

# Creating an Educational Program in the Endovascular and Hybrid Intervention; Experiences from the Japanese Society of Diagnostic and Interventional Radiology in Emergency, Critical Care, and Trauma (DIRECT)

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Diagnostic and interventional radiology (IR) techniques have recently shown significant efficacy in trauma care when combined with surgical procedures. A multifaceted approach to traffic accidents has reduced the number of trauma patients in Japan, which has necessitated simulation education to provide practical experience and ensure proficiency. The objective of this paper is to report the educational development of endovascular and hybrid workshops in Japan. The Japanese Society of Diagnostic and Interventional Radiology in Emergency, Critical care, and Trauma (DIRECT) was established in 2011 to maximize the benefit of diagnostic and IR in emergency or trauma settings. DIRECT conducts trauma endovascular workshops for emergency medicine physicians, acute care surgeons, and IR physicians. From July 2011 to June 2016, DIRECT has conducted 14 simulator workshops, six endovascular workshops using a porcine model, and four hybrid trauma management workshops, of which two were conducted with porcine models. The simulation workshop was designed for novice learners and included resuscitative endovascular balloon occlusion of the aorta (REBOA) deployment using a pressurized silicone model, catheter and guidewire manipulation with a three-dimensional (3D) vessel silicone model and virtual fluoroscopic simulator, and metallic coil deployment. Porcine simulations for intermediate-level physicians were conducted and endovascular tools included different occlusion materials. In the hybrid strategy model, by using a porcine model of injury, the participants combined both surgical and endovascular procedures such as REBOA, selective balloon occlusion, and N-butyl cyanoacrylate embolization. DIRECT is a vital bridge between emergency/trauma and IR, and workshops are essential for improved trauma care.

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## Conflicts of interest:

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## INTRODUCTION

Trauma care was established primarily by surgeons; thus, surgical procedures are historically considered the preferred methods of treatment [1]. Additional resources have recently become available. Current advances in diagnostic and interventional radiology (IR) have shown significant efficacy in endovascular hemostasis in trauma cases. Time is a critical factor in severe trauma patients [2,3]. However, it is difficult for in-house IR physicians to be available around the clock, particularly at night and on the weekends. Unacceptable delays in the treatment of exsanguinating patients may arise because the IR physicians must travel to the hospital, evaluate diagnostic images, and confer with the emergency medicine (EM) physician and/or acute care surgeon (ACS). Early activation of the trauma radiology team results in more accurate diagnostic imaging and more rapid deployment of IR procedures [4]. In this context, the Japanese Society of Diagnostic and Interventional Radiology in Emergency, Critical care, and Trauma (DIRECT) was created in 2011 to promote time-conscious trauma care. The objective of this paper is to report the development of the endovascular and hybrid educational workshop in Japan. This paper reviews the historical background of surgical and endovascular procedure training, as well as the formation of DIRECT and its training activities.

### ***Dramatic Decrease in Trauma and the Necessity of Educational Workshops***

A multifaceted approach to traffic accidents in Japan has dramatically reduced not only fatalities but also the number of trauma patients since 1970 [5,6]. Laws against illegal drugs and driving while intoxicated have contributed to a reduction in motor vehicle accident fatalities from 16,765 in 1970 to 4,117 in 2015 [7–10]. In addition, restrictions on firearm ownership resulted in a negligible number of trauma incidents involving gunshots, while there were 29,989 fatalities in the United States in 2014. The successful decrease in trauma has had a high impact on trauma education in Japan. The dearth of trauma cases has necessitated the use of cadavers, simulators, and porcine models to simulate trauma incidents to provide practical experience for clinically uncommon procedures.

The Advanced Trauma Life Support guidelines (ATLS) [1] have been paramount to the standardization of initial assessment and resuscitation, which are focused

on appropriate surgical intervention. They paved the way for a number of surgical skill improvement workshops using human cadavers or porcine models, which predate endovascular procedure workshops. Advanced Surgical Skills for Exposure in Trauma (ASSET) [11] and the Trauma Exposure Course (TEC) [12] are cadaver-using courses, while the Advanced Trauma Operative Management (ATOM) course (since 1998, United States) [13], Definitive Surgical Trauma Care (DSTC) course (since 1997, Australia and South Africa) [14], and Surgical Strategy and Treatment for Trauma (SSTT) course (since 2009, Japan) [15] use porcine models.

Human cadavers and porcine models have been used in endovascular procedures. Recently, approaches using synthetic materials and virtual reality simulators have become more popular [16,17]. Two trauma-specific workshops, Endovascular Skills for Trauma and Resuscitative Surgery (ESTARS) and Basic Endovascular Skills for Trauma (BEST), were reported in the United States and have been offered since 2013 [18,19]. These courses cover the fundamental procedures of resuscitative endovascular balloon occlusion of the aorta (REBOA).

### ***Trauma Radiology and DIRECT: EM/ACS-IR Bridge and Synergies***

Acutely time-conscious intervention is the primary prerequisite to realizing the benefits of IR following a traumatic event. The concept of damage control, usually applied to surgery, may also result in successful outcomes [20] and requires the use of highly time-conscious strategies. Previous literature [4] has also included the concept of the Prompt and Rapid Endovascular Strategies in Trauma Occasion (PRESTO) concept and the damage control IR (DCIR) algorithm, whereby a rapidly-deployed trauma radiology team resulted in improved practice decisions in endovascular and hybrid interventions.

In July 2011, DIRECT was formed to maximize the benefits of radiology in emergency and/or trauma settings, and to serve as a bridge between surgical and IR specialists. From July 2011 to June 2016, DIRECT has conducted numerous workshops, including the following: 1) diagnostic imaging courses (acute disease, 12 times; trauma, 10 times; up to 20 participants); 2) 14 endovascular workshops using simulators (18–20 learners, 7–12 instructors and several instructor candidates); 3) six endovascular workshops using porcine models (8 or 16 learners, 7–10 instructors and several instructor candidates, 8 learners/porcine); and 4) four hybrid

trauma management workshops using a porcine model (6 learners/porcine, 9–12 instructors). In total, over 250 students have been trained in the simulator workshops, 70 in the porcine model workshops, and 24 in the hybrid workshops. The participation fee was 10,000 JPY for the diagnostic imaging course and the simulator IR workshop and 50,000–60,000 JPY for the porcine IR workshop.

### **Training Endovascular Physicians for Trauma in DIRECT**

There are two primary approaches to implementing endovascular techniques in trauma: IR priority and EM/ACS priority. Both groups of physicians contribute different skills and knowledge. IR physicians may exhibit a relative lack of knowledge in traumatology; whereas, EM physicians/ACs often lack the technical skills routinely possessed by IR physicians. Additionally, ineluctable inter-departmental conflicts may cause concern regarding the appropriate qualifications and board certification. However, the understanding that time is of the essence is of crucial importance: lost time increases blood loss, and blood loss causes loss of life.

By transcending potential inter-departmental conflicts, we are certain that a combined IR–EM management strategy will be able to improve trauma care. Accordingly, DIRECT does not restrict admission to its workshops due to a participant's primary specialty; we have shared the concepts of trauma physiology and trauma IR with IR physicians, and likewise, we have taught endovascular techniques and pitfalls to EM/ACS personnel.

#### *Trauma radiology lectures and time-conscious management*

Workshop lectures consist of the following topics: 1) the basic theory and pitfalls of REBOA; 2) embolic materials such as gelatin sponges, metallic coils and N-butyl cyanoacrylate (NBCA); 3) virtual fluoroscopic imaging for IR procedure navigation with a 3D workstation using arterial phase CT data from trauma panscans (known as pre-procedural planning, PPP); and 4) trauma coagulopathy and trauma IR concepts, including DCIR.

#### *Endovascular training using simulators*

The simulation workshop is designed primarily for novice learners of IR and comprises the following: 1) REBOA deployment using a pressurized silicone model (Endo Vascular Evaluator (EVE), BR Biomedicals, Pvt. Ltd., New Delhi, India); 2) catheter and guidewire manipulation using a 3D vessel silicone model and a Vascular Intervention System Trainer (VIST)-C, (Mentice, Evanston, IL, USA); and 3) metallic coil deployment training (fibered detachable coil or water-pressured bare detachable coil) (Table 1).

REBOA, as opposed to resuscitative thoracotomy, has gained increasing acceptance as a less-invasive aortic occlusion method [21]. In Japan, REBOA has been used since the late 1990s in clinical settings [22]; However, standardized courses did not exist prior to DIRECT. In current practice, 7 Fr and 10 Fr sheath-compatible devices are commercially available in Japan [23] and are also used in the workshop. Training focuses on obtaining arterial access, manipulating the guidewire and catheter, and using imaging to confirm the guidewire within the aorta (ultrasound, X-ray) to obviate potential complications. Self-evaluation after the workshop indicated a significantly improved understanding of the lecture material and all endovascular procedures (Table 2).

#### *Endovascular skill simulation using a porcine model*

IR simulations, using a porcine model have been conducted by intermediate-level IR physicians (Table 1). NBCA is infrequently used in elective cases; therefore, porcine simulation is quite useful. All faculty and students attended a mandatory ethics and animal welfare lecture before undertaking any clinical procedures.

After placing the animals under general anesthesia, the bilateral femoral arteries were selected as the access routes. Participants subsequently prepared embolic materials. They next practiced catheters and guidewires manipulation with faculty assistance. The intercostal, internal iliac arteries, and some branches of the renal arteries were selected as the target vessels. PPP acquired from the pre-scanned CT data of each porcine model provided the anatomical information to accurately navigate to the target vessel (Figure 1). Vascular injury models were made by piercing the vessel wall against the stiff edge of the guidewire and/or balloon catheter. Workshop students alternately acted as the operator or the attendant, thereby gaining valuable insights into the complexities and nuances of the procedure (Figure 2). Self-evaluation after the workshop revealed significant improvement in understanding the selection of embolic materials, catheter manipulation, and gelatin sponge embolization (Table 2).

#### *Hybrid strategy model in porcine injury*

Recently, hybrid approaches (combined surgical and endovascular procedures) in trauma treatment have gained greater acceptance as advanced, feasible hemostatic interventions [24]. Even though specialized equipment is necessary to fully utilize hybrid treatment, this approach will change trauma strategies.

In the hybrid approach workshops, vascular accesses were established and a laparotomy was performed on a porcine model. The hybrid workshop focused on damage control endovascular procedures such as NBCA injection, REBOA, and selective balloon occlusion, which were combined with surgical approaches. Finally, the

**Table 1** Program in the DIRECT workshop.

Time	Lecture and Simulation
<b>Simulator Workshop</b>	
11:55–12:05	Introduction
12:05–12:50	Session 1
13:00–13:45	Session 2
13:55–14:40	Session 3
15:00–15:45	Session 4
15:55–16:40	Session 5
16:40–17:00	Debrief and questions
Booth	Practice materials
1	REBOA; lecture and simulation
2	Catheter manipulation using a silicone model and a virtual simulator
3	Metallic coil embolization using a flow conduit
4	Pre-procedural planning; lecture and practice
5	Trauma coagulopathy and interventional radiology (lecture)
<b>Porcine Endovascular Workshop</b>	
8:30–9:30	Introduction, pre-test, ethical lecture
9:30–11:30	Metallic coil and NBCA (lecture) and NBCA preparation
11:30–13:30	Metallic coil and NBCA embolization (Lunch break, 30 min)
13:30–14:30	REBOA procedure
14:30–16:30	Embolization for vascular injury model
16:30–17:00	Debrief and questions
17:00–17:30	Post-test
<b>Porcine Hybrid Workshop</b>	
9:30–10:30	Introduction, pre-test, ethical lecture
10:30–12:00	NBCA preparation and embolization 1
12:00–13:20	REBOA and selective balloon occlusion catheter (Lunch break, 25 min)
13:20–14:50	NBCA preparation and embolization 2
14:50–15:30	Injury Case Scenario 1
15:30–16:10	Injury Case Scenario 2
16:10–16:30	Debrief and questions

*REBOA, resuscitative endovascular occlusion of the aorta; NBCA, N-butyl cyanoacrylate; IR, interventional radiology.*

liver, kidney, spleen, and iliac arteries were injured so that the students could strategize and implement interventions. Participants worked under the direct supervision of endovascular and surgical faculty members, thereby benefiting from a multidisciplinary approach in this crucial field (Figure 3).

**Global Endovascular Workshops and Future Directions in Trauma Management**

Most participants in BEST or ESTARS courses are trauma surgeons or ACSs. However, and unfortunately, there are few experienced trauma surgeons in Japan because the number of trauma cases is decreasing and most general surgeons are unwilling to actively pursue ACS. Thus, EM physicians usually conduct the initial assessment and resuscitation. Consequently, some EM physicians have begun to choose IR fellowships as their subspecialty to perform trauma IR quickly and DIRECT

acts as a bridge to that training. In Sweden, the Endovascular hybrid Trauma and bleeding Management (EVTM) workshop began in 2015 [25], encompassing both surgical and endovascular approaches. The EVTm faculty and DIRECT collaboratively designed the workshop from the outset and such activity is spreading internationally.

In a limited number of non-standard, leading-edge “hybrid ER” facilities in Japan, CT scans, angiography, and surgery can be performed without patient transfer [26]. The use of CT as an aid to diagnosis, even in hemodynamically unstable patients in the trauma bay, may lead to a new era in trauma care.

DIRECT has taken a critical first step toward rapid radiological intervention in trauma cases. We strongly believe that sharing the knowledge and experience of trauma radiology among multidisciplinary professionals, multi-institutional staff, and internationally, will result in dramatic improvements in hybrid trauma management



**Table 2** Self-evaluation before and after the workshop.

	Before	After	P
<b>Simulator Workshop (n = 18)</b>			
Trauma IR concept	3.61 ± 2.17	6.61 ± 1.65	<0.001
Trauma coagulopathy	5.78 ± 2.69	8.78 ± 1.31	<0.001
Time consciousness in trauma care	5.83 ± 2.73	8.72 ± 1.23	<0.001
REBOA knowledge	3.44 ± 2.55	6.61 ± 1.88	<0.001
REBOA procedures	2.72 ± 2.30	6.17 ± 2.26	<0.001
Angiography catheter manipulation	1.78 ± 1.48	4.44 ± 1.72	<0.001
Microcatheter manipulation	1.39 ± 0.78	3.61 ± 1.69	<0.001
Gelatin sponge embolization	1.44 ± 1.10	2.94 ± 1.35	<0.001
Coil embolization	1.50 ± 1.10	3.39 ± 1.38	<0.001
NBCA-embolization	1.22 ± 0.55	2.28 ± 1.32	0.003
<b>Porcine Workshop (n = 12)</b>			
Selection of embolic materials	3.25 ± 2.30	4.67 ± 2.15	<0.001
Catheter manipulation	4.08 ± 2.11	6.25 ± 1.22	<0.001
Gelatin sponge embolization	3.83 ± 2.25	5.42 ± 1.83	<0.001
Coil embolization	3.17 ± 2.25	3.42 ± 2.43	0.191

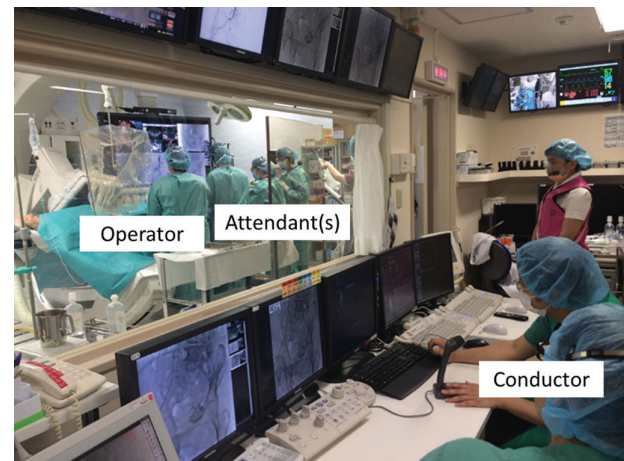
IR, interventional radiology; REBOA, resuscitative endovascular occlusion of the aorta; NBCA, N-butyl cyanoacrylate.

**Figure 1** Pre-procedural planning.

After CT scanning, pre-procedural planning (PPP) processed the data and traced out a virtual angiographic catheter route toward each target site. This virtual angiographic image gives the operator detailed anatomical information such as the root of the vessel or position of extravasation. The process can be attained within 5 minutes or less by a “conductor” doctor.

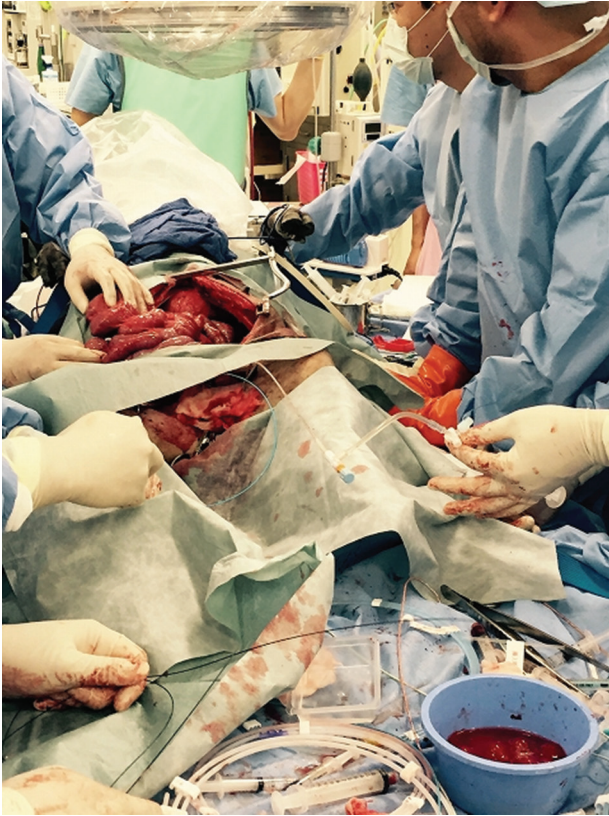
in the very near future. To objectively demonstrate the effect of the training package and the benefit to the patient, the EVTVM training material should be standardized and an accumulation of international experience should be established.

This paper has several limitations. First, our data could not provide exact data on how the participants changed before and after the workshop experience from evaluation of the questions because the program has

**Figure 2** Interventional radiology team with the conductor-operator-attendant system.

The conductor orchestrates and guides the operator during the procedure. This eliminates the operator's decision-making time while performing catheterization and optimizes procedural efficiency while minimizing human error in a time of haste. The attendant anticipates the subsequent maneuvers of the operator and prepares appropriate devices and embolization materials in a timely fashion.

improved gradually and was not able to accumulate the statistical results from the post-course questionnaire. Second, as trauma care systems vary widely among each institute or country, our experience may not be applicable in other countries. Despite these limitations, our experience in the development of an endovascular trauma workshop should be shared.



**Figure 3** Hybrid approach simulation in a porcine model.

Resuscitative endovascular balloon occlusion of the aorta (REBOA) was first placed in a simulated visceral injury and stabilized hemodynamics temporarily. The fluoroscopy above the operating theater made the procedure safe and rapid. Then surgical faculty assisted peri-hepatic packing. Finally, a trauma interventional radiology team consisting of participants performed angiography and embolized the remaining arterial extravasation.

## CONCLUSION

The necessity of simulation education in trauma is widely recognized. This paper reported how to create an educational program in the endovascular and hybrid workshops in Japan. DIRECT was established to bridge the gap between EM/ACS and IR. We strongly believe multidisciplinary collaborative approaches offer improved trauma care, and that sharing the educational experience internationally will accelerate the improvement of endovascular and hybrid approaches in trauma settings.

## ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This is a review article and does not contain any original human or animal data, therefore an ethics committee approval and consent to participate statement do not apply to this manuscript. The educational use of porcine received ethical approval from each institution and all

participants took mandatory ethics and animal welfare lectures and received approval.

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## REFERENCES

- [1] ATLS Subcommittee, American College of Surgeons' Committee on Trauma, International ATLS working group. Advanced trauma life support (ATLS(R)): the ninth edition. *J Trauma Acute Care Surg.* 2013;74:1363–6.
- [2] Lerner EB, Moscatti RM. The golden hour: scientific fact or medical “urban legend”? *Acad Emerg Med.* 2001;8: 758–60.

- [3] Howell GM, Peitzman AB, Nirula R, et al. Delay to therapeutic interventional radiology postinjury: time is of the essence. *J Trauma*. 2010;68:1296–300.
- [4] Matsumoto J, Lohman BD, Morimoto K, Ichinose Y, Hattori T, Taira Y. Damage control interventional radiology (DCIR) in prompt and rapid endovascular strategies in trauma occasions (PRESTO): A new paradigm. *Diagn Interv Imaging*. 2015;96:687–91.
- [5] Kaimila B, Yamashina H, Arai A, Tamashiro H. Road traffic crashes and fatalities in Japan 2000–2010 with special reference to the elderly road user. *Traffic Inj Prev*. 2013;14:777–81.
- [6] Nakahara S, Katanoda K, Ichikawa M. Onset of a declining trend in fatal motor vehicle crashes involving drunk-driving in Japan. *J Epidemiol*. 2013;23:195–204.
- [7] Christophersen AS, Morland J, Stewart K, Gjerde H. International trends in alcohol and drug use among vehicle drivers. *Forensic Sci Rev*. 2016;28:37–66.
- [8] Reducing gun violence: facts are stubborn things. *Lancet*. 2013;381:2055.
- [9] Liu C, Huang Y, Pressley JC. Restraint use and risky driving behaviors across drug types and drug and alcohol combinations for drivers involved in a fatal motor vehicle collision on U.S. roadways. *Inj Epidemiol*. 2016;3:9.
- [10] Cabinet Office GOJ. White Paper on Traffic Safety in Japan. <http://www8caogojp/koutu/taisaku/kou-wphtml>. 2015.
- [11] Bowyer MW, Kuhls DA, Haskin D, et al. Advanced Surgical Skills for Exposure in Trauma (ASSET): the first 25 courses. *J Surg Res*. 2013;183:553–8.
- [12] Gunst M, O’Keeffe T, Hollett L, et al. Trauma operative skills in the era of nonoperative management: the trauma exposure course (TEC). *J Trauma*. 2009;67:1091–6.
- [13] Jacobs LM, Burns KJ, Kaban JM, et al. Development and evaluation of the advanced trauma operative management course. *J Trauma*. 2003;55:471–9; discussion 9.
- [14] Boffard KD. *Manual of Definitive Surgical Trauma Care* 3E. CRC Press; 2011.
- [15] Watanabe H, Idoguchi K, Mizushima Y, et al. Training system of trauma surgery for young acute care surgeons: Surgical Strategy and Treatment for Trauma (SSTT) course. *Journal of Abdominal Emergency Medicine*. 2012;32:919–26.
- [16] Neequaye SK, Aggarwal R, Van Herzeele I, Darzi A, Cheshire NJ. Endovascular skills training and assessment. *J Vasc Surg*. 2007;46:1055–64.
- [17] Nesbitt CI, Birdi N, Mafeld S, Stansby G. The role of simulation in the development of endovascular surgical skills. *Perspect Med Educ*. 2016;5:8–14.
- [18] Brenner M, Hoehn M, Pasley J, Dubose J, Stein D, Scalea T. Basic endovascular skills for trauma course: bridging the gap between endovascular techniques and the acute care surgeon. *J Trauma Acute Care Surg*. 2014;77:286–91.
- [19] Villamaria CY, Eliason JL, Napolitano LM, Stansfield RB, Spencer JR, Rasmussen TE. Endovascular Skills for Trauma and Resuscitative Surgery (ESTARS) course: curriculum development, content validation, and program assessment. *J Trauma Acute Care Surg*. 2014;76:929–35; discussion 35–6.
- [20] Roberts DJ, Bobrovitz N, Zygun DA, et al. Indications for use of damage control surgery in civilian trauma patients: A content analysis and expert appropriateness rating study. *Ann Surg*. 2016;263:1018–27.
- [21] Stannard A, Eliason JL, Rasmussen TE. Resuscitative endovascular balloon occlusion of the aorta (REBOA) as an adjunct for hemorrhagic shock. *J Trauma*. 2011;71:1869–72.
- [22] Inoue J, Shiraishi A, Yoshiyuki A, Haruta K, Matsui H, Otomo Y. Resuscitative endovascular balloon occlusion of the aorta might be dangerous in patients with severe torso trauma: A propensity score analysis. *J Trauma Acute Care Surg*. 2016;80:559–67.
- [23] Teeter WA, Matsumoto J, Idoguchi K, et al. Smaller introducer sheaths for REBOA may be associated with fewer complications. *J Trauma Acute Care Surg*. 2016;81:1039–45.
- [24] Holcomb JB, Fox EE, Scalea TM, et al. Current opinion on catheter-based hemorrhage control in trauma patients. *J Trauma Acute Care Surg*. 2014;76:888–93.
- [25] ABO Trauma registry. <https://www.abotraumaregistry.com>.
- [26] Wada D, Nakamori Y, Yamakawa K, Fujimi S. First clinical experience with IVR-CT system in the emergency room: positive impact on trauma workflow. *Scand J Trauma Resusc Emerg Med*. 2012;20:52.