JEVTM

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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 the Department of Cardiothoracic and Vascular Surgery, Orebro University Hospital, Sweden.

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*.

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 Archives can be found on www.jevtm.com under journals and are there with no time or access limitations.

JEVTM is indexed in Scopus and Web Of Science.

Official publication of the Society of Endovascular Resuscitation and Trauma Management (EVTM)

In cooperation with Örebro University Hospital and Örebro University, Sweden.

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Author Guidelines

GUIDELINES FOR SUBMISSION

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)

Please ensure that names and contact details are included for **all** authors of a manuscript on the online submission system.

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. More information can be found below on the publication ethics of the JEVTM.
6. A clear statement that the authors follow the ethical guidelines as stated in the ethical section of the JEVTM.

Title Page

This should consist of the following:

- Title: This should be concise and reflect the type and purpose of the study.
- Authors: These should be listed in order for publication, with first name, initials and surname.
- Affiliations: The institution(s) that the authors are affiliated with should be listed. A full address is not required, but enough to ensure identification.
- Corresponding Author: This individual should be clearly identified, along with full institutional address and e-mail address.
- Presentation: The meeting where any of the submitted data was presented should be listed.
- Disclosure: To disclose any official information.
- Acknowledgements (Optional): Any acknowledgements that you would like to include.
- Conflicts of Interest (Compulsory): A conflict-of-interest statement regarding the authors. Where there is none, this should be clearly stated.
- Funding Declaration (Compulsory): Any grant funding should be listed or a negative statement should be included.
- Author Contributions (Optional): All authors are expected to have substantially contributed to the study and manuscript writing.

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, FULL CAPITALS**
Sub-Heading ***Bold and Italicized***, **Title Case**
Sub-sub-heading *Italicized*, *sentence case*

Abstract
The abstract should be a maximum of 250 words and consist of the following headings (but see specific manuscript types below for exceptions):

Background
Methods
Results
Conclusions

Keywords
Three to six appropriate keywords should be included.

Types of Article

Original Articles
Manuscripts reporting unique scientific studies should be no longer than 3000 words. They should consist of the following sections:

- Introduction: This should concisely present the background to the problem that the study hopes to answer. A hypothesis should be clearly stated.
- Methods: This section should be suitably detailed to permit replication of the study. The regulatory permissions for the study should also be detailed, e.g. Institutional Review Board, ethical committee etc., including a protocol/registration number. Where animal research has been undertaken, the institutional animal care and use guidelines that have been followed should be clearly stated.
- Results: These should involve the reporting of the salient positive and negative findings of the study in

clear language. The use of images, figures and tables are encouraged, of which the data should not be duplicated in the prose. There is no maximum number of figures or tables, but these should be appropriate to the study. Numerical results and *P* values should be reported to three decimal places.

- Discussion: This should place the reported study findings in the context of the literature. Limitations and future direction should also be discussed. Authors must be careful to ensure that conclusions are not overstated and are supported by data.

Editorials
Short, focused Editorials on an important aspect of endovascular hemorrhage control are welcomed. These should endeavor to bring attention to an important topic, or accompany an article published within the Journal. The latter will be invited by the Editor. Submitted manuscripts should be no longer than 1500 words. They will not contain an abstract or keywords.

Narrative Review Articles
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.

Systematic Reviews and Meta-Analyses
Where there is a topic within the subject area of endovascular hemorrhage control that has a substantial evidence base, a Systematic Review with/without a Meta-Analysis is considered more appropriate than a narrative review article. These articles should follow the methodology established by PRISMA.

Submission should be a maximum of 5000 words and authors should include a PRISMA checklist in their submission. The overall aim is to provide a pooled analysis that enables firm conclusions to be drawn on a particular subject.

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 of 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. The abstract should be unstructured and be a maximum of 150 words.

Images of Interest
The Journal accepts 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. They will not contain an abstract.

Case Reports
These are short case reports including current literature reviews. The submission should be a maximum of 1500 words. An abstract can be included but is not compulsory.

Conference Proceedings
Where a conference is affiliated to the Journal, the proceedings will be published as agreed by the Editorial Board.

Letters to the Editor
Letters for publication can be written to the Editor that comment on anything within the Journal.

EVTM-ST Section
The EVTM-ST Section will be a section of each JEVTM edition geared towards residents/fellows and education. The editors will invite one trainee to submit an interesting case report, and invite a reviewer to review and add a brief editorial. The editors should not be authors nor reviewers.

The components of the section will include a standard case report presentation with figures of CT or angio or anything interesting and pertinent. The discussion should finish with a "what I learned" summary/bullet points for education purposes. The brief editorial by the reviewer is the final paragraph.

The submissions should be a maximum of 1500 words. An abstract can be included but is not compulsory.

References

References should follow the Vancouver Style and should be noted in the text numerically in sequence within the text using square brackets, e.g. [1] or [1,2] or [1–3].

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;169:634–7.

Tang AL, Diven C, Zangbar B, et al. The elimination of anastomosis in open trauma vascular reconstruction. J Trauma Acute Care Surg. 2015; In Press. doi: XXXXXXXXXX.

(*Continued*)

(*Continued*)

Rasmussen TE, Tai NRM. Rich's Vascular Trauma. 3rd ed. Philidelphia: Elsevier; 2015.

Thamm DH. Miscellaneous tumors. In: Withrow S, Vail D, editors. Small Animal Clinical Oncology. 5th ed. St. Louis: Elsevier; 2013. pp. 679–88.

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

Figure/Tables

All figures/tables must be cited within the text, presented as Figure 1, Figure 2*a,b*, Figures 1 and 2, Table 1.

Figure captions should be styled as follows.

Figure 1 Title of figure.
Details of figure described below. (**a**) First sub item.
(**b**) Second sub-item.

Table captions are styled similarly.

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.

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.

ETHICAL AND LEGAL CONSIDERATIONS

The Journal is committed to maintaining the highest level of integrity in the content published. This Journal has a Conflict of Interest policy in place and complies with international, national and/or institutional standards on research involving Human Participants and/or Animals and Informed Consent. The Journal follows the Committee on Publication Ethics (COPE) regulations and subscribes to its principles on how to deal with acts of misconduct thereby committing to investigate allegations of misconduct, in order to ensure the integrity of research. The Journal may use plagiarism detection software to screen the submissions. If plagiarism is identified, the COPE guidelines on plagiarism will be followed. Content published in this Journal is peer reviewed (double blind review process). Detailed information will follow in the text below.

Authors' Responsiblities

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. All authors are obliged to provide retractions or corrections of mistakes after the review process. 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).

All published material will include the following Ethics Statement:

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Detailed Ethical Guidelines

Maintaining the integrity of the research and its presentation is helped by following the rules of good scientific practice, which are outlined here:

- The manuscript should not be submitted to more than one journal for simultaneous consideration.
- The submitted work should be original and should not have been published elsewhere in any form or language (partially or in full), unless the new work concerns an expansion of previous work. (Please provide transparency on the re-use of material to avoid the concerns about text-recycling ("self-plagiarism").)
- A single study should not be split up into several parts to increase the quantity of submissions and submitted to various journals or to one journal over time (i.e. "salami-slicing/publishing").
- Concurrent or secondary publication is sometimes justifiable, provided certain conditions are met. Examples include: translations or a manuscript that is intended for a different group of readers.
- Results should be presented clearly, honestly, and without fabrication, falsification or inappropriate data manipulation (including image based manipulation). Authors should adhere to discipline-specific rules for acquiring, selecting, and processing data.
- No data, text, or theories by others are presented as if they were the author's own ("plagiarism"). Proper acknowledgements to other works must be given (this includes material that is closely copied

(near verbatim), summarized and/or paraphrased), quotation marks (to indicate words taken from another source) are used for verbatim copying of material, and permissions secured for material that is copyrighted.
- Authors should avoid untrue statements about an entity (who can be an individual person or a company) or descriptions of their behavior or actions that could potentially be seen as personal attacks or allegations about that person.
- Authors are strongly advised to ensure the author group, the Corresponding Author, and the order of authors are all correct at submission. Adding and/or deleting authors during the revision stages is generally not permitted, but in some cases may be warranted. Reasons for changes in authorship should be explained in detail. Please note that changes to authorship cannot be made after acceptance of a manuscript.

In order to maintain the highest scientific standards, the Journal follows strict quality standards:

Upon request authors should be prepared to send relevant documentation or data in order to verify the validity of the results presented. This could be in the form of raw data, samples, records, etc. Sensitive information in the form of confidential or proprietary data is excluded.

If there is suspicion of misbehavior or alleged fraud the Journal and/or Publisher will carry out an investigation following COPE guidelines. If, after investigation, there are valid concerns, the author(s) concerned will be contacted under their given e-mail address and given an opportunity to address the issue. Depending on the situation, this may result in the Journal's and/or Publisher's implementation of the following measures, including, but not limited to:

- If the manuscript is still under consideration, it may be rejected and returned to the author.
- If the article has already been published online, depending on the nature and severity of the infraction:
  - an erratum/correction may be placed with the article
  - an expression of concern may be placed with the article
  - or in severe cases retraction of the article may occur.

The reason will be given in the published erratum/correction, expression of concern, or retraction note. Please note that retraction means that the article is maintained on the platform, watermarked "retracted", and the explanation for the retraction is provided in a note linked to the watermarked article.

Authors have an obligation to correct mistakes once they discover a significant error or inaccuracy in their published article. The author(s) is/are requested to contact the Journal and explain in what sense the error is impacting the article. A decision on how to correct the literature will depend on the nature of the error. This may be a correction or retraction. The retraction note should provide transparency as to which parts of the article are impacted by the error.

Editors' Responsibilities

The Editors of JEVTM have responsibilities toward the authors who provide the content of the Journal, the peer reviewers who comment on the suitability of manuscripts for publication, the Journal's readers and the scientific community, the owners/publishers of the Journal, and the public as a whole.

Reviewers' Responsibilities

Peer review assists editors in making editorial decisions and, through editorial communications with authors, may assist authors in improving their manuscripts. Peer review is an essential component of formal scholarly communication and lies at the heart of scientific endeavor.

Any invited referee who feels unqualified to review the research reported in a manuscript or knows that its prompt review will be impossible should immediately notify the editors and decline the invitation to review so that alternative reviewers can be contacted.

Any manuscripts received for review are confidential documents and must be treated as such; they must not be shown to or discussed with others except if authorized by the Editor-in-Chief (who would only do so under exceptional and specific circumstances). This applies also to invited reviewers who decline the review invitation.

Reviews should be conducted objectively and observations formulated clearly with supporting arguments so that authors can use them for improving the manuscript. Personal criticism of the authors is inappropriate. Reviewers should identify relevant published work that has not been cited by the authors. Any statement that is an observation, derivation or argument that has been reported in previous publications should be accompanied by the relevant citation. A reviewer should also notify the editors of any substantial similarity or overlap between the manuscript under consideration and any other manuscript (published or unpublished) of which they have personal knowledge.

Any invited referee who has conflicts of interest resulting from competitive, collaborative, or other relationships or connections with any of the authors, companies or institutions connected to the manuscript and the work described therein should immediately notify the editors to declare their conflicts of interest and decline the invitation to review so that alternative reviewers can be contacted.

Unpublished material disclosed in a submitted manuscript must not be used in a reviewer's own research without the express written consent of the authors. Privileged information or ideas obtained through peer review must

(*Continued*)

(*Continued*)
be kept confidential and not used for the reviewer's personal advantage. This applies also to invited reviewers who decline the review invitation.

Patient Anonymity and Informed Consent

It is the authors' 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 (see, for 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 far as possible.

Protection of Human Subjects & Animals in Research

For original articles in the Journal that report research involving animals, the corresponding author must confirm that all experiments were performed in accordance with relevant guidelines and regulations (i.e. IACUC guidelines and federal regulations, or EU guidelines for animal research). One recommended document for animals studies is the ARRIVE reporting guidelines (PLoS Bio. 2010; 8(6), https://doi.org/10.1371/journal.pbio.1000412). We encourage authors to follow the RRR principles of animal studies in medicine (https://www.feam.eu/wp-content/uploads/FEAM-Forum_Round-table-animals_Report_Final.pdf).

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 when possible if a waiver of regulatory requirements for obtaining and documenting informed consent applies.

Ethical Approval and Informed Consent
Ethical approval to report these cases was given by XXXXX. Written informed consent was obtained from xxxx.

Or in the negative

Ethical Approval and Informed Consent
Ethical approval was not required. Informed consent was not possible because XXXX and the information has been anonymised or Informed consent was not required.

All submissions are screened for inappropriate image manipulation, plagiarism, duplicate publication and other issues that violate research ethics. Depending on the outcome of these investigations, the Journal may decide to publish errata, or, in cases of serious scientific misconduct, ask authors to retract their paper or to impose retraction on them.

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.

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).

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/evtm-society.

The Membership fee is 50 USD biannually.

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).
- JEVTM – the Journal of Endoascular 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.

The 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.

Please consider joining by filling out the form at:
http://www.jevtm.com/evtm-society

Contents

Editorial

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EndoVascular resuscitation and Trauma Management Specialists in Training – The Future of EVTM Education

David T McGreevy[1], Daniel Sheffer[2], Maya Paran[2], Anna Stene Hurtsén[1], Camilla Cremonini[3], Enrico Cicuttin[3] and Boris Kessel[1]

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Residency and fellowship programs for surgical training have been around for close to 150 years; however, over the past 2–3 decades the individual surgical experience of the residents and fellows has changed dramatically [1–3]. Technological advances and their application in medical and surgical fields have been highly beneficial for patient outcomes, but they pose a significant challenge when educating future surgeons in trauma. New imaging technology has improved diagnosis and allowed for non-operative management of trauma patients who previously would have required an exploratory laparotomy. Artificial intelligence and computer vision has allowed for automated diagnostic imaging analysis. Advances in minimally invasive surgery and robotic surgery and an increase in procedures performed percutaneously has resulted in less exposure to elective open surgery, with those remaining cases often being conditions requiring expertise and experience [4]. In addition to this, regulations regarding working hours have reduced overall on-duty time, marginalizing evening and over-night hours where independence is gained. This not only results in direct limitation of surgical experience but also forces clinics to expand their employment of resident physicians, furthermore increasing competition for theatre time [5]. With the modern day surgical trainees already suffering from both reduced working and operating hours, healthcare and surgical education leaders need to respond to this rapidly changing landscape. If hands-on operative training is lacking, there needs to be an equally rapid advancement in modern ways of teaching surgery. Traditional surgical education can partly be provided through enhancement of existing educational tools not reliant on the physical patient. Considerable time needs to be spent in laboratories and workshops, like the EVTM workshop [6], to learn and master new skills, and advanced technological surgical training modules should be used, such as surgical simulators, including virtual and augmented reality. This will, however, bear with it financial implications and require administrative resources that surgical institutions need to be aware of and take into account. Training surgeons in this modern way comes with a huge cost. Recourses need to be acquired to meet these expenses and perhaps the medical industry who are fueling this medical revolution should partly take financial responsibility in training future surgeons. In addition, the use of pre-recorded videos of surgical procedures available online can be used as a complementary educational tool. For example, the EVTM academy website can serve this purpose where trainees can use these to go through an operation or part of a procedure, without the same stresses that exist in a live operating environment [7]. Another aspect is that this technological advancement will progress at different speeds in different parts of the world. Therefore, promoting international collaboration and exchange of surgical trainees in order to broaden their exposure can be beneficial for everyone. This form of fellowship program not only exposes the surgical trainees to diverse health care systems around the world, but also permits those from developing countries to get acquainted with expensive high-tech systems and those from developed countries to benefit from a higher volume of traditional surgical training.

In addition to practical training, theoretical training can and needs to adapt as well. One of the few benefits

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Figure 1 The EVTM-ST logo.

of the recent Covid-19 pandemic has been the expansion of online video communication. This has opened the door for improved international theoretical collaboration, and courses are now not limited to physical attendance. The EVTM-ST (EndoVascular resuscitation and Trauma Management – Specialists in Training) regular international case discussions that take place every month are one example of multidisciplinary theoretical collaboration where the trainees take it upon themselves to educate each other and share experiences from their own institutions (Figure 1). This not only improves trainees' surgical knowledge, but also helps promote communication, teamwork, and leadership, which are skills that will only become more important to master. Surgeons will in the future find themselves having to lead larger, more multidisciplinary teams including both medical and non-medical staff, and their ability to communicate will be crucial.

Finally, it is an exciting time to be training in surgery. New technology will allow the treatment of patients that were never able to be treated before and will require structural changes in both the way we work and the way we train. The gender imbalance that still exists within the profession will also hopefully improve as training and working patterns become more flexible, allowing surgery to remain an attractive specialty, even for those who seek a work–life balance rather than the traditional surgical career.

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[4] Latifi R, Rhee P, Gruessner RWG. Technological Advances in Surgery, Trauma and Critical Care. 1st ed. New York, NY: Springer; 2015. 659pp.
[5] Watson DR, Flesher TD, Ruiz O, Chung JS. Impact of the 80-hour workweek on surgical case exposure within a general surgery residency program. J Surg Educ. 2010; 67(5):283–9.
[6] Horer T. Resuscitative endovascular balloon occlusion of the aorta (REBOA) and endovascular resuscitation and trauma management (EVTM): a paradigm shift regarding hemodynamic instability. Eur J Trauma Emerg Surg. 2018;44(4):487–9.
[7] EVTM Academy [2022-06-19]. Available from: https://jevtm.com/academy/.

Tips and Techniques

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Technical Considerations for the Use of REBOA in the Management of Placenta Accreta Spectrum

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In recent years, the use of resuscitative endovascular balloon occlusion of the aorta (REBOA) has become popular to prevent or treat massive bleeding due to placenta accreta spectrum (PAS). There are multiple variations in the use of REBOA in this context, and although the experience of vascular surgeons with aortic balloons is extensive, there are particularities in the management of these devices in the obstetric population that deserve to be discussed. We discuss some technical considerations or "lessons learned" in our center that may be useful for other groups starting to use REBOA for PAS. Although REBOA is a useful strategy to prevent or treat massive bleeding due to PAS, its incorporation into management protocols must be carried out in a programmed and supervised manner.

Keywords: *Endovascular Procedures; Placenta Accreta; REBOA; Postpartum Hemorrhage; Vascular Surgical Procedures*

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The feared complication in placenta accreta spectrum (PAS) is massive bleeding, and multiple strategies have been described to prevent and treat it. Aortic endovascular occlusion to prevent bleeding from PAS has been used for almost 30 years [1], but its use by different groups around the world in recent years [2–4] has drawn attention to this strategy. With its high frequency of use, it has become evident that it is not a risk-free procedure [5], and like any complex procedure, "the trick is in the details".

Since 2016, resuscitative endovascular balloon occlusion of the aorta (REBOA) has been the preferred strategy in our center to prevent excessive bleeding due to PAS [6]. Although REBOA was initially applied before a laparotomy in all patients with a prenatal suspicion of PAS (via ultrasonography and/or magnetic resonance imaging), the possibility of false-positives in images, the possibility of achieving hemostasis without aortic occlusion (applied REBOA and unused) as the group improves their surgical skills, the documentation of REBOA complications [7] and the costs associated with its use have led our center to prefer its intraoperative application only in severe cases. After evaluating multiple difficulties during the treatment of PAS patients [7] and modifying our management protocol to obtain better results [6], we now share the following technical considerations or "lessons learned" in our center with the use of REBOA in PAS treatment (Figure 1):

1. Train yourself in the use of REBOA. The use of REBOA in trauma and PAS patients must be preceded by specific training in which the details of the use of this technology, originally known in other scenarios by vascular surgeons and hemodynamics specialists, are discussed [8]. Formal training for trauma surgeons, general surgeons, emergency medicine specialists, and other specialists is possible with well-designed simulation courses [9].

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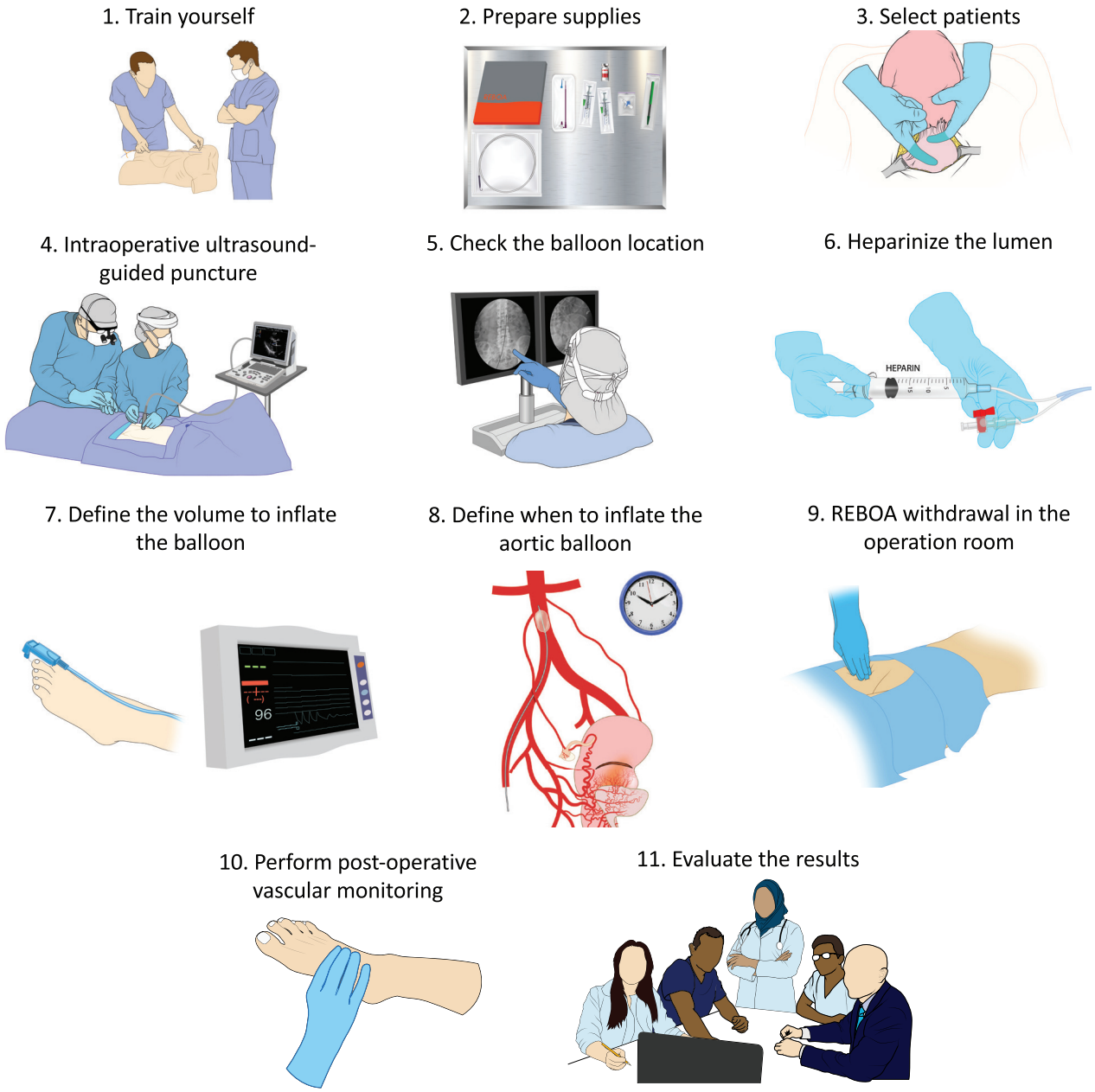

Figure 1 Steps to follow during the use of REBOA in patients with PAS.

2. Prepare the supplies to be used and notify your team. Never trust that your hospital "has everything you need" or that your colleagues know the procedure. The turnover of personnel in operating rooms is high, and the availability of supplies in a hospital is variable. Although there are kits with all the necessary supplies to perform aortic occlusion and balloons specifically designed for this purpose [10], it is possible that your hospital does not have this specific device; however, aortic occlusion may be carried out with another type of balloon, such as those designed to deploy endovascular prostheses. High elasticity balloons that are compatible with the smallest possible sheath diameter (<8 French) [11] and medium-stiff to stiff devices that can be placed without guidewire should be preferred [12]. There are multiple options available in the market [12,13], and their availability varies from country to country. Before starting a surgery, review the types of aortic balloons that are available and gather the following necessary supplies: the correct guidewire, sheath diameter, equipment to measure the distance to be inserted (metric ruler), and other supplies. Similarly, explain the procedure (step by step to be performed) and the expected hemodynamic effects to your scrub nurse, surgical team and anesthesiologist [14]. Not everyone is familiar with this procedure. We recommend preparing a specific table with all the required supplies to be quickly used if required.

3. Patients who can benefit the most from aortic occlusion should be selected. As its name indicates, PAS includes a spectrum of conditions, and in most cases, these diseases are not very serious and can be managed without vascular devices [15]. We recommend estimating the risk of bleeding based on PAS topography in prenatal images [16], followed by "intraoperative staging" of the lesion [17]. We recommend reserving aortic occlusions for cases with intraoperative evidence of parametrial invasion or severe vesicouterine fibrosis [6].
4. An intraoperative ultrasound-guided femoral puncture should be performed. Even in the hands of an expert, it is advisable to limit the number of femoral punctures during vascular access [8]. Furthermore, intraoperative REBOA application within the operating room should be preferred. The application of REBOA in zone 3 in a stable patient is a relatively simple procedure that does not require fluoroscopic guidance [18].
5. The balloon position can be confirmed with plain abdominal radiography or aorta palpation. The correct position of the balloon can be confirmed with a simple abdominal X-ray when observing the balloon's radiopaque markings at the level of the third and fourth lumbar vertebrae, which reduces the radiation exposure of the fetus [19]. In case of an application after fetal extraction, the balloon can be palpated in zone 3 of the aorta. Trying to locate the end of the catheter by ultrasound in a patient in a supine position with a gravid uterus is difficult. Locating the end of the catheter by fluoroscopy is unnecessary.
6. Administer heparin locally to the aorta before occluding it. Several heparin administration options have been described [20] but considering that obstetric patients generally have conductive anesthesia with an epidural catheter, the local application of small doses of heparin is preferable each time the aorta is occluded. In our center, we use a dilution of 5,000 IU of heparin in 100 mL of saline solution. We apply a dose of 300–500 IU (6–10 mL) before each aortic occlusion. With the same heparinized solution, we "wash" the lumens of all of the endovascular devices to be used (femoral sheath and aortic balloon). Administering heparin in a patient at risk of massive bleeding may raise concerns; nevertheless, the use of low bolus doses probably will not achieve systemic action, but will reduce the possibility of thrombosis locally. In the first four patients in which we used heparin, we measured activated clotting time, finding normal values (<180 seconds in all cases) before finishing the surgery. Although it is a controversial point, we observed that all cases of arterial thrombosis associated with REBOA in our center occurred in patients who did not receive heparin before aortic occlusion [7], with four cases of thrombosis in the 50 PAS patients managed with REBOA up to the date of publication of this paper.
7. Determine the volume that is needed to infuse the aortic balloon and minimize the occlusion periods. Aortic balloons designed to deploy endovascular prostheses in aneurysmal aortas are commonly used. These balloons are designed to reach diameters greater than those necessary to occlude the blood flow in aortic zone 3, so surgeons must choose an inflation volume that is different from that recommended by balloon manufacturers. We recommend using a pulse oximeter on the first toe contralateral to the catheter insertion site and stopping aortic balloon inflation when the oximetry curve disappears. We prefer short periods of aortic occlusion. Although the safety of aortic occlusions of up to 60 minutes has been described; in the setting of scheduled PAS surgery or the prophylactic use of REBOA, shorter occlusion times are generally required. To reduce the time of blood stasis (and the risk of thrombosis), in our center, we use a maximum 20-minute aortic occlusion period. If longer periods are required, we compress the bleeding area and allow a 5-minute distal arterial perfusion interval (with a deflated aortic balloon), followed by a new 20-minute aortic occlusion.
8. Determine when to inflate the aortic balloon. Although some groups inflate the aortic balloon immediately after the umbilical cord is clamped, it is possible to minimize occlusion time by maintaining fluid communication between the obstetrician group and those who manipulate the REBOA catheter. In elective situations, in the absence of preoperative bleeding and if an appropriate surgical technique is used, obstetricians can identify when massive bleeding will occur and may request aortic occlusion at that time. As the surgical competencies of the PAS team improve, the time to aortic occlusion may decrease [12]. Although aortic occlusion has been reported before a baby is born, there is no evidence of its safety, and it should be avoided in the absence of maternal hemodynamic instability, especially for viable fetuses [21].
9. Remove the REBOA catheter and the sheath in the operating room, as soon as possible. Some protocols recommend leaving the femoral sheath in situ for a variable period of time during the postoperative period, in the case that an endovascular procedure is required again. However, the ideal scenario is to achieve complete hemostasis in surgery before closing the laparotomy, and it is not good practice to leave the operating room without reassurance that the problem is under control. Almost all complications related to REBOA use are secondary to the arterial sheath required to deploy the REBOA catheter. Therefore, our group always withdraws the femoral sheath when surgeons confirm the control of bleeding

to minimize the risk of arterial thrombosis. The only situation in which deferred removal of the sheath might be preferred is in the presence of coagulopathy, a situation in which it is prudent to leave the sheath for a short period to correct coagulopathy and minimize the risk of hematoma formation.

10. Perform postoperative vascular monitoring. Not all complications of the use of REBOA are detectable at the end of surgery, and it is necessary to periodically evaluate the appearance of thrombosis and pseudoaneurysms. A distal pulse assessment is essential before leaving the operating room. In addition, it is necessary to request hourly vascular pulse checks in the legs for 24 hours after sheath removal. Some groups may include an ultrasound evaluation of the femoral artery 48 hours after sheath removal to assess pseudoaneurysm formation. Taking into account that most of these patients will be monitored postoperatively in an obstetric ward, where staff may not be used to assessing vascular complications, specific training may be necessary in this type of clinical vascular assessment.
11. Evaluate your results and actively seek options for improvement. Aortic occlusion is an infrequent procedure in obstetrics, and the training of interdisciplinary groups in its correct use takes time. It is very likely that failures in its use will occur during the "training curve", but each of these "failures" should also offer an "improvement opportunity" that the PAS team can use to improve its competency. Furthermore, get in touch with other PAS teams that use REBOA for interinstitutional collaboration and analysis of results at the multicenter level. It is important to adequately weigh the results of REBOA use for PAS patients. Maintain this contact for the long term and share your successes and failures.

Although REBOA is a useful strategy to prevent or treat massive bleeding due to PAS, its incorporation into management protocols must be carried out in a programmed and supervised manner. Prospective multicenter studies are essential to evaluate the best way to use this technology for PAS, minimizing the related risks. Figure 1 summarizes the steps used in our center for the use of REBOA in PAS patients and may be useful for groups that wish to use REBOA in the management of PAS.

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Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.

(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

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Conflicts of Interest

The authors declare that they have no conflicts of interest.

Author Contributions

AJN-C contributed to the design, planning and manuscript writing. FRH contributed to the design, planning and manuscript writing. CAO contributed to the design, planning and manuscript writing. ACA contributed to the design, planning and manuscript writing. JPC contributed to the design, planning and manuscript writing. LMVG contributed to the design, planning and manuscript writing. SES-D contributed to the design, planning and manuscript writing. AMB contributed to the design, planning and manuscript writing.

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Case Report

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Successful Endovascular Embolisation of an Unusual Giant Pseudoaneurysm of the Middle Colic Artery

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Visceral artery pseudoaneurysms (VAPAs) are extremely rare and pseudoaneurysms in the superior mesenteric artery (SMA) and its branches, particularly the middle colic artery, are the rarest. These account for 6–8% of all VAPAs with an incidence of 0.01%. They can be associated with an inflammatory disease (such as pancreatitis), infection or arise as a post-surgical complication, but they can also be due to a traumatic damage to the artery caused by a full-thickness slit in the arterial wall. They can be asymptomatic or manifest with symptoms such as abdominal pain, nausea and vomiting, local pressure symptoms (such as a pulsatile mass or a bruit) and gastrointestinal bleeding. Imaging techniques play a key role in the diagnosis of VAPAs and angiography still represents the gold standard, although nowadays it has a pivotal role for treatment with the possibility to perform an endovascular embolisation. In fact, although rare, VAPAs are of clinical importance mainly because they can cause life-threatening intra-abdominal or retroperitoneal haemorrhage and so prompt treatments are crucial, whether they are symptomatic, haemorrhagic or incidentally found. In the past, surgery was the treatment of choice, but in recent years with the improvement and development of interventional vascular techniques, surgery has been replaced by transcatheter endovascular embolisation due to its low morbidity and mortality and high success rate. In this article, we report the case of an unusual giant spontaneous pseudoaneurysm of the middle colic artery in a patient with a scoliotic abdominal aortic aneurysm successfully treated by endovascular embolisation.

Keywords: *Visceral Artery Pseudoaneurysm; Endovascular Embolisation; Superior Mesenteric Artery*

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INTRODUCTION

Visceral artery pseudoaneurysms (VAPAs) are rare vascular entities with significant clinical consequences [1–3]. Splenic artery VAPAs are the most frequently reported followed by the gastroduodenal and the pancreaticoduodenal arteries [3–7]. Superior mesenteric artery (SMA) pseudoaneurysms, and those associated with distal branches of the SMA, are the least likely reported VAPAs [1,3–6]. They can be associated with an inflammatory disease, like pancreatitis, infection or arise as a post-surgical complication, but they can also be due to traumatic damage to the artery caused by a full-thickness slit in the arterial wall [2,4–6,8,9]. They can be asymptomatic or manifest with symptoms such as abdominal pain, nausea and vomiting, local pressure symptoms (like a pulsatile mass or a bruit) and gastrointestinal bleeding [3,4,5,6,8]. Imaging techniques, such as ultrasound, Doppler sonography and computed tomography (CT), play a key role in the diagnosis of VAPAs. Angiography still represents the gold standard, although nowadays it has a pivotal role for treatment with the possibility to perform an endovascular embolisation [7,10,11]. Although rare, VAPAs are of clinical importance mainly because they can cause life-threatening intra-abdominal or retroperitoneal haemorrhages and so prompt treatments are crucial for them all, whether they are symptomatic, haemorrhagic or incidentally found [2,12]. Historically, open surgery represents the gold standard treatment; however,

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endovascular techniques have proven to be an effective alternative treatment for VAPAs and today an endovascular approach is considered the treatment of choice and the first-line treatment in patients who are poor surgical candidates and/or have unfavourable anatomy [1,7,10,13–15]. In this article, we report the case of an unusual giant spontaneous pseudoaneurysm of the middle colic artery in a patient with a scoliotic abdominal aortic aneurysm, successfully treated by endovascular embolisation.

Ethical Approval and Informed Consent

Ethical approval was not required. Informed consent was not required. The information has been anonymised.

CASE REPORT

A 70-year-old woman presented to our emergency department for right upper-quadrant abdominal pain and a persistent feeling of pulsation in the periumbilical region. Her medical history was notable for pemphigus, associated with a not well-specified collagen disease, and osteoporosis; moreover, she revealed to be already affected by an abdominal aortic aneurysm. There was no history of hypertension, smoking, trauma, fever or abdominal or chest infections. Her general physical examination was unremarkable. She declared that she was not taking medications or anticoagulant therapy and her laboratory tests were normal. A contrast-enhanced CT scan was performed, confirming the presence of a scoliotic and stretched abdominal aortic aneurysm (Figure 1*a,b*), with maximum transverse diameters of 45 × 48 mm^2, part of its sac filled with thrombus and a patent lumen measuring 27 × 30 mm^2. It also revealed an incidental finding of a giant pseudoaneurysm of the middle colic artery (Figure 1*b,c*), the first right branch of the SMA (Figure 2*a,b*), with maximum transverse diameters of 83 × 60 mm^2 and a longitudinal diameter of 100 mm. After a multidisciplinary discussion, the emergency surgeon, the vascular surgeon and the interventional radiologist agreed to perform a selective angiographic study to better investigate the incidental finding and eventually perform a minimally invasive endovascular approach to the pseudoaneurysm. In the angiographic suite, a selective SMA angiography was performed through a standard percutaneous right transfemoral approach, employing a 6-Fr-long introductory catheter (55 cm Flexor Check-Flo Introducer, Cook Incorporated, Bloomington, IN, USA), because of the scoliotic and stretched course of the abdominal aortic aneurysm, and a 5 Fr Cobra catheter (Cook Incorporated, Bloomington, IN, USA), confirming the CT findings and showing a giant pseudoaneurysm of the middle colic artery (Figure 3*a*), with no evidence of out-flow vessels and with a short and narrow in-flow tract (Figure 3*b,c*). An endovascular exclusion of the pseudoaneurysm was performed by transcatheter

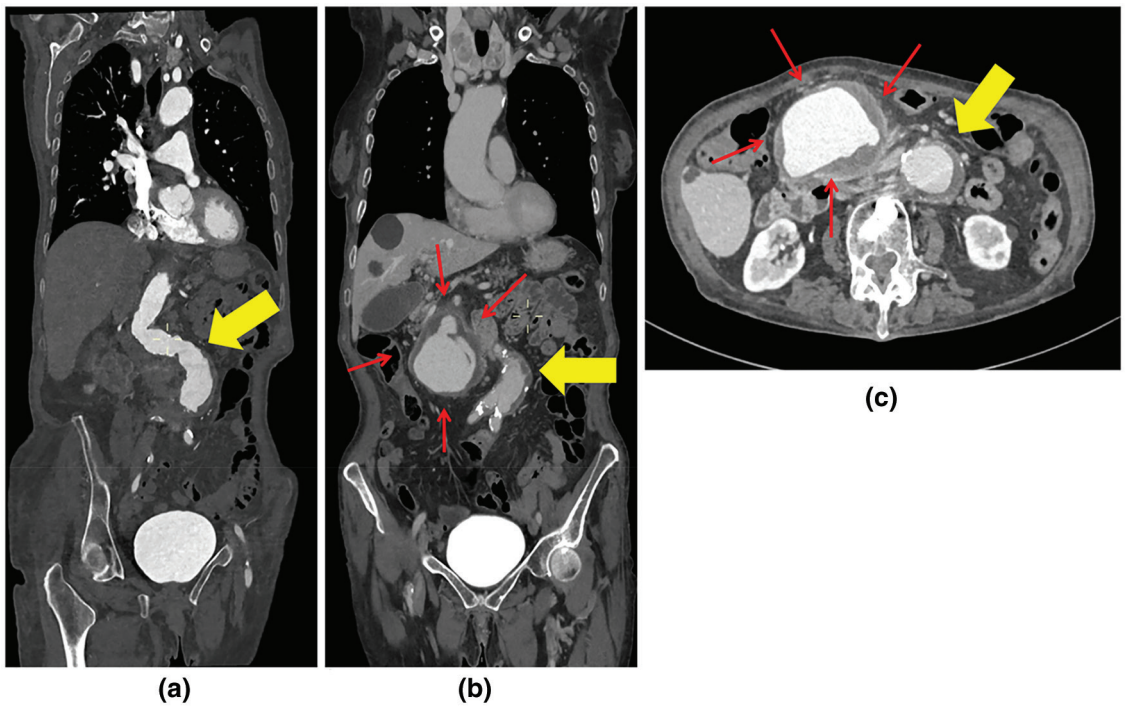

Figure 1 Preliminary CT scan. CT imaging showing coronal (**a**,**b**) and axial (**c**) reconstructions of a scoliotic and stretched abdominal aortic aneurysm (yellow arrows) with part of its sac filled with thrombus and the presence of a giant pseudoaneurysm of the middle colic artery (red arrows).

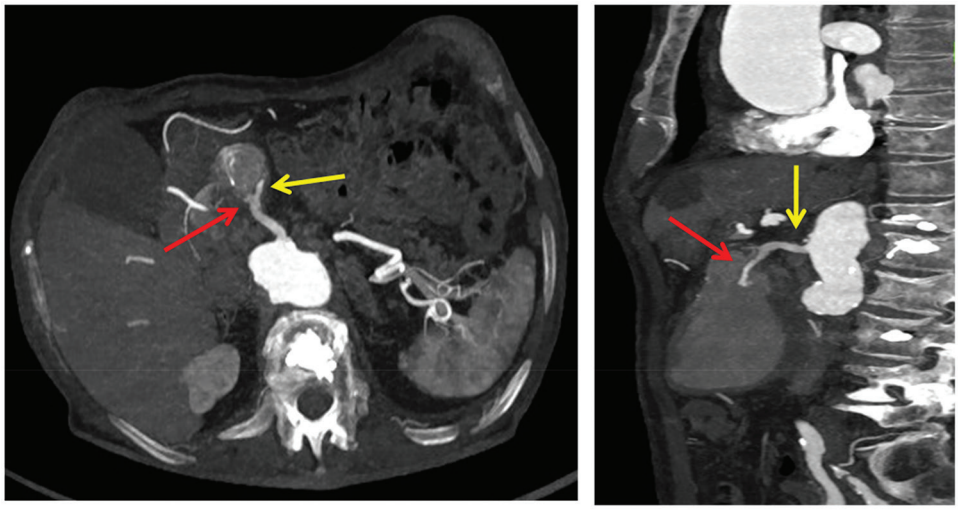

Figure 2 Preliminary CT scan. Maximum intensity projection (MIP) reconstructions showing the oblique axial (**a**) and sagittal (**b**) planes, the origin of the middle colic artery (red arrows) and in-flow tract of the giant pseudoaneurysm from the superior mesenteric artery (yellow arrows).

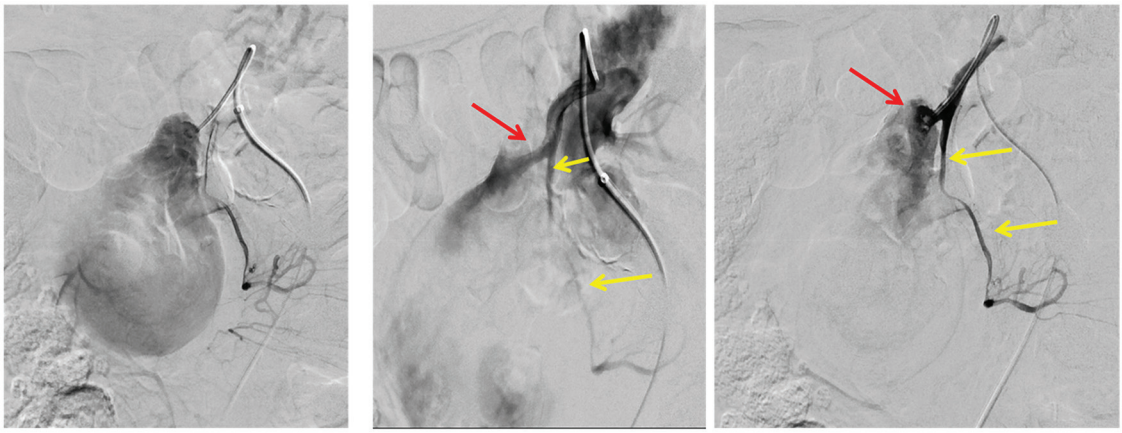

Figure 3 Digital angiography. Selective angiography of the superior mesenteric artery confirming the presence of a giant pseudoaneurysm (**a**) with no out-flow vessels and showing the origin of the middle colic artery (**b**,**c**) (red arrows) and in-flow tract of the giant pseudoaneurysm from the superior mesenteric artery (yellow arrows).

embolisation, releasing multiple coils (POD, Penumbra, Inc., Alameda, CA, USA; Ruby Coil, Penumbra, Inc., Alameda, CA, USA; Concerto, Micro Therapeutics Inc. d/b/a ev3 Neurovascular, Irvine, CA, USA) firstly into the pseudoaneurysm's sac, to create a solid scaffolding below, and then into its in-flow tract (Figure 4*a*) with coaxial technique, employing a microcatheter (Progreat 2.7 Fr, Terumo, Tokyo, Japan). Final angiography showed a complete exclusion of both the pseudoaneurysm and its in-flow tract (Figure 4*b*) together with patency of the SMA and its collateral branches. The patient was asymptomatic after the procedure and the technical success was confirmed by a contrast-enhanced CT scan performed 48 h later (Figure 5*a*,*b*), with neither evidence of revascularization of the pseudoaneurysm nor evidence of bowel ischemia; the patient was discharged 5 days after the embolisation. Six months after the procedure she is still asymptomatic and the endovascular embolisation has proven to be effective.

DISCUSSION

VAPAs are extremely rare, with splenic artery VAPAs being the most common [2,12]. Pseudoaneurysms of the SMA and its branches, particularly the middle colic artery, are the rarest, accounting for approximately

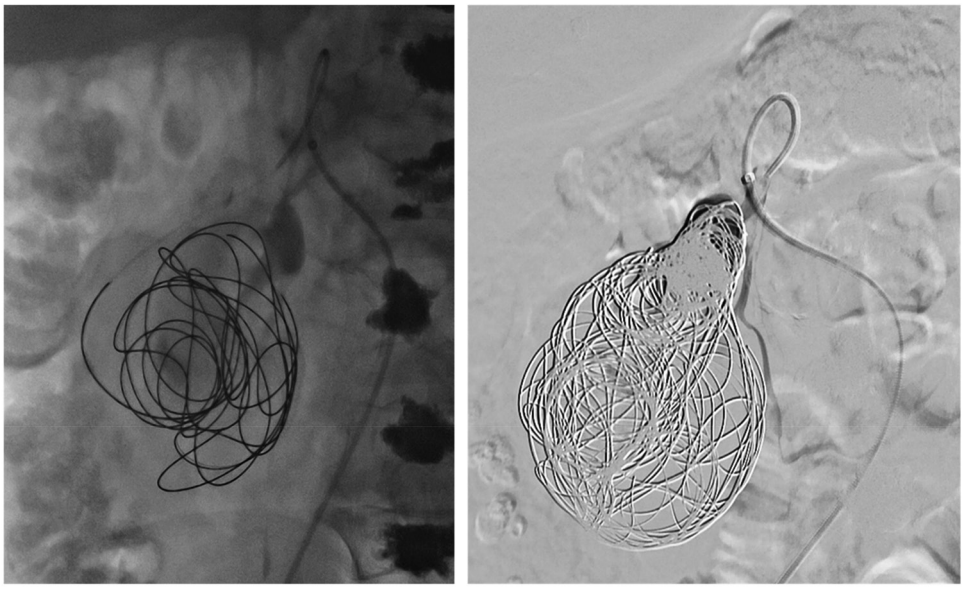

Figure 4 Digital angiography. Selective catheterisation, employing a microcatheter, of the pseudoaneurysm's sac (**a**) with subsequent endovascular embolisation releasing multiple metallic microcoils, firstly into the sac creating an underlying scaffold, and then into the in-flow tract of the giant pseudoaneurysm. Final angiographic control confirming successful endovascular exclusion of the pseudoaneurysm (**b**).

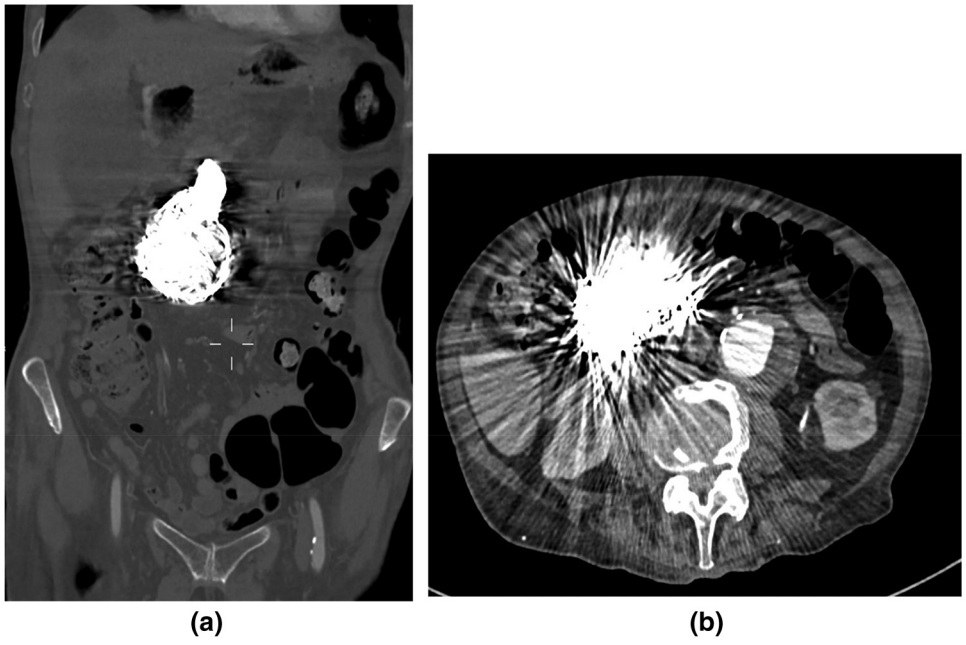

Figure 5 Follow-up CT scan performed 3 days after the procedure. CT imaging confirming, in coronal (**a**) and axial (**b**) reconstructions, successful endovascular embolisation with multiple metallic microcoils and no opacification of the giant pseudoaneurysm's sac and its in-flow tract.

6–8% of all VAPAs with an incidence of 0.01% [2,3,16,17]. True aneurysms involve all three layers of vessels, and most are asymptomatic, while false aneurysms or pseudoaneurysms are defined as a lack of complete arterial walls, which are lined by adventitia or by perivascular tissue. The rupture risk depends on the aneurysm sizes, shapes and locations, and pseudoaneurysms have a higher rupture risk compared to true

aneurysms [18,19]. Once ruptured, the reported mortality rate is up to 70% [18,20]. Vasculitis like polyarteritis nodosa, collagen vascular disorders like Ehlers-Danlos and Marfan's syndromes, and fibromuscular dysplasia are etiological factors associated with true SMA aneurysms, but the aetiology of VAPAs can be congenital, traumatic, due to infectious or inflammatory diseases (such as acute pancreatitis) or they can occur as post-surgical complications such as arterial dissection [4–6]. The most common cause of SMA pseudoaneurysms are represented by pancreatitis or trauma. The mechanism of vascular injury in pancreatitis involves pancreatic autodigestion enzymes being released into the perivascular space leading to enzymatic digestion of the arterial wall [2,21]. Rarer causes of SMA pseudoaneurysms include infective endocarditis or uncontrolled hypertension; in particular, visceral mycotic VAPAs are most commonly confined to the SMA and in 2.5–10% of cases they are associated with infective endocarditis [2,3,16,22]. In a reported SMA dissection case, another differential diagnosis is represented by segmental arterial mediolysis, a non-atherosclerotic, non-inflammatory arteriopathy of uncertain aetiology [18,23]. Imaging plays a key role in the identification of these conditions. The main diagnostic tools are ultrasound (US), Doppler US, contrast enhanced US (CEUS), CT and magnetic resonance imaging (MRI) [7,24–26]. Doppler US is the first choice for pregnant patients as it can be effective and sufficient, precisely depicting the location and the morphology of the false aneurysm in superficial anatomical districts. However, it has a lower accuracy in the abdomen because of intestinal bloating and has many limitations in emergency settings in non-collaborating patients. CEUS recently proved to be a powerful new tool for detecting false aneurysms, both for the first diagnosis in patients with a clinical suspicion and for follow-up after treatment, representing a faster, easier, cheaper, repeatable and, above all, valid and effective radiation-free imaging technique. CT angiography represents the current imaging technique of choice for diagnosis, showing the typical aneurysm body in the arterial phase as demonstrated in our case [7,24,26–29]. MRI proved to be more sensitive and specific; however, it is contraindicated for patients with pacemakers and metal prostheses, it is unsuitable for claustrophobic and respiratory distressed patients and its availability is still limited in emergency settings [7,24,27]. Although VAPAs of the SMA are very rare, their elevated risk of rupture (10–50%) and subsequent mortality (22–40%) make their prompt diagnosis and treatment mandatory [1,17,30]. In fact, the decreased integrity of the arterial wall makes VAPAs more prone to rupture than their true aneurysmal counterparts and can prove fatal [1,30]. Treatment options range from open surgery to endoscopic and endovascular procedures. Endovascular procedures are represented by coil embolisation or covered stent placement [2,21]. In the past, surgery was the treatment of choice for visceral artery aneurysms, but in recent years, with the improvement and development of interventional vascular techniques, surgery has been replaced by transcatheter endovascular embolisation due to its low morbidity and mortality and high success rate. In this way, an endovascular approach can be considered a safe alternative therapy to surgery [1,3,7,17,18,29,31–35]. These reasons informed our decision to perform endovascular embolisation to treat our patient. The target of the endovascular approach to pseudoaneurysms is both to fill the aneurysm's sac with embolic agents and to exclude the neck of the aneurysm from circulation [7,10,13–15]. The embolisation of the proximal and distal neck is the most commonly reported endovascular approach in such cases because it is necessary to exclude both in-flow and out-flow tracts to avoid the risk of later anterograde and retrograde reperfusion [7,36].

The most employed and effective embolic agent reported to successfully embolize the in-flow and out-flow tracts of the injured artery are metallic coils, which in most cases are sufficient and effective alone, as happened in our case in which we successfully employed only metallic coils for the embolisation [7,10,11,14]. In the reported case, the giant pseudoaneurysm had no out-flow vessels but a single in-flow tract represented by its neck. It suggested to us that the complete filling of both the sac and the neck with multiple metallic coils could be the right endovascular approach, especially with complete vascular exclusion and the sealing of its in-flow tract, to avoid the possibility that the pseudoaneurysm's sac could be afterwards exposed to the high pressure of the blood flow of the superior mesenteric artery, coming directly from the abdominal aorta, with the risk of recurrence of the pseudoaneurysm, due to eventual later deployment of the metallic coils, previously released, forward, into the fund of the sac [29]. In fact, these reasons are why we performed a packing of coils into the pseudoaneurysm's sac: to obtain an underlying solid scaffold, to allow a subsequent safe and effective packing of the too short and narrow in-flow tract, and to reduce the risk of late deployment of the coils released into the in-flow tract (into the giant pseudoaneurysm's sac) under the high pressure of mesenteric arterial blood flow. When embolisation is performed the weakness of the wall represents an additional problem to consider. This is because the fragility of the pseudoaneurysm may allow it to rupture during injection of the contrast agent or the chosen embolic agents when the catheter is wedged into the feeding vessel. In fact, a considerable increase in intra-aneurysmal pressure occurs when a notable amount of fluid is injected in a short time, such as during endovascular procedures. In this way, all the injecting pressure is transmitted to the aneurysm's wall and consequently rupture can occur [7,31,32]. Therefore, the advantage of transcatheter coil embolisation, with which no high pressure or large amount of fluid is

necessary during the procedure, is clear and well reported [7,31,37]. The reported rate of complications of endovascular embolisation is between 3% and 18%; the major complications are represented by intestinal infarct, infection, fever, dislodgement and migration of embolic agents, haematoma or pseudoaneurysm at the percutaneous arterial entry site and contrast induced acute renal failure [7,10,24,33,38–40]. In the reported case, there was a high risk of intestinal infarct, due to embolisation of the SMA and its main branches, because of eventual inadvertent migration and/or dislodgment of embolic material. However, the employment of a long introductory catheter, to preserve the stability of the endovascular approach, a microcatheter, to ensure the super selectivity of coiling, and the use of a mechanical embolic agent significantly avoided this risk and allowed us to perform a safe and effective embolisation.

CONCLUSIONS

Spontaneous VAPAs are extremely rare, especially pseudoaneurysms of the SMA and its branches; it is fundamental to urgently manage any VAPAs because of their high risk of rupture and the potential to be life threatening due to profuse haemorrhaging. In fact, it is important to remember that there is no correlation between the pseudoaneurysm size and its risk of rupture. Endovascular embolisation is a valid, minimally invasive, safe and effective alternative treatment to the traditional surgical approach with lower morbidity and mortality and high success rates, especially in those patients who are poor surgical candidates.

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Author Contributions

All the authors substantially contributed to the study and manuscript writing.

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Case Report

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Successful Endovascular Management of a Massive Hemoptysis due to a Rare Oncological Giant Pulmonary Artery Pseudoaneurysm

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Massive hemoptysis represents a distressing and life-threatening condition: 95% of cases originate from the bronchial artery system, with pulmonary arteries accounting for 6%–11% of cases. The most common etiology of hemoptysis from the pulmonary artery system is represented by pulmonary artery pseudoaneurysms (PAPs). PAPs are defined as the focal dilation of a pulmonary artery branch, involving only the adventice, with a higher risk of rupture than a true aneurysm. It constitutes a rare finding, often underdiagnosed by radiologists. However, PAPs can be life-threatening if undiagnosed due to a high mortality rate (50%). They frequently occur in patients affected by erosive inflammatory processes and necrotising infections of the lung or heart, but other etiological factors include trauma, vasculitis, neoplasia, pulmonary hypertension and Hughes–Stovin Syndrome. PAPs due to oncologic etiologies are rare. Among oncologic etiologies, the most frequent are represented by primary lung cancer rather than metastases. Today, CT angiography represents the imaging modality of choice; not only to establish diagnosis, but if performed with an appropriate timing of intravenous contrast, it also helps to plan therapy with an endovascular approach. In fact, endovascular treatment is the preferred therapeutic approach in managing hemoptysis due to PAPs, since a surgical approach is associated with a high risk of morbidity and mortality, especially in patients who are poor surgical candidates. In this article we report the case of massive hemoptysis due to an unusual giant PAP of the posterior lower branch of the right pulmonary artery, in a patient affected by pulmonary colliquated and confluent metastases, successfully treated by endovascular embolisation.

Keywords: *Hemoptysis; Pulmonary Artery Pseudoaneurysm; Endovascular Embolisation*

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INTRODUCTION

Pulmonary artery pseudoaneurysms (PAPs) represent an uncommon, but potentially fatal, cause of hemoptysis [1–3]. Their early identification is of fundamental importance, since massive hemoptysis from a ruptured PAP is fatal in more than 50% of patients [4]. PAPs are defined as a focal dilatation of a pulmonary artery branch, contained only by the outer vessel layer, constituted by the tunica adventitia [1,2]. They frequently occur in patients affected by erosive inflammatory processes and necrotising infections of the lung or heart, and in those who are at high risk of septic embolism [4,5]. Lung cavitations due to Mycobacterium tuberculosis infection have historically been associated with PAPs and these entities are known as Rasmussen aneurysms. Other etiological factors include trauma, vasculitis, neoplasia, pulmonary hypertension and Hughes–Stovin Syndrome [1,2]. Traumatic PAPs represent a very rare cause of hemoptysis and PAPs due to lung cancer are rare as well, with peripheral lung being, in oncologic patients, the most common site of

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onset [5–9]. In this article, we report the case of massive hemoptysis due to an unusual giant PAP of the posterior lower branch of right pulmonary artery in a patient affected by pulmonary colliquated metastases, successfully treated by endovascular embolisation.

Ethical Approval and Informed Consent

Ethical approval was not required. Informed consent was not required. The information has been anonymised.

CASE REPORT

A 68-year-old woman presented to our emergency department for repeated and worsening episodes of massive hemoptysis in the last 2 days, accompanied by severe dispnea. Her medical history was notable for mediastinal neuroendocrine carcinoma associated to pulmonary metastases, hypertension and type 2 diabetes mellitus; there was no history of smoking, trauma, fever, abdominal infections, or chest infections. Her general physical examination was unremarkable, she was not assuming anticoagulant therapy but her serum hemoglobin value was 5.9 g/dl. A contrast-enhanced CT scan of chest was performed, showing (Figure 1*a–d*) the lower right pulmonary lobe almost completely replaced by colliquated metastases, with evidence of a giant pseudoaneurym, with maximum transverse diameters of 30 × 28 mm, and a longitudinal diameter of 50 mm, of the posterior lower branch of the right pulmonary artery.

After a multidisciplinary discussion, the emergency surgeon, the vascular and thoracic surgeons and the interventional radiologist agreed to perform a selective angiographic study to better investigate the pseudoaneurysm and eventually perform a minimally invasive endovascular approach. In the angiographic suite, a selective right pulmonary artery angiography was performed, through a standard percutaneous venous right transfemoral approach, employing a 6 Fr long introductor-catether (80 cm Flexor Shuttle - SL Introducer, Cook Incorporated, 750 Daniels Way, Bloomington, IN 47404, USA), to get more stability of the coaxial system, and 5 Fr Cobra and MPA catheters (Cook Incorporated). Pulmonary artery angiography confirmed the CT finding, showing (Figure 2*a,b*) a giant pseudoaneurysm of the posterior lower branch of the right pulmonary artery. A super-selective catheterisation of the pseudoaneurysm's sac was performed employing a microcatheter (Progreat 2.7 Fr, Terumo, Shibuyau, Tokyo, Japan) followed by endovascular embolisation, through packing of multiple coils (POD, Penumbra, Inc. One Penumbra Place, Alameda, CA 94502, USA; Ruby Coil, Penumbra, Inc. One Penumbra Place, Alameda, CA 94502, USA) into the sac (Figure 3*a–c*) and its in-flow tract, finally sealing the

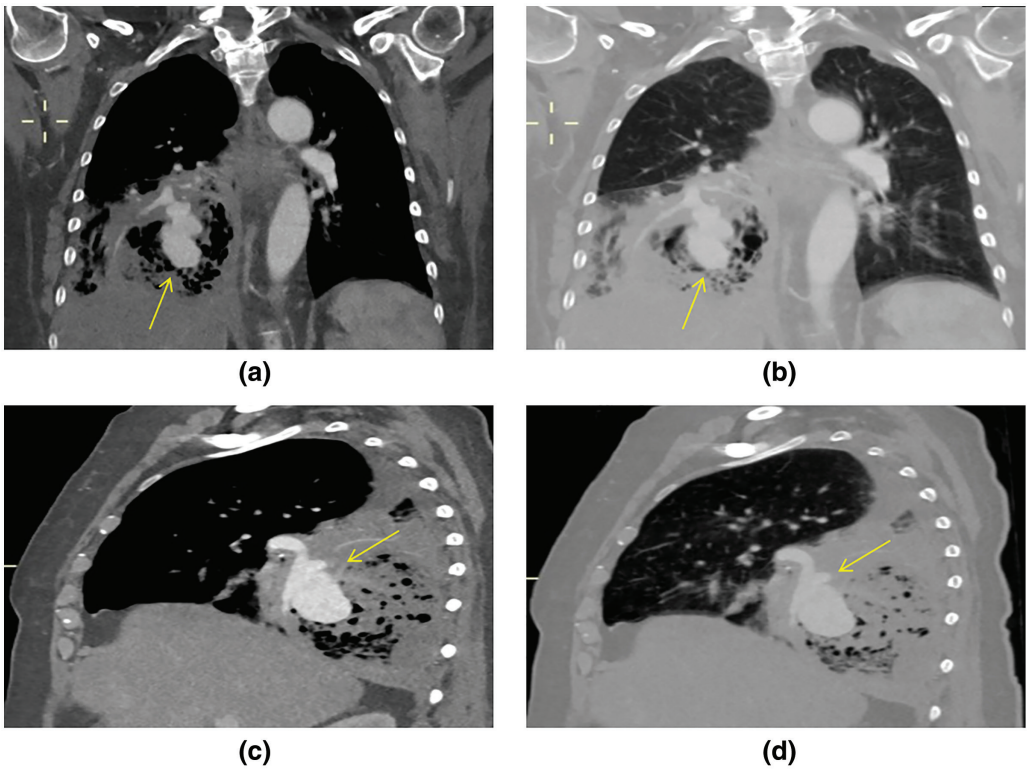


Figure 1 CT scan. CT scan showing in coronal (**a,b**) and sagittal (**c,d**) reconstructions showing the lower right pulmonary lobe almost completely replaced by colliquated metastases with evidence of a giant pseudoaneuryms (yellow arrows) of the posterior lower branch of the right pulmonary artery.

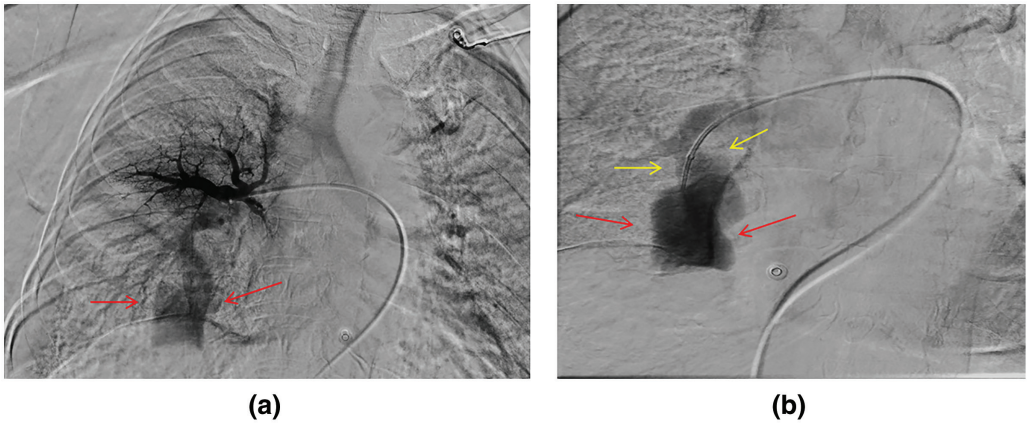


Figure 2 Digital Angiography. Selective angiography of the right pulmonary artery confirming the presence of a giant pseudoaneurysm (**a,b**) (red arrows) of its posterior lower branch; selective catheterisation of the pseudoaneurysm's sac (**b**) with evidence of the in-flow tract (yellow arrows).

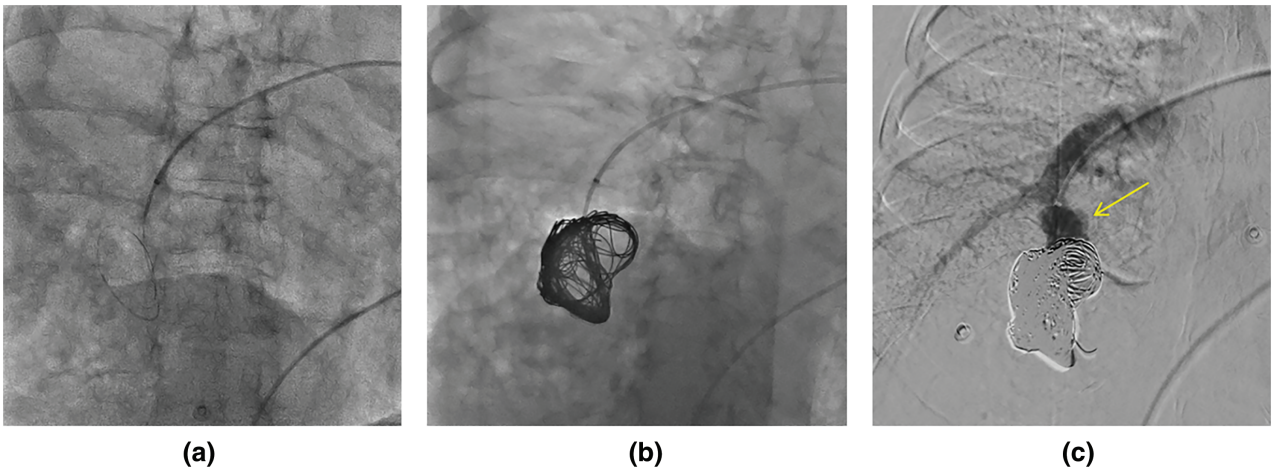


Figure 3 Digital Angiography. Selective catheterisation of the pseudoaneurysm's sac (**a,b**) with subsequent endovascular embolization, releasing multiple metallic microcoils; selective angiographic control (**c**) confirming successful endovascular exclusion of the pseudoaneurysm's sac with residual patency of its neck (**c**).

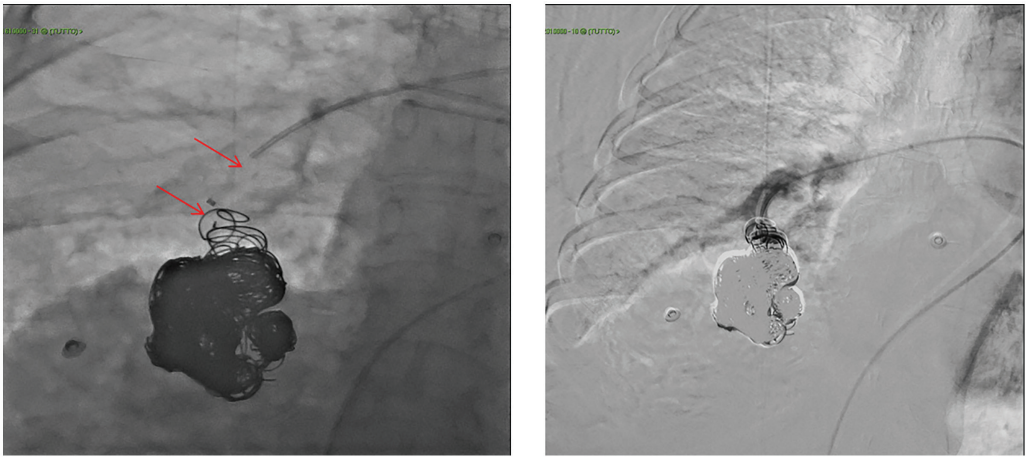
latter (Figure 4*a*) releasing an Amplatzer micro-vascular-plug (MVP-9Q, Medtronic, Inc. 710 Medtronic Parkway Minneapolis, MN 55432 USA).

Final angiographic control (Figure 4*b*) showed a complete exclusion of the pseudoaneurysm and its in-flow tract, with patency of the main trunk of right pulmonary artery and its remaining division branches. The patient was asymptomatic after the procedure, with significant improvement of serum hemoglobin values, and never experienced hemoptysis again; she was discharged 4 days after the embolisation.

DISCUSSION

Hemoptysis is the emission of red aerated blood from the mouth during a cough episode [5,10]. Massive haemoptysis is a blood loss of 300–600 mL over 24 hours and represents a distressing and life-threatening condition. Massive hemoptysis in 95% of cases originates from bronchial artery system, with pulmonary arteries accounting for 6%–11% of cases [5,7,10,11,12]. The most common etiology of hemoptysis from pulmonary artery system is represented by PAPs: it is a focal dilation of a pulmonary artery branch, involving only the adventice, with a higher risk of rupture than a true aneurysm. It constitutes a rare finding, often underdiagnosed by radiologists.

However, PAPs can be life-threatening if undiagnosed, due to a high mortality rate (50%) [5]. There are numerous potential etiologies of PAP: infection (tuberculosis, aspergillosis, necrotising pneumonia), iatrogenic (catheterisation of the pulmonary artery, lung radiofrequency ablation and surgical injury), trauma (penetrating or blunt injury), vasculitis (Bechet disease, Hughes–Stovin syndrome) and malignancy, usually primary lung cancer and rarely metastases [6–9,11,13–15].



(a) (b)

Figure 4 Digital Angiography. Endovascular embolisation **(a)** of the pseudoaneurysm's in-flow tract (neck) releasing metallic microcoils and its final sealing (red arrows) releasing an Amplatzer micro-vascular-plug; selective final angiographic control **(b)** confirming successful endovascular exclusion of the pseudoaneurysm's sac and its in-flow tract with patency of the main trunk of right pulmonary artery and its remaining division branches.

PAP due to primary lung cancer is rare and due to tumor necrosis: the pathological types of cancer involved in PAP are squamous-cell, small-cell and adenocarcinoma [6–9,15–17]. In the reported case, we described a rare giant PAP due to confluent colliquated mediastinal neuroendocrine carcinoma metastases, involving almost all the right lower pulmonary lobe. Patients affected by PAPs usually present with hemoptysis and hypoxemia, and sometimes experience chest pain too. Our patient, in fact, experienced in the last 2 days massive hemoptysis accompanied by severe dispnea. Chest radiography usually shows focal consolidation, solitary pulmonary nodules or multiple pulmonary nodules adjacent to the central or peripheral pulmonary vasculature [4,18]. Today, CT angiography represents the imaging modality of choice that not only establishes diagnosis, but, if performed with an appropriate timing of intravenous contrast, also helps to plan therapy with an endovascular approach. On CT angiography, PAPs appear as focal outpouchings of contrast medium adjacent to a pulmonary artery branch, showing the same contrast density as the pulmonary artery in all the dinamic phases of the study [1,2,4,11,19,20].

PAPs are more likely to rupture than true arterial aneurysm and, therefore, hemoptysis due to a ruptured PAP is often fatal and, in this way, it must be promptly recognised and treated [4]. Management of PAPs includes medical treatment, surgical approach and minimally invasive techniques. Antimicrobial therapy still keeps an important role in managing mycotic PAPs: empiric intravenous antimicrobial therapy targeting broad gram-negative and gram-positive coverage should be onset as soon as PAP is suspected. In addition, antifungal, antimycobacterial and antitreponemal therapy must be considered in immunocompromised patients [4].

An operative approach for PAPs is represented by open thoracotomy and aneurysm resection, with lobectomy for the involved pulmonary lobes. Surgical treatment, however, is associated with a high risk of morbidity and mortality, especially because patients affected by mycotic PAPs are usually acutely ill and with a poor pulmonary reserve [4,5,21,22,23]. Minimally invasive techniques, such as endovascular or percutaneous approaches, under CT scan, represent the elective initial therapy for these patients [5–9,15,16,24]. Urgent endovascular treatment is the preferred approach in managing hemoptysis due to PAPs, and such treatment should not be delayed: most PAPs can be successfully treated by endovascular procedures, mainly represented by endovascular embolisation [4,6–9,15,16,25,26]. These are the reasons why we decided to perform the endovascular embolisation in our patient and to attempt firstly a minimally invasive approach.

Many different embolic agents have been described, such as coils, Amplatzer vascular-plugs, detachable ballons, liquid agents (N-butyl cryanoacrylate, thrombin, Onyx), and stents [2,5–7,9,15,16,25]. The choice depends on the size of the PAP, the size of the neck, the location (proximal or distal) and the experience and preferences of the interventional radiologist [5,26]. Covered stent placement could be employed for endovascular treatment of central PAPs, especially if they are wide-necked, as the stent will maintain the permeability of the feeding artery. However, this may cause a risk of thrombosis or migration and, above all, eventual occlusion of other pulmonary artery branches, as seemed to be the case, after the preliminar angiographic

study, in our patient [4,5,6,17,18,24,27]. Moreover, potential graft infection, due to ongoing septic embolic phenomena, must be considered as a possible complication of covered stent placement and this approach should be avoided in patients with active bacteremia [4]. The target of the endovascular embolisation to pseudoaneurysms is both to fill the aneurysm's sac with embolic agents and to exclude the neck of the aneurysm from the circulation [28,29,30,31,32]. The embolisation of the proximal and distal neck is the most commonly reported endovascular approach because it is necessary to exclude both in-flow and out-flow tracts to avoid the risk of eventual late anterograde and retrograde reperfusion [28,33].

In the reported case, the giant pseudoaneurysm originated from a high-flow main division branch of the right pulmonary artery and had no out-flow vessels, but just a single in-flow tract, represented by its neck, which was, however, wide. The packing of the sac only is not enough as an endovascular approach, since it is necessary to seal its in-flow tract too, to avoid a later reperfusion of the sac due to the dislocation of the coils, already released, under the blood pressure of the main pulmonary artery [34]. Liquid agents in our patient were not indicated, as they could not have allowed a safe embolisation, due to the high-flow and wide-necked PAP, exposing the risk of a non-target embolisation [5,24,27]. For the reasons mentioned above, we decided to employ only mechanical agents, and not liquid agents, in our patient, and to perform first an endovascular embolization of the sac, to allow in this way a safer sealing of its wide in-flow tract by finally releasing the Amplatzer micro-vascular-plug.

CONCLUSIONS

PAPs are an uncommon, but potentially fatal, cause of hemoptysis; the most common etiology is represented by necrotising inflammatory processes, while less commonly they are due to to malignancy, more frequently primary lung cancer and rarely metastases. Since they are more likely to rupture than true arterial aneurysms, it is fundamental to promptly recognise and treat PAPs.

Endovascular embolisation represents a valid minimally invasive, safe and effective alternative treatment to the traditional surgical approach, with lower morbidity mortality and high success rates, expecially in those patients who are poor surgical candidates.

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Author Contributions

All the authors substantially contributed to the study and manuscript writing.

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Original Article

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REBOA and the Open Abdomen

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Background: Uncontrolled hemorrhage is a significant cause of death worldwide. Rapid bleeding control is a major life saving goal. Resuscitative endovascular balloon of the aorta (REBOA) is a minimally invasive technique that temporarily occludes the aorta and achieves hemorrhage control.
Methods: We present a case series of patients that underwent emergent laparotomy due hemorrhagic shock and were stabilized intraoperatively using REBOA.
Results: Between December 2018 and September 2021, intraoperative REBOA was inserted in six patients. Etiologies included two postpartum hemorrhages, two gastrointestinal bleeds and two trauma cases. REBOA was positioned and inflated in the descending aorta (n = 3) and infrarenal aorta (n = 3). In all cases, REBOA resulted in immediate stabilization of blood pressure, enabling definitive treatment. Partial inflation was performed in all cases after initial stabilization. There was one minor access related complication, treated successfully. There was no mortality at 6 months follow up.
Conclusions: REBOA is another important resuscitative tool to be considered, also in the open abdomen. It allows for hemodynamic stabilization and enables definitive surgical repair of other major injuries.

Keywords: *REBOA; Open Abdomen; Partial Inflation*

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INTRODUCTION

REBOA is a technique for temporary stabilization of patients with non-compressible torso hemorrhage. This technique has been increasingly used worldwide during the past decade [1]. REBOA placement involves maneuvering a compliant balloon over the wire into the aorta where it is then inflated, obstructing blood flow into distal circulation [2]. The rate-limiting and crucial first step of the procedure is arterial access, usually via the common femoral artery (CFA). In trauma cases, arterial access is typically gained in one of three ways: a blind percutaneous approach using anatomic landmarks and palpation, ultrasound (US)-guided percutaneous access, or surgical cut-down to facilitate direct visualization and access. In patients with severe hemorrhage in need of REBOA placement, the percutaneous approach using anatomic landmarks and palpation, when compared with US-guided femoral access, was used more frequently without an increase in complications [3]. Percutaneous and surgical cut-down have similar safety profiles and outcomes when used appropriately in selected patients [4]. The use of REBOA as a bridge to definitive control for massive hemorrhage has provided promising results also in non-trauma patients [5].

Accumulative data suggest that hybrid management may be associated with a shorter time from arrival to intervention, lower rates of unfavorable outcomes and a reduced requirement for red blood cell transfusion as compared with conventional management of trauma patients [6]. However, in real life scenarios, patients with hemorrhagic shock do not always receive early arterial access nor reach a hybrid operating theatre. Therefore, REBOA is another important resuscitative tool to be considered, also in the open abdomen.

METHODS

We present a case series of patients with hemorrhagic shock in which REBOA was placed after laparotomy.

Ethical Approval and Informed Consent

Ethical approval was not required. The information has been anonymized and informed consent was not required.

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Presentation: This data was presented at EVTM symposium 2021.

RESULTS

Between December 2018 to September 2021, intraoperative REBOA was placed in six patients. Etiologies of hemorrhagic shock included two postpartum hemorrhages, two upper or lower gastrointestinal bleeds and two trauma cases (one blunt and one penetrating). Tokai's rescue balloon (REBOA) was inserted by a vascular surgeon through a CFA cut-down, using an 8-Fr sheath. It was positioned and inflated in thoracic aorta Zone 1 (n = 3) and aortic bifurcation Zone 3 (n =3). In all cases, REBOA resulted in immediate stabilization of blood pressure allowing further definitive bleeding control. Partial inflation was applied in correlation to blood pressure. Five cases of REBOA were inserted without fluoroscopy and one case was performed in a hybrid suite with fluoroscopy. Heparin was not given systemically, the sheath was flushed with heparin solution. One minor access related complication occurred, with CFA local dissection and thrombosis that was repaired successfully after sheath removal. There was no major REBOA complications. All patients survived. No mortality was reported at 3 and 6 months follow up.

Cases

Case 1

A 28-year-old female presented with postpartum hemorrhage and hemodynamic deterioration after emergent cesarean section. She underwent an explorative laparotomy. Bleeding was identified from the uterus suture line and sutured. An hour later she deteriorated again and underwent re-exploration. An expanding retroperitoneal hematoma (Zone III) was found. Before transporting her to the angiography suite for possible embolization she was hemodynamically stabilized by massive blood transfusion and REBOA insertion through a left femoral cut-down. It was positioned and inflated in Zone 3 with immediate blood pressure stabilization, mean arterial pressure (MAP) increased from 60 to 112 mmHg. We transferred the patient to the angiography suite with full balloon inflation, then partial deflation in accordance with invasive MAP in the arterial line (AL). Full inflation time was about 15 minutes, and partial inflation was about 10 minutes. Angiography through the contralateral CFA revealed bleeding from the internal iliac artery (IIA) branch. Embolization was successfully performed and the patient was stabilized (Figure 1). The patient was discharged home a week later.

Case 2

A 35-year-old female with a history of Crohn's disease gave birth vaginally. Shortly afterward she started to complain about severe right flank pain with rapid hemodynamic deterioration. Immediate resuscitation with massive blood transfusion was initiated; however, she continued to deteriorate, and an emergent laparotomy was performed in a non-hybrid room along with CFA cut-down. REBOA was inserted through the right CFA, inflated in Zone 3 with immediate stabilization, and systolic blood pressure increased from 50 to 80 mmHg.

Upon exploration with midline laparotomy a large hematoma of the right kidney and abdomen was observed, along with lacerations of the inferior vena cava (IVC)

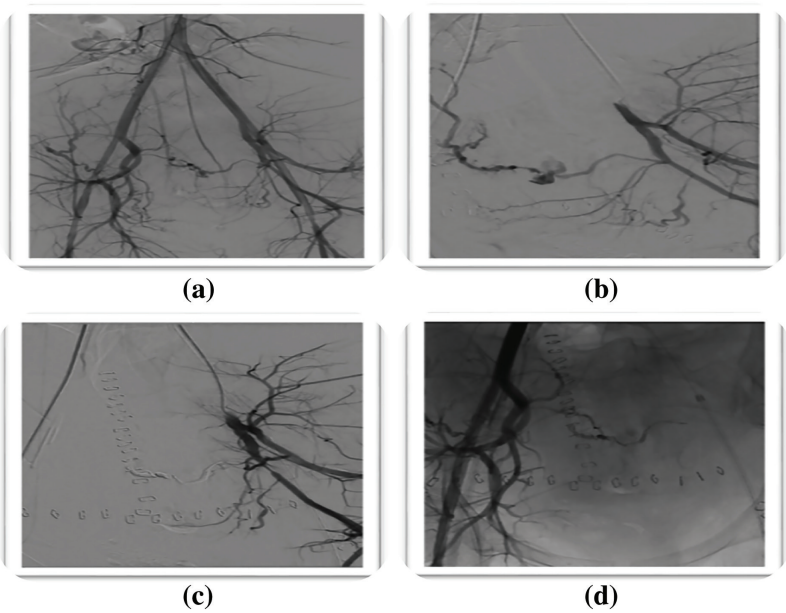


Figure 1 (**a**) Aortography through the right CFA, bleeding from IIA branch. (**b**) Selective left IIA angiography. (**c**) Selective embolization to the left IIA branch with onyx. (**d**) Selective right common iliac artery angiography.

near the origin of the right renal vein with active bleeding. REBOA at the aortic bifurcation reduced IVC bleeding and allowed for heart and brain resuscitation as she went into two episodes of ventricular fibrillation. Suture of IVC and right nephrectomy were performed. Total complete balloon inflation time was 20 minutes, whereas partial balloon inflation was applied intermittently for 60 minutes. The patient stabilized and was extubated on the same day and held her newborn on the next day.

Pathology confirmed fibromuscular dysplasia (FMD) with medial type and segmental thinning of the renal artery wall with rupture. Computed tomography of the abdomen, thorax and brain revealed dilatation of the left renal artery at the hilum, without other vascular pathologies. She was diagnosed with hypertension, stabilized successfully with medical treatment. Further follow up was recommended.

Case 3

A 24-year-old male presented with multiple gunshot wounds to the abdomen and lower extremity. On admission to the emergency room he was hemodynamically unstable, resuscitation was initiated without improvement and emergent laparotomy was performed. A Zone I expanding retroperitoneal hematoma was observed. REBOA was inserted through right CFA cut-down, inflated in Zone I, with immediate blood pressure stabilization from MAP 47 mmHg to 107–115 mmHg and subsequent partial inflation within a few minutes. Total partial inflation time was 20 minutes. A large laceration of the infra renal IVC without posterior wall involvement was detected and sutured (Figure 2). The patient was discharged to rehab 2 weeks later.

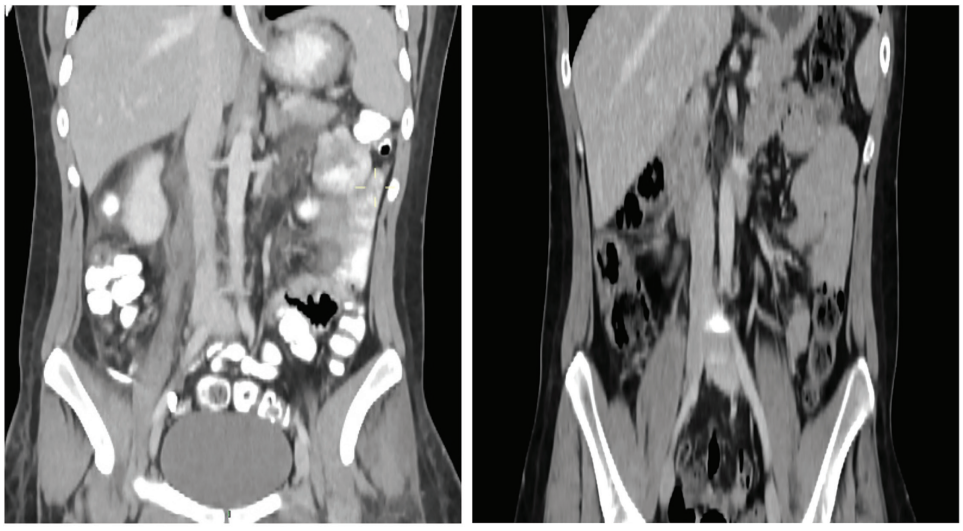
Case 4

A 29-year-old male, after a fall from a height, presented with multiple pelvic fractures. He was hemodynamically unstable, underwent emergent laparotomy with retroperitoneal hematoma. REBOA was inserted through the right CFA and inflated in Zone III, using partial inflation. Massive blood transfusion protocol, pelvic packing and external fixation was performed. REBOA was fully deflated and the patient was hemodynamically stable. After sheath removal, CFA and distal pulses were nonpalpable. CFA dissection with local thrombosis was successfully repaired. The patient was discharged to rehab a few weeks later.

Case 5

A 66-year-old male presented with poorly differentiated adenocarcinoma of the pancreas and underwent a Whipple's operation. One week later he presented with hemorrhagic shock, and he underwent selective angiography without an obvious bleeding source. He continued to be unstable and was taken immediately for laparotomy. A large hematoma without active bleeding was found in addition to pus, and repair of the pancreatic anastomosis was performed. He was treated with broad-spectrum antibiotics, in addition to massive blood transfusion and vasopressors. A follow up computed tomography angiography (CTA) was performed 2 days later, and no active bleeding was demonstrated.

A few days later, massive bleeding in the drains (500 ml within a few minutes) occurred with severe hemodynamic deterioration despite massive blood transfusion and increasing doses of vasopressors. He was taken again for emergency exploratory laparotomy. REBOA



(a) **(b)**

Figure 2 (**a**) Coronal CTA view with patent inferior vena cava (IVC) with local residual thrombus at the repair site, the patient received oral anticoagulation. (**b**) CTA 3 months later, patent IVC without residual thrombus.

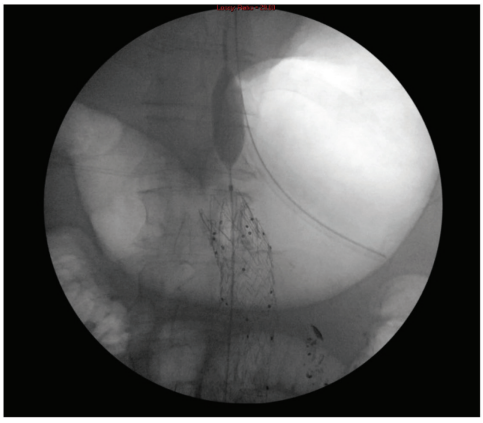


Figure 3 Fluoroscopy image, REBOA at Zone 1. The tip of the crown is on the superior mesenteric artery level, and the balloon is inflated in the supra celiac aorta.

was inserted through the right CFA and placed in Zone 1, facilitating resuscitation and definitive treatment. Invasive blood pressure was monitored through the radial AL, and the mean arterial blood pressure was 55 mmHg which increased to 75–80 mmHg after REBOA inflation. Exploration of the source of bleeding with partial and intermittent REBOA deflation in accordance with blood pressure allowed for detection of the bleeding source, primary repair of the common hepatic artery and ligation of the gastroduodenal stump was performed. Total full inflation time was 15 minutes. The patient had a prolonged recovery in intensive care unit and a surgical ward, and was discharged a few weeks later.

Case 6

A 72-year-old male had a history of elective endovascular aortic repair (EVAR) in 2010 and endovascular repair of a type I endoleak in 2018. He presented with upper gastrointestinal bleeding and severe hemodynamic instability that did not respond to massive blood transfusion protocol and increasing vasopressors doses. Therefore he was taken directly for emergent exploratory laparotomy. The differential diagnosis was ruptured abdominal aortic aneurysm, aortoenteric fistula or other upper gastrointestinal bleeding pathology. Simultaneously, laparotomy and REBOA insertion through a right CFA cut-down were performed. REBOA was positioned and inflated under fluoroscopy in the supra celiac aorta, with an increase of systolic blood pressure (SBP) of 60 mmHg to 80 mmHg (Figure 3). Afterwards, REBOA was temporarily deflated and angiography was performed to rule out aortic-related pathologies. Exploratory laparotomy was performed and a duodenal ulcer with active bleeding was found and repaired.

DISCUSSION

We present a subgroup of patients who required intraoperative proximal aortic control due to uncontrolled massive bleeding from various causes. REBOA presents advantages in comparison to an aortic clamp and there are a few reports that support this claim. Abe et al. showed that REBOA might be a favorable alternative method to aortic cross-clamping (ACC), especially for severe trauma below the diaphragm [7,8]. Prolonged aortic occlusion results in distal ischemia, which can exacerbate cellular injury following balloon deflation and reperfusion [9].

Current recommendations suggest that occlusion time should be less than 30 minutes [10,11]; this is not always practical due to the injury complexity. The technique of partial REBOA (P-REBOA) allows for a low-volume aortic flow around the partially deflated balloon minimizing the effects of distal ischemia. This REBOA technique was first described by Johnson et al. in 2016 [12], who, using a porcine hemorrhagic shock model, demonstrated that P-REBOA is associated with a more physiological hemodynamic profile than complete REBOA [13].

Animal studies suggest that P-REBOA can effectively maintain central perfusion with minimal metabolic burden and less adverse hemodynamic changes [14,15]. Other studies suggest that P-REBOA allows prolongation of the intervention time to over 60 minutes in Zone I [16], as well mitigating the hemodynamic liability of total occlusion and rapid balloon deflation [13].

Madurska et al. demonstrated that prolonged P-REBOA is associated with less organ failure than complete REBOA. P-REBOA might be a useful tool in safely prolonging REBOA while avoiding the detrimental consequences of prolonged complete occlusion [17]. Infrarenal REBOA avoids dissection of aortic bifurcation in a hostile abdomen, achieving control through the groin. Such dissection can increase the risk of other venous (inferior vena cava and iliac vein) injury, and sympathetic innervation damage.

REBOA is another resuscitative tool in our toolbox to be considered also in the open abdomen. REBOA allows for rapid hemodynamic stabilization and definitive multiteam surgical repair of major injuries with less morbidity.

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Author Contributions

All authors contributed to the manuscript writing.

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Case Report

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Resuscitative Endovascular Balloon Occlusion of the Aorta as a Bridge to Organ Donation after Blunt Trauma

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Solid organ transplantation is limited worldwide by a shortage of donor organs. Trauma patients with unsurvivable injuries comprise a large portion of potential organ donors, but many of them die from cardiovascular collapse before donation can be pursued. We report the use of resuscitative endovascular balloon occlusion of the aorta (REBOA) to stabilize a deteriorating patient with blunt trauma who was ultimately able to donate multiple organs and tissues. Survival to organ donation is a tangible and beneficial outcome of REBOA.

Keywords: *Resuscitative Endovascular Balloon Occlusion of the Aorta; REBOA; Traumatic Brain Injury; Organ Donation; Blunt Trauma*

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Despite increases in the number of organs transplanted each year, a substantial disparity remains between available organs and prospective recipients. As of August 2021, there were 106,782 candidates on the waiting list for a transplant in the United States [1]. Deceased patients comprise the majority of the current donor pool. In 2019, a total of 11,870 cadaveric donors provided 32,322 transplanted organs, representing 81% of organs transplanted that year. Among deceased donors, traumatic brain injury (TBI) is the second most common cause of death, closely following cerebrovascular accident.

The shortage of available organs has led to a variety of efforts to expand the potential donor pool. One strategy that could increase donation among patients with an unsurvivable TBI, many of whom die from cardiovascular collapse before organ procurement can occur [2–4], is the use of resuscitative endovascular balloon occlusion of the aorta (REBOA). Here we present a case in which REBOA facilitated rapid hemodynamic stabilization of a patient with blunt trauma who arrived *in extremis*, was found to have a devastating TBI, and survived to organ recovery.

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CASE

A 53-year-old woman was brought to our Level I trauma center in cardiac arrest following a high-energy motor-vehicle collision. According to prehospital providers, she had not had signs of life prior to arrival other than agonal respirations and had been undergoing cardiopulmonary resuscitation (CPR) for 17 minutes. Her pupils were fixed, and the only other external sign of injury was a lip laceration.

Because of the duration of CPR, we suspected that the patient's condition would not be salvageable, and she was not a candidate for resuscitative thoracotomy based on our institutional protocol [5,6]. However, when chest compressions were paused upon her arrival in the emergency department, she had a faint carotid pulse. The Extended Focused Assessment with Sonography for Trauma (E-FAST) was unremarkable. We, therefore, placed a 7-French introducer sheath into the right common femoral artery and inserted an ER-REBOA Catheter (Prytime Medical Devices, Boerne, Texas), which was positioned at 45 cm at the skin. Immediately after we inflated the balloon with 13 mL of saline-diluted contrast, her blood pressure increased to 117/60 mmHg. The time, catheter position, and balloon volume were

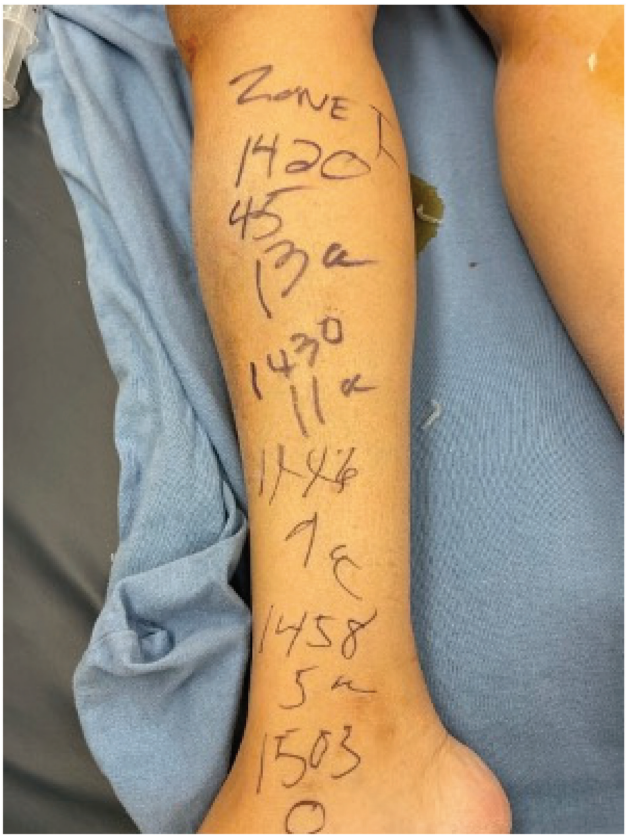

Figure 1 The time, catheter position, and balloon volume were recorded on the patient's right lower extremity.

recorded on the patient's right lower extremity (Figure 1). A chest radiograph confirmed that the balloon was in zone I of the aorta and that there were no major thoracic injuries (Figure 2).

While we were placing the REBOA, the patient was intubated, intravenous access was obtained, and the pelvis was stabilized with a sheet. The FAST was repeated and did not show free fluid in the abdomen. Her hemoglobin was 11.4 g/dL, and her base deficit –22.0 mmol/L. The patient was taken to the computed tomography scanner with the balloon partially inflated with 11 mL of contrast (Figure 3) and was found to have bilateral cerebral subarachnoid hemorrhages, left frontal lobe intraparenchymal hemorrhage, intraventricular hemorrhage, atlanto-occipital dissociation, multifocal C1 fractures, and bilateral rib fractures. The rest of the whole-body scan was unremarkable. At this point, 26 minutes after balloon inflation, she had received three units of red blood cells and two units of plasma and had a blood pressure of 133/118 mmHg. Having ruled out hemorrhagic shock, we stopped transfusing blood products and continued to remove fluid from the balloon (Figure 1). At 43 minutes after REBOA placement, the balloon was completely deflated, and the catheter was withdrawn. Her blood pressure was 110/83 mmHg.

The patient was admitted to the surgical intensive care unit. A norepinephrine infusion was needed to maintain a systolic blood pressure >100 mmHg. She did not have brainstem reflexes, and magnetic resonance imaging showed evidence of grade 1 diffuse axonal injury and diffuse hypoxic-ischemic injury. Our neurosurgery team deemed her condition unsurvivable. After her family was approached by the local organ procurement organization and gave authorization for donation after circulatory death, the liver and both kidneys were recovered on the fifth hospital day and transplanted into three recipients. Biopsies of the kidneys taken during procurement were negative for acute tubular necrosis.

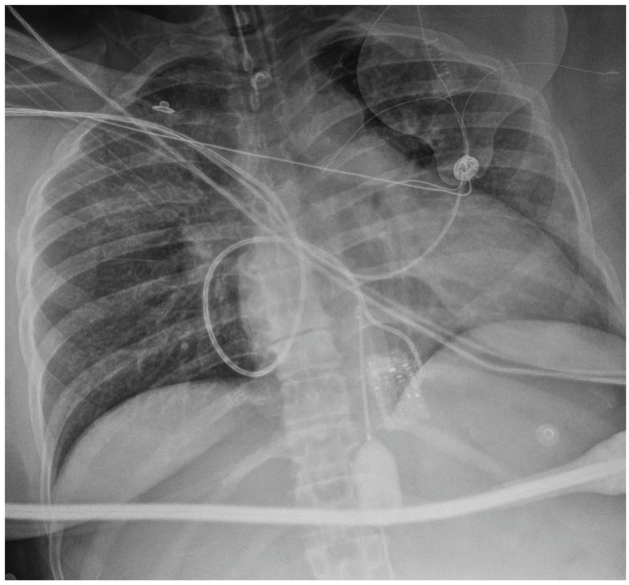

Figure 2 Chest X-ray immediately after balloon inflation.

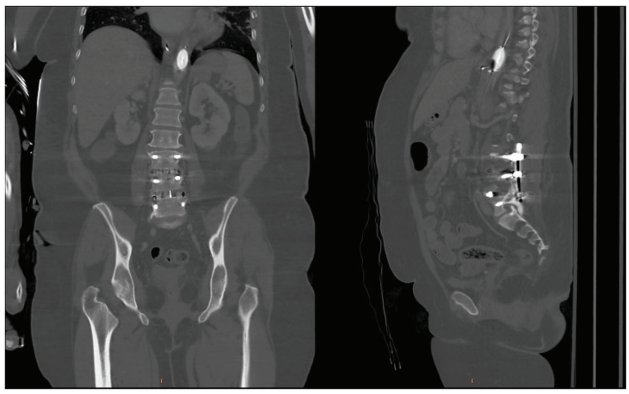

Figure 3 Coronal (left) and sagittal (right) views of the patient's computed tomography scan, which demonstrate positioning of the balloon in zone I just above the diaphragm.

Ethical Approval and Informed Consent

Ethical approval was not required. Informed consent was not possible because of the acuity of the patient's condition, and the information has been anonymized.

DISCUSSION

Brain injury, especially when progressing to brain death, is associated with hemodynamic, metabolic, and endocrine derangements that can result in multiorgan failure and cardiovascular collapse [7–10]. Consequently, one-quarter of trauma patients who are identified as possible organ donors are lost due to hemodynamic instability [2–4]. In our patient who arrived *in extremis* after a motor-vehicle collision, zone I REBOA deployment prevented imminent cardiovascular collapse and allowed for prompt diagnosis of her injuries as well as eventual evaluation for organ donation. The aorta was completely occluded for only 10 minutes, avoiding prolonged ischemia of the abdominal viscera. That timing was crucial because the duration of ischemia impacts the suitability of organs for transplantation. In livers, for example, warm ischemia times >20 minutes have been associated with decreased graft survival [11].

Utilization of REBOA to salvage possible organ donors follows numerous efforts over the last three decades to increase the quantity of transplantable organs [12]. The use of marginal or extended-criteria donors, including elderly, pediatric, and diabetic patients, has become more common. Longer cold ischemia times, non-heart-beating donation, and split-liver transplantation have become more widely accepted. Most recently, with the development of antiviral therapies, donors with bloodborne infections are allowed [13]. Success has been demonstrated with transplanting organs from patients with hepatitis C (HCV) to HCV-negative recipients. The 2013 HIV Organ Policy Equity Act allows HIV-positive individuals to donate to HIV-positive recipients and has been expected to expand the donor pool by 400–500 individuals annually. These strategies attempt to address the organ shortage crisis while conforming with the ethical expectations of society.

REBOA provides time for family members to make consensus decisions about organ donation. An alternative to REBOA for patients with unsurvivable injuries is the use of uncontrolled donation after cardiac death (uDCD) to maximize organ availability. uDCD is a form of organ recovery in which, once a patient has been declared dead, a procurement team is activated to recover organs. This strategy has increased available kidneys for transplantation in Europe [14]. Limitations include that organs undergo longer warm ischemia times, increasing the risk of non-function after transplantation [15]. uDCD has logistic, legal, and ethical barriers that currently hinder its use in trauma [16].

As this case demonstrates, survival to organ donation is a potential benefit of REBOA. While aortic balloon occlusion was first described in the trauma literature during the Korean War, its use has become more common due to technical improvements but remains controversial. In patients with hypovolemia, prompt aortic occlusion increases cardiac afterload and directs blood to the brain and heart. Thus, it is an integral step during resuscitative thoracotomy for injured patients *in extremis*. Initial investigations of REBOA have indicated a survival benefit in selected patients [17,18]. It is less invasive than resuscitative thoracotomy, which can also lead to organ donation [19]. Other applications of REBOA in the management of potential donors, for example, during normothermic extracorporeal perfusion after cardiac death [20], have been reported but require further investigation. Based on our experience with this patient, we advocate for more aggressive use of REBOA in the management of the hemodynamically unstable trauma patient, recognizing that it can increase the donor pool. Survival to organ donation should be studied in future work on outcomes of REBOA.

Conflict of Interest

The authors declare that they have no conflicts of interest.

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

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Author Contributions

JJS, DPF, and EEM cared for the patient in this case report. JJS, DPF, and HBM reviewed the literature and wrote the manuscript, which EEM critically revised.

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Case Report

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Transcatheter Arterial Embolization for Blunt Hepatic Trauma in a Preschooler

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Published reports regarding the use of transcatheter arterial embolization (TAE) for blunt hepatic trauma in young children, especially preschoolers (3–5 years old), are still scarce. We present a case report of a 4-year-old girl who was involved in a motor vehicle accident while sitting in the passenger seat without wearing a seatbelt. Focused Assessment with Sonography for Trauma and contrast-enhanced computed tomography scan showed severe liver injury with signs of active intraabdominal bleeding. Selective hepatic artery embolization was performed to control arterial hemorrhage. No procedure-related complications occurred, and she was discharged on foot on day 14. TAE is a safe and effective treatment for hemostasis in blunt hepatic trauma, and it should be strongly considered as a treatment option not only in adults but in young children as well.

Keywords: *Non-Operative Management; Blunt Hepatic Trauma; Pediatric Trauma; Transcatheter Arterial Embolization*

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INTRODUCTION

Transcatheter arterial embolization (TAE) is widely used as a safe and effective treatment for hemostasis in blunt hepatic trauma in adults [1]. However, published reports in the pediatric population, especially preschoolers (3–5 years old), are still extremely scarce. We report a case of severe liver injury in a 4-year-old who was successfully treated with TAE.

CASE REPORT

A 4-year-old girl with no history of illness was involved in a motor vehicle accident while sitting in the passenger seat without wearing a seatbelt. Primary survey findings were as follows: airway intact, respiratory rate of 22 breaths/min, SpO_2 of 100% (O_2 10 L/min with reservoir mask), heart rate of 126 b.p.m., blood pressure of 143/72 mmHg, no active bleeding on the body surface, Glasgow Coma Scale score 15 (E4V5M6), pupils equal and reactive at 4 mm, no hemiplegia. Focused Assessment with Sonography for Trauma (FAST) was positive with echo free space in Morrison's pouch and in the pouch of Douglas; chest X-ray and pelvic X-ray showed no abnormalities. Contrast-enhanced computed tomography scan (CE-CT) showed severe liver injury (American Association for the Surgery of Trauma (AAST) grade IV) with disruption of the liver capsule, extensive hemoperitoneum and contrast extravasation (Figure 1). Laboratory data showed elevated liver enzymes: asparate aminotransferase (AST) 484 U/L, alanine aminotransaminase (ALT) 288 U/L, total bilirubin 0.37 mg/dL, and lactate dehydrogenase (LDH) 956 U/L.

Besides being slightly tachycardic for her age, considering the fact that she was excited and crying throughout the physical examination, there were no specific vital sign abnormalities or physical findings suggesting that she was hemodynamically unstable due to hemorrhagic shock. However, repeat FAST after CE-CT

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Presentation: This case report has been presented at the 31st Kitanihon IVR Kenkyukai.

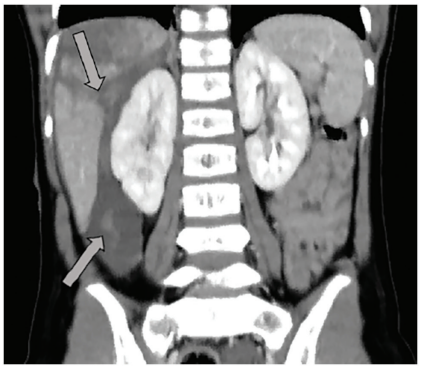

Figure 1 CE-CT on day 1. The coronal view shows the injury was mainly focused on the right posterior segment with disruption of the liver capsule, extensive hemoperitoneum, and contrast extravasation (arrows).

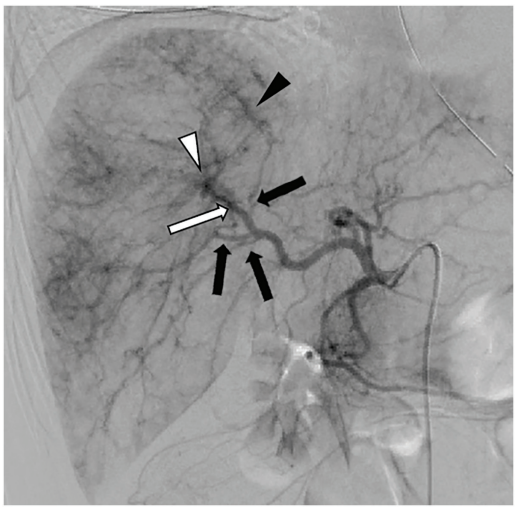

Figure 2 Common hepatic arteriography on day 1. Contrast extravasation (black arrowhead) and arterio-portal shunt (white arrowhead) visualized. Posterior segment branches (black arrows) were tightly embolized, and the anterior segment branch (white arrow) was modestly embolized.

showed enlargement of the echo free space and abdominal tenderness persisted, suggesting the duration of active intraabdominal bleeding.

We decided to take the strategy of non-operative management (NOM) with selective hepatic artery embolization to achieve hemostasis. Common hepatic arteriography showed contrast extravasation and arterio-portal shunt in the anterior and posterior segment branches of the right hepatic artery (Figure 2). No collateral circulation was visualized, and selective TAE was performed using a gelatin sponge cut into 1 mm pieces. From the CE-CT findings, we considered that the arterial hemorrhage was mainly from the posterior segment, so the posterior segment branches were tightly embolized, while the anterior segment branch was modestly embolized, just enough to decrease the peripheral flow of the artery.

After selective TAE, we confirmed the disappearance of contrast extravasation and arterio-portal shunt with right hepatic arteriography. No signs of hepatic vein or portal vein injury became apparent with venography and portography following celiac arteriography, denying the need for further intervention with laparotomy.

We used a 3 Fr system to minimize any risk of leg ischemia. The devices used for the procedure were as follows: XEMEX Introducer Set™ (3 Fr/30 cm, Zeon Medical Inc, Tokyo, Japan), CX Catheter-AII™ (Shepherd-Hook/3 Fr/60 cm, Gadelius Medical, Tokyo, Japan), Radifocus™ Guidewire M (0.025 inch/260 cm/Angled, Terumo Corporation, Tokyo, Japan), Carnelian MARVEL™ (Non-tapered, 1.9 Fr/1.9 Fr, Tokai Medical Products, Aichi, Japan), ASAHI CHIKAI™ black (0.014 inch/200 cm, ASAHI INTECC Co., Aichi, Japan). Considering the small diameter of the aorta, the tip of the CX Catheter-AII™ was slightly steam-shaped to improve the selectivity of the celiac artery.

No procedure-related complications occurred. She showed no signs of rebleeding after the procedure, elevated liver enzyme values normalized and was discharged on foot on day 14. Prior to discharge, we confirmed minor biloma formation at the site of the injury with follow-up CE-CT on day 12. We decided no intervention was necessary and continued outpatient follow-up with abdominal echography (Figure 3*a–d*).

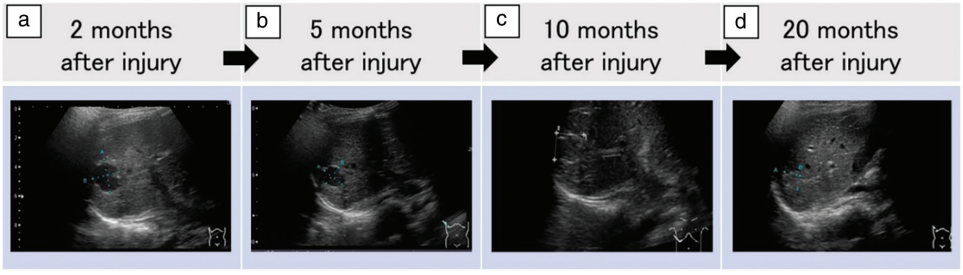

Figure 3 Abdominal echography at outpatient follow-up 2 months (**a**), 5 months (**b**), 10 months (**c**), and 20 months (**d**) after the injury. The biloma gradually became smaller and organized. Complete resolution was confirmed 20 months after injury.

The biloma gradually got smaller and organized, and complete resolution was confirmed 20 months after injury. Blood flow signal suggesting pseudoaneurysm formation or findings suggesting infection or abscess formation were not observed throughout the course of the case.

Ethical Approval and Informed Consent

Ethical approval was not required. Written informed consent was obtained from the patient's family for the publication of this case report.

DISCUSSION

NOM is considered the standard of care in children with blunt solid organ injury who are in a hemodynamically stable condition [2]. In the adult population, TAE is recognized as a well-established procedure that increases the success rate of NOM [3]. However, the role of TAE in NOM for pediatric blunt hepatic trauma is still unclear, and it is only in recent years that the procedure became recognized as a possible treatment option by the American Pediatric Surgical Association guidelines [4].

The novelty of our report is the successful application of TAE in a preschooler, with an in-depth description of the procedure using a 3 Fr system and extensive follow-up information. The literature describing the application of this procedure to young children, a preschooler as in our case, is limited to sporadic and brief case reports [5,6]. To be useful for future reference, reports of endovascular intervention for children must include precise details of the procedure, specifying the devices used and long-term follow-up information after the procedure to check for any possible complications, and, to our knowledge, this is the first report to do so.

While NOM for blunt hepatic trauma is considered the standard of care in stable children, the number of reports describing the failure of NOM without TAE is staggering, with reported failure rates being 5–30% [2]. Waiting for the patient to become unstable and then suddenly going into emergent laparotomy is a dangerous and unnecessarily risky strategy, when we have an alternative treatment option that enables safe and effective hemostasis. We strongly believe TAE for blunt hepatic trauma is also useful in young children and hope this case report will serve as one additional example showing the utility of the procedure.

No complications specifically related to the endovascular intervention occurred. In addition, no signs of arterial thrombosis, which is one of the noteworthy complications in pediatric interventional radiology [7], were observed. Biloma formation cannot be attributed as a specific consequence of the endovascular procedure, since it is one of the most common complications of liver trauma in NOM without TAE in pediatric hepatic trauma [8]. Further study is warranted regarding whether this complication rate alters by adding TAE to NOM in the pediatric population.

All radiographic tests and procedures were performed adhering to the As Low As Reasonably Achievable (ALARA) principle to minimize the effect of radiation in children, in accordance with the ICRP recommendations [9]. We decided the benefit of definite and immediate control of arterial hemorrhage profoundly outweighed the risk of radiation exposure from the procedure.

CONCLUSION

TAE is a safe and effective strategy to control arterial hemorrhage in blunt hepatic trauma. To raise the success rate of NOM, it should be strongly considered as a treatment option not only in adults but also in young children, and even in preschoolers.

Acknowledgements

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Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Author Contributions

TS was responsible for drafting, editing, and submission of the manuscript. KH, RU, YM, TI, TT, HK, and KS contributed to the critical revision of the manuscript for important intellectual content and provided intellectual input to the research and manuscript. All authors read and approved the manuscript.

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Case Report

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Successfully Stifling Retroperitoneal and Pelvic Exsanguination by Resuscitative Endovascular Balloon Occlusion of the Aorta in a Rural Setting

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Background: Torso hemorrhages are increasingly controlled by transient employment of Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA). Few studies report patients' conditions after the initial resuscitation period using REBOA, especially in a rural setting. We present a highly successful 1-year post-operative recovery using REBOA for retroperitoneal and pelvic exsanguination.
Methods: A 36-year-old female suffered a constellation of traumatic injuries after being ejected from her motorcycle. She arrived at a rural level 1 trauma center shortly thereafter.
Results: REBOA was employed to control profuse hemorrhaging and the patient had a highly resilient recovery after one year. A literature review was conducted to highlight the points of contention regarding the controversial use of REBOA.
Conclusion: REBOA can produce favorable results with minimal long-term deficits when controlling pelvic exsanguination.

Keywords: *REBOA; Pelvic Trauma; Hemostasis; Torso Hemorrhage*

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INTRODUCTION

Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) may be used to stabilize life-threatening pelvic hemorrhages when tourniquets are unfeasible. Among other benefits, it reduces exsanguination and restores blood pressure in profoundly hypotensive patients [1]. There are several reports of REBOA use for pelvic trauma [2,3] but few studies report outcomes after the initial resuscitation period [4]. The use of REBOA is controversial, however. Patients who qualify for REBOA must be selected judiciously as its negative effects may outweigh the benefit of hemostasis [5,6]. We present a case of a highly successful pelvic trauma recovery following a zone 3 (Figure 1) REBOA insertion.

Ethical Approval and Informed Consent

Ethical approval was not required and the information has been anonymised.

CASE PRESENTATION

A 36-year-old female arrived at a rural level 1 trauma center after colliding with a car and being ejected from her motorcycle. She remained awake and alert on the scene despite losing her helmet. She sustained a constellation of fractures involving the pelvic ring, bilateral pubic rami, the C7 vertebra, the right proximal humerus,

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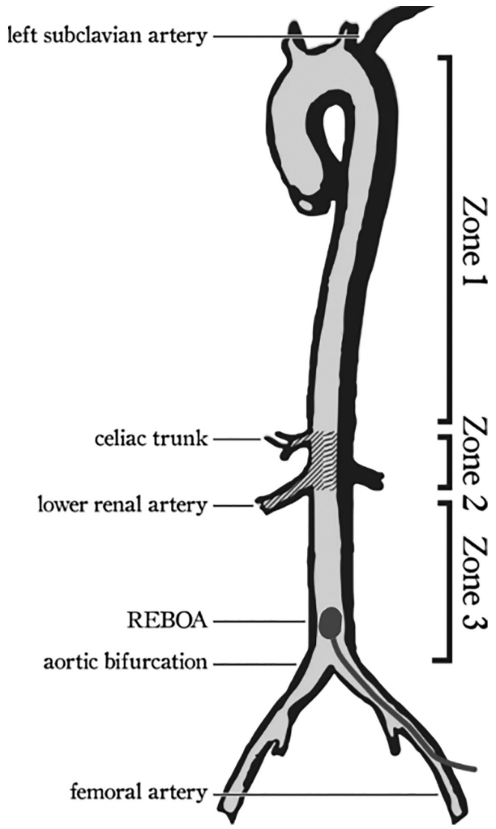

Figure 1 Anatomical distribution of REBOA.
The 3 zones of REBOA placement. Zone 3 consists of the infrarenal aorta. Adapted from Olsen et al. [7] (CC BY 4.0).

and the left femoral shaft (Figure 2) as well as a vaginal laceration. A Glasgow Coma Score of 3T inhibited history taking by emergency medical services personnel. En route she had a heart rate of 140 beats per minute and she was intubated with an endotracheal tube 5.2 cm above the carina. Cefazolin and tranexamic acid were also administered to prevent gram-positive infections and to induce fibrinolysis, respectively.

Upon arrival at the trauma bay a primary survey was conducted. The airway was confirmed, and profuse retroperitoneal and pelvic hemorrhaging were noted to cause hypovolemia with diminished carotid and femoral pulses. She was given two units of packed red blood cells, one liter of crystalloid fluid, and one unit of fresh frozen plasma to correct for hemorrhagic shock. She was also hypokalemic with 3.2 mmol/L of potassium from extensive rhabdomyolysis and hypovolemia. One ampule of bicarbonate was administered via intraosseous access for immediate intracellular potassium restoration. Acidosis was identified with an arterial partial pressure of carbon dioxide of 62.0 mmHg, bicarbonate of 10.6 mmol/L, and a lactate level of 13.7 mmol/L, which contributed to an anion gap of 24 mmol/L. A negative focused assessment with sonography in trauma (FAST) of the abdomen in conjunction with pelvic fractures on X-ray prompted a zone 3 REBOA inflation per hospital protocol. A pelvic binder was applied and a 7 French catheter was inserted through the femoral artery to place REBOA superior to the aortic bifurcation using the Seldinger technique. REBOA was measured at the

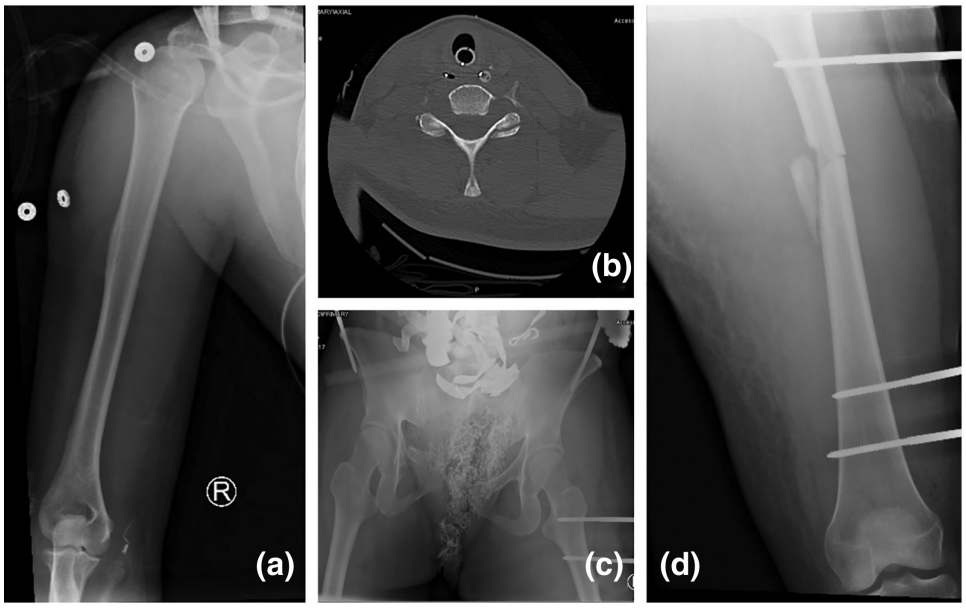

Figure 2 Bone fracture radiographs.
(**a**) Greater tubercle fracture of the right humerus. (**b**) Fracture of the right C7 transverse process. (**c**) Fracture of the right inferior rami. (**d**) Fracture of the left femoral shaft.

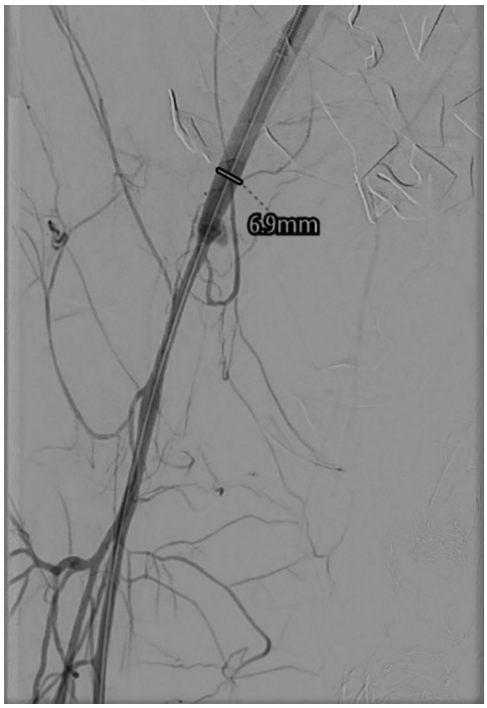

Figure 3 Angiogram.
Angiogram imaging of the right external iliac artery. An endovascular stent can be seen dilating the artery.

level of the umbilicus and inflated with 20 cc of saline. Animal studies suggest zone 3 REBOA placement is survivable up to 90 min [8]. Shortly afterward, her blood pressure increased from 94/55 to 148/88 and an echocardiogram verified improvements in cardiac functioning. A triple lumen catheter was secured in the right subclavian artery once initial attempts to insert it on the left were unsuccessful.

The patient was subsequently taken to the operating room for an exploratory laparotomy where a midline longitudinal laceration was identified extending from the vulva to the rectal wall and a thoracostomy was inserted to relieve a left pneumothorax. Hyperresonance on auscultation prompted a chest X-ray which identified the pneumothorax. Prolonged inflation of REBOA risks ischemia downstream of the aortic bifurcation so REBOA was deflated and withdrawn once the internal iliac arteries were bilaterally ligated. Ligation was reversed after two days. A post-operative computed tomography (CT) scan revealed an external iliac artery pseudoaneurysm requiring the insertion of an endovascular stent (Figure 3). The patient returned a month after the Viabahn stent was placed for follow up. At that time, she reported no defects in the right lower extremity but complained of tightness and aching in her left calf which was too debilitating to bear weight on. A venous duplex the same day revealed no deep vein thrombosis (DVT).

After the exploratory laparotomy, her left pelvis and femur were stabilized by an external fixation device. Open reduction and internal fixation of the pubic symphysis, insertion of a left sacroiliac screw, and repair of a comminuted greater tuberosity fracture were later performed. She also underwent a vulvovaginal laceration repair, perineorrhaphy, and an anal sphincteroplasty without complication followed by extensive pelvic floor physical therapy.

Comprehensive physical exams and imaging sought to detect inconspicuous injuries. A CT angiogram revealed a bilateral blunt cerebrovascular injury of the cervical internal carotid arteries (ICAs). Both the right and left ICAs had a dissection or an intramural hematoma, but a pseudoaneurysm was also suspected in the left ICA. Hospital interventional neuroradiologists concluded that intervention was unwarranted and that a 3-month angiogram follow-up alone would suffice. She was discharged from the hospital 27 days after the motorcycle crash and required no further management for her cerebrovascular injuries.

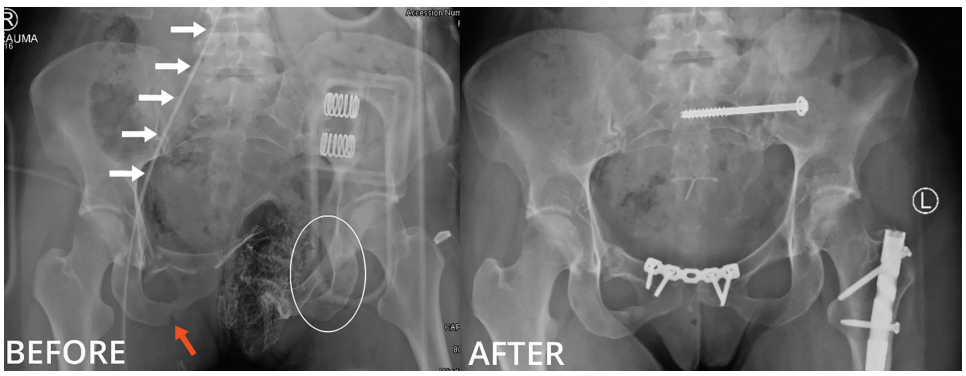

Figure 4 Orthopedic recovery.
AP pelvic X-Ray hours after the collision (left) and 6-months afterward (right). The five white arrows point to REBOA ascending the common iliac artery. The orange arrow points to a fracture of the right inferior pubic ramus. The white circle shows a left open book pelvic fracture. Corrections include a left sacroiliac screw, pubic symphysis plates, and an intramedullary nail fixation of the left femur.

The patient has had a remarkable recovery. Multiple consults with orthopedics in the following year ensured proper bone alignment (Figure 4) and a colostomy takedown greatly improved her quality of life. She came to the emergency room 2 months post-accident with an isolated DVT that was managed by switching from enoxaparin to rivaroxaban, which can be taken orally, while retaining the use of 325 mg of aspirin per CHEST guidelines [9]. She later returned for 5 days as an inpatient for thrombocytopenia which resulted in profuse vaginal bleeding and anemia. She received six units of packed red blood cells, three units of fresh frozen plasma, two units of platelets, and medroxyprogesterone as well as misoprostol to induce uterine contractions, expel uterine clots, and reduce bleeding. Rivaroxaban use was then contraindicated and suspended thereafter. Given persistent hemorrhaging and an unstable status, the patient underwent uterine artery embolization which significantly reduced further bleeding. She is back at work with no neurological deficits. However, she continues to be followed up for recurrent urinary tract infections, dyspareunia, and urge incontinence.

DISCUSSION

The efficacy and practicality of REBOA is complex given that patients present with significant variabilities in trauma localization and hemodynamic stability.

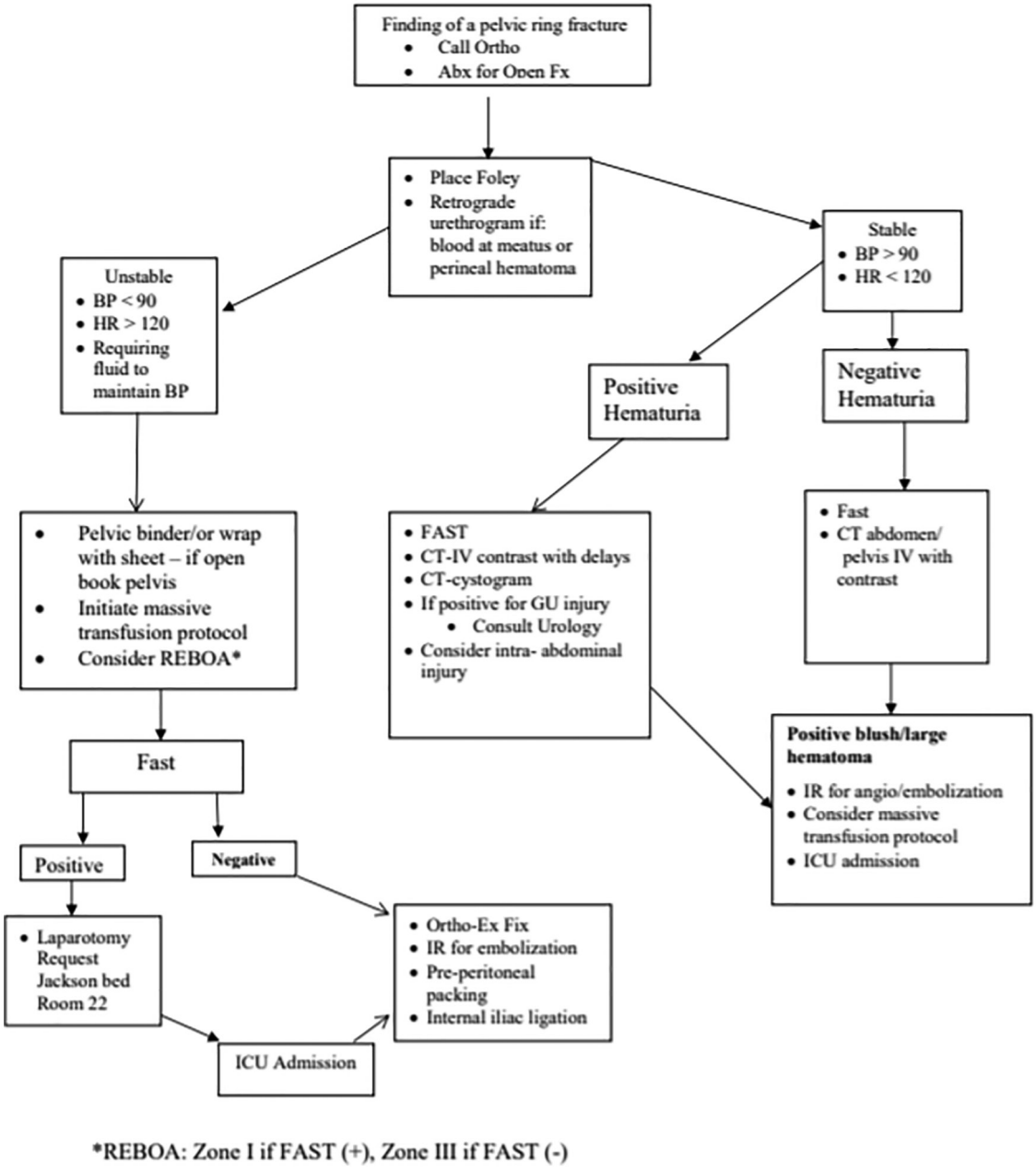

Figure 5 Institutional pelvic fracture management guidelines.

Trauma surgeons are often equipped with institutional algorithms that discern when REBOA insertion is optimal. At our institution, hemodynamic status, hematuria, and FAST results determine bifurcations in the decision management tree (Figure 5). If such factors compel REBOA use, a subsequent algorithm determines which zone REBOA should be employed (Figure 6). This algorithm contraindicates REBOA use if there is suspicion of aortic injury on chest X-ray.

Localization of trauma has a significant weight on REBOA's potential for success and complications. Bellal et al. argue that REBOA use is associated with higher mortality rates, lower extremity amputations, and acute kidney injuries, calling for clearer definitions of who benefits from REBOA [10]. This is partially due to where the trauma occurs. Thoracic trauma, such as injuries to thoracic veins or the subclavian arteries, is far less amenable to survival since zone 1 inflation occludes the renal arteries, superior mesenteric artery, and celiac trunk downstream. This lack of visceral blood flow is potentially lethal as it risks significant renal and gastrointestinal ischemia. For the same reason, those with pelvic hemorrhages are better suited for REBOA since these vascular branches are not obstructed by REBOA.

In a joint statement by the American College of Surgeons Committee on Trauma and the American College of Emergency Physicians, the consensus was reached that there is no high-grade evidence that REBOA outperforms the current standard of care. Moreover, level 1 trauma centers possess the lion's share of REBOAs, holding 87% of the devices in the US [4]. This makes it difficult to extrapolate REBOA's efficiency to lower-level trauma centers which are unequipped, in resources and expertise, to match the successful outcomes of larger institutions [11]. Level 1 institutions can provide total care to every aspect of injury whereas level 2 centers are able to initiate definitive care but may need to refer patients to level 1 centers which have more specialists and upgraded technology. Further studies examining the clinical utility and generalizability of REBOA are warranted.

We present a patient's 1-year post-operative recovery where the trauma was largely localized to the abdomen and pelvis. Uchino et al. describe an 86-year-old, hypotensive female who also sustained pelvic fractures from a vehicle collision [12]. However, instead of normalizing the patient's blood pressure, REBOA overshot considerably, reaching a systolic blood pressure of 180 mm Hg [12]. They theorize this exacerbated her intracranial

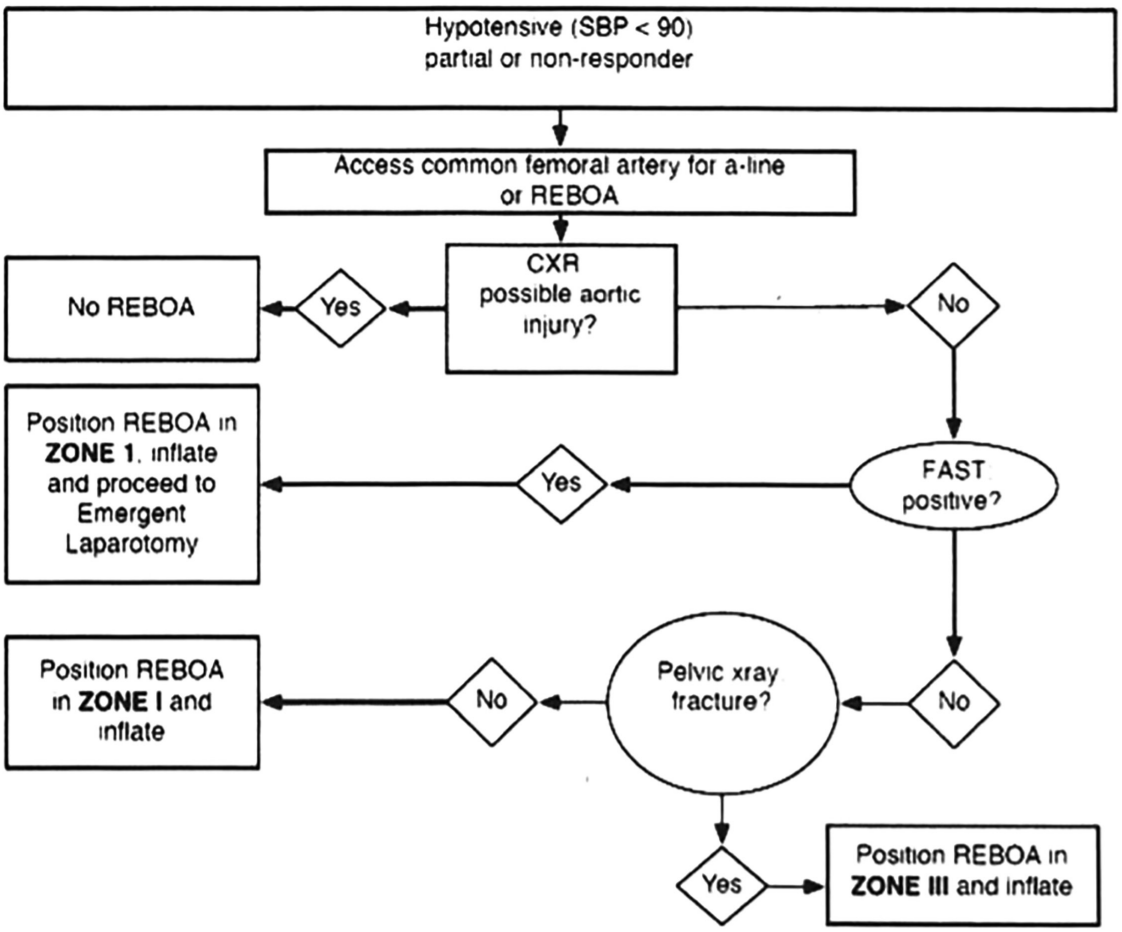

Figure 6 Institutional REBOA employment guidelines.

hemorrhaging which later led to cerebral herniation and death [12]. Rich et al. report the use of a roadside REBOA on a 23-year-old female complicated by left lower limb amputation [13]. They describe no further than 6-weeks of rehabilitative progress, during which only mild improvements were noted [13]. A right thigh seroma developed simultaneously, requiring three separate procedures to debride the wound and vacuum the fluid [13]. This greatly delayed the patient's rehabilitation [13]. In our case, REBOA induced no known long-term complications. A pseudoaneurysm did develop in the external iliac artery but likely emerged from trauma or endovascular access to the femoral artery since pseudoaneurysm development is seldom caused by REBOA [14]. Most pseudoaneurysms are iatrogenic [15]. The patient continues to be followed up for minor trauma and medication-induced complications.

CONCLUSION

This case demonstrates an exceptionally successful recovery from pelvic trauma using REBOA in a rural hospital. Exsanguination is difficult to control and is of foremost importance for life-threatening cases. REBOA can induce favorable results when applied to serious non-compressible pelvic hemorrhages.

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Author Contributions

All authors have made substantial contributions to this manuscript.

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EVTM-ST Section

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The Use of a Single Proglide for Large Sheath Delivery Systems

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Keywords: *Vascular Access; Closure Device*

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A percutaneous approach to EndoVascular Aortic Repair (EVAR) for aortic aneurysms requires large size sheaths. Access site management, however, remains a technical challenge. Several techniques have been described for access site hemostasis and post-procedure closure of the femoral vessels, both using open cutdown suture and percutaneous closure devices. The ISAR-CLOSURE and PEVAR trials have demonstrated that the use of vascular closure devices is non-inferior to manual compression or open femoral exposure, respectively, in terms of access-site complications and reduced time to hemostasis [1,2]. Maniotis et al. have demonstrated, through a systematic review, the benefits of using double Perclose ProGlide (Abbott Vascular, Santa Clara, CA, USA) suture mediated closure devices for sheath sizes larger of than 8 Fr [3]. The use of double or, in some cases, triple ProGlide devices may have several disadvantages because of technical complexity and increased time and cost, which are highly relevant in cases of ruptured aortic aneurysms. By utilizing a single ProGlide device placed at a 12 o'clock position, the access site can be continuously titrated per-procedure, allowing the downgrading of sheath size when necessary and distal flow to the lower extremities. After the procedure the access site can safely be closed by tightening the knot with the knot pusher after complete removal of both the sheath and guidewire. If oozing bleeding is observed, this is controlled by upward tension of the ProGlide sutures and simultaneous downward compression using a mosquito hemostat curved forceps, as displayed in Figure 1. A small

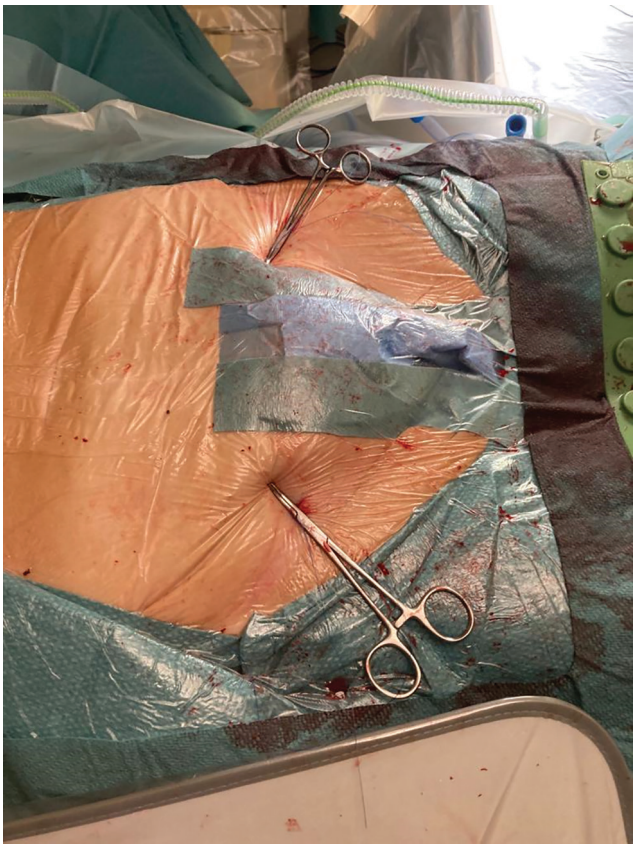

Figure 1 Hemostasis control after EVAR using bilateral single ProGlide devices with additional upward tension of the ProGlide sutures and simultaneous downward compression using mosquito hemostat curved forceps.

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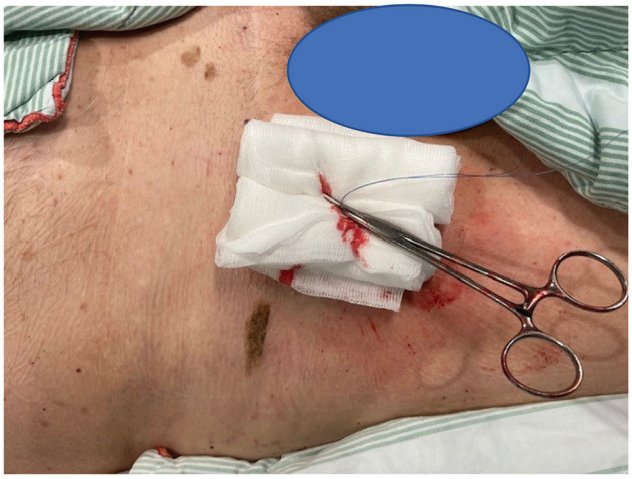

Figure 2 A small hemostatic or normal compress can also be used in the wound by tying the ProGlide sutures around it and tightening to minimize blood oozing.

hemostatic compress can also be used in the wound and, by tying the ProGlide sutures around the compress after they are tightened, oozing bleeding can be controlled, as seen in Figure 2. If adequate closure is not achieved, this is often observed before guidewire removal and another ProGlide can therefore be placed in the 12 o'clock position after the first one has been tightened as displayed in Figure 3; this may result in more effective closure as it allows the sutures to be placed further from each other.

At Örebro University Hospital we have adopted this technique for the closure of large bore accesses between 12 and 24 Fr after EVAR, thoracic EVAR (TEVAR) and fenestrated EVAR (FEVAR) in both elective and emergent cases. During 2021 this technique was used in around 40 cases of endovascular aneurysm surgery at our institution, with only one case failing (suture failure and stentgraft placement to cover the bleeding femoral artery access) and one requiring an adjunct fascia suture technique. We therefore believe that it is a safe and durable technique for closure of large bore access. It is now used routinely in all larger-bore access (as of today 24 Fr) and has been used also in smaller vascular access in non-arotic procedures (for example, 8 Fr).

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

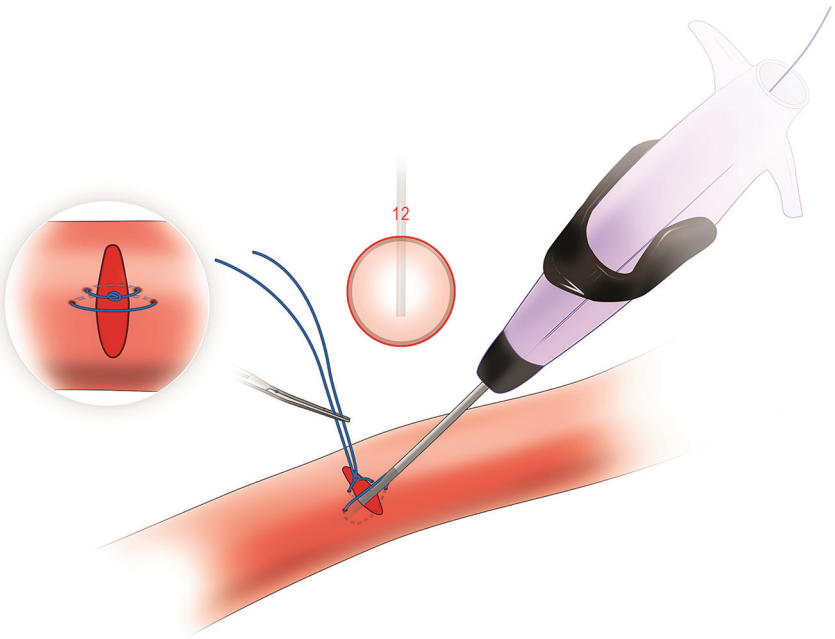

Figure 3 The placement of a second ProGlide suture, also at a 12 o'clock position. This can be performed as long as you still have the guidewire in place.

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Author Contributions

David McGreevy drafted and wrote the manuscript. Tal Hörer and Claes Forssell wrote and revised the manuscript.

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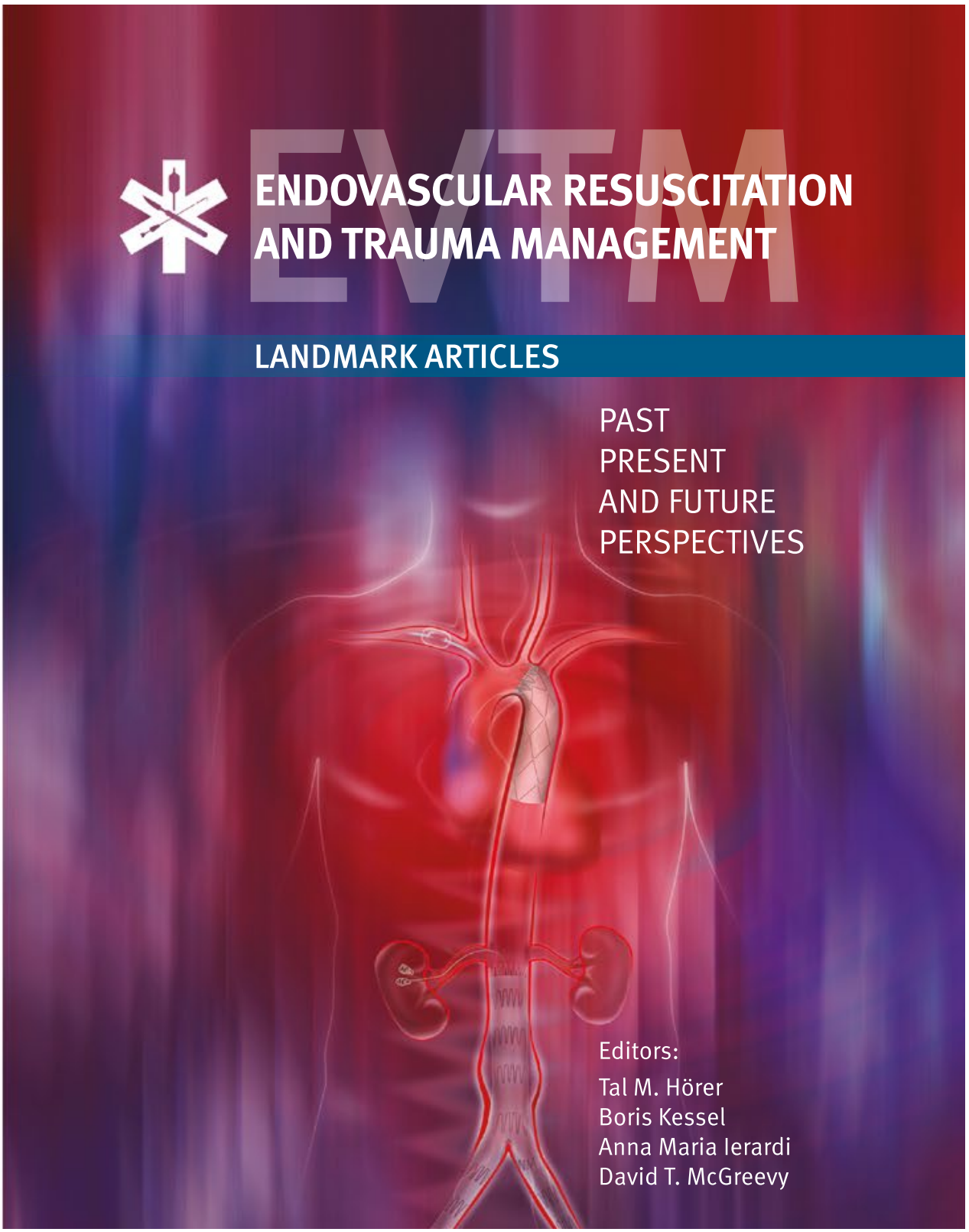

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One of the main EVTM-ST events is the monthly multidisciplinary international case discussions on Zoom. An appreciated concept with focus on allowing the participating trainees to discuss a presented EVTM case, with only one consultant present for guidance. Participants are from all around the world, from various disciplines and with different levels of experience. We have great discussions, exchange of knowledge and hear about different local experiences that everyone can learn from.

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VEITHsymposium, 15–20 November 2022, New York
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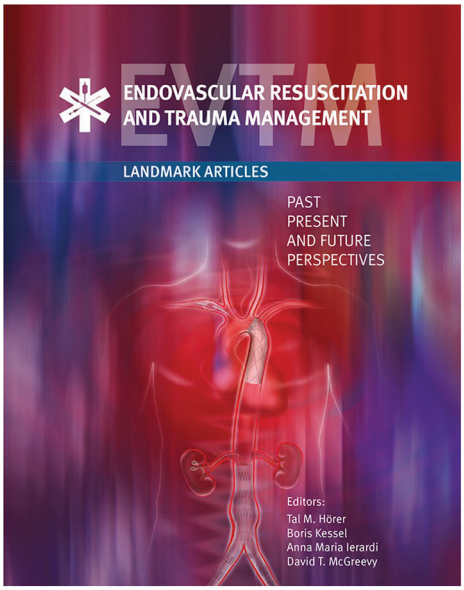

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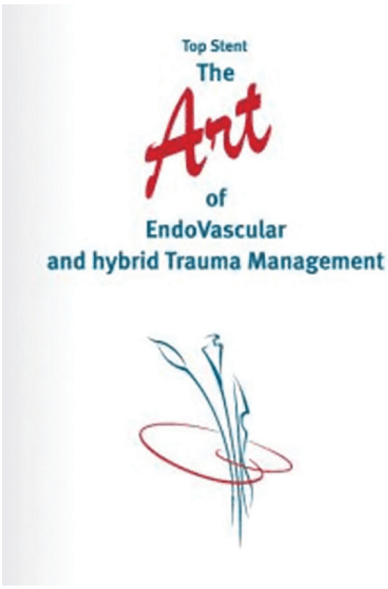

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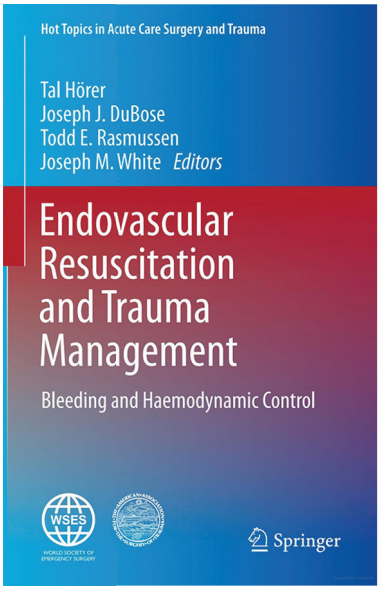

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It is a great pleasure to welcome you to the Pan-American EVTM - EndoVascular Resuscitation and Trauma Management to be hosted by the R Adams Cowley Shock Trauma Center in Baltimore, Maryland.

Our goal is to offer an excellent scientific program and an outstanding exhibition of the latest treatment options and technology within endovascular and hybrid resuscitation. With an international faculty of renowned experts and clinicians, we will cover most aspects of endovascular resuscitation, trauma, and bleeding management, REBOA, endovascular technologies and tools, as well as new concepts and algorithms for bleeding management from pre-hospital environments to the post-surgical period.

The EVTM symposiums are inspired by the collaboration with many centers and its extensive array of experimental research and clinical knowledge in endovascular and hybrid resuscitation including REBOA. We aim for good cooperation, open discussions, and debate, as well as high scientific data exchange. The EVTM symposiums offer a new, modern, live platform and we hope that you will be a part of it.

SUNDAY November 13th	
07.30-07.45	**Opening remarks -** *Charles Fox, Rishi Kundi and Boris Kessel*
ECMO. 6 min talk + 5 min discussions Moderators: James Manning (US) and Deb Stein (US)	
07.45-07.56	Awake ECMO or Traditional? - *Lena Napolitano (US)*
07.56-08.07	Arteriovenous ECMO for Trauma: Who, When, and What to Think About - *William Teeter (US)*
08.07-08.18	Venovenous ECMO in Trauma: Pulmonary Contusions, TRALI, and More! - *James O'Connor (US)*
08.18-08.29	Update on ECMO in COVID, Bicaval vs Right Heart Support - *Lena Napolitano (US)*
08.29-08.39	Panel Discussion and Audience Questions
08.40-09.00	**Breakfast in the exhibition area**
ENDOVASCULAR AND VASCULAR SURGERY I. 6 min talk + 5 min discussions Moderators: Omid Jazaeri (US) and Todd Rasmussen (US)	
09.00-09.11	10 year Experience with TEVAR for BTAI - *Fernando Joglar (US)*
09.11-09.22	Advanced Conduit Choice for Open Vascular Reconstruction: Beyond Saphenous Veins and PTFE - *Ravi Rajani (US)*
09.22-09.33	Definitive Endovascular Repair of Traumatic Arterial Injuries - Is It Time for An "Endovascular First" Approach Across the Board? - *Joe DuBose (US)*
09.33-09.44	Endovascular Management of Peripheral Trauma - *Anahita Dua (US)*
09.44-09.54	Panel Discussion and Audience Questions
ENDOVASCULAR AND VASCULAR SURGERY II. 6 min talk + 5 min discussions Moderators: Greg Magee (US) and Ravi Rajani (US)	
10.00-10.11	Endovascular Repair of Peripheral Vascular Injuries: Fifteen Years of Evolution in Care - *Raul Coimbra (US)*
10.11-10.22	Endovascular Management of Penetrating Trauma - *Fernando Joglar (US)*
10.22-10.33	Direct Site Endovascular Repair of Arterial Injuries - Is It Time to Remove the Suture Line Failures From Vascular Injury Repair? - *Joe DuBose (US)*
10.33-10.44	EVAR for 100% Ruptured AAA - *David McGreevy (SE)*
10.44-10.54	Panel Discussion and Audience Questions
ENDOVASCULAR AND VASCULAR SURGERY III. 6 min talk + 5 min discussions Moderators: Joe Dubose (US) and Melanie Hoehn (US)	
11.00-11.11	Hard Signs Gone Soft: A Critical Evaluation of Presenting Signs of Extremity Vascular Injury - *Anna Romangoli (US)*
11.11-11.22	Innovative Techniques for Ruptured Suprarenal and Thoracoabdominal Aortic Aneurysms - *Gregory Magee (US)*
11.22-11.33	Liquid Embolization for Trauma and Non-Trauma Patients - *Tal Horer (SE)*
11.33-11.44	Mangled Extremities and When to Reconstruct - *Pedro Texeira (US)*
11.44-11.54	Panel Discussion and Audience Questions
12.00-13.00	**Lunch in the exhibition area** **CONCURRENT RESIDENT SESSION**
KEYNOTE ADDRESS	
13.00-13.30	Keynote address - *Tom Scalea (US)*

ENDOVASCULAR AND VASCULAR SURGERY IV. 6 min talk + 5 min discussions Moderators: Megan Brenner (US) and Anahita Dua (US)	
13.30-13.41	Open Deployment of Endovascular Devices - *AJ Davidson (US)*
13.41-13.52	POPSAVEIT Score - *Gregory Magee (US)*
13.52-14.03	Post-Implantation Care Following Endovascular Management of Trauma - *Ravi Rajani (US)*
14.03-14.14	Retrohepatic Caval Injury and Its Management - *David Efron (US)*
14.14-14.24	Panel Discussion and Audience Questions
ENDOVASCULAR AND VASCULAR SURGERY V. 6 min talk + 5 min discussions Moderators: Fernando Joglar (US) and James O'Connor (US)	
14.30-14.41	Solid Organ Embolization for Hemorrhage: Why, When and How - *Joe DuBose (US)*
14.41-14.52	Vascular Injury at the Thoracic Outlet - *Deb Stein (US)*
14.52-15.03	Vein Ligation vs. Reconstruction - *Anthony Tannous (US)*
15.03-15.14	Venous Bypass for Chronic Iliocaval Occlusion - *Khanjan Nagarsheth (US)*
15.14-15.24	Panel Discussion and Audience Questions
15.25-15.45	**Coffee in the exhibition area**
HYBRID OR. 6 min talk + 5 min discussions Moderators: Anna Maria Ierardi (IT) and Yosuke Matsumura (JP)	
15.45-15.56	Effect and Cost-Effectiveness of the Hybrid Emergency Room for Severe Trauma - *Takahiro Kinoshita (JP)*
15.56-16.07	Helipad-to-Trauma Hybrid OR Pathway, STAT IR Process - *Laura Moore (US)*
16.07-16.18	Hybrid OR Uutilization at A Trauma Center: Balancing Gunshot Wounds and Elective Cardiovascular Surgery - *Ravii Rajani (US)*
16.18-16.29	Hybrid ORs: Should Hospitals Invest in Fixed Facilities vs. Purchasing Mobile Equipment - *Joe Galante (US)*
16.29-16.39	Panel Discussion and Audience Questions
INNOVATION IN RESUSCITATION AND CRITICAL CARE I. 6 min talk + 5 min discussions Moderators: Deb Stein (US) and Justin Richards (US)	
16.40-16.51	Catheter-Based Supersaturated Oxygen Therapy - *Graham Nichol (US)*
16.51-17.02	Clinical Data Strategies and Reporting for New Vascular Innovations: From Humacyte's HAV to pREBOA-Pro and Centers of Excellence - *Todd Rasmussen (US)*
17.02-17.13	Endovascular Support for Critical Care - *Timothy Williams (US)*
17.13-17.24	Incorporating Damage Control Resuscitation into EVTM? - *Juan Duchesne (US)*
17.24-17.34	Panel Discussion and Audience Questions
19.00	**Conference dinner**

MONDAY November 14th

INNOVATION IN RESUSCITATION AND CRITICAL CARE II. 6 min talk + 5 min discussions Moderators: Tom Scalea (US) and Anthony Tannous (US)	
07.30-07.41	Organ Dysfunction After Endovascular Resuscitation: What Happens After the Balloon Is Deflated - *Justin Richards (US)*
07.41-07.52	REBOA vs. Blood Transfusion - Effects on Coagulation, Metabolism and Hemodynamics - *David McGreevy (SE)*
07.52-08.03	The Role of Transesophageal Echocardiography in Endovascular Resuscitation - *Justin Richards (US)*
08.03-08.14	Utilization of TEG - *Anahita Dua (US)*
08.14-08.24	Panel Discussion and Audience Questions
08.25-08.45	**Breakfast in the exhibition area**
REBOA FOR NON-TRAUMATIC DISEASE. 6 min talk + 5 min discussions Moderators: Laura Moore (US) and David McGreevy (SE)	
08.45-08.56	How to Choose Which Patients Require Aortic Occlusion During the Surgical Management of Placenta Accreta Spectrum - *Albaro Jose Nieto-Calvache (CO)*
08.56-09.07	Non-Trauma Applications of REBOA - *Laura Moore (US)*
09.07-09.18	REBOA for Non-Traumatic Cardiac Arrest - *Austin Johnson (US)*
09.18-09.29	REBOA for Post-Partum Hemorrhage - *Megan Brenner (US)*
09.29-09.40	REBOA in Acute Cardiac Tamponade - *David McGreevy (SE)*
09.40-09.50	Panel Discussion and Audience Questions
REBOA FOR TRAUMA. 6 min talk + 5 min discussions Moderators: Jonny Morrison (US) and Zaf Qasim (US)	
10.15-10.26	New Trends in REBOA: South American Perspectives - *Joao Sahagoff (BR)*
10.26-10.37	Partial or Intermittent REBOA Techniques - *Matthew Martin (US)*
10.37-10.48	Tools to Facilitate the Use and Monitoring of Prehospital REBOA - *Maria Wikstrom (SE)*
10.48-10.59	Zone I vs Zone III REBOA for Postinjury Shock - *Ernest Moore (US)*
10.59-11.09	Panel Discussion and Audience Questions
REBOA: THE PAST AND THE FUTURE I. 6 min talk + 5 min discussions Moderators: Matthew Martin (US) and Albaro Jose Nieto-Calvach (CO)	
11.15-11.26	Automated Partial REBOA - *Luke Neff (US)*
11.26-11.37	p-REBOA Initial Experience - *Ryan Lawless (US)*
11.37-11.48	REBOA and Animal Studies: State of the Science - *John Holcomb (US)*
11.48-11.59	REBOA and Brain Perfusion: What Does the Animal Data Tell Us? - *Jonny Morrison (US)*
11.59-12.09	Panel Discussion and Audience Questions
12.15-13.15	**Lunch in the exhibition area**
REBOA: THE PAST AND THE FUTURE II. 6 min talk + 5 min discussions Moderators: Lena Napolitano (US) and William Teeterh	
13.15-13.26	REBOA with Distal Resuscitatiion During the Full Occlusion Period - *Shariq Syed Raza (US)*
13.26-13.37	The Evolution of REBOA - *Laura Moore (US)*
13.37-13.48	Therapeutic Hypothermia to Decrease Lower Extremity ischemia With REBOA Use - *Shahram Aarabi (US)*
13.48-13.59	Why Are Patients With Torso Hemorrhage Who Get REBOA Still Dying? - *Zaf Qasim (US)*
13.59-14.09	Panel Discussion and Audience Questions

SPECIALTIES AND EDUCATION I. 6 min talk + 5 min discussions Moderators: Raul Coimbra (US) and David Efron (US)	
14.15-14.26	Coordinating Vascular Trauma Surgical Care with Primary Trauma Service - *Christopher Ramos (US)*
14.26-14.37	Country-Specific Prehospital or Interfacility Transfer Logistics: What Only Works Here? - *Zaf Qasim (US)*
14.37-14.48	Creation of a Course to Teach SAAP - *James Manning (US)*
14.48-14.59	Development of REBOA Tele-Education Amid the Pandemic - *Yousuke Matsumura (JP)*
14.59-15.10	Vascular Injury Management and EVTM- Where do we stand? - *Boris Kessel (IL)*
15.10-15.20	Panel Discussion and Audience Questions
14.21-15.45	**Coffee in the exhibition area**
SPECIALTIES AND EDUCATION II. 6 min talk + 5 min discussions Moderators: Sheldon Teperman (US) and Khan Jan Nagarsheth	
15.45-15.56	EVTM for Specialists in Training - Growing the EVTM-ST Organization - *David McGreevy (SE)*
15.56-16.07	How Do The Formal Requirements to Become a Trauma Surgeon Differ Worldwide? - *Maria Wikstrom (SE)*
16.07-16.18	How to Set Up a Multi-Disciplinary REBOA Program - *Megan Brenner (US)*
16.18-16.29	Pediatric Vascular Trauma: What Everyone Needs to Know - *Adenauer Goes (BR)*
16.29-16.40	Significance of the Chief Imaging Analyst in EVTM - *Junichi Matsumoto (JP)*
16.40-16.50	Panel Discussion and Audience Questions
SPECIALTIES AND EDUCATION III. 6 min talk + 5 min discussions Moderators: John Holcomb (US) and Omid Jazaer (US)	
16.50-17.01	Imaging Technology and Trauma - *Anna Maria Ierardi (IT)*
17.01-17.12	Optimizing REBOA Education in the ED - *Ernest Moore (US)*
17.12-17.23	Who Should Be Doing REBOA? - *Shahram Aarabi (US)*
17.23-17.34	Carotid Injury: from Screening to Imaging to Management - *Adenauer Goes (BR)*
17.34-17.44	Panel Discussion and Audience Questions

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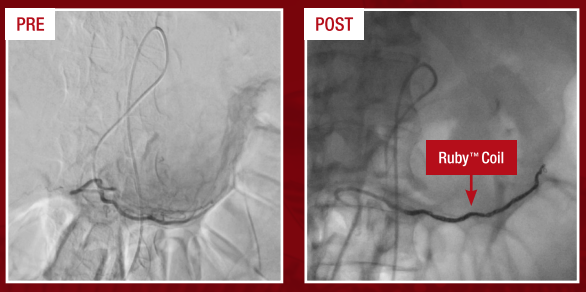

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1. Vogler J, Gemender M, Samoilov D. Packing density and long-term occlusion after transcatheter vessel embolization with soft, bare-platinum detachable coils. *Am J Interv Radiol.* 2020;4(2). doi:10.25259/AJIR_31_2019.
2. Enriquez J, Javadi S, Murthy R, et al. Gastroduodenal artery recanalization after transcatheter fibered coil embolization for prevention of hepaticoenteric flow: incidence and predisposing technical factors in 142 patients. *Acta Radiol.* 2013;54(7):790–794. doi:10.1177/0284185113481696.
3. Fohlen A, Namur J, Ghegediban H, et al. Midterm recanalization after arterial embolization using hydrogel-coated coils versus fibered coils in an animal model. *J Vasc Interv Radiol.* 2019 Jun;30(6):940–948. doi:10.1016/j.jvir.2018.05.005. Epub 2018 Aug 31.

a. 90 patients in GDA embolization. Mean follow-up 13.4 months.

b. Animal study comparing fibered coils to hydrogel coils showed recanalization rate >20%. n=12 sheep. Mean follow-up 4 months.

c. 142 patients in GDA embolization. Mean follow-up 101 days.

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