



Case report

Resuscitative endovascular balloon occlusion of the aorta (REBOA) successfully used in interhospital transport

Nung-Sheng Lin^a, I-Lin Wu^a, Po-Lu Li^a, Yu-Xuan Jiang^a, Yen-Yue Lin^{a,b,*}^a Department of Emergency Medicine, Taoyuan Armed Forces General Hospital, National Defense Medical Center, Taoyuan, Taiwan^b Department of Emergency Medicine, Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan

ARTICLE INFO

Keywords:Resuscitative endovascular balloon occlusion of the aorta (REBOA)
Major trauma
Pelvic fracture
Interhospital transfer
Ischemia time

ABSTRACT

Resuscitative endovascular balloon occlusion of the aorta (REBOA) is primarily utilized in traumatic noncompressible torso hemorrhage as a temporary approach to buying time until a definite intervention could be obtained. REBOA is mostly reported in in-hospital or pre-hospital settings. Its interhospital transfer use remains controversial. In this report, we present a case with pelvic fracture and hemorrhagic shock who underwent REBOA placement and was transferred from a local hospital to a trauma center successfully for further surgical intervention.

1. Introduction

Resuscitative endovascular balloon occlusion of the aorta (REBOA) helps control exsanguination from noncompressible torso hemorrhage [1]. In REBOA, the aorta is temporarily occluded using an endovascular balloon to decrease injury site bleeding and support cerebral and myocardial perfusion [1,2]. REBOA may be indicated for in-hospital transfer between the emergency department and the operating room, or pre-hospital use [2,3]. However, its use for interhospital transfer remains controversial, and the only reported case of interhospital transfer had a poor outcome.

[3]. Herein, we report a patient with hemorrhagic shock who was successfully transferred from a local hospital to a trauma center through REBOA implantation.

2. Case report

A 65-year-old female with hypertension and type 2 diabetes mellitus was sent to the Emergency department (ED) because of a traffic accident. She was hit by a car from her left side while riding a scooter. Initially, she was lethargic (GCS, E3V1M5; blood pressure, 85/54 mmHg; heart rate, 129 beats/minute). Pupils are symmetrical, 3 mm in diameter, and reactive to light with spontaneous limb movements. A left frontal hematoma, facial and scalp abrasions, swelling, and bruising on all four limbs, as well as deformities in both lower limbs, were revealed upon complete dressing. She was intubated and a larger bore intravenous catheter was inserted to transfuse 6 units of type-O concentrated RBC. Despite crystalloid hydration and blood transfusion, blood pressure continued to fall during resuscitation. Brain Computed tomography (CT) revealed right-sided minimal subdural hemorrhage and linear skull fractures (Fig. 1), and pelvic CT showed pelvic fracture (LC II; Young–Burgess classification), left-hip joint fracture with dislocation (Fig. 2), and fractures in both fibula and tibia bones. A pelvic binder was used to stabilize pelvic fracture and a trauma center was contacted to begin

* Corresponding author. No.168, Zhongxing Rd., Longtan Dist., Taoyuan City, 325, Taiwan.
E-mail address: yyline.tw@yahoo.com.tw (Y.-Y. Lin).

<https://doi.org/10.1016/j.heliyon.2024.e24525>

Received 23 March 2023; Received in revised form 6 January 2024; Accepted 10 January 2024

Available online 24 January 2024

2405-8440/© 2024 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

the transfer process. With ongoing shock, the left femoral artery was punctured percutaneously and an 8 French sheath was placed. A 7 French REBOA (Tokai Medical Products, Aichi, Japan) was inserted through the sheath at the 28 cm mark (zone 3). Sonography was used to verify that the REBOA was in the abdominal aorta. Initially, 2 ml of water was inflated into the balloon and the blood pressure trace at the side port of the sheath had significantly disappeared by the time 4 ml of water was inflated. Sonography was used again to confirm that the balloon was in zone 3 just above the aortic bifurcation. The mobile phone was used to keep in touch with the trauma center staff, informing them of the exact time of occlusion and preparing the transarterial embolization (TAE) room early for this patient. Consequently, her systolic blood pressure increased to 110 mmHg. Subsequently, she was transported to the trauma center immediately (38 km away) via an ambulance for approximately 38 min (total occlusion time: 80 min). An experienced special nurse and paramedic were arranged in the ambulance to provide continuous 4 units of matched concentrated erythrocyte transfusion with 6 units of fresh frozen plasma and maintenance of the REBOA line during the transfer. The patient immediately underwent TAE from the right femoral artery on arrival at the trauma center. The left inferior gluteal artery showed truncated with extravasation and bilateral internal iliac arteries were embolized with 10 ml Gelfoam on each side. The REBOA was left in place during TAE and removed after TAE. Further orthopedic surgeries were completed in various stages over the next few days. Eventually, she survived, and on hospital day 26, she was discharged with cognitive dysfunction, and memory loss and needed personal care for daily living. A planned rehabilitation program continued.

3. Discussion and conclusions

This case of REBOA performed in the ED with a successful interhospital transfer is the first to be reported in Taiwan. Current guidelines, such as ATLS, recommend interhospital transfer whenever the first institution cannot sufficiently provide patients' treatment needs [4]. Patients with major trauma should be sent to the nearest hospital for resuscitation and then transferred to a trauma center for a better prognosis [5]. Taiwan has a good medical and hospital grading system, forming a complete medical network, and interhospital transfer is common and efficient. REBOA could prolong time and sustain patients' vitality for further damage control surgery [6,7]. It may play a role in stabilizing patients with major trauma during their transfer to a higher-level trauma center.

Traumatic hemorrhage from noncompressible torso injuries is a leading cause of death in military and civilian trauma [6,8]. Although the favorable time limit for inflation remains unknown, a goal of less than 30 min and approximately 90 min of occlusion in zones 1 and 3, respectively, are suggested [9,10]. "Partial" or "intermittent" aortic occlusion of REBOA allows a low-volume aortic flow to distal organs, thereby proposed as a technique to alleviate complete occlusion's ischemic consequences [10]. If a longer transfer time is needed, partial aortic occlusion could be suitable to minimize serious complications. Our patient had serious and life-threatening trauma, but her injuries were mainly under the pelvic and lower-limb regions, thereby suitable for REBOA placement in zone 3 and allowing her to endure longer ischemic time. In addition, our patients' transfer time was below the ischemic time limit (both under 90 min). These two major key factors may make the interhospital transfer successful.

An occlusion time beyond 30–60 min increases metabolic derangement, causing organ damage [11]. The most commonly reported complications of REBOA include arterial injury, lower-extremity ischemia, arterial thrombosis/embolism, balloon migration from the initial zone of placement, and over-inflation-induced balloon rupture. Other less common complications are extremity compartment syndrome, hematoma formation at the site of access, bowel ischemia, and local infection. Acute kidney injury and extremity amputation were also reported [12]. REBOA usage may increase limb ischemia and reperfusion problems, so the need for crushing limb amputation should be considered as an early decision.

The effect of REBOA on the progression of traumatic brain injury (TBI) is controversial. REBOA may cause cerebral edema due to increased blood and intracranial pressure, which has been speculated to be detrimental. However, increased mean arterial pressure caused by REBOA may improve cerebral perfusion. One small study showed mortality and complications with REBOA do not differ between patients with and without concomitant TBI [13]. Most of the patients indicated for the use of REBOA are severely injured, like our patient, and maintaining blood pressure to keep the patient alive was the most important thing, despite the possibility of a

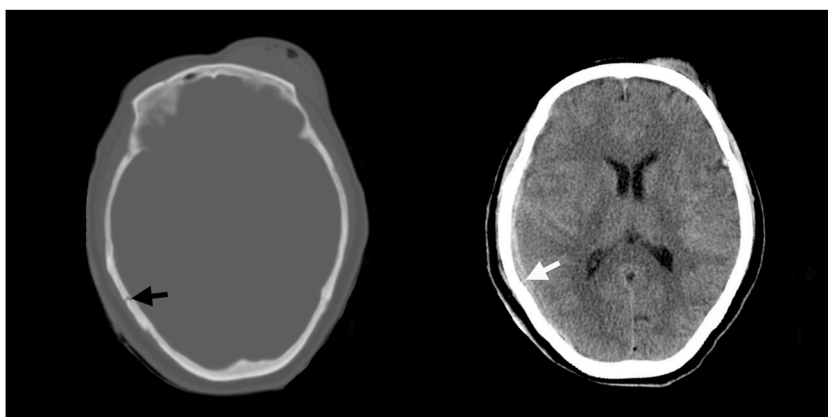


Fig. 1. Axial non-contrast CT of the brain showing right-sided skull fracture (black arrow) with adjacent small subdural hemorrhage (white arrow).



Fig. 2. 3D reconstruction computed tomography showing a pelvic fracture and a left-hip posterior dislocation with an acetabular fracture.

deteriorating brain hemorrhage. The use of REBOA may provide the last chance for the patient to be transferred to a trauma center. Our patient suffering from traumatic shock resulting from pelvic fractures and lower-limb injuries was successfully transferred to a trauma center by REBOA implantation. Emergency physicians may consider using REBOA in interhospital transfer if the transfer time is estimated to be below 90 minutes for patients suitable for zone 3 REBOA implantation. Further research is needed to determine the safety and efficiency of REBOA placement in interhospital transfer.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Data included in article/supp. Material/referenced in article.

A statement of informed consent

Informed consent was acquired from the patient and that the patient consented to the publishing of all images, clinical data, and other data included in the manuscript.

Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Nung-Sheng Lin: Writing – original draft, Data curation. **I-Lin Wu:** Funding acquisition, Conceptualization. **Po-Lu Li:** Writing – review & editing. **Yen-Yue Lin:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

Authors declare no actual or potential conflict of interest.

References

- [1] C.E. Van Skike, D.G. Baer, M.C. Spalding, M. Radomski, Complete and partial resuscitative endovascular balloon occlusion of the aorta for hemorrhagic shock, *J. Vis. Exp.* (2022), <https://doi.org/10.3791/63767>, 183.
- [2] R. Lendrum, Z. Perkins, M. Chana, M. Marsden, R. Davenport, G. Grier, et al., Pre-hospital resuscitative endovascular balloon occlusion of the aorta (REBOA) for exsanguinating pelvic haemorrhage, *Resuscitation* 135 (2019) 6–13, <https://doi.org/10.1016/j.resuscitation.2018.12.018>.
- [3] J. Zhang, J.D. Watson, C. Drucker, R. Kalsi, R.S. Crawford, S.A. Toursavadkoshi, et al., Resuscitative endovascular balloon occlusion of the aorta (REBOA) not yet applicable for widespread out-of-hospital use: a case of nonsurvivable complication from prolonged REBOA inflation, *Ann. Vasc. Surg.* 56 (2019) 354, <https://doi.org/10.1016/j.avsg.2018.08.108>, e5- e9.
- [4] American College of Surgeons: The Committee on Trauma, *Advanced Trauma Life Support: Student Course Manual*, American College of Surgeons, Chicago, 2018, pp. 242–252, 13.

- [5] J.C. Van Ditshuizen, C.R.L. Van Den Driessche, C.A. Sewalt, E.M.M. Van Lieshout, M.H.J. Verhofstad, D. Den Hartog, The association between level of trauma care and clinical outcome measures: a systematic review and meta-analysis, *J. Trauma Acute Care Surg.* 89 (4) (2020) 801–812, <https://doi.org/10.1097/ta.0000000000002850>.
- [6] P. Marciniuk, R. Pawlaczyk, J. Rogowski, J. Wojciechowski, L. Znanięcki, Reboa - new era of bleeding control, literature review, *Pol. Przegl. Chir.* 92 (2) (2019) 42–47, <https://doi.org/10.5604/01.3001.0013.5426>.
- [7] S.T. Hsu, Y.K. Fu, H.Y. Lin, W.C. Chiang, Y.C. Chiu, J.T. Sun, et al., Resuscitative endovascular balloon occlusion of the aorta for traumatic cardiopulmonary arrest in the emergency department: the first case with successful return of spontaneous circulation in Taiwan, *J Acute Med* 12 (3) (2022) 126–130, [https://doi.org/10.6705/j.jacme.202209_12\(3\).0006](https://doi.org/10.6705/j.jacme.202209_12(3).0006).
- [8] M.A. Thrailkill, K.H. Gladin, C.R. Thorpe, T.R. Roberts, J.H. Choi, K.K. Chung, et al., Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA): update and insights into current practices and future directions for research and implementation, *Scand. J. Trauma Resuscitation Emerg. Med.* 29 (1) (2021) 8, <https://doi.org/10.1186/s13049-020-00807-9>.
- [9] J. Inoue, A. Shiraishi, A. Yoshiyuki, K. Haruta, H. Matsui, Y. Otomo, Resuscitative endovascular balloon occlusion of the aorta might be dangerous in patients with severe torso trauma: a propensity score analysis, *J. Trauma Acute Care Surg.* 80 (4) (2016) 559–566, <https://doi.org/10.1097/ta.0000000000000968>. ; discussion 66-7.
- [10] H. Ando, R.H. Kaszynski, H. Goto, On-site placement of resuscitative endovascular balloon occlusion of the aorta (REBOA) in a hemorrhagic shock patient: a successful endeavor involving long-distance air transport, *Am. J. Emerg. Med.* 55 (2022) 227, <https://doi.org/10.1016/j.ajem.2021.12.055>, e1-e3.
- [11] V.A. Reva, Y. Matsumura, T. Horer, D.A. Sveklov, A.V. Denisov, S.Y. Telickiy, et al., Resuscitative endovascular balloon occlusion of the aorta: what is the optimum occlusion time in an ovine model of hemorrhagic shock? *European J. Trauma Emergency Surgery: Official Publication European Trauma Societ.* 44 (4) (2018) 511–518, <https://doi.org/10.1007/s00068-016-0732-z>.
- [12] K. Kinslow, A. Shepherd, M. McKenney, A. Elkbuli, Resuscitative endovascular balloon occlusion of aorta: a systematic review, *Am. Surg.* 88 (2) (2022) 289–296, <https://doi.org/10.1177/0003134820972985>.
- [13] T. Ogura, A.K. Lefor, M. Nakamura, K. Fujizuka, K. Shiroto, M. Nakano, Ultrasound-guided resuscitative endovascular balloon occlusion of the aorta in the resuscitation area, *J. Emerg. Med.* 52 (5) (2017) 715–722, <https://doi.org/10.1016/j.jemermed.2017.01.014>.