

A History of Neurosurgery in Canada

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ABSTRACT: Canada existed for more than half a century before there were glimmerings of modern neurosurgical activity. Neurosurgery had advanced significantly in Europe and the United States prior to its being brought to Toronto and Montreal from American centers. The pioneers responsible for the rapid evolution in practice, teaching and research are described. The interplay of scientific, professional, demographic and economic forces with general historical trends has produced dramatic changes in the way that neurosurgery is now practiced.

RÉSUMÉ: Une histoire de la neurochirurgie au Canada. Le Canada existait depuis plus d'un demi-siècle à l'avènement de l'activité neurochirurgicale moderne. La neurochirurgie a fait des progrès notables en Europe et aux États-Unis avant d'être importée de centres américains vers Toronto et Montréal. Nous décrivons les pionniers responsables de l'évolution rapide de la pratique, de l'enseignement et de la recherche en neurochirurgie. L'interaction entre les forces scientifiques, professionnelles, démographiques et économiques avec des tendances historiques générales a suscité des changements dramatiques dans la pratique actuelle de la neurochirurgie.

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Some excellent accounts on this subject already exist.¹⁻⁵ My acceptance of this task came after I recalled Winston Churchill's trenchant observation: "*History will be kind to me, for I intend to write it.*"

Our Relationship to the Nation's History

"*Nothing endures but change.*" Heraclitus

The British North America Act of 1867 united the province of Canada and the provinces of New Brunswick and Nova Scotia to create the Dominion of Canada. Even in the 19th century occasional operations on the brain were performed for obvious trauma.^{1,6}

In the "Great War for Civilization" (1914-18) surgeons Archibald and McKenzie rendered yeoman service overseas. Howard Hepburn was awarded the Military Cross from the King for conspicuous gallantry in saving others while wounded.⁷ Elvidge, not yet a neurosurgeon, served as a gunner at Passchendaele. Penfield suffered a broken leg when the ship carrying him across the Channel was torpedoed.⁸ More than 60,000 Canadians died in the conflict, a dreadful toll for a country of only eight million. In 1918-1919, in a comparable tragedy, 20 to 50 million world-wide died from a virulent strain of flu.

On the home front attempts to prohibit alcohol were more or less successful until the 1920s when government realized the futility of enforcement and grasped the potential benefits from taxing alcohol. Canada started to take responsibility for social welfare in the 1920s. The first full-time Canadian neurosurgeon, McKenzie, started to practice in Canada in 1924.^{2,9-14} In 1927 an old age pension of \$1/day, for over 70-year-olds who qualified

by a means test, was initiated - not overly generous since the median age at death was 51 in 1931. The first baby bonuses were seen in 1945. The Federal Health and Welfare budget was only 2% of national revenue. The pendulum would swing very far over the next few decades.

There have been numerous economic panics, recessions and one Great Depression that lasted from 1929 to the late 1930s. By 1933, 30% of the Canadian labour force was unemployed, 20% of the population subsisted on government hand-outs. Unrest resulted in five violent deaths in various strikes and demonstrations. In 1934 the Montreal Neurological Institute was founded during hard times. In that year Canadian mothers had a 1 in 200 chance of dying in childbirth; 1 in 2,000 Canadians died of tuberculosis, twice as many as died from strokes and half the number who died from cancer.

In the Second World War (1939-45) Stevenson, Botterell, Keith, Cone, Vance Macdonald, Taylor, Barlass, Elliot, Stewart, Peterson and F. Turnbull each wore the Canadian uniform in a theatre of war, Morley the British, Parkinson and Rasmussen the American¹⁵. Another 44,000 Canadians sacrificed their all for others in the defeat of murderous fascists.

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We live in a peaceful country. In almost a century and a half there have been only two political assassinations, one armed rebellion and one outbreak of terrorism. No innocent person has been hanged since 1962, although dozens of people have been murdered by persons previously convicted of murder. The past half century has seen many of the inmates of our asylums transferred to the sidewalks of our cities.

A wave of genuine jubilation swept over Canada in 1967 as we citizens celebrated the Nation's Centennial Year; the festivities were capped by the wonderful Montreal Expo.

In 1968 Pierre Trudeau became prime minister. In 16 years of power his government turned a nearly balanced set of books into a \$38.5 billion deficit and increased the national debt from \$17 to \$200 billion.¹⁶ In 1969 the Official Languages Act guaranteed anyone the right to receive service from the federal government in either official language in any part of Canada where numbers warrant. The days of currency and postage stamps being in English only were over. In Ottawa, Quebec and Moncton more than 40% of Canadians are bilingual, in the rest of Canada it is under 12%.

In 1980 the redoubtable neurosurgeon Dwight Parkinson, still brilliant and gifted, took up the cause as poster child of all those being drummed out of surgical practice by virtue of age. He won the battle but lost the war. The Supreme Court of Canada, composed of sympathetic fellow septuagenarians, declared he could not be summarily dismissed but his hospital gave him only one half operating day a month!¹⁷

In 1982 the Canadian Constitution was brought into being. It included the brain child of Pierre Trudeau, the "Charter of Rights and Freedoms", that changed the common law concept of being left alone unless you break the law to one of entitlement to an ill defined list of desirables.¹⁸ Quebec refused to participate in the patriation and in an attempt to placate that province the "Notwithstanding" clause, that permitted opting-out under certain conditions, was inserted. The Charter would be used to strike down the Lord's Day Act, abortion law, to provide protection for gays, to impose strict obligations on police and prosecutors, to throw out thousands of prosecutions because they were taking too long, led to charter rights trumping national security and provided employment to legions of lawyers. The rise of quasi-judicial Human Rights Tribunals is reassuring to all those who get their feelings hurt but few others.

In 1988 the Government formally apologized and provided cash compensation to Canadians of Japanese origins for their war-time treatment. Groups subsequently seeking redress included some Aboriginal peoples, Jews, Caribbean Blacks, Lepers, Chinese, Italians and Doukhobors. We have collectively failed to alleviate the relative poverty, unemployment and ill-health of First Nation Canadians. Pursuing the multicultural Holy Grail the majority acquiesced in the abandonment of the Red Ensign, Dominion Day, the singing of "God Save the Queen" and "The Maple Leaf Forever". Something of rarely seen Canadian patriotism burst into expression with the Vancouver Olympics of 2010, climaxing with Sydney Crosby's goal that produced a national outpouring of emotion unequalled since Paul Henderson's winning goal against the Soviets, with 32 seconds to go, 38 years before. A more somber expression has been in the common grief experienced as our dead young soldiers are brought home from Afghanistan.

"Tradition, indeed, is the most powerful binding influence the world knows. It lies deep in most of us, and pride in tradition supplies the glue that holds people and groups of people in cohesion. Pride in family and friends, in Alma Mater and profession, in race and birthplace, in state and nation. The controlling subconsciousness of one's stock and upbringing is something from which time and distance can never wholly wean us." Harvey Cushing.¹⁹

The deep empathy Canadians have for our American neighbours was evident during the horror of the assassination of President Kennedy in 1963 and the nightmare of the Twin Towers in 2001. Our solidarity extended to repelling communist aggression in Korea but did not involve participation in the Vietnam or Iraq Wars in which instances our government's views coincided with significant and well-informed minorities or majorities in the U.S. population.

Canada has evolved from a patriarchal, mainly European, avowedly Christian, white colony, supportive of the monarchy and the Empire. It has gone from two solitudes to many. Pessimists recently noted that most of the nation's institutions - the politicians, the judiciary, the military, the 'Mounties', the unions, the priestly classes, even doctors - have all lost their aura. No longer is anything sacred. Self-sacrifice for country seems somewhat anachronistic to many. However, as the celebrated author Peter Newman observed *"Too often - as a nation and as individuals - we have decried what we lack instead of celebrating what we have ... to most of the world's troubled citizens, Canada still appears to be blessed with the mandate of heaven."*²⁰

The Special Case of Quebec

The first surgeon to practice neurosurgery in Quebec was Edward Archibald. He also practiced thoracic surgery but wrote a paper on cerebral compression published in 1907 and a monograph on head injuries that appeared in 1908.²¹⁻²³ He became professor of surgery at McGill and invited Penfield to join him.

The first full time neurosurgeons in Quebec, arriving in 1928, were English speaking Americans, Penfield and Cone. Dr. Jean Sirois trained with Byron Stookey in New York from 1937 to 1939. For years he shouldered the neurosurgical burden in Quebec City alone. By 1940 the Montrealers were joined by Elvidge and by 1947 they had trained Claude Bertrand. The process of providing La Belle Province with native son neurosurgeons was well underway. L'Association des Neurochirurgiens du Québec had nine members in 1950. Their number grew to 16 in 1960, of whom four were native English speakers. A decade after the battle cry "Maître Chez Nous!" there were 15 members of whom two were native English speakers. In 1980 there was one of 17.²⁴

Theodore Rasmussen had the difficult task of following Penfield as Director of the Montreal Neurological Institute (MNI). He surpassed his mentor as a meticulous operator and carried the surgical treatment of epilepsy to new heights.²⁵

Jean Lesage had led his Liberal Party of Quebec to power with a mandate to remake their province, and remake it they did. In 1969 a balanced provincial budget was tabled. Not another would be until 1997 - 1998.¹⁶ A short-lived doctors' strike in

1970 saw the Provincial government threaten truly Draconian reprisal measures. In 1977 the separatist Parti Québécois under René Lévesque passed “Loi 101” a Charter of the French Language that was declared the official language of Quebec. Stating that every person in Quebec has the right to health services in French, professional orders were enjoined to issue permits only to persons who have knowledge of French appropriate to the practice of their profession. This law was seen as threatening by most Anglo-Quebecers. The Quebec population with English as a mother tongue dropped from 789,000 in 1971 to 190,000 in 1996. The Anglo-Scottish community decamped.

In 1960 36,000 persons in Quebec were employed in the public sector, 2% of the work force. By 1971 the number had swelled to 350,000 or 15%.¹⁶ Government expenditures at all levels accounted for about one-third of Quebec’s gross national product, by 1970 this grew to one-half. As clerical influence over society crumpled dramatically the social demographics in Quebec were radically altered. Quebec now has low levels of marriage, high levels of divorce, lone parenthood, child poverty, welfare dependency and low levels of fertility. Quebec is not alone among the provinces in these depressing social trends. In 1995 a Quebec business magazine’s listing of the 50 most powerful Quebecers included 46 French Canadians, two Jews and two others.

A slim majority of francophones, whose ancestors were born in Quebec, yearned for their own independent nation. In the sovereignty referendum of 1980 the proposal was defeated 59.56% to 40.44%. In 1993 a sizeable group in the Bloc Québécois party was elected to the Federal Parliament, ironically at one point even becoming the ‘Loyal Opposition’! In 1995 following the failure of Meech Lake and Charlottetown accords

to win support to woo Quebec back into the national family with respect to the patriated constitution, another referendum was held. It was a cliff-hanger, being narrowly defeated 50.58% to 49.42%, due, according to the Quebec premier, to the nefarious influence of outsiders and ethnics.

Medical practice in Quebec is currently conducted overwhelmingly in French. Quebec issued its own certificate to permit the specialist practice of neurosurgery until 2002 although now all practitioners must achieve the FRCSC. The ‘Francization’ of the Montreal Neurological Institute, like all Quebec institutions, is well under way. The basic neurosciences continue to be remarkably strong, arguably the most active community in the country. Through all this turmoil, relations between English and French speaking neurosurgeons were never less than fraternal, warm and courteous.

The Scientific Basis of Canadian Neurosurgery

Canadian neurosurgery did not spring into being *de novo*. It must be observed in all humility that the great advances were not made in this country (Table 1²⁶). Few of these ideas sprang into being without a chain of lesser precedents.

Before McKenzie returned to Toronto from Boston, neurosurgery was firmly established elsewhere (Table 2^{27,28}).

The pioneers of early neurosurgery and some of their accomplishments are listed (Table 3²⁸). “*Be not the first by whom the new are tried, nor yet the last to lay the old aside.*” Alexander Pope.

Canadians have made contributions to some of the modern neurosurgical advances which have generally been the result of cumulative individual efforts in many countries (Table 4).

Table 1: Great discoveries in science and surgery²⁶

Technical			Conceptual		
Year	Discovery	Discoverer (years)	Year	Discovery	Discoverer (years)
1846	Anesthesia	William Morton (1819-1868)	1858	Evolution	Charles Darwin (1809-1882)
1862	Germ Theory of Disease	Louis Pasteur (1822-1895)	1861	Cortical localization	Pierre-Paul Broca (1824-1880)
1865	Antiseptic Surgical Technique	Joseph Lister (1827-1912)	1870	Focal epilepsy	J. Hughlings Jackson (1835-1911)
1890	Rubber Gloves	William Halstead (1852-1922)	1889	Neuronal doctrine	Ramon y Cajal (1852 – 1934)
1895	X-rays	Wilhelm Röntgen (1845-1923)	1953	Double helix DNA	James Watson (1928- Francis Crick (1916-2004)
1902	Blood Vessel Repair	Alexis Carrel (1873-1944)			
1918	Cortical excision for epilepsy	Otfrid Foerster (1873-1941)			
1928	Penicillin	Alexander Flemming (1881-1955)			

Table 2: Diagnostic, technical and conceptual advances antedating modern Canadian neurosurgery^{27,28}

Year	Advance	Doctor
1851	Ophthalmoscope	Von Helmholtz
1861	Speech localization	Broca
1881	Cerebral localization	Fritsch and Hitzig
1889	Osteoplastic craniotomy rather than trephination	Wagner
1891	Lumbar puncture	Quinke
1892	Bone wax for hemostasis	Horsley
1897	Wire saw	Gigli
1898	Decerebrate rigidity	Sherrington
1911	Silver clips	Cushing
1914	Mechanics of hydrocephalus	Dandy and Blackfan
1918-20	Ventriculography, Pneumography, Head Lamp	Dandy
1919	Reduction and expansion of brain bulk	Weed and McKibbin
1921	Positive contrast myelography	Sicard
1922	Binocular operating microscope	Holmgren
1925	Power suction	Sturmann
1927	Angiography	Moniz
1928	Monopolar electro-surgery	Cushing and Bovie

Table 3: Early landmark events in neurosurgery²⁸

Year	Event	Neurosurgeon
1879	Meningioma successfully removed	Macewen
1884	Brain glioma removed	Bennet and Godlee
1887	Spinal tumour removed, laminectomy	Horsley
1887	Ten intracranial tumours removed	Horsley
1892	Partial intracranial resection of trigeminal ganglion	Hartley
1893	Intracranial abscesses cured	Macewan
1901	Retrogasserian trigeminal neurectomy	Spiller and Frazier
1909	Pituitary tumours removed	Cushing
1917	Series of partial removal of acoustic tumours	Cushing
1927	Total removal of acoustic tumours	Dandy
1933	Ruptured discs excised	Mixter and Barr
1936	Frontal lobotomy	Moniz
1938	Clipping of intracranial aneurysm	Dandy

Table 4: Modern neurosurgical advances

Technical	Conceptual
-Ventriculo-atrial and lumbo-peritoneal shunts	-Signal transmission
-Electrical and air-driven drills and saws	-Cortical localization
-Mannitol, furosemide, hypertonic saline	-Rehabilitation of cord injury
-Operating microscope, cameras, endoscopes	-Carotid disease & stroke
-Bipolar coagulation, hemostatic agents and drugs	-Relationship ICP & CBF
-Aneurysm clips and appliers	-Glasgow Coma Scale
-Self-retaining retractors	-Prospective clinical trials
-Stereotaxic apparatus	-Evidence based medicine
-Microneurosurgical instruments	-Objective scales for clinical status
-Endovascular technology	-Vegetative state, brain death
-Ultrasonic aspirators	
-Implantable electrodes	
-Drug delivery systems	
-Computerized radiology records, Image-guided technology	
-Implantable prostheses for skull and spinal reconstruction	
-Pulse oxygenators	
-CT and MR Imaging	

ICP = intracranial pressure; CBF = cerebral blood flow; CT = computerized tomographic; MR = magnetic resonance

Table 5: Some “fathers” of Canadian neurosurgery

Doctor	Year
William Osler	1849-1919
Harvey Cushing	1869-1939
Edward Archibald	1872-1945
Howard Hepburn	1885-1972
Wilder Penfield	1891-1976
Kenneth McKenzie	1892-1964
William Cone	1897-1959
William Keith	1902-1987
Frank Turnbull	1904-2000
Harry Botterell	1906-1997
Theodore Rasmussen	1910-2002
William Stevenson	1913-2006
Dwight Parkinson	1916-2005
Charles Drake	1920-1998
William Loughheed	1923-2004
Bruce Hendrick	1924-2001
Thomas Speakman	1924-1969
Harold Hoffman	1932-2004

Fathers of Canadian Neurosurgery

“Let us now praise famous men. And our fathers that begat us.” Ecclesiasticus XLIV:1

I include Osler²⁹⁻³³ because he encouraged Cushing to specialize in neurosurgery and he wrote several papers on neurosurgical topics. He also inspired both Cushing and the young Penfield. Cushing³⁴⁻³⁸, is included because he trained McKenzie and Penfield visited several times to learn from the master (Table 5). The men who laid the foundation of neurosurgery in this nation are pictured in the Figure.

“The history of the world is but the biography of great men.”
Thomas Carlyle

Could there be a typical neurosurgical personality?

“I knew Horsley, Macewen, Cushing, and Dandy. Oddly, I found all four to be similar in at least two regards. They were all brilliant contributors to our knowledge, and undoubtedly great figures in medical history, but they were all disagreeable, pompous, and tremendously impressed with their importance.”
W. E. Gallie (Professor of Surgery and Dean, Toronto) writing to T. P. Morley.¹²

Wilder Penfield was not the first full-time neurosurgeon in Canada but the achievements of this extraordinary man unquestionably place him as the pre-eminent Canadian neurosurgeon.³⁹⁻⁴⁸ He deliberately set out to follow in the footsteps of the legendary Osler and the imperious Cushing. His ability to gather talented people around him, to garner the support of wealthy foundations and patrons, was unique. He set out to achieve greatness and he achieved it. He built an imposing scientific institute during the Depression. No one else of his time trained as many leaders of American neurosurgery: Odom (Duke), Boldrey (UCSF), Pudenz (California), Ward (Washington), Evans (Cincinnati), Baldwin (NIH), Perot (South Carolina), Mullan (Chicago) to name a few.¹⁵ Some of the first neurosurgeons in Norway, Brazil, Lebanon, Japan, India and China spent time at the MNI. No one else of his generation would personally be introduced to Chiang Kai-shek and Mao Zedong.⁸ His works are more widely quoted than those of Cushing. Surprisingly, he did not seem to be entirely trusted by Cushing.³⁴ Despite not being a technically dazzling operator Penfield’s scientific observations will have lasting value which is unusual in our technologically driven specialty. His dream came true. *“How happy we should be that here, in this great Canadian city, an institution has grown up that arrests the attention and commands the admiration of the profession of medicine the world over.”* So said Vincent Massey, Governor General of Canada, speaking at the MNI, in 1955.⁴⁸ More than 75 years after he founded it, the MNI continues to be recognized as one of the world’s leading centers for the study and treatment of epilepsy.^{49,50} Within it much has been accomplished to answer the following questions that are etched on its outside wall:

Table 6: The chain of leadership at major English teaching centers

Institution	Chiefs and Start Year of Leadership
British Columbia Alberta ⁷	F. Turnbull '33, Lehmann '44, Moyes, Thompson '60, Durity '90, Redekop '02 H. Hepburn '34, Morton '51, Speakman '64, Allen '69, Weir '82, Petruk '86 and '99, Findlay '97, Aronyk '09
Calgary ⁶⁹	Taylor '69, F. LeBlanc '74, Sutherland '94, Midha '04
Saskatchewan ⁷⁰	Feindel '55, Stratford '59, Paine '62, Khan '74, Griebel, Meguro '05
Manitoba ¹⁷	Parkinson '57, Rankin-Hay '83, Hill '88, Christante '98, West '00
Ottawa	Peterson '54, Ivan '78, Richard '87, Benoit '97, Moulton '04
Western Ontario	C. Drake '69, Peerless '75, Girvin '90, Findlay '99, Lownie '00, Parrent '10
Toronto ⁷¹	McKenzie '24, Botterell '53, Morley '64, Hudson '79, Tator '89, Rutka '99 and Keith '33, Hendricks '64, Hoffman '86, Humphreys '96, J. Drake '03
McMaster	Reddy '00
McGill ^{42, 46}	Penfield '28, Rasmussen '64, Feindel '72, Bertrand '72, Olivier '91
Dalhousie ⁵⁶	Stevenson '48, Heustis '74, Holness '88, Menzes '00



Figure: Departed Fathers of Canadian Neurosurgery. From the left: Top row: Harold Hoffman, Arthur Elvidge, William Keith, William Cone, Dwight Parkinson. Second row: Theodore Rasmussen, Jean Sirois, Frank Turnbull, Kenneth McKenzie, Harvey Cushing. Third row: William Osler, Edward Archibald, Wilder Penfield, Charles Drake, William Stevenson. Bottom row: Harry Botterell, Howard Hepburn, Bruce Hendrick, Thomas Speakman, William Lougheed."

"Where shall wisdom be found? And where is the place of understanding?" (Verse 12, Ch. 27. The Book of Job, Old Testament).

Kenneth McKenzie was the first to restrict his practice to neurosurgery in Canada. Following his year with Cushing, he returned to Toronto in 1923, was not allowed on staff for a year, had to do general surgical cases for some years thereafter and did not get a dedicated neurosurgical operating room until 1929.¹² There were no neurosurgical residents until the 1930s. He persevered and became recognized as a major force in post-Cushing neurosurgery despite the fact that his treatment by

Toronto was distinctly less supportive than Penfield's reception by McGill. McKenzie's personality and technical mastery came to be internationally recognized.¹⁴ He had an immensely positive impact on his trainees. They in turn founded pediatric neurosurgery and general neurosurgery in Toronto, Halifax, London, Ontario and Vancouver. His trainees were W. Keith⁵¹ - 1930, F. Turnbull^{4,52,53} - 1931, E. Botterell^{54,55} - 1936, C. McCormick - 1942, W. Stevenson⁵⁶ - 1946, J. Cluff - 1948, C. Drake⁵⁷⁻⁵⁹ - 1949. Botterell, during and immediately following the Second World War, made dramatic contributions to the care of complete spinal cord injured patients with his neurological

colleague Dr. Albin Jousse. Before them, such cases were usually considered hopeless. The Toronto neurosurgical program flowered in the succeeding decades most notably with Lougheed⁶⁰, Tasker⁶¹ and Hendrick.⁶²⁻⁶⁴ New generations came through the ranks to build the largest training program in the country, possibly the continent. Toronto became Canada's leading center for neurosurgical clinical training and research.⁶⁵⁻⁶⁸

The only Canadian neurosurgeon to achieve the world recognition of Penfield was Charles Drake.^{15,57-59} In his day the neurosurgical reputation of London, Ontario momentarily eclipsed that of the other London. He was a neurosurgeon's neurosurgeon. He went boldly where others feared to tread and was the uncontested master of the basilar apex. His results with the most difficult vascular lesions were benchmarks to which others aspired. His symbiotic relationship with Henry Barnett was the most fruitful collaboration in Canadian clinical neuroscience of their generation. He had personal warmth that propelled him into the topmost leadership of virtually every major surgical organization he joined. Charles was universally liked and admired.

The torch was passed at our academic centers as indicated in Table 6.^{7,17,42,46,56,69-71} The first chiefs had more staying power than their successors.

Table 6 does not list many of those who made significant contributions to the advancement of Canadian neurosurgery by acting as program directors. An exemplar would be Christopher Wallace of Toronto who has overseen the training of many, as well as running the "William Lougheed Microneurosurgical Course" which has benefited neurosurgeons from across the country. It also does not acknowledge the huge contributions of those hardy souls who ventured into smaller centers, reliant mainly on their own resources initially, men such as Hetherington in Kingston, Sutherland in Sudbury, Kumar in Regina and Maroun in St. Johns.

Neurosurgeons have often been highly egocentric, ambitious, intolerant of criticism and given to intense rivalries. Cushing and Dandy had such a titanic competition. Misunderstandings based on different visions of how neurosurgery should develop in an area were often the basis for trouble. Keith resented McKenzie for years, Botterell and McKenzie kept their profound interpersonal differences private over the last few years of their professional relationship.¹² In Cone's bitter view, he was betrayed when Penfield passed him over as second Director of the MNI. Jasper left the MNI after receiving a dressing down by Penfield when the latter took umbrage at his neurophysiologist's openly expressed view on funding basic research at the institute. Parkinson held many of his colleagues in public contempt. Morton and Speakman had an irrevocable falling-out that made life difficult for all those around them.⁷ Peterson and his successor Ivan did not speak. This of course is not a complete list but I mention them as illustrative because the protagonists are all dead.

The third trimester of our nation's existence saw a flowering of neurosurgery as units developed mainly in university hospitals from sea to sea. Canadians contributed to the development of most fields of neurosurgery. In epilepsy diagnostic methods were improved, targets were refined and long-term results documented. Non-invasive localization of function can now precede operative intervention. New operations for spasmodic

torticollis were introduced. Stereotaxic surgery evolved, physiological information was gained, single cells were recorded, stimulation supplanted destruction and indications widened but cellular implantation has so far failed to take hold. Transphenoidal surgery matured with the introduction of fluoroscopy and the microscope. The neuropathology of pituitary tumours advanced. In vascular surgery the long-vein graft was described. Aperture clips were designed. The concept of management mortality for aneurysmal rupture was introduced. Early treatment was advocated. The influence of intracerebral and intraventricular hemorrhage on aneurysmal outcome was elucidated. Lysis for intracranial clot was begun. Prospective, randomized, blinded trials of chemotherapy were done. Multicentred trials involving Canadians established the lack of efficacy of extra-cranial intracranial bypass using the superficial temporal artery for atherosclerotic disease and the efficacy of carotid endarterectomy for moderate to severe carotid stenoses resulting from the same process. We have been participants in all the trials of putative anti-vasospastic agents and saw the successful introduction of one. Retrospective case series reviews gave way to prospective trials: as in agents to treat a wide variety of conditions such as steroids for acute spinal cord injury, implants with slow release chemotherapeutic agents for gliomas and optimum shunt valves. The rigor of prospective data collection was employed in lumbar discectomy, aneurysm clipping and temporal lobectomy. Pathophysiological mechanisms of cerebral vasospasm and spinal cord trauma were clarified with the introduction of animal models from Canadian laboratories and in the study of subdural hematomas in the wards. Organizations were formed to prevent head and spinal cord injuries. Contributions were made to cavernous sinus anatomy, peripheral nerve allografting, regeneration in the central nervous system, mechanisms of neuronal injury and the role of stem cells in gliomas. Outpatient neurosurgery has been evaluated. Image guidance systems and intraoperative MRI were improved and surgical robots developed. Gamma Knife surgery was introduced to Canada. Many in our company of more than 600 made lasting contributions to their patients and their students, to their families and society, and to medical science.

The Royal College and Formalized Neurosurgical Training

An Act of Parliament created the Royal College of Physicians and Surgeons of Canada (RCPSC) in 1929. Archibald was a founding member. The specialty committee of neurosurgery acts in an advisory capacity to the council. Neurosurgery was recognized as a specialty in 1945, certificates were granted in 1946. The neurosurgery fellowship exam was first offered in 1946, there were no takers.⁷¹ The first fellow to gain his status by examination was Claude Bertrand of Montreal. He was followed in the 40's by Ross Fleming, Joe Stratford, Allan Hepburn, Jack Mayer and Gilles Bertrand. Up to 1947, 22 established neurosurgeons received certification without being tested. Thereafter it was almost solely by examination for either a certificate or fellowship. In 1972 holders of the lesser certificate, on payment of \$500, received the fellowship, to the chagrin of some holders of the fellowship.¹⁷

Initially there were two formally constituted training programs, McGill and Toronto. By 1977 there were 13 (program directors): BC (Thompson); Alberta (Allen); Calgary (F.

Table 7: Number of graduates of RCPSC in neurosurgery per year

Decade	1940s*	1950s	1960s	1970s	1980s	1990s	2000s	Total
Total	18	49	61	91	123	136	186	664
Average	4.4	4.9	6.1	9.1	12.3	13.6	18.6	

*1946 – 1949, four years only

LeBlanc); Saskatchewan (Clein), Manitoba (Parkinson), Western Ontario (Peerless); Toronto (Morley); Ottawa (Peterson); Sherbrooke (Heon); MNI (Feindel); Montréal (Cartier-Giroux); Laval (G. LeBlanc); Dalhousie (Heustis). In 1975 there were 73 residents in neurosurgical training, 23 were Canadians.⁷¹ That proportion has steadily increased as has the numbers being trained (Table 7).

The chairs of the committee of neurosurgery of the Royal College in the early years included Penfield (1945-7); Cone (1947-51); Botterell (1951-3); C. Bertrand (1953-64); Turnbull (1957-64); Drake (1964-70); Morley (1970-6); Heon (1976-7); Thompson (1980-6).⁷¹

In the past two decades Toronto and McGill have been producing the most graduates (Table 8).

Of the neurosurgeons who participated in the Maintenance of Competence of the RCPSC in 2009, 67.6% were in Canada, 27.9% the USA, 2.1% South Africa and the remainder other countries. Neurosurgeons who have served their schools as Chairmen of Surgery include H. Hepburn (Alberta), Couillard (Sherbrooke), C. Drake (Western Ontario), Hansebut

(McMaster), Maroun (Memorial) and Weir (Alberta); as Chairman of Clinical Neurological Sciences, C. Drake; as Deans Botterell (Queens) and Weir (Chicago).

The Quest for Knowledge

“Truth in all its kinds is most difficult to win; and truth in medicine is most difficult of all.” Peter Latham, Collected Works, 1789-1875.

Tables 9, 10 and 11 list some Canadian efforts to prove the pen is as mighty as the scalpel.

“To gather knowledge, and to find out new knowledge, is the noblest occupation of the physician. To apply that knowledge with understanding, and with sympathy born of understanding, to the relief of human suffering is his loveliest occupation.” Edward Archibald, 1936.

Chairmen of the Editorial Board of the Journal of Neurosurgery were McKenzie, C. Drake, Weir, Girvin and Rutka. The neurologist R.T. Ross founded the Canadian Journal of Neurological Sciences in 1974. In 1988 the first neurosurgeon to act as Associate Editor was Weir (1988-1991) followed by Girvin (1992-1997), Lozano (1998-2006), and Findlay (2007 to date); many more served on the editorial board.

In 1984 over 300 former fellows of all disciplines returned to the MNI to celebrate the 50th anniversary. In 1988 over 100 former fellows and residents came to a pediatric neurosurgical reunion of the Toronto Sick Childrens' Hospital. Many had established their own units in other countries as well as in Canada.⁶⁴

Graduates of Canadian Medical Schools who achieved prominence in American neurosurgery include Black (Brigham), Colohan (Loma Linda), Cosgrove (Lahey Clinic), Couldwell (Utah), Demonte (MD Anderson), Konzdiolka (Pittsburgh), McDermonnt (UCSF), Schmideck (Hahneman), Shields (Kentucky), Stein (Columbia), Tranmer (Vermont), Macdonald and Weir (Chicago), and Whitcomb (Yale).

Organized Medicine

The Canadian Neurological Association held an inaugural meeting in Montreal in 1948. At the suggestion of C. Miller Fisher the name was changed the following year to Society, he liked the acronym! The new Canadian Neurological Society originally included neurosurgeons and neurologists. The neurosurgical presidents were W. Penfield 1949; F. Turnbull 1951; J. Sirois 1956; E. Botterrell 1958; C. Bertrand 1961; W.

Table 8: FRCSC graduates of neurosurgical programs, 1989 - 2009

PROGRAM	Number of Graduates	Average/Year
Toronto	76	3.6
McGill	46	2.2
Non-Canadian	39	1.9
McMaster	7	1.8
Alberta	28	1.3
Western Ontario	25	1.2
Ottawa	23	1.2
Montréal	21	1
British Columbia	16	.8
Calgary	16	.8
Manitoba	16	.8
Laval	15	.7
Saskatchewan	15	.7
Sherbrooke	14	.7
Dalhousie	11	.7

Table 9: Top cited articles in neurosurgical journals by Canadian neurosurgeons ranked in order of citations received*

Rank in top 100	Citation	Number of Times Cited
7	Wada J, Rasmussen T . Intracarotid injection of sodium amytal for the lateralization of cerebral speech dominance. Experimental and Clinical Observations. <i>J Neurosurg</i> . 1960;17:266-82.	876
24	Tator C, Fehlings MG . Review of secondary injury theory of acute spinal cord trauma with emphasis on vascular mechanisms. <i>J Neurosurg</i> . 1991;75:15-26.	523
39	Drake CG . Report of World Federation of Neurosurgical Societies committee on a universal subarachnoid hemorrhage grading scale. <i>J Neurosurg</i> . 1988;68:985-6.	409
42	Kassel NF, Peerless SJ , Durward QJ, Beck DW, Drake CG , Adams HP. Treatment of ischemic deficits from vasospasm with intravascular volume expansion and arterial hypertension. <i>Neurosurgery</i> 1982;11:337-43.	395
59	Rivlin AS, Tator CH . Objective clinical assessment of motor function after experimental spinal cord injury in the rat. <i>J Neurosurg</i> . 1977;47:577-81.	355
68	Botterell EH, Lougheed WM , Scott JW, Vandewater SL. Hypothermia and interruption of carotid or carotid and vertebral circulation in the surgical management of intracranial aneurysms. <i>J Neurosurg</i> . 1956;13:1-42.	327
70	Weir B , Grace M, Hansen J, Rothberg C. Time course of vasospasm in man. <i>J Neurosurg</i> . 1978;48:173-8.	325
83	Lasjaunias P, Chiu M, Terbrugge K, Tolia A, Hurth M, Bernstein M . Neurological manifestations of intracranial dural arteriovenous malformations. <i>J Neurosurg</i> . 1986;64:724-30.	306
92	Ferguson G . Physical factors in the initiation, growth and rupture of human intracranial saccular aneurysms. <i>J Neurosurg</i> . 1972;37:666-77.	299

*Source Ponce FA, Lozano AM. Highly cited works in neurosurgery. Part I: the top-cited papers in neurosurgical journals. A review. *J Neurosurg*. 2010;112(2):223-32.

Table 10: "Classics" - articles with more than 400 citations, Canadian neurosurgical authors*

Rank in 106 articles	Citation	Number of citations
10	Barnett HJM ... Ferguson GG , et al. Benefit of carotid endarterectomy in patients with symptomatic moderate or severe stenosis. North American Carotid Endarterectomy Trial Collaborators. <i>N Engl J Med</i> . 1998;339:1415-25.	1,110
20	Wada, J, Rasmussen T . Intracarotid injection of sodium amytal for the lateralization of cerebral speech dominance. Experimental and clinical observations. <i>J Neurosurg</i> . 1960;17:266-82.	876
37	Allen GS ... Weir BK , et al. Cerebral arterial spasm – a controlled trial of nimodipine in patients with subarachnoid hemorrhage. <i>N Engl J Med</i> . 1983;308:619-24.	638
63	Tator, C, Fehlings M . Review of secondary injury theory of acute spinal cord trauma with emphasis on vascular mechanisms. <i>J Neurosurg</i> . 1991;75:15-26.	523
66	Brem H, ... Mohr G, Muller P , et al. Placebo controlled trial of safety and efficacy of intraoperative controlled delivery by biodegradable polymers of chemotherapy for recurrent gliomas. <i>Lancet</i> . 1995;345:1008-12.	500
72	Wiebe S, Blume WT, Girvin JP , et al. A randomized, controlled trial of surgery for temporal-lobe epilepsy. <i>N Engl J Med</i> . 2001;345:311-18.	479
99	Lozano AM , et al. Effect of GPi pallidotomy on motor function in Parkinson's Disease. <i>Lancet</i> . 1995;346:1383-7.	418
102	Drake CG . Report of World Federation of Neurological Surgeons committee on a universal subarachnoid grading scale. <i>J Neurosurg</i> . 1988;68:985-6.	410

*Ponce FA, Lozano AM. Highly cited works in neurosurgery. Part II: the citation classic. *J Neurosurg*. 2010;112(2):233-46.

Table 11: Some Canadian neurosurgeons who have written more than 35 papers or books that have been cited more than 35 times* #

Author	No.cited >35	No. cited >50	No.cited>200	Max. citations
C.G. Drake	59	47	5	452
J.M. Drake	38	21	2	288
G.G. Ferguson	36	32	7	1346
M.G. Fehlings	59	34	3	713
H. Hoffman	58	49	1	288
R.P. Humphreys	54	41	2	288
A.M. Lozano	91	77	11	994
R.L. Macdonald	41	22	1	371
A. Olivier	55	40	7	448
W. Penfield	67	47	10	2585
J.T. Rutka	58	32	1	268
C. Tator	56	36	2	381
B.K.A. Weir	78	56	4	638

*The average *h* index for U.S. neurosurgical chairpersons was 25. The *h* is the number of papers published by an author that have received at least *h* citations. Thirty chairpersons were randomly selected. From: Lee J, Kraus KL, Couldwell WT. Use of the *h* index in neurosurgery. *J Neurosurg.* 2009;111:387-92. # Source. Google Scholar. April, 2010.

Keith 1962; A. and Elvidge 1964. The Canadian Neurosurgical Society branched off at the end of 1965, the first president was W. Stevenson 1966 followed by P. Lehmann 1968; W. Feindel 1969; C. Taylor 1970; M. Heon 1971; T. Morley 1972; K. Paine 1973; J. Stratford 1974; E. Hendrick 1975; G. Thompson 1976; J. Giroux 1977; W. Loughheed 1978; J. Fleming 1979; G. Bertrand 1980; P. Allen 1981; J. Hardy 1982; D. Heustis 1983; L. Ivan 1984; S. Schatz 1984; C. Tator 1985; F. LeBlanc 1986; I. Turnbull 1987; G. LeBlanc 1988; B. Weir 1989; A. Hudson 1990; A. Olivier 1991; H. Hoffman 1992; J-G. Villemure 1993; R. Holness 1994; J. Girvin 1995; N. Hill 1996; F. Maroun 1998; G. Ferguson 1999; G. Moulton 2000; B.Wheelock 2002; M. Hamilton 2004; D. Fewer 2006; J. Findlay 2008 and C. Wallace 2010.

There have always been strong bonds between American and Canadian neurosurgery. Archibald was a founding member of the American Board of Surgery. He was president of the American Surgical Association, the oldest and most prestigious surgical association in the USA. C. Drake would follow in his footsteps. Canadians who achieved the presidency of the American Association of Neurological Surgeons were F. Turnbull, McKenzie, Rasmussen, C. Drake⁷² and Rutka is now president-elect. The oldest neurosurgical organization, the Society of Neurological Surgeons, had Penfield, McKenzie and C. Drake as presidents. Penfield was President of the American Neurological Association. He and C. Drake were presidents of the Royal College of Physicians and Surgeons of Canada. C. Drake was also president of the American College of Surgeons and the World Federation of Neurosurgical Societies. C. Bertrand became president of La Société de Neurochirurgie de langue Française and the Neurosurgical Society of America.

Medical Manpower

The population per physician ratio in Canada fell from 857 in 1961 until it was 466 in 2005 (46% decrease), meanwhile the population of Canada grew from 18,238,300 to 32,422,920 (a

78% increase). More doctors are looking after fewer patients. Between 1970 and 1984 the number of MDs increased by 36%. Between 1961 and 1983 the number of public hospital beds fell from 1,058 per 100,000 to 703. Simultaneously the personnel/bed rose from 1.8 to 4. The average patient length of stay has fallen progressively over the past 50 years. A 2004 OECD report estimated that Canada had 2.3 doctors/100,000 persons (68,171 doctors). This ranked us 24th out of 28 industrialized countries. In 1970 with a ratio of 1.9/100,000 we had the second highest ratio of doctors to population. Only Korea, Mexico and Turkey of all the OECD countries now have fewer doctors relative to population. In 2005 Canada had 31,633 family doctors, 20,653 medical specialists and 7,866 surgeons. In 2005, 32.6% of Canadian doctors were 55 years or older. A study of the fall in physician supply between 1994 and 2000 identified the contribution of different factors as follows: decrease in medical school enrollment 11%, physician emigration 3%, longer postgraduate training 26%, decreased intake of international medical graduates 22%, changes in the rotating internship 21%, and increase in retirement rate 17%. This perfect storm of supply and demand mismatch was accelerated by: the increasing health care needs of an aging population, the ageing of the physician population with declining work load capacity, resistance of younger physicians to working long hours and being on constant call, an increasing proportion of female physicians who work fewer hours per day, fewer days per year and see fewer patients per day. No single body has the power to change things rapidly for the better; it takes about eight or nine years after high school to train a doctor currently. Control is hopelessly, widely diffused in different ways between the Federal and Provincial Governments, the Faculties of Medicine, the Medical Regulatory Bodies, the Health Care organizations (Hospitals), the College of Family Physicians, The Royal College of Physicians and Surgeons, The Medical Student and Resident Unions and the Canadian Medical Association (probably least of all). One of the ways we have tried to make-up for the short-fall in our own

trainees is to encourage immigration of international medical graduates. In 2007, 24% of our MDs got their medical degrees in other countries that needless to say cannot afford their exodus (1,213 from the Middle East, 3,256 from Africa, of whom 2,065 were South Africans, 2,632 from Asia of whom 430 were from Pakistan, 5,578 from Europe, mainly from the UK).

Among neurosurgeons there were 51 (22%) foreign medical graduates compared to 182 (78%) Canadian graduates in 2005. There were 12,040 Canadian educated physicians living in the USA in 2006. Canadian educated specialists practicing in the U.S. represented nearly 20% of the Canadian specialist work force. Each year from 1995-2004 an average 517 physicians who completed residency training in Canada left the country and only 273 returned. In 2004, for the first time this trend reversed, 262 left and 317 returned.

In 1978 Canada had 156 neurosurgeons for 23,444,200 people (about 1:150,000). The ratio of population to fee-for service neurosurgeons making more than \$60,000 gross in Canada in 2004/5 was 232,688:1 (213,149 in Quebec and 199,818 in Ontario). In 2005 in BC 32 neurosurgeons looked after 4,254,522 people (1:133,000).⁷³

The practice locations of 183 out of 189 neurosurgical graduates of Canadian programs between 1990 and 2002 were determined. Only 45% were practicing in Canada. In 2002 only six Canadian neurosurgeons practiced in cities with a population of less than 499,999.⁷⁴ In 2004 198 neurosurgeons were practicing in Canada giving a service ratio of .63/100,000 population (1/159,000). Ontario, Alberta and Quebec had the lowest neurosurgeon/population ratios, Ontario the lowest. Between 1993 and 2003 an average of 12.7 neurosurgical resident positions /year were matched, including foreign medical graduates with outside funding. Being trained were 14.6 residents/year, whereas only 6.5/year were required to maintain the existing work-force. Predicted upcoming annual retirement rates for neurosurgeons suggested 7.3 neurosurgeons/year would need to be replaced. In 1997 the American Board of Neurological Surgery announced it was going to phase out by 2002 its recognition of Canadian neurosurgical training to qualify for its examination, closed a major 'escape hatch'. The cry of overproduction was a striking reversal of the study of only five years before. No effective action was taken.

I have observed personally over the past 40 years strenuous efforts by well intentioned, and as well informed as possible, neurosurgeons attempting to predict shortages or gluts in the number of neurosurgeons being trained.⁷⁵ These were never, at least to date, very helpful or accurate because the system is chaotic, medical students, residents and practitioners have access to financial data and can read, scientific advances are not predictable, rational human beings will seek out optimal work environments, work habits change and we do not control manpower production or needs south of the border. Because of the many years of training, rapid adjustments are impossible. With rigid control of hospital beds, operating room access and positions now in the hands of others, excess production may now be a painful new development in Canadian neurosurgical history.⁷⁶⁻⁷⁸ There is a ray of hope in the looming shortage of specialists in the United States.⁷⁹

The Work and Health of Neurosurgeons

"I have seen a badly wounded brain heal." Galen

The emotional trauma of practicing neurosurgery in the early years was probably greater than now, given the inadequacy of diagnostic methods, the primitive state of therapy and the high operative mortality. *"The good Lord sends the general surgeon an occasional bad case to keep him humble, he sends the neurosurgeon an occasional good case to keep him sane."* Howard Hepburn.⁷ The behavior of some of the fathers of our specialty has suggested the likelihood of reactive depressive disorders. Suicide was not unknown. However, considering that many of the earliest generation were 'smokers' the average longevity of neurosurgeons indicates that a high-stress work life is not incompatible with a long existence (or that the leaders had good genes).

In the halcyon days before Medicare, my recollection is that patients would almost never wait more than a week or two to see neurosurgeons and access to operating rooms was equally prompt. In the 1960s and 1970s we were still in the era of 'woodpecker' surgery. Comatose patients would be assessed using plain skull x-rays that might show fractures, free air around the brain or a shift if the pineal gland were calcified. These features were very non-specific and could be misleading; so more often than we wished we were up in the middle of the night, sticking needles in the carotid arteries in the neck to inject dyes in order to visualize the patterns of the brain's blood vessels; or making multiple trephinations, looking for removable blood clots but often coming across only swollen brain that bulged out every incision we made. The crucial test of a neurosurgeon's mettle was to be able to get out of bed at 2 a.m. and drive through a blizzard to examine a drunk with a head injury.

In 1976-1977 the neurosurgical workload in Ontario was 9,043 including 751 brain tumours, 386 endarterectomies, 305 aneurysms and 79 pituitary tumours, excluding workers compensation (WCB) and out-of-province cases. In a six month period in 1977, 48 Ontario surgeons averaged 7 gliomas each, 31 - 2 non-gliomas, 38 - 4 aneurysms, 28 - 6 carotid endarterectomies, 20 - 2.4 pituitaries, 14 - 2 AVMs, 3 - 1.3 intramedullary tumours and 1 - 1 spinal AVM. In 1977 Ontario neurosurgeons performed 508 lumbar discectomies and 389 cervical discectomies (again excluding WCB cases). The percentage of lumbar discs being done by neurosurgeons had fallen between 1974 and 1977 from 27.2% to 18.3%, for cervical discs it held steady at 60%.⁸⁰ In 2005 in BC, 5,717 operations, including 1,333 craniotomies were performed. The average neurosurgeon did 178 operations including 42 craniotomies. A group of neurosurgeons in private practice averaged 212 operations each. If the number of aneurysms clipped over three years was averaged it would have been about seven per year per neurosurgeon in that group. The work load of Dalhousie's ten neurosurgeons is probably representative of Canada's academic centers. In 2005-2006, 1300 operations were performed (mean 130 per neurosurgeon), the types in order of frequency: spine, 'other', craniotomy, functional, pediatric and vascular. Western Ontario's most recent web page states that nine neurosurgeons do more than 1600 operations per year (mean 178). Concern is being voiced that orthopedics may absorb spine cases and neurovascular radiologists vascular conditions. A survey of the 3614 neurosurgeons (750 respondents) in the USA in 2006

yielded estimates of only 51 lumbar discectomies and 15 supratentorial craniotomies per year per neurosurgeon!⁸¹

In Canada median patient waiting times in 1997 from General Practitioner referral to receiving any type of specialist treatment varied from 10.2 to 13.7 weeks. In 2006 the comparable figures were 14.9 to 31.9 weeks. The 2004 National Physicians Survey found that 24% of Canadian neurosurgeons would see urgent referrals in about a week, 39% stated that non-urgent cases would have to wait more than three months.⁷⁷ The 2007 National Physician survey of Canada found that all surgical specialists worked 53.8 hours/week, 73% took additional call time.

The hours of work of residents are now deliberately limited to less than 80/week by complex regulations adopted from the USA. The adage that influenced prior generations *"If training is hard, war is easy"* is now viewed as being profoundly, politically incorrect. While staff and senior surgical residents may still view the new strictures as adversely affecting the acquisition of neurosurgical skills many younger doctors are happy with their "life-style" improvement.⁸² The Canadian Resident's Union is aiming for a one in five call frequency and appears to be gloating over zero tolerance policies for intimidation.⁸³ I suspect these changes would cause some of our greatest neurosurgeons to turn in their graves. The resident never walked the halls who was not intimidated by Wilder Penfield. I doubt that too many contemporary graduates will say, as Stanley Schatz said about his chief *"Botterell was a hero to me. I admired him, I respected him. I feared him but I trusted him. Indeed, as I conclude this reminiscence of a "wonderful residency" with Dr. Harry Botterell I am obliged to say that I, personally, adored the man."*⁵⁴ Program Directors must now attest to the attitudes and moral standing of their trainees. They are required to role-model and teach the resident how to be a medical expert, communicator, scholar, collaborator, manager, professional and health advocate. One is surprised that military hero, community activist and religious leader are not included. Despite the genuine efforts to make neurosurgical training a joyful and stress-free experience about a third do not complete it.⁸⁴ As residents perform relatively less work, programs must hire hospitalists, 'moon-lighters' and self-financed foreign trainees to carry the workload. While not unique to Canada the pressure of same day admissions, the growth of sub-specializations and fellowships and the reduction in duty hours all threaten the quality of neurosurgical training despite the mountains of paper being shuffled between bureaucrats.

Proving that hope springs eternal some Canadian neurosurgeons have played major administrative roles in their hospitals or other organizations: Turnbull (president of both the Canadian and the BC Medical Association), Weir (president of the Alberta Medical Association), Cochrane (BC Childrens Hospital), Myles (Alberta Childrens Hospital), Hudson (the Toronto Hospital), Allen (University of Alberta Hospitals), Girvin (University of Western Ontario Hospital) and Tucker (Canadian Medical Protective Association). Elgie (our only QC and FRCSC) became a minister in various Ontario cabinets. Phillipe Couillard served successfully as minister of health in Quebec. There are no neurosurgeons in Canada's parliament. Perhaps we can be reassured that there are currently four chiropractors.

Women in Neurosurgery

Females made up 29% of the Canadian medical work force in 2000; this is projected to reach 40% in 2015. In 2007, of the physicians under age 35, 53% were female and the trend is upward. Females make up the majority of medical students today. The number of first year female medical students outnumbered males for the first time in 1993/4. The number of women entering medical school increased 12 fold between 1958 and 2004. The number of men entering was less in 2004 than 1958. The number of female neurosurgeons in Canada in 2005 was 12 (5% of total) compared to 29 in cardiac and 198 in ophthalmology. In 2000, 20% of 100 neurosurgical trainees in Canada were women.⁷³

The first female to obtain the FRCSC was Jane Ann Johnson in 1972. She trained in Glasgow and practiced for a few years in Western Canada before leaving for the antipodes. The honour of being the first Canadian to train in Canada in neurosurgery and practice in this country for her entire career belongs to Betty McCrae, originally a Toronto neurologist, she is retiring this year after rendering distinguished service to the University of Calgary and the Foothills Hospital. She said *"There were obstacles but I chose to ignore them."* It is a safe prediction that the history of neurosurgery to be written in another few decades will see such women making substantial contributions.

The Economics of Neurosurgical Practice

"I regarded it as morally wrong that money in the bank, rather than severity of need, should determine who got what health care services." Tom Kent.

Partly because of the hold that this British born socialist speech writer had over the Prime Minister of Canada, Lester B. Pearson, Medicare was imposed on an indignant and unhappy medical profession.¹⁸ The sanctimonious politicians (Tommy Douglas and others) even while admitting that no patient was ever turned away from a doctor's office unable to pay, successfully portrayed their medical antagonists as mercenary in the public eye. The politicians were oblivious to the fact that a valuable commodity that is 'free' engenders an infinite demand. The costs of care have been borne not only by current taxation from general revenues but by taking on onerous debt that will be borne by future generations. Oblivious to that fact, the politicians of every stripe, basked in public approval for having given the population this great gift. *"Medicare is the most popular government program ever created."* Said Monique Bégin, Federal Minister of Health.

The Hospital Insurance and Diagnostic Services Act of 1957 introduced Federal funding to cover the costs of hospitalization for patients. In 1962 the doctors of Saskatchewan affronted by the holier than thou approach of the premier staged a 'strike'. They lost, he won. Thereafter Saskatchewan would have a relatively low percentage of doctors trained in Canada. The Medical Care Act of 1966 was an offer by the federal government to share half the costs of hospital and physician services. Federal contributions were made proportional to provincial ones so there was no incentive for the provinces to have user fees. The Canada Health Act affirmed public administration, comprehensive coverage of all medically necessary services, and universal coverage of all provincial

residents, portability and accessibility. The act laid down the rules for the transfer of health care monies from Ottawa to the Provinces. Initially the Federal Government paid the provinces 50 cents on the dollar but in subsequent difficult economic times the Federal Government reduced its percentage share of costs, the Provinces by then were hooked and had no way out. In 1977 the formula of shared costs was replaced by an arcane system of block funding and tax point transfers from the Federal government. The Federal contribution to publicly funded health services is now in the range of 15-30%. The hallmark of the Canadian system is that it is a 'Single-Payer' system in each Province.

Directly following the onset of socialized medicine in Canada, between 1966 and 1970, physicians incomes increased by 58% while the consumer price index increased by only 20%.¹⁸ As Aneurin Bevin boasted when he got British specialists to support the introduction of socialized medicine "*I stuffed their mouths with gold.*" The initial situation from the doctors' point of view was tolerable. This state of affairs would not last long. Ongoing warfare developed between Provincial paying agencies and professional associations over the fee schedules. Governments took to publishing annual gross payments to doctors without any explanation of the fact that doctors paid for their own employees, pensions, and other essential outlays. Between 1964 and 1984 the number of services per 1,000 beneficiaries of Medicare almost doubled, the number of laboratory tests almost tripled. Some doctors apparently bought into the concept that some things really are free. Various 'fixes' to a system spiraling out of control included community health organizations, value improvement and continuous quality improvement committees. They did not work.

In 1967 before Medicare, in net income nine Alberta neurosurgeons averaged \$40,538, the second highest of ten surgical groups. Medicare was introduced to Alberta in 1968. By 1970 ten Alberta neurosurgeons received average gross payments of \$55,428, the second lowest of ten surgical specialties.⁸⁵ In the 12 years (1996-1997 to 2007-2008) the average gross fee-for-service payment per neurosurgeon who received at least \$60,000 in Canada rose from \$251,415 to \$339,241 (a 35% increase). The rank among nine surgical specialties was sixth highest. Cardiac surgeons received 1.29 times the neurosurgeon's payment in both time periods and ophthalmologists made 1.31 times initially and 1.61 finally.⁷³

In 1984 the Canada Health Act was passed with support of all political parties, it banned 'extra-billing', which had never risen above 2.5% of payments. The Canada Health Act does not prevent the sale of insurance even for medically required services but six Provinces have done so. Private clinics are not specifically prohibited by Canada but may be in certain provinces. Health as a percentage of Gross National Product was 2% in 1940, and 9% in 1987. Between 1956 and 1971 health expenditures/capita increased at an average rate of 9.4%/year. By 1982, Canada had the fourth highest health care costs in the Western World. Health expenditures/capita in Canada in 1980 were under \$1,500, in 2002 they were \$3,671 and in 2008 \$5,200. Total health expenditures in 2007 were \$162 billion and \$172 billion the following year, a faster rise than rates for either population growth or inflation. Canada, between 2001 and 2006, had the fastest population growth of any G8 country, to 31.6

million. Although only 70% of Canadian health expenditures are from public sources this covers 99% of physician services and 90% of hospital care.

The reason why a majority of Canadians still think their Medicare system is a national treasure may be that they have not actually had to endure it. Causing patients to line up and wait months or years for medically indicated procedures amounts to making the system inaccessible or the proposed therapy unnecessary. Even the Supreme Court is beginning to see the light. The Federal politicians have turned a blind eye on the proliferation of private radiology clinics, particularly in Quebec. As the sense of entitlement has grown some patients and/or their families are now demanding to have the government (i.e. everyone) cover their costs of going to the 'best' doctors in the world, even if they are outside Canada.

In Canada we finance Medicare by general tax revenue at the Federal and Provincial levels. Some Provinces have imposed taxes known euphemistically as health premiums but they just go into general revenues as would any other tax.

Governments had to introduce more and more controls. Instead of acting only as the prime insurer they had to take over the micromanagement of a very complex system. Now they and their functionaries and economic advisers determine hospital budgets, negotiate reimbursement with doctors and related unions, decide terms of employment and conditions of work, and periodically try to dictate where doctors may practice. In their collective wisdom they also calculate how many doctors and nurses the system needs and therefore how many will be trained. They decide where hospitals will be built, their size and equipment. Ultimately they determine how long the queues will be for procedures, and which procedures will be selected as the favourites for 'wait time' reduction. The politicians at the pinnacle of these decision-making pyramids are in position for a few years only, virtually ensuring that expertise is not built up and that errors are repeated.

In 1970 there were 21 million potential patients with an average age of 26 years; in 2002 there were 31 million with an average age of 37 years. There has been a vast increase in medical knowledge, a corresponding gain in the complexity of medical technology and introduction of many new pharmaceuticals. Successive failed attempts by government to rein in costs have included reducing doctor numbers, reducing hospital bed numbers, reducing number of nurses trained, capping fees, banning extra-billing, restricting billing numbers for doctors, having nurse led clinics, limiting hospital bed access and available operating room time, introducing fixed global budgets for hospitals, attempting to introduce zero-base budgeting for hospitals who no longer knew what things cost, bringing in population-based funding, restricting access to the system by 'gatekeepers', having regional health 'authorities' force regionalization, 'rationalizing' care by forcing mergers of hospitals and allotment of tasks to them by fiat, expanding home care, reducing length of stay in hospitals, bringing in ambulance diversion schemes, encouraging hospital staff to do more with less, using quality assurance methods and constant improvement committees and imposing maximal sustainable utilization based on averages.⁸⁶ Have these Herculean measures worked to control costs? For 2007 health care spending was estimated to be over \$160 billion. For the 11th straight year health care spending

would outpace inflation and population growth. Public expenditure would be 71% and out-of-pocket private expenditure 29% of this total. Canadians now spend more on drugs than on doctors (16.8% versus 13.4%). The largest share of expenditures was on hospitals, about 28%. Since 1985, in billions of dollars spent, health spending has quadrupled! Doctors' percentage share of the pie has dropped significantly since the introduction of Medicare.

No matter how much patient care deteriorates in the public sector there are only few options available: travel to an American or other foreign facility, or seek help from alternative medical practitioners. Contrary to popular belief we have always had a "two-tier" system with Workers Compensation schemes favouring injured and sick workers. The wealthy have always been users of renowned Clinics to our south. Increasingly American facilities must be used by the Canadian public system when it becomes overloaded and is manifestly unable to cope with emergent cases. This is a one way street. Between April 2006 and February 2008 164 neurosurgical patients from Ontario were shipped to Michigan and New York State hospitals with broken necks, ruptured aneurysms and other cerebral emergencies despite the fact that there were Canadian neurosurgeons ready, willing and able to treat them.

Drivers for the cost of health care in Canada have included inflation, population growth and ageing. From 1980-1981 to 2000-2001 health expenditures in 1992 dollars on those over 65 increased 93.7% while as a proportion of the population their numbers increased only 33%. Expenditure for the entire population increased only 23% in that time. Only 13% of Canadians are over 65 years-of-age but such seniors consumed 45% of medical health expenditures in 2004. In that year per capita provincial expenditure was \$2,630 for all age groups, \$5,865 for 65 to 74-year-olds, \$10,342 for 75 to 84-year-olds and \$19,418 for those over 85 years-in-age. Between 1997-1998 and 2006-2007, government health spending increased on average 7.3% annually while provincial gross domestic product increased only 5.6%, raising concern that health spending would in the foreseeable future consume an unsustainable portion of provincial revenues.

In 2001/2 the proportion of physicians receiving at least half of their clinical incomes from alternative sources ranged from 1.5% in Alberta to 23.4% in Quebec. In every province the percentage of physicians in alternative funding schemes increased between 1995/6 and 2001/2. The dream of the early planners of Medicare - of having all doctors on salary - may be approaching reality. By 2000 only 43% of neurosurgeons were financially independent fee-for-service practitioners. In 2010, 13 Alberta neurosurgeons in one group, on an alternative payment plan, received net average payments of \$550,000 exclusive of out of province and Workers Compensation payments and on-call compensation. Neurosurgeons have never been on the bread line. Of course as salaried hirelings they are now almost totally at the mercy of their ministerial masters.

As judged by the ratio of 1st choice applicants to quota offered, the popularity of neurosurgery 1.1 (16 applicants for 15 slots) as a career choice in 2004, ranked well behind cardiac surgery (2.14), plastic surgery (3.18), ophthalmology (1.94), and urology (1.58). Dermatology at 2.83 was also high. Today's graduates are turning away from certain critical specialties

probably because they require prolonged, intense effort under difficult, unpleasant and unglamorous circumstances and the economic prospects are considered lacking.

As Medicare expenditures soared over the past dozen years each Province had at least one major study of health care (three each in Quebec and Alberta). All end up paying lip service to the sanctity of universal Medicare - all ignored the elephant in the room - that it was no longer affordable. Many provinces have gone into Brownian motion desperately trying to improve efficiency. Alberta recently junked the nine regional health boards it had created for this purpose in the early 1990s - Ontario reinvented its boards after having scrapped them in the late 1990s. Of the top 20 national health care systems, 17 are European and all have some combination of public/private financing.

New drugs and technologies are expensive and insistently demanded by patients and doctors. Ineffective, unscientific, alternative medical systems are flourishing. Entrenched special interests with a stranglehold on our broken system are battling creeping privatization as services decline. These groups now include significant numbers of doctors, usually younger. Some may wish to avoid the bother of justifying by their professional conduct the payment of a professional fee. Others feel they are occupying the moral high ground by supporting the ostensibly egalitarian system.

There is now much more intensive scrutiny of a doctor's practice and more arduous and stringent requirements to maintain and demonstrate continued competence. Many doctors sense that the public is demanding and ungrateful and feel they are perceived as being employees of their 'clients'. 'Burnout' is now a commonplace if not exactly honourable explanation of failure to perform.

The sometimes unbearable nature of the responsibilities borne by doctors, given the inevitability of error, is not generally appreciated... If medicine becomes de-professionalized, loses its direction in thickets of regulation born of bureaucratic distrust, and society loses sight of those very values that drove the profession to its present heights of achievement, mankind will lose a group of people who, hitherto, have been some of its most effective leaders in the battle against human suffering, frailty and vulnerability. It's as simple as that. Raymond Tallis.⁸⁷

Interestingly the discontents of our British and American colleagues are as evident as here, albeit for different reasons. We may be in the grip of societal trends more subtle than disbursement mechanisms.

The Dark Side

"Life is short, And the art long. The occasion instant. Experiment perilous. Decision Difficult." Hippocrates.

Few among us have been so fortunate or so gifted as to have avoided being accused of medical malpractice. The Canadian Medical Protective Association, a not-for-profit, mutual defense organization was founded in 1901 and incorporated in 1913. Ninety-five percent of Canadian physicians belong. In 2008, 884 new actions were brought; 354 plaintiffs were successful in court or received out of court settlement; 649 were successfully defended or dropped. New suits in 1996 had reached a high of 1,415. In 1995 average payout was \$181,281/case. By 2004 this

had risen to \$300,682/case. Once considered unethical, lawyers routinely take cases for a contingency fee, a 30% cut is common.

"All doctors who undertake the care of patients must expect to experience anxiety and disappointment but the surgeon's attentions are so direct, so personal and sometimes necessarily so hazardous that his anxieties are particularly acute, his disappointments singularly oppressive." Ian Aird.

Neurosurgeons are at risk since adverse events are so eloquent and catastrophic as well as being sometimes unavoidable. This is reflected in the annual dues, only Obstetricians have higher. The litigiousness of the region is probably a greater determinant than the quality of care. In 2010 Quebec neurosurgeons paid \$39,240, Ontario \$25,538 and the rest of the country \$16,584. Ontario obstetricians paid \$44,520. The unkindest cut of all is that doctors may now be sued if their patients suffer because of waiting for treatment.

Even the greatest amongst us have been known to fail. *"Dr. Dandy said 'My God, I went in on the wrong side!' He was completely crushed, tears streamed down his cheeks..."* Nurse for Dr. Dandy.⁸⁸

The Joys

Penfield had a hobby farm on a picturesque lake. McKenzie and Charles Drake greatly enjoyed golf and went for annual pheasant shoots on Pelee Island in Drake's plane. Outside the operating rooms and wards neurosurgeons of my acquaintance have found escape and solace in becoming yachtsmen, gourmet cooks, bird-watchers, artists, wilderness explorers, authors, world travelers, golfers, linguists, pilots, craftsmen, skiers, bird hunters, church elders, fishermen, photographers, scuba divers, amateur farmers, marathoners, medical historians, aircraft builders, connoisseurs, gardeners and collectors but like the rest of mankind they have generally had their moods most reliably sustained and raised by their spouses and children. The lives of neurosurgeons were sufficiently attractive (at least until the 1980s) that I. Turnbull, J. Drake, R. Bennet and G. Sutherland chose to follow in their fathers' footsteps.

CONCLUSIONS

The Rewards

"Thank God, I have done my duty." Horatio Nelson. At the Battle of Trafalgar, 1805.

The greatest professional reward for most neurosurgeons has been the gratitude of their patients, their students and fellow citizens. Wilder Penfield, Claude Bertrand, Charles Drake, Harry Botterell, William Feindel, Gilles Bertrand, Robert Elgie, Bryce Weir, Ronald Tasker, Charles Tator, Alan Hudson, Falah Maroun and Krishna Kumar were awarded the Order of Canada; Wilder Penfield the Order of Merit, the U.S. Medal of Freedom and 31 honorary degrees from universities. Harry Botterell and William Keith received the Order of the British Empire. Felix Durity gained the Order of British Columbia, Charles Drake the Order of Ontario and William Feindel and Jules Hardy the Order of Quebec. Charles Drake, William Feindel and Charles Tator were elected to the Canadian Medical Hall of Fame. The Medal of Honour of the World Federation was awarded to Jules Hardy.

Named chairs were established to honour neurosurgeons as follows: Frank LeBlanc (Calgary); Harold Hoffman, Charles Tator and Ronald Tasker (Toronto); Charles Drake (Western Ontario); Claude Bertrand (Université de Montreal); and William Cone (MNI-McGill).

The Grass Gold Medal for lifetime achievement in neurosurgical research of the Society of Neurological Surgeons has been awarded to Weir (1992), Richardson (1993), Tator (2002) and Rutka (2004). Academy Award winners of the American Academy included: Hill (1958); Tator (1963); Ferguson (1970); Nosko (1986); Rutka (1988) and Tymianski (1993). The Medal in Surgery of the Royal College of Surgeons of Canada was won by Allen (1958); O'Callaghan (1964); Little (1977); Lozano (1994); Fehlings (1996); Guha (1997); Tymianski (2003) and Dirks (2005). The Lifetime Achievement Award of the Canadian Neurosurgical Society went to Weir in 2006 and Tator in 2010.

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