Inaugural Lecture

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Brain matters: *Neurosurgery in a Developing Country*

Neurosurgery is the specialty concerned with treating diseases of the brain and spine that require surgical intervention. Our specialty has deep roots in the practice of neurology but also has a certain mystique, which often surfaces in the media.

Ian McEwan's novel "Saturday" describes a day in the life of Henry Perowne, a fictitious neurosurgeon [McEwan]. The author spent two years in the company of neurosurgeons, gaining a close appreciation for the details of our daily work. Describing an operation where the skull is opened to drain a blood clot on the surface of the brain, he writes:

"Looking down at ... Baxter's brain, Perowne can easily convince himself that it's familiar territory, a sort of homeland, with its low hills and folded valleys of the sulci, ... so easy to damage, with such terrible lifelong consequences. How much time has he spent making routes to avoid these areas, like bad neighbourhoods in an American city. And this familiarity numbs him daily to the extent of his ignorance, and of the general ignorance, ... could it ever be explained how matter becomes conscious?"

The title I have chosen for this inaugural lecture, "Brain Matters," is open to interpretation in various ways and I would like to explore these with you this evening.

Primarily, as McEwen observes, neurosurgery is the discipline that deals most directly with the matter or substance of the brain, which we literally touch every day in the operating room. However often we do this, we never lose the sense of dread that misadventure carries a huge cost, not just for the patient and their family, but also for us, as no specialty takes its complications more seriously than neurosurgery.

There is also a sense of awe for what lies before us, as the brain is also the matter of the mind, the most complex structure in the known universe. As we move forward in the 21st century, the thinking neurosurgeon is well-positioned to contribute directly to a deeper understanding of the brain.

There is a political dimension as well, that requires me to make the case for neurosurgery as a discipline that really does matter and I intend to do this, not just in general terms, but with developing countries, including South Africa, specifically in mind.

Just after I was appointed to the Chair, the Dean sent me a copy of a chapter from a very large textbook. The chapter itself is very short, perhaps because it was intended for surgeons, but more likely because it reviews a topic which has received very little attention, namely the place of surgery

in health systems [Debas]. I am pleased to tell you that the authors come to “the clear conclusion ... that surgery must be considered a public health priority.”

When you consider the wide range of conditions we treat, including some major contributors to the global burden of disease and suffering such as stroke and trauma, it cannot be denied that neurosurgery must matter in any healthcare system. It is seldom appreciated that brain tumours are in fact the second most common type of cancer in children and we strongly support public health strategies that will have an impact, such as the widespread use of folic acid.

The Alma Ata Declaration boldly aspired to “Health for All by the Year 2000”; while important gains have been made, there is also an increasing emphasis on a holistic approach to each individual patient. In that sense we practise the Primary Health Care approach every time we see a patient as decisions are always directed at the best interests of that particular patient. Pretty much any brain tumour can be removed, but we take seriously the injunction to “first do no harm”.

In fact, I would argue that there are few areas of human endeavour where such an emphasis is placed on the value and needs of an individual human being.

In exploring these themes, I would like to briefly outline the evolution of neurosurgery as a specialty before focussing on our practice at UCT, look in some detail at some of my particular areas of interest and then make the case for this specialty on our continent. Finally, I will consider a few of the challenges faced by academic surgeons and conclude with a vision for how we can continue to build on the tremendous opportunities we have.

Evolution of Neurosurgery

The practice of making holes in the skull of a living person, referred to as trephination, is an ancient art and the story of Neurosurgery must begin in Africa, in that the oldest trephined skulls, dating back 10,000 years, have been found in North Africa.

The oldest written record of surgical treatment is the Edwin Smith papyrus, thought to be the work of Imhotep, perhaps the greatest of all physicians. He describes 48 cases of which the majority concern injuries of the head and spine, surely the last time that neurotrauma received the prominence it deserves! The limitations of practise at that time are apparent in his recommendation that conditions such as quadriplegia following cervical spine fracture and post-traumatic meningitis were “ailment(s) not to be treated”, on grounds of futility [Feldman].

Despite the best efforts of various physicians over the next three millennia, operating on the living brain only became a realistic option once three critical developments had taken place. One historian has noted that the evolution of neurosurgery as a distinct specialty can be divided into three epochs, the premodern, which set the stage for the first real attempts to operate on the brain, followed by a 40 year period of gestation, giving birth 90 years ago to the specialty we know today [Greenblatt].

In the introduction to his masterpiece, Walter Dandy wrote:

“Surgery of the brain is the outgrowth of three discoveries of the nineteenth century- anaesthesia, asepsis and cerebral localization. Without asepsis (or antisepsis), surgery of the brain would never be

possible. With asepsis and without cerebral localization, it could be of but little value. With both asepsis and cerebral localization and without anaesthesia, it would be possible but greatly limited".

This has a contemporary ring when theatre lists are cut, due either to a shortage of either nurses or anaesthetists!

These three developments led to the first operation on a lesion based on clinical localization in 1879 when William Macewen in Glasgow accurately located and drained a blood clot in the brain, but it was the appointment of Victor Horsley as the first full-time neurosurgeon at Queen's Square Hospital in London that signalled the arrival a new specialty.

Horsley was a true scholar-surgeon in that much his clinical practice was complemented by ongoing basic science research. He was by all accounts a difficult man but he made many major contributions, not least the bone wax used to control bleeding to this day, as well as the concept of stereotaxis, which I will return to later. It is worth mentioning that Horsley was also a pioneering social activist, campaigning for women to get the vote and pushing the Queens Square hierarchy to make the first ever appointment of an Afro-Caribbean colleague as a consultant [Powell]. I must point out that this early activity was not confined to Britain as other European surgeons also played an important role in defining this new specialty.

Neurosurgery may have been conceived in Europe, but the birth took place on the East Coast where Harvey Cushing, strongly supported by Halstead and Osler, was the first American surgeon to commit his career to this previously unknown specialty. Cushing defined what he called "the special field of neurological surgery" in 1904; he was a meticulous surgeon, wrote prodigiously, and had a particular genius for organization and passion for training.

After a decade at Johns Hopkins he moved back to Boston where one of his trainees was Walter Dandy. The bitter rivalry that developed between them is legendary but Dandy was a true scientist and innovator, achieving a huge number of firsts, ranging from diagnosis in introducing the technique of ventriculography through to the treatment of hydrocephalus and aneurysms. Thanks to the efforts of Cushing, Dandy and a few other brave souls, there were enough neurosurgeons by 1920 for the first professional group to emerge, the Society of Neurological Surgeons.

It is obvious that our specialty has been enormously influenced by technology generally, and radiation medicine in particular, hence the close interactions between us and the radiologists and radiotherapists. The introduction of the operating microscope ushered in the era of microsurgery with a whole new range of surgical instruments. Further advances brought us minimally invasive techniques such as neuroendoscopy and interventional neuroradiology as well as a dazzling array of spinal instrumentation..... the list is endless. While this has hugely enhanced what we can do, it has never, and I expect will never, displace the central importance of taking a careful history and performing a decent examination.

This is not only a relatively young specialty, but also one that is differentiating at a very rapid rate, so much so that our practice today is already fundamentally different to when I finished my training 13 years ago. There are now at least eleven distinct subspecialties within neurosurgery, which is a challenge when one has to plan services and training.

Minimalism is a concept closely associated with the great Bauhaus architect Mies van der Rohe, who famously stated “less is more”. This concept has found expression in minimally invasive neurosurgery where technology has been harnessed not only to limit the surgical trauma imposed by the surgeon, but also to enable us to do more, as exemplified by the “keyhole concept”, where the endoscope gives the surgeon an even better view than the traditional operating microscope. Nanotechnology takes us to neurosurgery at the level of 10^{-9} and who knows what subcellular interventions lie ahead?

Neurosurgery at UCT

Turning our gaze closer to home now, the tale of Neurosurgery in Cape Town starts in 1946 with the arrival of De Villiers Hamman [Peter, 1999]. He literally and figuratively had to find his own place as this new specialty was banished to J block, which had been built as a private hospital alongside Groote Schuur in 1936 but had never really found a use.

Under Hamman’s quiet but convincing leadership neurosurgery took root at Groote Schuur, leading to the endowment in 1976 of a Chair of Neurosurgery in honour of Helen and Morris Mauerberger; their family have been stalwart supporters of the department ever since and I would like to pay special tribute to Mrs Estelle Yach whose ongoing interest and engagement with our activities is deeply appreciated.

Kay de Villiers, a full-time consultant since his return from training at Atkinson Morley Hospital in 1966, was the first incumbent. Widely acknowledged as the father of academic neurosurgery in South Africa, his wide-ranging interests ensured that his impact extended far beyond his own field. He has made a monumental contribution to medicine in South Africa and the intellectual life of this University and I’m very happy to say that he still plays an active role in our department.

Under his leadership the first sub-specialties emerged, namely pituitary surgery and paediatric neurosurgery but this was really taken to a new level when he was succeeded by Jonathan Peter in 1994. The department made enormous strides under Professor Peter’s leadership in that a wide range of subspecialties became well-established, a situation unique in our country. Apart from his towering role in South African neurosurgery, he has played an important role internationally in paediatric neurosurgery.

The success of my two predecessors is reflected in the depth of our department today. A particular strength is the strong relationship with colleagues in the private sector who serve as part-time staff and I would like to pay tribute to Drs Roger Melvill, Freddie Kieck, Shafik Parker, Norman Fisher-Jeffes, Grant White and David Carter in this regard. Groote Schuur Hospital is surely one of the world’s great hospitals and we have a duty to build on this legacy.

I have already mentioned Professor de Villier’s own interest in pituitary surgery, a story beautifully told in his own inaugural lecture, “Assailants of the Sella Turcica” [De Villiers]. This legacy has been continued by Associate Professor Patrick Semple, who now enjoys a really productive collaboration with Dr Darlene Lubbe from ENT, they have developed tremendous expertise in endoscopic pituitary surgery which has led to Groote Schuur being included in a recently established grouping of the world’s leading pituitary centres.

One of the most technically demanding areas in medicine is the management of cerebrovascular disease and we are truly fortunate to have a neurovascular surgical service second to none. Associate Professor Allan Taylor 's virtuoso surgical skills are now matched by his endovascular ability and together with Dr David Le Feuvre they deliver a level of care for adults and children that truly is unique in the country.

Treatment of aneurysms previously would have required a 3-4 hour craniotomy followed by a few days in ICU and prolonged hospitalisation; these patients are now treated within an hour in the cath lab and often go home within days. The benefits to the patient and the hospital are obvious. Their mentor Pierre Lasjaunias convened a meeting annually at Val d'Iser which defined the field, but their own international standing is such that they will be hosting the biennial World Federation of Interventional and Therapeutic Neuroradiology in Cape Town next year.

Spine surgery is literally the backbone of neurosurgery worldwide, and this is no different in South Africa where spine comprises over two thirds of the caseload in private practice. As with many areas of modern practice, it is susceptible to unproven new technology and we are fortunate to have someone in Dr David Welsh who combines a critical disposition with great surgical skill. David has led Neurospine at Groote Schuur for a decade and plays a major role in the Acute Spinal Cord Injury Unit, working closely with Associate Professor Rob Dunn from Orthopaedics.

One of the most exciting areas in neurosurgery today is that of "functional neurosurgery", in other words surgery that alters brain function in conditions ranging from epilepsy and movement disorders such as Parkinson's disease through to psychiatric disorders such as refractory depression. Dr Sally-Jane Röthermeyer has been appointed to develop this area at Groote Schuur and we have a unique opportunity to evaluate the role for this type of surgery in developing countries when Roger Melvill, Sally and I will host a meeting of the World Society for Stereotactic and Functional Neurosurgery next year.

Almost half of the patients we treat at Groote Schuur Hospital have sustained a traumatic brain injury and this has required specific responses, such as the recent establishment of a High Care Unit alongside our ICU, enabling us to further develop expertise in neurocritical care.

We have enjoyed a very productive partnership with ComaCARE, an NGO primarily concerned with the well-being of patients and their families following a brain injury; not only do they directly enhance the care we provide, but they have reminded us that there is more to consciousness than the Glasgow Coma Scale and have also facilitated many opportunities, such as the visit to Groote Schuur by Ben Zander in 2008.

I want to now turn to an institution that epitomises Zander's possibility in action, and that is Red Cross Children's Hospital.

Operation Theatre was a wonderful project run by the Children's Hospital Trust; I want to thank the Trust most sincerely for the amazing support they give the hospital- much of what I'm now going to talk about was made possible by their work. I also acknowledge the extremely full, in fact overflowing, hospital that lies behind this theatre and the hundreds of people who work so hard to try to make it run smoothly.

From the founding of Red Cross in 1956, various neurosurgeons cared for children with neurosurgical problems but the return of Dr Warwick Peacock from a fellowship at Sick Kids in Toronto in 1979 really got Paediatric Neurosurgery off the ground as a distinct sub-specialty.

"Passionate" is the word that best described Warwick's approach to his work and this ensured that this new discipline flourished. When he finally accepted a position at UCLA in 1986, his lifelong friend Jonathan Peter took over and built the service further [Peter, 1995]. I was fortunate to run this unit for a decade from 1997 and privileged to then be able to hand this on to someone of the calibre of Associate Professor Tony Figaji; the unit has been further strengthened by the recent appointment of Dr Llewellyn Padayachy.

Clinical medicine is a lifelong learning process- as one of our most admired colleagues, the late Tony Hockley said: *"I spent the first ten years of my career learning how to operate, the next ten years learning when to operate, and the rest of my career learning when not to."*

Despite the fact that we sometimes deal with rather grim and even dreadful situations, clinical medicine is also very rewarding! We interact with patients and their families in so many different settings and often get to know them really well, which is a real joy. Communication with parents is such an important part of the job but we don't always get this right- one day I was seeing a little chap for routine follow-up of a shunt which had been placed in a cyst at the back of his brain. This condition, first described by Walter Dandy and his trainee Earl Walker, is known as Dandy-Walker syndrome and on this occasion I was concerned that he seemed a bit unsteady on his legs, suggesting the cyst may have expanded. After watching him walk up and down the consulting room a few times, I asked his mother:*"wanneer het hy so begin loop mevrou?"* She looked at me as though I was a complete idiot and replied scornfully: *"dokter, hy het altyd so geloop want jy weet mos, hy's 'n dandy walker!"*

I would like to illustrate what our work entails by looking at four of the conditions we treat:

1. Hydrocephalus
2. Head injury, or as it is now known, traumatic brain injury
3. Functional neurosurgery, particularly the treatment of epilepsy and spasticity
4. The separation of conjoined twins

Of course we treat many other conditions, including congenital abnormalities such as spina bifida and craniosynostosis, brain and spinal tumours, various infections and a long list that I won't inflict on you today, but I have chosen these particular areas in order to make three points:

1. New technology, when used appropriately, makes a real difference to what we can offer patients
2. Well-planned research translates into meaningful improvements in patient outcomes: our challenge is to ensure that research and service delivery proceed hand-in-hand
3. As South Africans, we can be pioneers even in technologically demanding fields such as neurosurgery

There is perhaps a fourth theme- neurosurgery may not be the least stressful way to earn a living, but at times we do have a lot of fun!

Hydrocephalus

Hydrocephalus is a good place to start as this condition was the birthplace of pediatric neurosurgery. Hydrocephalus is what is says- too much water in the head. In young children with unfused skulls, this leads to a relentless increase in the size of the head, as shown in this diagram from Severinus, the oldest known medical illustration of the condition. Various attempts were made to understand how this condition came about but these were limited by a poor understanding of human anatomy and physiology [Goodrich].

The most elegant studies were those of Retzius and Key at the Karolinska, confirming that there was in fact a circulation of cerebrospinal fluid or CSF, which is initially produced by a structure called choroid plexus in the ventricle and then circulates through a series of cisterns at the base of the brain. There are various narrowings where this pathway can become blocked, leading to a build-up of fluid within the ventricles. This obstruction may be congenital, due to an abnormality in the early formation of the brain (most common in the setting of spina bifida), or as a result of haemorrhage, trauma, infection or a brain tumour.

The traditional treatment for hydrocephalus is insertion of a narrow silicon tube, a so-called ventriculo-peritoneal shunt which diverts the excess fluid from the brain to the abdomen. The humble shunt represents one of the most inspiring stories in modern medicine.

Right up to the 1950's various extreme remedies had been attempted but none had proved to be effective in treating hydrocephalus. Casey Holter was one such patient who developed progressive hydrocephalus; his father however refused to accept that this could not be treated. The difference was that John Holter was an aeronautical engineer who during the war had learnt the properties of silicon, a newly invented substance used to insulate jet aircraft engines. He was able to manufacture a shunt for his own son, giving rise to a technology that literally has saved millions of lives, and preserved brain function in even more.

Despite massive technological advances over the past 6 decades however, these mechanical devices are replete with potential problems, with up to 50% malfunctioning in some way within the first 3-5 years; sadly Casey Holter died of a shunt complication at the age of three and every neurosurgeon has a rogues gallery of scans showing all sorts of complications, usually due to shunts implanted elsewhere of course!

With this background, a different treatment strategy was welcome. Endoscopy as a concept has been around for a century, but advances in glass rod endoscopes by Hopkins, working for the Karl Storz Company, coupled with modern camera technology made this widely applicable. Hydrocephalus has been the most important indication for endoscopy, where the enlarged cavities of the ventricles ensure adequate working space. Endoscopic procedures seek to restore the normal intracranial CSF circulation by creating an opening internally which will bypass the blockage which caused hydrocephalus, an idea first proposed by Dandy.

Neuroendoscopy has also given us new insights into old foes. The ravages of tuberculosis are well known to anyone attending inaugural lectures at this medical school; the most lethal complication of the disease is tuberculous meningitis or TBM and more than half of these patients develop

hydrocephalus [Figaji, 2003i]. Here is a case where one can see how the basal cisterns have become scarred, blocking CSF flow.

There is of course more to TBM than just hydrocephalus; we have all learnt a great deal from the work of Johan Schoeman and Richard Hewlett at Stellenbosch University and I am delighted that Ursula Rohlwink is now undertaking a doctoral study in this area in our unit, generously funded by CIDRI. A case such as this pineal tumour really encapsulates the notion of minimally invasive surgery; conventionally, this would have required a shunt followed by a lengthy operation but with the endoscope one was able to treat the hydrocephalus with an ETV and then biopsy the tumour which turned out to be a germinoma and was cured with radiotherapy.

We are fortunate to be able to refer our patients on to oncologists and radiotherapists with great expertise and I would like to make particular mention of Jeanette Parkes who cares for children and adults with brain tumours with such dedication and compassion.

Traumatic Brain Injury

I want to now consider *traumatic brain injury*, one of the greatest scourges of our society. TBI is classified on the basis of the 15-point Glasgow Coma Scale into mild, minor, moderate and severe; mild head injury is common (in fact, I think it is just not possible for anyone, especially boys, not to sustain one mild or minor TBI in childhood) but severe TBI, in other words those patients with a Coma Score below 9/15, is what concerns us now.

It is not widely appreciated that trauma is the number one cause of death for South Africans between the ages of four and eighteen, and more than half of these deaths are due to brain injury [Groenewald]. One can summarise this data in the simple but appalling statement that the risk for a South African child to die from a head injury is eight times that of his counterpart in the USA.

We all know the common mechanisms of injury; while motor vehicle accidents are the most common cause for severe injury, the level of violence in our society is reflected in the fact that a children's hospital has to have a sign at the entrance indicating guns aren't welcome. Child abuse is a problem worldwide and although we seldom see so-called "shaken babies" in our practice, we commonly see children injured in the crossfire of domestic violence [Fieggen, 2004].

The damage done at the time of impact is referred to as the "primary injury"; at present there is little we can do for that, and the main goal of treatment is to prevent the complications which cause so-called "secondary injury", such as shock or low blood pressure, low levels of glucose and oxygen, or raised pressure within the head, which reduces the flow of blood to the brain.

The outcome for severe TBI at Red Cross Children's Hospital in the nineties mirrored that around the world with a mortality of over 40% [Semple]. I want to briefly describe three interventions that have changed this picture profoundly.

Firstly, the rediscovery of an operation called *decompressive craniectomy,* a story of serendipity which also illustrates how clinical advances often begin with one patient.

Walking into the hospital to finish off a research project, I ran into a friend who was an obstetrician. He had seen a little boy fall from a height during a church service, landing on his head. I guess

obstetricians are good at making quick decisions and he immediately stuck the unconscious child (and bewildered parents) in his car and drove straight to Red Cross Hospital. Within half an hour the child had been stabilized and scanned, but he was clearly deteriorating fast. He had a very shallow blood clot on the right side but a very swollen brain. Because the skull is an unyielding container, swelling of the brain leads to an increase in pressure within the skull- so-called raised intracranial pressure, or ICP, which if unchecked causes further brain damage and ultimately death.

At the time, this was not a situation where surgery was considered helpful- these children usually died and conventional wisdom was that surgery only increased the chance of having a vegetative survivor. The acuteness of the situation suggested though that we really had nothing to lose and we took the boy to theatre for a craniotomy, opening the dura with dread expecting the damaged brain to swell uncontrollably. With expert anaesthetic management (and here I want to specifically acknowledge the skills of the anaesthetists who are such critical allies in the operating theatre) the situation was controlled and the patient returned to the ICU with an intracranial pressure monitor in place. To my amazement, he was not only alive the next morning, but had normal ICP and a respectable looking CT scan. Although he clearly sustained a severe injury to the brain, this involved his non-dominant hemisphere and his outcome has been really gratifying.

Here is a subsequent case; again, there is very little blood to drain, but by opening the skull one is able to make space for the swollen brain. We were one of the first centres to advocate this procedure in certain circumstances and this has since become standard practice around the world [Figaji, 2003ii]. It seems to me that the benefits in adults are a bit less clear; this may be why it had such a bad reputation at the outset and underscores the importance of the old adage that one should look at child as not simply a small adult.

The second major advance that happened shortly after we adopted decompressive craniectomy as a routine was the consolidation of the various ICUs at Red Cross into a single combined unit under the leadership of Andrew Argent, whose inaugural lecture you will be able to enjoy later this year. When the outcomes of severe TBI were analysed in 2005, the picture had changed quite dramatically with mortality having dropped to 25% [Richards], reflecting our more aggressive surgical approach coupled with more comprehensive ICU care, concentrating on getting the basics right.

Our TBI management was taken to a new level when Tony Figaji joined the Paediatric Neurosurgery Unit at Red Cross Hospital, embarking on a PhD in TBI management. It is worth pointing out that until a few years ago we had pretty much only one parameter for monitoring the injured brain at the bedside, intracranial pressure; quite the opposite of the cardiovascular, pulmonary or renal systems where a whole range of monitors are available. Recently however, various new technologies have emerged, each of which gives valuable information, particularly when analysed simultaneously. This has given rise to the concept of “multimodality monitoring” of the injured brain.

Perhaps the most useful of these is brain tissue oxygen monitoring, which is illustrated here. A fine electrode is placed in the brain parenchyma and this provides real-time indication of oxygen levels in the brain. The main finding has been the startling discovery that even when we get the basics right and all the numbers are normal, fully 80% have episodes of reduced brain oxygenation which would not have been detected by other means [Figaji, 2008]. This is important for two reasons- these episodes can cause further brain damage, and specific measures can be instituted to correct them in most cases.

The significance of this is shown here; we have established that brain oxygen levels are the strongest predictor of outcome in the brain-injured child [Figaji, 2009]. This research has also validated decompressive craniectomy, showing that the postoperative improvement in ICP is matched by a highly significant increase in brain oxygenation. Even more interesting, is the extent to which collecting all this data is giving us a great deal more insight into the complexity of brain injury with sometimes unexpected associations found between blood pressure, ICP, brain oxygen levels and various other parameters.

The most important result has been the impact on mortality, which is now around 10% [Figaji, personal communication], a level just about unheard of anywhere in the world. It is important to emphasize the fact that this has not led to a large number of very disabled survivors and I think this is a terrific example of the way in which properly planned clinical research not only yields meaningful data, but also improves clinical care.

It is important to emphasize the fact that these results do not only reflect excellent ICU care, but a continuum of care from roadside to hospital and then home, with paramedics, nurses, registrars, radiographers, physiotherapists, occupational therapists and social workers all playing crucial roles.

We all celebrated South Africa's first goal in the 2010 World Cup tournament, but how sad that just a day earlier Zenani Mandela died in a car accident. Our responsibility extends beyond the hospital walls and we are grateful to the Paediatric Surgeons at Red Cross Hospital who established the Child Accident Prevention Foundation 20 years ago, now Childsafe led by the head of Paediatric Trauma, Professor Sebastian van As. The good news is that prevention strategies do work- we noted a fall in deaths due to gunshots following implementation of gun control legislation.

As previously mentioned, *functional neurosurgery* is where things get really interesting, as this refers to surgery that literally alters the function of the brain. We can't do anything to make a normal brain work better (not yet anyway!) but we can do a lot to help children with epilepsy and spasticity.

Epilepsy

Epilepsy is the most common disorder treated by neurologists, with around 1% of the population afflicted with this potentially devastating condition. Many patients are well controlled on medication but these drugs have their own troublesome side-effects.

The good news is that as many as 1 in 4 patients with epilepsy may be cured with surgery. Identifying these patients requires expert evaluation by a multidisciplinary team including neurologists and neuroradiologists. A number of different operations may be considered but I will briefly describe the most effective one, which just happens to have a great South African pedigree.

This little chap had such catastrophic epilepsy he ended up ventilated in ICU for months, having tried every possible drug. His EEG showed that the abnormal brain waves were confined to one side of the brain, while the other half of his brain appeared to be normal. This meant that he was a candidate for an operation called *hemispherectomy*, where one removes or disconnects the entire hemisphere to prevent spread of the abnormal electrical activity, leaving part of the hemisphere in place to avoid leaving too large an empty space in the head. One would expect that removing half the brain would have devastating consequences and this is only done in very specific circumstances- the epilepsy must arise only from one side of the brain with the other being normal, there must already be a

neurological deficit and the patient must be young enough for the opposite hemisphere to start taking over some of the functions lost, through a phenomenon known as plasticity.

Roland Krynauw worked as a consultant neurosurgeon in Johannesburg following his neurosurgical training at Oxford; although he retired at a young age, he is remembered for describing this operation in an attempt to cure epilepsy long before any decent drugs were available. The modern surgical approach focuses more on disconnection of the entire hemisphere while attempting to leave as much of the tissue in place so as not to creat too large a space. This particular patient was operated 8 years ago and remains seizure-free, off medication and he has now finished school and has a job. This is not an unusual result- 90% of appropriately selected patients will be cured by this surgery.

Spasticity

Another important South African contribution has been the procedure of *selective dorsal rhizotomy*, done to relieve the spasticity which often troubles children with Cerebral Palsy.

There are two groups of nerves running into the spinal cord, those in the front, the anterior or ventral roots convey the nerve impulse from the spinal cord to the muscles, while those at the back, the posterior or dorsal roots, convey sensory signals back to the spinal cord. Over a century ago Sherrington established in an animal model that cutting the dorsal roots of the lower part of the spinal cord would diminish spasticity. The explanation for the benefit of this procedure is that it interrupts an abnormal reflex circuit; the problem is, if one cuts the entire dorsal root all sensation is lost and this causes further neurological compromise.

This was introduced into clinical practice by Foerster, a German neurologist who became a surgeon in order to do the operations that he couldn't persuade others to do; various complications ensured this operation never gained widespread acceptance until a number of refinements were introduced in Cape Town by Warwick Peacock, prompted by Leila Arens who cared for many of these children and supported by Roland Eastman who helped work out the neurophysiology [Peacock].

The operative set-up is shown here; electrodes are placed in various muscle groups. The spine is then opened and each of the nerve roots of the cauda equina identified. Each of the dorsal roots is divided into rootlets and stimulated, with the most abnormal ones being divided. The benefits are immediate and obvious, but the question is whether this is sustained? Happily Warwick had enlisted the assistance of Professor Kit Vaughan who did gait analysis on an early cohort of these children preoperatively and they have now been followed up at regular intervals, most recently at by Nelleke Langerak for her PhD. The good news is that not only is the reduction in spasticity sustained on objective assessment [Langerak, 2008], but quality of life is markedly improved with very few long-term spinal complications [Langerak, 2009].

Conjoined twins

Conjoined twins always seem to grab the headlines and questions are asked whether the resources required in doing such an operation can be justified in a country such as ours? This is a complex debate but there are two points I would like to make in this regard: primarily, we have an obligation of care in trying to improve the lot of these unfortunate children, and there may also be important scientific lessons to be learnt.

Since the pioneering work of Professor Cywes, Red Cross Hospital has been a leader in the treatment of this exceptionally rare condition [Rode]. These children are pygopagus twins, joined at the rump. On MRI it was apparent that the lower ends of their spinal cords were fused, seen here at surgery, clearly a very different situation to the normal cauda equina we just saw [Fieggen, 2003].

Understanding how this comes about would give us tremendous insight in the early developmental biology of the nervous system. The South African Noble laureate Sydney Brenner recently pointed out in this lecture theatre that clinicians have a crucial role to play in unravelling the findings of molecular medicine as we are uniquely placed to be human phenotypers, describing clinical findings in detail. We must take advantage of the clinical research opportunities that arise, even rare and esoteric conditions, in keeping with the adage that "there are two types of research, applied research and research that has not yet been applied."

Neurosurgery in Africa

So here we are back at our Operating Theatre at Red Cross, with fantastic facilities, able to put together teams of top colleagues from around the world to develop new techniques (for example, here we see the team that helped us launch our intraoperative neurophysiology program last year, an amazingly exciting project that I would love to tell you about), but are we perhaps a little confused? After all, we are in Africa, the continent that gave rise to the human brain and also happens to be shaped almost like a brain; although our continent isn't short of hospital beds, very little money is spent on running them, and this translates into few nurses and even fewer doctors.

This translates into hardly any neurosurgeons; this data was published a decade ago but things haven't changed much [El Khamlichi]. Only five countries come close to the ideal ratio of one neurosurgeon per 125, 000 people; most African countries have a few million people per neurosurgeon while some have no neurosurgeons at all.

Of course the question may be asked, is there a role for neurosurgeons in Africa? I hope that I have already given you some examples this evening of work that we do that is relevant elsewhere on our own continent. Clearly the patients are there and there is no question that there are sufficient highly capable doctors that with the correct training could meet the needs of these patients.

We have trained a number of neurosurgeons from elsewhere in Africa and having visited these colleagues in Uganda and Zambia, it has become clear to me that there is a bigger role that has to be played in that neurosurgery cannot be practised in isolation. More than most other specialties, we are absolutely dependent on a very wide range of colleagues and the neurosurgeon therefore needs to play a leadership role in developing the type of healthcare system that can deliver such comprehensive care.

Given the massive shortage of properly trained neurosurgeons, another question that is often asked is whether some abbreviated sort of training might be suitable for Africa. This is a question that many have grappled with, not least my Harvard-trained colleague Dr Ben Warf who established a paediatric neurosurgical service in Mbale in eastern Uganda, with the help of CURE International, a faith-based organization [Warf].

These photographs were taken at one of a number of workshops held in Mbale, teaching medical officers from around Africa how to treat hydrocephalus, but he and I share the conviction that a

half-trained neurosurgeon is more dangerous than no neurosurgeon. It may take longer, but it is better to take the trouble to train someone fully, who is then fully equipped to develop services in their own country. There can be no better example of this than the fact that Ben was able to hand over the running of his hospital to Dr John Mugamba, a Ugandan neurosurgeon who had trained in our department.

I think this concept is conveyed very well in the lines from NP van Wyk Louw's poem, inscribed at the entrance to the medical school at Stellenbosch University: *"'n beitel moet kan klip breek, as hy 'n beitel is".*

One must be realistic and acknowledge that there are numerous barriers to developing neurosurgery in Africa. Just before the World Cup, the magazine *Africa Report* published an article analysing the factors holding back soccer on our continent. These included moribund leadership, leading to a lack of direction and the loss of talented players to overseas clubs, which is completely understandable given the poor infrastructure they faced at home with corruption snuffing out any chance of turning this around.

Go to any international neurosurgical conference and you will find a number of well-trained African neurosurgeons; chances are though that they are part of the "diaspora" and not working in their country of birth. The small base of neurosurgeons and other disciplines, is exacerbated by long distances and the challenge of travel not only leads to late presentation by patients, but limits interaction between colleagues within a country. Real linguistic and cultural barriers make it difficult to build bridges; at the present time we have the rather pitiful situation of three competing neurosurgical organizations all claiming to represent Africa.

But there are things that can be done. We, and other South African centres, are training neurosurgeons who intend to return to their own countries and increasingly international organizations are stepping up to the plate in making an effort to contribute to training in Africa. When we hosted the ISPN meeting in Cape Town, no fewer than 14 African countries were represented, and delegates from over 50 countries were inspired by Archbishop Emeritus Desmond Tutu's opening address, speaking to our shared humanity. Apart from having doctors come here to train, we can go to them and we have been fortunate to run Neuroendoscopy courses in various centres around Africa.

I believe that a niche area for UCT is the development of *appropriate technology*, such as that described a few weeks ago by Professor Heather Zar who developed a low-cost spacer for treating asthma.

One of the skills one has to master as a young trainee neurosurgeon is the challenge of tapping an unseen abscess or ventricle deep within the brain, using various external landmarks, but these become less reliable as the target gets smaller or deeper. The solution is a technique known as stereotaxis, which enables the surgeon to locate a target deep within the brain with the aid of an external reference system, such as a frame fixed to the patient's head. As I mentioned earlier, Horsley came up with this idea [Horsley]; the key concept is to view the brain as a 3-dimensional space where each point had a unique set of x-, y- and z- co-ordinates.

Horsley only used his stereotactic frame in the animal lab and amazingly it took 40 years before this concept was applied in clinical practice. Although such frames could be used with plain X-rays, this was cumbersome and unreliable and stereotaxis took a huge leap forward with the advent of CT scanning and later MRI, leading to an exponential growth in applications.

The problem is this technology is very expensive and therefore not widely available even today, let alone when I was a registrar in training. Working with Professor Peter and Professor Laurie Adams, retired professor of land surveying at UCT, my friend and fellow-registrar Allan Taylor and I developed a simple, safe and accurate stereotactic system which became known as the "Cape Town Stereotactic Pointer", or CTSP [Fieggen, 2009].

Performing a stereotactic operation with the CTSP entails the four simple steps of suturing a halo to the scalp before scanning the patient and then calculating the 3-dimensional coordinates which enable one to set the stereotactic device.

This system was patented by the MRC and subsequently manufactured and marketed by a company called Fibretek; this little device has proven to be popular with neurosurgeons in developing countries as it is accurate, simple to use and cost-effective, with close to 70 sold around the world, and we'll soon notch up our half century in India! In working on this project, I was inspired by the words I saw on a door during a tough time for British science: *"We have no money, therefore we shall have to think."*

Of course life is not just sweetness and light and in closing, I want to briefly touch on some of the challenges faced by academic surgeons broadly, and by academic neurosurgeons in South Africa.

Challenges for academic surgeons

Surgical journals don't always hit the high notes when it comes to scientific credibility and impact factors and *The Lancet* recently carried an interesting series on surgical research, highlighting some of the reasons for this. Most importantly, surgeons need to be able to operate and this takes time; also the "gold standard" of the randomised controlled trial may not be widely applicable and is certainly a poor tool for assessing innovation which often happens on the hoof. Furthermore, when surgeons do try to compete for research grants they are often overlooked by funding agencies more interested in other conditions [Ergina].

While I may have painted a rosy picture of academic neurosurgery at UCT, I don't take this for granted at all as academic neurosurgery in South Africa is not in good health. There are various reasons for this, not least the imbalance between the private and public sectors in terms of potential income and available infrastructure. Surgeons need to operate and dwindling theatre time, shortages of nurses and diminishing access to technology are real problems.

The pathological imbalance of our healthcare system is evident in data on the availability of MRI scanners in various countries, supplied by the Radiological Society of South Africa. In the private sector, South Africa has more MRI scanners per capita than Holland, Korea and Canada, but when one looks at the country as a whole we just about drop off the scale.

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There is no doubt that we are privileged to work in the Western Cape, where we have a very functional healthcare system, but we cannot expect that the government will be able to bridge the increasing gap bewteen what we have and what we need.

Even in the private sector, medicine is becoming more and more costly and establishing real centres of excellence for complex conditions really does makes sense. Fruitful discussions between Neurosurgery, Neurology (Associate Professor Roland Eastman), Neuropsychology (Professor Mark Solms) and Neuropsychiatry (Professor Dan Stein) strongly suggest that we have a real opportunity to achieve such a centre in the area of Clinical Neurosciences at UCT.

We already have the required human resources in having a critical mass of experts in all these areas, many of whom are nationally and even internationally recognised, and we have the flexibility presented by having a private academic hospital alongside a public teaching hospital.

I hope that in the next few years we will be able to bring these disciplines closer together, with the intention of delivering the very best possible care to patients in both the public and private sectors on the basis of clinical need.

This will enable us to retain and grow the expertise we currently enjoy, develop the state-of-the art infrastructure we need in terms of clinical space, imaging, operating theatres and even shared academic space, ensure we can train colleagues adequately and serve as a springboard for translational research as well as nurturing a greater interest in basic neuroscience research.

The magic of this idea is that it is based in reality. The juxtaposition of Groote Schuur Hospital with the critical mass of patients we already serve, the opportunities presented by UCT Private Academic Hospital and the international standing of our University and Medical School really does give us an opportunity to do great things.

Acknowledgements

We have all been helped in many ways in our lives and careers and an inaugural lecture is a time to reflect on this, with the privilege of publicly acknowledging people.

Without the patients we serve I would have had very little to say tonight, so that is where I would like to start. We can never overestimate the stress they, their parents and families endure and it is a privilege to intersect with people's lives in such a profound way.

I hope I have adequately conveyed the respect and affection I have for my colleagues in neurosurgery at UCT; I inherited an amazingly functional department which continues to go from strength to strength, long may that last.

We all work with so many terrific colleagues both at Red Cross Children's Hospital and Groote Schuur, and I would like to acknowledge them all, as well as those in management of the hospitals and the Provincial Health Department.

I feel privileged to be part of the University of Cape Town and this Faculty; thank you to all those who make these Inaugural Lectures such special occasions.

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I want to thank a few specific people. When I took a year off to complete a BSc (Med), I was very fortunate that Bob Millar agreed to take me on for my research project and my time in his Regulatory Peptides lab was one of the most stimulating experiences of my career. When I returned to the clinical years I was fortunate to learn about clinical research with Zephne van der Spuy. Generous funding from UCT enabled me to gain a solid grounding in Neuroscience at the Institute of Psychiatry in London. I have always had a great deal of support at Red Cross, and would like to thank Heinz Rode for his guidance throughout my tenure as head of Paediatric Neurosurgery. Many other superb teachers shaped my career, but this evening I think particularly of two who are no longer with us, Professor Tony Fairall and Professor Ralph Kirsch.

Although I didn't realise it at the time, my journey into neurosurgery began the day I walked into res at UCT. Driekoppen residence had been established for the ex-servicemen returning from the war, one of whom was my father Tony, who sadly died far too young for me to hear first hand of all his wild adventures, but in choosing his old res I became part if the extended family of Warwick and Ann Peacock who took an almost parental interest in the wellbeing of the reprobates in their care. By now it should be obvious just how much they both shaped my career and I owe them both an immense debt of gratitude for their support and friendship over three decades.

It is a remarkable coincidence really that my greatest role model has been Warwick's lifelong friend, Jonathan Peter. When I returned from my travels, I was fortunate to be the first registrar employed by the newly appointed Professor Peter. Always considerate to his patients, consistent in his approach to their problems and fair and even-tempered with his junior colleagues, open to new ideas I could not have asked for a better mentor. He would sit for hours in theatre while I scratched away at a tumour, calmly prodding me in the right direction, but only when asked and it is only fair that he gets to have the last word tonight.

Neurosurgery is a consuming career, and I'm afraid my family and friends have borne the brunt of this. Andrew and I were privileged to grow up in a loving and supportive home with a mother who instilled a real sense of social justice as well as a love of literature and travel. I want to thank my extended family, cousins and in-laws, some of whom were able to be here tonight which really means a lot. I'm sorry my ever-supportive parents-in-law Gerda and Jack couldn't be here.

How do I even begin to thank my wife and children? Those who know Karen know how she always shuns the limelight but she is just the most amazingly capable person who just gets so much done, and then manages to look after me, Josh and Liam so well. Thank you so much for your unfailing love and support.

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