Occasional review

Scotland: the birthplace of surgical neurology*

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It was Norman Dott (fig 1) who was responsible for resurrecting the appreciation and memory of the world's first neurological surgeon, Sir William Macewen, from the dust-bin of the forgotten past. Macewen, like his contemporary, Antony Chipault of France, had been forgotten and ignored. Yet Macewen was the Father of Neurological Surgery, not Sir Victor Horsley of England, nor Harvey Cushing of the United States, great as both of these pioneers were. It is Macewen of Glasgow who wears that crown (fig 2).

Can anyone imagine a more unlikely place than Glasgow to have been the birthplace of our specialty? I can not. When I first visited Glasgow over 50 years ago I was not impressed. It was truly a backwater. True it was an important port and an outstanding place for ship-building, but it was not at that time a great scientific medical centre. Yet it was here that Macewen performed the first craniotomy based solely upon neurological signs and symptoms,

without any external manifestations of the lesion.

Inca Indians in Peru, Egyptians, Italians, and others, had performed cranial surgery long before Macewen. Their operations had been performed either for obscure reasons or for intracranial haemorrhages and tumours where there was external evidence of the existence of pathological lesions. Macewen operated upon brain abscesses or tumours solely upon the basis of neurological signs and symptoms caused by these lesions. The concept and performance of Macewen's first successful craniotomy for an intracranial lesion did not spring from the mind of Macewen completely unfledged. Like other pioneers he stood upon the shoulders of others who had gone before him. He benefitted from surgical training at the hands of Lord Lister. He had the benefits of the general anaesthetic properties of chloroform and ether which had been discovered only a relatively short time earlier. But most of all he

Fig 1 *Norman Dott*

Fig 2 *Sir William Macewen*

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benefited by the work of Pierre Paul Broca of Paris, Fritsch and Hitzig of Germany, John Hughlings Jackson and David Ferrier of England who had established the fact that the brain does not function as a single unified organ but has within it a localisation of functions. Their contributions gave Macewen the facts upon which he based his diagnoses.

The rugged, reliant character of the Scottish people is legendary. In addition to their many other accomplishments, there is none that demonstrates their intelligence, their ability, their courage, and their persistence as does the performance of the first successful operations for tumours and abscesses of the brain by Sir William Macewen.

Macewen based his diagnosis and localisation of tumours on the work of neurologists. This relationship, this dependence of neurological surgery upon neurology clearly demonstrates what was then and what must always be the case. Unfortunately, there have been times when this relationship was characterised more by antagonism than by cooperation. It has been said that the neurologists of Queen Square in London retarded the development of neurological surgery in England by 25 years. Certainly such outstanding neurosurgeons as Sir Geoffrey Jefferson and Sir Hugh Cairns encountered this lack of cooperation there. As a result both men gave up their efforts to develop neurological surgery at Queen Square and went elsewhere—to Manchester and to Oxford—to lay the ground work for present day neurological surgery in England. To those of you

who may doubt that such antagonism existed, let me say that it did. I know. I was there. I trust that your presence here today indicates that such antagonism no longer exists.

Sir William Macewen did not enjoy the recognition in Great Britain which he deserved. There were those who questioned that he had operated successfully upon tumours of the brain, of the spinal cord, and upon intracranial abscesses. Proper recognition was not denied to him elsewhere. The Johns Hopkins University in the United States offered him the Chair in Surgery. After careful consideration he declined this post. Why? Because the University would not grant him control over the education and conduct of the nurses on the surgical service. He was fighting against windmills more powerful than himself.

We are here today to honour the memory of Normal Dott. He was a cherished, personal friend whose memory I am most happy to salute on this occasion. Dott united in his person my country, having been trained by Harvey Cushing, and Great Britain. He brought modern neurological surgery to Scotland and together with Sir Geoffrey Jefferson and Sir Hugh Cairns to all of the British Isles.

Dott was one of the outstanding neurological surgeons of the world. He struggled constantly to obtain the recognition for Macewen which the latter deserved, but that was a small part of Dott's overall accomplishments. Undoubtedly his strong character

Fig 3 Sir Victor Horsley

Fig 4 Otfrid Foerster and Harvey Cushing

and determination arose largely from his genetic background. He was of Huguenot descent. This was a magnificent heritage, one which led Dott like his ancestors to fight against overwhelming odds. The Huguenots were a determined and resistant people. They resisted the kings of France and the princes of the Catholic Church. Rather than capitulate they defended their freedom and their religion with their lives and against torture and starvation. They saw their homes burned to the ground rather than surrender. In Foix they themselves were burned at the stake and *en masse* in a chateau. At La Rochelle they were driven into the sea and departed for Scotland and other refuges from intolerance. Only their king, Henry the 4th, gave up his religion for the throne of France with the famous words, "The throne is worth a mass".

In addition Dott was born and raised in Scotland, son of another tough and resilient people. With this background he was well equipped to struggle with the odds presented by the victims of tumours of the brain, and the pain and disabilities which came from an injury to his hip in early life. This was to be an added burden during almost all of his professional career.

During Dott's lifetime surgical neurology was to experience an almost unbelievable growth and development. Neurology began with Romberg in Germany, Charcot and Pierre Marie in France, and with a large number of distinguished men in Great Britain, largely at Queen Square in London, but also with the Bramwells and others in Edinburgh. What was neurology like in those early years? It was a descriptive clinical specialty which endeavored to correlate signs and symptoms with demonstrable pathology, to provide differing entities with names and to determine prognosis. For many years neurology was stymied there. It was a diagnostic and prognostic specialty without any therapy. It is not surprising, therefore, that fifty years ago neurology was a dying specialty. Young physicians were avoiding it because with neurology as a specialty they could not make a living. For the next quarter of a century it remained so, withering on the medical vine. It remained so in the United States until the 1950s when our Federal Government adopted a suggestion made by a neurological surgeon, Harvey Cushing, at the close of World War I, that a national neurological institute be developed. The National Institute of Neurological Diseases and Blindness (now the National Institute of Neurological and Communicative Disorders and Stroke) became a driving force in neurology in the 1950s. It stimulated research and provided funds to support research in the United States and in other countries. It stimulated and provided funds to train teachers, investigators, and

practitioners of neurology. Out of this came a resurgence of neurology, primarily because new means of understanding neurological diseases were developed. Methods and means of treating and preventing neurological diseases were discovered. Since then the number of departments and of practitioners of neurology has increased amazingly. Fortunately this era of progress is not over. Neurology can today stand proudly on its own two feet and continue to progress.

Neurology, however, still has to its discredit a sizable blind spot. To be sure, this blind spot is gradually shrinking but it has not yet disappeared. To what do I refer? The antisurgical attitude of some neurologists. Why they are so hesitant to recognise what surgical neurology has to offer is a mystery to me. As recently as the 1960s we saw many neurologists opposing the surgical treatment of ruptured intracranial aneurysms. Other antagonisms to surgical therapy were present, though less obvious. Fortunately this antagonism is diminishing and more and more they recognise that neurological surgery has something to offer their patients.

There is still more that neurologists can do. It has long been apparent that intracranial aneurysms are best treated early while the patients are in good clinical condition. Yet all too frequently the first rupture of an aneurysm is not recognised. Were such first

Fig 5 Walter Dandy

ruptures to be more commonly recognised and if all patients were referred for surgical treatment early and while they are still in good condition the mortality and morbidity which is still far too high would be dramatically lowered.

For years neurological surgeons have been falling flat on their faces in the treatment of cerebral gliomas. We are doing but little better today in the treatment of these tumours than Macewen did over 100 years ago. Most victims of cerebral gliomas still die from their tumours. Yet it is obvious that if these tumours are completely removed they can be cured. In spite of our faulty terminology these tumours are not malignant as cancers elsewhere in the body are malignant. All too often cerebral gliomas are operated upon when they are the size of oranges and lemons, after they have invaded the basal ganglia and the corpus callosum. Why? Because they are being referred for surgical treatment months, even years, after the first symptoms appeared. If they were carefully examined much earlier they could be recognized when they are much smaller and more readily removed. We have in computed tomography and nuclear magnetic resonance the means to do this.

The fault here is not entirely that of the neurologists. We have too many timid neurosurgeons. Those who are content with a biopsy and are unwilling to undertake the aggressive surgery necessary to eradicate these tumours completely. We have also at our disposal numerous improved surgical techniques, including stereotactic surgery, by means of which these tumours can be biopsied and totally removed. The time for greater cooperation among us is at hand.

Let us look now at the history of surgical neurology. It began here in Scotland in 1879 when Macewen diagnosed, localised, and removed a brain tumour. He continued forward removing other brain tumours, tumours of the spinal cord, and achieved an unequalled success in treating abscesses of the brain. A few years later Alexander Hughes Bennett, a neurologist, and Rickman Godlee, a general surgeon, diagnosed and removed a brain tumour. With that startling success Godlee disappears from the neurosurgical scene. But he was soon followed by another Englishman, Sir Victor Horsley, (fig 3), who in 1886 in collaboration with Sir William Gowers, who diagnosed the lesion, removed a spinal cord tumour. Others soon followed: Durante in Italy, Krause in Germany, Keen in the United States. That these lesions could be diagnosed and removed was now apparent, but the price was too high. The post-operative mortality of a number of these surgeons reach as high as 65%. As a result neurological surgery was losing favour. It, too, was dying, and

continued to decline until the turn of the century, when a determined young surgeon, Harvey Cushing, appeared on the scene (fig 4). He had graduated from Harvard Medical School and served a period in surgical training with William S Halsted at the Johns Hopkins Hospital. Halsted was a meticulous surgeon who avoided damage to tissues and thus reduced the incidence of surgical infection and improved his results. What first stimulated Harvey Cushing's interest in surgery of the nervous system remains obscure. In any event, having completed his training at The Johns Hopkins he set sail for England to learn how to do neurosurgery. Here he was disappointed with what he saw. The crude surgery of the nervous system which he encountered at the hands of Horsley discouraged him. It was so different from the meticulous surgery of Halsted.

In the physiological laboratories of Hugo Kronecker in Bern, Switzerland he began to investigate the effects of increased intracranial pressure. What originally stimulated these researches is not known but the results were obvious. He demonstrated the effects of increased intracranial pressure on the pulse rate, the blood pressure, and the respiration. Even more important these few months of investigation turned Cushing's thoughts back to

Fig 6 Sir Hugh Cairns

surgery of the nervous system. Another experience reinforced this interest.

On his way home to Baltimore he stopped for a short time in Liverpool and visited the laboratories of one of the world's greatest neurophysiologists, Charles Sherrington. While there Sherrington invited Cushing to expose the brains of the apes upon which he, Sherrington, was working. The die was now cast. Cushing headed for home to become a surgical neurologist. He did not meet with encouragement from Halsted but in a fashion characteristic of Cushing he persisted. His first endeavour was to train himself as a neurosurgeon. His next to demonstrate that surgery on the brain could be performed without killing the patient. This remained his guiding light throughout his career. He reduced the mortality of operating upon brain tumours to the unbelievable figure at that time of 10%.

In 1912 he moved from Baltimore back to Boston, to Harvard University, and to the Peter Bent Brigham Hospital, but not for long. With the outbreak of World War I he joined with the medical department of the British Forces and when the United States entered that war he transferred to the US Army. Although he had done many things prior to that including writing his books on pituitary tumours and tumours of the acoustic nerve, his greatest work now began. During the next 13 years following World War I he trained many of the men who were to become the leaders in neurological surgery throughout the world.

While still at Hopkins he had trained Walter Dandy (fig 5) and Howard Naffziger, who later was the pioneer in neurological surgery on our Pacific coast. He trained Hugh Cairns (fig 6) who with the great Geoffrey Jefferson of Manchester (fig 7) were to revive neurological surgery in England, and Norman Dott, who returned home to Edinburgh. There were others both in continental Europe and in the United States. Probably these men whom Cushing trained were his greatest accomplishment.

As is commonly known there developed a bitter antagonism between Cushing and Walter Dandy, one of his first pupils. This antagonism arose out of the basic nature of these two men and out of the differing philosophy toward neurological surgery. Both were stubborn and opinionated. The basic problem came about when Cushing called Dandy a liar, saying that Dandy's claim to having removed acoustic neuromas completely was not and could not be true. But there was another, more deepseated fundamental difference. As was pointed out earlier, Cushing's aim was to operate upon patients without killing them. To achieve this goal he often did not completely remove tumours and developed such palliative operations as the subtemporal decompres-

sion. Dandy's goal, however, was to cure the patient of his tumour. To this end he strove constantly to achieve a total removal of all tumours. As a result he had a considerably higher surgical mortality than did Cushing, but in his eyes, Dandy's, he achieved more valuable results, the cure of the patient's disease. There were other differences.

Cushing was a careful diagnostician and surrounded himself with competent men who could help him attain an accurate diagnosis. Cushing was interested in the nature of the tumours which he removed and out of this grew his support of the careful studies of these tumours by Percival Bailey and their books on tumours of the glioma group and on vascular malformations and tumours of the brain. Dandy, on the other hand, was a poor diagnostician and a rapid, rough operator. He had little interest in the pathology of the tumours which he removed. Both were giants in their own right and each made major contributions to neurological surgery.

What was transpiring elsewhere in the world and what major advances were yet to come? In Germany, Krause, in spite of writing a book on neurological surgery, was making little progress, nor did his pupils. Progress in that country had to await an unpredictable development which arose out of

Fig 7 Sir Geoffrey Jefferson

World War I. Otfried Foerster of Breslau was the man (fig 4). He was a medical neurologist who by force of circumstances became a neurosurgeon. He came from an academic family. His father was the professor of archeology at the University of Breslau. Foerster himself spoke a number of languages well. He could and did lecture well in English without a note. The short time that I spent with him in 1930 was one of the most stimulating of my entire life.

Foerster was a most energetic man. He arose early, at about 5:00 am and worked in his study writing. His study was a remarkable room. Neither his wife, his daughters, nor the maids were allowed to enter it. As a result everything was covered with dust. The room was bare of furniture except for a desk and a chair in the corner farthest from the door. The floor was covered with reprints and journals in piles each about a foot high. At about 8:00 am he made his way to his private clinic which was nearby. Promptly at 11:00 am I would meet with him in a small restaurant where we would sit and talk for about an hour and enjoy a "zweite fröhstuck"—a second breakfast. Our discussions roamed the field of neurology. When we left the restaurant we went to the public hospital. Foerster would make rounds on the patients, would operate

and then would examine brains and microscopic slides in the laboratory. Foerster was a poor surgeon but he knew and recognised that. He frequently expressed his regrets that he could not operate as Cushing did. His equipment was primitive, the lighting practically nonexistent (fig 8). He operated under local anaesthesia which his associates referred to as "vocal", not "local" anaesthesia. I once asked Professor Foerster why he became a neurosurgeon, as he was a man without any surgical training or background. He replied that he had to make the diagnosis, tell the surgeon (Mikulicz) where to operate and what to do, and then the patients all died. As Foerster said, "I decided I could do no worse". Of course, he did much better, and in the process shed much new light on the function of the spinal nerve roots and the areas of innervation of the posterior roots, on spasticity and on functional localisation in the cerebral cortex. In this latter he followed closely in the footsteps of Oskar and Cecile Vogt whom he greatly admired.

Recognition of Foerster's accomplishments came almost entirely from outside of Germany. In Germany he was looked down upon by the surgeons because he had no surgical training, and by the neurologists because he performed surgical opera-

Fig 8 Otfried Foerster operating. From left to right, Bucy, Foerster, surgical nurse and Ludwig Guttmann (Courtesy of Dr Henry Schwartz)

tions. He was the teacher of Ludwig Guttman who escaped to England from Nazi Germany, developed rehabilitation of those paralysed by injury to their spinal cords, was Knighted by the Queen and made a special citizen of Aylesbury where he lived.

Sir Ludwig was but one of the many gifts of energetic, intelligent Jews which a mad, angry Adolf Hitler made to Great Britain and the United States. Guttman was stimulated to do what he did by a Scot, George Riddoch, a neurologist. Riddoch had seen the pitiful state of those paralysed by injury to their spinal cords during the first World War. He was convinced that this could, in large measure, be avoided and he was determined to do something about it. Guttman was relatively free from major responsibility as he worked with Hugh Cairns at Oxford. Riddoch went to him and asked if he would accept the responsibility of doing something about those with injured spinal cords. Guttman agreed to do so if he were given a free hand. Riddoch saw to it that he was not only free to do what he thought best but that he was given the facilities with which to do it. In World War I those paralysed by spinal injury seldom lived for more than one or two years. During those few months their lives were miserable. They not only had paralysed arms and legs but were also a stinking mess with their faecal and urinary incontinence and their bed sores. Guttman changed all of that. He gave the victims of spinal cord injury hope—hope that they could be self reliant, could be mobile, could play games, hold a job and be productive. Sir Ludwig has often been criticised in Great Britain because of his opposition to laminectomy in the treatment of spinal cord injury. Yet if one will look at the results of laminectomy in those cases, 40 years ago, one can only realise that Sir Ludwig was right at that time. Changes which have occurred since in the surgical treatment of spinal injury in no way prove that he was wrong then. The only ones who are wrong are those who persist at the present time in opposing surgical treatment of spinal injury.

But let us turn our attention back to other men and other countries. I have never ceased to be amazed at the width and depth of the English channel. It has been a barrier to ideas on many occasions. Even so, a French surgeon, Antony Chipault, began doing neurological surgery in 1892. Then, as for many years thereafter, he suffered the antagonism of the neurologists. Brissaud remarked, "Surgery of tumours of the brain is sad surgery". To which Chipault replied, "The clinic is still sadder, which gives only false, vague or too long delayed diagnoses". Chipault wrote three books on neurological surgery which were widely read throughout the western world. But this flame was all too soon extinguished. In 1907, at the age of 41 years, he

developed a paraplegia and retired to exile in the Jura Mountains of France.

So far as neurological surgery was concerned France was to lie fallow until 1911 when Thierry de Martel (fig 9) performed his first neurosurgical operation, the successful removal of a tumour from the spinal cord. This was over 30 years after Macewen had begun neurosurgery in Glasgow, and

Fig 9 *Thierry de Martel*

25 years after Horsley had removed a spinal cord tumour. De Martel was to experience the same resistance to neurological surgery that was to frustrate others, before and after him. Because neurological surgery was new and untried he was not permitted to operate in any of the hospitals in Paris. Instead he performed his first operations in an obstetrical clinic which functioned under the direction of a personal friend. Later he transferred his surgical activities to the American Hospital in Neuilly, just outside of Paris.

De Martel's early training had been as an engineer. His mechanical ability is evident in the many innovations which he brought to neurological surgery. He invented the automatic trephine, a haemostatic forceps, a self-retaining retractor. He devised the sitting position for his patients during operations. De Martel was a haughty, arrogant, austere man, very conscious of his own aristocratic background. Undoubtedly these characteristics led to one of the tragedies of French neurological surgery. To any who are not familiar with this story it is worthy of repetition, even those who have heard it may find its recital of interest.

Clovis Vincent (fig 10) was a neurologist who had been trained by Babinski. Both he and Babinski referred their patients needing neurosurgical operations to de Martel. De Martel and Vincent became fast friends, although de Martel could never forget his aristocratic background. Whenever he became perturbed by something Vincent said or did he would refer to him as a peasant. One day de Martel came to Vincent and remarked that he had heard that there was a man, Cushing, in Boston who was doing remarkable neurological surgery. He asked Vincent to accompany him to the United States. At first Vincent demurred, saying that as de Martel was the surgeon, there was no reason why he should go. Finally Vincent capitulated and the two Frenchmen, neither of whom spoke English well, departed for Boston. When they arrived at Cushing's clinic they were delighted to find a man, Percival Bailey, who spoke French fluently. They quickly tied themselves to him and followed him wherever he went. As they were approaching the end of their visit, Vincent said to Bailey, "Why do not the patients who have been operated upon for a cerebellar tumour have a hernia in the back of their head like ours do"? Bailey replied, "That is very simple. After removing the tumour Dr Cushing carefully closes the neck muscles". On their return to Paris Vincent said to de Martel, "Now you must close the neck muscles securely after you have removed a cerebellar tumor". De Martel snapped, "I am too busy to do that. If you want the neck muscles closed you can do it yourself". That was de Martel's mistake. Thereafter at

the conclusion of cerebellar operations Vincent would scrub in and close the neck muscles and the skin. Soon he began to think, "If I can close these wounds why can I not open them and remove the tumour?" Somewhat later when de Martel was away from France Vincent operated upon a brain tumour. When de Martel returned he was furious. Thus ended a close and beautiful friendship which was never restored. Yet Vincent in his inaugural lecture when he became Professor of Neurological Surgery in Paris in 1939, paid great credit to de Martel whom he recognised as his teacher.

Having decided to become a neurosurgeon, Vincent, with two of his pupils, set out again for the United States. This time he went to Chicago to learn neurosurgical technique from Percival Bailey. On his return to Paris he found that no hospital would permit him to operate. However, he had a neurological service at La Pitié. With his own funds he turned one room into an operating room and his wards into neurosurgical wards. In the ensuing years Vincent became the acknowledged Father of Neurological Surgery in France and trained many of the French men who now are recognised as leaders in the field.

During World War II the difference between de Martel and Vincent was striking. When the Germans marched into Paris de Martel committed suicide. Vincent remained at his hospital and his wards became an important station in the French underground. There English and American aviators shot down over France found food and a bed where they

Fig 10 Clovis Vincent

could rest with their heads wrapped in an unnecessary bandage until means became available to get them back to England.

At the turn of the century neurological surgery came to the north of Europe. Where did it first appear? On the eastern shores of the Baltic in Tartu, Esthonia, in the person of Ludvig Puusepp (fig 11). Puusepp had been trained in neurology and stimulated to become a neurosurgeon by Vladimir Bechterew, a famous neurologist who was very interested in the relationship of the nervous system to vegetative functions. Bechterew was very dissatisfied with the attempts of the general surgeons to operate upon the nervous system and established an operating room in the Department of Nervous and Mental Diseases at the St Petersburg Military Medical Academy. Puusepp performed his first neurosurgical operation there in 1899. In 1907 Puusepp was appointed to the first chair in surgical neurology in Russia at the St. Petersburg Psycho-Neurological Institute. He was made a professor in 1910. In World War I he was wounded in combat, and returned to his post in St. Petersburg. He remained there until 1920 when he returned to his home in Esthonia. There he built a busy neurosurgical clinic with patients from all of the eastern Baltic countries. Young physicians also came to him from various parts of Europe for training in neurological surgery. In spite of his pioneer work and his outstanding achievements the Soviet Union has forgotten him. To them Burdenko is the Father of Soviet Neurological Surgery.

It was some time before neurological surgery crossed the Baltic to Sweden. In the 1920s Herbert Olivecrona (fig 12) began his work in Stockholm. He was a master neurosurgeon. He soon became not only the leading neurosurgeon of Continental Europe but the leading teacher. His pupils came from all parts of the world. The most outstanding pupils in Sweden were Sjöquist, a brilliant innovator, who died at an early age; Gösta Norlén, who pioneered in operations upon intracranial aneurysms and arteriovenous malformations; and Lars Leksell, an outstanding investigator in the functions of the nervous system and in stereotactic surgery. It is fair to say that with Olivecrona neurological surgery came of age in Continental Europe.

Fortunately none of you will ever know from personal experience what neurological surgery was really like in the 1920s. The fact is that it was a bloody mess, and I use the word "bloody" both in the English slang sense and in its correct sense. At that time the neurological surgeon was constantly confronted with a serious problem in a black box. He knew that something was wrong inside of the

skull but he often did not know what it was or where it was. All the information which he had by which to make a diagnosis was the neurological abnormalities which the patient presented. If the patient complained only of severe headaches or only had had a convulsion he was powerless to make an accurate diagnosis, that the pathological lesion was a tumour, or where it was located. Means of more accurate diagnosis began to develop gradually and they came from a variety of sources.

In 1918 Walter Dandy developed ventriculography and pneumoencephalography, but this important means of making a diagnosis took over a decade to achieve wide acceptance. Soon Sicard, a French neurologist, invented myelography with lipiodol. This test did for tumours of the spinal cord what ventriculography had done for tumours of the brain. In the later 1920s Egas Moniz, a Portuguese neurologist, invented cerebral angiography. This test expanded our knowledge by enabling us to learn more about the vascularity of tumours and about vascular lesions. Approximately 35 years later René Djindjian in Paris expanded angiography to the spinal cord. About 1929 Hans Berger demonstrated that the brain created differences in electrical potential which could be recorded. Electroencephalography soon followed as a diagnostic tool. With the development of more accurate methods of diagnosis electroencephalography gradually disappeared.

Fig 11 Ludvig Puusepp

I have noted previously that early neurological surgery, particularly operations upon brain tumours was a "bloody mess". All too frequently when the surgeon would open the skull and the dura mater the increased intracranial pressure would force the brain out through the craniotomy, the brain would rupture and the surgeon would be confronted with uncontrollable bleeding. In the 1920s Cushing, in collaboration with one of his most brilliant pupils, Kenneth McKenzie of Toronto, Canada, devised the silver clip for the occlusion of blood vessels. This was a most valuable addition to the surgeon's armamentarium for the control of bleeding from vessels which he could see or feel. Bleeding from lesser vessels or oozing from the brain surface was still beyond his ability to control except by packing the wound, pressure upon the bleeding surface, and prolonged waiting. In the late 1920s a physicist, Bovie, came to Cushing with the idea of coagulating vessels and bleeding surfaces with a electric current. The development of the Bovie electric cautery and of the silver clip now made the control of haemorrhage feasible. Control of the increased pressure, except for the removal of ventricular fluid, was still to wait another quarter of a century.

In the 1940s George Moore developed the idea that radioactive substances could localise in brain tumours because the blood-brain barrier did not apply to these lesions. But the use of radioactive scanning did not become useful until the 1960s when technical means of columnating the radioactive discharges became available. In the 1940s, also, Franc Ingraham and his collaborators in physical chemistry at Harvard University developed fibrin foam which proved of great use in controlling bleeding from cerebral tissues. It was soon replaced by foam made from gelatin, an invention also from the laboratories at Harvard.

In the 1950s neurological surgery began moving ahead at an accelerated rate. The problems of increased intracranial pressure were largely met by the introduction of the use of urea to decrease such pressure by Manucher Javid. Javid is a native of Teheran, Iran, who became the head of neurological surgery at the University of Wisconsin. Previously hypertonic saline and glucose had been used for this purpose but they were unsatisfactory. Hertel as early as 1914 and later Fremont-Smith and Forbes, Settlage and his pupils, the Smythes and Theodore Roberts had all experimented in animals with the intravenous administration of urea but Javid was the first to demonstrate the usefulness of urea in human beings with intracranial tumours. Later others demonstrated that mannitol was preferable to urea but it was Javid who had blazed the way.

In 1959 Lyle French and Joseph Galicich at the

University of Minnesota demonstrated the effectiveness of dexamethasone in relieving cerebral oedema. James Greenwood at Baylor University in Houston, Texas invented the bipolar coagulating forceps which greatly reduced the spread of the coagulating current beyond the bleeding vessel. This invention permitted Greenwood to progress on to the successful removal of intramedullary gliomas of the spinal cord. Earlier others had attempted the removal of such tumours, notably Charles Elsberg of New York and others, but their efforts had met with only limited success. In 1953 and 1954 Max Sadove, an anaesthesiologist at the University of Illinois, introduced the use of bistrium and the following year of Arfonad to lower arterial pressure during operations upon vascular lesions and extremely vascular tumours. Earlier other attempts to reduce the arterial pressure during neurosurgical operations had been used, such as bleeding the patient and producing spinal anaesthesia, but these had serious drawbacks.

In the 1960s the microscope began to be used more extensively in neurosurgical operations. This instrument had for a number of years been used by the otolaryngologists and ophthalmologists. Now no

Fig 12 *Herbert Olivecrona*

neurosurgeon would think of performing many operations without the microscope.

About 1970 an electrical engineer, Geoffrey Hounsfield in England, invented computed tomography. As soon as this became available it spread across the neurological and neurosurgical world like wildfire. I need not tell this audience how valuable this invention has become. Now similar diagnostic and research tools are becoming available. Positron emission tomography holds great promise but probably will be of greatest value in research. Nuclear magnetic resonance provides similar pictures and being cheaper will have more widespread clinical use.

With all of these advances it has been possible to achieve greater results. Neurosurgical patients now are operated upon with a much reduced risk of dying from the operation. Their postoperative condition is much better than formerly. They live longer. Aneurysms and arteriovenous malformations, both intracranial and intraspinal, are being dealt with much more safely and effectively than formerly. Intracranial infections are no longer the *bête noire* they once were.

Nevertheless with all these advances there are still problems. These must and can be solved. There are several but some are of greater importance than others.

Earlier I have noted that we can do much better in the treatment of intracranial aneurysms and cerebral gliomas. Improvement with these disastrous lesions no longer requires improvement in diagnostic techniques nor in surgical methods. We already have these in hand. What is required is further education of the general medical profession. This is a responsibility of both neurologists and neurosurgeons. This education must begin with our medical students and must continue with the practicing physicians and surgeons. The patients with both of these lesions must be examined, diagnosed and treated much earlier than they now are. We must cease regarding glioblastomas as malignant tumours similar to carcinomas of the lung and the stomach. Initially these tumours are localised in a very limited part of the brain and at their beginning they are small. They seldom metastasise and then only under unusual circumstances. At the present time these tumours are not going to be cured either by radiation or chemotherapy. They must be surgically completely removed if we are to obtain a cure. The aneurysms, whether they are symptomatic or not, must be surgically excluded from the circulation. Arteriovenous malformations must be totally removed as soon as their presence is recognised.

One of the most serious problems related to subarachnoid haemorrhage of aneurysmal origin is

cerebral vasospasm. We must learn more about its pathogenesis and its treatment. Here further research is badly needed. Basic neuroscientists as well as clinicians must become involved in these investigations. There is a peculiar thing about research. Most of the time it is the young investigators who make the significant contributions. Successful research requires the efforts of intelligent, energetic young people who do not know that it can not be done.

Another neurosurgical problem which must be dealt with is congenital malformations of the spinal cord. Surgical treatment of these lesions is rarely satisfactory. We can cover them up but we can not cure them. In many instances, however, they can be prevented. This is being done now in a few isolated centres in France, in the United States, and perhaps elsewhere. The possibility that a foetus is developing with a serious congenital neurological defect can now be easily recognised by techniques now available. They should be and those pregnancies with a defective foetus should be terminated. There is no excuse for condemning these children to lives with paralysis of their legs, bowel and bladder, with an absence of sensation.

Still another area in which we have made progress but not enough is spinal cord injury. Prior to the mid 1940s paraplegics and quadriplegics died soon after their injury or if they survived they lived out a dismal life. Sir Ludwig Guttmann working at Stoke Mandeville in England demonstrated that the complications of paraplegia could be largely avoided and that these people could live active, productive lives. That was a great step forward from the years which had gone before. In the 1960s Albin and White and Thomas Ducker demonstrated that the paralysis from injury to the spinal cord is not necessarily a permanent one. Their research needs to be expanded in human beings. There is more to be done both experimentally and clinically to achieve the best methods of reversing the paralysis from injury to the spinal cord. What is even more urgent in this regard is to utilise the knowledge we now have more effectively. Much has been accomplished in this regard here in Edinburgh. Still too many patients with fractured spines are not being adequately immobilised immediately after their injury and as a result go on to becoming quadriplegic and paraplegic unnecessarily. Others with partial injury to their spinal cords are not being adequately treated so that they may recover from their paralysis or so that it does not progress. An even smaller number of patients with complete functional interruption of their spinal cords are not being given the chance to recover which obviously exists. All too often neurological surgeons have ignored these problems

and have permitted the orthopedic surgeons and the rehabilitation experts to assume responsibility for these patients. I would not deny the importance of what these specialties can do for paraplegic and quadriplegic patients, but if cures and improvement are to be obtained, not just teaching patients to live with their disabilities, then neurosurgeons must assert themselves for it is the immediate acute care which is important.

Some of the most common and devastating neurological disorders with which we are all confronted is traumatic craniocerebral injury. These are most commonly the result of vehicular accidents. We must cooperate with governmental authorities to reduce speed on our highways and get all drivers who are under the influence of alcohol off our roads. We must recognise that craniocerebral injuries simi-

lar to injuries of the spinal cord are seldom maximal at the time of the accident. The damage increases subsequently. This fact demands the earliest possible as well as the most beneficial treatment. Fortunately efforts in this direction are being taken both in Europe and in the United States. In the forefront of those striving to improve this situation are Professors Jennett in Glasgow and Miller here in Edinburgh. Donald Becker in Richmond, Virginia is likewise striving to improve this situation.

In the past 100 years neurological surgery has achieved much, but there is still much to be done. An even greater future lies ahead. The task is not an easy one. It never was. Norman Dott would have been among the first to agree and to have applauded your efforts and your ultimate success.