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Neurosurgery in India: An Overview

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This overview of neurosurgery in India during the last six decades gives a holistic perspective of the phenomenal advances made. Neurosurgical education, the change in clinical spectrum of diseases and their presentation, evolution of various subspecialties and societies, the state of research, the issues peculiar to India, including the urban–rural health divide, the increasing role of information and communication technology in neurosurgery, and the gradual but definite global recognition of Indian neurosurgery will be addressed.

INTRODUCTION

India, where every sixth human on *Terra firma* resides, is indeed a paradox. We can plant a flag on the moon and convince NASA that water is available there. We have 920 million mobile phones with mBanking, mEntertainment, and mCommerce growing exponentially. At the same time, we have a long way to go to achieve the minimum norms prescribed by the World Health Organization in the field of health care. Although considered an "emerging economy" and a potential superpower, we are still a developing country, as exemplified by our low gross domestic product and per-capita income.

This diversified scenario can be extrapolated to neurosurgery as well. It is a matter of justifiable pride that today, with 15 to 20 outstanding centers of excellence, no Indian needs to go overseas for any type of neurosurgical management. We have robotic radiosurgery, robots for telestroke care, deep brain stimulation (DBS), facilities for clipping giant basilar artery aneurysms under cardiac arrest, the ability to perform the most complex multidisciplinary skull base surgery, preserve hearing in acoustic schwanomas, and deploy neuroendoscopy and intraoperative magnetic resonance imaging (MRI). However, these state-of-the-art facilities are few and far between. A total of 800 million Indians living in suburban and rural India still have very limited direct access to even primary general neurosurgery because most of the 1800 neurosurgeons live in urban India. Chennai (Madras), with a population of 9 million, has 110 neurosurgeons, which is also the number of neurosurgeons catering to 250 million in North Eastern India.

SOCIETIES

"Audacious" would best describe Jacob Chandy, B. Ramamurthi (**Figure 1**), S. T. Narasimhan, and Baldev Singh, when, undaunted, they formed the Neurological Society of India (NSI) in 1951. A combined society of all those who were working in neurosciences was their dream. Today, with a membership of 2565, including 1983 in the neurosurgical section (including residents), 518 neurophysi-

Key words
- History of Indian neurosurgery
- Neurosurgery in India

Abbreviations and Acronyms
AVM: Arteriovenous malformation
CME: Continuing medical education
CT: Computed tomography
DBS: Deep brain stimulation
ICT: Information and communication technology
MRI: Magnetic resonance imaging
NSI: Neurological Society of India
OT: Operating theater
PET: Positron emission tomography
WFNS: World Federation of Neurosurgical Societies

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cians, and 59 from the allied sciences, the NSI is the hub from which other societies have grown. The NSI was the first professional society in India to start a formal continuing medical education (CME) program as early as 1977. In 1997 during the author's tutelage as Secretary, NSI became the first professional society in India to have its own website. The quarterly newsletter has since become totally electronic, and the society is on its way to becoming "paperless," including e-Elections and e-Communications. The journal of the NSI, *Neurology India*, was one of the first journals in the world to make available the full text electronically and even on a mobile platform The impact index of *Neurology India* is increasing steadily, as are its overseas contributors.

In 1992, the Indian Academy of Neurology was born. Subsequently, many more societies were started, including, among others, The Skull Base Surgery Society of India, the Indian Society of Cerebrovascular Surgery, Indian Society for Stereotactic & Functional Neurosurgery, Neurotrauma Society of India, Pediatric Neurosurgery Society of India, Neuro Oncology Society, Neurosurgical Society of India, Neuro Spine Society of India, Association of Neuroradiologists, Society of Indian Neuro Nurses, and the Indian Society for Study of Pain. The NSI continues to be the grandmother society, emphasizing that even in the era of super subspecialization, a holistic view of the nervous system, from the balcony, is still important.

NEUROSURGICAL EDUCATION

The first informal training program in neurosurgery in India commenced at Madras in 1956. In 1961 Dr. K. V. Mathai became the first to get an M.S. Neurosurgery degree in the country, from the Christian Medical College, Vellore. In 1968 Dr. T. S. Kanaka became the first woman in Asia to qualify as a neurosurgeon from the Madras Institute of Neurology. Now, 45 years later we have approximately 1800 neurosurgeons (including about 25 women) for 1200 million people. Of the 330 approved medical colleges, only 59 have neurosurgical departments recognized for an MCh Neurosurgery training program, with an approved intake of 190 per year. The duration of the course varies from 3 years for candidates who have a master's degree in general surgery or 5 or 6 years for those with an MBBS degree (ie, the basic medical degree obtained after 5.5 years after 12 years of schooling).

Recognizing the acute shortage of doctors and specialists, the erstwhile very stringent criteria for accreditation for postgraduate training recently have been relaxed. Retirement age in national institutes is 62 years of age (likely to be made 65) in private medical colleges 70, and in most states 60. Each recognized "teacher" can take two new candidates every year for training. This potential for an exponential increase in training brings with it major challenges in maintaining a high, uniform quality of training. The National institutes (All India Institute of Medical Sciences New Delhi, National Institute of Mental Health and Neurosciences Bengaluru, Postgraduate Institute of Medical Education and Research, Chandigarh, Shree Chitra Thirunal Thiruvananthapuram, and Sanjay Gandhi Postgraduate Institute of Medical Sciences Lucknow) have an excellent system of training. A trend in the last 15 years has been the increasing availability of tertiary neurosurgical facilities in the private sector. Thirty-two such institutions, including corporate hospitals, trust hospitals, and large nursing homes, are now accredited for neurosurgical training. Forty-two candidates can be selected every year. Approximately 30 candidates (57% of those appearing) qualify for the national board certification every year. A total of 140 new neurosurgeons per year, including MChs from universities, is obviously woefully inadequate for India.

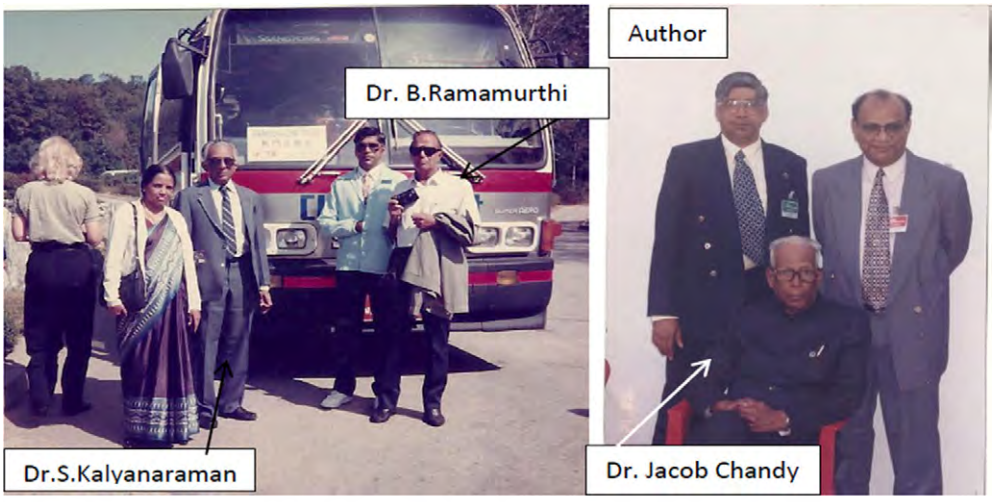

Figure 1. Drs. Jacob Chandy and B. Ramamurthi, founders of Indian neurosurgery. Dr Kalyanaraman, a pioneer in development of stereotactic surgery.

Although state-of-the-art corporate hospitals like Apollo and Hinduja, which are accredited for residency programs by the National Board of Examinations, are well equipped and have no dearth of clinical material, there are limitations in opportunities for residents training here for actual "cutting and stitching." Residents at state medical colleges, which have postgraduate training programs, receive more hands-on exposure, but the facilities available and the background of the teaching personnel vary. Kalyanaraman (**Figure 1**) was the first Indian neurosurgeon to obtain a PhD as early as 1964 from the University of Edinburgh. This was not only the first PhD in neurosurgery in the United Kingdom but perhaps the first in stereotactic surgery worldwide. Today there are still only about 25 PhDs in neurosurgery in India. During the last 15 years, several multiauthored compendiums on neurosurgery, operative neurosurgery, and other related disciplines have been published. New journals are also appearing. A 2-/3-year Doctor of Medicine degree in neuroanesthesia, neuropharmacology, and other niche areas are now available in addition to fellowship training programs, including but not limited to neurocritical care and functional neurosurgery. Publication and presentation of papers is a prerequisite for all exam-taking residents. Realizing that unlearning and relearning is critical, state medical councils are introducing mandatory CME credit hours.

CONFERENCES

Every week somewhere in India there is a workshop, seminar, or conference on some aspect of neurosurgery. Many of these include cadaveric dissections and computer-based simulations. Following the 9th congress of the World Federation of Neurosurgical Societies (WFNS) held in Delhi in 1989, international conferences are now being held periodically in India. Annual conferences of the NSI now include joint meetings with overseas associations like the Congress of Neurosurgeons, Italian Society, German Society, and so on. After the 1989 WFNS conference, the WFNS (I) Trust was constituted, with the savings of US$160,000, because the Government of India regulations at that time did not permit repatriation of funds outside India. The trust, with Prof A. K. Banerji as Hon Secretary, has been doing yeoman service since. In the last 12 years alone, 75 conferences have been supported in India. Partial travel assistance was given to 377 for attending conferences (200 overseas) and to 30 for overseas training. Seven neurosurgeons from different countries were given assistance for training in India.

RESEARCH AND PUBLICATIONS

The NSI was the first specialist medical society in India to start its own medical journal—*Neurology India*—in 1953. It is a paradox that although we are overwhelmed with clinical material (or perhaps because of this) Indian neurosurgery has not imbibed in the "publish-or-perish" western culture. Barring the national institutes, many centers just do not have the wherewithal to meticulously document, retrieve, analyze, and follow up the large number of patients treated. As an illustration, the author has since 1995 treated approximately 400 cases of cerebral arteriovenous malformations (AVMs) with linear accelerator (i.e., ~~linac~~)-based radiosurgery and subsequently with the CyberKnife (**Figure 2**; Accuray, Sunnyvale, California, USA). However, not many publications have ensued.

Hopefully in the ensuing digital era, it will be possible for many younger neurosurgeons to start publishing. At least 25 intercontinental, phase 2 and phase 3 multinational research projects are currently ongoing. These include several in the private sector, eg, the CRASH (Corticosteroid Randomization After Significant Head Injury) trial, intratumoral drug delivery for recurrent gliomas, role of endoscopy in infantile aqueduct stenosis ^{131}I-tagged monoclonal antibody instillation into glioblastoma multiforme, and the Surgical Trial in Intracerebral Haemorrhage (STICH) trial for intracerebral hemorrhage. The National Brain Research Centre at Delhi, the Indian equivalent of the National Institute of Neurological and Communicative Disorders and Stroke, is a very well-equipped center for fundamental research in neurobiology, providing teachers and human resources for research as well.

CLINICAL NEUROSURGERY

A clinician par excellence, it is in the DNA of the neurosurgeon in India never to discount history and observations of the patient and the family. In these days of evidence-based medicine and protocol-driven guidelines, the pressure to keep up with the Joneses with the use of technology is very high. However, we still believe that customized management for the individual patient is the sine qua non of neurosurgery, not placing the patient in an appropriate algorithm. It is not just patient survival, but at what cost—financial, emotional, and quality of life—that is equally important. Harvard Business School, citing examples of decisions taken by Fortune 500 CEOs, concede that there is still a place for emotional intelligence. "Gut feeling" sometimes scores over sophisticated business analytics, and we believe that this is often so in neurosurgery. I started my residency in 1975 injecting air into the lumbar cerebrospinal fluid to diagnose brain tumors. The journey from the BC (Before Computers = Before Christ) era has been fascinating and mind boggling. In just four decades, under-

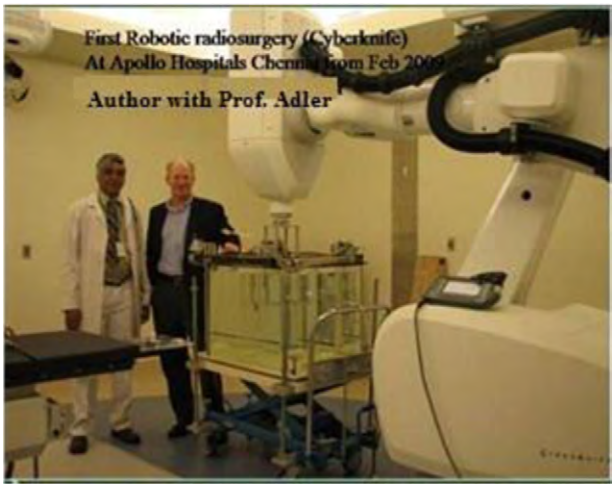

Figure 2. First CyberKnife procedure in South Asia.

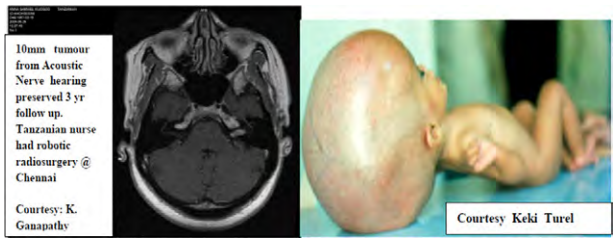

Figure 3. Clinical examples.

staffed, overcrowded wards dealing primarily with infections (tuberculomas, cysticercosis), head trauma, and giant tumors are giving way to state-of-the-art neurosurgical units.

The spectrum of diseases and the clinical presentation also has changed dramatically. Aneurysms and AVMs are no longer uncommon. They are often discovered before they bleed. Neurosurgical complications of lifestyle and noncommunicable diseases like hypertensive intracerebral hematomas and infarctions producing a mass effect are steadily increasing. Postcardiac surgery drug-induced intracerebral hemorrhage and subdural hematoma are now frequently occurring. With increasing longevity and better oncology services, metastasis in the brain are less uncommon. In the 1980s, acoustic schwanomas used to present with intracranial tension and cranial nerve deficit. The use of shunts was routine for posterior fossa tumors. Today they are being discovered at the intracanalicular stage (**Figures 3** and **4**), with the patient's hearing preserved!

In urban India, patient expectations have increased tremendously. Postoperative facial weakness is unacceptable. Ventriculograms, carotid angiograms, and myelograms have been replaced with functional MRI, magnetic resonance tractography, and magnetic resonance spectroscopy. Stereotactic biopsies from the brain stem and even excision of appropriately selected brain stem gliomas is available in many units. Surgeons in most tertiary neurosurgical centers are very busy performing 1300 to 1800 major operative procedures annually. The All India Institute of Medical Sciences, in New Delhi, has the largest neurosurgery department in the country, with 18 faculty members and 45 residents. More than 3000 procedures are performed per year. Despite this, the waiting time for an elective neurosurgical procedure in a national institute could be as long as 6 to 12 months. Although there is almost no waiting time in private hospitals, the lower-income group cannot afford the cost, although it is a fraction of the international cost—with similar outcomes.

OPERATING THEATERS (OTs)

Although there may still be a few OTs without a microscope, most OTs, particularly in the cities, are becoming better equipped. Intraoperative navigation, intraoperative depth electrode recording, sonography, and facilities for sterotactic craniotomy often are available. At present, there are five OTs with intraoperative MRI facilities (**Figure 5**). A recent trend is the reducing dependence on overseas manufacturers for equipments. Indian shunt tubes and a variety of neurosurgical instruments are actually being exported to several countries. In 1991 Bose and Charu Apte developed an indigenous arc-centered stereotactic apparatus, followed by a radiofrequency lesion generator.

STEREOTACTIC AND FUNCTIONAL NEUROSURGERY (SFNS)

In the 1940s bold pioneers like Chintan Nambiar, a surgeon at Stanley Medical College, Madras, performed stereotactic chemopallidectomy freehand. To quote Ramamurthi, "The surgeon was bold and the patients bolder." Varma in Bangalore developed a freehand technique of lesioning the thalamus in patients with Parkinson disease. In many, the tremor arrested when the needle reached the target. This was followed by chemothalamotomy with absolute alcohol. Balasubramaniam and Ramamurthi performed chemopallidectomy by using the balloon cannula technique of Cooper as early as 1962. Dentatectomy was performed for spasticity hypothalamotomy for severe hyperkinetic disorders; cingulotomy for intractable

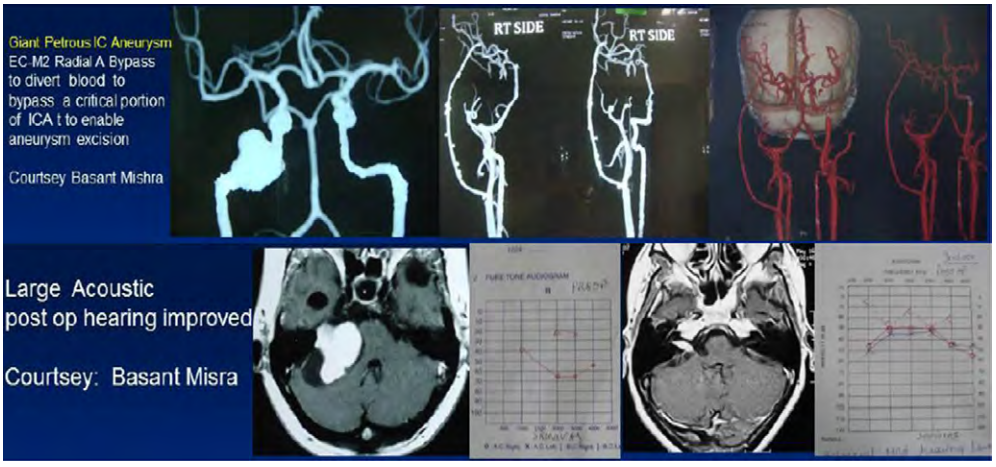

Figure 4. Clinical examples to demonstrate standard of care available.

Figure 5. Intraoperative magnetic resonance imaging performed at Max Hospital Delhi in 2006.

terminal cancer pain, drug addiction, and obsessive compulsive neurosis; and amygdalotomy for aggressive behavior disorder.

SFNS was at its peak between 1962 and 1978, particularly at the Madras Institute of Neurology, where almost 1700 procedures were performed during this time (**Figure 6**). The Indian Society for Stereotacic and Functional Neurosurgery was formed in 1997. The 150 members of the society have a workshop and a conference in alternate years. In the last decade there has been a renaissance of SFNS. Access to sophisticated imaging, intraoperative neurophysiology monitoring, extensive clinical experience, and previous, advanced training in specific fields from various centers around the world all have contributed.

EPILEPSY SURGERY

Presently there are around 15–20 dedicated epilepsy surgery programs in India performing approximately 400 to 500 surgeries per year—a miniscule number for India. These include anterior temporal lobectomy and amygdalohippocampectomy. These centers have 3-T MRI, prolonged video electroencephalogram, single-photon emission computed tomography, positron emission tomography (PET), neuropsychologists, and epileptologists.

DBS

This procedure was started in India by Dr Paresh Doshi at the Jaslok Hospital and Research Centre, Mumbai. This is one of the active SFNS departments in the country and offers a fellowship program as well. Today there are approximately 12 centers at which DBS is performed. Cost continues to be a major deterrent to the procedure because insurance or reimbursement is usually not available. An attempt is being made to revive "psychosurgery," with Indian psychiatrists being persuaded to take a proactive role.

Figure 6. Indigenous deep brain stimulation at Madras Institute of Neurology, 1977.

STEREOTACTIC RADIOSURGERY

The first stereotactic radiosurgery procedure in South Asia (linac-based) was performed in May 1995 by the author at the Apollo Hospitals Chennai. In April 2009 the same team introduced the first frameless robotic radiosurgery in South Asia Today there are approximately 15 linac-based radiosurgery units, seven Gamma Knife units, and three Cyberknife units. AVMs continue to be the commonest indication for SRS. Unlike in the west, secondaries form a small number.

NEUROIMAGING

With the universal presence of computed tomography (CT) scanners (4900 in India) even in small towns and the increasing availability of MRI scanners (n = 1700) and 1500 catheter laboratories, including a large number of mobile labs, earlier diagnosis is now possible, particularly in the metros and larger cities. Even in public hospitals, where investigations are free, the waiting time is just 1 or 2 days. In the private sector, nonemergency MRI scans are available 20 hours a day and for 8 hours even on Sundays. Also available are 320-slice CT, PET-CT, PET-MR, transcranial Doppler, nuclear scans, intraoperative MRI, and even mobile CTs. CT angiography is generally used as a screening tool, with digital subtraction angiography confined to further in-depth evaluation. An ultrasound center in Chennai (Mediscans) has achieved global recognition for diagnosing central nervous system anomalies, even at the 12th week of gestation. In collaboration with the state government of Tamilnadu, Mediscan is now deploying this cutting-edge technology on a mass scale, contributing to significant earlier diagnosis of congenital central nervous system anomalies.

SPINAL SURGERY

Spinal surgery, the bread and butter of neurosurgeons, has now evolved into highly sophisticated, image-guided, cost-effective, same-day procedures, including minimally invasive percutaneous and endoscopic procedures. Cervical and lumbar disk replacement is performed in several units. Dependence on imported screws and plates are decreasing. Sophisticated cadaveric dissection programs focusing on lateral mass screw placement, posterior transarticular screw placement, and lumbar pedicle screw placement are now available. Craniovertebral junction surgery workshops are popular. Intraoperative electrophysiological monitoring is often used as an adjunct. Talks are under way regarding starting a 2-year spinal surgery degree program.

NEUROTRAUMA

Neurotruama is a major constituent of general neurosurgery. Levels of specialization vary. Although active prehospital management by trained paramedics has converted the "golden hour" into "platinum minutes," and even with the emergence of air ambulances, there are large areas of the country for which specialist care for head trauma is not available.

SKULL BASE SURGERY

Skull base surgery is increasingly being performed with additional support from specially trained otolaryngologist, plastic surgeons, and maxillofacial surgeons. Trained nurses, neuroanesthetists, neuroradiologists, and neurointensivists complement the team.

ENDOVASCULAR NEUROSURGERY

Endovascular neurosurgery has provided a new perspective in treating evolving stroke, embolizing tumor vessels, AVMs, coiling of aneurysms, stenting as well as intraoperative management and confirmation of successful surgery.

NEUROANASTHESIA

Following the introduction of a 2-/3-year Doctor of Medicine degree in neuroanesthesia, a band of formally trained neuroanesthetists is now available. Awake craniotomy, minimally invasive cranial and spinal neurosurgical procedures, endoscopy, and interventional neuroradiology offer a challenge to anesthetists. However most "neuroanesthetists" are anesthetists working in the neurosurgery OT. Many neurosurgical centers still function in a "sharing mode" with multipurpose anesthetists.

NEUROPATHOLOGY

As early as 1955 Dr. Darab Dastur opened the first neuropathology center in Mumbai. Today tertiary neurosurgical units have well-trained, dedicated neuropathologists. There has been a reverse "brain drain" of western-trained Indians coming back to their homeland. The National Institute of Mental Health and Neuro-Sciences at Bangalore has a dedicated national brain bank. Excellent neurogenetics services are available at the Sir Ganga Ram Hospital New Delhi.

NEURONURSING

It is not surprising that there is an acute shortage of trained neurosurgical nurses. At the same time, the Society of Indian Neuro Nurses is steadily growing and continue to hold their annual conferences with the NSI. Postgraduate and doctoral programs in neuronursing are available.

NEUROINTENSIVE CARE

The last decade has witnessed the starting of large dedicated neurointensive care units with trained intensivists. In a few of the tertiary neurosurgical centers, neuro-opthalmology, neurophysiology, neuroendocrinology, and neurorehabilitation are also evolving as distinct subspecialties in most tertiary in tertiary centers.

NEURAL TRANSPLANTATION AND STEM CELL RESEARCH

As early as 1982, a neural transplantation unit was set up in the neurosurgery department at All India Institute of Medical Sciences with the help of the Department of Science and Technology, Govern-

Figure 7. Author doing clinical tele-evaluation.

ment of India. Presently, several centers are conducting studies on mesenchymal stem cell transplantation for Parkinson disease and spinal cord injury. The government has invested approximately US$8.0 million for stem cell research in the last 2 years. Draft guidelines for stem cell research in the country have been formulated and are being debated. Several neurosurgical departments are involved in this cutting-edge study.

INFORMATION AND COMMUNICATION TECHNOLOGY AND NEUROSURGERY

ICT in neurosurgical parlance in India will soon signify information and communication technology! Distance will eventually become meaningless, and geography will become history! Tomorrow's neurosurgeon will be part of a new emerging ecosystem comprising digital health, digital hospitals, electronic medical records, hospital information systems, telemedicine, telementoring, and even mHealth. With a low-cost Indian tablet, he/she will be available to talk to anyone, anytime, anywhere. Professor Google and Doctor Facebook are empowering the urban IT-savvy Indian patient, providing him/her with real-time access with almost the same exabytes of information to which the neurosurgeon now has access.

"Caveat emptor," let the buyer beware—the neurosurgeon of India in 2020 could very well be on the receiving end. Today, younger neurosurgeons have their own websites and use social networks for their professional advancement. The author has personally given approximately 1200 teleconsultations (**Figures 7** and **8**) during the last 13 years, including making many eHome visits. Telecamps from very small aperture terminal–enabled Hospitals on Wheels have included neurosurgery. For the last 3 years, monthly neurosurgical grand rounds are carried out linking Chennai, Delhi, Hyderabad, Ahmedabad, Bhubaneshwar, Madurai, and Bengaluru in the Apollo Hospital Group. Many international grand rounds have been done with overseas centers (**Figure 9**). Of the 300 CME lectures given through multipoint video conferencing to 32 countries in Africa simultaneously, from Chennai, through the Government of India Pan African eNetwork, 25 have been in neurosurgery. The last WFNS educational course held at Bhubaneshwar in eastern India in November 2012 was telecast to nine neurosurgical departments in the Apollo group, which was in addition to global webcasting. Once the central and state governments and the community at large realize that telemedicine is the only way to extend the reach of specialist health care to suburban and rural India, urban-based neurosurgeons will necessarily have to embrace this technology. Preliminary results from the handful of telestroke units are very encouraging.

INDIAN NEUROSURGERY ABROAD

Because of the earlier socioeconomic milieu, the participation of Indian neurosurgeons in continental and global meetings was limited. Today, we are secretaries, vice presidents, presidents of continental and world societies in different neurosurgical disciplines,

Figure 8. Examples of neurosurgical teleconsults to Andaman islands 2000 km away.

Figure 9. Neurosurgical teleconferences.

and honorary presidents of the WFNS. We are on the editorial boards of many international neurosurgical journals, publish in journals with a high impact index, contribute chapters in international text books, and are often invited as guests of honor in prestigious overseas conferences. Hopefully an India-based neurosurgeon will be the next Secretary of the WFNS.

SOCIAL ACTIVITIES

Neurosurgeons in India contribute their might in several programs with a societal impact. Filing a Public Interest Litigation, the author appeared before a division bench of the Madras High Court for court intervention to implement a law making helmets mandatory for two-wheeler users. Following the author's efforts in creating an awareness of brain death in the neurosurgical community and subsequently facilitating the first multiorgan transplantation in India in 1995, cadaver transplants have steadily increased as the result of the proactive measures taken by neurosurgeons in the certification of brain death. Awareness programs have been organized for police and ambulance drivers.

CONCLUSION

During the last 10 years there has been a significant increase in neurosurgical services in the private sector. This is not surprising considering that 78% of health care expenses in India are met out of pocket. Unfortunately, this migration is at the expense of the erstwhile full-time academic centers, who in yesteryear were primarily responsible for training the trainers. When government-sponsored universal health coverage and PPP (public private partnership) become a reality, quality affordable neurosurgery in India will hopefully be available to all. A combination of the surgical skills of India's master surgeon Sushrutha, the compassion of Kolkata-based Mother Theresa, the scientific acumen of Sir C. V. Raman who, exemplifying innovation in the 1930s, received a Nobel prize, the pragmatic "Karma Yoga" (enunciated in the Indian scriptures where the highest form of worship is work without seeking rewards), and the shrewdness and IT skills exemplified by the Indian IT industry will produce Superman, which is what the neurosurgeon of India needs to and will surely be! In the years to come, neurosurgeons in India will no longer talk of achieving world class. The world of neurosurgeons will talk of achieving India class.

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