

Chapter 14

How to perform, learn, and train

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In the past, endovascular techniques have predominantly been in the domain of interventional radiologists, with the majority of techniques focused on the treatment of non-urgent, age-related disease changes. Influenced by major developments in management of combat related trauma in Afghanistan and Iraq in the last 15 years, as well as the development of lower profile endovascular devices and techniques, application of endo-vascular methods in haemorrhage control has been experiencing a recent surge. Application of interventional techniques in trauma is growing and there is a parallel need for translating the basic endovascular skill set to non-IR practitioners such as trauma surgeons, and emergency physicians. **Endovascular management of trauma is in its infancy** and a lot is still to be accomplished in order to optimise training in this field.

This chapter aims to present some of the higher order issues in EVTm, such as the philosophy and learning that is required to effectively deliver this type of intervention. It also aims to present the various options for training in this evolving discipline.



EVTM Skills

Endovascular procedures are complex and require skills used mainly in an interventional radiological setting. EVTm demands fine manual dexterity, familiarity with devices used for access and haemorrhage control including sheaths, wires, catheters and embolization materials as well as knowledge of the exact procedural steps. These skills should be integrated into general trauma management and the overall institutional haemorrhage control paradigm – with awareness of both endo and hybrid approaches.

To deliver optimal care to a trauma patient using endovascular techniques, an operator needs to have basic trauma skills, and a range of endovascular skills including: vascular access, REBOA, catheterization of main aortic branches, embolization and stenting.

Remark:

» Sounds scary? Sounds like it takes long time to learn these things? You have a point there. This is a very serious matter and training is essential for using EVTm tools! Some can learn basic EVTm fast and for some this might take year!

Practitioners should have the capability of obtaining access using a variety of methods (cut-down, blind, ultrasound and fluoroscopy-guided puncture), interpret images obtained via CT, ultrasound and angiography and have a general understanding of radiation exposure and measures that should be implemented to maximise the safety of patients and staff in an IR or hybrid suite. An important difference between endovascular manoeuvres in routine IR practice and trauma is the **tempo** required by the operator performing the procedure on a hemodynamically compromised patient and need to quickly respond to changes in the patient's physiological signs and angiography findings.

A Team Philosophy

Whether a local endovascular care system is led by a trauma surgeon, interventionalist or an emergency physician, successful implementation of EVTm requires a **multidisciplinary approach** and active involvement of trauma surgeons, interventional radiologists, and anaesthesiologists. Only a few centres enjoy the optimal model for endovascular trauma care delivery, where an

interventional radiologist or an endovascular surgeon enjoys being an integral part of the trauma team. The involvement of such individuals occurs from the time of the patient's arrival in the emergency department, carrying the responsibility of the procedure whilst maintaining continuity of care. Although it is unlikely that such a model will be adopted worldwide anytime soon, but growing implementation of EVTm and likely eventual integration into routine emergency care highlight the need to develop a structured learning process for in-hospital trauma teams and practitioners.

When it comes to endovascular intervention specifically, a successful team should be led by an operator who is cognizant of the extent and limitations of her skill set, but also of the capabilities of the rest of the team including scrub nurses and radiographers. Adequate **team based training** is crucial to developing a well-organized trauma team where every member has their place and contributes to the optimal care of the patient. This includes the scrub nurse being able to prepare the necessary equipment for each specific intervention, to the radiography technician who should aim to prevent unnecessary exposure to ionizing radiation. Team training can be enhanced with moulage scenarios where teamwork in emergency care can be practiced with improved realism.

In-depth familiarity with local facilities (IR suite, hybrid theatre etc.) and awareness of availability of specific endovascular devices



Figure 1: A Simple illustration of team approach during REBOA procedure.



Figure 2



Figure 3



Figure 4

Figure 2-4: The EVTm workshop in Örebro, Sweden

through regular, periodic evaluation and an appropriately stocked inventory is an important adjunct to interventional team organization and is critical in saving time during critical moments of the procedure.

EVTm Training Courses

At the time of writing this publication, several courses are internationally known to be offering hands-on endovascular skills training to trauma surgeons and emergency physicians, interventional radiologists and intensivists involved in care of trauma patients.

The **EVTm workshop** is the only known European workshop organized biannually in Örebro, Sweden, aimed at teaching basic endovascular access skills, REBOA, basic embolization, and hybrid bleeding control methods. This two-day workshop uses a combination of seminars, group discussions and dry and wet lab hands-on training including endovascular virtual reality (VR) simulators, animals and cadavers. debates, discussions, cases, models and live tissue training. Vascular access and REBOA are just some of the key issues in this workshop. The EVTm workshop is a platform for sharing information and skills and aims at surgeons, intensivists and IR people from around the world. The Swedish residents trauma workshops (Örebro, Sweden) are also done yearly and is a mixture of both traditional trauma care and some basic endovascular methods as REBOA.



The **Endovascular Skills for Trauma and Resuscitative Surgery** (ES-TARS) is a comprehensive 2-day course based in the USA, which utilizes lectures, endovascular VR simulators and live animal laboratories for training skills in femoral arterial access, proximal and distal arterial control techniques, angiography, coil embolization, REBOA, and shunt placement.

The **Basic Endovascular Skills for Trauma** (BEST™) course has been adopted by the American College of Surgeons Committee in Trauma (ACS COT). Originally developed in the University of Maryland's Shock Trauma Canter in Baltimore, there is planned expansion of the course to other locations around the USA. The one-day, concise and intensive curriculum focuses on training REBOA with the use of virtual reality endovascular simulation and models of pressurized cadaveric vasculature.

Another international training event is the **Diagnostic and Interventional Radiology in Emergency, Critical care, and Trauma** (DIRECT) course which has been developed in Japan and taught in Japanese. This 1-day event is aimed at emergency and medicine physicians as well as trauma surgeons and interventional radiologists and consists of didactic seminars and hands-on workshops with VR simulators and embolization materials.

There are new workshops and courses coming up in Europe (for example in London) and it appears that the interest in courses is huge.

Simulation

Endovascular procedures are characterised by the need to manoeuvre a wire within a three-dimensional vessel, whilst observing its position on a flat screen. In the trauma setting, in the presence of haemodynamic instability, the complexity of endovascular manoeuvres is further expanded by constant anticipation of changing physiology and the need for increased tempo to control bleeding in time to save the patient. The learning curve needed to obtain proficiency in endovascular trauma skills is steep and renders the traditional apprenticeship learning model inefficient. A range of simulation modalities allows trainees of a variety of backgrounds with different levels of experience learn and practice manual skills without compromising patient safety. With a variety of available simulation modalities, a trade-off between fidelity, access and cost exist. Whilst human and animal cadavers as well as VR simulators are more realistic, their use is usually limited to training more advanced en-

dovascular techniques such as embolization and stenting, leaving more simple training devices to rehearse basic skills such as access and wire and catheter manipulation.

Synthetic models

A number of man-made trainers, phantoms and manikins are available, commercially depending on the particular skill needed to practice. These range from simple manikins with dyed liquid which can be used for ultrasound guided Seldinger technique vascular access, to more sophisticated phantoms with branched vessels and pressurised fluid. Simple trainers can be assembled at home using basic materials such as a segment of tubing fixed to a working table which serves as a blood vessel, allowing rehearsal of vascular access through cannulation and use of sheaths, catheters and wires. By connecting transparent plastic tubes at different angles to represent arterial branches, one can practice catheterizing those branches or even embolizing them with hand-made coils. A few realistic artificial simulators allow puncturing a pulsating artery, but they are usually expensive. Depending on availability (usually limited to large centres), a pulsating pump can be connected to an artificial vessel in a simulator to allow more realistic representation of an artery. The more creative and determined trainees, might find that a home-made device composed of chicken thigh connected to a pulsating pump with liquid, provides a realistic training tool for US guided access of small vessels. There are now on the market 3D models that “real” anatomy (e.g., 3D Imprimis Ltd as well as well as other companies within the endovascular industry).

VR Simulators

While there is no replacement for live patient experience, with constantly improving technology, there is a growing access to sophisticated, high fidelity, digital software based, virtual reality simulators- which have been proven to safely aid development and assessment of advanced endovascular skills. Although they are expensive and access is limited, VR simulators can be used to train endo skills in an educationally oriented environment, without time constraints, risks to patient or ionizing radiation. Depending on software provided, VR trainers can be patient specific and use simulated fluoroscopic imaging



allow training a variety of scenarios including internal hemorrhage control techniques and REBOA. VR simulators not only allow training but can also provide objective assessment of performance of technical skills, radiation exposure and contrast media use, and have been validated for their use. Despite their wide range of benefits VR simulators are expensive, require extensive setup and high maintenance due to frequent breakdowns. They are usually limited to large centres and training courses.

Live animal training

Anaesthetized large animals (usually swine and sheep) provide an invaluable adjunct to improving manual endovascular skills due to their degree of realism, however they require specialist facilities. Animal models are expensive and are associated with ethical and legal issues limiting their access. In practical terms, the blood vessels in animal cadavers are thinner and smaller than those of humans, making vascular access more difficult. Animals also tend to lack atherosclerotic disease and cannot always reflect the obstacles met when cannulating human vessels with calcified plaques. Animal training can be done in different scenarios and recently, a pre-hospital REBOA helicopter/battlefield was performed on pigs. This, or a similar, model might be of interest for pre-hospital training.

Human cadavers

A human cadaveric model with artificially established pulsatile arterial flow following thrombolysis, provides a high-fidelity training tool, allowing practicing vascular access techniques and REBOA within a full procedure setting from arterial access to closure. Similar to animal cadaveric models, there is limited availability due to high cost stemming from complex preservation and storage needs of the cadavers. There are now some perfusion cadaver models that are very realistic for endo training, and some under development.

Case reviews

Multi-disciplinary team meetings where cases are reviewed can be a great adjunct in EVTM training. Interdepartmental collaboration involving radiologists, orthopaedic surgeons, emergency physicians, and anaesthetists, where

knowledge and experiences are shared, can enhance the educational experience. During these case reviews, two schools of thought are often discussed: *pro* endo and *pro* open surgery, as the nature of these meetings is usually retrospective the applied method of management as well as the outcome is known. Drawing a conclusion, a moderator might pay special attention to both methods of treatment focusing on advantages and disadvantages in every particular case. In case of lack of consensus on the appropriate treatment modality, the residents can be asked to prepare a presentation of a literature based review on the topic in question, in order to help resolve controversy.

Visual documentation

Visual documentation of cases (video recordings, radiology images) are a great adjunct to case reviews and provide an excellent learning tool for trauma surgeons. Video recording ideally with a dialogue commentary by an operator can help a trainee improve their decision making skills with regards to specific steps of the procedure sequence. Similarly, recordings where a trainee is involved can be reviewed and used for constructive assessments of their skills once the procedure has been completed.

Training programs

Whilst most clinicians appreciate the importance of minimally invasive procedures in trauma, and there are some available training



Figure 5: Photo from a video. Video documentation of REBOA in the ER. You can find more material on the www.jevtm.com



Figure 6



Figure 7



Figure 8



Figure 8



Figure 10



Figure 11



Figure 12



Figure 13



Figure 13

Figure 6-13: Training on different models for EVTM and REBOA.

aids in the form of training manuals and videos available pertaining to management of certain types of injuries. Despite available simulation modalities and courses a young trauma surgeon will be disadvantaged by limited skills development, unless they have an educational supervisor who oversees a structured EVTm training in their clinical practice. Well organised training programs and EVTm workshops are hard to come by. Only a few training programs in trauma surgery include a short block (up to 6 months) of interventional training in their curricula, and although currently considered optimal in terms of development of manual skills and “endovascular thinking”, with growing prevalence of EVTm over the standard open approach in trauma surgery, the trauma surgery training needs will increasingly necessitate a review in resident training curricula. Developing a network with local/ national radiological and surgical societies is crucial in gaining support and optimising the quality of EVTm training.

Word of advice:

- » We all highly recommend taking courses, workshops and other training forms in order to get at least basic training in EVTm issues before performing them on patients!