



Committee on Advanced Subspecialty Training (CAST) Society of Neurological Surgeons

PROGRAM REQUIREMENTS FOR FELLOWSHIP TRAINING IN NEUROENDOVASCULAR SURGERY

I. DEFINITION AND SCOPE OF EDUCATION

A. Definition

Neuroendovascular surgery (NES) is a subspecialty that uses minimally invasive catheter-based technology, radiological imaging, and clinical expertise to diagnose and treat vascular diseases of the central nervous system, as well as other disorders of the head, neck and spine and their vascular supply. The unique clinical and invasive nature of this subspecialty requires special training and skills.

B. Duration and Scope of Training

The educational program in NES may be enfolded and completed within the neurosurgical residency, or accomplished after completion of formal prerequisite training. The program shall offer 1 year of dedicated and continuous advanced medical education and training in NES, to be delivered AFTER satisfactory completion/validation of catheter-based skills and competency, as well as all other pre-requisites for each individual specialty.

Such pre-requisite training may include an ACGME-recognized neurosurgical residency, an ACGME-recognized neurology residency followed by a stroke or critical care fellowship, or an ACGME-recognized radiology residency followed by a neuroradiology fellowship during which there has been at least 6 months of focused clinical service in a neurosurgery, vascular neurology or neurointensive care program.

II. INSTITUTIONS

A. Sponsoring Programs

A CAST-approved program for advanced training in NES must exist within or be closely affiliated with an ACGME-accredited neurosurgical residency training program.

B. Setting

The NES training program must include educational activities in an environment that includes open vascular neurosurgery, neurocritical care, stroke neurology, neuroradiology, and state-of-the-art neuroimaging. The institution must have an endovascular unit and a Neurologic/Neurosurgical Intensive Care Unit or dedicated beds in a general ICU devoted to neurological and neurosurgical conditions and adult and pediatric patients.

III. PROGRAM PERSONNEL AND RESOURCES

A. Program and Program (Co)Director

A fellowship in NES must have a fellowship program director or co-director certified by CAST and either the American Board of Neurological Surgery, American Board of Radiology, or the American Board of Neurology and who have also fulfilled any other respective subspecialty requirements, including MOC.

The fellowship program director:

- must have special expertise in NES, and his/her practice should be concentrated in this field.
- is responsible for establishing and maintaining the matrix curriculum, the selection and supervision of the trainees, and the selection of faculty.
- should evaluate the trainees on a regular basis with formal, written evaluations to ensure that matrix and key milestone and core competencies are met.
- must have adequate support from the institution and sponsoring department to carry out the mission of the program.
- must be (co)appointed by and be responsive to the Chair of the sponsoring ACGME Program in Neurological Surgery.

Faculty evaluations by both the fellowship program director and the trainees should be done regularly.

Trainee and faculty evaluations must be reviewed at least annually by the sponsoring ACGME neurosurgery training program director and any other appropriate institutional review committee to ensure the educational effectiveness of the program.

B. Faculty

The fellowship must include at least two (2) faculty members with special expertise in NES who are board certified/board eligible by the American Board of Neurological Surgery or certified by the American Board of Radiology or American Board of Neurology and possess other additional educational qualifications as determined by CAST and its NES Advisory Council (NESAC).

The faculty must:

- have documented qualifications to supervise patient care and instruct all fellows in the training program
- devote sufficient time to the educational program to fulfill their supervisory and teaching responsibilities
- demonstrate a strong interest in the education of fellows
- support the goals and objectives of the educational program.
- provide didactic teaching and direct supervision of residents'/fellows' performance in-patient management and in the procedural, interpretive, and consultative aspects of NES.

- stimulate scholarly activities and be able to direct residents/fellows in the conduct of such activities.
- hold appointments in an ACGME accredited neurosurgical, neurology or radiology residency-training program.
- in good standing on the staff of the participating institution

Non-physician faculty and other personnel should:

- include all additional and necessary professional, technical, and clerical personnel to support the program.
- include specially trained nurses and technicians who are skilled in NES, radiological equipment, critical care instrumentation, respiratory function, and laboratory medicine.
- be appropriately qualified in their fields.
- possess appropriate institutional appointments.

C. Facilities and Resources

In order to evaluate and treat patients with cerebrovascular diseases:

- the imaging equipment and procedure rooms must be appropriately equipped and available for the performance of all NES procedures.
- physiologic monitoring and resuscitative equipment must be present in the procedure rooms.
- imaging equipment should include biplanar fluoroscopy with digital subtraction and roadmap capability and rotational 3-Dimensional imaging.
- the training program needs to be hospital-based to provide the adequate in-patient, outpatient, emergency, and neurointensive care necessary for the care of the NES patient.
- ancillary up-to-date imaging such as MRI and CT with perfusion analysis software and ultrasound must be available.

The NESAC will determine the adequacy of these facilities and resources at each training program.

IV. FELLOW APPOINTMENTS, including trainee-to-faculty ratio

The appointment of fellows must not dilute or detract from the educational opportunities available to regularly appointed neurosurgery residents.

The total number of trainees (resident and/or fellows) in the program must be commensurate with the capacity of the program to offer an adequate educational experience in NES for each trainee. To ensure adequate teaching, supervision, trainee evaluation and their academic progress, the trainee-to-faculty ratio must be **at least two full-time NES faculty for one graduating trainee completing the training program each year.**

The number of CAST-approved fellowship spots will thereafter be determined by CAST with NESAC counsel. Increased faculty numbers will be required to gain additional numbers of CAST-approved fellowship spots, and numbers will be

adjudicated based on commensurate faculty clinical and academic experience, and by any dilution by fellows not tracking for CAST certification.

Satisfaction of these requirements needed to provide the appropriate educational environment and training oversight will be determined by the NES Review Committee (NESAC) of CAST for each accredited fellowship.

V. PROGRAM CURRICULUM

A. Program Design

The object of providing these program requirements is to specify a curriculum of knowledge and clinical skills as well as a training environment and administrative resources for residents and NES fellows to develop advanced proficiency in the endovascular management of cerebrovascular disease; to develop the qualifications that facilitate supervision of Neuroendovascular Services; and to educate trainees in state of the art neuroendovascular procedures.

Existence of required program design and sequencing of educational experiences and training environment are requisite for SNS CAST Programmatic accreditation and individual trainee certification.

The program must possess a written statement that outlines its educational goals and objectives relative to knowledge, skills, and other competencies. This statement must be distributed to fellows and faculty, and must be reviewed with the trainees prior to their assignments.

Trainees completing NES fellowship training will be expected to:

- demonstrate mastery of all NES milestones as described by SNS/CAST through Level 5 for cerebrovascular diseases
- undertake investigations into the various areas of NES, such as new instrumentation, identification of important physiologic parameters, evaluation of pharmacologic agents in cerebrovascular patients, health outcomes and/or health policy issues related to NES.

B. Fellowship training structure

NeuroEndovascular Surgery training for neurosurgeons, neurologists, and neuroradiologists can be divided into three separate stages, including:

1. preliminary subspecialty training

Neurosurgeons:

- satisfactory completion of a 7-year ACGME approved residency

Neurologists:

- board certification in their primary ABMS Board (Neurology) subspecialty certification from an ACGME-accredited Vascular/Stroke Neurology Fellowship with at least 3 months in the neurointensive care

unit, or completion and certification from a UCNS or CAST approved Neurocritical Care Fellowship

- satisfactory participation of any MOC requirements thereafter as required for the maintenance of good standing within these training organizations

Radiologists:

- board certification in their primary ABMS Board (Radiology)
- subspecialty certification in Neuroradiology
- at least 6 months of clinical service in a neurological surgery, vascular neurology or neurocritical care program prior to entering the final advanced year of NES fellowship
- satisfactory participation of any MOC requirements thereafter as required for the maintenance of good standing within these training organizations

2. endovascular prerequisite training

Neurosurgeons:

- performance of at least 200 catheter-based diagnostic and/or interventional cerebral angiographic procedures as primary operator, completed during residency or as a separate experience after completion of residency.
- demonstrated competency in catheter techniques, as validated by the Fellowship Program Director, and
- milestones 1-4 for cerebrovascular diseases and NES completed and signed off by both the residency and NES fellowship program directors

Neurologists:

- performance of at least 200 catheter-based diagnostic and/or interventional cerebral angiographic procedures as primary operator, completed during their subspecialty training or as a separate experience after completion of that training.
- demonstrated competency in catheter techniques, as validated by the Fellowship Program Director, and
- milestones 1-4 for cerebrovascular diseases and NES completed and signed off by both the subspecialty and NES fellowship program directors

Radiologists:

- performance of at least 200 catheter-based diagnostic and/or interventional cerebral angiographic procedures as primary operator, completed during their subspecialty training or as a separate experience after completion of that training.
- demonstrated competency in catheter techniques, as validated by the Fellowship Program Director, and
- milestones 1-4 for cerebrovascular diseases and NES completed and signed off by both the subspecialty and NES fellowship program directors

3. **advanced endovascular training**

Neurosurgeons:

- 12 continuous months of a dedicated NES fellowship experience (to be performed no sooner than PGY6 after completion of their preliminary subspecialty requirements and endovascular pre-requisites as outlined above) during which the fellow performs a broad spectrum of endovascular procedures as defined by core-competency requirements
- satisfactory completion of milestone level 5 for cerebrovascular diseases and NES signed off by the NES Fellowship Program Director

Neurologists:

- 12 continuous months of a dedicated NES fellowship experience (to be performed after completion of their preliminary subspecialty requirements and endovascular pre-requisites as outlined above) during which the fellow performs a broad spectrum of endovascular procedures as defined by core-competency requirements
- satisfactory completion of milestone level 5 for cerebrovascular diseases and NES signed off by the NES Fellowship Program Director

Radiologists:

- 12 continuous months of a dedicated NES fellowship experience (to be performed after completion of their preliminary subspecialty requirements and endovascular pre-requisites as outlined above) during which the fellow performs a broad spectrum of endovascular procedures as defined by core-competency requirements
- satisfactory completion of milestone level 5 for cerebrovascular diseases and NES signed off by the NES Fellowship Program Director

C. pre-requisite training: curriculum/Matrix elements for Milestone levels 1-4 completion, including the following:

- Proper use of needles, catheters, guidewires, and contrast material,
- Fundamental understanding of radiation physics, biology and safety,
- Interpretation of cerebral angiography, neurovascular and neuroradiological studies
- Pathophysiology of cerebrovascular diseases,
- Coagulation pathways, testing and manipulation
- Evaluation and management of patients with cerebrovascular diseases
- Critical care management of the acute vascular patient, including placement of invasive monitoring devices
- Clinical indications, risks, and limitations of endovascular neurosurgical procedures,
- Understanding alternatives to NES including medical and surgical options,
- Generating procedural reports that include and adhere to CPT coding.

A Matrix consistent with these elements has been created and designed alongside accompanying Milestones to ensure successful and proficient completion of these elements. The trainee is expected to be well versed in the pathophysiology of cerebrovascular disease and understanding neuroradiological studies such as CT

and MR. Additionally, such training can be further developed by focusing on neuroangiography, other neurovascular studies such as cervical and transcranial dopplers, and physiological studies such as CT and MR Perfusion, SPECT and PET. The didactic components of radiation biology and safety must be delivered to the trainee to protect them and their patients from widespread and unnecessary exposure to radiation involving endovascular procedures.

Critical care training and management of the acutely ill or recently treated vascular patient is a fundamental tenet of NES training. This training includes ICU management of patients who: are ventilated, have elevated intracranial pressures which are being monitored, need or have in place central venous access or pulmonary artery catheters with issues of central venous volumes and their titration, have systemic infections and sepsis, experience acute cardiac dysthymias and failure, renal failure and other conditions routinely encountered in the care of NES patients in the ICU. Trainees should be routinely exposed to and well versed in usage of the National Institutes of Health Stroke Score (NIHSS). The prerequisite rotation must also focus on the complexities of anticoagulation and their reversal algorithms in the management of endovascular patients, as well as the specific manipulations of central and cerebral hemodynamics in patients with ischemia and other specific management issues particular to the NES patients.

The practical endovascular training aspect for trainees can be significantly buttressed by incorporating simulation based modules. Completing 20-50 simulated procedures before he/she encounters the first patient allows the incoming trainee to develop hand-eye coordination, a skill that is key for performing endovascular procedures. Flow-based simulators may also augment training programs, allowing the trainee to learn more than just catheter manipulation but also proper flush management, fluoroscopy time, optimization of viewing angles and reduction of radiation exposure to patients and self.

Finally, all trainees should perform at least 200 catheter-based diagnostic and/or interventional cerebral angiographic procedures as primary operator. This experience must be concluded BEFORE entering Advanced NES training. The trainee must thereafter demonstrate competency in catheter techniques, as validated by the Fellowship Program Director, before beginning their Advanced NES training.

D. Advanced NES fellowship training: curriculum/Matrix elements for Milestone level 5 completion

A Matrix consistent with these elements has been created and designed alongside the accompanying Milestone to ensure successful and proficient completion of these elements, and includes:

- Arterial and venous angiographic anatomy of the brain, spinal cord, head, neck and spine including collateral anastomoses, anatomic variants and modifications induced by disease processes.

- Bony and soft tissue anatomy and physiology of brain, head and neck and spine
- Cerebral blood flow and its physiology and pharmacology.
- The technical aspects of endovascular neurosurgery including:
 - Arterial and venous access techniques
 - Catheter systems, nomenclature, and selection
 - The spectrum of embolic and sclerosing agents
 - The spectrum of stents, balloons, and other endovascular devices
 - Aneurysm treatment
 - Arteriovenous malformation embolization
 - Complications of endovascular procedures and their management
 - Treatment of dural arteriovenous fistulae
 - Treatment of acute cerebral ischemia
 - Treatment of cerebral vasospasm
 - Provocative testing
 - Electrophysiologic monitoring
 - Extracranial occlusive disease including atherosclerotic disease and dissection
 - Intracranial occlusive disease including atherosclerotic disease and dissection
 - Traumatic vascular lesions of the CNS, head and neck and spine
 - Balloon test occlusions
 - Tumor or vascular lesion embolization, intracranial and head and neck
 - Embolization for epistaxis
 - Spinal embolization
- Pharmacologic agents
 - Contrast materials
 - Sedatives and anesthetics
 - Analgesics
 - Thrombolytics
 - Antiplatelet agents
 - Antithrombotics
 - Vasoactive agents including vasopressors and vasodilators
- Periprocedural follow-up
 - Patient evaluation and decision making
 - Neurointensive Care
 - Long-term follow-up

E. Curriculum/Core Competency Requirements during Advanced NES Subspecialty Training

Candidate: The continuity of care must be of sufficient duration so that the trainee is familiar with the outcome of these procedures. A minimum of **250 'interventional' procedures** as primary operator are required to ensure that the trainee receives the needed exposure to the diversity of cerebrovascular diseases and the endovascular procedures brought to bear in their treatment. This number should include:

- 40 aneurysm treatments including 10 ruptured aneurysms
- 20 intracranial embolizations (AVM, AVF, Tumor)

- 25 intracranial or extracranial stent placements (at least 5 in each category, and may include stents or flow divertors for aneurysms)
- 30 acute ischemic stroke treatments
- 10 intracranial infusions (e.g. vasospasm, chemotherapy, stroke)
- 5 extracranial embolizations
- 5 spinal angiograms and/or embolizations

A candidate unable to complete the required interventions during the 12 months must extend their training and/or seek training at other institutions to accomplish this requirement.

Program: Each program must perform at least **250 therapeutic NES procedures** per year. A program that does not meet individual recommended numbers for specific procedures detailed above may develop partnerships and collaboration with other programs/institutions to provide the necessary experience to their trainees. Programs failing to meet these criteria jeopardize their CAST accreditation, and must promptly rectify any deficiencies and establish corrective actions in accordance with directives received from CAST and the NESAC.

The institution where the training program is based should have an emergency room, an ACGME approved neurosurgery training program, (ideally) training programs in Neurology and Neuroradiology, and a dedicated neurointensive care unit. Ideally, there should be a robust open surgical neurovascular program at the same institution also designated as a Comprehensive Stroke Center to provide a comprehensive array of options and their exposure to trainees. The institution should have a well-developed peer-review process for identification of complications and their discussion in a multidisciplinary fashion. The institution should also have a rigorous program to log all neuroendovascular procedures performed at the institution through a database.

F. Documentation of Clinical Experiences

Endovascular database: The fellowship program should collect data for all cases in a NESAC approved endovascular database, which permits data entry for ALL endovascular procedures at each participating institution and their subsequent clinical outcomes. This dataset should be applied to local, regional, and national standards to provide comparative effectiveness between different approaches and their respective outcomes, to prepare for expected federal and state reporting requirements for outcomes based reimbursement; and for many other potential academic and research related opportunities.

Patient Population:

- The institution's patient population must have a diversity of illnesses from which broad experience in NES therapy can be obtained. The case material should encompass a range of neurological diseases, focusing on neurovascular pathology.
- An adequate variety and number of NES procedures must be available for each trainee. These procedures include treatment of aneurysms, brain arteriovenous malformations, arteriovenous fistulas of the brain, tumors of the central nervous

- system, occlusive vascular diseases, revascularization, traumatic injury, maxillofacial vascular malformation, and tumors.
- In addition, the program must provide adequate training and experience in invasive functional testing.
 - Each trainee must maintain a personal case log, which the program director must certify at the completion of training.
 - The NES program director must submit the entire clinical experience of the NES program and its trainees in the format prescribed by NESAC. The list of procedures and the logs must be made available to the NESAC at the time of its review of the NES training program.

G. Residents/Fellows Scholarly Activities

Each program must provide an opportunity for trainees to participate in research or other scholarly activities, and trainees must participate actively in such scholarly activities.

Conferences and Didactic Training

- Trainees must make daily rounds with the attending faculty during which patient management decisions are discussed and made.
- Conferences should be organized by the faculty and held to allow discussion of topics selected to broaden knowledge in the field of NES. Specifically, teaching conferences should embrace the scope of NES as outlined above. Conferences should include journal clubs, pathology meetings, and neuroanatomy dissection, simulation and flow-model courses related to NES.
- There must be interactive didactic conference time and interdepartmental meetings between neurosurgeons, neuroradiologists and neurologists and any other specialties as indicated that may be relevant to patient care.
- Regular review of all mortality and morbidity related to the performance of NES procedures must be documented. Trainees must participate actively in these reviews, which should be held at least monthly.
- Trainees should be encouraged to attend and participate in local extramural conferences and should attend at least one NES related national meeting (CV Section of AANS/CNS, SNIS, SVIN) and one advanced course related to NES while in training.

Scholarly Activity

Scholarship can be defined as the scholarship of *discovery*, as evidenced by peer-reviewed funding or by publications of original research in peer reviewed journals; the scholarship of *dissemination*, as evidenced by review articles or chapters in textbooks; and the scholarship of *application*, as evidenced by the publication or presentation of specialty specific educational information at local, regional, or national professional and scientific society meetings.

Complementary to the above scholarship is the regular participation of the teaching staff in clinical discussions, rounds, journal clubs, and research conferences in a manner that promotes a spirit of inquiry and scholarship (e.g., the offering of

guidance and technical support for fellows involved in research, such as research design and statistical analysis); and the provision of support for fellows' participation, as appropriate, in scholarly activities.

Graduate medical education must take place in an environment of inquiry and scholarship in which trainees participate in the development of new knowledge, learn to evaluate research findings, and develop habits of inquiry as a continuing professional responsibility. The responsibility for establishing and maintaining an environment of inquiry and scholarship rests with the teaching staff. While not all members of a teaching staff must be investigators, the staff as a whole must demonstrate broad involvement in scholarly activity. The staff activity should include:

- active participation in regional or national professional and scientific societies, particularly through presentations at the organizations' meetings and publications in their journals.
- participation in research, particularly in projects that are funded following peer review and/or result in publications or presentations at regional and national scientific meetings.
- offering of guidance and technical support (e.g., research design, statistical analysis) for residents/fellows involved in research.
- provision of support for resident/fellow participation in scholarly activities

Research and research facilities: A subspecialty program should have an investigational component such that the trainees may become familiar with the design, implementation, and interpretation of clinical and basic research studies. Facilities should be made available to support research projects pertinent to endovascular therapies.

Interchange With Trainees in Other Specialties and Students: Trainees should be encouraged to participate in research activities with residents and staff in other related specialties. They also should be encouraged to attend and participate in clinical conferences. It is desirable that they participate in the clinical teaching of neurological surgery, neurology and radiology residents/fellows and medical students.

VI. DUTY HOURS AND THE WORKING ENVIRONMENT

Providing fellows with a sound didactic and clinical education must be carefully planned and balanced with concerns for patient safety as well as resident and fellow well-being. Each program must ensure that the learning objectives of the program are not compromised by excessive reliance on trainees to fulfill service obligations. Didactic and clinical education must have priority in the allotment of fellows' time and energy.

Duty hour assignments must recognize that faculty and fellows collectively have responsibility for the safety and welfare of patients.

A. Supervision of Residents/Fellows

- All patient care must be supervised by qualified faculty. The fellowship program director must ensure, direct, and document adequate supervision of fellows at all times.
- Trainees must be provided with rapid, reliable systems for communicating with supervising faculty.
- Faculty schedules must be structured to provide fellows with continuous supervision and consultation.

B. Duty Hours:

- Duty hours are defined as all clinical and academic activities related to the fellowship program; i.e., patient care (both inpatient and outpatient), administrative duties relative to patient care, the provision for transfer of patient care, time spent in-house during call activities, and scheduled activities such as conferences.
- Duty hours do *not* include reading and preparation time spent away from the duty site
- All residents in pursuit of NES training must comply with the ACGME guidelines for duty hours, and both the fellowship program director and resident program director must ensure, direct, and document adequate supervision at all times
- Faculty and fellows must be educated to recognize the signs of fatigue, and adopt and apply policies to prevent and counteract its potential negative effects.

C. On-Call Activities: The objective of on-call activities is to provide fellows with continuity of patient care experiences throughout a 24-hour period. *In-house call* is defined as those duty hours beyond the normal work day, when fellows are required to be immediately available in the assigned institution. Back-up support systems must be provided when patient care responsibilities are unusually difficult or prolonged, or if unexpected circumstances create resident fatigue sufficient to jeopardize patient care.

D. Oversight: Each program must have written policies and procedures consistent with the Institutional and Program Requirements for trainee duty hours and the working environment. These policies must be distributed to the trainees and the faculty. Duty hours must be monitored with a frequency sufficient to ensure an appropriate balance between education and service.

VII. EVALUATION

A. Resident

1. Formative Evaluation:

The faculty must evaluate in a timely manner the fellows whom they supervise. In addition, the training program must demonstrate that it has an effective mechanism for assessing trainee performance throughout the program, and for utilizing the results to improve performance.

Assessment should include:

- the use of methods that produce an accurate assessment of the fellow's competence in patient care, medical knowledge, practice-based learning and improvement, interpersonal and communication skills, professionalism and systems-based practice.
- the regular and timely performance feedback to fellows that includes at least semiannual written evaluations. Such evaluations are to be communicated to trainees in a timely manner, and maintained in a record that is accessible to each resident/fellow.
- the use of assessment results, including evaluation by faculty, patients, peers, self, and other professional staff, to achieve progressive improvements in the fellow's competence and performance.

2. Final Evaluation:

The program director must provide a final evaluation for each fellow who completes the program. This evaluation must include a review of the trainee's performance during the final period of education, and should verify that the fellow has demonstrated sufficient professional ability to practice competently and independently. The final evaluation must be part of the fellow's permanent record maintained by the institution.

B. Faculty

The performance of the faculty must be evaluated by the program no less frequently than at the midpoint of the accreditation cycle, and again prior to the next site visit. The evaluations should include a review of their teaching abilities, commitment to the educational program, clinical knowledge, and scholarly activities. This evaluation must include annual written confidential evaluations by residents.

C. Program

The educational effectiveness of a program must be evaluated in a systematic manner. In particular, the quality of the curriculum and the extent to which, the educational goals have been met by trainees must be assessed by the subspecialty program director. Written evaluations by trainees should be utilized in this process.