Boston children's hospital and the origin of pediatric neurosurgery

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Abstract The Department of Neurosurgery at Boston Children's Hospital (BCH) has had a rich and sustained tradition of excellence over the years. This review traces the history of neurosurgery at BCH and the seminal role the department has played in advancing the field of pediatric neurosurgery worldwide (Fig. 1).

Background

The Peter Bent Brigham Hospital (PBBH) opened its doors in 1913. Peter Bent Brigham, a self-made millionaire, restaurateur, railroad executive, and philanthropist, had left a \$1.3 million bequest to establish a hospital to provide care for the sick and indigent population of Suffolk County. The funds were not to be used for 25 years after his death, and ultimately went to the purchase of the Ebenezer Francis estate, which became the site not only of PBBH, but also Boston Children's Hospital (BCH) and Harvard Medical School (HMS), institutions that have maintained their close geographic and medical alliance to this day.

PBBH recruited Harvey Cushing, a young 44-year-old graduate of Yale College and HMS who was working at Johns Hopkins Hospital at the time, to be its inaugural Surgeon-in-Chief. Cushing was also named the Moseley Professor of Surgery at HMS. The opening of the Brigham was an historic event, and Cushing's friend and mentor from Hopkins, Sir William Osler, traveled to Boston to join him for the celebration.

Cushing had served his residency training at Hopkins under William Stewart Halsted and remained on the faculty

there, where he focused on surgery of the central nervous system and laid the foundation for the practice of neurological surgery as we know it today. By the time Cushing was 32 years old, he held the rank of Associate Professor of Surgery at Hopkins.

When Cushing came to PBBH in 1913, he began operating on children with neurosurgical disorders. The children would come from BCH over to PBBH where Cushing would carry out the surgery, and then be transferred back to BCH for their postoperative care. By 1926, Cushing had operated on over 1,000 brain tumor patients, and more than 150 of them were children under the age of 15. With great vision, he recognized the need for a dedicated service to care for children with surgical disorders of the nervous system.

Franc Douglas Ingraham and the origin of pediatric neurosurgery

In 1929, Cushing directed his disciple, Franc D. Ingraham, to begin a Department of Neurosurgery at BCH. Thus began the first pediatric neurosurgical service in the world.

Ingraham was a gifted technical surgeon and a shy, humble man. He was born in Minneapolis, Minnesota in 1898 and received his undergraduate training at Harvard, initially showing an interest in philosophy and music. He went on to graduate from HMS, where he had developed a fascination with surgery of the central nervous system. Ingraham served his surgical residency at PBBH, where he came under the influence of Cushing. After spending a year with Cushing, Ingraham went to Hopkins to work with Walter Dandy. Cushing, who himself had spent a year studying in Europe before joining the faculty at Hopkins, was a strong advocate for the "Wanderjahr", the precursor of today's traveling fellowship.

But Ingraham's trip to Baltimore was aborted early, because Dandy and Cushing were at odds and Dandy would not

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Fig. 1 (Figure 1 is also the cover illustration): Watercolor of the Hunnewell Building, Boston Children's Hospital, which opened in 1914 and still stands today. Artist: Mark Waitkus, commissioned by Boston Children's Hospital, 2006. Courtesy of the Archives Department, Boston Children's Hospital. *On the cover* (same illustration as Figure 1): Watercolor of the Hunnewell Building, Boston Children's Hospital, which opened in 1914 and still stands today. The Department of Neurosurgery is situated on the second floor of this building

allow Ingraham in the operating room. So Ingraham subsequently went to Oxford as a Brigham Traveling Fellow to work in the physiology laboratory of Sir Charles Sherrington. In Sherrington's lab, he collaborated with John Farquhar Fulton, who would later become the Sterling Professor of Physiology at Yale, Cushing's biographer and Ingraham's brother-in-law through marriage to Lucia Wheatland, the sister of Martha Wheatland, Ingraham's wife. Sherrington commented that Ingraham was the finest technical surgeon ever to work in his lab.

It was on his return to Boston from Oxford that Ingraham founded the neurosurgery service at BCH, which quickly gained respect nationally and internationally. Ingraham was able to attract an assembly of talented neurosurgeons to train with him, including Donald Matson, Eben Alexander, Edgar Bering, Robert McLaurin, Bruce Hendrick, John Shillito, Ernest Matthews, and Larry Page. Ingraham made substantial contributions to pediatric neurosurgery with publications on infantile subdural hematoma, craniosynostosis, hydrocephalus, spina bifida, and brain tumors. In 1954, he and his protégé, Donald Darrow Matson, published the *Neurosurgery of Infancy and Childhood*, which became the first pediatric neurosurgery textbook in the world.

Although he shunned the spotlight, Ingraham served in numerous leadership capacities throughout his career. From 1944 until his retirement in 1964, he was Chief of Neurosurgery at Children's and also Chief of the Adult Neurosurgical Service at PBBH. He was a charter member of the Harvey Cushing Society (later renamed the American Association of Neurological Surgeons) and served as its president from 1944–1946. He was a director of the American Board of Neurological Surgery and served on the Study Section of the

National Institute of Neurological Disorders and Blindness. He was a member of the editorial board of the *Journal of Neurosurgery* for 9 years.

On a personal note, Ingraham was an avid athlete who enjoyed figure skating, horseback riding, and tennis. He loved sailing and was often out at sea with family and friends, including the Nobel laureate John Enders. Ingraham frequently sailed with his neighbor, General George S. Patton, who served as commander of the Seventh United States Army and the Third United States Army in the European Theater during World War II.

Ingraham suffered from serious illness throughout his life. He developed severe bronchial asthma as a child and underwent a radical paranasal sinus exenteration in Baltimore in the early 1930s, just after beginning his academic career. Because of this illness, he subsequently did no academic work for 9 years. He also suffered from chronic recurrent back pain related to a gymnastics injury as an undergraduate at Harvard with an exacerbation years later when he fell off a horse. Ingraham suffered a serious myocardial infarction in 1962 and retired in 1964. He died of a second myocardial infarction in 1965 at the age of 67 years [1, 2].

The Matson years

Following Ingraham's death, Donald Matson took over as Neurosurgeon-in-Chief at PBBH and BCH.

Matson was born in 1913 in Fort Hamilton, NY, the youngest of four sons of an army colonel. He obtained an undergraduate degree from Cornell in 1935 and graduated from HMS in 1939. He chose to do his residency at PBBH and BCH in order to work with Ingraham. Matson's training was interrupted by World War II, and he joined the 4th Auxiliary Surgical Group in Europe. During the war, he worked as a neurosurgeon close to the front lines under the leadership of Brigadier General Elliott Cutler, who would ultimately succeed Cushing as surgeon-in-chief at PBBH. Before going off to war, Matson married Dorothy Everett, a psychiatric social worker, with his friend and colleague Eben Alexander attending as his best man. Matson returned to BCH as a research fellow and subsequently became Ingraham's partner. He was close to Ingraham personally and professionally, and became godfather to Ingraham's daughter, Alice Wheatland Ingraham.

Matson was a brilliant technical surgeon. He resected craniopharyngiomas in the era before the operating microscope. He perfected the lumbar-ureteral shunt for hydrocephalus, which entailed the removal of a kidney, and flawlessly performed his own nephrectomies. Like his mentor Ingraham, Matson was a member of the editorial board of the *Journal of Neurosurgery*, a director of the American Board of Neurological Surgery, and President of the American Association of Neurological Surgeons (AANS). Unfortunately, he was

unable to attend the AANS meeting of his presidency, which was held in Cleveland, Ohio in 1969, to commemorate the 100th anniversary of Harvey Cushing's birth. Matson had been stricken with the illness that would ultimately end his life, Creutzfeldt-Jacob Disease. He died in 1969 at the age of 56, surviving his mentor Ingraham by only four years. When Ingraham had died in 1965, Harvard established an endowed chair in his honor. After a three year review process, Harvard named Matson the inaugural Franc D. Ingraham Professor at HMS in 1968. Sadly, he only held that title for 1 year prior to his untimely death.

Transition years

Following Matson's death in 1969, John Shillito became the Acting Chief of Neurosurgery at PBBH and BCH. Born in Cincinnati, Ohio in 1922, Shillito was a graduate of Harvard College and HMS. He joined the faculty of PBBH and BCH to work with Ingraham and Matson. Shillito made pivotal contributions to pediatric cerebrovascular disease and craniosynostosis. With Matson, he collaborated on *An Atlas of Pediatric Neurosurgical Operations*, which was published in 1982, 13 years after Matson's death. The illustrations for the book were done by the artist Mildred Coddington, who had formerly worked with Cushing. Shillito stepped down as acting chief in 1971, but remained a member of the faculty until his retirement in 1995. He is remembered by his former residents for his emphasis on both technical expertise and professionalism in neurosurgical training. His numerous leadership roles include President of the Congress of Neurological Surgeons, President of the Society of Neurological Surgeons, Vice President of the Neurosurgical Society of America, and a Director of the American Board of Neurological Surgery. In retirement, Shillito moved to Pittsboro, North Carolina with his wife of 55 years, Bunny Hubbard, where he continued to explore his lifelong interest in photography. He died in 2012 at the age of 89.

The modern era

In 1971, W. Keasley Welch was recruited from Denver, Colorado to become the second Franc D. Ingraham Professor of Neurosurgery at HMS and chief of the services at Brigham and Children's. Born in Bridgeport, Connecticut in 1920, Welch did his undergraduate work at the University of Pittsburgh and earned his medical degree at Yale. His medical school training became complicated when he contracted pulmonary tuberculosis, necessitating hospitalization for a period of 6 months. He went on to do his residency at the Montreal Neurological Institute (MNI) under the direction of William V. Cone and Wilder Penfield. When Welch scrubbed on his first surgical case at the MNI, he was taught how to gown and

glove by the OR Supervisor, Elizabeth MacRae, who subsequently became his wife.

Welch had a lifelong interest in the physiology of cerebrospinal fluid, and was on sabbatical working with Hugh Davson at the University College, London when he was recruited to lead the group at Harvard. He continued his interest in hydrocephalus in Boston and published *The Physiology and Pathophysiology of Cerebrospinal Fluid* with Davson in 1987. Welch expanded the neurosurgery service at Children's, adding Ken Winston, Garry Fischer, and Larry Page to the faculty. He was plagued by emphysema and poor health and retired as Chief of Neurosurgery in 1985. He died in 1996 at the age of 75.

In 1987, Peter M. Black became Neurosurgeon-in-Chief at Brigham and Women's Hospital (BWH) and BCH. The name BWH originated in 1980 as the result of a merger of three HMS teaching hospitals: PBBH, the Robert Breck Brigham Hospital, and the Boston Hospital for Women. Black was also named the third Franc D. Ingraham Professor of Neurosurgery at HMS. He was born in Canada, did his undergraduate training at Harvard, and earned his medical degree from McGill and a subsequent doctorate in philosophy from Georgetown. After completing residency training at

Table 1 John Shillito fellows at Boston children's hospital

Year	Name	Current Position
1991	Benjamin Warf	BCH
1992	Mark Luciano	Cleveland Clinic
1993	David Adelson	Phoenix Children's Hospital
1994	Faith Barnett	Scripps Clinic
1995	David Frim	University of Chicago
1996	Michael Medlock	North Shore Children's Hospital
1997	Mark Proctor	BCH
1998	Jeffrey Campbell	Dupont-Nemours Children's Hospital
1999	Jodi Smith	University of Indiana
2000	David Sacco	Southwestern University
2001	Michael McCue	University of Minnesota
2002	Ethan Bernardete	Thomas Jefferson Neurosciences Center
2003	Edward Smith	BCH
2004	Cormac Maher	University of Michigan
2005	Paul Klimo	LeBonheur Children's Hospital
2006	Edward Ahn	Johns Hopkins University
2007	Ron Grondin	Tacoma Children's Hospital
2008	Suresh Magge	Children's National Medical Center
2009	Eric Jackson	Johns Hopkins University
2010	Lance Governale	Ohio State University
2011	Lissa Baird	Oregon Health Services University
2012	Sarah Jernigan	University of Miami
2013	Scellig Stone	BCH
2014	Kristopher Kahle	BCH Fellow

Massachusetts General Hospital (MGH) and serving on the faculty there, he succeeded Welch at BWH and Children's, having previously spent a fellowship year in hydrocephalus and physiology with Welch and Antonio V. Lorenzo. Black's research focus was on brain tumors and his clinical expertise was in pediatric and adult brain tumors, image-guided surgery, epilepsy, and hydrocephalus. He chaired the editorial board of *Neurosurgery* and served as President of the World Federation of Neurosurgical Societies.

Under Black's leadership, the neurosurgery service at BCH continued to grow. He recruited R. Michael Scott from Tufts, Joseph R. Madsen from MGH, and Liliana C. Goumnerova from the Hospital for Sick Children. In 1994, the Brigham introduced the first intraoperative MRI scanner in the world. In 2005, BCH introduced the world's first intraoperative MRI scanner in a children's hospital.

In 2004, the adult and children's services split and R. Michael Scott became Neurosurgeon-in-Chief at BCH. The following year Scott was awarded the Fellows Family Chair in Pediatric Neurosurgery. Black stepped down as chief at BCH in 2004 and as chief at BWH in 2007, where he was succeeded by Arthur L. Day [3].

Scott had done his undergraduate training at Williams and earned his medical degree from Temple, the institution where his father, Michael Scott, served as chairman of the department of neurosurgery for more than three decades. Scott completed his residency at MGH and was recruited from Tufts, where he worked for 15 years, to run the pediatric neurosurgery service at BCH. He established a pediatric neurosurgery training program and an endowed fellowship, named in honor of John Shillito, that has attracted applicants from around the country. The Shillito Fellows have gone on to leadership positions across the country (Table 1). BCH continues to have close ties with BWH and the two institutions have a shared residency program.

Scott is known internationally for his work in pediatric cerebrovascular disease, brain tumors, and congenital malformations. He recruited three former Shillito Fellows to join the faculty: Benjamin C. Warf, Mark R. Proctor, and Edward R. Smith. During his tenure, Scott served in numerous leadership roles including chair of the AANS/CNS Joint Section on Pediatric Neurosurgery, president of the American Society of Pediatric Neurosurgeons, director of both the American Board of Neurosurgery and the American Board of Pediatric Neurosurgery, and chairman of the Accreditation Council of Pediatric Neurosurgery Fellowships. For years he has played keyboard for the Neurosurgical Jazz Quintet. His wife Susan is a former operating room nurse at Tufts.

In 2011, Al Cohen was recruited from Rainbow Babies and Children's Hospital/Case Western Reserve University, to follow Scott as Neurosurgeon-in-Chief at BCH. Cohen became the fourth Franc D. Ingraham Professor of Neurosurgery at HMS. His areas of interest are minimally invasive

neurosurgery and pediatric brain tumors. Cohen began a Minimally Invasive Neurosurgery Laboratory and research fellowship, and recruited another former Shillito fellow, Scellig Stone, to join the group, bringing the number of pediatric neurosurgeons on the faculty to nine, the largest pediatric neurosurgery service in the world. In 2013, BCH united with MGH, BWH, and Beth Israel Deaconess Hospital to form an academic Department of Neurosurgery at HMS.

At BCH, each faculty member has a specialized area of clinical and research expertise. Scott, neurosurgeon-in-chief emeritus, created a world-class cerebrovascular program. Smith, his disciple, is director of cerebrovascular disease. Madsen, who holds the Endowed Webster Chair in Neuroengineering, is director of epilepsy surgery. Goumnerova is director of neurosurgical oncology at BCH and the Dana Farber Cancer Institute. Proctor is vice chair of the department and director of the spine, trauma, and craniofacial services. Warf, who holds the Endowed Chair in Hydrocephalus and Spina Bifida, is director of neonatal and congenital neurosurgery. In 2007, Warf received the Humanitarian Award from the American Association of Neurological Surgeons and in 2012 he was awarded a John D. and Catherine T. MacArthur Fellowship for his contributions to international neurosurgery. Shenandoah Robinson is director of functional neurosurgery and runs the spasticity program. Scellig Stone, the newest member of the department, was recruited from Toronto to develop a pediatric deep brain stimulation/movement disorders program. Larry Benowitz, PhD is internationally-recognized for his work on optic nerve and spinal cord regeneration and serves as director of the neurosurgical laboratories.

Moving forward, the Department of Neurosurgery at BCH hopes to continue its tradition of excellence by attracting the best and brightest students, nurses, residents, fellows, researchers, and observers from around the globe. Together, our aim is to help chart a course for the future of pediatric neurosurgery and ultimately, to improve the care of children with surgical disorders of the nervous system.

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