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SIR A. L. MUDALIAR ENDOWMENT LECTURES

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SURGERY AND INDIA

I

Sir Arcot Lakshmanaswami Mudaliar belonged to the rare class of men who touch many fields and adorn whatever they touch. An obstetrician par excellence, he safely brought into the world a generation of Indians who witnessed and took part in the final phase of our struggle for freedom; a master teacher, he inspired thousands of students in their medical career and influenced future generations including my own through his famous text book: an eminent academic reformer, he altered the landscape of medical and secondary education through the Chairmanship of Commissions which bear his name; a symbol of India's cultural and scientific life, he added distinction to the Executive Board of the UNESCO and WHO and played no small role in their activities; a distinguished leader of opposition in the Madras Legislative Assembly, he won the respect of the Treasury Benches and the admiration of fellow members by his eloquent interventions: a noted educationist, he guided the destiny of the Madras University for nearly three decades to establish a record which was never to be broken. To these shining qualities of his, the gods added a majestic personality and silver tongue which left an indelible impression on anyone who had the good fortune to listen to him. He dominated the world of medicine and education in India for over half a century

and left inspiring footprints on the sands of time. As my own teachers were his students, I can claim the privilege of being a Prasishya of Sir AL Mudaliar and these lectures to be a tribute to my Guru. I am deeply grateful to the University of Madras for inviting me to deliver these lectures which will deal with India's role in the historical drama of surgical evolution in the world. It is my belief that Sir Arcot would have approved of my theme, profoundly interrested as he was in all aspects of medical science and education.

Surgery. like music and language, is a primordial enterprise of man. It had no founder, no date of birth, no place of origin and no recognisable pattern of growth. Born in the dim past of the human race, surgery synthesised, over long centuries, healing traditions which blended intellectual vision with manual technique. Whitehead wondered whether the human hand created the brain, or the brain created the hand. The intimacy and reciprocity of their connection were nowhere as brilliantly seen as in the practice of Religio Chirurgie. The story of surgery demonstrated as never before the triumph of the human instinct to translate thought into manual skill and manual activity into thought.

For evidence of the Prehistoric Phase of surgery, one must look to Peru, Europe and several tribal regions of the world which yielded a tell-tale crop of trephined skulls during archaeological excavations. It was common practice among their peoples to use sharpened flints to trephine skulls, to drain abscesses and to scarify tissues. Decompressive trephining for epilepsy and mental disorders was then a common operation which was not infrequently repeated five

times upon the same person. Primitive man dressed his wounds with ashes or balsam; he sucked and cauterised them when poisoning was suspected. Prehistoric bones show clear evidence of amputation which must have been carried out with neolithic saws of stone remniscent of the teeth of animals. The effectiveness of these archaic instruments was dramatically shown by Hollander who employed them to complete an experimental amputation in seven minutes! Even from the fragmentary evidence in stone and implements one cannot but respect the surgical efforts of our ancestors who battled against heavy odds. While no evidence of surgical procedures was seen in the ruins of Mohenjo Daro, the elaborate domestic bath rooms, latrines, covered sewers and drainage systems of the Indus Valley Civilisation are a significant reminder of their high standards of hygiene which suggest parallel developments in surgery.

The Bronze and Iron ages ushered in metallic instruments which demonstrated for the first time the powerful impact of new materials on the historical development of surgery, a phenomenon which would reappear with the advent of plastics three thousand years later. The flowering of surgical instrumentation in the form of saws, files, and other implements which have been unearthed in India, Egypt and Europe marked a dramatic improvement over stone tools and immediately extended the scope of surgical operations. Narcotics, opium, hemp and alcoholic drinks provided marginal anaesthesia which was supplemented by the physical control of patients. The new phase of the practice of medicine and surgery a thousand years before the Buddha was nevertheless dominated by magic, incantations, amulets and rituals as testified by numerous references in the Atharva Veda. During this

period which could be regarded as the Religious Phase in surgery, diseases often got cured or relieved spontaneously or by procedures which "ministered to the mind diseased and plucked from the memory a rooted sorrow". For all the magic and ritual, the prehistoric and religious phases of surgery contained, in a quintessential form, all the elements which transformed it over long years into a mighty human adventure. Our surgical ancestors were no less imbued than their twentieth century descendants with concern for suffering, curiosity for disease phenomena, passion for handcraft and eagerness for absorbing new technology.

While the accumulated wealth of clinical observation and growing knowledge of medicinal plants extended the domain of treatment, a new stimulus for surgical advance came with the advent of iron which was widely used for the manufacture of instruments. These developments would account for the high standards of medical and surgical practice which prevailed in India, Egypt and Greece a hundred years before the Buddha. The pre-Buddhist Century marked the commencement of the Classical Phase when Ayurveda in India and the Pythagorean movement in Greece flourished and observations and experience of earlier centuries became instruments of new progress. Past theories on tridosha and bodily harmony as well as familiarity with iron found new life in families of surgical principles and techniques and a new technology. It was altogether a heroic age for surgery. Sushruta and Hippocrates dominated the scene in India and Greece, but scores of men elsewhere in China and Egypt practised the new art and extended its frontiers through clinical experiments and daring action punctuated by many a false start and incorrect conjecture. If Pythagorean doctrine defined health

as a condition of perfect equilibrium, Ayurveda prescribed the "harmonised pursuit of happy material existence, proper secular conduct and spiritual salvation through a correct understanding of the relationship between man, his world and the ultimate source of his consciousness." Holistic medicine of our time proclaims no more than a pristine idea that has blossomed into a modern concept.

The practice of surgery reached its high water mark during the Classical Phase when Sushruta waxed in the Indian surgical firmament. He lived in the 6th or early 5th century BC as Panini who is definitely known to have lived in the fourth century BC does make a reference to him. Notwithstanding the fact that the original Sushruta Samhita was lost and what we have today is a rescension prepared by Nagarjuna, the alchemist, in the third or fourth century AD, the magnificent volume surpasses every known classical text in encyclopaedic coverage of topics, descriptions of several hundred diseases and their management and above all, the masterly treatment of surgery.

Sushruta was a teacher par excellence who prescribed qualifications for surgical studentship and insisted on practical training beyond reading and discussions. He recommended the use of large fruits, dead animals and dead human bodies for training in excision, incision, suturing and the study of anatomy. He was a technologist who classified surgical instruments into twenty types of sastras or sharp instruments and one hundred and one types of yantras or blunt instruments and described their construction and use in profuse detail. He was an embryologist whose concepts of human embryology anticipated modern findings and whose views on the emergence mental functions in the human foetus continue to excite interest. He was a

dietician who accepted no taboo on eating beef or any other kind of animal meat and offered elaborate guidance on the place of fruits, cereals milk and honey in diet. As a hygienist he advocated purification of water by boiling and set forth the ideal habits for healthful living which included dental care, exercise, massage, use of foot wear and umbrellas and avoidance of easing in public places.

Sushruta classified and described several hundred diseases and taught their recognition by a process of physical diagnosis. He knew diseases to be curable, relievable or incurable and their causes to be proceeding from the body or mind, from the environment or from God's will. He recognised the sequential stages of pre, intra and postoperative management and outlined the steps appropriate for each stage. He insisted on perfect surgical cleanliness and demanded that surgeons clip their nails, wash their hands and instruments in medicated water and arrange for the fumigation of the operating room with medicinal and aromatic herbs. He carried out operations for cataract, dental caries, urinary stones, removal of foreign bodies, piles and fistulae, fractures and plastic reconstruction of the nose and ear. He knew thermal cauterisation, suturing with single or braided thread of cotton, hemp or mane of horses and bandaging. He warned of the special difficulties in treating Brahmins who knew too much, high ranking officials, members of the Royal Family and laymen with pretensions to medical knowledge! He treated all patients who sought his help regardless of their caste or status and regarded it his duty to apply all his skill, faculties and knowledge in his service to them. He left us the richest legacy in surgery and a shining legend which would rekindle the spirit of surgery through the ages.

A contemporary of Sushruta whose name inspired the western world was Hippocrates of Cos. He became the 'Father of Medicine' and his prescriptions came to represent the right approach to the problems of health and disease. Regardless of whether Corpus Hippocraticum consists of books written entirely by the master or includes interpolations as suspected by no less a person than Galen, it is generally regarded as a faithful reflection of the Hippocratic way which emphasised observation and reasoning and prized purity of life and compassion. The sixty odd books of the Corpus contain little anatomy but include philosophical discussions, classic descriptions of diseases, a theory of four humours, a highly prescient view of the comparative anthropology of Asia and Europe, detailed prescriptions for diet, an account of the treatment of fractures and dislocations, sound observations in obstetrics and gynaecology and the historic treatise on medical ethics with the famous Oath. His aphorisms became equally famous and some like 'Life is short, the art is long, the opportunity is elusive, experience is fallacious, judgement is difficult have become popular favourites.

There can be little doubt that Hippocratic writings owe their present shape to the great medical schools of Cos and Cnidus which were the leading medical centres of the fifth and fourth century BC in Greece. They were magic centuries when great schools of medicine simultaneously flourished in Greece as well as at Taxila and Banaras in India with legendary physicians such as Agnivesa and Sushruta on their rolls. Jivaka, the physician of the Buddha, belonged to this galaxy and left many a story of greatness as a superb physician and teacher. While preserving the devotional element, the Classical Phase

of surgery and medicine marked a major departure from the Religious Phase in so far as it shifted the responsibility for curing or relieving ailments from the gods to man. It was an age of intellectual ferment when philosophical efforts scaled new heights and offered profound insights into the human condition and the unity of existence in the universe. We would understand modern surgery better for having read Sushruta and Hippocrates because old knowledge is the very means for us to come upon the new.

The movement that formed Sushruta and Hippocrates and that they helped to form had similar growth patterns in their lands of birth until Renaissance injected fresh direction and unprecedented power into the medicine of Europe. In India, Buddhist literature of subsequent times refers to Jivaka's medical training for seven years at Taxila, his reverential care of the Buddha and his surgical operations on patients for the correction of intestinal volvulus and the removal of 'worms from the head'. Ashoka's establishment of infirmaries for men and animals in his vast domain including the frontier regions of Pandya and Keralaputra advanced the care of the sick which had previously been restricted to private homes. Artha Sasthra which reflects the social and administrative practice of the Mauryan State decrees various punishments for a great variety of public health offences such as adulteration of food, dumping of waste on the road, poisoning and quackery. Census had already come into existence in Mauryan times and the extent of illness and disability in the community was known however imperfectly. Nevertheless the surgical pace of Sushruta's time had already slowed down toward the beginning of the Christian Era. Even though the Buddha did not prohibit all operations,

the Buddhist embargo on bloodshed did discourage surgry even as it discouraged unnecessary and possibly dangerous procedures by vagabond quacks. To add to the disparagement of surgery, Kautilya's provision for the stringent punishment of physicians whose patients died or developed serious complications appeared as a fresh deterrent. Manu had in fact assigned a low social position to the physician and declared him unfit to offer food or to be invited or auspicious occasions. In the early years of the Christian era, the dark phase of stagnation had already crept in and one would look in vain for successors who kept Sushruta's torch aflame. The practice of therapeutics did however make slow progress and assimilate remedies from Arab and Greek systems which had made their appearance in India. The famous compendia of Vaghbhata I and II of first and seventh centuries and the Nidana of Madhava of the ninth century testify to the high standards of diagnosis and treatment even though they no longer emphasised surgery. Vaghbhata I did add six more surgical instruments to Sushruta's original list, but his tenor was overwhelmingly medical. Authoritative manuals as they were and continue to be, one misses in them the flashes of originality and master touch of Sushruta and Charaka. Tenth century saw the advent of mercury, sulphur and copper in medical treatment and the birth of the Sidha system which was described by Vrinda. Chakrapanidatta who wrote a commentary on Kadambari expanded on Vrinda's Sidha Yoga in the eleventh century and Vangasena, Sothal, Sarangadhara and others continued the exercise in compilation, description and classification in the three succeeding centuries. Bhava Misra's Bhava Prakasa appeared in the sixteenth century and received an enthusiastic welcome as it

amounted to an independent and updated version of the Ashtanga Hridaya of the seventh century. Bhava Misra wrote lucidly and included accurate descriptions of new diseases such as 'Phirangi Roga' for which he prescribed mercurials. On the whole, intellectual energy was expended and time frittered away in endless disputations and the preparation of commentaries, compilations, glosses and glossaries even upto the eighteenth century when the Yoga Ratnakara and Siva Tattva Ratnakara appeared. After the Classical Phase, Indian surgery witnessed a long phase of stagnation and decline until it lost place to its European counterpart in the nineteenth century. The spirit of divine curiosity, innovative skill and surgical daring which marked Sushruta's endeavour evaporated over these dark and unhappy centuries. Manual arts and crafts including surgery were no longer looked upon with respect. Surgery slowly perished and with it perished whatever possibilities India had in experimenal science for medical applications.

The European record after Hippocrates scarcely differed from that of Post-Sushruta India until Renaissance set the Western sky aflame. In the Greeco-Roman interlude, Heliodorus performed internal urethrotomy for stricture and Antyllus described ligation treatment for aneurysms. Then came Galen who knew it all and who had an answer for every problem and a theory for every phenomenon. His writings had such an overpowering appeal for the European mind that medicine in Europe referred back everything to his as the final authority for nearly fourteen centuries. For all his obsession with vitalism, invisible pores in the interventricular septum and laudable pus, Galen was an experimental physiologist. He explored neurologic function by the

experimental production of hemiplegia and aphonia and demonstrated that heart would continue to beat after excision independently of its nerve connections. Despite Galen, science and medicine were snubbed in tyrannical Rome which encouraged surgery to the extent it was necessary for wars but employed medical slaves for all other purposes before the second century. With the decline of the Roman Empire, respect for magic gained ascendancy and physicians became mercenaries and vendors of quack medicines. The Eastern part of the Roman Empire fared no better in the Byzantine Phase as its medicine was dominated by poultices, talismans and incantations. For a thousand years Byzantium was flooded with compilations including a well known volume by Paul of Aegina, but surgical progress was conspicuously absent. The Mohammedan and Jewish Phase which lasted for three hundred years from 700 AD deified therapeutics and ignored surgery. While Europeans under Christianity played with talismans and charms, Mohammedan and Jewish Physicians tended to look on them with benign contempt.

Four centuries of the Medieval Phase from 1000 AD followed the death of Greek science and the collapse of the Roman Empire. The great need of Europe in this crisis was for spiritual regeneration rather than intellectual development, a need which was met by the Christian Church with its emphasis on symbolism and compassion. Compassion found fulfilment in nursing the sick and erecting hospitals but the Age of Faith suppressed freedom of thought and proscribed the works of Hippocrates. The fundamental error of divorcing surgery from medicine culminated in the surgeon being regarded as an underling. The interdiction of Pope Innocent

III on the shedding of blood hastened the downfall of surgery which was left to the barbers and lowly folk. Military surgeons were obliged to shave their men as part of their duties right up to the time of Frederick the Great. Surgery melted away and barely survived in the hands of faithful and obscure followers of the craft including barbers. Medical art on the other hand was replaced by faith healing. In this sea of decadence and superstition, the school of Salerno appeared mysteriously as an island of Hippocratic medicine and excellence. Even after its sack in 1194, the tradition of Salerno survived and one of its exponents—Lanfranck—was responsible for founding the French school of surgery in 1255. It was to his credit that he lamented the schism between surgery and medicine and demanded that a surgeon should also be a physician. His life coincided with the founding of medical schools in Paris, Bologna, Oxford, Montpellier, Padua and Naples.

The Phase of Renaissance from 1400–1600 signalled the revival of learning and a moment of joyful liberation for Europe. Heliocentric astronomy of Copernicus, discovery of America, growth of vernacular literature, advent of printing, beginning of modern chemistry and physics set the stage for two glorious centuries which had no parallel in India. They cleared the accumulated intellectual rubbish of the past and gave birth to Thomas Linacre, Fernel, Leonardo, Vesalius and other men of genius who revitalised medicine. Vesalius, in particular, taught anatomy by dissection and gave a new direction to surgery by his classic volume on the fabric of the human body. But surgery had its hero in Ambrose Pare who won as much love for his humanity as acclaim for his surgical contributions. He invented inst-

ruments, reintroduced ligature, designed artificial limbs, described the strangury of enlarged prostate and carried out podalic version. He immortalised the surgeon's endeavour in his profound and moving statement "I dressed the wounds: God healed them". Notwithstanding Pare and true surgeons like him, numerous wandering quacks continued to practise lithotomy, cataract removal and other operations in Renaissance Europe with disastrous results. A notable development was the formation of the United Barber - Surgeons Company in the city of London in 1540 with Thomas Vicary as its first Master. It was however a far cry from the Royal Society or French Academy which were "critical, rapacious to correct error, yet tolerant from knowing that error is an inevitable step in acquiring new knowledge".

Renaissance heralded the seventeenth century which produced Newton, Bacon, Gilbert and William Harvey. Even though circulation of blood had been anticipated by Leonardo, Vesalius and Servetus, it remained for Harvey to experiment and produce evidence that heart acts as a muscular pump for propelling blood and that blood motion is circular and continuous. His observation that the actual quantity of blood, as measured by him, made it obligatory for it to return to the heart by the venous route was the first application of measurement in medicine. Soon Leeuwenhock introduced the microscope and opened a new world in biology and medicine and Malpighi surpassed all predecessors in his contributions to histology and embryology. The impact of Copernican astronomy, Newtonian mechanics, Napier's logarithms and Descarte's physical concepts on medical thought was profound and irreversible. But surgical standards in Europe continued to remain poor and

blood letting dominated surgical practice. Operations were carried on by surgeons, barbers, bath keepers and vagabonds and 'stones' removed from the head for insanity by quacks. Amputation of limbs and breasts was performed frequently and for wrong reasons. Physicians, surgeons and barbers united, disunited and reunited and spent their time in interminable intrigues against each other throughout the eighteenth century. Into this sombre world came John Hunter who established surgery as a branch of scientific medicine, deriving its sustenance from physiology and pathology. To quote Garrison 'Hunter found surgery a mechanical art and left it an experimental science'. We may truly regard the Modern Phase of surgery to have begun with Hunter

II

John Hunter was a genius whose brilliant mind garppled with an astonishingly wide range of problems. He developed new methods for treating gun shot wounds, aneurysms and ruptured tendons; introduced the feeding tube and a ventilator; made original studies on the pathology of shock, pyemia, phlebitis and intussusception; studied the human teeth; dissected and described 500 species of animals; collected over 10,000 specimens for his museum; conducted physiologic experiments such as those on gastric function during hibernation and made other contributions each one of which would have entitled him to scientific immortality. While he will stand out as one of the greatest surgeons the world has ever seen, his influence on the subsequent evolution of surgery flowed from an unprecedented approach which characterised all his biomedical effort. In the first place he would not study human development, structure or function except in the context of corresponding phenomena from the animal kingdom. Secondly he refused to divorce form from function which were to him inseparable and reciprocally related. Thirdly he would insist on questioning nature for answers to biological problems in the form of simple and elegant experiments. His reply to his famous disciple, Jenner, 'Don't think: try' was characteristic of him. These three elements of the Hunterian approach had a profound effect on the subsequent development of biology, medicine and surgery which were never to be the same after Hunter. Through another

disciple, Physick, Hunter sowed the seed of experiment which characterised the growth of American Surgery. At a different level he retrieved the social position of surgery, and, in the words of a contemporary, 'He alone made us gentlemen'.

Europe which had outdistanced India in medicine and surgery during Renaissance received its boost from five sources in its triumphant march during the nineteenth century which incidentally witnessed the entry of European medicine in India in the form of the Indian Medical Service. First of all, the political revolution of America and France exalted the liberty of man and the dignity of manual labour. In consequence, large sections of the population such as Jews who had been denied civil liberties entered the intellectual main stream which ferried the society to higher levels of discovery and achievement. Secondly, collateral and momentous developments in physics, chemistry and biology swayed medicine and surgery which adopted concepts and discoveries of laboratory sciences as the sole instruments of progress. Physical chemistry, spectroscopy, electromagnetism, Roentgen rays, radium, theories of vision and ophthalmoscope and a wide range of similar scientific advances altered the face of European medicine and surgery which saw the rise of remarkable figures such as Virchow, Astley Cooper, Dupuytren and Pirogoff.

Thirdly, while advancing sciences made medicine and surgery more physical, more chemical and more biological, the battle for public health ensured sanitary reform and a more healthy environment not only for the emerging industrial communities but also for the infirmaries. Thanks to the Chadwick Report in UK

and Shattuck Report in the USA it was recognised in mid 19th century that the health of the community did not so much depend upon hospitals as on sanitation with adequate water supply and sewerage. Medical officers of Health, the earliest career specialists in community medicine, began to be appointed and the first appointee in UK was Dr. William Duncan of Liverpool who took office in 1847 against severe criticism, of all people, from the physicians. John Snow's classic studies on the transmission of cholera in London soon laid the ground work for epidemiology and the scientific basis for public health which in turn provided the fuel for an organised assault on diseases. A solid foundation was laid for vital statistics in a climate of statistical ardor which made room for human ignorance as an explicit factor in making estimations and traced its origin to Laplace, Poisson, Galton and others. Public health measures, vigorously implemented, set Europe firmly on the road to the status of the 'developed' and radically altered the working environment of the surgeon.

Whereas the effects of socio-economic revolution and public health movement on surgery were indirect and the influence of sciences far reaching, the impact of anaesthesia and antisepsis as the fourth and fifth factors was dramatic and immediate during the nineteenth century. To be sure, surgery before anaesthesia was largely confined to superficial maladies. The trephining of skull, amputation or gangrenous limbs, incision of fistulae or removal of cataracts could be carried out quickly without undue prolongation of the patient's suffering. It must however be admitted that surgical practitioners of all shades were largely oblivious of the pain inflicted by surgery and were content to depend on intoxication with alcohol,

inhalation of sponges saturated with poppy extracts, momentary induction of unconsciousness by the digital occlusion of carotid arteries or physical restraints. Inhalation anaesthesia had to wait for the discovery of oxygen and carbon dioxide by Lavoisier and the recognition that the main purpose of respiration was the exchange of oxygen and carbondioxide.

Paradoxically Humphrey Davy's observation on the pleasurable and analgesic effect of nitrous oxide led to 'nitrous oxide follies' in Britain and United States rather than its trial for inhalation anaesthesia. One of the probable participants in the nitrous oxide revels — Dr. Long — introduced its inhalation for surgical operations and dental extractions in the University of Georgia even though the University Professors had preferred mesmerism and hypnotism. After a failed attempt at ether anaesthesia which ended in the tragic suicide of a dentist in Boston, Morton resumed the effort and removed a carious tooth under ether anaesthesia in 1847. He followed up his initial success by its triumphant administration during the removal of a tumour of the jaw by Dr. Warren of the Massachusetts General Hospital who exclaimed to the gallery 'Gentlemen, this no humbug'. Oliver Wendell Holmes suggested the name of anaesthesia for the new speciality which became a momentous event, unmatched in the annals of altruism. Surgery became painless for the first time in its long history. The only surviving obstacle to the general acceptance of surgical operations became the universal fear of hospital infection or 'hospitalism' which was countered by the later development of antisepsis by Lister.

Joseph Lister started his medical studies a year after Semmelweis expounded his doctrine on puerperal fever. He had developed an interest in micros-

copy from his father, a wine merchant, who had been elected to the Royal Society for notable work on microscopic lenses. While pursuing a successful career as Professor of Surgery at Glasgow, his keen scientific mind had already uncovered the mechanism of dilatation of the pupil, overthrown the prevailing theory on the initiation of coagulation by ammonia liberation and rebelled against the concept of laudable pus. Stung by a mortality rate of 45% for amputations, he turned his attention to the great work of Pasteur who had demolished the theory of spontaneous generation and established the microbial basis of putrefaction and fermentation. The possiblity of controlling microbial growth by chemical means excited Lister who hit upon carbolic acid which had been employed earlier for the disinfection of sewage at Carlisle. He employed it with complete success and underscored its importance by titling his paper 'On the antiseptic principle in the practice of surgery'. He developed a method for obtaining pure cultures of the lactic acid bacillus and worked constantly at improving his techniques and using them to extend the frontiers of surgery. Lister's antisepsis broke the last barrier in the march of surgery which emerged triumphant and confident Garrison, in fact, regards him as the greatest of scientific surgeons. Unquestionably Listerian legacy underlies and enriches modern surgery; the new domain of asepsis would have become scarcely accessible to us without the use of his antiseptic principle.

Freed from social constraints, nourished by basic sciences, rendered clean by sanitation, relieved of pain by anaesthetics and made safe by antisepsis, surgery burst upon the twentieth century with new aspirations and high confidence. Old barriers fell

and almost all organs became amenable to elective surgery. Billroth pioneered gastrointestinal surgery including oesophageal resection, Victor Horsley initiated neurosurgery and Hugh Owen Thomas led the way in orthopaedics. Spencer Wells was acclaimed as the master of operations for ovarian conditions and Sauerbruch broke the barrier of the thoracic wall with his pneumatic chamber. If Halsted and Cushing symbolished the impending dominance of American surgery, Alexis Carrel followed the trail blazed by Jassinowski and Jaboulay in vascular suture and established a record in vascular reconstruction, organ transplantation and tissue culture which sparkled half a century ahead of their time.

The Second World War stimulated spectacular progress in surgical methods and organisation in Europe and America and hastened the production of penicillin which Fleming had discovered many years earlier. Penicillin signalled the full scale entry of science into surgery in so far as it eliminated known pathogens by well understood mechanisms of intervention. Millions of patients owed their life to penicillin and other antibiotics which appeared in dazzling succession and opened a new era in the treatment of surgical infections and infectious diseases. But the wind that transformed surgery during the Second World War and post war years was by no means a purely antibiotic wind because it included major contributions from engineering and physical sciences. Their presence became so pervasive and applications so common that one might possibly miss the technologic dominance in contemporary surgery altogether. What were these technologies and how did they fit into the historical evolution of surgery?

The surgeon's passion for better tools and instruments dated back to ancient times and the magnificent obsession with instrumentation technology is in full bloom today. If new alloys and computer aided design and manufacture changed surgical instruments beyond recognition, the laboratory was revolutionised by a staggering variety of smart instruments including cell counters, autoanalysers, gas chromatographs, scintillation counters and blood gas analysers. While imaging by Roentgen rays evolved into image intensification and computerised tomography, new species of imaging techniques emerged based on raadioisotopes, ultrasonography, nuclear magnetic resonance and positron emission. Postoperative monitoring by counting pulse and measuring blood pressure yielded place to multi-channel electronic instruments which simultaneously monitored a dozen physiological parameters. Fibreoptic technology transformed endoscopy which peered into every hollow viscus and body cavity. Contrary to popular belief, the role of instrumentation extended beyond diagnosis and monitoring and included several therapeutic functions. The old example of radiotherapy was joined by vigorous offsprings such as balloon angioplasty, laser ablation of tumours and ultrasonic elimination of renal stones. Conditions which were clear indications for surgery barely ten years ago became nonsurgical thanks to the array of intervention procedures. Never had instrumentation had it so good in medical applications and never did it owe more to electronics and computers which burgeoned in post war years.

Unlike instrumentation, the technology of medical devices entered surgery no more than thirty or forty years ago. Unlike instrumentation which looked to electronics, devices technology called upon materials

science to develop biocompatible materials and biomedical engineering to fabricate devices. In a few decades medical devices poured into every branch of surgical practice and revived the old dream of 'spare part surgery'. Apart from the enormous number of disposables such as sutures, catheters, blood storage bags and artificial kidneys, the family of implantables grew rapidly including hydrocephalus shunts, prosthetic joints, cardiac valves, pacemakers, vascular grafts, mammary prosthesis and numerous other members. The cumulative impact of devices technology on the development of surgery was no less profound than that of the advent of iron thousands of years earlier. Medical devices not only fathered a large industry and hastened the technological fermentation of surgery: they also raised fundamental questions on biocompatibility and how synthetic materials might conform to the specific environment of tissues as diverse as bone, brain, eye and arteries.

While physical and engineering sciences altered surgical practice by the introduction of instrumentation and devices, biological sciences nearly stole the show by their dramatic contributions to organ transplantation which opened a new and exciting chapter in the history of surgery. Hybridoma, recombinant DNA, tissue culture and enzyme engineering hold so bright a hope for the future that the twentyfirst century has been confidently predicted as the harbinger of the Biological Phase of surgery.

Momentous as technologies were and continue to be, they do not tell the whole story of the twentieth century phenomenon in surgery. The pioneering spirit which blends the gift for experiment with the talent to spot and assimilate advances from other disciplines

did as much to accelerate and direct the course of surgery as the technologies themselves. Lister had demonstrated a hundred years earlier the spectacular effect of applying the nascent knowledge of microbiology to surgery. Twentieth century witnessed the triumphant use of the Listerian approach which opened unforeseen vistas and brought the future all too soon to surgery. The finest example of this phenomenon is my own speciality, cardiac surgery, which leaped from infancy to maturity in less than forty years and skipped childhood and youth in the bargain. John Gibbon and Charles Hufnagel stand out as the champions of experimentation and technology assimilation which nurtured the precocious growth of cardiac surgery. Moved by the sudden death of a patient from massive pulmonary embolism, Gibbon resolved to develop a system for heart-lung bypass which would enable the surgeon to shut off cardiopulmonary functions and remove the embolus through pulmonary arteriotomy. While the aim was humanitarian, the idea of heart lung bypass was adopted from the physiologists who had used it earlier for experimental studies. The translation of the technique to man was a twenty year tapasya when Gibbon freely sought and received the support of IBM engineers in the design, fabrication and optimisation of a vertical screen oxygenator, blood pump and other accessories of the Gibbon machine which gave a quantum leap to cardiac surgery. Hufnagel who inherited the Carellian trail in vascular reconstruction connected a cadaveric kidney to the brachial vessels of a young woman in acute renal failure as a Postdoctoral Fellow at the Peter Bent Brigham Hospital and opened the chapter of hemodialysis. He followed up the vascular effort by the use of polymethyl methacrylate tubes for the replacement canine

thoracic aorta in the early forties and joined Gross and Crafoord in being among the first to repair the coarctation of aorta. From the permanent intubation of the thoracic aorta to the implantation of a ball valve for aortic regurgitation was an exciting Odyssey for Hufnagel who braved no little scepticism on his way. If the endeavour of Gibbon and Hufnagel illustrates the powerful impact of experiment and lateral assimilation on surgery, Sones demonstrated the seminal role of technologic innovation by his introduction of selective coronary angiography which literally gave birth to coronary artery surgery.

Advances in science and technology and their discovery and assimilation by pioneers were the primary determinants for the flowering of surgery in our times. A third and secondary factor had to do with the reality of the Industrial Age which impinges on us on every side and at all levels. New drugs, new instruments, new tools and new devices are the products of industry which has learnt that investing in knowledge is the most profitable form of investment. Every cycle of manufacture and use of products leads to refinement and improvement which in turn become the fuel for the development of the next generation of products. As the pace of the industrial society quickens and leaves the world breathless, the time gap between the successive models of industrial products tends to narrow sharply. This phenomenon of rapid change has had its inevitable repercussion on surgical practice with the likely result that a surgeon from the nineteen thirties would be bewildered by the organisation of a modern operating room and intensive care unit. As the world marches on to a post-industrial society one may expect surgery to keep in step and reach higher levels of achievement. No one doubts

any more that the absorption of science and technology into the fabric of surgery which began in the present century will continue at an every-increasing rate and transfigure surgical concepts and practice at progressively shortening intervals. But surgery will not be reduced to an exercise in biotechnology and robotics any more than life will be fully analysed in terms of physics and chemistry. The challenge ahead for surgery will arise not so much from a loss of identity or the impact of techno-industrial escalation as from the ancient abligation to tend the flame of compassion.

III

Fostered by Sushruta and his predecessors, Indian surgery enjoyed an early spurt in growth until it was overtaken by premature senility. If India dominated my first lecture which dealt with the forenoon of surgery she dropped out altogether from the second which covered noontide when science had made its entry into surgery. The sun set too soon for surgery in India, ushering in darkness at noon with no Salerno or Ambrose Pare to lighten the gloom. Its fate reminds one of Viswamitra who strode the Balakanda of Ramayana like a colossus only to disappear for ever from the eventful chapters which followed.

The fact of Indian surgical decadence is undeniable. The Ayurvedic tests which followed Sushruta Samhita laid progressively less emphasis on surgery and authorities ranging from Vaghbhata to Bhava Misra exalted medical therapy to the near exclusion of surgery. Surgical procedures described by Sushruta probably ceased to be in vogue as early as the seventh century when the Ashtanga Hridaya appeared. The technology for surgical instrumentation melted away unwept and unsung. Surgery had masters and schools no more and its techniques survived only in the grand old text and in the erratic hands of itinerant practitioners. It should however be noted that surgery no more than shared the general fate of medicine which had its own tale to tell. "Indian medicine", says a European observer, "was in possession of an imposing treasure of empirical knowledge and technical achievement: It reached to the heights of a systematising,

theorising school of thought, but it lacked the freedom or individual action essential to the pursuit of real science: it lacked too unprejudiced judgement and the possibility of criticism, not stopping short even of venerable doctrines. In the strange repressive cultural conditions is rooted the destiny that was to cut short the process of evolution and to lead to scholastic petrifaction. No new era has dawned for this middle age as in the long silent past. So even today, the edifice of Indian medicine stands unaltered, lonely, apart, far from the everflowing stream of progress". The circumstances which led to the decline and downfall of Indian surgery are of supreme importance in so far they contain the roots of our present condition and the key to our surgical future. They had, as we shall see, less to do with surgical happenings than with political and social events which occupied the Indian stage from the sixth century BC to the sixth century AD when the Gupta empire came to an end.

Sixth century BC represented a pivotal stage in Indian history when the Indo-Gangetic plain saw the rise of numerous kingdoms and the growth of tribal organisations of Vrijjis, Vrishnis, Bhojas, Licchavis, Mallas and others. Bimbisara ruled Magadha and Udayana of Bhasa's Plays occupied the throne at Ujjain. The ritualistic religion of the Vedas had largely given place to the supremacy of Upanishadic doctrines and the veneration of asceticism. This was the intellectual and spiritual climate which witnessed the ministry of the Buddha whose influence on secular and religious life was incalculable. Religious movements as well as secular knowledge made parallel advances during this period which saw the emergence of professions or guilds of architects, craftsmen, carpenters, weavers, bricklayers and merchants. Phy-

sicians and surgeons chose not to organise but to carry on their practice as itinerants or in the Gurukula tradition. The political and intellectual climate of the sixth and fifth centuries BC was so charged and the organisation of craftsmen so effective that their joint impact could not but elevate surgery to the high level it attained in the Sushruta Samhita. In the fourth century BC, Alexander invaded the Gandhara satrapy of the Persian Empire and Punjab and opened an Indo-Greek exchange of ideas in science and philosophy even though its impact on Indian surgery was not perceptible. The Indian response to Alexander's incursion was the organisation of the Mauryan empire of Chandra Gupta whose system of administration is described in detail in the Arthasasthra. It is significant that Arthasasthra, eloquent as it is on wars, punishment by mutilation and medical treatment for a variety of ailments, is silent on surgical practice which might have started on its descent already. In the hands of Asoka who expanded Chandra gupta's empire the state became "an instrument for the establishment of peace, goodwill and compassion." Asoka opened infirmaries for man and animals inaugurating a new and compassionate chapter in the history of medicine. Taxila became a famous centre for learning with a high reputation for medical studies which attracted students from India and abroad. Even though the concept of Tridosha became well established, physical diagnosis refined and pharmacopea enlarged during Mauryan times, surgical techniques did not share the progress in medical science. In fact, when the Kushan ruler, Kanishka, established his empire after the Mauryas, his physician was none other than Charaka whose classic Samhita said little on surgery. The two hundred years of Gupta empire which followed marked the high water

mark of attainment in literature, religion, art and other fields of human endeavour in India and the emergence of Banaras as a parallel centre of medical eduction. But surgical practice continued to decline until the final blow came with the sack of Taxila by Mihiragula who tormented the northwest after the fall of the Gupta empire in 544 AD. No other political event before or after the destruction of Taxila seems to have had a direct role in the enervation of Indian surgery which never recovered and slumbered through subsequent centuries when India was convulsed with numerous political events. It became a fossil reminding us of a brilliant past and a premature end.

What exceeded political changes in importance were social events which cast their shadow on all branches of human endeavour including medicine and surgery. The Smrithi writers upheld chaturvarnya and laid the scriptural basis for the caste system which assigned an inferior position to artisans, weavers and craftsmen who were held ineligible for receiving a classical education. A consequence of deifying intellectualism at the cost of labour was the growth of social attitudes which regarded manual work with disdain. A society which rated initiation into the secrets of mantras higher than sublime craftsmanship could not appreciate surgical technique or encourage the growth of surgery. The constant denigration of the human body which was regarded as unclean and unholy, the obsessive fear of defilement and the growth of numerous taboos relating to contact with blood or body parts or secretions were powerful factors in lowering the status of the surgeon and the weakening of general interest in surgery. Moreover the Buddhist interdiction on bloodshed contributed to surgical

decline in the same manner as the decree of Pope Innocent III inhibited European surgery in the medieval period. Surgeons also paid a heavy price for failing to create guilds to protect their professional interests on the pattern of merchants and artisans who organised so effectively during Mauryan times. The organisational failure is puzzling as the Arthasasthra had clearly included all classes of physicians in the category of artisans. The degradation of the medical profession towards the beginning of the Christian era is evident from Manusmrithi as well as Arthasasthra. To quote Manu "Physicians, image-worshippers for gain, sellers of meat, and such as live by low traffic, must be shunned in oblations both to the deities and to progenitors". To Manu's insult Kautilya later added injury by the punitive provisions in his Arthasasthra. According to Kautilya "Physicians undertaking medical treatment without intimating to the Government the dangerous nature of the disease shall, if the patient dies, be punished with the first amercement. If the death of a patient under treatment is due to carelessness in the treatment, the physician shall be punished with the middlemost amercement. Growth of disease due to negligence or indifference of a physician shall be regarded as assault or violence". While the code of Kautilya probably kept in check the murderous humbug of itinerant quacks, it had the unintended effect of inhibiting surgical procedures whose failures were immediately obvious and could invite severe punishment. No wonder Indian surgery, and to a lesser extent medicine, collapsed under the heavy weight of social stigma and disabilities. Unfortunately the decadence in surgery and sciences was matched by the growth of conceit and foolish pride which reached monumental proportions by the eleventh century. To recall Alberuni's famous remarks

"Hindus believe that there is no country but theirs: no nation like theirs: no king like theirs: no religion like theirs : no science like theirs: they are haughty, foolish, vain, self-conceited and stolid. They are by nature niggardly in communicating that which they know and they take the greatest possible care to withhold it from men of another caste among their own people, still much more, of course, from any foreigner. According to their belief, there is no country on earth but theirs, no created beings besides them have any knowledge of science whatsoever. Their haughtiness is such that, if you tell them of any science or scholar in Khurasan and Persis, they will think you to be both an ignoramus and a liar. If they travelled and mixed with other nations, they would soon change their mind, for their ancestors were not as narrow minded as the present generation is". A fatal error was made in the insistence that all that was to be known was already known and that what was familiar was obliged to appear in the unfamiliar. Nothing could destroy the remaining spark of life in Indian surgery more than the cancerous growth of conceit which fed upon intellectual rubbish and the uncritical adulation of the past. The Unani interlude during the Mughal period scarcely entered the surgical pages.

What reappeared in India during the nineteenth century was not Indian surgery but European surgery operating on the Indian soil. Neither did it refer to Indian concepts nor adopt Indian techniques with the solitary exception of rhinoplasty. Even its historical view chose to ignore the great role that India had played at the dawn of surgery. Nevertheless, long starved of new knowledge and cut off from scientific currents elsewhere, Indians took to the new surgical

movement with unbounded enthusiasm. Their adoption of its symbols, concepts, methods and tools was so total and rejection of India's faded legacy so complete as to have few parallels in other civilisations. The volume and variety of surgical activities and trained personnel expanded rapidly in India during the first half of the twentieth century and reached spectacular proportions during the post Independence decades. Surgical specialities and training programmes multiplied and degrees proliferated. What started as a trickle of Indian physicians and surgeons trekking to Britain for training in the late nineteenth century became a flood in the twentieth engulfing even North America. Indian surgeons won respect and acceptance all over the world and prided themselves in their competence and universality of outlook. But there was a fly in the ointment and a sour note in the symphony of triumph. For all the achievements, India's name did not figure in the honour roll of nations which contributed to the advancement of surgical knowledge despite her wholehearted adoption of European medicine and surgery. In fact, no concept, no discovery, no technology or procedure originated in India which shaped or directed the course of global surgery. Had the springs of original thinking run dry in our soil ? Had our civilisation grown old and reached a stage when it could only perform repetitive acts and no longer adapt its jigs and spindles for new poduction? What had gone wrong? What indeed had happended to us ?

One could argue that the socio-political factors which caused the eclipse of Indian surgery are by no means powerless today and that they continue to operate under labels and forms which are appropriate to the present age. Great universities are destroyed

by political infiltration as effectively as by the raid of a tyrant: a society which worships gold despises compassion and converts surgery into a commercial enterprise: denial of opportunities to gifted students in the garb of egalitarianism hurts scientific progress as surely as the social oppression of the weaker sections in earlier times; a climate where knowledge is no longer prized encourages the delusion that borrowed discoveries are one's own achievement: and shining in borrowed feathers engenders dangerous conceit. While these views may be arguable, what is resoundingly true is the fact that India enjoyed a free ride in surgery from the nineteenth century, borrowing Western theory and practice and contributing nothing of her own. Unlike Varahamihira who assimilated Greek ideas and used them as instruments for creating a new domain of astronomic knowledge, surgeons condemned themselves to borrowing in perpetuity. What was borrowed did not strike roots in the Indian soil with the certainty that the next generation of surgical techniques and goods would be imported again. This is remniscent of the record of Indian industry which is so utterly dependent on licence know-how after four decades of Independence and cannot claim even a semblance of self-reliance. Contrast the Indian chronicle in medicine and surgery with the American record of the late nineteenth and early twentieth centuries! Both countries lacked a self-reliant base and both looked to Europe for know-how and training in the nineteenth century. Edinburgh, London, Vienna and Berlin received young men from India and the United States in the late nineteenth century for training in medicine and surgery which were throbbing with excitment at that period of time. The pilgrimage led to vastly dissimilar results however. Whereas the Indian visitors returned to build legendary

reputations, practice and clinics, the Americans succeeded in using their training as an engine for progress which would soon excel the record of Europe. India could not boast of a Welch or a Johns Hopkins as an outcome of her nineteenth century contact with Europe and colonial rule would be no more than a feeble excuse for her failure.

It is imperative that we turn things around and, to borrow an industrial phrase, build a surgical base which can be self-generating. Our very survival as a self-respecting nation demands no less because ruin is the destination of a race which lives on borrowed intellectual capital. Tomorrow surgery will have marched forward yet more, and there will be no appeal from the harsh judgement which will befall the chronic intellectual debtors. It is not my case that we should aspire to develop everything in surgery by ourselves. India is too large, her population too massive, and her requirements too varied for such an objective to be realistic. Instead our surgical capacity and technology must become such, that while our time scales and priorities may bar the development of a technology, we can definitely accomplish any job if and when occasion demands no matter whether the challenge relates to transplants or an artificial heart. A new breed of surgeons must emerge who will claim Sushruta and Hunter as their common heritage and make it their business to harness science and technology for the fulfilment of the ancient objectives of surgery. Relief of suffering will be their aim; new discoveries in science, technology and medicine, their pabulum; ablend of surgery and technology, their culture; and thought crystallising in manual action, their practice. To achieve this goal, our policies of yesterday will not do. A New Deal in surgery is the need of the hour.

We can do no more than touch upon the basic elements of the New Deal which must restructure all aspects of surgical education, training and research with the sole object of building an Indian identity in surgery. The task is so gigantic that its accomplishment will call for nothing less than the vision and genius of Sir AL Mudaliar. In my own utopia, the syllabus would exhibit surgery as part of man's ancient endeavour to heal and to refine handcraft. The boundaries of the syllabus would contract or expand as old knowledge becomes obsolete and new horizons appear. Nor would it shrink from incorporating discoveries and ideas which advance surgical endeavour regardless of their origins in folklore, physics, biology, or aerospace engineering. Its training programme would expose the neophyte to the excitement of diagnosis and operative technique and instil in him a deep sense of reverence for the linkage of form and function in the human body. He would see himself in line with all handcraft men who love to use their hands for creating things of beauty. He would learn that the training process would last till death claimed him and that the success of his training would be measured in terms of his ability to heal and to discover. Surgical endeavour in turn would unite surgeons and gifted scientists from varied disciplines who share a joint culture and the power to extend the frontiers of surgery. The new race of surgical scientists would address themselves to the central problems of quality, creativity and accessibility of surgery in India no matter by whom their efforts are applauded or ignored; they would acknowledge that surgical instrumentation, rhinoplasty and a host of other subjects which filled Sushruta's mind have become today something to be taken for granted, something known and familiar, someting essential towards further endeavour.[1] They

would nevertheless recognise that achievements of Indian surgery, even when they appear brilliant and prescient, deal with but segments within a vast and expanding framework of experience and knowledge; that the old knowledge, as the pathway to the new, had left us a boundless area of unknown; and that the exploration of the unknown must be valued to the extent it betters the human condition and directs the course of global surgery. Inheritors as we are of a noble tradition in surgery, we must learn to accept that we are nothing without the work of our predecessors and contemporaries, yet we are more; that the new transcends, rather than abrogates the old; and to transcend, we must leave the old intact in its realm and move on to build our halls in the evergrowing mansion of surgery. The river of Indian surgery, long reduced to a trickling stream, would then swell and dance and flow into the mainstream, enriching it and making its waters whole.