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ORIGINAL ARTICLE - NEUROSURGERY TRAINING

EANS Basic Brain Course (ABC): combining simulation to cadaver lab for a new concept of neurosurgical training

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Abstract

Background Neurosurgical training has traditionally been based on an apprenticeship model that requires considerable time and exposure to surgeries. Unfortunately, nowadays these requirements are hampered by several limitations (e.g., decreased caseload, worktime restrictions). Furthermore, teaching methods vary among residency programs due to cultural differences, monetary restrictions, and infrastructure conditions, with the possible consequence of jeopardizing residents' training.

Methods The EANS Basic Brain Course originated from a collaboration between the Besta NeuroSim Center in Milano and the Swiss Foundation for Innovation and Training in Surgery in Geneva. It was held for 5 neurosurgical residents (PGY1-3) who participated to this first pilot experience in January 2019. The main goal was to cover the very basic aspects of cranial surgery, including both technical and non-technical skills. The course was developed in modules, starting from the diagnostic paths and communication with patients (played by professional actors), then moving to practical simulation sessions, rapid theoretical lessons, and discussions based on real cases and critical ethical aspects. At the end, the candidates had cadaver lab sessions in which they practiced basic emergency procedures and craniotomies. The interaction between the participants and the faculties was created and maintained using role plays that smoothly improved the cooperation during debriefs and discussions, thus making the sessions exceedingly involving.

Results At the end of the course, every trainee was able to complete the course curriculum and all the participants expressed their appreciation for this innovative format, with a particular emphasis on the time spent learning non-technical skills, confirming that they feel this to be a fundamental aspect of a comprehensive training in neurosurgery.

Conclusions It is possible that this combined concept of training on technical and non-technical skills, using emerging technologies along with pedagogic techniques and cadaver dissection, may become the state-of-the-art for European Neurosurgical training programs in the next future.

Keywords Neurosurgical training · Non-technical skills · Simulation · Brain surgery · Cadaver dissection · Hands-on course

Alessandro Moiraghi and Alessandro Perin contributed equally to this work.

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Introduction

The training of young neurosurgeons is a current issue and one of the most important challenges for experienced neurosurgeons. The current system of neurosurgical training is based on an apprenticeship model which, compared with the past, is hampered by an increasing number of trainees and young specialists due to European work time restrictions [1, 9, 25]. Furthermore, teaching methods vary due to cultural differences, monetary restrictions, and infrastructure conditions [20, 27]. As a result, surgical standards might differ among European countries, with the possible consequence of jeopardizing training and patients' safety [7, 28].

Anatomical dissection courses, combined with annotated live surgeries performed by senior surgeons, have proved to be best accepted by students. The increasing difficulty in cadaver training, primarily due to decreasing access and law's restrictions, is another challenge that affects young neurosurgeons practical training and professional growth. The use of simulation in neurosurgical training may allow young neurosurgeons to enhance their technical skills in a safe environment, without exposing patients to unnecessary risks which might be attributed to inexperience [8, 26]. A few recent publications have demonstrated the efficacy of simulation [17, 21–23] and these tools can surely become an important complement to cadaveric dissection training, but not yet a real alternative to date [10, 16].

The challenges to this apprenticeship model are becoming more and more evident, especially concerning training of the so-called non-technical skills [11]. Furthermore, the assessment of residents' psychomotor skills by consultant surgeons is both subjective and incomplete [10] and often does not address learning how to act outside the operative room. Valid objective criteria for technical and non-technical skills assessment are often not included in neurosurgical curriculum.

Our aim is to propose a new concept for neurosurgical training, developing a course able to provide, at the same time, theoretical and practical skills and to introduce the participants to non-technical skills training, in order to significantly impact on their clinical daily practice, not only on their ability to perform craniotomies. As a pilot experience, we principally focused our attention on course design, feasibility, and participants' feedback in order to understand if this concept could be appreciated, reproduced, and upgraded in future editions.

Methods and materials

The EANS Basic Brain Course was hosted by the Besta NeuroSim Center (BNSC) in Milano, Italy, the 21th and 22th of January 2019 and by the Swiss Foundation for Innovation and Training in Surgery (SFITS) in Geneva, Switzerland, from 23rd to 25th of January 2019; it was run for 5 neurosurgical residents (PGY1-3) who participated in the first pilot experience.

Course design

Born from a cooperation between the two training centers and respective neurosurgical teams, the course was included in the EANS course schedule for 2019. The course design was conducted by the following authors (AM, AP, KS, FD, and TRM) and followed by two experts in course management (NS and JG). The whole course program was designed based on the "experiential learning" methodology. The main goal was to cover all the basic aspects (the ABC) of cranial surgery. Due to the necessity to merge our experiences and technical set-up (with simulators and cadaver lab), we decided to perform the inaugural course in two different venues, moving by train faculties and participants from Milano to Geneva. This posed an apparent logistic challenge, given the necessity to travel and the risk of losing time in a very tight program.

The course was developed in modules starting from the diagnostic path and communication with "patients" (played by professional actors), practical simulation sessions, short theoretical lessons, discussions based on real cases and on case-related ethical aspects and, finally, cadaver sessions on basic emergency procedures and craniotomies.

Non-technical skills

The first part of the course was mainly dedicated to simulation and interaction with "patients" for a holistic development of technical and non-technical skills. Both the participants and the faculty were immersed in the 3D simulation environment of the BNSC, discussed a series of clinical situations, and performed surgical tasks on dedicated simulators.

For non-technical skills, the pedagogy we used is activity/scenario/problem-based learning, more generally called "learning by doing". After being provided with the very few necessary theoretical inputs, the small group of young neurosurgeons was immersed in a particular situation with a whole set of concrete inputs about a simulated patient: CT, MRI results, etc. They could study and discuss those results with the faculty. Then they decided what they should ask for of additional tests in order to narrow the diagnostic window. The results of those tests were provided to them. One learner was responsible for interviewing the patient (role-played by an actor, who had been fully briefed by the faculty). The other learners were silently attending this interview to be able to provide feedback.

Systematically, at the end of the interview, a debrief was led by a facilitator regarding what the learner thought about what s/he had done, what were her/his feelings, and what s/he would have done differently in the future. Then the other young surgeons also provided their inputs to their colleague and finally the faculty expressed their views and gave advice on how the interview could be improved.

All diagnostic images were visualized on 3D screens, thanks to Vesalius platform, a virtual reality system that allows recreating a tridimensional model of the whole patient's anatomy from CT, MRI, or PET images. Invasive investigation and treatment were discussed. Pre-operative planning was made by the trainees using the Surgical Theater, a simulator that allows reconstructing a patient-specific 3D model that helps to pre-operatively evaluate the case, analyze the anatomy, and determine the best procedure to perform. If needed, an informed consent was obtained from the simulated patients by the participants, and a practical session started on simulators.

In addition, as this course was intended for educating young residents, a fundamental aspect to be considered was psychological profiles; therefore, the participants were given specific psychological and psychomotor test, such as:

- The Sixteen Personality Factor Questionnaire (16PF) [4, 5], Fifth Edition, a 185-item norm-referenced and self-administered test that evaluates the psychological profiles of the resident
- The Raven's Progressive Matrices (RPM) [6], a nonverbal test used to measure abstract reasoning and to estimate fluid intelligence
- The Spatial Ability Test (SPA) [14] that evaluates the capacity to understand and remember the spatial relations among objects
- The Purdue Pegboard Test (PBT), a psychomotor skills test, which allows giving a measure of innate ability in terms of dexterity and bimanual coordination

Simulation

With regard to the simulation part, participants were able to train their technical skills on simulated tasks according to the progression of the patient story. This aim was possible thanks to the use of NeuroVR (CAE Healthcare Inc.) and ImmersiveTouch (ImmersiveTouch®), two simulators that allow replicating surgical tasks and interventions in a 3D virtual reality with haptic feedback and enable the residents to improve their performance on different procedures. In particular, NeuroVR platform (Fig. 1) allows performing a simulated tumor debulking such as a meningioma and a glioblastoma, an endoscopic third ventriculostomy (ETV) procedure and a microsurgical hemostasis task; meanwhile, with ImmersiveTouch (Fig. 2), the residents performed simulated external ventricular drainage (EVD) positioning, intraparenchymal hemorrhage drainage, and lumbar puncture procedures. During all these tasks, the Besta staff supervised, helped, and instructed the participants with a one-to-one interaction.

To complete the scenario, there were also two stations equipped with surgical microscopes and plastic models to simulate dural suture and gel models to reproduce tumor resection with an ultrasonic aspirator [2, 3, 18, 21, 23, 24, 29].

The trainees had also the possibility to train with a simulator able to reproduce intraoperative ultrasound for brain tumor resection, the USim (Fig. 3), with the objective of improving their confidence with this technique which requires important spatial orientation abilities [22]. After every practical session, each story continued with patients' post-operative examination and follow-up, paying attention also to the psychological impact that this path may have had on the patient. The participants were put in contact with possible complications and had to explain to the "patients" how they planned to deal with them. After every simulation session, the stories continued in the same way with treatment planning and practical session with simulators. A step-by-step feedback from the participants, the faculty, and the "patients" was obtained with a special emphasis for ethical consideration.

Cadaver lab

The second part of the course took place in the SFITS cadaver lab, where the trainees were practicing patient-positioning, the use of head-holders, neurosurgical OR set-up, and handling of basic cranial instruments, followed by a classical training session using high-speed drills. Then they performed basic emergency procedures such as EVDs, burr holes for chronic subdural hematomas, and decompressive craniectomies (supratentorial and infratentorial), as well as basic supratentorial convexity approaches, with and without neuronavigation, finishing the program with the pterional craniotomy. During this second part of the course, we took advantage of the skills obtained during the first part of the course and transposed it to practical skills. Theoretical sessions made of face-to-face lectures were reduced to the minimum and just gave the participants the key points of every procedure.

Evaluation

After the course, a complete debrief of every part of the course was made by a discussion between all trainees and faculties. This was a special opportunity to have a 360° feedback. Every participant provided a personal evaluation at the end of the course and also filled out an anonymous feedback survey in order to have an objective evaluation according to the European EACCME accreditation system [19]. The accomplishment of the course curriculum was evaluated by the faculties considering trainee's work during the whole course.

Fig. 1 The NeuroVR is a simulation platform that reproduces microsurgical tasks. Thanks to is binocular vision and haptic feedback it allows to perform a simulated tumor debulking such as a meningioma and a glioblastoma and microsurgical hemostasis. Another task allows simulating an endoscopic third ventriculostomy procedure

Results

At the end of the course, every trainee was able to complete the course curriculum. The results of the anonymous evaluation survey were very positive concerning the usefulness of the topics learnt during the course on their daily clinical practice (Table 1). The program, organization facilities, and training materials were all positively reviewed by all participants. We must mention that, due to a delay in the transfer by train, we had to modify day 3 and day 4 schedules in order to maintain the course curriculum as it was planned and complete it.

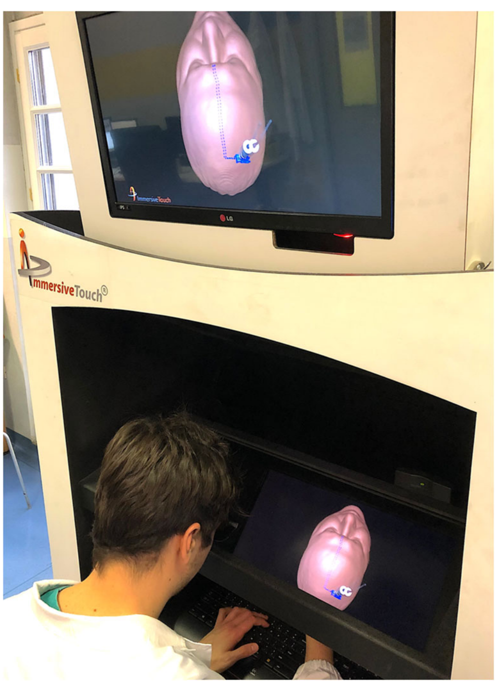

Fig. 2 The ImmersiveTouch allows training on virtual reality 3D reconstructed patients, with haptic feedback, simulating procedures like EVD positioning, intraparenchymal hemorrhage drainage, and lumbar punctures

Concerning the course contents and way of teaching it, the survey showed that all participants were convinced of the usefulness of these methods and confirmed the level of participation that we observed during all the phases of the course (Table 2). Only one participant out of 5 considered the simulation sessions “fairly useful” as well as for the dexterity tests, while the other four trainees considered the use of simulators “extremely useful” and 3 of them expressed the same about dexterity tests, while one considered it “useful.” All the participants considered “extremely useful” both the use of clinical stories to involve them in the different modules during the first part of the course and the basic surgical skills session at the beginning of the second part (Table 2).

Another important aspect emerging from the survey is the strong relationship and cooperation with the faculty members that were more accessible to them, as they were all together involved in the same situations (stories, simulations, discussions…) and not only in frontal lectures. Lastly, all the participants agreed that the course was overall free of commercial biases and that the information provided during the course is consistent with the current standard of care.

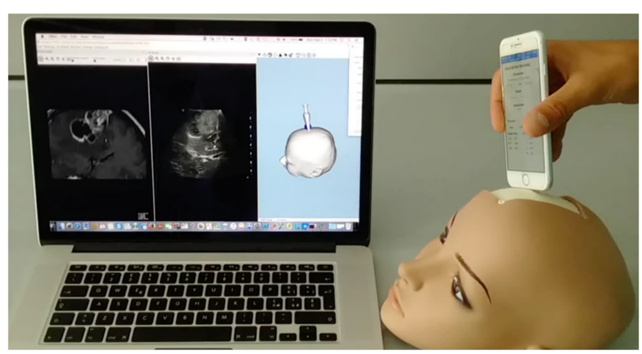

Fig. 3 The USim allows connecting a smartphone to a computer using the USim application. Using the smartphone as a US probe, it is possible to simulate many intraoperative ultrasound examinations. The goal is to improve understanding of US semeiology and to familiarize with US spatial orientation studying a large library of co-registered US and MRI images of intracranial tumors

Table 1 Overall evaluation of the course by the trainees

	Usefulness	Learning outcomes	Program	Organization	Facilities	Pedagogical material
Excellent	5	5	3	4	4	4
Good			2	1	1	1
Fairly good						
Poor						
Very Poor						

With regard to the psychological and psychomotor test, the results of RPM, SPA, and PBT are shown in Table 3. In particular, regarding PBT, a score was assigned ranging from 1 (poor) to 5 (excellent) based on their performance. The psychological profiles of the residents, which emerged from the 16PF, are summarized in Fig. 4.

Discussion

Despite technological and social evolution during last decades, surgical training is still mainly based on an apprenticeship model, and the way of teaching has not changed. Most of the basic skills a surgeon needs are, in fact, self-learned by watching and repeating what senior surgeons do. This way of learning is potentially dangerous for patients and is very time-consuming. The application of new technologies and new teaching methods should be mandatory not only in neurosurgery but also in all surgical fields.

A new concept for neurosurgical training

At SFITS, around 300 surgical courses are organized per year, 290 of which are pure classical hands-on courses divided into a theoretical part of frontal lectures and a practical subsequent part on anatomical models, cadavers, or animal parts, with very few possibilities of interaction between the participants and the faculty. Our goal is to create a course able to change the paradigm of neurosurgical training. The experience and knowledge gained during the last years at the BNSC on simulation in neurosurgical training was fundamental to create a balanced program, including at the same time non-technical skills, simulation, and training on cadavers.

Because of the course design, the trainees were continuously obliged to have step-by-step discussions (between themselves, with the faculty, and with actor patients), checking and rehearsing every decision made and getting real-time feedback in every situation. Involving them in role plays, currently used in courses dedicated to other professionals (engineers, high tech professionals…), we were able to stimulate an active participation and strengthen technical and non-technical skills during discussions and debriefs. Special focus was given to ethical considerations related to surgical indications, informed consent and how to obtain it properly, and how to face bad news announces and personal considerations on specific surgical tasks. At the end of the course, all the participants expressed appreciation for this format, with a particular emphasis on the time dedicated to non-technical skills development, confirming that they consider it fundamental for their training [15]. Furthermore, the experience and self-confidence acquired during the simulation sessions were considered very beneficial prior to the cadaver dissections.

Advantages of the experiential pedagogical strategy

This type of pedagogy brings all the main ingredients of a good learning process:

- Safe learning environment: simulation, instead of real situation, allows the learner to make mistakes with no consequence, providing opportunities to “try” at no cost.
- “Almost real” situation: the simulation was as close as possible from real cases. All the medical results were

Table 2 Summary of trainees’ specific evaluation for each session

	Clinical stories	Simulation sessions	Basic skills	Cadaver lab	Discussion sessions	Dexterity tests
Extremely useful	5	4	5	4	4	3
Useful				1	1	1
Fairly useful		1				1
Not useful						
Undecided						

Table 3 Raven's Progressive Matrices, the Spatial Ability Test, and the Purdue Pegboard Test results obtained by the 5 participants. The Pegboard Test results are classified as (1) poor, (2) low average, (3) average, (4) high average, and (5) excellent

Code of experimental subject	Advance Progressive Matrices (Percentiles)	Spatial Ability Test (Correct answer)	Pegboard Test				
			Left hand level	Right hand level	Both hands level	Left + right + both hands level	Assembly level
1	70	36/45	1	2	2	1	1
2	65	24/45	3	2	3	1	1
3	80	N.A.	1	1	1	1	2
4	90	43/45	3	2	3	3	3
5	80	32/45	3	2	3	3	3

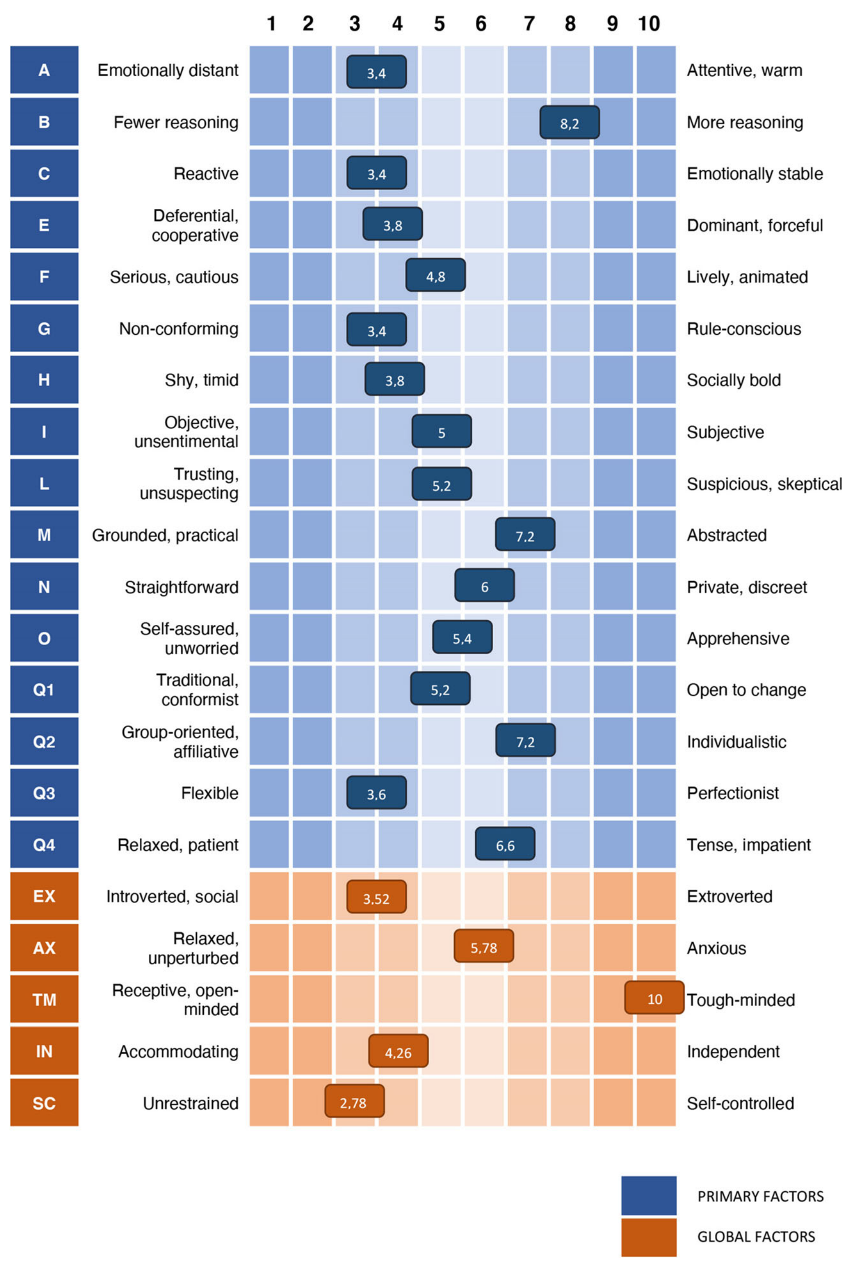

Fig. 4 The psychological profiles of the residents which emerged from the 16PF

taken from real anonymized patients, and professional actors were hired to play the patients roles. Attempting to solve a real problem increases the learners' interest and therefore their engagement and willingness to learn.
- Immediate feedback: the learner systematically gets feedback almost in real time (from colleagues and faculty) and can integrate immediately what was good and what s/he has to improve in her/his way of doing. Getting feedback on their activity increases the possibility for the learners to become aware of their mistakes and allows them to capitalize on their strengths. Having a small group of learners was also a way of individualizing the training.
- Learning in a group: feeling being part of a group increases the level of engagement of the learners and hence their motivation and capacity to learn. This was enhanced by few group activities (icebreakers, inclusion, and communication exercises), followed by a debrief about what lessons could be learned and applied in their day to day job from the exercises.
- Immediately applicable: the learning can be immediately applied in the real professional situations.

Keep it simple

The most appreciated parts of the course were the clinical stories and the basic surgical skills. We also believe that in a course for beginners (resident PGY1-3), it is very important to teach some surgical autonomy. Participants' feedback was an important confirmation to us that technical skills alone are not enough to make today's trainees able to face daily clinical practice with confidence. They want to learn how to handle surgical instruments as well as how to talk with a patient to correctly obtain an informed consent, or to explain him that he had a complication and that he needs to be re-operated. This change of mindset is also demonstrated by the emerging interest in the literature on non-technical skills over the last few years [12, 13].

Limitations

The main pitfalls of this pedagogic strategy are the necessity to keep all the trainees focused and to have them participate by overcoming their fear to actively participate to every session. At the beginning, it is important to encourage them and to make them comfortable to discuss and give continuous feedback. Shyness and the fear of being wrong are the worst enemies during these kinds of activities. For that reason, we decided to move all the trainees as well as the faculty from the BNSC in Milano to the SFITS in Geneva, building day-by-day a relationship between them. On the other hand, the transfer by train represented a problem itself obliging us to make some program changes on day 3 and day 4 due to a train delay.

Given the fact that it was a pilot experience with only 5 participants, no objective assessment of the educational gains was made. The evaluation was mostly based on participants' subjective feedback and faculties' evaluation that considered the curriculum accomplished for every trainee.

The need of expensive technologies and facilities and the high trainee-to-faculty ratio make this model non-reproducible for low–middle-income countries for now.

Future perspectives

The main objective for the next edition of this course will be to make it feasible with 12 participants while maintaining the same pedagogic methods. We strongly believe that this combined concept of training on technical and non-technical skills, using emerging technologies, novel pedagogic concepts, and cadaver dissection, can be implemented in future editions and with an increasing number of young residents participating. The course takes place in a structured revision of the EANS hands-on courses which took place in the last years. Considering only cranial courses, we believe that the ABC course could be considered a valid alternative to the Cranial Step I course, which covers almost the same surgical curriculum in a more classic way. The other cranial courses such as the EASN Cranial step II and the historical EANS hands-on course in Lyon are more advanced courses that include posterior fossa and endoscopic approaches for the skull base, which fit better for older residents and junior consultants.

With regard to the simulation part, the course, as a pilot study, made it possible to verify the feasibility of the project and better define the interweaving between technical and non-technical skills during a simulated story. As future perspectives, an analysis of the data will be conducted emerging from the simulator and a possible correlation between simulation and the skills shown to the cadaver lab will be studied.

The authors believe this experience could be important, along with the concept of driver's license, in the future, to set a new state-of-the-art for European Neurosurgical training programs, with the objective to uniform residents' training and patient care standards.

Conclusions

The EANS Basic Brain Course (ABC) was a pilot study to implement and evaluate the feasibility of a new concept of neurosurgical training. Despite its limitations, we had very good feedbacks from all the trainees. This concept of training on technical and non-technical skills, using emerging technologies along with pedagogic techniques, as well as cadaver dissection, needs further validations in order to become a structured course in European Neurosurgical training programs in the next future.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest..

Informed consent Informed consent was obtained from all individual participants included in the study.

Disclaimer The sponsors had no role in the design or conduct of this research.

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