



# Journal of Endovascular Resuscitation and Trauma Management

Volume 3, Issue 2, Summer 2019, ISSN: 2002-7567

## Issue highlights

Damage Control Interventional Radiology for Critically Unstable Patients

Partial REBOA in Elderly Patients and in rAAA

Thrombolysis for Trauma-associated Inferior Vena Caval Thrombosis

Zone III REBOA for Temporary Control of Pelvic Bleeders...

Selected abstracts from the EVTm symposium St. Petersburg 2019



# JEVTM

## Journal of Endovascular Resuscitation and Trauma Management

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**This is the** *Journal of Endovascular Resuscitation and Trauma Management*. We want to provide a truly Open Access platform for the dissemination of knowledge and peer-reviewed research in the field of endovascular and hybrid hemorrhage control.

To achieve this, we do not wish to be bound by medical discipline, country, resource or even the conventional rules of medical publishing. To achieve this goal, we have assembled an Editorial Board of clinicians and scientists who are experts within the field. This project is generously supported by a grant from Örebro University Hospital Research Unit.

We are keen to receive manuscript submissions that present new original findings, review important topics or educate our readers on any aspect of hemorrhage control, where an endovascular technique has been employed. This can either be in isolation or in combination with open surgical techniques (hybrid surgery). For further information for authors, please see [www.jevtm.com](http://www.jevtm.com).

As the subject of hemorrhage and resuscitation is a common problem across many medical disciplines, we encourage submissions from all specialties: vascular, trauma, acute care, obstetrics, emergency medicine, to mention a few.

The Journal will publish quarterly and will be truly Open Access. There will be no article processing charges or publishing fees. All articles will be published online and indexed using a digital object identifier. The Journal aims to be PubMed cited by 2019.

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# Author Guidelines

A manuscript submitted to the Journal must constitute a unique piece of work that is not under consideration for publication, in part or whole, by another journal. Submissions should preferably be produced using Microsoft Word, although other formats will be considered.

The submission process requires three discreet documents:

1. Cover Letter
2. Title Page
3. Manuscript (including Abstract, Tables and Figures)

## Cover Letter

This should be written by the corresponding author and must contain the following:

1. The type of manuscript submission (Original Article, Review Article etc)
2. A sentence or two on the subject of the study.
3. Confirmation that the study is not under consideration for publication by another journal.
4. Confirmation that all of the authors have made a substantial contribution to the manuscript and that they have seen and approved the submission draft.
5. A conflict-of-interest statement regarding the authors. Where there is none, this should be clearly stated.

## Title Page

This should consist of the following:

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## Main Body

This should consist of text in 12 pts, double spaced with a justified margin, written in US English. While each article type has specified headings, the use of sub-headings is encouraged to aid clarity. These should be formatted as follows:

Main Heading Bold  
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The abstract should be a maximum of 250 words and consist of the following headings:

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Methods  
Results  
Conclusions

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This style of article can afford the author considerable latitude in examining a pertinent topic in endovascular hemorrhage control. The literature should be examined objectively and presented to the reader in the context of current understanding. The author should be able to synthesize a narrative, which leaves the reader with a good understanding of an emerging or controversial topic. The author is welcome (and encouraged) to express an opinion, but where this is the case, it should be clearly stated.

Articles should be a maximum of 5000 words. There is no formal structure; however, the use of logical headings/sub-headings is important to enable readers to follow the article easily. The abstract should also be unstructured and be a maximum of 150 words.

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## Tips and Techniques

In the evolving world of endovascular hemorrhage control, the advice and opinion of actively practicing clinicians is of great importance. Both solicited and unsolicited submissions are reviewed, both on major or minor components on endovascular techniques. This can be presented in the context of "evidence" or just as an opinion. The use of quality images and diagrams is encouraged. The submission should be a maximum of 1500 words.

# Author Guidelines

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Rather than accept case reports, the Journal will prefer images of interest, which include a short commentary. The aim of this section is to demonstrate and illustrate an educational message, rather than just to demonstrate dramatic pathology. Images can be submitted as a multi-panel with a series of scans/photographs in order to support the message presented in the narrative. The submission should be a maximum of 250 words.

## Resident Corner

Short article managed and written by residents (no senior authors) with educational value (max word count 1500)

## Support for Language and Article Content

The aim of the Journal, in addition to the dissemination of peer-reviewed evidence, is to support English-second-language authors and early career scientists. Provided that a submitted manuscript has good scientific merit, the Journal is able to provide a free language editing service. Furthermore, where article content would benefit from high-quality figures, artwork can be commissioned to support the publication.

## References

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An example article:

Stannard W, Rutman A, Wallis C, O'Callaghan C. Central microtubular agenesis causing primary ciliary dyskinesia. *Am J Respir Crit Care Med.* 2004;169:634.

Where there are more than six authors, the first three should be included followed by et al .

## Supplementary Digital Content

Where manuscripts would benefit from additional content (datasets, images, video), which does not necessarily need inclusion in the published article, supplementary digital content (SDC) can be hosted. This includes, but is not limited to, tables, figures or video. Authors should include in their cover letter a description of this content and its purpose.

## Ethical & Legal Considerations

A submitted manuscript must be an original contribution not previously published (except as an abstract and should be indicated); Cannot be under consideration for publication in other journals; and, if accepted, must not be published or reproduced elsewhere. The final responsibility for the scientific accuracy and validity of published manuscripts rests with the authors, not with the Journal, its editors, or the publisher (Örebro University Hospital).

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It is the authors's responsibility to ensure that a patient's anonymity is protected, to verify that any experimental investigation with human subjects reported in the manuscript was performed with informed consent and follows all the guidelines for experimental investigation with human subjects required by the institution(s) with which all the authors are affiliated and/or ethical committee processing. Authors are asked to comply with the general guidelines for integrity protection, as listed by the health ministries in the EU, the EU commission and US department of health. (example: <https://www.hhs.gov/hipaa/forprofessionals/special-topics/research/index.html>). Authors should mask patient's eyes and always remove patient names from figures as well as genital organs as possible.

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All studies of human subjects must contain a statement within the Methods section indicating approval of the study by an institutional review body (i.e. Institutional Review Board or ethical committee), and, if appropriate, a statement confirming that informed consent was obtained from all subjects if possible. If no legally informed consent can be obtained, such as in research carried out with human subjects receiving emergency treatment, authors should indicate as possible if a waiver of regulatory requirements for obtaining and documenting informed consent applies.

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## General statement

Patients have a right to privacy that should not be infringed without informed consent. Identifying information, including patients' names, initials, or hospital numbers, should not be published in written descriptions, photographs, and pedigrees unless the information is essential for scientific purposes and the patient (or parent or guardian) gives written informed consent for publication. Informed consent for this purpose requires that a patient who is identifiable be shown the manuscript to be published. Authors should identify Individuals who provide writing assistance and disclose the funding source for this assistance.

Identifying details should be omitted if they are not essential. Complete anonymity is difficult to achieve, however, and informed consent should be obtained if there is any doubt. For example, masking the eye region in photographs of patients is inadequate protection of anonymity. If identifying characteristics are altered to protect anonymity, such as in genetic pedigrees, authors should provide assurance that alterations do not distort scientific meaning and editors should so note.

The requirement for informed consent should be included in the journal's instructions for authors. When informed consent has been obtained it should be indicated in the published article.

- *International Committee of Medical Journal Editors ("Uniform Requirements for Manuscripts Submitted to Biomedical Journals") -- February 2006*

JEVTM follows guidelines and best practices published by professional organizations, including Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals by ICMJE, and Principles of Transparency and Best Practice in Scholarly Publishing (joint statement by COPE, DOAJ, WAME and OASPA).

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# Introduction to the Sixth Edition of the JEVTM

**Igor M Samokhvalov MD PhD Colonel (Ret.)**

*Honoured Physician of the Russian Federation, Deputy Chief Surgeon of the Russian Army,  
Professor and Chair of War Surgery Department, Kirov Military Medical Academy, Saint-Petersburg, Russia*

Dear Readers,

Welcome to the second edition of the JEVTM!

In 1866, the Great Russian surgeon and scientist Nikolai Pirogov wrote: “A new era for surgery will begin, if we can quickly and surely control the flow in a major artery without exploration and ligation”. This era has now arrived and it is called EVTm. Our mission has been to maximize the benefits of endovascular technologies for trauma and bleeding patients: from the first attempts of REBOA by Carl Hughes in the 1950s with hand-made aortic balloon occlusion catheters used in our department since the early 1990s, to modern successful cases of out-of-hospital REBOA use in combat and civilian casualties for ruptured aneurysms, post-partum hemorrhage and trauma.

In this edition, you will find articles related to a new strategy of damage control interventional radiology (DCIR), partial REBOA in elderly patients and in ruptured aortic aneurysms, thrombolysis for trauma-associated

inferior vena cava (IVC) thrombosis, simulation models for training of REBOA, contemporary utilization of Zone III REBOA, and more.

As a continuation of EVTm development, Russian surgeons, emergency physicians, anesthetists, and others will be involved in the world of EVTm, participating in expanding the horizons of trauma care and cultivating the endovascular mindset. Also published in this edition are some of the abstracts that will be presented at the EVTm conference in Russia, St. Petersburg (7 June 2019). More than 35 oral and 30 poster presentations will make this conference a scientific feast for our audience. By adopting these new techniques for bleeding management, we are following Pirogov’s motto—to achieve fast endovascular hemorrhage control—which can only be done as part of an interdisciplinary approach.

We look forward to seeing you in Saint Petersburg at the EVTm-Russia meeting!

[www.evtm.org](http://www.evtm.org)

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# Contemporary Utilization of Zone III REBOA for Temporary Control of Pelvic and Lower Junctional Hemorrhage Reliably Achieves Hemodynamic Stability in Severely Injured Patients

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Joseph Dubose MD RVPI FACS FCCM<sup>1</sup> and AAST AORTA Study Group

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**Background:** Aortic occlusion is a valuable adjunct for the management of traumatic pelvic and lower extremity junctional hemorrhage.

**Methods:** The American Association for the Surgery of Trauma Aortic Occlusion in Resuscitation for Trauma and Acute Care Surgery registry was reviewed for patients requiring Zone III resuscitative endovascular balloon occlusion of the aorta (REBOA) from eight verified trauma centers. After excluding patients in arrest, demographics, elements of treatment, and outcomes were identified.

**Results:** From November 2013 to December 2016, 30 patients had Zone III REBOA placed. Median age was 41.0 (interquartile range, IQR, 38); median injury severity score was 41.0 (IQR 12). Hypotension (SBP < 90 mm Hg) was present on admission in 30.0% and tachycardia (HR > 100 bpm) in 66.7%. Before REBOA placement, vital signs changed in this cohort with hypotension in 83.3% and tachycardia noted in 90%. Median initial pH was 7.14 (IQR 0.22), and median admission lactate 9.9 mg/dL (IQR 5). Pelvic binders were utilized in 40%. Occlusion balloon devices included Coda™ (70%), ER REBOA™ (13.3%), Reliant™ (10%). After REBOA, hemodynamics improved in 96.7% and stability (BP consistently > 90 mm Hg) was achieved in 86.7%. Median duration of REBOA was 53.0 mins (IQR 112). Median PRBC and FFP requirements were 19.0 units (IQR (17) and 17.0 units (IQR 14), respectively. One amputation unrelated to REBOA utilization was required. Systemic complications included AKI (23.3%) and MODS (10%). REBOA specific complications included groin hematoma (3.3%) and distal thromboembolization (16.7%). Survival to discharge was 56.7%, with in-hospital deaths occurring in the ED 7.7%, OR 23.1%, ICU 69.2%.

**Conclusions:** This review discusses the specifics of the contemporary use of Zone III REBOA placement as well as local and systemic complications for patients in extremis with pelvic/junctional hemorrhage. Further review is required to determine optimal patient selection.

**Keywords:** Zone III REBOA; Pelvic Bleeding; Junctional Hemorrhage

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**Author contributions:** JP was the primary author, performed literature searches, study design, data analysis, interpretation, and writing. MB performed study design, data analysis, interpretation, and critical revision. AP performed data analysis and interpretation as well as critical revision. LM performed study design and data collection. TS performed study design and critical revision. JD performed study design, data collection, data analysis, data interpretation, and critical revision.

**Conflicts of interest:** MB, Clinical Advisory Board Member, Prytime Medical; JP, Speaker, Prytime Medical.

**Funding:** None.

**Presentation:** This data was presented at the 31st Annual Eastern Association for the Surgery of Trauma, January 12, 2018, in Lake Buena Vista, FL.

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## INTRODUCTION

Hemorrhage remains the leading cause of preventable death in both the civilian and military sectors, with a majority of patients having noncompressible torso hemorrhage (NCTH) in the truncal or junctional regions [1,2]. In patients with pelvic fractures or junctional bleeding, a multidisciplinary approach is necessary consisting of interventions performed in the pre-hospital setting, the trauma bay, the operating room (OR) and/or the angiographic suite.

Previously, in patients with exsanguinating pelvic hemorrhage, the only methods for immediate bedside control consisted of ongoing blood transfusion as well as pelvic wrapping with a binder or sheet. If the patient came into the trauma bay in cardiac arrest or progressed to cardiac arrest, open thoracic aortic cross-clamping has been used for proximal control with poor survival [3].

Balloon occlusion of the aorta, originally described for abdominal aortic rupture in the setting of vascular disease [4,5] has been modified to develop a similar strategy for NCTH [6]. The effectiveness of resuscitative balloon occlusion of the aorta (REBOA) for traumatic hemorrhage has been shown in multiple animal models [7] and through clinical experience [8].

In certain centers, REBOA has become an important adjunct in the treatment of life-threatening abdominal, pelvic, and junctional hemorrhage. In these centers, this procedure has essentially replaced emergency department thoracotomy with open aortic cross-clamping in traumatic arrest resulting from bleeding at these same locations [9].

The authors believe that Zone III REBOA offers a minimally invasive approach for proximal control in pelvic and junctional bleeding. In specific patients, arresting hemorrhage at the aortic bifurcation may stabilize patients, by decreasing bleeding and may facilitate hemodynamic stability for these patients to travel to more definitive care beyond the emergency department.

We utilized the American Association for the Surgery of Trauma (AAST) Aortic Occlusion for Resuscitation in Trauma and Acute Care Surgery (AORTA) database to examine the contemporary utilization of distal (Zone III) REBOA for management of traumatic pelvic and lower extremity junctional hemorrhage.

## METHODS

The AAST AORTA registry is a prospectively collected observational database, reporting aortic occlusion by endovascular and open means for all noncompressible torso trauma.

The prospective observational AORTA study was approved by the AAST Multicenter Trials Committee. All data were obtained from level I and level II trauma centers, as verified by the American College of Surgeons. All centers obtained individually local institutional

review board approval before participation. Data were collected prospectively and entered by registrars, designated by individual centers, into the online data collection portal resource developed by AAST.

Adult trauma patients (age 18 or older) undergoing Zone III REBOA placement were examined. Data included patient's demographics, admission physiology, admission laboratory results, and injury severity score (ISS). The timing, type, delivery, and duration of Zone III balloon occlusion were recorded. The physiologic response was recorded with hemodynamic stability for the AORTA trial defined as SBP consistently >90 mm Hg after inflation. Patient transfusion requirements, subsequent systemic and local complications, as well as outcomes, were reviewed.

AORTA registry patients requiring Zone III REBOA from eight American College of Surgeons verified level I and level II trauma centers were examined. Patients presenting in cardiac arrest at the time of aortic occlusion (AO) were excluded from this study, as it is the opinion of the authors that Zone I REBOAs should be placed in this case for exsanguination below the diaphragm, whether the source is abdominal or pelvic/junctional. Demographics and elements of treatment and outcomes were identified.

Values are reported as means  $\pm$  standard deviation (SD) for continuous variables with normal distributions as determined by the assessment of a skewness calculation. Continuous variables not possessing normal distribution are reported as median and interquartile range (IQR). Categorical variables are expressed as percentages. All analyses were performed using the Statistical Package for Social Sciences (SPSS Mac) version 22.0 (SPSS Inc, Chicago, IL).

## RESULTS

From November 2013 to December 2016, 30 patients meeting the criteria were identified with Zone III REBOA placement, among eight contributing ACS level I and level II trauma centers. The majority of patients were male ( $n = 25$ , 83.3%), with a mean age of 41 (IQR 38) years. The most common mechanism was blunt ( $n = 29$ , 96.7%) with nearly a third ( $n = 9$ , 30%) injured by motor vehicle accident, followed by pedestrian versus automobile, motorcycle crash, fall, unknown blunt mechanism, and then gunshot wound. Hypotension (systolic blood pressure (SBP) < 90 mm Hg) was present on admission in 30.0% and tachycardia (heart rate (HR) > 100 bpm) in 66.7%. Before REBOA placement, vital signs changed in this cohort with hypotension noted in 83.3% and tachycardia noted in 90%. Mean initial pH was 7.14 (IQR 0.22), and mean admission lactate 9.9 mg/dL (IQR 5). The mean ISS was 38 (IQR 12). Patients had a mean intensive care unit (ICU) length of stay (LOS) of 15 (IQR 14) days and a mean hospital LOS of 26 (IQR 40) days (Table 1).

**Table 1** Demographics of study population.

	<i>N</i> = 30
<b>Age, y (IQR)</b>	41 ± 38
<b>Male, <i>n</i> (%)</b>	25 (83.3)
<b>Mechanism, <i>n</i> (%)</b>	
Blunt	29 (96.7)
Motor vehicle accident	9 (30)
Pedestrian vs auto	6 (20)
Motorcycle crash	6 (20)
Fall	5 (16.6)
Unknown blunt mechanism	4 (13.3)
<b>Penetrating</b>	1 (3.3)
GSW	1 (3.3)
<b>Admission parameters</b>	
Hypotension < 90 mmHg, <i>n</i> (%)	9 (30)
Tachycardia >100 mmHg, <i>n</i> (%)	20 (66.7)
Admission pH	7.14 (0.22)
Admission lactate, mg/dL	9.9 (5)
Admission GCS	8 ± 5.63
<b>Preplacement parameters</b>	
Hypotension < 90 mmHg, <i>n</i> (%)	25 (83.3)
Tachycardia >100 mmHg, <i>n</i> (%)	27 (90)
<b>ISS</b>	38 (16.8)
<b>Intubated on admission, <i>n</i> (%)</b>	12 (40)
<b>ICU LOS, d</b>	15 (14)
<b>Hospital LOS, d</b>	26 (40)
<b>Discharge disposition, <i>n</i> (%)</b>	
Rehab/Nursing facility	16 (53.3)
Home	1 (3.3)
<b>Mortality</b>	13 (43.3)

GSW, gunshot wound; GCS, Glasgow coma score; ISS, injury severity score; ICU, intensive care unit; LOS, length of stay.

For REBOA placement, a majority (66.6%) were placed in the emergency department with the remainder in the OR. The operating physician was typically a Trauma/Acute Care Attending in 80%, followed by Trauma/Acute Care Fellow, Surgical Resident, and Vascular Attending. Techniques for access included percutaneous with landmarks in 50%, ultrasound guidance in 30%, with the remainder via fluoroscopy or cut down. Facilitating positioning was performed via plain film in 50%, fluoroscopy in 16.7%, and via ultrasound in 3.3%. No imaging (using external landmarks only) was the approach employed in 26.7%, and for 3.3% the approach utilized was not adequately described. Occlusion balloon devices included Coda™ (Cook Medical, Bloomington, IN) in a majority (70%), followed by ER

**Table 2** REBOA placement.

	<i>N</i> = 30, <i>n</i> (%)
<b>Location of AO attempt</b>	
ER	20 (66.6)
OR	10 (33.3)
<b>Technique for access</b>	
Percutaneously with landmarks only	15 (50)
US	9 (30)
Fluoroscopy	3 (10)
Cut down	2 (6.6)
Not adequately described	1 (3.3)
<b>Background of operator</b>	
Trauma/ACS Attending	24 (80)
Trauma/ACS Fellow	1 (3.3)
Surgical Resident	1 (3.3)
Vascular Attending	1 (3.3)
Not adequately described	3 (10)
<b>Imaging to facilitate positioning</b>	
None/external landmarks	8 (26.7)
Plain film	15 (50)
C-arm fluoroscopy	5 (16.7)
Ultrasound	1 (3.3)
Not adequately described	1 (3.3)
<b>Type of balloon</b>	
Coda	21 (70)
ER REBOA	4 (13.3)
Reliant	3 (10)
Not adequately described	2 (6.6)

ER, emergency Room; OR, operating room; US, ultrasound; ACS, acute care surgery.

REBOA™ (Prytime, Boerne, TX), and Reliant™ (Medtronic, Minneapolis, MN) (Table 2).

Zone III AO was successful in all patients (*n* = 30, 100%). Hemodynamics improved in 29 patients (96.7%). Hemodynamic stability consistently above 90 mm Hg was noted in 86.7% of patients. The median duration of occlusion was 53 minutes (IQR 112). Transfusions were required in all patients. The median number of packed red blood cells (PRBC) was 19 units (IQR 17) and fresh frozen plasma (FFP) 17 units (IQR 14), respectively (Table 3).

Pelvic binders were present on arrival in 30% of patients. Six patients (20%) had no additional documented procedures noted; however, two of these patients expired, one in the emergency department and the other in the OR. Ten patients (33.3%) had single modality treatment following Zone III REBOA, with six patients requiring exploratory laparotomy with associated

**Table 3** Results of aortic occlusion at Zone III and associated procedures.

	N = 30, n (%)
<b>AO successful</b>	
yes	30 (100)
<b>HD improved</b>	
Yes	29 (96.7)
<b>HD stable</b>	
SBP consistently > 90 mm Hg	26 (86.7)
<b>Duration of inflation, min (IQR)</b>	53.0 (112)
<b>Transfusion</b>	
PRBC	19 (17)
FFP	17 (14)
<b>Pelvic binder</b>	12 (30)
<b>Associated procedures</b>	
None	6 (20)
<b>Single modality</b>	10 (33.3)
Ex Lap alone	6 (20)
PP alone	1 (3.3)
Ex Fix alone	2 (6.7)
AE alone	1 (3.3)
<b>Multiple modality</b>	14 (46.7)
Ex Lap/PP	2 (6.7)
Ex Lap/PP/Ex Fix	2 (6.7)
Ex Lap/PP/AE	3 (10)
Ex Lap/Ex Fix	4 (13.3)
Ex Lap/Ex Fix/AE	1 (3.3)
PP/AE	1 (3.3)
Ex Fix/AE	1 (3.3)
<b>Additional procedures</b>	
Craniectomy	0 (0)
Thoracotomy	0 (0)

AO, aortic occlusion; HD, hemodynamics; SBP, systolic blood pressure; PRBC, packed red blood cells; FFP, fresh frozen plasma; Ex Lap, exploratory laparotomy and associated procedures; PP, pelvic packing; Ex Fix, pelvic external fixator; AE, angiographic embolization.

abdominal procedures alone, one patient requiring pelvic packing alone, two patients requiring external fixator alone, and one patient requiring angioembolization alone. Almost half of the patients ( $n = 14$ , 46.7%) required multimodal treatment following REBOA placement (Table 3). No patients in this sample size required craniectomy or thoracotomy for associated neurologic or cardi thoracic injuries.

Local complications were present in seven patients, most commonly distal embolization in five patients (16.7% of entire cohort). One of these patients also had

**Table 4** Complications and mortality.

	N = 30, n (%)
<b>Local</b>	
Hematoma	1 (3.3)
Pseudoaneurysm	0 (0)
Extremity ischemia	0 (0)
Stenosis	0 (0)
Distal embolization	5 (16.7)
Infection requiring Abx and/or drainage	2 (6.6)
Need for patch angioplasty	3 (10)
Need for arterial bypass	0 (0)
Need for amputation	1 (3.3)
<b>Systemic</b>	
Any complication/death	20 (66.7)
AKI	7 (23.3)
Sepsis/septic shock	5 (16.7)
MODS	3 (10)
Bacteremia	2 (6.6)
Paraplegia	1 (3.3)
<b>Survival to discharge</b>	17 (56.7)
<b>Hospital mortality</b>	13 (43.3)
ED	1 (7.7)
OR	3 (23.1)
ICU	9 (69.2)

Abx, antibiotics; MODS, multiple organ dysfunction syndrome; AKI, acute kidney injury; ED, emergency department; OR, operating room; ICU, intensive care unit.

a local hematoma, requiring no additional treatment. Infection locally, requiring antibiotics or surgery, was present in two patients (6.6% of entire cohort) (Table 4).

A majority of the patients ( $n = 20$ , 66.7%) experienced some type of systemic complication or death. Acute kidney injury (AKI) was the most common systemic complication ( $n = 7$ , 23.3%), followed by sepsis ( $n = 5$ , 16.7%), multiple organ dysfunction syndrome (MODS) ( $n = 3$ , 10%), bacteremia ( $n = 2$ , 6.6%), and paraplegia ( $n = 1$ , 3.3%). Seventeen patients (56.7%) survived until hospital discharge. Of the 13 deaths, initial GCS was 3 in nine patients (69.2%) with signs of life (pupillary response, organized cardiac rhythm, spontaneous movement) being completely absent in two patients (15.3%), 2/3 absent in four patients (30.7%) and 1/3 absent in three patients (23.1%) and only intact in four patients (30.7%). In regards to time to death, six patients (46.2%) died within the initial 24 hours of admission, and an additional three patients (23.1%) died within 48–72 hours of admission, and the remainder passed away between 6 and 16 days. A majority of

these survived to the ICU, where nine patients (69.2%) succumbed to their injuries, while three patients (23.1%) died in the OR and one patient (3.3%) in the emergency department (ED) (Table 4). The overall ISS trended slightly higher in the patients who died, with an increase in associated thoracic and neurologic injuries.

## DISCUSSION

In our multi-institutional study, we describe the contemporary use of REBOA in Zone III for temporary control of pelvic and lower junctional hemorrhage. Pelvic fracture with associated shock has been reported in up to 14% of patients with associated mortality rates above 30% [10]. Although the source of hemorrhage may be from somewhere other than the pelvis in these polytrauma patients, REBOA may be considered as an adjunct for hemorrhage control. REBOA may be deployed rapidly, by trained personnel, anywhere along the continuum of care to arrest or decreased hemorrhage.

Non-invasive methods, such as the pelvic binder, can be placed by Emergency Medical Services at the point of injury, decreasing the volume of the pelvis and decreasing the potential space for blood loss. If not placed in the pre-hospital environment, this can also be placed in the ED. Depending on the patient's hemodynamics and response to transfusion, potential AO can occur as a more invasive adjunct to stabilize the patient for ongoing hemorrhage control.

Angioembolization is a key adjunct in patients with pelvic fracture. Overall, 26% of our patients had pelvic embolization, either alone or in combination therapy. This value is comparable to the results of Constantini et al. from the AAST multi-institutional trial on current management of hemorrhage for severe pelvic fractures, where angioembolization was required in 9.6% of all patients presenting to the centers and in 24.7% of those presenting in shock [10].

Pre-peritoneal packing performed via a low-midline incision or Pfannenstiel incision, initially described by Smith et al. [11] was performed in nine patients (30%) after REBOA utilization, either alone ( $n = 1$ , 3.3%) or in combination with another modality, most commonly exploratory laparotomy/pelvic packing/angioembolization.

Mortality in our group reached 43.3%. This rate is similar to the published reports of pelvic fracture with hemodynamic instability, ranging from 21 to 50% [12–16]. All of the patients that died had significantly elevated ISS scores (22–57) with at least one other significant associated injury in another body system, besides pelvic trauma.

The first clinical series of the use of REBOA following trauma was by Brenner et al. in 2013. This study used all CODA balloons with wires and 12 F sheaths. This study showed an increase mean SBP for patients requiring both Zones I and III placement; however, 12.5% (3/14) of patients required amputations due to

ischemic limb complications after arterial access. Two of the three were associated with extensive associated extremity or pelvic injury and only one was a result of iatrogenic vascular injury following multiple attempts in an obese patient [17]. Our study showed one patient that required an amputation. This patient had Zone III occlusion performed with the 7 F ER REBOA. He presented with a SBP of 94 mm Hg and HR of 154 BPM with an ISS of 41. He required multiple operations initially, including exploratory laparotomy with bowel resection, as well as Ex-Fix placement. He had a prolonged hospital course (85 ICU days and 78 ventilator days) with many complications, including AKI (requiring dialysis), bacteremia, pneumonia, sepsis/septic shock requiring vasopressors, MODS, as well as local infection requiring antibiotics and surgery. No further details surrounding the amputation were noted in the registry.

In our study, a majority of the balloons were the CODA, delivered through a large 12 F sheath all of which require operative repair. Since this data was extracted, many centers have shifted to the lower profile ER REBOA catheters. Intuitively, a smaller device for delivery and deployment should have a lower complication profile than a larger, more obstructive device. The ER REBOA uses a smaller, 7 F sheath, requiring pressure to remove if done percutaneously, or a cut-down if done open. Teeter et al. showed that with the smaller device via 7 F sheath placement, no sheath related complications were identified in placement or removal during a 30 day follow-up period [18].

In regards to the variance in sheath sizes in our study, 7–12 F, local complications at the access site can occur. In the recently published Shock Trauma series, three minor reconstructions were required, due to low cannulation of the CFA, at the bifurcation or in the superficial femoral artery. Two of these complications were with the 12 F sheath, and one with the 7 F sheath [19]. Similarly, in our study, three patients required patch angioplasty, two from the 12 F group and one from the 7 F group.

This series represents contemporary practice at eight level I and level II trauma centers. With the option for endovascular AO, many centers are starting to place femoral arterial lines in an expedited fashion for any trauma patient with potential NCTH that may appear to be in shock. As seen by Hampton et al., the limiting factor in time to placement is initial arterial access, therefore in this patient population, once access is obtained, the sheath can be upsized and the catheter placed in a timely fashion [20].

This study has several limitations. The data was collected from eight level I and level II trauma centers, with their own capabilities and practice patterns. The data was predominantly taken from using the 12 F CODA, which is likely to be less commonly utilized in the era since the introduction of 7 F alternative platforms. As this is a review of registry data, several factors may not be captured, such as physician preference/perspective,

occlusion type (total, partial, intermittent occlusion) and institutional policies. Not all data fields were fully entered on every patient. Data points are also inserted as a single number and may not truly reflect the fluidity of the patient situation, specifically with hemodynamic instability. Bias in this sample population can be inferred since a significant number of patients had a high ISS with elevated AIS graded injuries in other body areas besides the abdomen with no patient undergoing a craniectomy or thoracotomy. Monitoring devices, such as an intracranial device were also not noted.

Through the AORTA registry, our experience shows that Zone III occlusion for pelvic and junction bleeding is a safe method that can be done by appropriately trained personnel at the bedside to improve and maintain blood pressure, in order to transport the patient for their next step in hemorrhage control. With continued training and use of REBOA for NCTH, the AORTA database can continue to mature and greater insight can be made in this population with the advancement of technology and adaptation of the procedure in the treatment algorithm of pelvic and junctional hemorrhage.

## CONCLUSIONS

Zone III REBOA for early control of pelvic or junctional hemorrhage in patients in extremis provides hemodynamic stability, with minimal complications, sufficient to achieve definitive control in environments beyond emergency departments. As experience increases and devices change, the AAST AORTA database can better elucidate optimal indications and outcomes for pelvic trauma.

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# Successful Partial Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) in an Octogenarian Trauma Patient

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**Background:** To perform effectively Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) in an extreme elderly trauma patient, the distinct issues that make a difference are the anatomical and physiological changes. Multiple maneuvers were performed simultaneously for favorable outcomes to balance between critical organ perfusion and bridging control of bleeding.

**Method:** We demonstrate how to perform successfully REBOA in an octogenarian patient with coma and profound hypotension on arrival. A primary survey found unstable pelvic fracture and severe head injury. Admission laboratory investigations in the intensive care unit showed normal renal and liver function with not significantly increased serum lactate.

**Conclusion:** To perform ABO/REBOA in an extremely elderly trauma patient, the partial balloon technique with a goal systolic blood pressure to balance associated injuries in polytrauma patients is essential. The specific concern in this group would be related to reserve function and changing vascular access. Techniques for detection and solving uneventful conditions should be prepared and learned to successfully save elderly patients.

**Keywords:** *Resuscitative Balloon Occlusion of the Aorta; REBOA; Trauma; Resuscitation; Hemorrhage control*

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## INTRODUCTION

Uncontrolled hemorrhage is the most common cause of preventable death in trauma patients [1]. Most cases of uncontrolled hemorrhage present with non-compressible torso hemorrhage (NCTH), such as intra-abdominal bleeding, pelvic fracture, and junctional hemorrhage, which cannot be controlled by simple hemorrhagic control methods [2]. During this endovascular intervention era, a technique called endovascular resuscitation using resuscitative endovascular balloon occlusion of the

aorta (REBOA) has been introduced to facilitate early hemorrhage control [3–9]. Compared to non-REBOA patients, REBOA showed significantly better hemorrhage control in the pelvic trauma group [5,10].

It is also important to note the anatomic and physiologic changes that develop in older patients (age >65 years) that make REBOA more challenging, such as atherosclerosis and organ reserve, respectively. These concerns must be considered and addressed in addition to the customary resuscitation concerns and objectives that include bridge

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therapy and critical organ perfusion. This case was complex because we had to balance between the need for damage control resuscitation [11] and the simultaneous need not to worsen the patient's traumatic brain injury (TBI). It is challenging to balance these two opposing objectives, especially when Advanced Trauma Life Support (ATLS®) protocol [12] calls for maintenance of blood pressure above the average to ensure adequate perfusion to critical organs, such as the brain.

However, the supraphysiologic pressure that is caused by REBOA zone I may influence adverse physiologic outcomes, and may also increase the risk of bleeding in proximal organs. As such, a target systolic blood pressure (SBP) should be achieved and maintained using partial REBOA (P-REBOA), especially in older patients with TBI who have a potentially progressive intracranial hemorrhage (ICH). Multiple studies of P-REBOA in a porcine model showed increased proximal pressure and extended survival time compared to the none REBOA group [13,14].

## CASE DESCRIPTION

An 86-year-old male cyclist who was struck by a car was transferred to the Level I Trauma Center at Siriraj Hospital (Bangkok, Thailand) within 30 minutes of the accident. His clinical signs upon arrival were coma, SBP of 120 mmHg, irregular heart rate at 110 beats per minute, and oxygen saturation of 90% at room air. During the initial assessment, the patient was given 1 liter of fluid due to tachyarrhythmia, and the patient responded. A primary survey found an unstable pelvic fracture and clinically severe head injury with a Glasgow Coma Scale (GCS) score of 8 (Figure 1). On physical examination, the abdomen showed no distension, no peritoneal sign, and no visible wound. Focused assessment sonography for trauma (FAST) initially gave a negative result. A pelvic binder was applied and the orthopedic team was consulted for a treatment plan.

Our goals of resuscitation were hemorrhage control and maintenance of SBP above 100 mmHg due to the patient's TBI and extreme elderly age to prevent secondary brain injury and to maintain critical organ perfusion.

During the 1-hour wait for computed tomography (CT) imaging results and for multidisciplinary team planning, the patient developed hypotension. His lowest SBP was 50 mmHg. Resuscitation was started with blood transfusion. Due to the patient's clinically profound shock, a decision was made to perform REBOA to increase the patient's SBP to ensure critical organ perfusion.

The REBOA protocol at our center requires an adjunct primary survey by FAST and chest X-ray (CXR). The results of those two investigations showed no evidence of cardiac injury, including pericardial effusion or great vessel injuries, such as widening mediastinum, massive left hemothorax, or loss of aortic knob.



**Figure 1** Portable pelvic X-ray demonstrated comminuted acetabular fracture, and head of femur penetrating the pelvic wall on the patient's right side.



**Figure 2** Portable X-ray in the trauma resuscitation room confirms intra-aortic balloon position at zone I of the aorta.

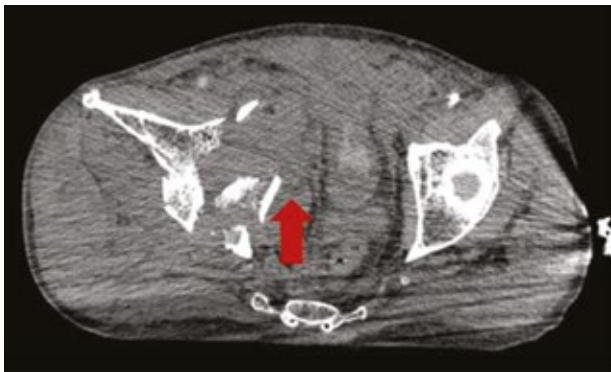
The decision to position the balloon at zone I was predicated on his extremely unstable condition, and we could not conclusively exclude the involvement of intra-abdominal organ injury. A FAST examination is operator-dependent and cannot exclude retroperitoneal bleeding.

Zone I REBOA was performed via the left common femoral artery by palpation technique using femoral sheath 7 Fr 10 cm Radiofocus Introducer II (Terumo Medical Corp. Ethicon, MD, USA) with an intra-aortic balloon (Rescue Balloon, Tokai, Japan).

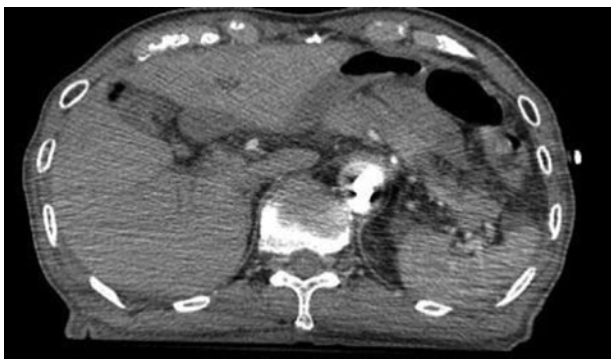
We used a surface marker at just above the xiphoid process as a landmark for positioning the balloon. After the REBOA balloon insertion, the position of the balloon was confirmed by mixed contrast inflation and portable X-ray in the trauma resuscitation room (Figure 2).

Due to the patient's advanced age and the known age-associated reduction in organ reserve, the balloon





**Figure 3** CT imaging demonstrating the comminuted fracture pattern, extravasation from the right internal iliac artery, and no other intra-abdominal injury.



**Figure 4** Abdominal CT scan showing partial balloon inflation with perfusion to visceral abdominal organs and the intra-aortic lumen.

was only partially inflated with 15–18 mL of normal saline solution (NSS) and contrast solution (1:1). Arterial line monitoring was commenced to achieve an SBP above 100 mmHg due to the presence of coexisting TBI. This was performed with the aim of preserving visceral perfusion in the part distal to the balloon, and to prevent supraphysiologic pressure in organs proximal to the balloon, which can increase cardiac workload and increase the chance of intracranial bleeding.

After REBOA, a CT scan was performed to evaluate associated injuries while the operating room and angiography suite were simultaneously prepared. The results showed extravasation from the right internal iliac artery, and no other intra-abdominal injury (Figure 3). CT scan showed successful partial balloon inflation with visceral perfusion of the abdominal organs (Figure 4). The CT scan of the head revealed minimal subdural hematoma. The consulting neurosurgeon evaluated the patient and decided to manage the patient non-operatively.

The CT result showed no intra-abdominal injury, so the balloon was repositioned to zone III under fluoros-



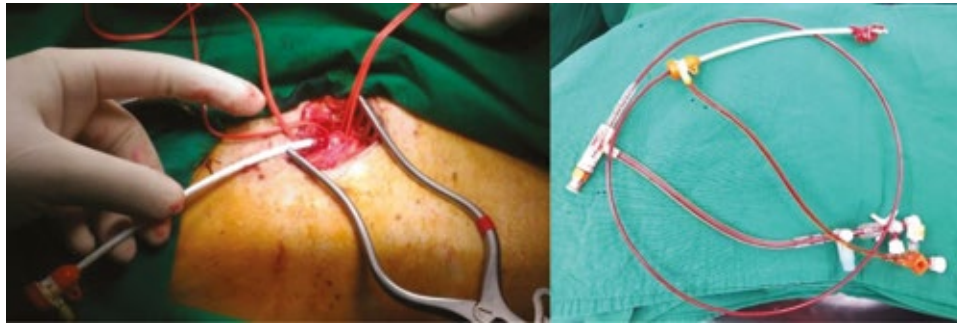
**Figure 5** Intraoperative aortography showing the collapsed intra-aortic balloon with patent aortic column. No extravasation was presented.

copy before the first operation. The appropriate surgical and orthopedic procedures were then performed by surgical and orthopedic teams.

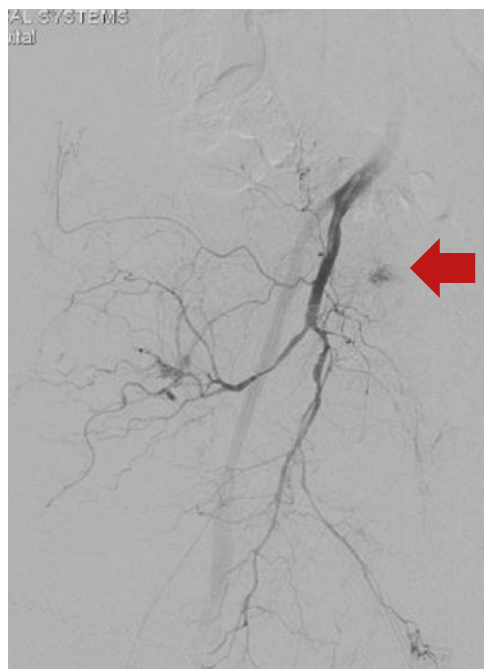
After repositioning of the balloon to zone III and during all necessary operations, the patient remained hemodynamically stable. Unexpectedly, during deflation of the balloon before removal, we observed fresh blood through the balloon port. A ruptured balloon was suspected, which was subsequently confirmed by aortography (Figure 5). A decision was immediately made to remove the balloon by an open technique based on our prediction that the balloon would be unable to be withdrawn through the 7-Fr sheath (Figure 6). After that operation was performed, the patient was sent to the angio-suite for angioembolization at branches of the right internal iliac artery with glue embolization (Figure 7).

Throughout all of the procedures to stop the bleeding, including skeletal traction, pelvic external fixation, pre-peritoneal pelvic packing, and angioembolization at the right internal iliac artery, the patient was given only 4 units of packed red blood cells (PRBCs), and no inotropic support was required. The first 2 units were rapidly given during REBOA implementation due to clinical hypotension, and the other 2 units were given during all of the procedures that were performed after REBOA placement.

Total inflation time was 167 minutes, including the no occlusion period during partial and intermittent REBOA technique (P-REBOA and I-REBOA, respectively). Regrettably, there was a misunderstanding among the residents and nurses regarding who would be responsible for recording and timing inflations and deflations across the 167 minutes of REBOA time, so it is not known how much REBOA was P-REBOA and how much was I-REBOA.



**Figure 6** Open removal of the balloon revealed a small hole in the balloon and blood in the balloon port and catheter system.



**Figure 7** Angiography demonstrated extravasation from branches of the right internal iliac artery before embolization was performed.

Admission laboratory investigations in the intensive care unit showed normal renal and liver function. Serum lactate was not significantly increased (from 4.3 to 5.6 mEq/L). Coagulopathy was shown based on prolonged prothrombin time (PT) of 18.1 seconds, activated partial thromboplastin time (APTT) of 38.7 seconds, and low fibrinogen level of 129.1 mg/dL.

## DISCUSSION

Elderly status and extreme elderly status is defined as ages older than 65 years and 80 years, respectively [15]. Patients in both of these age categories often have anatomic and physiologic presentations that are different

from those observed in patients in younger age categories. The most notable anatomic change is the presence of atherosclerosis [16]. Regarding physiologic changes, decreased organ reserve is often observed among older people, especially the central nervous system, cardiopulmonary, and renal function.

In every trauma case, the trauma team performs an initial assessment according to Advanced Trauma Life Support (ATLS®) standard. Our patient was a transient responder, given his later development of profound shock. Our primary goals of resuscitation were hemorrhage control and maintenance of SBP above 100 mmHg due to his advanced age and the presence of TBI. This case was particularly complex because we had to navigate the delicate balance between damage control resuscitation and attempting not to worsen the patient's TBI. NCTH is a well-known leading cause of traumatic death [2,12], and pREBOA was needed in this case as a bridge therapy until definitive hemorrhage control could be achieved. Several studies have reported the advantages of REBOA in sub-diaphragmatic bleeding, including pelvic fractures [5,7,9,10].

Regarding the technique used for vascular access, we decided to introduce a 7-Fr sheath due to the patient's extremely unstable condition and the immediate need to increase the patient's blood pressure. A palpation-blind method, which relies upon anatomical correlation, was used. The catheterization was performed by a cardiothoracic trauma surgeon.

P-REBOA and I-REBOA were implemented in this case due to concerns about visceral blood supply impairment related to age, and our awareness that overinflation of the balloon could cause supra-physiologic pressure to organs proximal to the balloon, such as the brain, heart, and lungs. P-REBOA and I-REBOA are able to control the proximal pressure, so we chose to use these techniques to balance the effect of REBOA and to ensure visceral perfusion.

The balloon type that was used in this case did not have a side port for pressure measurement. Accordingly, arterial line monitoring was established in the resuscita-

tion room by an anesthesiologist. This monitoring method provided precision guidance for us to achieve our SBP goal. To verify correct P-REBOA, we used decreasing contralateral palpable distal pulse and simultaneously adjusted the volume, as needed, to achieve our SBP goal. CT scan confirmed patent visceral organ perfusion.

We changed P-REBOA and I-REBOA multiple times to maintain our SBP goal of 100 mmHg. During resuscitation, we found the patient's physiologic status to be very dynamic. The balloon inflation amount was adjusted between 15–18 mL to reach the SBP goal.

Concerning the amount of volume and SBP, as shown in peripheral arterial monitoring, the benefit of a relation between central and peripheral pressure might help obtain a more precise goal in resuscitation and less complication from supraphysiologic pressure in the proximal area to the balloon.

There are multiple possible causes of balloon rupture, including the amount of balloon inflation in a hypovolemic patient and atherosclerotic change in an elderly patient [16]. CT scan showed heavily calcified plaque along the aorta and arteries that could have caused the balloon to rupture (Figure 8).

Multiple P-REBOA and I-REBOA inflation cycles did not reveal any bleeding through the arterial port until our preparation for balloon deflation and removal. After confirming the balloon's position at zone III by fluoroscopy, the balloon showed good contour and no extravasation in the aortic column. No physiologic change occurred nor was any resuscitation needed before the balloon ruptured.

Regarding the outcome of TBI, the patient demonstrated persistent drowsiness the day after the surgery. CT scan of the head was repeated, and the results showed the progression of ICH. Neurosurgical evaluation revealed survivable TBI with no mass effect, such as midline shift. The prognosis was discussed with relatives, and a non-operative approach was decided due to the patient's advanced age. At approximately 3 months after surgery, the patient died due to respiratory failure and sepsis. During admission, his clinical status was stable with no need for inotropic support or renal replacement therapy.

Our review to identify the cause of intracranial bleeding progression revealed the presence of undetected and uncorrected coagulopathy. Accordingly, assessment for coagulopathy has been added to the multidisciplinary assessment protocol. Although we do not currently have this instrument at our center, thromboelastography would improve our ability to identify the presence of or risk for coagulopathy in traumatized patients. ICH progression may also have been due to supraphysiologic pressure from the REBOA even though we attempted to maintain SBP at a high enough pressure to perfuse organs, but not high enough to worsen the ICH.



**Figure 8** CT scan showed heavily calcified plaque along aorta and arteries, especially in the infra-renal abdominal aorta.

A combination of factors presented in this case highlights the delicate balance that must be achieved in older traumatic injury patients with coexisting TBI that require REBOA. Given the range of events and outcomes that can occur or develop, the multidisciplinary trauma team should be alert for and know how to manage endovascular-related complications.

## CONCLUSION

Partial REBOA was shown to be effective for controlling pelvic fracture-related hemorrhage in the profiled octogenarian trauma patient with coexisting TBI. However, this case was complicated by the competing needs of controlling bleeding, maintaining critical organ perfusion by increasing SBP, and not worsening the patient's ICH. The details provided in this report may help to improve existing protocols for managing this type of case at other centers.

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# Thrombolysis for Trauma-Associated Inferior Vena Caval Thrombosis can be Safe in Selected Patients: A Case Report and Review of the Literature

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Traumatic injury results in significant physiological changes that place patients at elevated risk for venous thromboembolism (VTE). Percutaneous catheter-directed thrombolysis has been recommended as first-line therapy for the treatment of VTE but is relatively contraindicated in trauma cases due to increased risk of bleeding. The authors present a case to support the opinion that thrombolysis for trauma-associated inferior vena caval thrombosis can be safe in selected patients, with a discussion of existing literature.

**Keywords:** *Vascular; Trauma; Thrombolysis; Thrombosis; Vena Cava*

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## Case Report

A 55-year-old male presented to the regional major trauma centre following a fall from height whilst flying a Microlight aircraft. He was haemodynamically stable on admission and found to have soft tissue injuries and an unstable L2 vertebral body fracture. Admission was arranged under neurosurgeons for surgical management of the fracture. He was unable to have his surgery in the subsequent 9 days due to development of an ileus which splinted his diaphragm and limited his ability to be ventilated in a prone position. On day 9 post-injury, he was noted to have developed swollen legs and an ultrasound duplex confirmed acute bilateral femoral deep venous thrombosis. His surgery was postponed as venous phase computed tomography (CT) demonstrated a thrombosed

inferior vena cava (IVC) with bilateral iliac, femoral and popliteal vein occlusions (Figure 1). The IVC had an anomalous appearance suggesting a congenital narrowing of the renal and immediate suprarenal segment but not involving the hepatic segment.

Despite the recent significant trauma, the risk of bleeding was considered to be low and a decision was made to perform catheter-directed chemical and mechanical thrombolysis. Suprarenal IVC filter was placed via the right internal jugular vein approach. Under local anaesthetic, 6 Fr sheaths were placed into each popliteal vein. Initial venography confirmed the CT findings and thrombolysis was commenced through bilateral popliteal venous catheters (100 cm length, 40 cm infusion length; Cragg Mcnamara EV3) using a total dose of 1 mg/hour Alteplase split between the two catheters. Intravenous heparin was also given via a peripheral intravenous line. Good thrombus clearance was demonstrated after 36 hours of thrombolysis. Further Angiojet (Boston Scientific) thromboaspiration was performed achieving good clearance of the residual thrombus in the iliac veins and the IVC (Figure 2).

Despite this, there was significant residual narrowing and poor flow within the IVC. The IVC was treated with high-pressure balloon angioplasty to 18 mm (Atlas, Bard) and stented with two overlapping 20 mm × 100 mm venous stents (Sinus-XL, Optimed) (Figures 3 and 4). This produced a good final result with excellent contrast

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**Author contributions:** All authors have contributed substantially to the development of this manuscript.

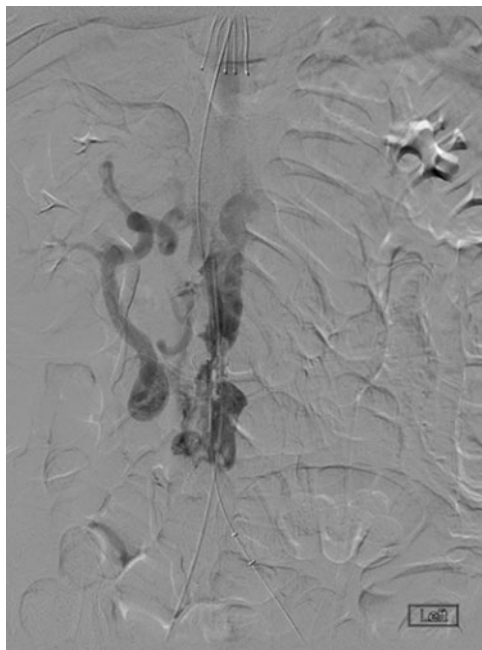
**Conflicts of Interest:** All authors have no conflicts of interest to declare.

**Funding:** None.

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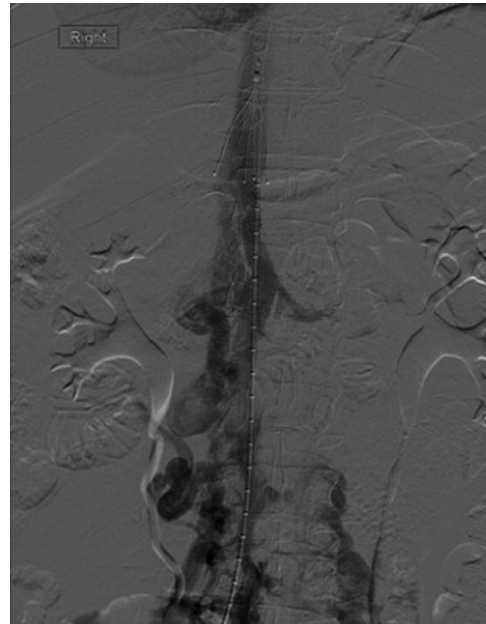
**Figure 1** Coronal CT image demonstrating IVC thrombosis.



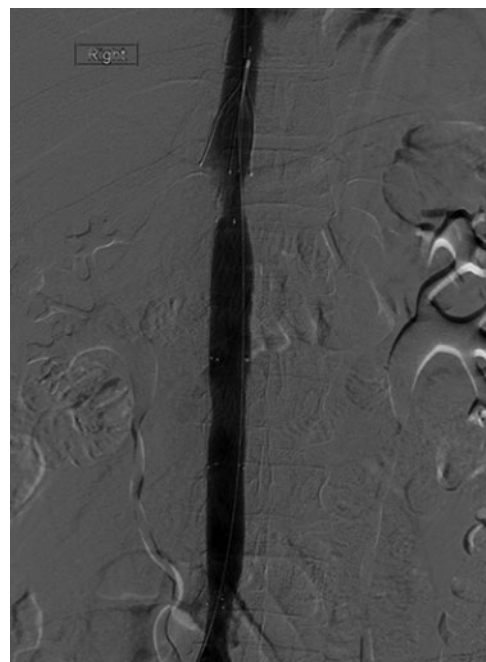
**Figure 2** Fluoroscopic image of IVC following thrombolysis.

flow across the stent; the suprarenal IVC filter was removed prior to discharge from hospital.

It was felt that the risk of re-thrombosis would be high if anticoagulation was paused to operate on the patient's spine in the first 3 months. He was therefore discharged on therapeutic subcutaneous enoxaparin and advice of initial bedrest. CT venography at 6 weeks (Figure 5) showed good



**Figure 3** Fluoroscopic image of IVC following thrombolysis and balloon dilatation.



**Figure 4** Fluoroscopic image of the IVC with stents in situ.

stent placement and patent vessels. At 3 months, repeat imaging of his spine showed fracture healing and he started to mobilise, with guidance from physiotherapists. He was converted to a direct oral anticoagulant (DOAC) medication at this point for ongoing anticoagulation. Follow up is now clinical, with interval duplex scans. At the clinic, approximately 3 months later, he was complaining of dependant leg swelling but no evidence of chronic venous



**Figure 5** Coronal venous phase CT image demonstrating the IVC appearance on follow up imaging (45 days post-stent insertion).

changes or ongoing pain. He continues to wear compression hosiery and has a plan for lifelong anticoagulation.

## DISCUSSION

Traumatic injury results in significant physiological changes that place patients at elevated risk for venous thromboembolism (VTE), a term that encompasses both deep vein thrombosis (DVT) and pulmonary embolism (PE). Patients exhibit elevated serum levels of inflammatory cytokines (including interleukin (IL)-6, IL-8, and tumour necrosis factor-alpha) and thrombin. This systemic inflammatory response results in a hypercoagulable state that increases the likelihood of developing VTE [1]. The incidence of deep vein thrombosis in trauma patients has been reported to be 7–58% depending on the diagnostic methods used [2]. The pathophysiology associated with polytrauma and hypercoagulability is most widespread and potentially destructive in the first 72–96 hours following injury [3]. However, another study reported that the highest risk occurs in the first 3 months after injury, with incidence at 10.3% in patients with traumatic pelvic fractures, vertebral fractures and spinal cord injuries [4]. Trauma patients may require prolonged anaesthesia for procedures, followed by periods of bed rest, and those with orthopaedic injuries require post-operative immobilisation or protected weight bearing, which may contribute to venous stasis [1,3]. This, along with hypercoagulability and endothelial injury, comprise Virchow's Triad, the trio of conditions that contribute to venous thrombosis [1].

Percutaneous catheter-based therapies (either pharmacological or pharmacomechanical) have been recommended as first-line therapy for early thrombus removal in patients with VTE, whether isolated to calf veins, the femoropopliteal veins or involving the iliofemoral veins, with or without extension into the IVC [5]. In the UK, NICE guidelines reserve thrombolysis for patients with symptomatic iliofemoral DVTs who can be treated within 14 days of symptom development [6]. Thrombolysis has been demonstrated to effectively dissolve the clot to result in complete thrombus breakdown more often than with standard anticoagulant therapy and venous patency is better maintained. The use of an endovascular technique to lyse the clot also allows for the opportunity to correct any anatomical anomalies. In the case presented, the patient was found to have an IVC anomaly which undoubtedly contributed to his risk of developing an IVC thrombosis. The prevalence of congenital venous malformations in the population has been estimated at 1%, with anomalies of the IVC present in half of these cases. Theoretically, these anomalies may contribute to VTE due to the increased risk of venous stasis [7]. In a small study of 56 patients with VTE, 45 were found to have anatomical abnormalities of thrombosed deep veins; the most common lesion was common iliac vein compression by the iliac artery [8].

## Benefits of Thrombolysis Over Anticoagulation in Trauma

Numerous risk factors for DVT have been reported in the trauma literature, including age, injury severity, polytrauma, fracture of the pelvis, femur, or tibia, spinal cord injury, central vein cannulation, number of procedures, and medical comorbidities including diabetes and obesity [1]. Despite polytrauma being a stated risk factor for VTE, preventative methods, particularly heparin medications, are not used due to increased risk of bleeding. Regardless, VTE continues to occur despite the use of preventative measures such as vena caval filters, heparin medications, elastic stockings, and sequential compression devices [3], and no one method is proven to prevent VTE in 100% of cases. The nature of polytrauma can often confound the diagnostic process and lead to delayed recognition and treatment.

The incidence of symptomatic PE is much less common than DVT [2], although post-traumatic PE is associated with a high mortality rate, especially in those with associated heart failure [2,3,9]. Guidelines state that in the management of high-risk PE, thrombolysis is the first line treatment unless an absolute contraindication exists [3].

## Post-Thrombotic Syndrome

Patients who suffer VTE despite reversible provoking factors such as trauma have a long-term risk of

recurrence greater than 20% [9]. They are prone to the development of short and long-term complications such as post-thrombotic syndrome (PTS) which can affect functional capacity and quality of life. Alongside recurrence, the anatomic extent of the DVT is a significant factor [9], with one study stating that proximal (acute iliofemoral) DVT was the strongest independent risk factor for developing PTS, with a twofold increase in likelihood [10]. Male sex and elevated BMI are also factors which increase risk [10].

PTS is a complex syndrome involving pain, swelling, oedema and skin induration, which has been reported to significantly impact physical and mental health. It is estimated that the economic burden in the United States is US\$200 million annually [11]. Evidence from a 2016 Cochrane review of thrombolysis for DVTs suggests that fewer patients develop PTS when treated with thrombolysis. Seventeen randomised controlled trials (RCTs) with 1,103 participants were included in the analysis, and 9 of these specifically included patients who had proximal DVT, with or without concomitant calf thrombosis. The majority excluded patients who had undergone surgery in a defined time period (i.e. 3–14 days) or were considered post-traumatic. The conclusion is that thrombolysis increases the patency of veins and reduces the incidence of PTS following proximal DVT by one-third. Evidence suggests that systemic administration and catheter-directed thrombolysis have a similar efficacy [12].

### **Risks of Thrombolysis in Trauma**

The use of thrombolysis is associated with bleeding complications, stroke or intracerebral haemorrhage. The Cochrane review states that strict eligibility criteria appear to improve safety and may be necessary to reduce the risk of bleeding complications, which may limit the applicability of this treatment [12]. NICE guidelines state that catheter-directed thrombolytic therapy should be considered only in patients who have a low risk of bleeding and a life expectancy of more than a year [6]. Most trauma patients are likely to be at increased risk for bleeding depending on their mechanism of injury. It is generally recognised that major abdominal surgery within the preceding 48 hours or gastrointestinal (GI) or genitourinary (GU) bleeding within 14 days are relative contraindications to thrombolysis so any trauma requiring an operative intervention may not be appropriate in the early phase of treatment; the presence of a recent intracranial haemorrhage is an absolute contraindication [2]. However, the risk of bleeding in patients with non-haemorrhagic trauma who are being managed conservatively is more difficult to quantify. The therapeutic window of safety is narrow when using thrombolytic agents, as such careful patient selection is of utmost importance. Risk versus benefit should be considered on an individual case

basis. Complications are not uncommon, with one study reporting an incidence of 21% [2].

### **CONCLUSION**

Multiple dynamics in trauma patients make treatment decisions complex. VTE in trauma remains a significant risk and some of the longer term morbidity might be reduced with timely thrombolysis in symptomatic patients with a low risk of bleeding. It is the opinion of the authors that the technique should be reserved for specific cases after thorough investigation and consideration of the risk/benefit ratio and performed in line with a departmental protocol to reduce any undue risk to the patient.

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# Partial Aortic Occlusion using Resuscitative Endovascular Balloon Occlusion of the Aorta (P-REBOA) in Ruptured Abdominal Aortic Aneurysm: A Case Report

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Ruptured abdominal aortic aneurysm is often a fatal event without immediate intervention for the associated hemorrhagic shock and impending cardiovascular collapse. We report a case of a ruptured abdominal aortic aneurysm managed with partially occlusive resuscitative endovascular balloon occlusion of the aorta (P-REBOA) as a means to gain proximal control and tailor blood pressure goals, while allowing time to obtain access and repair the ruptured aneurysm.

**Keywords:** REBOA; Abdominal Aortic Aneurysm; Hemorrhagic Shock; P-REBOA

Received: 21 January 2019; Accepted: 21 April 2019

## BACKGROUND

Although care for a ruptured abdominal aortic aneurysm (rAAA) has significantly improved in the last decade, it remains a nearly universally fatal event without immediate operative repair, with mortality rates ranging from 53% to 90% [1]. It is still the 13<sup>th</sup> leading cause of death in the United States [2]. Current treatment options for repair of an rAAA are open surgical repair and endovascular stent-graft repair (EVAR). The management of hemorrhagic shock from an rAAA is critical to the patient's outcome and aims primarily to not only keep the patient alive until the control of bleeding is achieved but also to restore organ perfusion [1]. Refractory hemorrhagic shock often mandates emergent

aortic control typically done through an abdominal incision.

Resuscitative balloon occlusion of the aorta (REBOA) is considered a less invasive alternative for emergent aortic control and, recently, more often described in the trauma literature for the control of non-compressible torso hemorrhage. While the use of REBOA may prevent exsanguination and augment cardiac perfusion, the benefits must be weighed against the potential consequences of sustained complete aortic occlusion, primarily distal ischemia and reperfusion injury. The concept of partial REBOA (P-REBOA) is a potential strategy to minimize these potential consequences by allowing sustained low volume distal flow to the viscera and lower extremities while maintaining blood pressure and cerebral perfusion. This report describes the novel adaptation of P-REBOA for a patient in hemorrhagic shock from rAAA as a means to gain proximal control and tailor blood pressure goals while allowing time to obtain access and repair the ruptured aneurysm.

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## CASE REPORT

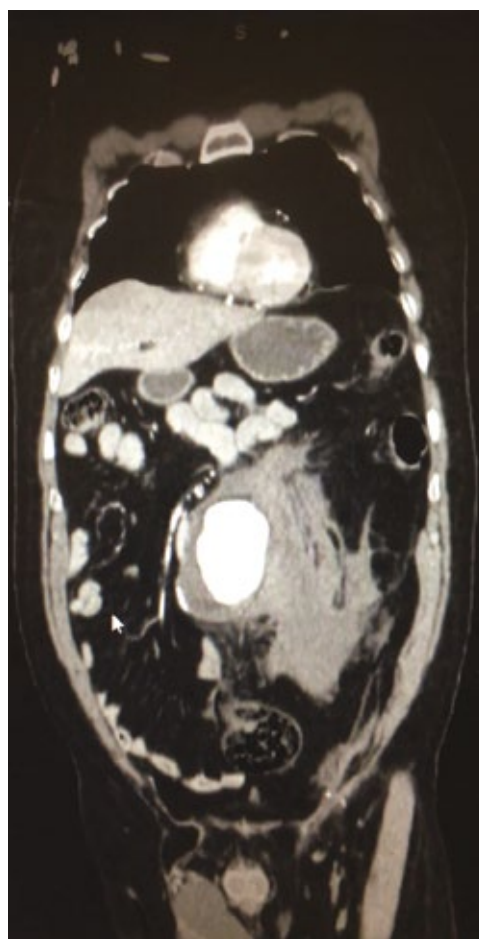
A 71-year-old male with a past medical history significant for hypertension and hyperlipidemia presented to



an urban Level I trauma center's emergency department with hypotension to a systolic blood pressure of 80 mmHg by palpation, severe acute abdominal pain and distension. The patient's skin was cool and diaphoretic. An approximately 8 cm aortic aneurysm was identified by point-of-care ultrasound. Massive transfusion protocol was initiated. Computed tomography (CT) imaging confirmed a 9.6 cm ruptured aortic aneurysm with active bleeding into the retroperitoneum (Figure 1). The neck of the aneurysm appeared to be juxtarenal with no proximal landing zone to facilitate endovascular repair, making open surgical repair the only viable option. An associated large left-sided retroperitoneal hematoma was present from the L1 vertebrae to the lower pelvis.

As the vascular surgeon on call was not in-house, the patient was taken initially to the operating room (OR) for surgical control of bleeding by the acute care surgery team. Upon arrival at the OR, the patient's systolic blood pressure was noted to be 60 mmHg. However, the patient had preserved mental status. Due to this, it was decided to delay anesthesia induction and intubation. Under ultrasound guidance, right femoral arterial access was achieved and a 7 French (Fr) introducer was placed. An ER-REBOA catheter (Prytime Medical Devices, Boerne, TX) was then passed beyond the aneurysm sac, into the distal thoracic aorta above the diaphragm under fluoroscopic guidance. Simultaneously, a large bore central venous line, as well as a left radial arterial line, were placed. Both the radial arterial line as well the introducer side port were connected to pressure transducers on the anesthesia monitor. Satisfied with catheter positioning, the balloon was gradually inflated and the systolic pressure of the radial arterial line was noted to rise from 60 mmHg to a range between 80 and 90 mmHg. Satisfied with the patient's hemodynamics at this time, the focus shifted to assessing his physiologic ability to tolerate partial distal perfusion. Using the transduced arterial pressure from the introducer side port as a marker for distal perfusion, the balloon was slowly inflated by about 0.5 to 1 cc every 30 seconds until the side port arterial pressure decreased from 60 mmHg to range between 30–40 mmHg systolic. The patient's hemodynamic status was constantly re-assessed during this process of establishing P-REBOA.

With hemodynamic control, the patient was safely intubated, prepared and draped for exploratory laparotomy. Approximately 1 L of blood was evacuated from the peritoneum. The small bowel was lateralized, exposing the ruptured aneurysm. The retroperitoneum was explored with dissection down to the aorta, and the iliac vessels were identified. Importantly, there was minimal active bleeding noted. At this point, the vascular surgeon arrived. The REBOA catheter was deflated and removed quickly to allow cross-clamping of a very short segment of the infrarenal aorta just above the neck of the aneurysm. The iliac vessels were also controlled. The aneurysm was opened and surgically repaired using a size matched



**Figure 1** CT scan of the patient showing ruptured abdominal aortic aneurysm with active extravasation and retroperitoneal hematoma.

bifurcated Dacron graft (Hemashield Gold, Maquet, Wayne, NJ). Total aortic occlusion time was approximately two hours, including REBOA time. A concomitant left hemicolectomy was required for bowel ischemia.

The operation was complicated by two episodes of ventricular fibrillation and asystole with the return of spontaneous circulation after brief cardiopulmonary resuscitation. These events occurred in the setting of opening the separate distal anastomoses and reperusing their respective legs. The left distal limb developed an acute thrombus and required a catheter thrombectomy and redo of the anastomosis. During the course of the operation, the patient developed hypotension, coagulopathy and was requiring multiple pressors. The decision was made to leave the patient in bowel discontinuity, pack the abdomen open, and bring the patient to the surgical intensive care unit (SICU) – returning for a second look only if the patient stabilized.

His postoperative course was complicated by persistent hypotension and coagulopathy, acute respiratory distress syndrome, acute kidney injury, anuria and further

episodes of asystole. His next of kin eventually selected Do Not Resuscitate order and care was withdrawn on hospital day two.

## DISCUSSION

Ruptured AAA is a cause of severe hemorrhagic shock, which carries substantial mortality [1,3]. The use of REBOA in traumatic non-compressible torso hemorrhage has seen the re-emergence of intra-aortic balloon occlusion, which was first introduced during the Korean War [4]. REBOA is considered in almost any case of intraabdominal or pelvic hemorrhage with impending cardiovascular collapse such as cases of penetrating injury to the abdomen or pelvis, blunt trauma without severe chest injury but with a positive focused abdominal sonography in trauma, severe hemorrhage from pelvic fractures, and lower extremity trauma with impending cardiovascular collapse [5,6]. Its use has also been described in cases of complex retroperitoneal hemorrhage, ruptured splenic artery aneurysm and hemorrhagic shock from ectopic pregnancy [1,7–9,14,20]. One case has even illustrated the successful use of REBOA *distal* to a ruptured thoracic aortic aneurysm, although this is currently considered unconventional [10]. Endovascular aortic occlusion has in some centers largely replaced performing an emergency department thoracotomy to assist with last-ditch resuscitative efforts for patients in end-stage hemorrhagic shock from trauma. Clearly a less invasive approach, the REBOA catheter has been refined to a smaller, guidewire free version, and no longer requires fluoroscopic guidance, known as ER-REBOA [11].

REBOA has been shown to increase central and proximal perfusion, restore hemodynamic stability and provide a little more time for operative preparation and planning for hemorrhage control [14,15]. However, prolonged complete aortic occlusion has its limitations and consequences such as organ injury, distal ischemia, and death [16,17]. There is also the potential of cardiac and pulmonary failure and worsening of traumatic brain injury due to supraphysiologic proximal perfusion [18,19]. These effects can make weaning from complete occlusion difficult and potentially lethal.

One strategy to mitigate some of the consequences of complete aortic occlusion is to allow persistent low volume distal flow to the viscera and lower extremities. This concept of P-REBOA has been shown in animal studies to have an improved hemodynamic response, allow longer occlusion times, and encourage small increases in intracerebral and proximal perfusion pressures compared to complete occlusion [20,21]. Moreover, the implementation of P-REBOA may improve the efficacy of resuscitation and, in patients who tolerate it, allow for preserved critical organ perfusion above the balloon and a hypotensive state below, potentially decreasing the incidence of distal ischemia and damage from reperfusion injury [22,23]. Other possible benefits

of P-REBOA include extension of survival and the possibility of visualizing contrast blushes during (CT) angiography that would otherwise not be visualized with complete aortic occlusion [19,22]. In countries such as Japan, P-REBOA is performed more often than complete REBOA [2,20]. A suggested approach has been to start with complete REBOA to allow for clot formation, followed by deflation and further resuscitation using P-REBOA to allow some distal perfusion [19,23–25]. Finally, a recent novel study has incorporated automated extracorporeal circuits with complete REBOA in a swine model of uncontrolled hemorrhage to regulate proximal aortic pressure and provide controlled distal aortic perfusion [18].

P-REBOA requires arterial access, which can be accomplished using an ultrasound-guided percutaneous stick. After the introduction of a 7-Fr vascular access sheath, the ER-REBOA catheter can then be inserted. A Coda balloon (Cook Medical, Bloomington, IN) can be used instead but requires upsizing to a 12-Fr sheath, cumbersome wires and also imaging guidance for accurate placement – qualities not easily adaptable to most trauma bays. The depth for ER-REBOA can easily be determined using radiography or external landmarks [12,13]. Distal thoracic aorta positioning can be accomplished by placing the occlusion balloon over the sternal notch and externally measuring the distance to the entry point on the sheath. Similarly, for distal abdominal aortic occlusion, the occlusion balloon is placed at the level of the umbilicus and measured to the femoral access point. Once intra-arterial positioning is satisfactory, the balloon is gradually inflated while continuously monitoring blood pressure feedback via the device's arterial line. Connecting the side port on the arterial access sheath to a pressure transducer will allow monitoring of distal perfusion pressure. Alternatively, a contralateral femoral arterial line may be inserted and used.

Although prospective Level I evidence is not yet available, early retrospective data support the use of REBOA in controlling hemorrhagic shock. Preoperative deployment of REBOA for complete aortic occlusion in nontraumatic abdominal hemorrhage has been described before [26]. However, in the case presented here, specifically deploying P-REBOA preoperatively not only allowed proximal control of hemorrhage in an already unstable patient but also provided some degree of distal perfusion to critical organs. Moreover, the temporal stabilization of vitals allowed the acute care surgeon to start the intraabdominal access and exposure and prepare the field for the necessary vascular repair. This report offers a paradigm shift in urban trauma centers where an in-house surgeon has the ability to manage shock in nontraumatic intraabdominal hemorrhage with adjuncts such as REBOA. Although the patient in this case ultimately did not survive, the pragmatic approach used can in similar situations provide several benefits. It can potentially lead to a decreased need for

referral to another hospital and decreased time to abdominal incision when a vascular surgeon is not immediately available. In addition, knowing there is proximal aortic control, flexibility in the length of operation may be increased and possibly mitigation of reperfusion injury given modest amounts of distal perfusion.

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# Gossypiboma: Is it always what it appears to be? A Rare Complication in Everyday Practice

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**Background:** While the management of liver injury is usually conservative, the major indication for surgery remains hemodynamic instability. Different techniques are described for hemostasis in cases which require surgery. Several commercial hemostatic agents are readily available and can be used as an adjunct after the repair of liver injuries. One of the most well-known local agents is gelfoam, which is used in multiple fields of surgery. The purpose of this work is to present a very rare complication of liver surgery in trauma, using gelfoam following hepatic angioembolization, mimicking gossypiboma.

**Design:** A case study describing a hemodynamically unstable patient who had a penetrating liver injury. Hemostasis was achieved by liver suture and gelfoam with subsequent angioembolization. In the post-operative period, the patient demonstrated signs of intraabdominal sepsis due to liver abscess. Repeated attempts of percutaneous drainage failed, and all cultures were negative. Due to a strong suspicion of a forgotten abdominal pad (gossypiboma), the patient underwent an operation and the object was removed. The final pathological report showed no textile in the specimen, the findings were compatible with a piece of gelfoam without signs of absorption.

**Conclusions:** Commonly used hemostatic agents are made of gelatin gelfoam, microfibrillar collagen, thrombin, and fibrin sealant. Gelfoam is available in sponge or powder form. The sponge can be left in place and is supposed to be completely absorbed in four to six weeks. In the relevant literature, only one case of gelfoam use related to granuloma formation. In our case, the radiologic findings in the liver were interpreted as an abscess. The suspicion of a foreign body was raised only during the second admission and thus forced us to operate. There is no clear reason why the piece of gelfoam was not absorbed in that time period. Our assumption is that post-angiography liver ischemia may have disturbed the process of fibrin destruction. The major take-home message is that the lack of gelfoam absorption may mimic an abdominal foreign body, and this needs to be considered in post-operative care.

**Keywords:** *Liver Trauma; Gelfoam; Gossypiboma*

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## INTRODUCTION

The liver is one of the most commonly injured organs in abdominal trauma. Most cases of hepatic injuries are managed conservatively with a success rate of 90% [1,2]. In cases which require surgery, different techniques are described for hemostasis. Several commercial hemostatic agents are readily available and can be used as an adjunct after the repair of liver injuries [3,4]. One of the most well-known local agents is gelfoam, which is used in multiple fields of surgery.

Here we present a case of a very rare complication while using gelfoam, mimicking gossypiboma.

### CASE DESCRIPTION

A 47-year-old male patient was admitted to the trauma unit after being stabbed in the lower segment of his right chest. He also had additional multiple stab wounds to the back, and upper and lower extremities. On admission, the patient looked pale and agitated, his initial blood pressure was 80/40, pulse over 130 per minute. On auscultation, breath sounds were slightly diminished on the right, where a wound with evisceration of omentum was seen 3 cm above the right chest cage. After insertion of a chest tube into the right thorax, and evacuation of a small amount of air and blood, the patient was then immediately taken to the operating room. During surgery, 1.5 L of blood were found inside the abdominal cavity, a deep liver, segment IV, laceration was demonstrated, with active arterial bleeding. In addition, a 3 cm diaphragmatic tear was also demonstrated.

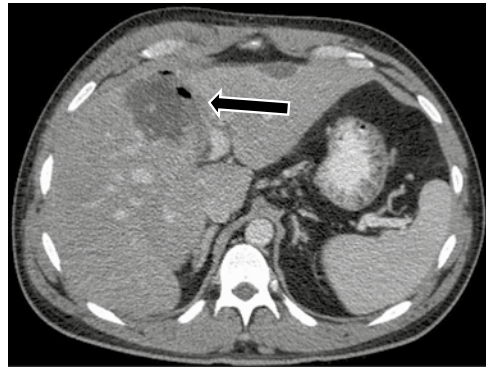
The bleeding from the liver was stopped by the insertion of a piece of gelfoam into the wound and by suturing of the liver above in order to create a local tamponade effect. The procedure was completed with formal liver packing, diaphragm repair, and the abdomen was closed with a Bogota bag, as is acceptable in "damage control".

In the post-surgery period, the patient was stable and was then transferred to the angiographic unit. On angiography, extravasation was demonstrated from one of the intrahepatic arteries, and successful angioembolization was achieved. Forty-eight hours later, a relaparotomy was performed and the liver packing was removed. No bleeding or bile leakage were observed, drains were left inside the abdomen, and the abdomen was sutured closed. In addition, all surgical instruments and tagged pads were accounted for.

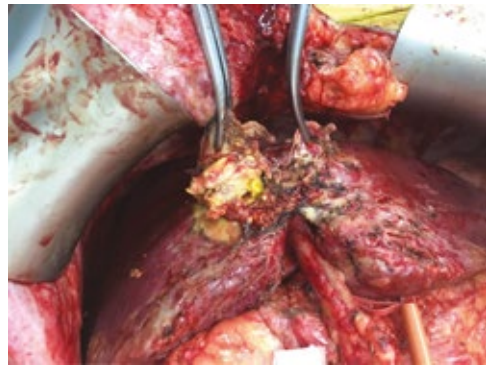
At post-operative day 6, after the second operation, bile leakage was visualized in a drain located in the Morrison pouch, and due to continuous bile leakage an endoscopic retrograde cholangiography (ERCP) was performed with stent insertion into the common bile duct. A few days later the leak stopped, and the drain was removed at post-operative day 13.

At post-operative day 17, the patient developed chills and an elevated fever. As can be seen in Figure 1, abdominal CT scan revealed an intrahepatic collection in segment IV, but transcutaneous CT guided drainage did not contain pus or other infected fluids. The patient continued to suffer from an elevated fever and elevated WBC count despite wide spectrum antibiotic administration. Another CT scan was performed on post-operative day 21, and it showed similar findings.

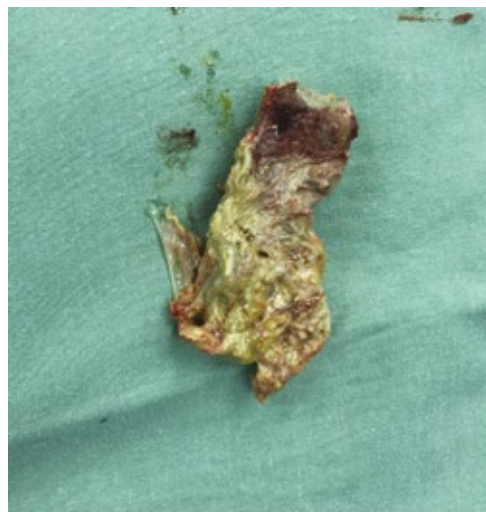
Another attempt of percutaneous drainage was performed, but no pus or other fluid was obtained. This was followed by a gallium scan, which was interpreted as negative. Gradually, the condition of the patient



**Figure 1** Contrast-enhanced abdominal computed tomography demonstrating a hypodense lesion containing gas bubbles, suspected to be a liver abscess. Source: Hillel Yaffe Medical Center media archive.



**Figure 2** Resection of foreign body from segment IV of the liver taken during foreign body resection from the patients liver in "Tel Hashomer" hospital.



**Figure 3** Macroscopic view of the resected foreign body from segment IV of the liver taken during foreign body resection from the patients liver in "Tel Hashomer" hospital.

improved, his temperature normalized, and he was discharged at post-operative day 31.

Two weeks later, the patient was readmitted with complaints of biliary discharge via the midline scar. An abdominal CT fistulography scan revealed a hepatocutaneous biliary fistula originating from the right lobe of the liver, and a strong suspicion of a foreign body. However, no signs of marked pads were observed.

Due to the presence of recurrent biliary fistula originating from the right liver lobe, and high suspicion of gossypiboma in place, the patient was transferred to a tertiary medical center with a hepatobiliary department. The patient underwent surgery in which a gray abscess-like mass was demonstrated. After the opening of the mass, a foreign body sized  $8 \times 3 \text{ cm}^2$  was resected from segment IV (Figures 2 and 3), and a drain was left in the perihepatic space.

After the surgery, the patient was uneventfully discharged at post-operative day 9. A final pathologic report showed no textile in the specimen, and findings were compatible with a piece of gel form with no signs of absorption.

## DISCUSSION

The liver is one of the most commonly injured organs in abdominal trauma [5]. Most hepatic injuries are minor and heal spontaneously with non-operative management, which consists of observation and the adjunctive use of arteriography and embolization. Hommes study on 99 patients, in whom non-operative management was initiated, found only 5% failure of conservative management, not related to the grade of the injury [6]. However, other studies report that about 17% of patients with hepatic injury will require surgical intervention [7].

When surgery is required, a systematic approach is used to control bleeding while conserving liver parenchyma, hepatic resection is reserved for severe injuries. The use of damage control techniques during the initial laparotomy, specifically perihepatic packing, reduces the extent of subsequent surgical procedures [8]. Several commercial hemostatic agents are readily available and can be used as an adjunct after repair of liver injuries. The most commonly used agents are gelatin gelfoams, oxidized cellulose, microfibrillar collagen, thrombin, thrombin with gelatin (“Floseal”), and fibrin sealant.

Gelatin (“Gelfoam”, “Surgifoam”) is a hydrocolloid made from acid partial hydrolysis of porcine-derived collagen that is whipped into foam and then dried. It is available in sponge or powder form. Gelatin sponge absorbs blood or fluid up to 40 times its weight and can expand up to 200% in dimension. The sponge can be left in place and should be completely absorbed after four to six weeks [9].

There are several reports of adverse reactions in the use of gelfoam. Gabay in his review on absorbable hemostatic agents reported cases of elevated fever without demonstrable infection, most probably because a piece of gelfoam might form a nidus of infection and potentiate bacterial growth [10]. Foreign body reactions, “encapsulation” of fluid, and hematoma have also been reported. Reviewing relevant medical literature, we found only one case of gelfoam use related to granuloma formation. In this specific case, a giant cell occurred in the brain, most probably due to the blockage of cerebrospinal fluid [11].

In our case, the radiologic findings in the liver were interpreted as an abscess. The suspicion for a foreign body was raised only on the second admission and this forced us to re-operate on the patient. We can only speculate why the piece of gelfoam was not absorbed in that time period. Our opinion is that post-angiography liver ischemia may have disturbed the process of fibrin destruction. The major take-home message is that lack of gelfoam absorption may mimic abdominal foreign body, and this needs to be considered in late post-operative care.

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# Selected abstracts accepted for the EVTM St Petersburg meeting 7th June 2019

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## A Bespoke Selective Aortic Arch Perfusion Catheter, Delivered with Intravascular Ultrasound Guidance, Allows Simultaneous Aortic Occlusion and Retrograde Perfusion in a Pressurised Human Cadaveric Model: A First-In-Human Feasibility Study

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**Background:** Resuscitative endovascular balloon occlusion of the aorta (REBOA) is becoming an established therapy for achieving rapid aortic control of severe haemorrhage. It is an attractive endovascular solution for the prehospital and austere military damage control setting. If passive aortic control is not enough to stabilise the patient, or if effective cardiac output is lost, the ability to retrogradely infuse into the aorta, upstream of the occluding balloon is an attractive manoeuvre. This should improve coronary and cerebral perfusion, avoiding prolonged cerebral and myocardial hypoperfusion and resulting injury. A bespoke selective aortic arch perfusion (SAAP) catheter has been effective in animal models of traumatic cardiac arrest but has not been demonstrated in a human model to date.

**Methods:** A bespoke SAAP catheter was introduced via a 14 Fr femoral arterial sheath into the aorta of a Thiel-preserved externally-pressurised cadaveric model. Fluoroscopic and intravascular ultrasound (IVUS) guidance were used to confirm balloon placement in the aorta, and that deployment had been achieved with apposition of the balloon to the vessel wall.

**Results:** The SAAP catheter delivered easily without the need for a guidewire, under direct fluoroscopy using standard techniques. Balloon apposition to the aortic wall was achieved and confirmed using a digital IVUS catheter. Retrograde infusion of a 50:50 mixture of normal saline and iodinated contrast was performed by hand-injection, and fluoroscopic imaging confirmed the ability to perfuse carotid, vertebral and coronary vascular beds. No aortic wall injury was noted on subsequent angiography.

**Conclusion:** For the first time, in a human pressurised cadaveric model, SAAP of the aorta has been made possible via a bespoke catheter. This procedure combines simultaneous aortic occlusion with the ability to retrogradely perfuse the cardiac and cerebral circulations, which are of key importance during cardiac arrest and states of low-output.



# Feasibility and Clinical Outcome of REBOA in Patients with Impending Traumatic Cardiac Arrest

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**Background:** Resuscitative endovascular balloon occlusion of the aorta (REBOA) may improve systolic blood pressure (SBP) in hypovolemic shock. It has, however, not been studied in patients with impending traumatic cardiac arrest (ITCA). We aimed to study the feasibility and clinical outcome of REBOA in patients with ITCA using data from the ABO Trauma Registry.

**Methods:** Retrospective and prospective data on the use of REBOA from 16 centers globally were collected. SBP was measured both at pre- and post-REBOA inflation. Data collected included patients' demography, vascular access technique, number of attempts, catheter size, operator, zone and duration of occlusion, and clinical outcome.

**Results:** There were 71 patients in this high-risk patient group. REBOA was performed on all patients, in a majority using a 7 Fr catheter placed on the first attempt through blind insertion and inflated in Zone I for a period of 30 to 60 minutes by emergency room doctors, trauma surgeons or vascular surgeons. SBP significantly improved following the inflation of REBOA and 38% of the patients survived.

**Conclusions:** Our study has shown that REBOA is feasible in patients with ITCA, SBP can be elevated and 38% of the patients survived.

## Hepatic Arterial Embolization in the Management of Liver Trauma: Fourteen Years of Experience in a Reference French Trauma Center

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**Background:** Retrospective observation study of hepatic arterial embolization (HAE) procedures among 485 patients with liver trauma admitted in a referral trauma center for 14 years (2004–2018).

**Methods:** From 2004 to 2018, 48 patients (10%) underwent HAE in Grenoble-Alpes Trauma Center for the treatment of a liver trauma (4 penetrating and 44 blunt). The degree of hepatic injury according to AAST grade, hemodynamic status at the time of admission, demographic data, the timing of procedures, and complications was assessed.

**Results:** There were 28 men and 20 women, with a mean age of 36.2 years. Thirty-eight patients had a liver trauma of grade 3 and over (79%). Fourteen patients were in shock at the admission. One-month mortality was 6%. The main complications were inflammatory syndrome (25%), abdominal compartment syndrome (ACS) (21%), biliary leak and biloma (17%), and liver ischemia (13%). Indication of HAE was based on CT scan contrast leakage in the initial CT in 33 cases (71%), aneurysm in 2 cases and arteriovenous fistula in 1 case. Eleven (24%) patients with unresponsive shock underwent surgery and/or SAE without a CT scan.

In all patients, bleeding was stopped (HAE success rate was 100%), with 3 patients require re-embolization (first HAE success rate 94%). Thirty-two patients required surgical intervention before or after embolization (67%): 11 hepatic packing, 4 hepatic resections, and 17 lavage laparoscopy. Four Pringle maneuvers were performed, two temporary and in two cases the tourniquet was lifted through the incision and released in the arteriography room to allow embolization.

The initial procedure was: a) Primary HAE (HAE at admission): 27 cases (56%). Seventeen patients had secondary surgery (12 laparoscopic lavages, 2 hepatic packing, 2 delayed hepatic resections, and 1 laparoscopic cholecystectomy for gallbladder necrosis). b) Combined HAE (HAE + laparotomy during the same hour at admission): 6 cases (13%). c) Secondary HAE after laparotomy (laparotomy then HAE): 5 cases (10%). d) Secondary HAE after nonoperative management (NOM) (NOM then HAE): 10 cases (21%).

Fifteen patients were embolized with coils or microcoils, 17 with resorbable gel, 6 with coils, 3 with a plug or prosthesis, 2 with Lipiodol and Histrocyl, and 5 with combined devices. The median time to embolization was 3.38 hours and 62.5% of the patients were embolized within the first 6 hours following their arrival at the Trauma Center.

**Conclusion:** Overall, 10% of admitted hepatic trauma undergoes HAE in our center, with a median time to embolization of less than 4 hours, a mortality rate of 6% and an HAE success rate of 93% in our series (100% after re-embolization), comparable to data of a recent meta-analysis showing a success rate of 80–97% and a mortality rate of 1–8%.

## Endovascular Techniques to Treat Pancreatogenic Hemorrhage

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**Background:** Pancreatogenic bleeding is concerning because even patients treated by open surgery have a high rate of fatality. According to current literature, endovascular embolization is a highly effective method of hemorrhage control in such scenarios. It has also been shown, that the transfer to a higher level of care facility improves outcome. Our hospital is an only regional facility that has all the capabilities to treat complex pancreatic pathology. The aim of this study was to create a logistic system for the treatment of patients with pancreatogenic bleeding and evaluate the effectiveness of endovascular techniques.

**Methods:** A retrospective study of patients with pancreatogenic hemorrhage who underwent embolization and were admitted to our hospital during March 2012–November 2018 was performed. At the beginning of this study period, a system of communication and feedback in all regional hospitals, criteria for transportability, pancreatic-focussed protocols to diminish delivery time and time to embolization and special CT-protocols were created. An angiosuite was started on a 24/7 basis with interventional radiologists available in-house.

**Results:** Sixty-five embolizations were performed on 61 patients during the study period. Forty-eight patients were referred from other hospitals in Ekaterinburg and from the Sverdlovsk region. Among the sources of bleeding, most of the patients ( $n = 33$ ) suffered from hemorrhagic complications of chronic pancreatitis, 19 from necrotizing pancreatitis, and 9 had postoperative hemorrhage after pancreatic surgery. Technical success was achieved in 100% of the cases. The clinical effect of embolization was noted in 93%. Four patients necessitated additional endovascular embolization procedures, of which 2 patients had a bleeder in another artery (not pancreatic). One patient developed severe colon ischemia which resulted in a colostomy.

**Conclusion:** Endovascular embolization is an effective tool for hemorrhage control in severe pancreatogenic bleeding. Developed logistics, new diagnostics, and treatment protocols are essential to reduce mortality and morbidity.

## Effectiveness of Endovascular Hemorrhage Control in Gastrointestinal Bleeding

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**Background:** The aim of this study was to evaluate the effectiveness of endovascular techniques for gastrointestinal (GI) bleeding with a high risk of recurrence.

**Methods:** A retrospective study of patients with GI bleeding treated in our facility during a period of 2 years (2017–2018) was performed. All patients underwent primary gastroduodenoscopy. The type of bleeding was classified by Forrest (F). Risk of recurrent bleeding was assessed using the Rockall's system. All patients received antisecretory therapy. If conservative treatment failed and there was a high risk of recurrent bleeding, endovascular techniques were then used to control the bleeding.

**Results:** This study enrolled 160 patients. Sources of recognized bleeding were distributed as follows: duodenum peptic ulcer – 69 (43.1%) patients, stomach ulceration – 65 (40.6%), gastric cancer – 23 (14.4%), and gastroduodenalis artery pseudoaneurysm as a consequence of chronic pancreatitis – 3 (1.9%). In 98 patients (61.2%) with F1-F2b bleedings, combined endoscopic hemostasis was used. Sixty-two (63.2%) patients were successfully treated by conservative methods. Thirty-six (26.8%) underwent endovascular surgery. The left gastric artery was embolized in 10 patients with chronic gastric ulceration and 13 patients with gastric cancer (Group 1). Ten patients with chronic duodenum ulcer and 3 with pseudoaneurysms, were scheduled for gastroduodenal artery embolization (Group 2).

Technically successful embolization in Group 1 was performed in 60.8% of cases (8 with gastric ulcers and 6 with cancer). The remaining 9 patients underwent conservative treatment. Bleeding reoccurred in these patients in 77.7% of cases ( $n = 7$ ). Among them, 4 underwent repeated endoscopic hemostasis, 3 had open surgery (subtotal gastric resection or bleeding point suturing). Six patients died (66% lethality rate). Clinical effectiveness of the left gastric artery embolization was achieved in 71.4% of cases ( $n = 10$ ). Recurrence of bleeding was recorded in 4 patients (28.6%). Two patients died (14.3%). Another two patients underwent additional endoscopic hemostasis.

In Group 2, technical success was achieved in 100% of cases. However, in 15.4% ( $n = 2$ ), bleeding reoccurred. Either repeated endoscopy or open surgery was needed to control the bleeding. One patient died (7.7%).

**Conclusion:** Endovascular surgery allows the achievement of hemostasis in 71% of patients with a high risk of rebleeding and diminishes mortality and morbidity.

# Endovascular Hemorrhage Control of Postoperative Pancreatic Hemorrhage

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**Background:** Pancreatic resections are usually performed for tumors and complicated chronic pancreatitis. Although lethality is decreasing to 5%, a number of postoperative complications remain high even in specialized centers and can reach 50%. The most dangerous and severe complication in pancreatic surgery is postoperative bleeding. It accounts for 4–30% and is associated with lethality of about 3–60%. The aim of our study was to analyze our experience in the treatment of postoperative bleedings.

**Methods:** It is a retrospective study embracing the period 2014–2018 and includes patients with postoperative hemorrhagic complications after pancreatic surgery. The type of treatment, endovascular interventions, and outcome were analyzed.

**Results:** During the study period 524 patients underwent resection pancreatic surgery. Fifty-six of them (10.7%) developed postoperative hemorrhage: 35 (62.5%) had intraabdominal hemorrhage, 18 (32.1%) had intestinal hemorrhage, and 3 (4.4%) had a combination of the two types of hemorrhage. Overall, 14.3% (8) of complications developed within the first 24 hours postoperatively, and 85.7% (48) developed later than 24 hours. Most commonly (49%) postoperative hemorrhage developed after cancer resections. To control hemorrhage, a laparotomy was performed in 20 patients (35.7%) and endovascular surgery in 29 patients (51.8%). Among those who underwent endovascular treatment, 10 patients had surgery for recurrent hemorrhage: 3 after relaparotomy and 7 after endovascular surgery. From 29 patients who had endovascular treatment, 8 underwent stenting and 21 underwent embolization. The total lethality rate was 17.8% ( $n = 10$ ). Among the patients who underwent relaparotomy for hemorrhage control, 7 (35%) died; and among those who underwent endovascular surgery, 3 (10.3%) died.

**Conclusion:** Postoperative hemorrhage after pancreatic resections is a serious complication. Endovascular hemorrhage control is now the most effective and least invasive to control such hemorrhage. Endovascular surgery implementation resulted in decreased postoperative mortality.

# Endovascular Treatment of Postoperative and Posttraumatic Hepato-Pancreatic Hemorrhage

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**Introduction:** The aim of our study was to evaluate the results of diagnostic angiography and endovascular treatment of postoperative and posttraumatic hemorrhage in the hepato-pancreato-duodenal region.

**Methods:** All patients who had either postoperative or posttraumatic hemorrhage in a hepato-pancreato-duodenal region and admitted to two divisions of our academy during the period of 2006–2018 were included in the retrospective analysis. For the purpose of embolization, either coils or N-butyl cyanoacrylate (NBCA), Onyx, or gelfoam were used. In hemorrhage from pancreatic arteries, targeted vessel embolization was performed. In liver artery injury, proximal embolization was used.

**Results:** Forty patients were included in the study in total. Twelve patients were diagnosed with pancreatic intracystic hemorrhage caused by either its percutaneous or transgastric drainage. Six patients had splenic artery hemorrhage into a lumen of pancreatic enteroanastomosis, another 6 from arteria hepatica propria into a lumen of hepatic enteroanastomosis and/or intraabdominally, 4 from the superior mesenteric artery into a lumen of hepatic enteroanastomosis and/or intraabdominally, 8 hemobilia after percutaneous biliary drainage, 4 posttraumatic liver injuries after surgery in this zone. In all cases, angiography allowed the source of hemorrhage to be defined. Contrast extravasation was revealed in 17 patients and pseudoaneurysms in 12 patients. Indirect signs of hemorrhage took place in 6 patients.

In 9 patients with major visceral artery pseudoaneurysms, stent grafts were placed. In 2 cases of liver injuries, branches of the portal vein were embolized. Primary hemostasis was achieved in all cases. Complications developed in 2 patients postoperatively. One patient who had a splenic artery embolized with NBCA developed a splenic abscess (addressed with ultrasound-guided drainage). Recurrence of hemorrhage was registered for 4 (11.4%) patients: one was embolized, and the remaining 3 underwent emergency laparotomy. There were no fatalities in the postoperative period.

**Conclusion:** Endovascular techniques are effective in controlling postoperative and posttraumatic hemorrhage in the hepato-pancreato-duodenal region. These techniques reduce mortality and morbidity.

## Impending Rupture of a Traumatic Giant Pseudoaneurysm of the V2 Segment of the Vertebral Artery: A Successful Hybrid Approach and Outcome. A Vascular Surgeon View

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**Background:** Vertebral artery (VA) aneurysms are rare clinical findings, representing 1% of supra-aortic aneurysms. The most common cause of extracranial VA aneurysms (EVAA) is penetrating neck trauma, but they can also occur secondary to dissection, atherosclerosis, infection, collagen vascular diseases, and inherited connective tissue disorders. EVAA are very uncommon accounting for 0.5% of all aneurysms; they generally affect the most mobile segment, which is the V3 segment, followed by the V1 segment. The rupture of an EVAA can lead to catastrophic bleeding and pose a diagnostic and therapeutic challenge. VA injuries constitute less than 1% of all the vascular injuries and less than 1–6% of all the vascular injuries in the cervical region. Penetrating VA injuries are rare and injuries were previously missed prior to the routine use of angiography in diagnosing penetrating neck injuries. Frank hemorrhage was the impetus for the decision for operative exploration at the onset.

**Case description:** Here we report the largest pseudo aneurysm reported in the literature. It was impending to rupture, arising from the second part of the right vertebral artery (V2) in a 35-year-old male. CT-angiography confirmed the presence of extracranial pseudoaneurysm involving the 2nd part of the right VA, measuring 10 × 7.5 cm<sup>2</sup>. The aim of this study was to focus on a very rare vascular injury that a vascular surgeon can encounter throughout his daily work and highlight the treatment options in an emergency situation, putting into consideration the availability of different tools. We went through a hybrid approach where the proximal parent vertebral artery was controlled with a 3-mm balloon (30 mm length), through a rapid right trans brachial access followed by deployment of two coils, but surgical exposure and ligation of the V3 part was mandatory due to refilling of the aneurysm through retrograde flow from the contralateral VA. The postoperative period was free of any cerebrovascular ischemic signs followed by recovery.

## REBOA is Effective in Reducing Intraoperative Blood Loss During C-Section in Cases of Abnormal Placenta

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**Background:** According to the WHO, post-partum hemorrhage (PPH) is the leading cause of maternal mortality in the world. Abnormally invasive placenta (a/in/percreta) is one of the main causes of PPH. It usually takes place in 1:500 to 1:2500 pregnancies. As the number of C-sections is increasing over recent years, the number of abnormally invasive placenta has increased. The average intraoperative blood loss during these C-sections is about 3–5 L and can reach 10 L to necessitate a massive blood transfusion. Around 75% of such operations end with hysterectomy. Resuscitative endovascular balloon occlusion of the aorta (REBOA) is now an option for blood loss prevention in cases of abnormally invasive placenta during C-sections. The aim of our study is to analyze all the cases of REBOA use in a single perinatal center.

**Methods:** This is a retrospective study covering the period of November 2018 to March 2019, and all the cases of REBOA used are included in the analysis. Diagnosis of abnormally invasive placenta was confirmed by preoperative ultrasound and MRI. Under epidural anesthesia, a radial artery was cannulated for invasive blood pressure monitoring, and a femoral artery was cannulated (8 Fr) under ultrasound guidance for REBOA catheter placement. For the procedures, a rescue balloon (Tokai Medical, Japan) was used in all cases. A deflated balloon was positioned above the aortic bifurcation under trans-lumbar ultrasound guidance. Once the C-section was done and the child removed, the balloon was inflated and metroplasty performed. After the operation, the sheath was removed by manual compression.

**Results:** Five patients underwent preventive REBOA. All the patients tolerated the procedure. Mean operative procedure time was 56 (48–67) minutes, occlusion time was 20 (16–29) minutes. Average blood loss was 620 mL (300–1000 mL). Fluid replacement therapy included  $1600 \pm 200$  mL of crystalloids, and no blood components were needed. No complications were recorded and all patients were discharged on postoperative day 5.

**Conclusion:** Preventive REBOA for abnormally invasive placenta is a safe and effective procedure for reducing intraoperative blood loss.

## First Experience of a Femoral Artery Catheterization for Potential REBOA During Inter-Hospital Transportation by HEMS in Russia

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**Background:** Resuscitative endovascular balloon occlusion of the aorta (REBOA) is now increasingly used for trauma management around the world. It is usually performed upon the patient's admission in the emergency room or operating room. However, prehospital and transfer REBOA have been recently described in the literature. Here we present the first Russian experience of prehospital endovascular resuscitation and trauma management implementation when a femoral artery was accessed for possible REBOA during the transportation of an unstable patient.

**Case description:** A 58-year old male involved in a road traffic accident was delivered to a rural trauma center in the Leningrad Region. On admission (about one hour after the injury), the following lesions were revealed: blunt chest trauma with multiple rib fractures on the left with pulmonary contusions, unstable pelvic fractures, multiple left femur and tibia fractures.

The patient was intubated, and a diagnostic peritoneal lavage was performed (negative) followed by external pelvis and left femur fixation. Hemoglobin level dropped from 11 to 9 g/dL and continued decreasing. Blood transfusion was limited by 2 units of packed red blood cells due to a lack of blood in the rural facility. Blood pressure (BP) remained unstable with systolic BP not higher than 100–110 mm Hg while norepinephrine was given at 0.2 mcg/kg/min.

Twelve hours later, there was a significant loss in vitals: hemoglobin level decreased to 8 g/dL and then to 7.2 g/dL with systolic BP around 90 mm Hg, likely due to persistent pelvic bleeding. A decision was made to transfer the patient to a Level 1 trauma center by helicopter.

Due to the patient's instability (norepinephrine 0,14 mcg/kg/min, BP 100/70), the decision was made to place a deflated REBOA catheter into the aortic Zone III and inflate it in case of a sudden loss of systemic BP. Supposed transport time was 50–60 minutes. On an ICU bed, the 11 Fr introducer was placed into right femoral artery under ultrasound guidance. Due to the relative stabilization of the patient immediately before transport, no catheter was inserted and a sheath was used for BP monitoring. Time for the sheath placement, which was performed by a helicopter emergency medical service (HEMS) anesthetist, was 9 minutes. Total transportation time was 48 minutes.

During transportation, the patient remained vitally stable (BP not less than 95/70), so there was no need for a REBOA-catheter insertion. At the Level 1 trauma center, a massive transfusion protocol was initiated. Thromboelastography showed normal coagulation. No severe acidosis was found in blood gases (pH 7.35; BE-2). A small correction of an external pelvis fixator was performed by a skilled orthopedic surgeon. Femoral artery access was removed by manual compression with no complications. The patient was then stabilized with uneventful recovery.

**Conclusions:** Preventive femoral artery cannulation prior to transport of a hemodynamically unstable patient allowed minimizing risks of fatal non-compressible bleeding en route. In this case, artery cannulation at the most crucial and sophisticated stage was made in a relatively calm ICU setting by a HEMS crew. REBOA catheter insertion was wisely delayed to the point of potential BP fall due to transport exposure factors. In addition, artery cannulation can be used for invasive BP measurement and repeated blood gas analysis.

## Arterial Embolization for Recurrent Gastrointestinal Bleeders in Elderly Patients

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**Background:** Endoscopic hemorrhage control is a gold standard in the treatment of peptic ulcers accompanied by gastrointestinal (GI) bleeding. Saint Petersburg data shows a lethality rate of 5% in 2016 for GI bleeding, and post-operative lethality is 8.5%. As endovascular techniques are developing, arterial embolization (AE) is an alternate option if conservative treatment with endoscopy fails, especially in high-risk patients. The aim of our study was to analyze the effectiveness of AE in elderly patients with GI bleeding.

**Methods:** This is a retrospective study of consecutive patients admitted to our facility with recurrent GI massive bleeding who underwent angiography and AE for hemorrhage control during the period of 2013–2017. The severity of physiology abnormalities was assessed using the APACHE II scale, the severity of GI bleeding was assessed using Forrest's classification.

**Results:** A total of 20 patients met the inclusion criteria. The median age was  $62.7 \pm 14.8$  years. According to APACHE II, 14 patients had a score of 26 or more, and 4 patients had a score of 20–25. Upon angiography, the bleeder was localized on the stomach small curvature in 14 cases, the back duodenum wall in 6 patients. Endoscopy revealed callous ulcers more than 2 cm in diameter in 8 cases. According to the Forrest classification, patients were distributed as follows: IA, 2; IB, 3; IIA, 10; IIB, 5. In 3 cases, there was a failure of endoscopic hemostasis. Bleeders were embolized by either a combination of glue and microcoils ( $n = 10$ ), or glue ( $n = 3$ ), or microcoils ( $n = 4$ ), or a combination of microcoils and gelfoam ( $n = 3$ ). Technical and clinical (hemorrhage control) success of AE was achieved in 95% of cases ( $n = 19$ ). One patient had a 60%-stenosis of a proximal part of the gastrosplenic trunk making selective catheterization hardly possible. No recurrent bleedings were registered. Three patients died in the postoperative period (15% lethality rate) due to severe co-morbidities and heart failure.

**Conclusion:** AE is a feasible option for GI hemorrhage control, especially in elderly patients with peptic ulcers. Additional studies are warranted to define an optimal cohort of patients, indications, a type of AE, and an optimal embolizing technique and agent.

## Pelvic Angiography for Polytrauma Patients: A Single-Center Experience

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**Background:** The aim of our study was to evaluate the effectiveness of pelvic angiography (PA) followed by internal iliac artery (IIA) embolization to control bleeding in cases with polytrauma and severe unstable pelvic fractures.

**Methods:** A retrospective study of all the polytrauma patients with unstable pelvic fractures who were admitted to our trauma center and underwent PA during the period of 2014–2018 was performed. Time of transportation to our hospital, the severity of trauma (according to the ISS), door-to-angio time, duration of PA, results of PA, and transfusion requirements were recorded and analyzed. As the first stage of care, external fixation of pelvic ring fractures was performed. Then, if instability maintained or a patient deteriorated pelvic packing was done. As a next step, PA was done to rule out an arterial source of bleeding.

**Results:** Fifteen patients were enrolled in this study. Most of them (74%) were male. Among these, there were 7 falls (46.7%), 7 road-traffic collisions (46.7%), and 1 was compressed by a heavy object (6.6%). According to the Tile classification, there were 1 type A, 6 type B, and 8 type C fractures. Average time of transportation to a hospital was  $67.9 \pm 14.8$  minutes. The average ISS score was  $35.67 \pm 10.77$ . According to the H.C. Pape classification (2005), there were 5 patients with borderline conditions and 10 with unstable hemodynamics.

All patients underwent external pelvic fixation. Among them, five patients underwent pelvic packing and the others were transferred immediately to an angiosuite. The REBOA procedure was performed in zone III for temporary hemorrhage control only once. Upon PA, arterial “blush” and sharp “cut-off” were found in 5 (33%) and 3 (20%) cases, respectively. These patients then underwent a therapeutic endovascular intervention. The other 7 patients only had diagnostic PA.

Median door-to-angio time was  $323.5 \pm 164.4$  minutes. Duration of the procedure was between 30 and 85 ( $47 \pm 18$ ) minutes. Selective and non-selective embolizations were performed in 6 and 2 cases, respectively. Transfusion requirements were  $2.80 \pm 0.67$  units of packed red blood cells during the first 24 hours in ICU. Twenty-four-hour survival was 80% (12 patients) and total survival rate was 60% (9 patients). Median stay-in-hospital time was  $37.4 \pm 14.1$  days.

**Conclusion:** Angiography allowed the recognition of an arterial source of bleeding in every second polytrauma patient. In all cases, embolization was effective in controlling bleeding and there was no recurrence of bleeding until discharge.

## Uterine Artery Embolization for Abnormally Invasive Placenta: An Experience of Collaboration Between a Perinatal and a Regional Center

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**Background:** Post-partum hemorrhage (PPH) is a blood loss of more than 10% of circulated blood (or 500 mL) during a vaginal birth or more than 1,000 mL during a Caesarean delivery (physiologic hemorrhage). A blood loss of 10–30% is pathologic, and more than 30% is massive. The latter occurs in 5% of all deliveries. Massive PPH is an important source of maternal mortality (15–25% of cases). To prevent PPH different techniques were proposed, and one of them is uterine artery embolization (UAE). The aims of UAE are: 1) uterine preservation, 2) reducing blood loss, 3) stable delivery, 4) decrease of maternal mortality. We investigated the effectiveness of this method to control PPH.

**Methods:** This is a retrospective study summarizing all patients admitted to our hospital with abnormally invasive placenta and underwent a hybrid operation (UAE and C-section) from June 2015 to March 2019. The type of operations, anesthesia, access, and operative time were recorded.

**Results:** Forty-one patients were analyzed. Every woman underwent a hybrid operation. Median parameters were: age 33.1 years, gestations 3.8, deliveries 2.9, and gestational age 37.5 weeks. Thirty-two patients were intubated, and the rest underwent spinoepidural anesthesia. Different vascular accesses were used for operations: both femoral arteries in 25 cases (61%), one femoral artery in 3 cases (7%), and a brachial artery in 13 cases (32%). Operative time was 184.8 (105–301) minutes and median blood loss was 1282 (500–5,000) mL. There were no complications and no cases of maternal mortality registered. In only one case, extirpation of the uterus was performed on the 2<sup>nd</sup> postoperative day.

**Conclusion:** The hybrid approach (angiography + C-section) for childbirth complicated by abnormally invasive placenta is an effective and safe technique, which, however, necessitates a multidisciplinary approach (anesthetists, perfusionists, Ob&Gyn, neonatologists, IR, urologist, nurses).



# Our Experience in Implementation of Endovascular Techniques in Vascular Trauma

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**Background:** The aim of this study was to present our experience in endovascular procedures performed for vascular injuries.

**Methods:** This is a retrospective study embracing the period of June 2005 to March 2019. All the endovascular procedures for trauma performed in our center during this period were analyzed. The type of operation was also recorded. Embospheres, poly(vinyl alcohol), coils and microcoils, gelatin sponge, and glue were used for the embolization of bleeders. In arterial perforations and aortic ruptures, a stent graft was implanted.

**Results:** Eighty-nine patients were included in this study. The median age was  $56 \pm 19$  years (53 male, 36 female). They underwent 94 endovascular procedures. Embolizations were performed for postoperative hemorrhage control of urologic patients, after ear, nose and throat and gynecology operations, and GI bleeders in 13, 12, 11, and 9 patients, respectively. Other bleeders were embolized in 4 patients. Microcoils were super-selectively placed in 3 patients with perforations of coronary artery branches. Twenty patients had percutaneous coronary intervention-associated coronary artery perforations which caused hemopericardium. Seventeen of them, 2 patients with blunt traumatic aortic injuries, 13 patients with femoral/brachial puncture-site bleeding, and 5 patients with iatrogenic iliac artery perforations were successfully treated with stent-graft placement. The total lethality rate was 2.2% (2 patients). One patient died a few hours after thoracic endovascular aortic repair. Another patient died the day after stent-graft placement in an injured coronary artery.

**Conclusion:** Endovascular procedures in different vascular injuries are effective and safe.

# Endovascular Resuscitation with Aortic Balloon Occlusion in Pediatric Trauma: A Case Report

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**Background:** Resuscitative endovascular balloon occlusion of the aorta (REBOA) is currently evolving and its use for trauma and resuscitation management in adults is increasing. There is, however, no detailed data published on its use in pediatric trauma. We describe a case of REBOA for traumatic hemorrhagic instability in a pediatric patient according to the concept of EndoVascular resuscitation and Trauma Management (EVTm) at Örebro University Hospital in April 2019.

**Case description:** An 11-year-old boy arrived at the emergency room by air ambulance after a motor vehicle accident with a positive seat-belt sign. During transport, due to total hemodynamic collapse, cardiopulmonary resuscitation was initiated with a return of spontaneous circulation though continued episodes of bradycardia. Bilateral common femoral artery (CFA) access (8 Fr) was gained in the emergency room and REBOA was placed uninflated in Zone I by landmark guidance. The patient was rapidly transferred to the operating room for an explorative laparotomy. A systolic blood pressure (SBP) of 40 mm Hg was registered on arrival to the surgical suite and total REBOA in Zone I was performed for 7 minutes. Massive transfusion and damage control surgery were performed stopping a massive mesenteric arterial hemorrhage, the patient stabilized with an SBP of around 110 mm Hg. Both CFA accesses were closed by manual compression. There were no complications related to the use of REBOA. The patient is currently undergoing abdominal reconstructive surgery.

**Conclusion:** REBOA for endovascular resuscitation may be an additional method for temporary hemodynamic stabilization in pediatric patients and was in this specific case used instead of thoracotomy for hemodynamic instability.

# Irreversible Sudden Cardiac Arrest in Potential Transplant Surgery: Problems and Perspectives

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**Background:** Extracorporeal membrane oxygenation (ECMO) is used more and more often around the world for the treatment of critically unstable patients. In some cases, ECMO is the only way to save patients' lives. It is used for sudden cardiac arrest (SCA) at the prehospital stage of care when standard cardiopulmonary resuscitation (CPR) is not effective. However, when invasive lifesaving techniques (ECMO-CPR, balloon contrapulsation) are also ineffective, an ultimate possibility of donor organ transplant surgery should be always kept in mind for ongoing ECMO (according to a brain death protocol) and after the withdrawal of care for futility (ECMO-saving perfusion, ECMO-SP). **Methods:** All patients with ongoing CPR (Lucas-2) admitted to our emergency department during the period of October 2017–March 2019 were included in this study. A decision for ECMO-CPR was made by an ECMO-team leader after appropriate diagnostic tests (angiography, CT, ultrasound, ECG, etc). In 20 minutes after biological death was assured, the perfusion was initiated. If the return of circulation and cardiac rhythm was achieved using ECMO-CPR, confirmation of brain death was performed using standard criteria. This study was approved by the local Ethical committee.

**Results:** Thirty-four patients were admitted to our emergency department during the study period. Sixteen potential donors met the inclusion criteria. The median age was  $48.3 \pm 4.5$  years. Nine potential donors were excluded at a phase of cannulation and ECMO initiation due to technical problems, massive bleeding, cannulas migration or oxygenator thrombosis. An additional four donors were excluded due to ineffective perfusion, serologic and histologic exclusion criteria. In two cases with a return of cardiac rhythm, brain death was diagnosed. The ECMO-SP protocol allowed ten kidneys and two livers to be transplanted with good clinical results (one after ECMO-SP, one from a brain-dead donor).

**Conclusions:** ECMO-CPR is effective in patients with cardiac arrest. Time limits and laboratory markers have to be promptly followed. ECMO centers are needed for taking care of patients with SCA. Those patients have to be immediately transported from the scene to such centers. If any criteria of irreversible brain injury are met, then ECMO-CPR can be used as a bridge for organ transplantation. Anoxic perfusion using ECMO-CPR can be initiated immediately after the termination of CPR. It helps to decrease the time of the "no-touch" period for brain death criteria diagnosis (the same as the apnea test).

**Funding:** This study was supported by grant RSF #17-18-01444 (2017).

## Feasibility of Blind Versus Ultrasound-Guided Vascular Access and REBOA on Board of a Medical Helicopter in a Hemorrhagic Ovine Model

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<sup>4</sup>Royal Infirmary of Edinburg, Scotland, UK

**Background:** The aim of this study is to evaluate the feasibility of en route resuscitative endovascular balloon occlusion of the aorta (REBOA) on board of a helicopter.

**Methods:** Six sedated male sheep (weighing  $47.5 \pm 4.0$  kg) were placed on a spineboard, underwent a controlled venous hemorrhage until the systolic arterial pressure (AP) dropped to  $<90$  mmHg, and were placed into a low capacity Eurocopter EC-350. During a 30-minute normal flight, every animal underwent blind (left side) and ultrasound-guided (US) (right side) vascular access (VA) to the femoral artery followed by REBOA: the first catheter into zone I and the second into zone III. The 7-Fr Rescue (Japan) and the 10-Fr MIT (Rus) balloons were used without primary wire insertion. Every VA procedure was limited to 10 minutes. In case of blind VA failure, an alternate US-puncture was also available at the left side. Six experienced flight anesthetists previously trained in REBOA with one assistant were enrolled in the study. VA and REBOA catheter placement (confirmed by X-Ray) success rate and timing were recorded.

**Results:** Nine of 12 VAs (75%) were successful: 1/6 blind punctures compared to 8/9 US-punctures ( $p = 0.011$ ). However, correct wire insertion and sheath placement was performed in 1/6 animal in the blind group and only in 6/9 animals in the US-group ( $p = 0.119$ ). It took 65 (interquartile range, 30–242) seconds for US-puncture and 4 minutes on average to get the sheath in. Among 9 VAs, there were 2 REBOA failures (1 ruptured balloon [MIT] and 1 mistaken vena cava placement primarily recognized by a sudden drop of AP and later confirmed by X-Ray). Overall, 5/7 balloons were placed in the desired position: 4/5 in zone I and 1/2 in zone III. The average time for a successful REBOA procedure was 5.0 (4.6–9.3) minutes (1 min after sheath placement).

**Conclusion:** Our study demonstrates the potential feasibility of the en route REBOA which can be performed within 5 minutes. US-guidance is critically important to achieve en route VA.

**Funding:** This study was supported by grant RSF#17-73-20318.

## Battlefield Extracorporeal Cardiopulmonary Resuscitation (ECPR) for Out-of-Hospital Cardiac Arrest: A Pilot Feasibility Study on Large Animals

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IM Samokhvalov<sup>1</sup>, ON Reznik<sup>2,3</sup>, AE Skvortzov<sup>2,4</sup>, RI Minnullin<sup>5</sup>,  
RR Kasimov<sup>5</sup> and D Kerslake<sup>6</sup>

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**Background:** The aim of this study is to evaluate the feasibility of pre-hospital extracorporeal cardiopulmonary resuscitation (E-CPR) in the military exercise setting simulating a modern armed conflict.

**Methods:** Two sedated 40-kg *Sus scrofa* were enrolled. After controlled removal of 1L of blood, potassium chloride was administered to achieve cardiac arrest (CA). A minute after the CA was confirmed by ultrasound, an external compression device was applied for ongoing CPR. The animal was then transported to Role I. Both the femoral artery (10 Fr) and vein (18 Fr) were cannulated and E-CPR was immediately initiated using a portable perfusion device (PEVK, TransBioTech.Ltd/Skolkovo). Once the circuit was stabilized, the animal was then evacuated by a helicopter to Role 2 where the study was terminated.

**Results:** Both animals developed persistent CA and were transported to Role I. In the first animal, in 25 min after CA both artery and vein were cannulated and E-CPR initiated with a blood flow rate (BFR) of 2.5 L/min. The animal tolerated a 15-min flight well and stayed alive for 4 hours without return of spontaneous circulation. However, abdominal compartment syndrome was developed due to severe blood loss (hemoglobin level decreased from 10.2 to 3.6 to 1.3 g/dL), shock (mean arterial pressure decreased from 97 to 47 to 34 mmHg) and extensive fluid replacement (9 L), which caused a drop of the BFR to 400 mL/min. After a decompressive laparotomy was performed, the BFR restored

to 1.5 L/min. In the second swine, femoral vein cannulation was successful 17 min after CA; however, 2-hour multiple attempts to cannulate peripheral arteries (both femoral and carotid) were unsuccessful due to spasm and hypotension, and, finally, open aortic cannulation allowed launching the circuit. However, due to extensive bleeding, the study was terminated for futility.

**Conclusion:** Our study demonstrates the potential feasibility of battlefield E-CPR, but it is futile without aggressive damage control resuscitation.

**Funding:** This study was supported by grant #MK5676.2018.7.

## EVTM SAINT-PETERSBURG, JUNE 2019

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## Conference Highlights



### Bleeding

Open, endovascular and hybrid techniques in trauma and bleeding  
Vascular injuries in civilian and military settings  
Endovascular control of different bleeders in trauma and non-trauma  
Pelvic bleeding: open and endovascular control



### Polytrauma

Current concept of trauma care  
Endovascular control of different bleeders in trauma and non-trauma



### REBOA

REBOA and vascular access



### Diagnosis

Ultrasound and CT in trauma and bleeding management



### Resuscitation

Endovascular techniques for trauma and non-trauma cardiac arrest  
Extracorporeal life support



### Administration

Some aspects of training  
Multidisciplinary EVTM approach



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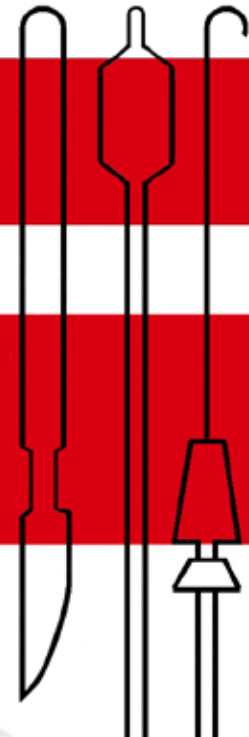
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# Pan-American EVT<sup>M</sup>

Endovascular Resuscitation & Trauma Management

17-18 November 2019

Preliminary Program

SUNDAY November 17 <sup>th</sup>	
07.30-07.45	<b>Introduction</b> - Chuck Fox, Ernest Moore, Joe DuBose
07.45-09.10	<b>Trauma Applications of EVT<sup>M</sup> - REBOA.</b> 8 min talk - 5 minute discussion Moderators: Chuck Fox (Denver, CO, USA), Todd Rasmussen (Washington, DC, USA)
07.45-07.58	Endovascular resuscitation and trauma management in 2019 - A trauma leaders perspective - Ernest Moore (Denver, CO, USA)
07.58-08.11	Who are the caretakers of vascular injury for the future? - Michael Sise (San Diego, CA, USA)
08.11-08.24	The Endovascular Resuscitation and Trauma Management Society - Mission and future - Tal Hörer (Orebro, Sweden)
08.24-08.37	Pre-hospital EVT <sup>M</sup> applications in the civilian realm - Challenges and opportunities - Laura Moore (Houston, Texas, USA)
08.37-08.50	The role of the Emergency Medicine provider in EVT <sup>M</sup> - Zaf Qasim (Philadelphia, PA, USA)
08.50-08.58	REBOA as a transfer adjunct? - Joe Galante (Sacramento, CA, USA)
08.58-09.10	<b>Panel Discussion and Audience Questions</b>
09.10-09.40	<b>Break</b>
09.40-10.57	<b>Beyond trauma: Endovascular Adjuncts in Post-partum hemorrhage and medical arrest</b> 8 min talk - 5 minute discussion Moderators: Paula Ferrada (Richmond, VA, USA), Rishi Kundi (Washington, DC, USA)
09.40-09.53	Post-partum hemorrhage and EVT <sup>M</sup> : the problem defined - Mike Belfort (Houston, Texas, USA)
09.53-10.06	The Cali mal-positioned placenta registry - an update - Dr. Albaro Nieto (Cali, Columbia)
10.06-10.19	High risk OB and REBOA in the US: present status and future studies - Karin Fox (Houston, Texas, USA)
10.19-10.32	REBOA capabilities and embolization in high risk obstetrics - current and future state - JR Taylor (Little Rock, Arkansas, USA)
10.32-10.40	REBOA use in medical arrest - an update - James Daley (New Haven, Connecticut, USA)
10.40-10.57	<b>Panel Discussion and Audience Questions</b>
10.57-12.15	<b>Endografts and hybrid environments</b> 8 min talk - 5 minute discussion Moderators: Jerry Fortuna (St Louis, Missouri, USA), Juan Duchesne (New Orleans, LA, USA)
10.57-11.10	Endovascular stent graft repair of blunt thoracic aortic injuries - an update - Pedro Teixeira (Austin, TX, USA)
11.10-11.23	Stent graft repair of non-aortic arterial injuries - who, when, where - Ravi Rajani (Atlanta, GA, USA)
11.23-11.36	Endografts as shunts and in hybrid approaches - AJ Davidson (Sacramento, CA, USA)
11.36-11.49	Hybrid operating environments - The Canadian experience - Chad Ball (Calgary, Alberta, Canada)
11.49-11.57	Hybrid OR utilization - The Shock Trauma experience - Jonny Morrison (Baltimore, Maryland, USA)
11.57-12.15	<b>Panel Discussion and Audience Questions</b>
12.15-13.15	<b>Lunch &amp; Resident Symposium</b>
13.15-14.40	<b>EVT<sup>M</sup> and embolization for hemorrhagic control</b> 8 min talk - 5 minute discussion Moderators: Mike Sise (San Diego, CA, USA), Fernando Juglar (San Juan, Puerto Rico)
13.15-13.28	Embolization options for trauma - coils, plugs or liquid agents, practice options and data - Josh Adams (Roanoke, Virginia, USA)
13.28-13.41	Splenic embolization: Who, when, how - Ben Zarzaur (Indianapolis, Indiana, USA)
13.41-13.54	Embolization for pelvic hemorrhage, where does it fit in the algorithm? - Melanie Hoehn (Denver, CO, USA)
13.54-14.07	Acute GI bleeds - potential role for REBOA and embolization - Joseph Ibrahim (Orlando, Florida, USA)
14.07-14.20	[TBA]
14.20-14.28	EVT <sup>M</sup> in elective surgical interventions - potential oncologic and orthopedic indications - Anna Romagnoli (Baltimore, Maryland, USA)
14.28-14.40	<b>Panel Discussion and Audience Questions</b>
14.40-15.45	<b>Endovascular resuscitation and ECMO</b> 8 min talk - 5 minute discussion Moderators: Jim O'Connor (Baltimore, Maryland, USA), Jeremy Cannon (Philadelphia, PA, USA)
14.40-14.53	Early ECMO for trauma in 2019 - William Teeter (Chapel Hill, North Carolina, USA)
14.53-15.06	ECMO and transport - Why and how - Phil Mason (San Antonio, Texas, USA)
15.06-15.19	Establishing a regional Acute Lung Unit with ECMO capability = challenges and opportunities - Jay Menaker (Baltimore, Maryland, USA)
15.19-15.32	ECMO - Who should own the technology and how should they be trained? - Lena Napolitano (Ann Arbor, Michigan, USA)
15.32-15.45	<b>Panel Discussion and Audience Questions</b>
15.45-16.15	<b>Break</b>
16.15-17.30	<b>EVT<sup>M</sup> emerging technologies</b> 8 min talk - 5 minute discussion Moderators: Jim Manning (Chapel Hill, North Carolina, USA), Mike Dubick (San Antonio, Texas, USA)
16.15-16.28	Selective aortic arch perfusion - who and how? - James Ross (Portland, Oregon, USA)
16.28-16.41	It's not just about aortic occlusion: aortic flow regulation for traumatic injury - Tim Williams (Winston-Salem, NC USA)
16.41-16.54	Partial occlusion catheters: Promise and initial data - Marty Schreiber (Portland, Oregon, USA)
16.54-17.07	Intermittent vs. partial occlusion: which is the feasible answer? - Matt Martin (San Diego, CA, USA)
17.07-17.15	IVC filters: New technologies, new opportunities - Fernando Juglar (San Juan, Puerto Rico)
17.15-17.30	<b>Panel Discussion and Audience Questions</b>
19.00	<b>Dinner</b>

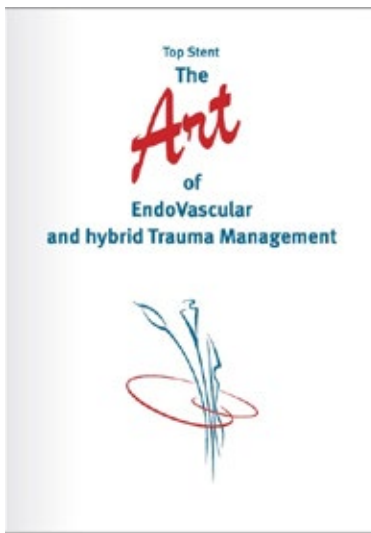
<b>MONDAY November 18<sup>th</sup></b>	
07.35-07.45	<b>Introduction</b> - Joe DuBose (Baltimore, Maryland, USA)
07.45-09.10	<b>REGISTRY DATA and REBOA Study design - updates</b> 8 min talk - 5 min discussion Moderator: Ernest Moore (Denver, Colorado), Joao Sahagoff (Brazil)
07.45-07.58	AAST AORTA REGISTRY - Update 2019 - Joe DuBose (Baltimore, Maryland, USA)
07.58-08.11	The European ABO Trauma Registry - David McGreevy (Orebro, Sweden)
08.11-08.24	The UK REBOA study - an update - Jan Jansen (Birmingham, AL, USA)
08.24-08.37	What the literature tells us: Scoping out REBOA - Andrew Beckett (Toronto, Ontario, CA)
08.37-08.45	Building the ideal study of REBOA: Present challenges and future opportunities - Bellal Joseph (Tucson, Arizona, USA)
08.45-09.10	<b>Panel Discussion and Audience Questions</b>
09.10-09.40	<b>Break</b>
09.40-11.05	<b>EVTM challenges: reperfusion and refining patient selection</b> 8 min talk - 5 minute discussion Moderators: Sheldon Teperman (Bronx, New York, USA), Lena Napolitano (Ann Arbor, Michigan, USA)
09.40-09.53	Resuscitation and REBOA - an anesthesiology perspective - Sam Galvagno (Baltimore, Maryland, USA)
09.53-10.06	Endovascular temperature modulation of re-perfusion injury - Graham Nichol (Seattle, Washington, USA)
10.06-10.19	Modifying the response to reperfusion pharmacologically - what is the answer? - Hasan Alam (Ann Arbor, Michigan, USA)
10.19-10.32	REBOA and TBI: Absolute contraindication? - Luke Neff (Winston-Salem, NC, USA)
10.32-10.40	Training for high quality ultrasound guided femoral arterial access: Are we doing enough? - Juan Duchesne (New Orleans, LA, USA)
10.40-11.05	<b>Panel Discussion and Audience Questions</b>
11.05-12.20	<b>Endovascular training issues</b> 8 min talk - 5 minute discussion Moderators: Michael Sise (San Diego, CA, USA), Melanie Hoehn (Denver, CO, USA)
11.05-11.18	Basic Endovascular Skills for Trauma Course: an update - Laura Moore (Houston, Texas, USA)
11.18-11.31	Building the optimal training platform for the EM members of the EVTM team - Austin Johnson (Sacramento, CA, USA)
11.31-11.44	Integrated DOD training and ESTARS - Jason MacTaggart (Lincoln, Nebraska, USA)
11.44-11.57	Military REBOA use - How forces train and utilize this technology on the modern battlefield - Jacob Glaser (San Antonio, TX, USA)
11.57-12.05	Prehospital use of REBOA in the military - Fact or fiction - Jen Gurney (San Antonio, TX, USA)
12.05-12.20	<b>Panel Discussion and Audience Questions</b>
12.20-13.30	<b>Miscellaneous Provocative Topics</b> 7 min talk - 5 minute discussion Moderators: John Holcomb (Houston, Texas), Omid Jazaeri (Denver, Colorado)
12.20-12.32	Complications of REBOA: why vascular surgeons need to stay involved in this technology - Greg Magee (Los Angeles, CA)
12.32-12.44	How to build a hybrid OR when the institution cannot afford it - Omid Jazaeri (Denver, Colorado)
12.44-12.56	Prehospital transport of patients with REBOA at high altitude - Becky Vogel (Denver, Colorado)
12.56-13.08	REBOA for Venous Injury - Rina Porta (Sao Paulo, Brazil)
13.08-13.20	Single side branched thoracic stents for repair of blunt thoracic aortic injury - Greg Magee (Los Angeles, CA)
13.20-13.30	<b>Panel Discussion and Audience Questions</b>
13.30-13.45	<b>Conclusion and final words: EVTM Society, JEVTM, and the next Pan American Meeting</b> - Chuck Fox, Tal Hörer, Joe DuBose



The **JEVTM Society** and **Denver University Hospital** welcome you to participate in the **2nd Pan-American EVTm meeting** at **The Westin Denver International Airport** November 17th and 18th 2019.

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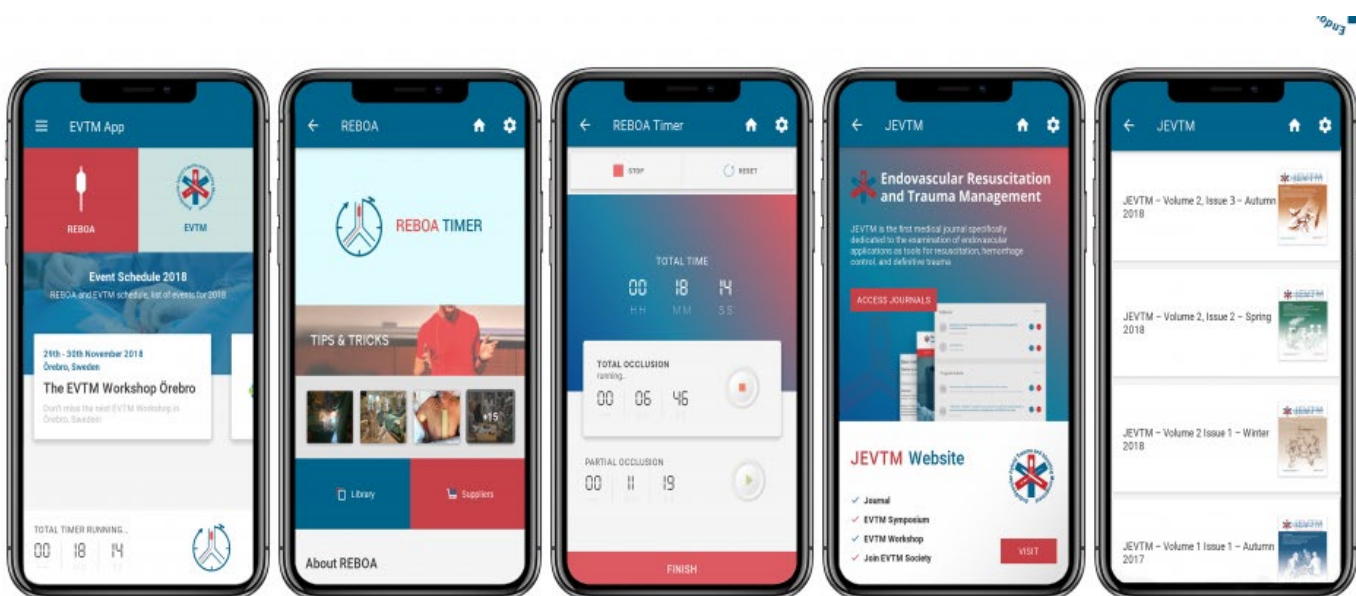


The Top Stent project is a multidisciplinary work manual for EVTVM. 28 experts from around the world give tips and tricks for EVTVM and REBOA.

The manual was released during the EVTVM 2017 Symposium and is now distributed as a non-profit project at production costs of 302 SEK with addition to delivery by post. If interested, send an e-mail to: [asa.strandberg@regionorebrolan.se](mailto:asa.strandberg@regionorebrolan.se) and state: number of books, address of shipment and address for invoice.

Some of the issues raised in the manual are:  
Vascular Access, Tips and Tricks  
Endovascular resuscitation

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# EVTM Society

## Join the Endovascular Resuscitation Platform

**The EVTM society is a non profit organization that aims to share information on advanced methods for bleeding control and endovascular resuscitation, exchange of data, and cooperation and education. It is also designed to serve as a professional platform for the multidisciplinary approach.**

By joining the EVTM Society you will be part of this global development.

**To join, please visit [jevtm.com](http://jevtm.com) and click on “Join EVTM Society” in the menu.**

Membership is free at this stage.

### **Vision and Mission:**

Our mission is to promote optimal treatment and new methods for bleeding control in trauma and non-trauma patients, and state-of-the-art endovascular resuscitation. This will be achieved by a joint international body that will support the following:

- A web-based free platform for EVTM issues ([jevtm.com](http://jevtm.com)).
- JEVTM – the Journal of Endovascular Resuscitation and Trauma Management, an open access peer-reviewed journal.
- The EVTM round table symposium, a platform for continuous debate and data exchange.
- Educational opportunities in the form of manuals (Top Stent), courses, workshops, and web seminars.
- Promoting open dialogue and cooperation between societies, organizations and the industry.
- Promoting new guidelines and recommendations for EVTM-related issues and protocols.
- Promoting research in EVTM-related areas, both human and animal.
- Promoting PR for EVTM issues, grants, and collaboration with industry.
- Encouraging residents and young colleagues to carry out research on EVTM issues.
- Promoting cooperation and data exchange with other medical instances.

### **Structure:**

The EVTM council, led by the society chair will change membership periodically (i.e., after two years). The council aims to have one or two representatives from each participating country and discipline.

The EVTM society is supported at this stage by Örebro University Hospital in all financial respects (as part of EVTM research group support). This support has been granted for the forthcoming two years.

The main task of the council is to pave the way for the EVTM venture, and promote the JEVTM/EVTM symposium, EVTM-related courses, cooperation, and free exchange of information.

Members will obtain free access to all JEVTM information and discussions as well as regular updates on EVTM-related activities, education, and developments. Members will also be offered a reduced fee for the EVTM round table symposium.

EVTM Society is registered in Sweden, and is managed in collaboration with the EVTM program at Örebro University Hospital, the JEVTM journal and web platform, and other institutes.

Since the society is registered in Sweden, it will follow the rules and guidelines of the Swedish government and the EU. Expansion to other countries is welcome, but should follow our ethical guidelines and the EVTM society should be named in all documents appropriately.

**Call for collaboration:** We call out to physicians with an interest in endovascular resuscitation, trauma and bleeding management. We need the contributions of the medical professionals who want to be a part of our venture.

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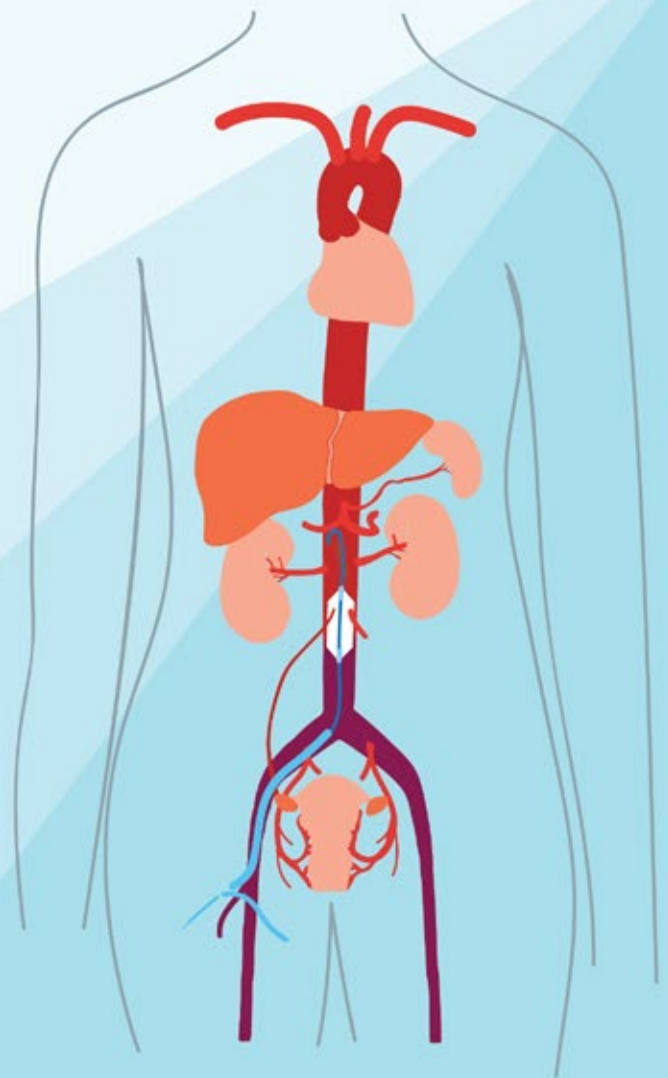
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