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ORIGINAL ARTICLE - NEUROSURGERY TRAINING

Defining activities in neurovascular microsurgery training: entrustable professional activities for vascular neurosurgery

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Abstract

Background Entrustable professional activities (EPAs) represent an assessment framework with an increased focus on competency-based assessment. Originally developed and adopted for undergraduate medical education, concerns over resident ability to practice effectively after graduation have led to its implementation in residency training but yet not in vascular neurosurgery. Subjective assessment of resident or fellow performance can be problematic, and thus, we aim to define core EPAs for neurosurgical vascular training.

Methods We used a nominal group technique in a multistep interaction between a team of experienced neurovascular specialists and a medical educator to identify relevant EPAs. Panel members provided feedback on the EPAs until they reached consent.

Results The process produced seven core procedural EPAs for vascular residency and fellowship training, non-complex aneurysm surgery, complex aneurysm surgery, bypass surgery, arteriovenous malformation resection, spinal dural fistula surgery, perioperative management, and clinical decision-making.

Conclusion These seven EPAs for vascular neurosurgical training may support and guide the neurosurgical society in the development and implementation of EPAs as an evaluation tool and incorporate entrustment decisions in their training programs.

Keyword Assessment · Competency-based education · Entrustable professional activities · Patient care · Practice-based learning and improvement · Vascular neurosurgery

Background

The treatment strategy for intracranial vascular pathologies has changed over the past 3 decades due to advances in endovascular and radiosurgical techniques. This transformation poses challenges to the future of microsurgery due to a significant decrease of surgical procedures. Experts nevertheless foresee a lasting role for open microsurgery in vascular neurosurgery [2, 4]. Microsurgery is of particular value in the treatment of arteriovenous malformations, complex aneurysms, and revascularization or flow replacement strategies, but there will be an equilibrium on non-ruptured aneurysms as well. This means a reduction in caseload and a shift towards more complex pathology.

Due to the growing complexity and centralization of care, a good microvascular neurosurgeon will have to function in a collaborative team of endovascular specialists and vascular neurologists in a tertiary care setting. These developments will require adaptation for vascular training since traditional training and examination methods of timed exposure and knowledge assessment cannot fully measure and guarantee the required competencies. Medical education has shifted to a competency-based system over the years, to educate and evaluate trainees more effectively and efficiently. Competencies are defined in so-called entrustable professional activities (EPAs). The Royal College of Physicians and Surgeons of Canada has defined two vascular EPAs: "Performing

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surgery for patients with an intracranial aneurysm" and "Performing surgery for patients with spontaneous intracerebral hemorrhage with or without an underlying vascular malformation" [5]. However, they do not include EPAs on complex vascular pathology, which presents a significant part of the surgical spectrum. The integration of the competency-based system into the traditional training would provide additional possibilities to ensure a high level of competency and skilled vascular neurosurgeons in the near future. Hence, the aim of this work is to develop a competency-based framework for general and complex vascular pathology to assist in resident and fellowship training.

Methods

Definitions

Entrustable professional activities

In order to operationalize a competency-based medical education program, curriculum development is based around EPAs. Where competencies describe the qualities of an individual person, EPAs describe the work that the professional must do [7]. EPAs require the professional to integrate multiple competencies from several domains that focus on individuals and their knowledge, skills, and attitudes.

Entrustment level scale

The entrustment level scale evaluates to what extend a trainee can be trusted to execute the EPA which is the focus of assessment. Although adjusted versions exist, a five-level entrustment scale is most commonly used [1, 7]:

1. Observation but no execution, even with direct supervision
2. Execution with direct, proactive supervision
3. Execution with reactive supervision, i.e., on request and quickly available
4. Supervision at a distance and/or post hoc
5. Supervision provided by the trainee to more junior colleagues

Nominal group technique

We convened a group of cerebrovascular specialists in a six-stage approach to gain consensus on the EPAs [3]. (1) The first group consisted of two neurosurgeons (JHVL, HJS), one medical education specialist (BM), and a hybrid neurosurgeon (HB), who participated in a nominal group technique on the identification of the EPAs. (2) Each specialist was involved in direct patient care, worked with residents or fellows, and was an experienced medical educator. This was followed by a group discussion of each EPA and its competencies until agreement among the experts was reached. (3) Two authors (JHVL, HB) drafted the EPAs based on analysis of the collected data. (4) Subsequently, a cerebrovascular specialist (DH) independently reviewed the EPAs and competencies in direct communication with the corresponding author (JHVL). (5) A multidisciplinary international group of cerebrovascular specialists (panel members of the EANS vascular section) reviewed the EPAs and competencies. (6) The first group of specialists then refined and finalized the EPAs based on the feedback. The finalized EPAs were approved by all specialists.

Results

Phases 1 to 3

There were eight candidate activities that were reduced to five during the first round of discussion and eventually increased to six after revision in the final round resulted in the aneurysm surgery activity being split. We excluded the following EPAs: "professional development" because it does not entail a unit of work and therefore does not qualify as an EPA and "spinal arteriovenous malformations" due to the low incidence.

Phases 4 and 5

The multidisciplinary international group of cerebrovascular specialists (panel members of the EANS vascular section) revised all six activities. Of these activities, none required major revisions to the description, but all six required minor changes. The reviewers suggested adding a separate EPA for spinal dural fistulas. The reviewers did not discard any activities.

Phase 6 (Final review)

The first group of specialists reviewed the work of the reviewer in detail, made minor changes to all six activities, and added an EPA for spinal dural fistulas. The authors unanimously agreed to accept the seven activities as EPAs.

We have defined the following six EPAs:

EPA 1: Non-complex aneurysm surgery
EPA 2: Complex aneurysm surgery
EPA 3: Bypass surgery
EPA 4: Arteriovenous malformation resection
EPA 5: Spinal dural fistula
EPA 6: Perioperative management
EPA 7: Clinical decision-making

Fig. 1 Non-complex aneurysm surgery

1. Title of the EPA

Non-complex aneurysm surgery

2. Description

This EPA includes no more and no less than

- Non-complex surgical clipping of ruptured and unruptured intracranial aneurysms

Context: both elective and emergency setting.

Limitations: This does not include surgical wrapping or vascular reconstructive surgery. Excluded are aneurysms with wide necks, large aneurysm size, dolichoectatic or fusiform morphology, previous endovascular therapy, intraluminal thrombus formation or atherosclerotic walls.

3. Most relevant domains of competence

This EPA represents a key task of vascular microneurosurgery. Most relevant domains of competence are medical expert, communicator and collaborator.

4. Required Knowledge, Skills, and Attitudes (SKAs)

Knowledge:

- Vascular anatomy and understanding of the configuration of the aneurysm (neck) in relation to the parent and branching arteries.
- Understanding aneurysm projections and blood flow dynamics.
- Knowledge on the ischemic tolerance of the particular territories (e.g. terminal branches versus non-terminal branches, the ACOM or MCA).
- Knowledge on the behavior of the clip after release.

Skills:

- The ability to identify the most direct route to the aneurysm and parent arteries that requires minimal retraction and surgical resection. Though this, perform individually tailored craniotomies (e.g. sylvian craniotomy for middle cerebral artery aneurysms) instead of performing a standard approach (e.g. pterional approach for anterior circulation aneurysms).
- Aneurysm dissection and the ability to create a clear mental image of the expected configuration.
- Temporary clipping and identification of the necessary clip length.
- Control over intraoperative ruptured aneurysm with temporary clipping of all afferent and efferent arteries.
- Inspection and judging of the temporary and permanent clipping, which allow a posterior view of the aneurysm.
- Permanent clipping and to provide solutions for incomplete clipping of the neck or arterial trapping.

Attitude:

- Professional and cautious patient communication whilst taking possible cognitive impairment following aneurysmal subarachnoid hemorrhage into account.
- Interdisciplinary treatment decision should include patient's preferences.
- Willingness to accept that the experience of the available endovascular or microsurgical partner should also be considered in treatment decisions.

5. Information to assess progress

Satisfactory observation of all SKAs by an experienced vascular neurosurgeon. Residents and fellows should document their progress in a log. How often a fellow or resident should perform the SKAs for a summative entrustment decision is left to the discretion of the local structures and educational framework. Entrustment is formalized by public announcement towards the patients.

6. When is unsupervised practice expected?

In general for most residents execution of this EPA is only under proactive, direct supervision. Ultimately, a vascular fellow or neurosurgical resident should reach unsupervised execution of the EPA (level 4) before transition to a full-time vascular neurosurgeon.

7. Expiration date

One year without practice after summative entrustment decision

Fig. 2 Complex aneurysm surgery

8. Title of the EPA

Complex aneurysm surgery

9. Description

This EPA includes no more and no less than

- Complex surgical clipping of ruptured and unruptured intracranial aneurysms. As such, it presupposes all aspects of non-complex aneurysm surgery listed under EPA 1.

Context: both elective and emergency setting.

Limitations: none

10. Most relevant domains of competence

This EPA represents a key task of vascular microneurosurgery. Most relevant domains of competence are medical expert, communicator and collaborator.

11. Required Knowledge, Skills, and Attitudes (SKAs)

Knowledge:

- Knowledge of various supplementary techniques to facilitate neurosurgical clip reconstruction such as rapid ventricular pacing, adenosine-induced flow arrest, suction decompression and short hypothermia.
- Understanding of neuroprotective drugs (e.g. barbiturates, thiopental) in order to reducing blood flow in the target territory of neighboring territories.

Skills:

- Wrapping techniques (e.g. Teflon, encircled clips etc.) for fusiform or dissecting aneurysms.
- Complex clip reconstructions (e.g. tandem technique or parallel clipping).
- Thrombectomy of a partially thrombosed aneurysm.
- Surgical trapping, if this involves an insufficiently collateralized vascular segment, flow replacement by bypass surgery.

Attitude:

- Professional and cautious patient communication whilst taking possible cognitive impairment following aneurysmal subarachnoid hemorrhage into account.
- Interdisciplinary treatment decision should include patient's preferences.
- Willingness to accept that the experience of the available endovascular or microsurgical partner should also be considered in treatment decisions.

12. Information to assess progress

Satisfactory observation of all SKAs by an experienced vascular neurosurgeon. Residents and fellows should document their progress in a log. How often a fellow or resident should perform the SKAs for a summative entrustment decision is left to the discretion of the local structures and educational framework. Entrustment is a formalized by public announcement towards the patients.

13. When is unsupervised practice expected?

In general, the entrustment level for most residents is observation without allowance to practice the EPA. A vascular fellow or neurosurgical resident should reach unsupervised (level 3) before transition to a full-time vascular neurosurgeon.

14. Expiration date

One year without practice after summative entrustment decision

Fig. 3 Bypass surgery

15. Title of the EPA

Bypass surgery

16. Description

This EPA includes no more and no less than

- Bypass surgery for revascularization and flow replacement in ischemic cerebrovascular disease or complex surgical clipping of ruptured and unruptured intracranial aneurysms. As such, it presupposes all aspects of non-complex and complex aneurysm surgery listed under EPA 1 & 2.

Context: mostly elective setting.

Limitations: none

17. Most relevant domains of competence

This EPA represents a key task of advanced vascular microneurosurgery. Most relevant domains of competence are medical expert, communicator and collaborator.

18. Required Knowledge, Skills, and Attitudes (SKAs)

Knowledge:

- Knowledge of imaging modalities to assess the need for flow replacement strategies. (MRA NOVA, CTP, OEF-PET / Diamox / DSA with balloon occlusion test)
- Understanding of neuroprotective drugs (e.g. barbiturates, thiopental) in order to reducing blood flow in the target territory of neighboring territories.
- Knowledge of possible donor vessels, indications and contraindications (STA, radial artery, saphenous vein (SVG) anterior tibial artery) (e.g. for RAG: spasm, size below 2.5 mm, prior use for radial artery lines, absence of palmar arch, e.g. for SVG: valves, low kink resistance, size and volume mismatch, inability to remodel)
- Knowledge of flow capacities with low flow (STA) or high flow strategies (RAG/SVG EC-IC bypasses) and intraoperative cut flow index.
- Knowledge of length of bypass graft.
- Knowledge of anticoagulation strategies (ASS/ Heparin)
- Knowledge of treating spasm in graft of host vessels.

Skills:

- Anastomosis techniques (side to side, end to side, end to end)
- Complication treatment (anastomosis thrombosis)

Attitude:

- Professional and cautious patient communication whilst taking possible cognitive impairment following aneurysmal subarachnoid hemorrhage into account.
- Interdisciplinary treatment decision should include patient's preferences.

19. Information to assess progress

Satisfactory observation of all SKAs by an experienced vascular neurosurgeon. Residents and fellows should document their progress in a log. How often a fellow or resident should perform the SKAs for a summative entrustment decision is left to the discretion of the local structures and educational framework. Entrustment is formalized by public announcement towards the patients.

20. When is unsupervised practice expected?

In general, the entrustment level for most residents is observation without allowance to practice the EPA. A vascular fellow or neurosurgical resident should reach unsupervised (level 3) before transition to a full-time vascular neurosurgeon.

21. Expiration date

One year without practice after summative entrustment decision

Fig. 4 Arteriovenous malformation resection

22. Title of the EPA

Arteriovenous malformation resection

23. Description

This EPA includes no more and no less than

- Resection of arteriovenous malformations, ruptured or unruptured. As such, it presupposes all aspects of non-complex aneurysm surgery listed under EPA 1.

Context: both elective and emergency setting.

Limitations: none

24. Most relevant domains of competence

This EPA represents a key task of vascular microneurosurgery. Most relevant domains of competence are medical expert, communicator and collaborator.

25. Required Knowledge, Skills, and Attitudes (SKAs)

Knowledge:

- Knowledge of AVMs and architectural classification
- Knowledge of ICG
- Understanding of neuroprotective drugs (e.g. barbiturates, thiopental) in order to reducing blood flow in the target territory of neighboring territories.

Skills:

- Dissection of AVMs.
- Protection of draining veins

Attitude:

- Professional and cautious patient communication whilst taking possible cognitive impairment following AVM hemorrhage into account.
- Interdisciplinary treatment decision should include patient's preferences.
- Willingness to accept that the experience of the available endovascular, microsurgical or radiotherapy partner should also be considered in treatment decisions.

26. Information to assess progress

Satisfactory observation of all SKAs by an experienced vascular neurosurgeon. Residents and fellows should document their progress in a log. How often a fellow or resident should perform the SKAs for a summative entrustment decision is left to the discretion of the local structures and educational framework. Entrustment is formalized by public announcement towards the patients.

27. When is unsupervised practice expected?

In general, the entrustment level for most residents is observation without allowance to practice the EPA. A vascular fellow or neurosurgical resident should reach unsupervised (level 3) before transition to a full-time vascular neurosurgeon.

28. Expiration date

One year without practice after summative entrustment decision

Fig. 5 Spinal dural fistula

29. Title of the EPA

Spinal Dural Arteriovenous Fistula

30. Description

This EPA includes no more and no less than

- Resection of spinal dural arteriovenous fistula's.

Context: both elective and emergency setting.

Limitations: none

31. Most relevant domains of competence

This EPA represents a key task of vascular microneurosurgery. Most relevant domains of competence are medical expert, communicator and collaborator.

32. Required Knowledge, Skills, and Attitudes (SKAs)

Knowledge:

- (Angiographic-) Vascular anatomy
- Knowledge of spinal fistula's and AVM s and architectural classification
- Knowledge of ICG
- Knowledge of benefits and harms of (preoperative) embolization
- Knowledge of the risks, morbidity and mortality and the most likely natural course of the disease in current literature as well as of the own institution

Skills:

- Thoracic segment identification using fluoroscopy
- Intradural exposure
- Coagulation and transsection of abnormal dural arteriovenous shunt.
- Protection and recognition of normal essential arterial supply (e.g. radicular medullary artery)
- Being able to lead an informed discussion with other neuro-vascular experts or in the setting of a specialized vascular board

Attitude:

- Professional and cautious patient communication.
- Interdisciplinary treatment decision should include patient's preferences.
- Willingness to accept that the experience of the available endovascular, microsurgical partner should also be considered in treatment decisions.

33. Information to assess progress

Satisfactory observation of all SKAs by an experienced vascular neurosurgeon. Residents and fellows should document their progress in a log. How often a fellow or resident should perform the SKAs for a summative entrustment decision is left to the discretion of the local structures and educational framework. Entrustment is formalized by documentation.

34. When is unsupervised practice expected?

In general, the entrustment level for most residents is observation without allowance to practice the EPA. A vascular fellow or neurosurgical resident should reach unsupervised (level 3) before transition to a full time vascular neurosurgeon.

35. Expiration date

One year without practice after summative entrustment decision

Fig. 6 Perioperative management

36. Title of the EPA

Perioperative management

37. Description

This EPA includes no more and no less than

- Pre- and postoperative care of aneurysm, AVM and bypass surgery patients

Context: ambulatory and inpatient setting

Limitations: only for vascular neurosurgery

38. Most relevant domains of competence

This EPA represents a key task of vascular microneurosurgery. Most relevant domains of competence are medical expert, communicator and collaborator.

39. Required Knowledge, Skills, and Attitudes (SKAs)

Knowledge:

- Understanding the choice of treatment and timing of securing vascular pathology
- Understanding of the cerbrovascular (patho)physiology
- Knowledge on diagnostic modalities; TCD, CTA, CTP, MRA and DSA
- Endovascular treatment modalities such as intra-arterial Nimodipine therapy and balloon angioplasty
- Intensive care medicine; knowing analgesia and sedation, ventilation, blood pressure controle, positive inotropic drugs and fluid therapie.
- Principles of hydrocephalus management

Skills:

- Basic intensive care medicine; TCD, intubation/tracheotomy, central venous and arterial catheters
- Being able to interprete neuroradiological imaging
- External ventriculostomy and internal shunting techniques

Attitude:

- Professional and cautious patient communication whilst taking possible cognitive impairment following intracranial hemorrhage into account
- Interdisciplinary treatment decision
- Observe professional training in intensive care medicine and neuroradiology

40. Information to assess progress

Case-based discussions with a supervisor. Satisfactory observation of all SKAs by an experienced vascular neurosurgeon. Residents and fellows should document their progress in a log. How often a fellow or resident should perform the SKAs for a summative entrustment decision is left to the discretion of the local structures and educational framework. Clinics can implement a 360-degree feedback system to assess the functioning as a member of an interdisciplinary team.

41. When is unsupervised practice expected?

Both residents and fellows should, as a health care professional; be able to practice the EPA with supervision at a distance or post hoc.

42. Expiration date

One year without practice after summative entrustement decision

Fig. 7 Clinical decision-making

43. Title of the EPA

Clinical decision-making

44. Description

This EPA includes no more and no less than

- Being able to make clinical decisions independently. Staying up to date and knowing the limitations of treatment options and guidelines.
- Clinical quality management, striving to safety and efficacy.
- Function as a professional member of an interdisciplinary team.

Context: clinical care, science and teaching

Limitations: only for vascular neurosurgery

45. Most relevant domains of competence

Most relevant domains of competence are medical expert, communicator, collaborator, scholar and professional.

46. Required Knowledge, Skills, and Attitudes (SKAs)

Knowledge:

- Knowledge of relevant and recent scientific results
- Knowledge of (inter) national guidelines
- Understanding of the principles of quality/safety management
- Having a clear definition of standard procedures
- Knows about effective teamwork and communication

Skills:

- Conduct scientific database research on a specific clinical case
- Evaluate research data and evaluate transferability to the clinical situation
- Identify research questions from clinical practice if evidence is limited
- Command of the basics; write communicate, summarize and report, including the ability to maintain confidential material
- The ability of self-reflection and critique in order to identify systemic flaws
- Balance of technical knowledge and interpersonal skills; the ability to communicate medical information to non-medical people
- Effective and safe communication with colleagues and team members

Attitude:

- Practice of evidence based medicine
- Staying up to date; attending congresses relevant to vascular neurosurgery
- Willingness to keep record of surgical complications; regular audits and comparing results with benchmarks
- Is aware of own limitations.
- Observe professional training in other neurovascular centres (e.g. fellowship)
- Recognizes the role, responsibilities, contributions and value of all team members

47. Information to assess progress

Case-based discussions with a supervisor. Residents and fellows should document their complications in a log and compare them to benchmark results. Clinics can implement a 360-degree feedback system to assess the functioning as a member of an interdisciplinary team.

48. When is unsupervised practice expected?

Both residents and fellows should, as a health care professional; be able to practice the EPA with supervision at a distance or post hoc.

49. Expiration date

One year without practice after summative entrustment decision

Figures 1, 2, 3, 4, 5, 6, and 7 present a detailed description of each EPA.

Discussion

We identified seven EPAs based upon their particular value in vascular microsurgery, for which we foresee a continuing role in vascular microsurgery. The present manuscript presents an attempt to add a competency-based system to traditional training in vascular neurosurgery.

Although this concept was initially developed to operationalize competency-based postgraduate medical education, it is now widely applied in health professions education [6, 8]. The Accreditation Council for Graduate Medical Education and the American Board of Surgery both have identified the need for competency-based skills assessments in surgical training, based upon a reported lack of confidence of surgical residents at the time of graduation [9]. By definition, EPAs allow for residents and fellows to achieve competence at different rates to increase surgical autonomy. This transition from traditional training and examination methods seems particular relevant for vascular microneurosurgery since technical advances in endovascular treatment modalities result in a reduction of caseload, whereas governments and patients increasingly demand metrics of competency for operative performance. EPAs present us with a possible framework for these metrics and can be added to residency and fellowship programs [9]. So far, there exists no threshold of competency metrics within the essential EPAs, but it is possible that governing bodies in the future will determine such a threshold for accredited residency and fellowship programs.

A recent study evaluated the appropriateness of the EPA "performing intracranial aneurysm surgery" for general residency and found that it was more suitable for a fellowship [8]. Since most of these activities are nowadays acquired during dedicated fellowships, these specialized EPAs are more suitable for this setting. The more general EPA's numbers six and seven are also suitable for neurosurgery residency.

We are reasonably confident that this list of EPAs represents the core of vascular microsurgery. The EPAs proposed in the present article however are not meant to be infallible, and it is possible that other vascular specialists identify other relevant EPAs not included in this manuscript. The EPAs may also not fully reflect national or institutional priorities and may be adjusted to fit local vascular units.

These EPAs represent the core professional acts of vascular microsurgeons to provide safe and effective neurosurgical care. They thus are the activities that teachers should trust residents of vascular fellows to perform under varying degrees of supervision, and the supervision should ask whether he or she trusts the resident or fellow to perform these activities under what level of supervision. Medical educators should rate resident or fellow performance on EPAs using the before-mentioned entrustment scales. We do not aim to define training outcomes but rather focus on reaching an agreement on how to describe the stage a trainee is at for a given procedure. Continuing work would describe in more detail what a modern European cerebrovascular neurosurgeon should resemble in terms of experience. The neurosurgical society will need to determine the best methods of implementing the EPAs within vascular neurosurgery fellowship programs. [2] This study presents a foundation for the use and further development of specific EPAs for competency-based training of neurovascular microsurgical residents and fellows.

Conclusion

These EPAs aid to focus on authentic professional work of vascular neurosurgeons and will represent the basis for assessment in vascular neurosurgery training.

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Declarations

Ethics approval This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of interest The authors declare no competing interests.

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