

REVIEW

DERLEME

**TRAINING STANDARDS FOR NEUROINTERVENTIONAL PROCEDURES REGARDING ENDOVASCULAR
TREATMENT AND SECONDARY ENDOVASCULAR PROTECTION OF ACUTE ISCHEMIC STROKE**

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ABSTRACT

Endovascular treatments for acute ischemic stroke have taken their place in evidence-based medicine. The implementation of this treatment, which is included in the guidelines, is only possible by increasing the number of neurointerventional specialists who have received sufficient training. In randomized controlled studies, experts who received adequate training to perform neurointerventional treatment were included. As the treatment of acute ischemic stroke extends to the first 24 hours after symptoms and patients with large infarcts are included in the treatment, the number of neurointerventional specialists who will apply this treatment must increase. A certain theoretical and practical training program has been organized to increase the number of interventional neurologists. In this article, educational pathways and standards for interventional neurologists are determined.

Keywords: Interventional neurology, stroke, endovascular.

AKUT İSKEMİK İNME ENDOVASKÜLER TEDAVİSİ VE İKİNCİL ENDOVASKÜLER KORUMASIYLA İLGİLİ

ALINACAK NÖROGİRİŞİMSSEL İŞLEMLERİN EĞİTİM STANDARTLARI

ÖZ

Akut iskemik inmede endovasküler tedaviler kanıta dayalı tıpta yerini almıştır. Kılavuzlara giren bu tedavinin uygulanması ancak yeterli eğitimi almış nörogirişimsel işlem ancak uzman sayılarının artırılması ile mümkündür. Randomize kontrollü çalışmalarda yeterli eğitimi almış nörogirişimsel tedaviyi yapacak uzmanlar yer almıştır. Akut iskemik inme tedavisinin semptom sonrası ilk 24 saate kadar uzaması, geniş infarktli hastaların tedaviye alınması sonucunda bu tedaviyi uygulayacak nörogirişimsel uzman sayısı artmak durumundadır. Girişimsel nörolog sayısını arttırmak için belli bir teorik ve pratik eğitim programı düzenlenmiştir. Bu makalede girişimsel nörologlar için eğitim yolları ve standartları belirlenmiştir.

Anahtar Sözcükler: Girişimsel nöroloji, inme, endovasküler.

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INTRODUCTION

Neurointervention is a specialty in the diagnosis and treatment of vascular diseases of the central nervous system, requiring clinical and technical expertise, and utilizing technology and neuroimaging modalities.

The training program for neuro-angiographic interventionists focuses on understanding vascular neuro-anatomy and neuropathophysiology, developing catheter skills, interpretation of multi-modality neuroimaging, decision-making during diagnostic and therapeutic procedures, and management of complications.

The institutions that address the standardization of training for neuroendovascular interventions and provide the certification system aim to train qualified neurointerventionalists. In particular, after the studies in 2015 in which the use of mechanical thrombectomy in cerebral arterial occlusions was proven in randomized trials, it was clearly demonstrated that mechanical thrombectomy has a clear role in the treatment of strokes with uncertain timing and late strokes (1,2). The number needed to treat (NNT) for a patient to benefit from endovascular treatment, meaning the number of patients who need to be treated for one to experience a positive outcome in order to live independently, is only between 4 and 8, as reported in this study (3). This excellent result in randomized trials also depends on the experience and quality of training of the neurointerventionalist. In recent years, thrombectomy has also been performed in patients presenting with large infarcts on neuroimaging.

The increasing adoption of neurointerventional procedures after their powerful therapeutic effect in stroke patients with large vessel occlusion has increased the rate of clinical application. However, it also led to the re-evaluation of the training standards of interventional neurologists (1,2). In recent studies, it has been reported that endovascular treatment of stroke patients with arterial occlusion, especially in patients with large infarcts, is more effective compared to the medical treatment group (4). Therefore, in the future, the demand for neurointerventionalists to work 24/7 in the treatment of acute stroke is expected to increase.

In the United States, the training of physicians who can perform neurointerventional

procedures is well-defined. The Accreditation Council for Graduate Medical Education (ACGME), the Society of NeuroInterventional Surgery (SNIS), the United Council of Neurological Specialties (UCNS), the American Association of Neurological Surgeons (AANS), the Congress of Neurological Surgeons (CNS), and the American College of Radiology (ACR) have issued guidelines specifying the number of diagnostic and interventional procedures required for adequate training (4-10).

In Europe, no formal certification system is available to set common standards for training and review them periodically. However, the European Union of Medical Specialists (UEMS) is the representative body of the National Associations of Medical Specialists in the European Union countries, and it sets standards of healthcare practice for neurointerventional procedures and encourages adherence to these recommendations (8).

In China, the training requirements for neuroentrepreneurs are set out in an official regulation issued by the Ministry of Health in 2012. This regulation requires a minimum of 2.5 years of full-time education to acquire competence in neurointerventional procedures. At least 9 months of this period must be spent in neurosurgery, neurology, and neuroradiology (5-11).

In Japan, the Japanese Society for Neuroendovascular Therapy (JSNET) developed a system for specialty qualification in 1997 and established an examination system in 2002 (7).

Training standards for interventional neuroangiographic procedures in various countries around the world are summarized in Table.

Each country needs to have its own criteria. The current conditions of the country, especially the number of trained neurointerventionalists who can meet the need for acute thrombectomy, may lead the way in determining the training standards. Türkiye currently defines criteria for the training of interventional neurologists. Various training pathways are available for interventional neurologists with a range of requirements. These training pathways are described below. Therefore, we have also realized the need to define guidelines regarding the training for "Interventional Vascular Neurology" in our country. In Türkiye, a

progressive certification and modular training system is applied for Interventional Neurologists' training. In the future, we plan to use distance education systems in training. Specifically, performing the interventional procedure and providing training on the procedure should be considered separately. Training centers should be high-volume centers in the modality they provide training, the responsible trainer should be highly experienced and have a superior level of knowledge, and the center should operate on a 24/7 basis and be managed by at least two neuroendovascular operators. Patient prognosis in high-volume centers with endovascular treatment of acute ischemic stroke is better than in low-volume centers. In randomized controlled trials, centers implementing endovascular treatment of acute stroke have a neurointensive care and stroke unit, and neurointerventionalists have a certain level of experience. Therefore, training in neurointerventional treatment should include

certain theoretical and practical knowledge. In particular, this article discusses the training (Certificate 1) in endovascular treatment of acute ischemic stroke and secondary endovascular protection (Figure 1). The present article does not include training regarding topics such as aneurysms, dural arterio-venous fistula, tumor and middle meningeal artery embolization, arteriovenous malformation, and spinal vascular diseases (Certificate 2) (Figure 2). However, the path that Interventional Neurologists need to take to obtain Certificate 2 is outlined in Figure 2. In determining the standards of the training to be received by interventional neurologists, the maximum criteria for thrombectomy application of neurointerventionalists in the Turkish Ministry of Health Stroke Communiqué were taken into consideration. In light of recent developments, the criteria for receiving training and the criteria for centers to provide training can be updated. Criteria are shown in Table.

Table. Training standards for neurointerventional treatments in various countries around the world.

	Recommended case volumes	Precondition Diagnosis	Duration of neuroangiographic training program
European training guideline (8)	100 endovascular intervention cases per year, 50 percutaneous spinal intervention cases per year For accreditation: 50 cases per year, spinal interventions or endovascular treatment of ischemic stroke		24 months specialized interventional neuroradiology training
Criteria for Training and Accreditation of the Spanish Society of Neuroscience (9)	Less than 100 therapeutic procedures: approximate numbers for certification are 25 cerebral aneurysms, 15 AVMs, 15 extracranial angioplasties and stent placement, 10 acute stroke treatments, 15 miscellaneous procedures (including intracranial angioplasty, venous vascular malformations, tumor embolization, etc.), five spinal endovascular procedures, 15 spine interventional procedures (vertebroplasty, kyphoplasty, or paraganglioma embolizations, biopsies, etc.).	Minimum 100 diagnostic cerebral angiograms	18-month advanced specialized training in neurointervention techniques
CAST and NESAC training standards (6)	250 interventional treatment procedures: 40 aneurysms, 20 intracranial embolizations, 25 intracranial or extracranial stents, 30 stroke treatments, 10 intracranial infusions, 10 extracranial embolizations, 5 spinal angiograms and embolizations	Minimum 200 cerebral angiograms	12 months of specialized neurovascular training after completing prerequisite training and 200 cerebral angiogram moments At least 2 years of training
CCINR Training guideline (7)	20 vascular reconstruction/ angioplasty (10 as primary), 10 cases of particle embolization (5 primary operators), 10 cases of liquid embolization (5 primary operators), 60 aneurysms: 20 aneurysms with remodeling/stenting (30 primary operators), knowledge of neurophysiological tests with 40 stroke cases		
Common criteria of SVIN and other associations (Society of Interventional Neurology)	Characteristics of the training center are defined rather than the training criteria of the operator.	In the audits, the operator must achieve at least 60% recanalization on the TICI 2b-3 scale, and the new irrigation area embolism must be less than 15%.	Two years of training after Neurointensive Care or Vascular Neurology Fellowship. Radiology, Neurology, and Neurosurgery were allowed to train in the joint association criterion.

CHAPTER 1

Training overview - Application requirements for Certificate 1

Certificate 1 includes certification in endovascular treatment of acute ischemic stroke and secondary endovascular protection in stroke

Prerequisites for eligibility for training:

Who can apply for certification?

1. To apply for the Interventional Neurology Certificate Program, candidates must have completed their neurology clinical specialty training and compulsory service.
2. Certificate 1 includes the training certificate in acute endovascular treatment of ischemic stroke, and endovascular therapy in secondary and primary stroke prevention (carotid stent angioplasty, vertebral, subclavian stenting and angioplasty, intracranial stenting).
3. The criteria for training centers for Certificate 1 are described in Chapter 2.
4. Neurologists who are to be trained for diagnostic and interventional procedures should preferably have previous experience in neurological intensive care and cerebrovascular diseases. The training period is 12 months without interruption for neurologists working as research assistants and/or specialists in centers approved by the Turkish Ministry of Health as Stroke Centers. Candidates are required to attach a document showing that they have worked in cerebrovascular diseases and neurology intensive care for at least 12 months. The training period (Certificate 1) is 15 months for candidates who do not work in the field of neurological intensive care and cerebrovascular diseases and who have not worked as a research assistant or specialist (at least 12 months) in the Ministry of Health Stroke Center. The responsible person of the training center may extend the training period for an additional three months (18 months). After completing the training, the candidate is entitled to receive certification upon success in the theoretical exam.
5. Apart from this training pathway, if the candidate interventional vascular neurologist is to be recruited as a second interventional neurologist to a center with an experienced

interventional neurologist (who has worked for at least 2 years after training) and if the candidate is to stay in the center where they receive training, they should receive at least 3 months of training in one of the centers designated as an interventional neurology training center by the Turkish Neurology Society (TNS) Interventional Neurology Working Group (INWG) and/or the Turkish Cerebrovascular Diseases Society (TCVDS) after being trained for at least 1 year in the center. The interventional neurologist responsible for the training at the approved training center may extend the training period if deemed appropriate. The candidate interventional neurologist can receive the certificate after working for at least 6 months after completing the training in the center where they are to permanently serve.

6. Another training pathway for the candidate is to receive training from trained and experienced neurointerventionalists in other disciplines who are not neurologists. If deemed appropriate by the INWG board of directors and/or the Turkish Cerebrovascular Diseases Society (TCVDS), an interventional neurologist candidate can receive training and certification in a center that is not an interventional neurology training center and does not have an Interventional Neurologist, provided that the following conditions are met.
 - a) Being trained under an interventional neuroradiologist or neurosurgeon who is accepted by INWG and/or TCVDS, and having at least 5 years of experience in neurointerventional procedures.
 - b) Having two neurointerventional specialists accepted by INWG and/or TCVDS in the center where they work.
 - c) After receiving training at the relevant center, the candidate must work continuously for at least 3 months at the training center where there is an interventional neurologist approved by INWG and/or TCVDS. The duration may be extended by the interventional neurologist responsible for the training.
 - d) The candidate's case report must be signed by the education officer responsible for neurointerventional procedures and the head of the INWG

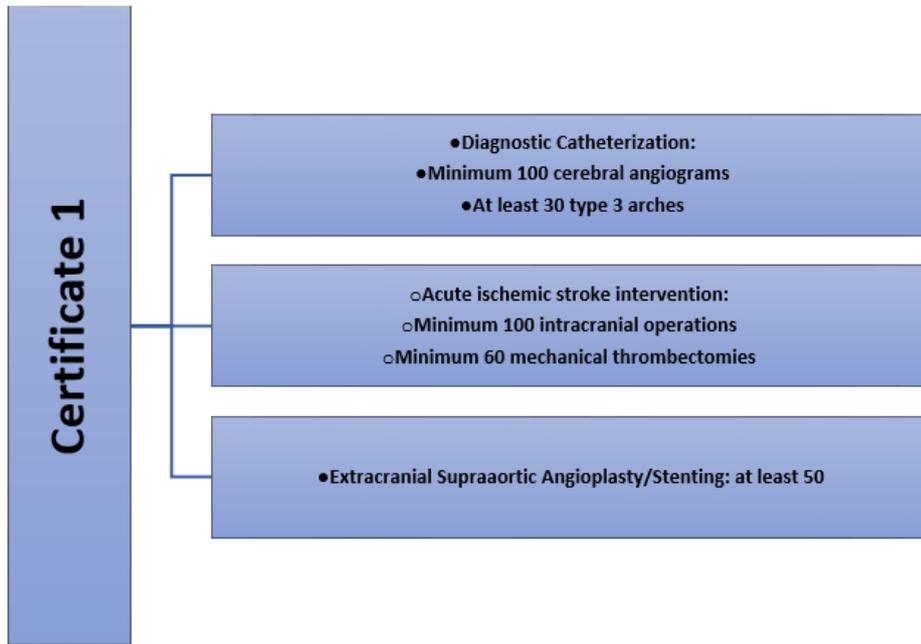


Figure 1. Certificate 1 (Acute ischemic stroke and endovascular prophylaxis of ischemic stroke) training standards.

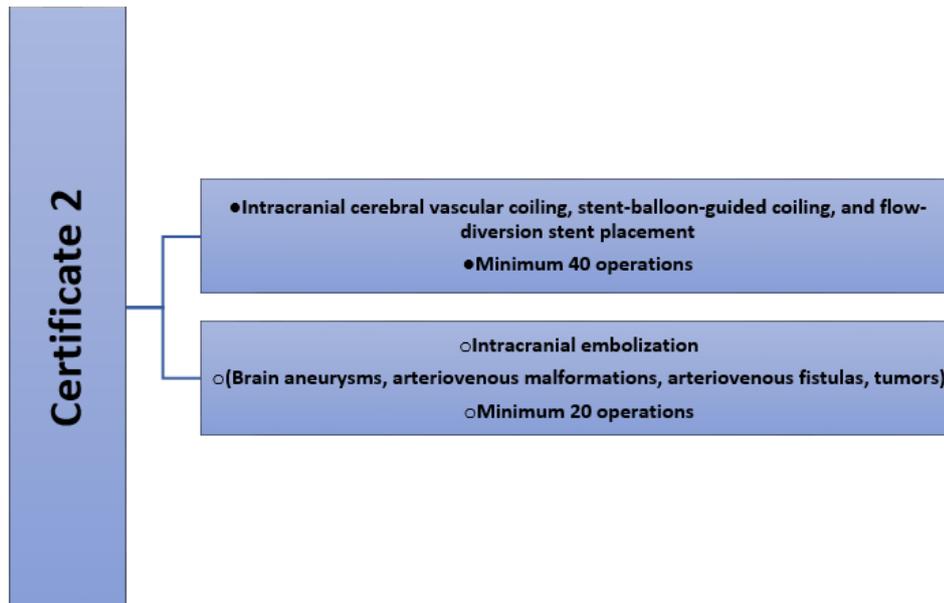


Figure 2. Certificate 2 (Hemarragic stroke, aneurysm, arteriovenous malformation, tumor and middle meningeal artery embolization) training standards.

- e) The candidate must have attended the theoretical modules of interventional neurology (Certificate 1) and passed the relevant theoretical exam.
7. The "Interventional Neurology Working Group" decides on the acceptance of the

applicant to the certification (Certificate 1) program. The candidate's employment in a city or region without a comprehensive stroke center is a priority criterion for admission to the program. However, the candidate's academic background, references, and

- proficiency in English are also crucial for the evaluation.
8. The training received by the candidate during the residency period cannot be considered in the entire certification program, however, the duration of interventional neurology training can be reduced in accordance with the above criteria. The training certificate is only awarded to post-specialty physicians.
 9. The applicant must submit a letter of intent and 3 letters of reference to INWG and/or TCVDS.
 10. As of 2023, specialists who intend to be certified in interventional neurology must take a written examination prepared by the examination commission established by the INWG and/or TCVDS. If the candidate passes the exam, the certification process is completed. All candidates must complete the modular system training before the exam. The certificate of attendance for the courses organized in the modular system must be submitted to the working group chair or training officer. Courses in the modular system are announced to candidates. Candidates are notified in advance of the subjects and courses for which they are responsible.
 11. Specialists who study abroad must have at least one year of training in "Interventional Vascular Neurology or Neuroangiography". In case the duration is less than 1 year, the training period within the certification program should be completed to 1 year in designated certification centers. After one year of training, the clinical and practical knowledge of the candidates is examined by the commission formed by the INWG and/or TCVDS "Interventional Neurology Working Group". Eligible candidates are entitled to receive Interventional Neurology Certificate if they are successful in the exam.

What are the minimum requirements for a candidate to take the certification exam?

1. The candidate must have performed at least 100 DSA procedures as a primary operator in the center where they received training. The DSA procedure includes carotid, intracranial, vertebral, and spinal diagnostic procedures.
2. The candidate must have participated as a primary and/or secondary operator in a total

- of 100 intracranial interventional procedures (at least 60 of which must have been mechanical thrombectomy).
3. The candidate must have participated in a total of 50 extra-cranial interventional procedures as a primary and/or secondary operator.
4. The candidate is required to submit the case report signed by the training supervisor to the head of the working group, showing the cases performed in the center in which the candidate received training.
5. The candidate must have submitted the certificate of attendance of the theoretical modular system courses attended to become an interventional neurologist to the head of the GNCB group and the education officer at the center where they work.
6. In order to obtain the certificate, the candidate must pass the theoretical exam organized by the working group. Candidates who pass the exams organized by associations such as EXMINT, ECMINT, and ESNR are exempted from the working group exam.

CHAPTER 2

Content, duration, and location of training programs for neuroangiographic procedures

In which centers can I get Certificate 1 training?

1. The main objective of training is to achieve the predetermined goals for the program. A combination of theoretical and practical applications should be provided to ensure competence.
2. The entire training program should be conducted in centers approved by TNS-IVNWG and/or TCVDS. The centers should have neurological intensive care units and be accredited as Stroke Centers by the Ministry of Health. The working group and/or TCVDS is responsible for the supervision of the centers.
3. All neurointerventionalists providing training must be approved by TNS-INWG and/or TVDS.
4. Training program requirements approved by the INWG and/or TCVDS must be met.

To become a training center, the following conditions must be met:

- a) At the training center, a minimum of 150 intracranial (100) and extracranial (50)

- neurointervention cases should be performed annually. The center must perform at least 80 thrombectomies annually.
- b) The center must perform at least 100 DSAs annually.
 - c) The Interventional Neurology training center must have at least 2 interventional neurology specialists. The center supervisor must be an experienced operator with at least 5 years of post-certification experience in neuroangiographic procedures. The second specialist in the center must have at least certificate 1 for neurointerventional procedures.
 - d) In the training center, one of the two operators can be an interventional neurologist and the other operator can be a Radiologist or Neurosurgeon. The instructor must be a radiologist performing neurointerventional procedures or an operator approved by the Neurosurgical Interventional Neurology Study and/or TBDHD. One of the operators must have at least 5 years of experience (including the period of training) in the relevant field. One of the operators can be a certified interventional neurologist.
 - e) Training centers are audited every two years by the GNCG and/or TBDHD.

After completing training in a training program approved by the GNCG and/or TBDHD, the specialist will be able to perform neurointerventional procedures in a clinically structured stroke center.

The aim of the training program approved by the GNCG is to equip the interventional neurologist candidate with the necessary qualifications by providing the following attributes:

- a) Acquiring knowledge of basic and clinical neuroscience (neuroanatomy and anatomy for the head, neck, spine, cranial and peripheral nerves, neuropathology and biology of neurological disorders, understanding their natural history and course).
- b) Development of skills necessary to independently perform, decide, and interpret common therapeutic and

- diagnostic neurointerventional procedures.
- c) Gaining experience and awareness of treatment risks and complication management. Having the theoretical and practical knowledge to manage the complications that will arise in endovascular treatment of acute stroke and secondary prophylaxis of ischemic stroke.
- d) Expanding the cognitive abilities and communication skills necessary to establish healthy communication with patients and family members regarding the management and planning of neurointerventional procedures, to ensure communication with physicians and other health personnel in the referral chain, and to ensure the management of the referral system.
- e) Complete training in Neuroanatomy and Neurovascular Embryology, anatomy of the head, neck, and spinal region with a special focus on arterial and venous functional anatomy, neurovascular neurobiology, neurophysiology, neuropathology, neurovascular regulatory mechanisms and pathophysiological theories, neurovascular diseases
- f) Recognizing stroke diagnosis, treatment, primary secondary prevention strategies, stroke etiology, pre-hospital and in-hospital acute stroke organization
- g) Knowing neuroimaging modalities used in diagnostic and therapeutic neurointerventions (CT, MRI, ultrasound, DSA, etc.)
- h) Acquiring knowledge of clinical pharmacology to enable the interventional neurologist trainee to use various pharmacological agents (antihypertensives, vasopressors, antiepileptics, analgesics, sedatives, vasodilators, anticoagulants/antiplatelets, thrombolytics, etc.) for each operation.
- i) Completing their education through active participation in seminars or programs on radiation physics and biology of image-guided modalities in both diagnostic and therapeutic neurointerventions, and safety and protection protocols for patients and staff in accordance with

national laws regulating the use of medical radiation (e.g. Turkish Atomic Energy Authority Radiation Protection Training)
 In summary, the objective of the training

program approved by the INWG and/or TCVDS is to enable qualified physicians to create an appropriate diagnosis, treatment, and follow-up algorithm by making use of the above-mentioned knowledge and experience (Figure 3).

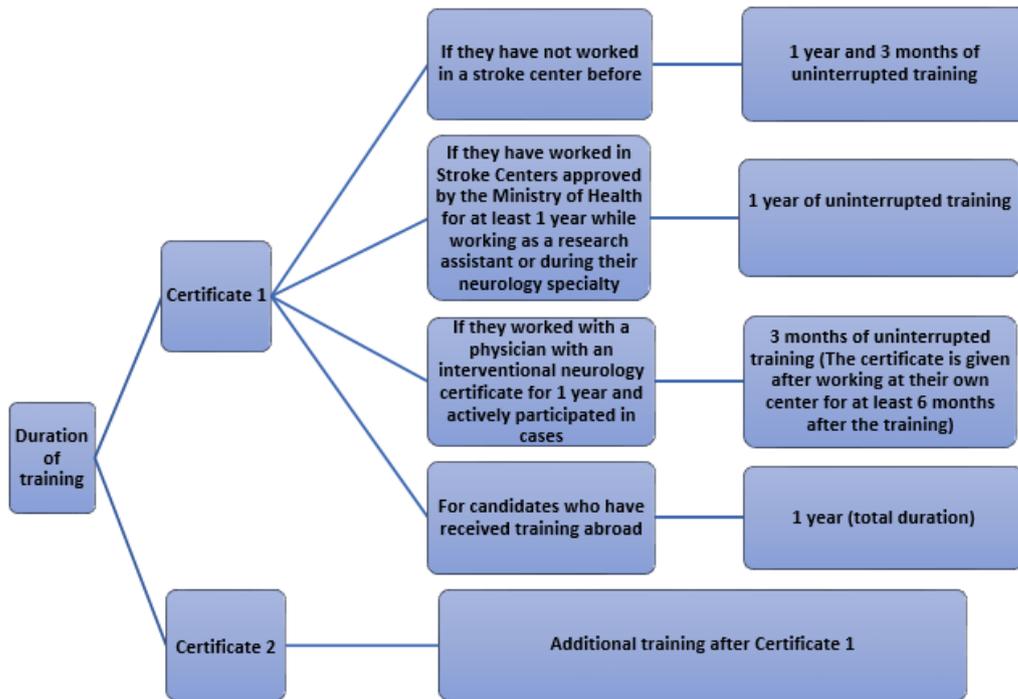


Figure 3. Time required to obtain interventional neurology certification and alternative training strategies.

Responsibilities of the program director:

The program director should have at least 5 years of post-certification experience in neurointerventional procedures. The program director, in consultation with other training officers, should assess the qualifications and progress of each candidate at least twice a year, with comprehensive assessment reports to be submitted. Assessment includes evaluation of the candidate’s medical knowledge, technical skills, attitudes and interpersonal relationships, decision-making, and clinical management. The program director should manage the program, supervise the faculty, and ensure that the conduct of the program meets the requirements of the GNCG or other required national academic standards. The director should use a case report based on patient information, including

documentation of patient images where necessary. After reviewing and revising the data submitted by the candidates, the program director approves it and submits it to the INWG board for approval. The program manager should also be able to use e-proctorship/e-learning strategies to perform the required number of procedures remotely after training using the latest advances in technology (12-14).

CHAPTER 3

How will the certification exam for neuroangiographic procedures be conducted?

The Certificate Examination System is a technology-driven platform created, maintained, and updated by GNCG to simplify graduation final exam activities, including defining exam patterns

with question banks, objective/subjective question sections, and execution. The exam is conducted in a paperless electronic environment using computers or mobile devices. Candidates can take the exam using any desktop, laptop, or mobile device. The theoretical exam might be expanded by combining simulation and newly developed technological tools in the future.

CONCLUSION

The training recommendations for neuroangiographic interventions establish a standardized and structured model. This enables physicians to perform neurointerventional procedures safely and effectively.

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Ethics

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