Neurointerventional Training for Neurosurgeons: Past, Present, and Future

Girish Rajpal[1]

[1]Department of Interventional Neurology, Max Hospital Patparganj and Vaishali, New Delhi, India

Address for correspondence Girish Rajpal, MCh (Neurosurgery), Head–Interventional Neurology, Max Hospital Patparganj and Vaishali, New Delhi, India (e-mail: drgirishrajpal@live.in).

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Abstract

Endovascular therapy as any other specialty has continuously been developed since 1904, but acceptability among neurosurgeons remains low despite being other subspecialties and techniques, like endoscope and for that matter microscope also, being adopted very rapidly. From injecting particles for vascular lesions to balloons for fistulas and arteriovenous malformations and embolizing agents to detachable coils for aneurysm coiling, it has come a long way. Old generations of neurosurgeons used to perform carotid puncture for diagnosing mass lesions, but once CT/MRI came in to the picture, this procedure was stopped and handed over to radiologists. A debate continues among neurosurgeons about the feasibility of aneurysm coiling since international subarachnoid aneurysm trial (ISAT) and doubts about the long-term efficacy of this novel treatment cost a subspecialty. With the recent addition of endovascular treatment of stroke and long-term efficacy of endovascular treatment of aneurysm, there is a lot of debate among clinicians and nonclinicians about who will be the true heir of this sub specialty.

Keywords
- cerebral angiogram
- DSA
- neurosurgeons
- neurointervention
- training
- aneurysm coiling
- stroke

History (Past)

The year was 1926, when Egaz Moniz, a Portuguese neurosurgeon, visualized blood vessels in the brain with radiographic means using strontium and lithium bromide initially and 25% sodium iodide solution later on, developing the first cerebral angiogram.[1] But long before that in year 1904, James Dawbarn, again a surgeon, injected beeswax mixture into the branches of external carotid artery for head and neck malignancies after surgically exposing them.[2] Surprisingly, therapeutic neurointerventional development took precedence over diagnostic cerebral angiogram during the early days; long before Serbinenko,[3] Russian neurosurgeon introduced detachable balloons in 1971 for treatment of traumatic carotid cavernous fistula (CCF) and saccular aneurysms. It was Brooks[4] in 1930 who described embolization of CCF by muscle pieces.

The year 1953 was the year that one may consider to be a watershed point in the history of neurointervention (NI) when Dr. Sven Seldinger, a Swedish radiologist, developed a percutaneous arterial puncture technique using a needle and wire.[5] The first use of catheters for cerebral angiography is credited to another Swedish radiologist named Stig Radner,[6] who, way back in 1947 while trying to catheterize coronary vessels through radial artery, accidently cannulated vertebral artery and performed cerebral angiography. Both these innovations opened up numerous possibilities in the field of NI, but neurosurgeons ignored these advances and hence most of the neurosurgeons world over continued to perform diagnostic cerebral angiography via carotid artery with direct needle puncture and radiologist catheter-based cerebral angiography via Seldinger technique.[7] Although over the next decade or so—till the invention of computed tomography (CT) in 70s and subsequent diagnosis of brain lesion by CT when neurosurgeons all together completely stopped doing even carotid punctures and radiologists promoted themselves from film changers and readers to interventionists—little progress was made in the field of arteriovenous malformation (AVM) apart from embolization by Luessenhop and Spence[8] by exposing internal carotid artery and injecting methacrylate spheres, and Alskne and Fingerhut,[9] who stereotactically inserted needle and directed iron particles into an aneurysm via magnetic field. Meanwhile, radiologists gained experience with catheter-based angiography, and

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Boulos et al[10] embolized brain AVMs from a catheter in the internal carotid artery. Similarly, Newton and Adams[11] treated spinal cord malformations. Kerber and Pevsner[12] independently developed silicone microcatheter which was used in 1974 to embolize occipital AVM. Although Serbinenko[3] had already published his study of detachable balloon for treatment of CCF and aneurysms in 1971, by that time European radiologists already took the world stage in NI. Djindjian[13] was the most famous in those times as he imparted training to neurointerventionists of France and other countries.

In 1991, Guido Guglielmi,[14] an Italian neurosurgeon, and Ivan Sepetka developed detachable platinum coil for the endovascular treatment of aneurysm, changing the course of vascular neurosurgery for years to come; however, again, neurosurgeons across the world remain skeptical regarding this novel treatment modality even when ISAT[15] was started in 1994 and published in 2002. It was not that the coils were not used before but the unique concept involved redesigning and controlled detachment of coils unlike the pusher and free coils developed by Hilal.[16] Also, what was missed in all these years of hardware development was a contribution by an engineer named Engelson in 1985 at Target Therapeutics who invented a variable stiffness microcatheter with radiopaque marker at the tip along with a steerable microguide wire.[17] In subsequent years, endovascular aneurysm treatment technique and technology advanced at a rapid pace from different modifications of coil for better packing density of aneurysm to balloon remodelling technique[18] and stent-assisted coiling for wide neck and broad-based aneurysms. Most of the aneurysms considered uncoilable before are now being treated with latest devices like flow diverter device[19] and intrasaccular devices.

The year 2015 was the most impactful year in the history of the neuroendovascular field as numerous trails[20-22] confirmed the benefit of mechanical thrombectomy over intravenous actilyse alone among patients afflicted with acute ischemic stroke with large vessel occlusion. Again, as in previous years, basking in the glory of newer successful modality, more techniques and hardware, right from thromboaspiration catheters and newer stent retrievers to balloon-guide catheters, were being developed to make this form of treatment more successful. In 2018, with DAWN[23] and DIFUSE 3[24] trials, a treatment window for mechanical thrombectomy was extended from 6 hours to 24 hours in a selected group of patients. Although Guglielmi was known for his contribution of coils in aneurysm treatment, one of his lesser known, but arguably his biggest contribution was intra-arterial therapy in acute ischemic patients way back in 1991.

In India, neuroradiologists played the primary role of neurointerventionist in most public institutes, except a few. The G.B. Pant Institute, Delhi, is one where neurointervention is part of the training of neurosurgical resident by virtue of the vision of Prof. A. K. Singh. Prof. Daljit Singh is currently training the next generation of neurointerventionists among neurosurgeons (the subsequent history of NI in India is through personal communication with Dr. Anil Karapurkar).

All departments of neurosurgery did their own diagnostic neuroradiology until the advent of CT scan which became available in 1978 at AIIMS and at Mumbai in 1982.

Diagnostic neuroradiology included plain radiography, ventriculography, cerebral angiography, myelography, and PEG (pneumoencephalography). Cerebral angiography was carried out by the percutaneous puncture of the carotid artery in the neck.

At KEM Hospital and Seth G S Medical College, Mumbai, transfemoral cerebral angiography was started in early 1976. NI was started in a small way in 1977. Dr. Sunil Pandya, Professor and HOD neurosurgery, performed the first procedures. Subsequently, Dr. R. D. Nagpal and Dr. Anil Karapurkar also started conducting NI procedures. After there was a serious complication, it was decided to go for formal training in NI.

Karapurkar was deputed by the Bombay Municipal Corporation for undergoing training in France. He was also provided financial support by the R D Birla Smarak Kosh of Bombay Hospital. His training tenure in France lasted from September 1980 to March 1981. In this period, 2 months were spent at The Hospital Foch in Suresnes for trans-sphenoid surgery under Prof. Gerard Guiot, 2 months under Prof. Bernard Pertuiset at the Pitie Group of Hospitals, Paris, for microvascular surgery, and under Prof. Luc Picard at the University Hospital, Nancy, France for NI (interventional radiology [INR]). Prof. Luc Picard had been trained by Prof. Rene Djindjian. They were the pioneers and doyens of neurovascular intervention worldwide.

Immediately thereafter, Karapurkar also spent 3 weeks as an observer at the University Hospital London, Ontario, under Prof. Gerard Debrun in April 1981. Here he observed a complication, the management of which served him well throughout his career. The complication was a microcatheter stuck in a distal branch of the posterior cerebral artery. It was managed by performing an angiogram from the other femoral artery to confirm robust circulation. The catheter was then cut in the groin and left behind. In 1987, under the Indo-French Exchange Program (FIAP), Karapurkar underwent further training under Prof. Picard at Nancy and Prof. J M Moret of Fondation Ophthalmique de Rothchilde, France. In 1985, he conducted live workshops with operations and didactic lectures for neuroscientists and radiologists from across India. Live operations were telecast from the cath laboratory to the auditorium for the first time with two-way live communications. Dr. N. K. Mishra, Professor of neuroradiology at AIIMS, had attended this first of its kind of workshop in India. Prof. R. V. Phadke, who later became HOD neuroradiology at SGPGI Lucknow, had his first exposure to NI. Prof. Luc Picard of Nancy, France, was the guest faculty. In 1991, he underwent a 1-month observership under Prof. J. M. Moret of Rothschilde Ophthalmic Hospital, Paris, (Fondation Ophthalmique de Rothchilde). From 1989 to 1994, Dr. Ravi Ramakantan, Head of the radiology department, would sometimes assist in brain AVM procedures. Until 1993, only neurosurgery residents were being trained in NI. From 1993, the department of radiology deputed a

resident for exposure in NI. In 1994, Dr. Uday Limaye, Lecturer in radiology joined for training in INR.

After Karapurkar took voluntary retirement from KEM Hospital, Seth GS Medical College in 1996, Limaye took over NI at KEM Hospital with the strong support of Prof. S. K. Pandya, HOD neurosurgery. Subsequently, he built up the best department of NI in the country. He trained several radiologists and clinicians in the art and science of NI.

Karapurkar moved to Indraprastha Apollo Hospital, New Delhi, and worked there from 1996 to 2002. He trained Dr. Harsh Rastogi, Radiologist, who continues to provide NI services to the Apollo Hospital.

In 2002, Karapurkar moved back to Mumbai. He worked from 2002 to 2007 at Bombay Hospital, 2007 to 2011 at H N hospital, and 2009 onwards till date at Breach Candy Hospital.

From 2002 onwards he trained several neurologists, neurosurgeons, and radiologists. There was a 3-month observership program which ran from 2002 to 2010. Since 2008, Fellows are being taken for training in NI with the training period being 2 years. Dr. Anand Alurkar, Neurologist, who trained from 2002 to 2003 has been training neurologists since many years.

He trained many radiologists, neurologists, and neurosurgeons Later on, Dr. Shakir Hussain in 1999 trained at Zurich under Prof. Anton Valavanis who began NI in Delhi. Both of them started training young generations of neurosurgeons and neurologists in neurointerventional procedures but it was slow, painful, and, during those times, difficult to convince fellow clinicians to take NI as fulltime specialization.

NI was being practiced in the late 70s at only three places in India—KEM Hospital & Seth GSMC, Mumbai, Dr. V. R. K. Rao at Sri Chitra Thirunal Institute, Trivandrum, and Dr. N. K. Mishra, AIIMS, Delhi. At NIMHANS Bangalore, NI started in the late 80s. Other institutions such as PGI Chandigarh, SGPGI Lucknow started in the nineties and thereafter. SRMC, Chennai, under Prof. Santhosh Joseph started post 2002. In 1987, Prof. B. Y. T. Arya of NIMHAS, Bangalore, went to Nancy in order to undergo training under Prof. Picard. Dr. Jayakumar, also of NIMHANS, went to Nancy in the late 80s. Prof. V. R. K. Rao was also supposed to go to Nancy but could not because of some problems with visa.

Although there is lot of noise among young neurosurgeons regarding NI today, one cannot ignore the fact that NI's present form is because of some of the pioneering work done and dedication shown by neuroradiologists like Prof. Lasjaunias, Prof. Jacques Moret, Prof. Laurent Pierot, and Prof. Anton Valavanis who not only contributed to techniques and technology but also trained future generations of neuroscientists across continents, without any bias between neurosurgeon, neuroradiologist, or neurologist.

Conflict (Present)

Considerable progress has been made in NI in the last decade than in any of the previous years. Many neurosurgeons now, especially the young, have got attracted to this branch as a promising career option or addition to their neurosurgical skills. In India, neuroradiologists or personnel with radiology background constitute the major work force, approximately 60%, in NI, followed by neurosurgeons (30%), and neurologists trained in neuroendovascular procedures (10%). Although these demographics are changing rapidly with increase in number of neurosurgeons and neurologists, the majority are either not trained or are "fly by night" or "one night" neurointerventionists being proctored by nonmedical industry people driven by market forces, ignoring the fact there is human cost involved in this. It is like clipping an aneurysm without knowing how to do proper craniotomy, forgetting that minimally invasive nature of treatment cannot reverse or decrease the severity of pathology. Adding to this already constrained space, of which approximately 15 to 20% of all neurosurgical cases constitute vascular cases,[25] cardiologists calling themselves "neurocardiologist" are also pitching in with reasons like already trained in hardwares of catheters and wires. This statement has two flaws: one may be that a cardiothoracic surgeon, or for that matter any surgeon, trained to handle scalpel can become a neurosurgeon by the above logic and second, principle of modern medicine is based on imparting knowledge of specialty-wise pathology and treatment rather than studying the hardwares.

The biggest advantage of neurosurgeons, learning both clipping and performing NI, is also its biggest disadvantage, according to me. Although decision-making to clip or coil may be easy or sometimes biased also, but still because of alternative option to clip, mastering to coil may be hampered, and hence majority end up being both clipper and coiler—a hybrid neurosurgeon—which is the increasing trend. In public sector hospitals or institutes, it may be possible to do so, but in private I do not think one can have sufficient patients to justify being able to do clipping and coiling equally good. The only advantage, according to me, of being a neurosurgeon doing NI is to provide a honest and unbiased opinion about the mode of treatment. But NI in today's world is not coiling only; it is way beyond that and to become a fulltime neurointerventionist in itself is a satisfying opportunity.

Neurointerventional Training (Future)

The best way to train is to include NI as a part of neurosurgical residency training. But given the current situation, most of the institutes lack this facility to train neurosurgical trainees. Therefore, as a starting point, at least rotational posting in the neuroradiology department could be made compulsory for cerebral digital subtraction angiography (DSA), which will prove to be a herculean task. As a matter of fact, this will give future neurosurgeons some idea whether to pursue the dream or goal of NI, instead of following the herd mentality of glamorous and upcoming subspecialty. There are numerous guidelines from different societies regarding how to train future generations of neurointerventionists. Most of the societies agree on starting with a minimum of 100 cerebral angiograms as first

operator before starting with NI procedures based on Connors review of cognitive and technical demands of cervicocerebral angiography.[26-28] Then, there is the duration of training from a minimum of 12 months to 24 months.[27] The duration of the training period of 2 years is endorsed by both Indian bodies of NI, namely, Society of NeuroVascular Interventions (SNVI) and Society of Therapeutic NeuroIntervention (STNI) along with requisite numbers of procedure. Most of the Western societies asked to prolong the training period if the trainee did not complete the defined number of procedures.

A month back, I conducted an informal survey among neurosurgeons to determine the duration of NI training post M.Ch. Although the result varied from 15 days to 2 years, but the majority agreed on at least a year of structured training.

Along with duration of training and number of procedures needed to train, there is one very important aspect which both these societies forget to mention in their draft training module, that is, radiation safety which is among the poorest in clinicians. Also, there should be a minimum standard of equipment required to perform NI like flat panel high resolution image intensifier cath laboratory, with road map fluoroscopy, and, if possible, simultaneous real-time unsubstracted flouroscopy and three-dimensional rotational angiography with on-spot CT (dyna CT for Seimens and XpertCT for Philips) facility.[29]

Conclusion

Competency in NI involves learning the tools and techniques which are different than what we learned as neurosurgeons. One needs time, discipline, and devotion to this field. A neurosurgeon is aware of the high-level of skill, responsibility, and burden that comes along with clipping an aneurysm; being a neurointerventionist does not lower the moral obligation to this dreadful pathology. Although the learning curve for coiling may be shorter but one needs to be a lifetime student in NI to master the finesse of endovascular neurosurgery.

Conflict of Interest
None declared.

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