History of neurosurgery at University of Toronto: the St. Michael’s story

Naif M. Alotaibi, MD,1,2 Daipayan Guha, MD,1,2 Christopher S. Ahuja, MD,1,2 Julian Spears, MD,1 Paul J. Muller, MD,1 William S. Tucker, MD,1 Alan R. Hudson, MB,1 and R. Loch Macdonald, MD, PhD1–3

1Division of Neurosurgery, Department of Surgery, and 2Institute of Medical Science, University of Toronto; and 3Division of Neurosurgery, St. Michael’s Hospital, Labatt Family Centre of Excellence in Brain Injury and Trauma Research, Keenan Research Centre for Biomedical Science, and the Li Ka Shing Knowledge Institute of St. Michael’s Hospital, Department of Surgery, University of Toronto, Ontario, Canada

In this paper, the authors describe the history of neurosurgery at St. Michael’s Hospital, University of Toronto. St. Michael’s has long been regarded as one of the top teaching and research hospitals in Canada. A detailed literature review of published and unpublished works was performed to formulate a succinct but in-depth review of its development, successes, and challenges. This fascinating 125-year history serves as a reminder of the importance of their institution’s origins, and the authors hope that it will be a useful guide for developing programs around the world.

https://thejns.org/doi/abs/10.3171/2016.9.JNS161119

KEY WORDS neurosurgery; history; St. Michael’s Hospital; University of Toronto

For more than 90 years, the Division of Neurosurgery at the University of Toronto has been training and educating neurosurgeons from all over the world.3 Currently, neurosurgery is an established specialty in 4 teaching hospitals affiliated with the University of Toronto (St. Michael’s Hospital, Sunnybrook Health Sciences Centre, Toronto Western Hospital, and the Hospital for Sick Children). Each hospital embraces a rich history of surgical expertise and provides diverse patient encounters for residents and fellows.15,25

In this report, we describe the history of neurosurgery at St. Michael’s Hospital and highlight the founders’ roles in restructuring the division. No physician was appointed at St. Michael’s Hospital unless he or she held a university position; thus, all appointments were joint hospital/university jobs, and promotion in academic rank was according to the university criteria. All significant leadership roles in the Department of Surgery are on 5-year appointments, which can be renewed once. This constant renewal and modernization of leadership is a key factor in the success of both the University of Toronto and St. Michael’s Hospital program. We hope that this historical perspective of our leadership and program can act as a guide for developing programs around the world.

Methods

We conducted a literature review using MEDLINE, Embase, Science Direct, and Google Scholar. We also searched St. Michael’s Hospital and City of Toronto archives to extract related published articles, books, and historical reports and pictures. To further verify the content, emeritus faculty from St. Michael’s Hospital reviewed the manuscript.

The St. Michael’s Story: the Sisters of St. Joseph

In the 19th century, an unanticipated influx of immigrants to Toronto generated a critical strain on public health and financial and educational resources. The streets
were laden with desperately poor and ill patients. Armand-François-Marie de Charbonnel, Bishop of Toronto (1850–1860), asked the Sisters of St. Joseph (a Roman Catholic religious congregation of women that originated in 1650 in France) to start working on instituting charitable hospitals, schools, boarding homes, and orphanages. In 1885, the Sisters created a boarding house for working women, Notre Dame des Anges, at 32 Bond Street. To address the further need for care of the poor in the south of Toronto, the Sisters founded St. Michael’s Hospital in 1892, with Mother de Chantal as its first superior (Fig. 1). It is thought that it was her idea to establish a hospital.

A strong supporter of the Sisters’ initiative was Robert J. Dwyer (Fig. 2). Dwyer graduated from the University of Toronto in the year that St. Michael’s was founded and was one of the few physicians at the time to hold membership in the Royal Colleges of Physicians of the United Kingdom. He became St. Michael’s first house surgeon, a role that he fulfilled passionately. Dwyer was well known for his exemplary clinical and teaching skills, as described in an obituary letter in the Canadian Journal of Medicine and Surgery in 1920: “The deceased was a great teacher … not only by reason of his gift of imparting knowledge, but for his ability to communicate his penetrative diagnostic acumen.”

On July 1, 1892, St. Michael’s Hospital opened its doors with only 26 beds, 6 physicians, and 4 nurses. Within a few years, a dedicated emergency department was created, and the hospital officially started accepting medical students for training. By 1912, St. Michael’s boasted a 300-bed capacity and 5 operating suites. An official reciprocal agreement with the faculty of medicine at the University of Toronto was penned in 1920, which endures today. St. Michael’s is currently the only Level 1 adult trauma center in downtown Toronto, with 463 acute adult inpatient beds, 20 operating rooms, and more than 1600 nurses (Fig. 3). Li Ka Shing Knowledge Institute of St. Michael’s opened in 2011 and forms the hub for leading researchers and educators at St. Michael’s.

The Early Years

There is evidence that neurosurgical procedures were being performed at St. Michael’s before the development of specialized neurosurgical services at the hospital and...
during the same time when Kenneth G. McKenzie (Canada's first neurosurgeon) was practicing and training residents at Toronto General Hospital. The earliest published neurosurgical work at St. Michael's dates back to 1938 when David Pratt published a case report on pineal tumor surgery. Pratt used an occipital-transventricular approach that, at the time, was used only by a few skilled neurosurgeons in the world. This report is credited as one of the first successful surgeries for pineal tumors in the world. Pratt also published his clinical experiences with brain abscesses and ventriculitis. 

Pratt graduated from the University of Toronto in 1926 and was a recipient of the Ellen Mickle Scholarship, which funded his studies in Freiburg, Germany. He joined St. Michael's surgical staff in 1927 and subsequently was certified by the Royal College and the American College of Surgeons. The surgeon-in-chief at the time, George Wilson, described Pratt (Fig. 4) in an annual report as someone who “always wears striped trousers, short coat, wing collar and bow-tie.”

It is unclear whether Pratt had any working relationship with McKenzie at that time or even where he learned his neurosurgical techniques. He was also not mentioned in any of the previous historical works on the history of neurosurgery in Toronto and Canada.

**The First Neurosurgeon at St. Michael's Hospital**

W. Keith Welsh graduated from the University of Toronto with honors in 1926 and trained under the mentorship of Norman Shenstone, one of the fathers of thoracic surgery in Canada. In 1947, he became chief of the Department of Surgery and began developing dedicated divisions for plastic surgery, orthopedic surgery, and neurosurgery. One of his achievements was assigning energetic young doctors to lead these divisions. In 1954, Welsh appointed William J. Horsey as the first head of the Division of Neurosurgery. Within a few years, Horsey was able to establish the first dedicated operating room for neurosurgery and a combined nursing unit for neurological and orthopedic patients.

Horsey was an outstanding student and received a scholarship to enroll in medical school at the University of Toronto. He graduated in 1944 with the Cody Silver Scholarship.
Medal and Chappell Prize for best surgical student. After he finished his surgical internship at St. Michael’s Hospital, he joined the Royal Canadian Army. After discharge in 1946, he worked in the Department of Anatomy at the University of Toronto as a teaching assistant, followed by a year of neurosurgical research at Johns Hopkins Hospital in Baltimore. Horsey returned to Toronto as a resident in neurosurgery under the direction of Harry Botterell, mentor to Toronto’s greatest neurosurgeons (William Lougheed, Ross Fleming, Ron Tasker, and Harold J. Hoffman). Horsey became the first of 6 chief residents under Botterell (Fig. 5).16,17

Horsey performed further training in neurosurgery across Europe, including Queen Square in London, England. In July 1954, he was chosen to be the first head of the Division of Neurosurgery at St. Michael’s Hospital in Toronto (Table 1). Most Canadian historians concur that he established that division to become a major neurosurgical center in Canada for clinical care and education. He was the only neurosurgical staff for 6 years, performing surgical cases (including aneurysm cases) with the aid of the operating room nurse Mary Allen and interns only. Mary Allen was Horsey’s right hand for many years. He built the service single-handedly until Stanley W. Schatz (second neurosurgeon at St. Michael’s Hospital) arrived in 1961 to take some of the surgical load. Both were very similar in their thinking and took teaching responsibilities seriously.

After the retirement of Keith Welsh, Horsey became surgeon-in-chief in 1968, and, at that point, almost everyone in the hospital knew him. He was available to residents and students as seen in one of the intern’s diary notes about him:26

Always available, he roamed the halls of the hospital smoking his pipe. He loved the emergency department and frequently would appear unannounced. A couple of suggestions and a little humor and he would be on his way. His rapier wit was subtle and funny but occasionally made the recipient feel more than a little foolish. He enjoyed a good party and no annual Christmas party would have been complete without him leading the entire assembly in a Gay Gordon.

Horsey was appointed full professor at the University of Toronto and was also appointed chairman of the medical advisory board at St. Michael’s Hospital, a position he held for many years. He was probably one of the first neurosurgeons to introduce the operating microscope for lumbar discectomy as well as the anterior approach to the cervical spine in Ontario or even Canada.17,21

After his retirement in 1989, Horsey was recognized for his major influences on clinical research with the establishment of the Horsey Prize for best resident research presentation given yearly at the Botterell lectureship at the University of Toronto (Supplementary Table 1). Horsey died in 2002.

The Hudson Years

Alan Hudson attended medical school in Cape Town, South Africa. After graduating in 1960, he joined Groote Schuur Hospital in Cape Town as a general surgery resident to Professor J. H. Louw, a pioneer in pediatric surgery for congenital small-bowel disorders.28 Hudson subsequently undertook research training under E. Bruce Hendrick in 1962 at the Hospital for Sick Children, assessing the epidemiology of traumatic brain injury in children.29

Interestingly, in 1964 Hudson applied to Toronto for further training in general surgery and was surprised that he was offered a training position in neurosurgery for which he never applied. Hudson started his neurosurgical training at St. Michael’s Hospital under the mentorship of Horsey and Schatz. During this time (1965–1968), the St. Michael’s Hospital resident was on call all year and responsible for all encephalograms, ventriculograms, and angiograms until the arrival of a specialized neuroradiologist (C. Gonzolves), who decreased the residents’ duties over these investigations. Every ward was headed by a nun in religious habit. The nuns were very supportive of the residents, with whom they shared the vocational focus of caring for the patients. There was no question that the nuns created the spirit at St. Michael’s Hospital, and all residents were welcomed, regardless of creed or color.

Hudson was awarded the McLaughlin Fellowship to pursue further training in peripheral nerve science with Professor G. Weddell at University of Oxford.32 He was then appointed as neurosurgery faculty at St. Michael’s in 1970 (Fig. 6). The 3 neurosurgeons (Hudson, Horsey, and Schatz) relied enormously on the nurses to monitor their critical patients on the mezzanine floor (4 M) while they were in the operating room. Consequently, they designed a large neurosurgical ICU in the center of the new ward.

TABLE 1. Heads of the Division of Neurosurgery at St. Michael’s Hospital (1954–2016)

<table>
<thead>
<tr>
<th>Year Appointed</th>
<th>Neurosurgeon</th>
</tr>
</thead>
<tbody>
<tr>
<td>1954</td>
<td>William J. Horsey</td>
</tr>
<tr>
<td>1977</td>
<td>Alan Hudson</td>
</tr>
<tr>
<td>1983</td>
<td>Paul Muller</td>
</tr>
<tr>
<td>1993</td>
<td>William Tucker</td>
</tr>
<tr>
<td>2000</td>
<td>Richard Moulton</td>
</tr>
<tr>
<td>2007</td>
<td>R. Loch Macdonald</td>
</tr>
<tr>
<td>2015</td>
<td>Julian Spears</td>
</tr>
</tbody>
</table>

FIG. 5. Portrait of W. J. Horsey, the first head of the Division of Neurosurgery at St. Michael’s Hospital (left) and a picture of him during his last operative spine case in 1989 (right). Copyright St. Michael’s Hospital Archives. Published with permission.
on Victoria Street to support nurses’ exchanges between ward and ICU at any time. Hudson became head of the Division of Neurosurgery in 1977. He established the first dedicated neurosurgical ICU and was able to increase the neurosurgery bed capacity to 41 beds. Furthermore, the neurosurgery service officially received approval for elective operating time. The division also fostered strong, collaborative relationships with leaders from the Divisions of Neurology (Henry Berry and Joseph Marotta) and Pathology (Juan M. Bilbao) and organized the first ever city-wide multidisciplinary brain tumor program.

Hudson was the first neurosurgeon to establish St. Michael’s and Toronto on the world stage as a center of excellence for peripheral nerve surgery and science. His laboratory had many distinguished visitors, including Sir Sydney Sunderland. Hudson is remembered by the Canadian media as the first surgeon in the world to have successfully performed a sciatic nerve allotransplant. He also became chairman of the Division of Neurosurgery at the University of Toronto and the first chairman who brought the annual meetings of the World Federation of Neurosurgical Societies, American Association of Neurological Surgeons, Congress of Neurological Surgeons, and Society of Neurological Surgeons to convene in Toronto. Following his term as chairman in 1989, Dr. Hudson was first appointed surgeon-in-chief, followed by appointments as president and chief executive officer of The Toronto Hospital. The institution expanded during his term to include the Toronto Western and Princess Margaret Hospitals and to become known as the University Health Network. The Alan and Susan Hudson Chair in Neuro-Oncology has been established at the University Health Network, as has the Hudson Teaching Award given annually at the William S. Keith Lectureship for the best resident and faculty teacher in the Division of Neurosurgery (Supplementary Table 2).

**Era of Subspecialization**

Stan Schatz decided to leave St. Michael’s Hospital in 1973 and spent the remainder of his career in Hamilton, Ontario. This led to the recruitment of William S. Tucker and Paul J. Muller, both graduates of the University of Toronto. They followed Alan Hudson and became division heads in 1983 (Muller) and 1993 (Tucker). Their main focus was initiating a neurosurgical subspecialty practice at St. Michael’s. They recruited faculty in neurotrauma (Richard Moulton), complex skull base and pituitary (Harley Smyth, Michael Cusimano), and spine (Richard Perrin) and strengthened the operative abilities of the division (Fig. 7, Supplementary Table 3). Muller focused on intrinsic brain tumors, while Tucker focused on complex aneurysms and carotid surgeries. It was the first time for significant diversification of experiences for residents at St. Michael’s.

Bill Tucker was also the first head of the trauma service and trauma team leader at St. Michael’s Hospital, a largely medical role that was present in only few centers in North America. Based on a 1984 annual hospital report, trauma at St. Michael’s was one of the busiest services in Ontario, with 151 admissions for polytrauma with injury severity scores greater than 16, and 61 cases that required craniotomy.

The development of a trauma and neurosurgery ICU combining the disciplines of neurosurgery, general surgery, and orthopedics into a cohesive unit was a very successful step of this era. From its early years in 1985, 1986, and 1987, the unit served 778, 828, and 846 neurosurgical patients, respectively. To this day, the trauma and neurosurgery ICU serves hundreds of critically ill patients every year.

**William S. Tucker**

Bill Tucker joined the neurosurgical faculty in 1977. He received his training in Toronto from 1969 to 1975. Following his Royal College certification in neurosurgery, he went to the University of Colorado for basic science research under the mentorship of Wolff M. Kirsch. Tucker served as the residency program director in Toronto for many years and also was Toronto’s site coordinator for major international studies that involved the natural history of intracranial aneurysms. He was also the first head of the trauma service and trauma team leader at St. Michael’s Hospital, a largely medical role that was present in only few centers in North America. Based on a 1984 annual hospital report, trauma at St. Michael’s was one of the busiest services in Ontario, with 151 admissions for polytrauma with injury severity scores greater than 16, and 61 cases that required craniotomy.

The development of a trauma and neurosurgery ICU combining the disciplines of neurosurgery, general surgery, and orthopedics into a cohesive unit was a very successful step of this era. From its early years in 1985, 1986, and 1987, the unit served 778, 828, and 846 neurosurgical patients, respectively. To this day, the trauma and neurosurgery ICU serves hundreds of critically ill patients every year.

**Era of Subspecialization**

Stan Schatz decided to leave St. Michael’s Hospital in 1973 and spent the remainder of his career in Hamilton, Ontario. This led to the recruitment of William S. Tucker and Paul J. Muller, both graduates of the University of Toronto. They followed Alan Hudson and became division heads in 1983 (Muller) and 1993 (Tucker). Their main focus was initiating a neurosurgical subspecialty practice at St. Michael’s. They recruited faculty in neurotrauma (Richard Moulton), complex skull base and pituitary (Harley Smyth, Michael Cusimano), and spine (Richard Perrin) and strengthened the operative abilities of the division (Fig. 7, Supplementary Table 3). Muller focused on intrinsic brain tumors, while Tucker focused on complex aneurysms and carotid surgeries. It was the first time for significant diversification of experiences for residents at St. Michael’s.

Bill Tucker was also the first head of the trauma service and trauma team leader at St. Michael’s Hospital, a largely medical role that was present in only few centers in North America. Based on a 1984 annual hospital report, trauma at St. Michael’s was one of the busiest services in Ontario, with 151 admissions for polytrauma with injury severity scores greater than 16, and 61 cases that required craniotomy.

The development of a trauma and neurosurgery ICU combining the disciplines of neurosurgery, general surgery, and orthopedics into a cohesive unit was a very successful step of this era. From its early years in 1985, 1986, and 1987, the unit served 778, 828, and 846 neurosurgical patients, respectively. To this day, the trauma and neurosurgery ICU serves hundreds of critically ill patients every year.

**William S. Tucker**

Bill Tucker joined the neurosurgical faculty in 1977. He received his training in Toronto from 1969 to 1975. Following his Royal College certification in neurosurgery, he went to the University of Colorado for basic science research under the mentorship of Wolff M. Kirsch. Tucker served as the residency program director in Toronto for many years and also was Toronto’s site coordinator for major international studies that involved the natural history of intracranial aneurysms. He was also the first head of the trauma service and trauma team leader at St. Michael’s Hospital, a largely medical role that was present in only few centers in North America. Based on a 1984 annual hospital report, trauma at St. Michael’s was one of the busiest services in Ontario, with 151 admissions for polytrauma with injury severity scores greater than 16, and 61 cases that required craniotomy.
service at St. Michael's Hospital. He was appointed president of the Canadian Medical Protective Association from 2007 to 2010 and retired from St. Michael's Hospital and the University of Toronto in 2010 as professor emeritus.

Paul Muller

Paul Muller finished his undergraduate studies in Toronto and graduated from the Faculty of Medicine at the University of Toronto in 1969. Muller entered the neurosurgical training program in Toronto in 1970. Following his clinical training, he undertook graduate studies at the Institute of Medical Sciences in Toronto and received his master’s degree on the topic of experimental neurooncology; he was awarded the most prestigious Canadian neurosurgical award named the K. G. McKenzie Prize for basic neuroscience research. His research field was focused on photodynamic therapy for patients with malignant gliomas.56 Dr. Muller continued a very active and busy practice until his retirement in 2013. He is currently professor emeritus in the Department of Surgery at the University of Toronto.

Richard Moulton

Richard Moulton graduated from the medical school at University of Calgary in 1979. He then received his training in neurosurgery from 1979 to 1984. Because of his strong interest in neurotrauma, he went to the Medical College of Virginia to be trained under the supervision of Professor Anthony B. Marmarou.37 Moulton joined the neurosurgery staff at St. Michael’s in 1986. He also served as the next division head after Bill Tucker. Moulton further characterized the role of neurosurgery in brain injury management that inspired many residents and fellows to pursue careers in neurotrauma. In 2004, Dr. Moulton left St. Michael’s to become the chairman of neurosurgery at University of Ottawa, where he continues to work as a faculty member.

The Surgeon-Scientist Generation

R. Loch Macdonald was recruited in 2007 to become the next division head. In this period, neurosurgery at St. Michael’s underwent a reorganization of its clinical and basic science research into dedicated subdivisions, linking related teams of neurosurgeons, neurologists, interventional neuroradiologists, and intensivists into an integrated neuroscience research group. Macdonald and his faculty (Fig. 8, Supplementary Table 4) supported the infrastructural advancement of St. Michael’s by acquiring the latest operative and research technology including image guidance, endovascular devices, and laboratory equipment. He also continued the classic Horsey tradition of hosting neurosurgery rounds every week to highlight important educational points for residents, fellows, and medical students. The annual number of operative cases reached record highs during Macdonald’s term as division head.

The Division of Neurosurgery also became one of the world’s leading centers in aneurysmal subarachnoid hemorrhage (aSAH) treatment and research with the establishment of the new neurovascular center. The center includes a multidisciplinary team from radiology (Tom Marotta, Walter Montanera, Dipanka Sarma, and Aditya Bharatha) and neurosurgery (Julian Spears and R. Loch Macdonald). The team also established the first Acute Carotid Clinic in Canada (http://carotid.ca/) to allocate rapid detection and triaging of patients with symptomatic carotid stenosis. This collaborative team meets weekly in the Marotta Clinic, named in honor of Joe Marotta’s contributions in neurology and medicine at St. Michael’s Hospital, to discuss decisions on complex neurovascular conditions that require input from many areas. The division is currently the home for the world’s largest international aSAH data registry.29 In 2016, Jefferson Wilson was recruited as a neurosurgeon-scientist to join the current collaborative spine team from orthopedics (Henry Ahn) and neurosurgery (Howard Ginsberg).

R. Loch Macdonald

Loch Macdonald obtained his medical degree from the University of British Columbia, after which he completed a PhD program in experimental surgery at the University of Alberta in Edmonton under the mentorship of Bryce Weir.11 He subsequently undertook his neurosurgical training at the University of Toronto. Following a clinical fellowship in open vascular surgery in Toronto, he was recruited to the University of Chicago Medical Center in
1993 as an assistant professor. He directed the University of Chicago neurosurgery residency program from 2000 to 2003. In 2007, Macdonald was recruited to Toronto as head of neurosurgery at St. Michael’s Hospital, as well as full professor in the Department of Surgery at the University of Toronto. He held the Keenan Endowed Chair at St. Michael’s Hospital until 2016. His productive research program focuses on the basic mechanisms of vasospasm in subarachnoid hemorrhage, on which he is a world expert. He has published numerous clinical papers that studied risk factors and outcomes of aSAH and vasospasm and is highly active in maintaining the Subarachnoid Hemorrhage International Trialists (SAHIT) repository.

Academic and Educational Contributions of St. Michael’s

The University of Toronto and St. Michael’s Hospital have a lengthy record of distinction in Canadian research and education. One of the most important accomplishments was the division’s participation in the Arthur and Sonia Labatt Brain Tumor Research Centre project for identification of human brain tumor initiating cells, which led to a landmark paper in Nature. Horsey described the earliest surgical experience for early anterior operation in acute injuries of the cervical spine and a novel modified drill guide for anterior cervical fusion. Hudson published extensively in basic science research investigating the pathophysiology of peripheral nerve injury, regeneration, and allotransplantation. His laboratory graduated many prominent fellows with interests in peripheral nerve surgery and neurosurgery. Among these are Susan E. Mackinnon, a plastic surgeon who went on to a brilliant career in the United States and made significant contributions to women in surgery in North America; Abhijit “Ab” Guha, a Toronto-trained neurosurgeon and innovative brain tumor researcher (Dr. Guha died in 2011); and Fred Gentili, a world-renowned skull base surgeon at the Toronto Western Hospital.

In addition to his work as a site director for multiple large international vascular trials, Bill Tucker was the first Canadian neurosurgeon to show the value of reoperation large international vascular trials, Bill Tucker was the first at the Toronto Western Hospital.

All University of Toronto neurosurgical residents are part of the Gallie Program. The Gallie Program is an integrated residency program in the diverse specialties of surgery. At each hospital, the division head of neurosurgery directs that hospital’s neurosurgical unit and its related role in neurological education for fellows, residents, and students. Over the years, St. Michael’s division heads and faculty have influenced many residents and fellows in their surgical training. The division hosts 3 weekly grand rounds to discuss cases and clinical decisions in general neurosurgery, neurooncology, and cerebrovascular surgery. Furthermore, the division organizes city-wide rounds featuring prominent visiting professors from all over the world, including visits from Hans Peter Richter, Hanno Millesi, Giuseppe Lanzino, Henry Marsh, Christopher M. Wallace, and David G. Kline. Lastly, St. Michael’s Hospital provides 4 well-established fellowship programs in cerebrovascular (including endovascular), skull base, and spinal surgery, as well as surgical education.

The Future

The prospective objectives of the Division of Neurosurgery at St. Michael’s Hospital are to continue its world-leading care for patients and to sustain the high-quality research in aSAH, neurotrauma, brain tumors, clinical epidemiology, and clinical trials design. It is anticipated that, in 2019, the hospital will finish major redevelopment projects that will include new operating rooms with state-of-the-art medical imaging equipment.

Acknowledgments

We thank Ms. Teruko Kishibe, archivist, St. Michael’s Hospital Archives, for facilitating access to the archives of the Division of Neurosurgery. We dedicate this work to St. Michael’s neurosurgery nurses, nursing practitioners, and secretaries for their hard work in taking care of our patients for all the past years.

References


Disclosures
Dr. Macdonald reports that he receives grant support from the Physicians Services Incorporated Foundation, the Brain Aneurysm Foundation, the Canadian Institutes for Health Research, and the Heart and Stroke Foundation of Canada, and is chief scientific officer of Edge Therapeutics, Inc.

Author Contributions
Conception and design: Macdonald, Alotaibi. Acquisition of data: Alotaibi. Analysis and interpretation of data: Alotaibi, Guha. Drafting the article: Alotaibi, Guha, Ahuja, Tucker, Hudson. Critically revising the article: Macdonald, Spears, Muller, Tucker, Hudson. Reviewed submitted version of manuscript: all authors. Study supervision: Macdonald.

Supplemental Information
Online-Only Content
Supplemental material is available with the online version of the article.

Correspondence
R. Loch Macdonald, Division of Neurosurgery, St. Michael’s Hospital, University of Toronto, 30 Bond St., Toronto, ON M5B 1W8, Canada. email: macdonaldlo@smh.ca.