

NEUROSCIENCES: AN OVERVIEW

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Introduction

Neuroscience as a distinct discipline was initiated in India only after our Independence even though some isolated examples of work in the field could be found earlier also. The contributions to neurosciences in the country have been a subject of several reviews over the years (Maheswari & Tandon, 1982; Maheshwari, 1988; Pandya, 1989; Tandon, 1991, 1995, 2000). This write-up is aimed at to briefly highlight the major contributions during 1960-1980. Tribute must be paid to some of the pioneers who laid the foundation of this edifice and are not with us anymore. The names of Drs. Jacob Chandy, B. Ramamurthi, R.G. Ginde, R.N. Chatterji, Ashok Bagchi in Neurosurgery, Baldev Singh, T.K. Ghosh in Neurology, B.K. Bacchawat in Neurochemistry, D.K. Dastur in Neuropathology, B.K. Anand and A.S. Paintal in Neurophysiology, K.P. Bhargava in Neuropharmacology readily come to mind. Fortunately the other pioneers are still active and with us. There is no doubt that there are others who also contributed to this development. It is not intended to minimize their contributions by not naming them individually. Their contributions find detailed reference in the comprehensive volume – Neurosciences in India: Retrospect and Prospect edited by Sunil K Pandya (1989). Similarly the work of pioneers in Psychiatry and allied sciences has been documented in a volume – Mental Health: An Indian Perspective (1946-2003) edited by S.P. Agarwal (2004). Another interesting source of some historical interest is the monograph edited by Prof. K. Rajasekharan Nair – Evolution of Neurosciences in India (1998) as also the autobiography of Prof. B. Ramamurthy – Uphill All the Way.

Neurosciences comprise of a large number of distinct disciplines, fortunately now seamlessly merging into one another. Unlike in the West, the seeds for their development in India were laid by clinicians – Neurologists, Neurosurgeons, & Psychiatrists. However, the leaders of these disciplines were deeply conscious of the need for development of the allied basic neurosciences – Neuroanatomy, Neurophysiology, Neurochemistry, Neuropharmacology, and Neuropathology etc. There have thus been continued additions to these with the emergence of other specialties as Neuroimaging, Neuroanaesthesia, Neuroendocrinology, Neuroophthalmology, Neurootology, Neurotraumatology, on the clinical side and Developmental Neurobiology, Neurotoxicity, Neuro-oncology, Neuro-immunology, Neurovirology, System Neuroscience, Computational Neuroscience etc on the basic side. We continue to see new additions like Cognitive Science and Behavioral Sciences in its fold. Over the years we have witnessed the development in all these fields in the country. Individuals, groups, departments and specialized centres have provided nuclei of excellence in all fields of neurosciences in the country. However, it must be mentioned that while clinical neurosciences progressed rather rapidly resulting in creation of a number of specialized centres at Vellore, Chennai,

Bangalore, Kolkata, Delhi, Thiruvananthapuram etc., parallel development of basic neurosciences was relatively slow and patchy and unfortunately remains so even today. Thus soon after the initiation of the first Department of Neurosurgery by Dr. Chandy at CMC, Vellore in later part of 1949, efforts were made to enlarge the scope of neuroscience by adding Neurology (1951), Neurochemistry (1957), Neurophysiology units/departments. Similarly when Dr. B. Ramamurthi joined the Madras Medical College, a department of neurosurgery was established in 1950. Progressively Neurology, Neuroradiology, and later Neuropathology and Neurochemistry were added. This then in a course of twenty years developed into a multidisciplinary distinct Institute of Neurology. Yet it lacks Neuroanatomy, Neurophysiology, and Neuropharmacology even today. The story was repeated at several centres – Bombay (Mumbai), Calcutta (Kolkata), Hyderabad etc. but at none of these institutions all major neuroscience disciplines existed to constitute a comprehensive neuroscience centre. National Institute of Mental Health & Neurosciences which existed as a Mental Hospital earlier wisely planned to add other neuroscience disciplines e.g. Neurology, Neurosurgery, Neuropathology and later Neuro-physiology, Neurochemistry, Neuropharmacology, All India Institute of Medical Sciences, New Delhi, by a fortunate coincidence, had basic neurosciences strengths in Neuroanatomy, Neurophysiology, Neurochemistry, from its inception to which were added the clinical departments of Psychiatry, Neurology, Neurosurgery, Neuroradiology, Neuroanaesthesia when it was elevated as a Neuroscience Centre. However, the basic neurosciences remained as part of the major disciplines of Anatomy, Physiology, Pathology, and Biochemistry. Recognizing the need to strengthen the basic neurosciences in the country the Department of Biotechnology, Government of India, decided to establish a comprehensive multidisciplinary Brain Research Centre, which is less than a decade old. The faculty of this centre represents expertise in most basic neuroscience disciplines from molecular biology and genetics to systems neuroscience and computational neuroscience (Tandon, 1999a, b). By design it didn't have clinical disciplines. Recently nuclei of Cognitive Science departments / centres have been established at Allahabad and Hyderabad. Similarly a Behavioral Science Department / Centre has been initiated at Delhi.

Increasing support for these developments has been forthcoming recently from the Departments of Science and Technology, Biotechnology in addition to Indian Council of Medical Research and Council of Scientific & Industrial Research. (Tandon, 1995).

The last decade has not only seen the establishment of the National Brain Research Centre for postgraduate education and research but also initiation of comprehensive neuroscience postgraduate courses at the Jiwaji University, Gwalior, NIMHANS Bangalore, and TIFR Mumbai. In addition to the already existing postgraduate courses in Neurology, Neurosurgery and Psychiatry degree courses have also been started in Neuroradiology, Neuropathology, and Neuroanaesthesia. Increasing importance of neurosciences has prompted the Indian Institute of Science

Bangalore, to initiate an independent department. Several national laboratories of CSIR e.g. CDRI, IITR, CCMB, IICB and several others like NCBS Bangalore are actively involved in neuroscience research providing opportunity for Ph.D. degree.

In parallel with these developments we have witnessed the emergence of scientific societies and academies for promotion of these disciplines. Starting in 1951, the Neurological Society of India was an umbrella body for all neuroscience disciplines. It currently has over 1500 members. Recent years have seen a rapid increase. It has also nucleated several sub-speciality groups like Societies for Paediatric Neurosurgeons, Stereotactic Neurosurgery, Neurotrauma, Skull-base Surgery, Society for Cerebrovascular Diseases etc. Since 1953 it publishes its own journal *Neurology India*. The Indian Psychiatry Association was established in 1947.

Initiated in 1982, but formally registered in 1984 the Indian Academy of Neuroscience was created by the efforts of Professor K.P. Bhargva, B.N. Dhawan, M. Hasan, S.S. Parmar and P.K. Seth. The Academy, which is celebrating its Silver Jubilee currently, has 800 life members. While clinical disciplines are not excluded; its primary objective was to promote basic neurosciences. A detailed write up about the Academy is published separately. It publishes its own journal, *The Annals of Indian Academy of Neurosciences*.

In the meanwhile an Academy of Neurology was established in 1991. It has 795 full members and about 250 associate members. It published its own journal *Annals of Indian Academy of Neurology* since 1998.

From the above account it will be obvious that there has been a progressive evolution of all major disciplines of Neurosciences in the country. This is specially so during the last decade. We have now fully developed clinical centres, staffed by competent clinicians, equipped with state-of-art facilities comparable to the best anywhere. There are a number of institutions where high quality work is going on in practically all branches of neurosciences.

The Indian Academy of Neurosciences decided to put together at one place an update of the status of neurosciences in the country particularly highlighting the developments during the last decade or so. While this is being done for individual disciplines by a chosen leader of the field, I would like to take this opportunity to briefly mention some of the most outstanding examples of contributions of the pioneers of Indian Neurosciences for the benefit of the younger generation who may not be aware of the work of researchers of earlier years or not have easy access to the reviews referred to above. Mention is made of what may be considered some landmark contributions nationally relevant and internationally recognized. Obviously there would be a personal bias in selecting these, which is by no means meant to be a comprehensive catalogue. Such details are available in the references mentioned earlier (Pandya, 1989; Tandon, 1991; Tandon & Gouri-Devi, 2000). Let me hasten to apologize to those whose work does not figure here even though it

may be equally or even more valuable than those included. I have intentionally not included most of the contributions during the last decade or so as these are expected to be covered by the authors of the individual disciplines.

Neurophysiology

The studies of B.K. Anand and his group on regulation of food intake and the identification of the hypothalamic feeding and satiety centres would undoubtedly qualify to be among the landmark contributions (Anand, 1960, 1961; Anand et al., 1961, 1962, 1967). In addition this group made a number of studies on the functions of the limbic system for regulating affective behaviour and visceral responses in monkeys and cats (Anand et al 1959). Similarly the seminal work of A.S. Paintal on J – receptors (Paintal, 1967, 1986, 1989, 1992) and other visceral receptors like type B – atrial receptors, mucosal mechanoreceptors of intestines and pressure-pain receptors of muscles has got international recognition.

A number of students trained by Dr. Anand – Dua-Sharma, GS Chinna, KN Sharma, SK Manchanda, Usha Nayar and T. Desiraju went on to become leaders in their own right and produced some outstanding researchers. Similarly, Dr. Paintal's students like Marcus Devanandan, W. Selvamurthy and Ashima Anand continued his traditions.

P. Brahmayya Sastry who in 1957 joined the Department of Physiology of the Andhra Medical College, Visakhapatnam contributed a great deal on factors influencing acetylcholine synthesis, storage and release in nervous tissue.

T. Desiraju who moved from AIIMS to NIMHANS, Bangalore lead a very active group working on diverse subjects like neural mechanisms of sleep, organization of prefrontal cortex and thalamo-cortical connexions, neuron-physiology of Yoga and theories of consciousness.

V. Mohan Kumar at AIIMS and BN Mallick also trained at AIIMS (and later moved to Jawaharlal Nehru University) continued to advance the frontiers of sleep research. The former contributed a series of papers on functions of the preoptic areas. KN Sharma along with S. Dua-Sharma who moved to Bangalore initially continued their interest on feeding behaviour and its regulation later diversified to neural control of reproduction, neural organization in nociception and pain. They produced a stereotactic atlas of canine brain.

High altitude physiology attracted the attention of a number of investigators – H.S. Nayar, M.S. Malhotra, W. Selvamurthy.

Neuroanatomy

A.C. Das and his colleagues – Mahdi Hasan, K.K. Bisaria at K.G. Medical College, Lucknow carried out internationally recognized gross anatomical studies on the intracranial venous sinuses, the tentorium cerebelli, the tentorium notch,

the anomalies of the posterior communicating arteries, the superficial Sylvian vein, and grooves on the occipital lobe of Indian brains which were published in such prestigious journals as *Anatomical Record*, *Journal of Anatomy* (London) and *Journal of Neurosurgery*. N.H. Keswani at AIIMS established a virtual school of neuroanatomy, which included V. Bijlani, Gomathi Gopinath, Shashi Wadhwa who made (and the Department continues to do so) outstanding contributions on developmental neurobiology. Some of the most outstanding of their contributions include birth weight and development of cerebellar cortex (Bijlani et al., 1980), the salivatory centres in the brainstem of monkey (Bijlani & Keswani, 1970), and more recently studies utilizing latest techniques of immunohistochemistry, stereology, electron microscopy, and neurochemistry have explored the development of the human brain at different ages of gestation. Some of these studies are first in the world. In late nineteen eighties and early nineties, under the leadership of Gomathi Gopinath a large number of papers were published on fetal neural transplant in rodents and mammals. Later on this became a subject of research at IITR, Lucknow.

Hasan and his colleagues at Aligarh Muslim University contributed a large number of studies on neuroanatomical changes in ageing brain as also the effects of a variety of neurotoxins using electron microscopy.

Neurochemistry

It was only in 1960s that centres devoted to neurochemistry were established at Baroda, Calcutta, Delhi and Vellore. Subsequently these spread to Chennai, Bangalore, Mumbai, Hyderabad and Thiruvananthapuram. The foundation for neurochemistry was laid by J.J. Ghosh, B.K. Bachhawat, C.V. Ramakrishnan, P.S. Sastry and their colleagues. G.P. Talwar who initially devoted to research on neurochemistry later committed himself to pursue immunology. Other outstanding researchers of the earlier years included D.K. Basu, A.S. Balasubramanian, P.S. Sastry, M.S. Kanungo, Shail Sharma, P.K. Sarkar, S.L.N. Rao, R. Rajalakshmi, K. Subba Rao. Some of the most outstanding contributions of these investigators were study of nucleic acid and protein metabolism, lipid metabolism, metabolism of sulphated compounds, studies on brain enzymes (hexokinases, dehydrogenases and oxidases, lysosomal hydrolases, acetylcholinesterases etc.), neurotransmitters and their receptors specially opiate receptors. Detailed studies were carried on myelin, synaptogenesis and neural membranes. Nutrition and brain development were studied by a number of scientists which included several important events such as cellular proliferation, nucleic acid and protein turn over, dendritic arborization, myelination and synaptogenesis (Rajalakshmi and Ramakrishnan 1972). Most of the contributions in this field were summarized in a monograph by Tandon and Gopinath (1984) published by the Indian National Science Academy, New Delhi. Special mention may be made of one of the earliest studies on enzyme arylsulphatase, lipid peroxidation, enzymatic formation of PAPS (3-phosphoadenosine-5-phosphosulphate). These studies led to the discovery of the etiology of metachromatic leukodystrophy. Original studies were made on

biosynthesis of phospholipids components of the myelin membrane specially ethanolamine plasmalogens sulfatides, gangliosides & cholesterol. The Wolfram protein phosphorylation was another such study. Among the studies on effect of drugs and toxins in the brain the pioneering studies on mechanism of neurotoxicity of *Lathyrus sativus* deserve special mention. Further elaboration of these and other neurotoxins continues to be carried out at IITR, Lucknow (P.K. Seth and colleagues) and NBRC, Manesar (V. Ravindranath).

Neuropathology

In 1949, the Indian Council of Medical Research established a Neuropathology Unit at Tata Memorial Hospital, Bombay under the leadership of Dr. V.R. Khanolkar, CGS Iyer and DK Dastur later joined this unit. Initially studies were carried out on experimental poliomyelitis in monkeys and neural lesions in different types of leprosy. A referral centre for neuropathology was thus established. Iyer later moved to Central Leprosy Teaching and Research Institute at Chingelput, Tamilnadu and Dastur established one of most productive Departments of Neuropathology at JJ Hospital and later at Bombay Hospital. A decade later Dr. S. Sriramachari started the Department of Neuropathology at the National Institute of Mental Health and Neurosciences, but he soon moved to ICMR. When neurosurgery was started at AIIMS, New Delhi, he provided the neuropathology support as an Honorary Professor. In the meanwhile Dr. Ilona Bubelis set up a department at KEM Hospital, Mumbai where she trained DH Deshpande who later took over the Department. Dr. KM Wahal at KGMC, Lucknow who was trained in neuropathology in USA provided the service to the Neurosurgery Unit but did not pursue a career in neuropathology. Dr. Subimal Roy was persuaded to take up neuropathology as a full time commitment at AIIMS. Dr. AK Banerjee devoted himself to neuropathology at Postgraduate Institute at Chandigarh in 1971. Dr. Sarla Das after completing her training under Dr. Sriramachari moved to Cuttack in 1971 and later moved to NIMHANS, Bangalore as Head of Neuropathology. Dr. Sarasa Bharati joined the Department of Neuropathology at the Madras Neurological Institute. Chitra Sarkar succeeded Subimal Roy and SK Shankar took over from Sarla Das and are currently providing leadership at AIIMS & NIMHANS. Dr. Radhakrishnan started the Department of Neuropathology at SCTIMST, Trivandrum in 1978.

It is not surprising that the most outstanding contributions in this field are those related to infections of the nervous system – leprosy, tuberculosis, cysticercosis, fungal infections and Japanese encephalitis. CGS Iyer at Chingelput, CK Job and KV Desikan at Vellore, VR Khanolkar, DK Dastur, NH Antia, L Mehta, SS Pandya at Mumbai (Bombay), MC Vaidya at New Delhi carried out extensive studies on all aspects of pathology, pathogenesis, electrophysiology and surgery of neural leprosy. MG Deo and GP Talwar independently developed a vaccine, while Indra Nath studied the immunology of this disease. It is worth mentioning that Barry Bloom, an international authority on mycobacterial diseases, once remarked that research on leprosy in India has become a cottage industry. Dastur,

1955; Khanolkar, 1964; Antia et al., 1970; Dastur, 1978; Dastur, 1983; Job, 1970; Job and Desikan, 1968, are just a few examples of some the critical studies.

Similarly neurotuberculosis – tuberculous meningitis, tubercluoma – was a subject of a large number of studies including its microbiology, pathology, pathogenesis, diagnosis, imaging and therapy. In addition to detailed clinical studies by most of the neurologists and neurosurgeons of the era, a large number of detailed studies on pathology of tuberculous meningitis and tubercluomas, some unique observations on tubercluous encephalopathy, radiculopathy, arteritis, spinal meningitis with myelo-radiculopathy, and tuberculous abscess deserve special mention. It will be difficult to name the large number of contributors to this subject. However, much of the work carried out is summarized in some of reviews on the subject (Dastur and Lalitha, 1973; Tandon et al., 1988). In a Textbook on Infections of the Nervous System Kocen writing on tuberculosis of the nervous system stated, “In more recent years, the major contributions on both pathology and the varied clinical manifestations of tuberculosis of the brain and spinal cord have come from workers in India in particular Dastur, Tandon and Wadia (Kocen, 1987).

Pathology of Japanese encephalitis has been a subject of detailed investigations at NIMHANS, Bangalore (Deshpande, Shanker and Gouri-Devi). While detailed pathogenetic and virological studies were carried out at KGMC Lucknow and National Institute of Virology Pune by UC Chaturvedi, Asha Mathur and Kalyan Banerji. Recently candidate vaccines have been developed at National Institute of Immunology, New Delhi and Indian Institute of Science, Bangalore.

Parasitic diseases especially neurocysticercosis attracted the attention of a large number of pathologists and clinicians alike. An immunodiagnostic test for neurocysticercosis has been developed indigenously. Clinico-pathological differences between the disease as seen in India and in other parts of the World were highlighted by Tandon (1989). Studies on fungal infections of the CNS – aspergillosis, cryptococcosis, mucormycosis and several others have been reported. A recent issue of Neurology India (volume 55, 2007) provides a comprehensive review on the subject highlighting the Indian contributions.

A large number of pathological studies on brain tumors have been reported over the years. These deal with routine histopathology, electron microscopy, imunohistochemistry for tumour markers, tissue culture, proliferation index determination, in-vivo cell kinetics, and in-vitro drug sensitivity etc. Correlation of ultrastructural and endocrinological parameters on pituitary adenomas, revealed interesting original observation of great clinical relevance (Roy, 1977, 1983)

Neuropharmacology

Drugs acting of central nervous system have fascinated a number of pioneers of Indian Pharmacology. The most outstanding among them is no doubt Dr. RN Chopra, who was elected as President of the Indian National Science Academy

(1939-40). Besides producing the first comprehensive documentation of indigenous plants of therapeutic value, he initiated the work on hypnotic effect of *Rauwolfia serpentina* in 1940. This lead was later pursued by BB Bhatia at Lucknow and JC Patel at Bombay. Post independence in addition to the existing pharmacology departments in the medical colleges the creation of Central Drug Research Institute, Lucknow, and other such centres provided new stimulus to research in neuropharmacology. Some of the important names of this era include KP Bhargava and his associates and students at KGMC, Lucknow, the school established by BN Dhawan and RC Srimal at CDRI, RB Arora and NK Bhide at AIIMS, New Delhi, UK Seth and Nilima Kshirsagar at Mumbai, PC Dandiya and MK Menon Jaipur, C Sarkar and DK Ganguly at the Indian Institute of Chemical Biology, Kolkata, PSRK Harnath at Hyderabad, SK Bhattacharya and PK Das at BHU, Varanasi, SK Kulkarni at Chandigarh, among others. They contributed extensively on central vasomotor control, chemoreceptor trigger zone (emetic centre) in medulla, neurotransmitters involved in thermoregulation, stress related gastric ulcer, drug induced stereotypy, neuro-pharmacological studies on blood-brain barrier, central nervous system stimulants and depressants, neurotransmitter action and their receptors and factors influencing their regulation, mechanism of action of a variety of analgesics, antiepileptics and other centrally acting agents. Much of these researches have been summarized by Bradley B and Dhawan BN (1976) and PK Das and BN Dhawan in a monograph published by INSA in 1984. Stimulated by the earlier work of Chopra and later GV Satyawati at BHU several scientists explored a large number of plant derived centrally acting compounds like Asarone, Jatamansome, *Withania somnifera*, Bascoside A & B from *Bacopa monnieri* (Dhawan & Patnaik, 1989).

Several new synthetic drugs were also developed. These include antidepressant amitriptyline by CIBA-GEIGY, neuroleptic centbutindole, antidepressant centpropazine and local anaesthetic centbucridine by CDRI as well as neuromuscular blocking agent chandonium iodide jointly developed by Punjab University, Chandigarh and CDRI.

In recent years a new impetus has been given to neuropharmacology by some of the major pharma-industries like Ranbaxy, Cipla, Reddy and Wockhardt.

Neurotoxicology

Neurotoxicity has assumed a significant concern in recent years as a large number of drugs, substances of abuse, chemicals, natural constituents of plants affect the nervous system and lead to various types of nervous system disorders. Industrial chemicals such as lead, manganese, methyl mercury, certain pesticides and several others have been implicated in learning, memory and diseases like Parkinson's, Alzheimer's, attention deficient syndrome, etc. Several institutions all over the country are undertaking studies on the neurotoxicity of chemicals. The major contribution have been made from IITR, Lucknow (earlier ITRC), NIMHANS,

Bangalore and NBRC, Manesar. The thrust has been to delineate the basic mechanisms of neurotoxicity of these chemicals and understand the factors influencing the neurotoxicity. Attempts have also been made on protection of the neurotoxic effects using plants extracts and antioxidants but such studies are confined to experiment levels.

Clinical Neurosciences

In this limited overview it is not possible to even briefly summarize the Indian contributions in this field. Excellent reviews on neurology (NH Wadia), neurosurgery (RG Ginde & VK Kak) and neuropsychiatry (A. Venkoba Rao) have been provided in *Neuroscience in India: Retrospect and Prospect* (Pandya, 1989). Additional inputs have been included by Tandon (1991), Tandon and Gouri-Devi (2000), Chopra and Sawhney (1999). To highlight the importance of clinical research examples of a few outstanding contributions by the pioneers are mentioned here. At the cost of repetition it is once more emphasized that this is not a comprehensive review. The examples included here relate to the diseases more frequently encountered in India or where the variations in their incidence, manifestations or course as compared to other regions of the world have been observed. Special attention has been given to interdisciplinary investigations to highlight the value of such cooperation.

During the initial years most clinical researchers were busy highlighting the patterns of CNS disorders and their relative incidence compared to the West where most of them were trained. The high incidence of neurotuberculosis, brain abscess and neurosyphilis (at least in some of parts of the country) was not surprising. Large series of patients with tuberculous meningitis (TBM), its sequelae and tubercluomas were reported from all over the country specially Madras and Bombay. Their pathology, pathogenesis, clinical features, problems of diagnosis and strategy for management were investigated by multidisciplinary teams consisting of clinicians, pathologists, microbiologists and radiologists. These contributions have been summarized in a series of critical research papers and reviews published nationally and internationally by Ramamurthy (1956), Ramamurthy and Natarajan (1960), Ramamurthi (1972), Udani, Parekh and Dastur (1971), Dastur and Desai (1965), Dastur and Udani (1966), Dastur and Dave (1977), Tandon and Pathak (1973), Tandon, Bhatia and Bhargava (1988) and many other. Proceedings of a National Seminar, organized by the Indian (now called National) Academy of Medical Sciences were published in 1972. Poliomyelitis, Japanese Encephalitis, Cerebral Cysticercosis, Brain Abscesses, Kyasanur Forest Disease and more recently HIV infection of the brain have been the subject of a large number of publications. It will not be possible to describe these in detail but mention may be made of two unique clinical syndromes of infective origin encountered in India i.e. single 'ring' or 'disc' enhancing lesion producing focal epilepsy and enterovirus 70 disease (acute haemorrhagic conjunctivitis associated with neurological manifestation). The former had been reported from all parts of India soon after the introduction of CT Scan and accounted for nearly 20 percent of all patients presenting with focal

epilepsy. It was discovered to be of varied etiology, presented a peculiar feature of “disappearing” and “reappearing”, lesion without any specific treatment. Ultimately it was established that majority of these lesions were solitary cysticercus cyst (Goulatia et al., 1987; Bhatia & Tandon, 1988; Wadia, 1987; Chandy & Rajsekar, 1988).

In March 1971 and again in 1981, an epidemic of acute haemorrhagic conjunctivitis affecting several million people occurred in India. Wadia and his colleagues ultimately reported the neurological disorders associated with this infection and along with Kono from Japan confirmed the neurovirulence of the causative virus (Kono et al., 1974; Wadia et al., 1983).

As mentioned earlier a number of typical manifestations of well known neurological disorders or some new syndromes constituted several important publications. These included Infantile Tremor Syndrome, Madras Motor Neuron Disease, Tropical Spastic Paralegia, Monomelic amyotrophy, Olivopontocerebellar degeneration associated with slow eye movements and peripheral neuropathy, hot-water epilepsy among others. These have already been included in textbooks.

An unusually high incidence of Congenital Atlanto-axial Dislocation and cranio vertebral anomalies was reported from many centres in the country. Its diagnosis, clinical picture, associated medullospinal compression and surgical management have been a subject of a large number of publications and monographs.

In the field of neurotraumatology special mention need to be made of pioneering studies on temporal lobe lesions, brainstem pathology, posttraumatic brain oedema, cranio-cerebral erosion, brachial plexus injuries and optic nerve injuries.

Among cerebrovascular diseases, unusually high incidence of stroke-in-young and cortical venous thrombosis needs special mention.

Brain Tumours their pathological, clinical and therapeutic aspects – were the subject of a large number of studies. Notwithstanding the high quality of many of these studies there were no distinctive or unique features, which deserve to be recorded in this presentation. It may, however, be mentioned that there are several centres in the country where several hundred brain tumours are operated upon every year with results comparable to the best anywhere.

Another area of major contributions extending over a number of years is one of stereotactic neurosurgery, particularly functional neurosurgery by the group at Madras (Chennai) – B Ramamurthi, V. Balasubramaniam, S. Kalyanaraman & T.S. Kanaka. This received much deserved international recognition.

Concluding Remarks

Beginning with very modest but determined efforts of its founding fathers, neurosciences have come a long way in the country. There are some outstanding groups, departments and centres both in clinical and basic disciplines. Last decade specially has witnessed a more rapid growth. As will be observed from the examples quoted here, and many others experts in this volume, it is obvious that internationally competitive and nationally relevant researches have been possible, often under very difficult circumstances. However, the environment is rapidly changing with state-of-art facilities available at many centres in the country. It is expected that there would be quantum jump both in the quantity and quality of research contributions in future. However, considering the growing importance, of the discipline, the availability of newer technologies with vastly improved prospects of exploring the most complex organ of the body – the brain, the overall efforts in the country remain sub-critical. The Academy of Neurosciences has to play an important role in attracting talented young researches to this ever expanding and challenging field and provide them with stimulating environment to pursue a gratifying career.

In the end let me once again reiterate that this presentation is not a comprehensive review. It has an undeniable subjective bias dictated partly by constraints of limited personal knowledge of the vast field under review. I am sure the deficiencies will be covered by other contributors to this volume. The studies mentioned here are just to demonstrate that high quality research had been possible in the country even when resources were limited and with increasing opportunities one has very high expectations for future.

Appendix

In addition to those whose work has been quoted, I feel that mention must be made of those who struggled hard in different parts of the country to serve the cause of neuroscience in the earlier years of its development. I would like to pay my tributes to each and every one of them. I am conscious that even now many who deserve to be included in this list would have been left out; A more detailed account of the development at various centres is provided by RG Ginde in volume edited by Sunil Pandya.

Bangalore: (Bangaluru)

R.M. Verma (Neurosurgery)

K.S. Mani (Neurology)

G.N.N. Reddy (Neurosurgery)

B.S. Das (Neurosurgery)

Sarla Das (Neuropathology)

M. Gouri-Devi (Neurology)

A. Chandramukhi (Neuromicrobiology)

Bombay (Mumbai)

Menino De Souza (Neurology)
E.M. Bharucha (Neurology)
P. Bharucha (Paediat. Neurology)
Anil Desai (Neurology)
P.M. Dalal (Neurology)
Bhim Singhal (Neurosurgery)

Homi Dastur (Neurosurgery)
Sanat Bhagwati (Neurosurgery)
P.P. Irani (Clinical Neurophysiology)
S.K. Pandya (Neurosurgery)
V.S. Lalitha (Neuropathology)
Gajendra Sinh (Neurosurgery)

Calcutta (Kolkata)

R.N. Chatterji (Neurosurgery)
Asoke Bagchi (Neurosurgery)
R.N. Roy (Neurosurgery)
T.K. Ghosh (Neurology)
S.R. Das Gupta (Neuropharmacology)

Chandigarh

D.R. Gulati (Neurosurgery)
V.K. Kak (Neurosurgery)
J.S. Chopra (Neurology)
A.K. Banerjee (Neuropathology)

Cuttack

Sananthan Rath (Neurosurgery)
B.S. Das (Neurosurgery)

Delhi

S. Janaki (Neurology)
Vimla Virmani (Neurology)
Sumedha Pathak (Neurology)
A.K. Banerji (Neurosurgery)
Arjun Sehgal (Neurosurgery)
B. Prakash (Neurosurgery)
Ravi Bhatia (Neurosurgery)
Subimal Roy (Neuropathology)
Chitra Sarkar (Neuropathology)
Sneh Bhargava (Neuroradiology)
R.K. Gulatia (Neuroradiology)
G.S. Chinna (Neurophysiology)
S.K. Manchand (Neurophysiology)
Shail Sharma (Neurochemistry)
B. Jaikhanani (Neurochemistry)
T.C. Anandkumar (Neuroendocrinology)

Gwalior

B.N.B. Rao (Neurosurgery)

R.S. Dharkar (Neurosurgery)

Hyderabad

S. Balaparameshwara Rao (Neurosurgery)

B. Dayanand Rao (Neurosurgery)

D. Raja Reddy (Neurosurgery)

Jaipur

M.G. Sareen (Neurosurgery)

S.R. Dharkar (Neurosurgery)

Ahmedabad

B.J. Damani (Neurosurgery)

P.R. Thakore (Neurosurgery)

Lucknow

Vijay Dave (Neurosurgery)

Goodwin Newton (Neurosurgery)

Devika Nag (Neurology)

Madras (Chennai)

K. Jagannathan (Neurology)

Arjun Das (Neurology)

K. Srinivasan (Neurology)

S. Kalyanaraman (Neurosurgery)

T.S. Kanaka (Neurosurgery)

Madurai

M. Natrajan (Neurosurgery)

K. Srinivas (Neurology)

Patna

Ramesh Chandra (Neurosurgery)

Ranchi

R. Prasad (Neurosurgery)

Trivandrum (Thiruvanthapuram)

M. Sambasivan (Neurosurgery)
D. Rout (Neurosurgery)

Varanasi

K.C. Mukherjee (Neurosurgery)
S. Mohanty (Neurosurgery)
K.C. Katiyar (Neurology)
P.K. De (Neurophysiology)

Vellore

K.V Mathai (Neurosurgery)
Jacob Abraham (Neurosurgery)
Marcus Devanandand (Neurophysiology)
G.M. Taori (Neurology)

Army Medical College

Col. A.C. Roy (Neurosurgery)
Brig Mahendra Singh (Neurosurgery)
Brig Virendra Mohan (Neurosurgery)
Col. M.L. Suri (Neurology)
LT Col. P.K. Sethi (Neurology)
Col B.C. Bhattacharya (Neurology)
LT Col. V.S. Madan (Neurosurgery)

This list is not in any chronological order. Most of the names included are those who started their specialty services in 1960-1970 era in academic institutions. The list excluded those who have already been mentioned in the text of this write-up.

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