Prytime Medical™ STAAR Trainer) utilizing an 8- or 10-point checklist based on PGY level, and which emphasized knowledge of anatomic landmarks, correct placement and inflation based on zone. All evaluations were completed by ATLS-certified trauma attendings with experience in REBOA placement. Overall percentages were recorded (0–100%). Endpoints included early, mid and late performance—designated as beginning score, mid and late scores ranging from 2 to 12 months. Individual and class-based performance were followed over time. Paired T-test was used to compare performance in repeat learners and Pearson's coefficient used to evaluate the strength of association between time between training and performance.

Results

25 residents participated in REBOA training (9 PGY-2 and 14 PGY-3 and 2 PGY-5s), with 5 repeat learners in the PGY-2 class and 11 repeat learners in the PGY-3 class. The majority of learners were PGY-3. Median early performance score was 62.5% (IQR 56–81) for the PGY-2 class and 91.6% (IQR 75–100) in the PGY-3 class (Fig. 1, Median PGY-2 and PGY-3 class scores over time). Overall late performance score was 100% (IQR 100–100) for the PGY-2 class

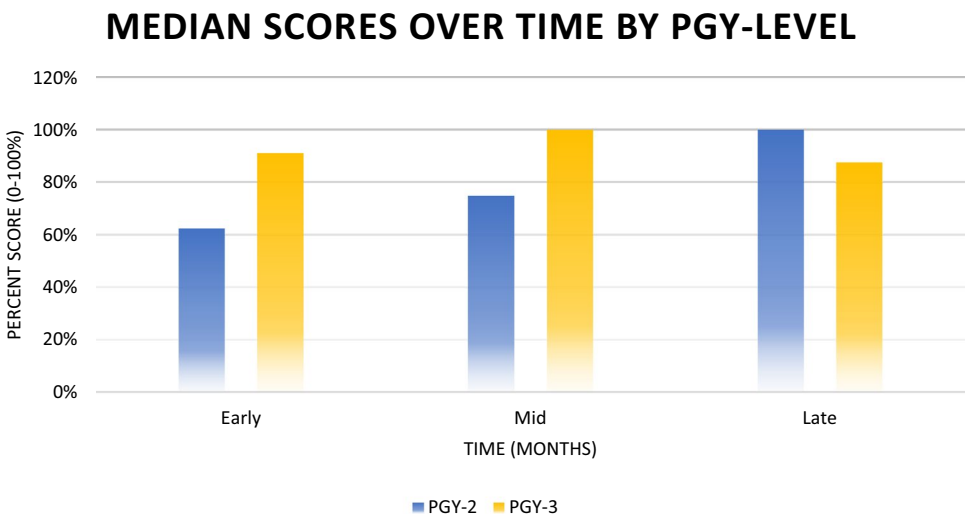

Fig. 1 Median scores (0-100%) of REBOA simulation performance by PGY level over time (months)

and 87.6% (IQR 86–90) in the PGY-3 class. Median time between assessments was 4 months (IQR 2–6) in the PGY-2 class and 5 months [3–5] in the PGY-3 class. Repeat learners in the PGY-2 class demonstrated significant improvement (Fig. 2, Median PGY-2 class scores in repeat learners over time (early versus late), ID = de-identified learners), whereas the score difference in the PGY-3 class exhibited some skill deterioration. Pearson's coefficient was used to evaluate strength of correlation between length of time between training and score, with a very weak correlation in the PGY-2 class ($r^2 = -0.13$); however, this was more pronounced in the PGY-3 class ($r^2 = -0.44$) (Fig. 3, Median PGY-3 class scores in repeat learners over time (early, middle, late).

Discussion

Standardized, consistent and long-term training in REBOA remains sparse and requires further robust evaluation to effectively implement a REBOA program into trauma systems.

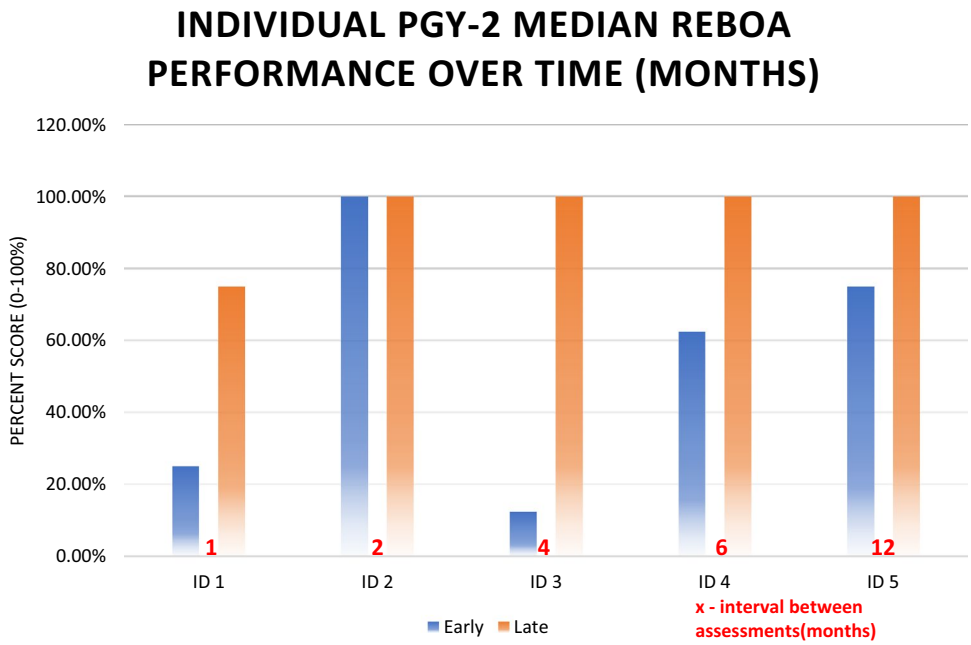

Fig. 2 Median Scores (0-100%) of REBOA simulation performance in PGY-2 repeat learners over time (months). x = interval between assessments (months)

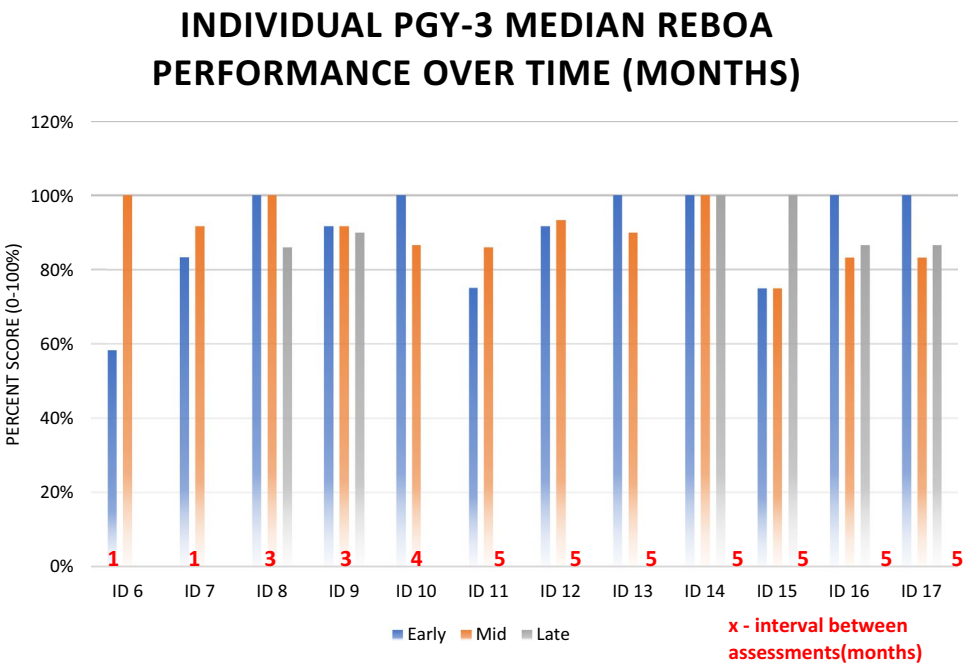

Fig. 3 Median scores (0-100%) of REBOA simulation performance in PGY-3 repeat learners over time (months). x = interval between assessments (months)

Training programs in REBOA continue to evolve, with limited consensus regarding the appropriate training structure for residents and surgeons, level of training at which the course be introduced, and standardized methods of evaluation to assess competence and knowledge of the procedure. A recent systematic review highlighted the variability in training programs and the need for a validated assessment tool [6]. REBOA training programs vary in design from didactic to hands-on, including porcine models, haptic feedback models and motion analysis [4, 6–10]. Of these, perfused models have been widely implemented in procedural training for hemorrhage control with good success [11]. The time between training sessions also varies with some studies reporting quarterly trainings including surgeons, residents, and ancillary staff and others suggesting a one-time course mostly tailored for advanced providers with prior surgical or endovascular experience [10, 12, 13]. Furthermore, limited data have been published on longitudinal learning data and skills retention from these programs [6, 9].

Given the lack of training in REBOA amongst trainees and need for longitudinal assessment, we organized a monthly trauma procedural and simulation program for surgical trainees PGY-1–5. This program emphasized hands-on procedural technique on a perfused manikin and assessed knowledge of anatomic landmarks, equipment, and procedural technique. These training procedural skills are essential to resuscitative care and were followed over one year. PGY-2 and PGY-3 trainees comprised the majority of trainees with standardized assessment over this period and overall improvement in both classes. We did note an inflection point at the 5–6-month mark where trainees demonstrated some skill degradation with strong negative correlation between length of time between training and score. This inflection point is consistent with previously published work which also demonstrated skill degradation at 6 months [5].

There are several limitations to this study, including small sample size and inter-rater reliability amongst instructors. Despite utilizing standardized, PGY-level-based assessments, this inter-rater reliability can persist, and was not explored during this study. Additional assessments exist, including those in structured courses focused on endovascular skills tailored for trauma surgeons [4, 10]; however, these are deployed at the fellow or faculty level. Our training and simulation program and results demonstrate that surgical trainees are capable of learning and retaining knowledge and skills for REBOA, including indications, anatomy, equipment needs and procedural steps.

Conclusion

Our results highlight the importance of early introduction to and more frequent training in emergent resuscitative skills as REBOA to mitigate skill degradation. Furthermore, REBOA training can be taught successfully to surgical trainees, in contrast to prior studies that have focused on fellows or faculty. Further investigations include continued longitudinal assessment throughout surgical training, video-based assessment of technique, and validation of a standardized checklist.

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Code availability Excel for basic statistics, otherwise not applicable.

Declarations

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval All human studies were approved by an institutional research council and were performed in accordance with ethical standards.

References

1. Joseph B, Zeeshan M, Sakran JV, Hamidi M, Kulvatunyou N, et al. Nationwide analysis of resuscitative endovascular balloon occlusion of the aorta in civilian trauma. JAMA Surg. 2019;154:500–8.
2. Anderson KL, Morgan JD, Castaneda MG, Boudreau SM, Araña AA, et al. The effect of chest compression location and occlusion of the aorta in a traumatic arrest model. J Surg Res. 2020;254:64–74.
3. van der Borger Burg BLS, van Dongen TTCF, Morrison JJ, HedemanJoosten PPA, DuBose JJ, et al. A systematic review and meta-analysis of the use of resuscitative endovascular balloon occlusion of the aorta in the management of major exsanguination. Eur J Trauma Emerg Surg. 2018;44:535–50.
4. Brenner M, Hoehn M, Pasley J, Dubose J, Stein D, et al. Basic endovascular skills for trauma course: bridging the gap between endovascular techniques and the acute care surgeon. J Trauma Acute Care Surg. 2014;77:286–91.
5. Hatchimonji JS, Sikoutris J, Smith BP, Vella MA, Dumas RP, et al. The REBOA dissipation curve: training starts to wane at 6 months in the absence of clinical REBOA cases. J Surg Educ. 2020. https://doi.org/10.1016/j.jsurg.2020.05.003.
6. Engberg M, Taudorf M, Rasmussen NK, Russell L, Lönn L, et al. Training and assessment of competence in resuscitative endovascular balloon occlusion of the aorta (REBOA)—a systematic review. Injury. 2020;51:147–56.
7. van der Borger Burg BLS, Hörer TM, Eefting D, van Dongen TTCF, Hamming JF, et al. Vascular access training for REBOA placement: a feasibility study in a live tissue-simulator hybrid porcine model. J R Army Med Corps. 2019;165:147–51.
8. Brede JR, Lafrenz T, Krüger AJ, Søvik E, Steffensen T, et al. Resuscitative endovascular balloon occlusion of the aorta (REBOA) in non-traumatic out-of-hospital cardiac arrest: evaluation of an educational programme. BMJ Open. 2019;9:e027980.

9. Neequaye SK, Aggarwal R, Van Herzeele I, Darzi A. Cheshire NJ Endovascular skills training and assessment. J Vasc Surg. 2007;46:1055–64.
10. Villamaria CY, Eliason JL, Napolitano LM, Stansfield RB, Spencer JR, et al. Endovascular Skills for Trauma and Resuscitative Surgery (ESTARS) course: curriculum development, content validation, and program assessment. J Trauma Acute Care Surg. 2014;76:929–35.
11. Grabo D, Polk T, Minneti M, Inaba K. Demetriades D Brief report on combat trauma surgical training using a perfused cadaver model. J Trauma Acute Care Surg. 2020;89:S175–9.
12. Burkard DJ, Thompson J, Dull M, Haverkamp J, Koestner A, et al. Resuscitative endovascular balloon occlusion of the aorta process improvement: examining a novel case evaluation tool and standardized simulations. J Trauma Nurs. 2020;27:82–7.
13. Darrabie MD, Croft CA, Brakenridge SC, Mohr AM, Rosenthal MA, et al. Resuscitative endovascular balloon occlusion of the aorta: implementation and preliminary results at an academic level I trauma center. J Am Coll Surg. 2018;227:127–33.