Franc D. Ingraham and the genesis of pediatric neurosurgery

Historical vignette

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In 1929, Franc D. Ingraham, Harvey Cushing’s protégé, established the first pediatric neurosurgical unit in the world at Boston Children’s Hospital and dedicated his career to the neurological care of children. He trained with both Cushing and Dandy and spent 1 year working in Oxford with Sherrington, who considered Ingraham to be the finest operative surgeon ever to work in his laboratory. Ingraham was instrumental in developing novel treatments, which he compiled in his classic book, *Neurosurgery of Infancy and Childhood*. Although he was modest and shy, Ingraham loved to entertain children with magic and enjoyed photography in and out of the operating room. Unfortunately, his career was plagued by personal illness, and he died young in 1965 at the age of 67. Despite his prolific 36-year neurosurgical career, Ingraham remained an associate professor at Harvard at his retirement. To recognize his remarkable contributions, Harvard established an endowed chair in his name in 1967. Ingraham was a pioneer and a leader in the development of pediatric neurosurgery by virtue of his imagination, intelligence, and ability to lead and inspire others. Cushing has come to be regarded as the founder of neurosurgery. It is fair to conclude that Ingraham, his disciple, is the founder of pediatric neurosurgery.

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**KEY WORDS** • Franc D. Ingraham • history • pediatric neurosurgery • Boston Children’s Hospital • Harvard Medical School

**NEUROSURGERY** was practiced sporadically in children from prehistoric times until the early 20th century. In 1913, Harvey Cushing arrived at the newly opened Peter Bent Brigham Hospital (PBBH) as its inaugural surgeon-in-chief. He began operating on children with various neurological disorders, performing the surgery at PBBH and then transferring the patients back to Boston Children’s Hospital (BCH) for postoperative care. Prior to Cushing’s arrival, general pediatric surgeons would operate occasionally on BCH patients for such conditions as myelomeningocele. By 1926, Cushing had operated on more than 150 brain tumors in children. In 1929, he recognized the need for a dedicated specialty of pediatric neurosurgery. He asked his disciple, Franc D. Ingraham, to begin a pediatric neurosurgery service at BCH (Fig. 1). Such was the origin of the first neurosurgical unit in the world dedicated to the care of children.

Pediatric neurosurgery was largely an unexplored specialty at the time. It was the era when the roentgenogram was the best available imaging modality, hemo-

Abbreviations used in this paper: BCH = Boston Children’s Hospital; PBBH = Peter Bent Brigham Hospital.
would not allow Ingraham near the operating room, and therefore, Ingraham returned to Boston early. He spent another 1 year with Cushing and then went to Oxford as a Brigham Traveling Fellow, where he worked in the physiology laboratories of Sir Charles Sherrington. There he also worked with John Fulton, who was later to become his brother-in-law through marriage into the Wheatland family of Boston. Sherrington was fond of Ingraham and considered him to be the finest operative surgeon ever to work in his laboratory.6,29,36

Ingraham started working as a pediatric neurosurgeon at BCH in 1929. He was instrumental in defining and developing various methods of surgical treatment for neurosurgical disease in the pediatric population, especially the classification and treatment of hydrocephalus, spina bifida and cranium bifidum, craniosynostosis, and brain tumors, including craniopharyngiomas. These experiences were compiled in his book, *Neurosurgery of Infancy and Childhood*, first published in 1954 (Fig. 3). Its second edition was written in 1969, solely by Donald Matson, who also coauthored the first edition.20,29,30 Ingraham constantly strived to devise new surgical techniques and refine old ones. He contributed to the neurosurgical literature with 45 different publications, ranging from animal experiments to large clinical series.

Ingraham recognized the importance of growth as a modifying influence in the approach to surgery of the central nervous system and stressed the importance of prophylactic surgical procedures. He could command complete confidence in patients, their relatives, and pediatricians with awe-inspiring brevity and convince all as to the benefits of preventive surgery. Even though the results may have been unimpressive at the time of execution, they were often extremely rewarding in the long run. Ingraham also believed that a neurosurgeon's task did not begin and end at the operating room door. Instead he felt that continuous care of children under one authority was superior to division of responsibility among several.29

In the early days of World War II, Elliott Cutler, surgeon-in-chief at PBBH, was taken away from the hospital for duties with civil defense. Ingraham then took over the care of the neurosurgical patients at the Brigham as well as at BCH. This proved a fortunate circumstance, as it led to the establishment of a combined neurosurgical service and specialty training program, which has continued to expand and develop ever since.29,36

Following the war, Ingraham directed the establishment of animal and laboratory facilities in the Carnegie building adjacent to BCH. First used by the neurosurgical service, these laboratories expanded to include the general surgical and orthopedic departments. They have been the site of many significant contributions in the succeeding years.29

Ingraham’s position of leadership and respect was called upon at BCH in the years 1945–1947, when he served as surgeon-in-chief in the interval between William Ladd’s retirement and the appointment of Robert...
Gross. For the next two decades, pediatric neurosurgery really began to flourish at BCH, while there was relatively little neurosurgical activity at the PBBH. In 1953, the service developed a residency program centered at BCH.

Ingraham’s Illnesses

Unfortunately, Ingraham’s career was plagued by personal illness. As a child he had recurrent bouts of bronchial asthma. His parents were devout Christian Scientists, so during childhood his only treatment was “steam and prayer.” Asthma continued to plague him throughout his adult life. In the early 1930s he went to Baltimore to have a radical sinus exenteration, which left him anosmic. There were many occasions when he nearly died. Questions were raised as to whether he should try to pursue his career, but he persisted. At one point, shortly after they were married, Ingraham and his wife, Martha, even moved to Arizona because of his chronic health problems. It was only after the availability of penicillin and corticosteroids that he was able to resume his normal pace of activity.

Ingraham fractured his spine in a gymnastics injury when he was a Harvard undergraduate. An accomplished equestrian, he later reinjured his back in a fall from a horse and was plagued by chronic back pain as an adult. He became an avid ice skater. According to his daughter Alice, one reason for this is that skating helped make his back feel better (A. W. Ingraham, personal communication, 2012). He became an accomplished skater and would often leave the Children’s Hospital with his skates in his briefcase to spend his lunch break at the Boston Skating Club, according to Claire McCarthy from the Department of Physical Therapy at BCH.

Ingraham retired on August 31, 1964, as associate professor of surgery, emeritus, in the Faculty of Medicine at Harvard. He had angina as an adult and died of a myocardial infarction at his home in Brookline on December 4, 1965, at the age of 67, in his second year of retirement.

Academic Accomplishments

In 1929, Ingraham published 3 papers describing animal experiments studying emotional disturbance after section of the corticohypothalamic tract, the regeneration response of the sympathetic trunk to injury, and the effects of cervical sympathetic trunk stimulation to cerebral angiospasm. He did no academic work for the next 9 years because of recurrent respiratory problems. Then in 1938, Ingraham began a reinvigorated career with an article presenting 16 cases of intraspinal tumors in infancy and childhood.

In 1939, Ingraham and Henry Heyl reported 11 cases of infantile subdural hematoma. Many of these patients had bilateral subdural hematomas and retinal hemorrhages. Ingraham and Heyl effectively disputed nutritional and infectious causes as the prime etiological factor in these cases. Later, Ingraham and Matson coauthored “Subdural hematoma in infancy,” detailing their experience with 98 more cases. Their earlier statement “the frequency with which subdural hematoma is found in infancy is proportional to the intensity with which it
is sought” was confirmed. Whereas the treatment was fundamentally a neurosurgical problem, suspicion of the diagnosis rested primarily with the pediatrician and the general practitioner. Ingraham also demonstrated salutary results after evacuation of extradural hematomas.17

During World War II, while he had taken over the care of neurosurgical patients at PBBH, Ingraham worked with Edwin J. Cohn and other members of the Department of Physical Chemistry at Harvard Medical School on the development and application of fibrin foam, a porous mass of fibrillar fibrin. Fibrin foam, which was a by-product of the blood fractionation program carried out at Harvard under a US Navy contract, proved of inestimable value, not only in treating war casualties but also in surgery of all types, including neurosurgery.29 Fibrin film became a valuable dural substitute and proved effective in the prevention of meningocerebral adhesions.2,4,14 It even proved superior to muscle, introduced as a hemostatic agent by Cushing in 1911. Fibrin foam became an excellent hemostatic agent when moistened with a solution of human thrombin13,14,16 and was a precursor to gelatin foam, a hemostatic agent now used by neurological surgeons throughout the world. Harvard's fibrin foam was held as one of war's greatest finds.29

In 1943, Ingraham published the first of a series of 5 articles on “Spina bifida and cranium bifidum,” reporting a total of 546 cases, including 279 involving patients with myelomeningocele. Nearly half of the patients with spina bifida were treated surgically, and the immediate operative mortality was 12%. Ingraham argued that one-third of these patients could expect a relatively “normal” life. An unduly pessimistic prognosis was therefore unwarranted until individual evaluation had been carefully pursued.27 Ingraham also operated on children with diastematomyelia, and after brief follow-up observations, he was convinced that it was beneficial to carry out surgery during infancy and early childhood whenever the diagnosis was made.31

In 1948, Ingraham and coworkers described 50 patients with craniosynostosis, 44 of whom were treated surgically. Only half of these patients were less than 1 year old.11 The mortality for surgical treatment of craniosynostosis in infants was negligible when proper supportive measures were provided. Earlier Ingraham had performed animal experiments with interposition of various foreign materials to delay the closure of surgically created artificial sutures. He used fibrin film, oxidized cellulose gauze, tantalum, methyl methacrylate, and polyethylene, concluding that the latter was more inert and effective.22 In 1954, Ingraham and Matson identified aesthetic benefits as an indication for surgery, thus marking the introduction of the modern era of craniofacial surgery.28,29

In 1952, Ingraham and colleagues24 published the first account of the use of adrenocorticotropic hormone and cortisone as adjuncts to surgical treatment of craniofibromygioma following their initial use in pituitary tumor surgery by Roche in 1950.30 This helped reduce postoperative hypothalamic crises, thus making recovery smoother. This early experience foretold the current general use of adrenal corticosteroids to minimize the cerebral swelling that complicates many intracranial operations.39

The management of hydrocephalus has always presented a challenge for neurosurgeons. Ingraham performed experimental studies on cats, dogs, and Rhesus monkeys to elucidate CSF circulation. He also described methods to induce experimental hydrocephalus.12,15 Due to unsatisfactory results from ventriculo-ureterostomy and ventriculo-peritoneostomy, Ingraham continued his search for a more favorable site for CSF diversion. Ventriculo-thoracostomy (into the pleural space) and ventriculo-lymphangiostomy (into the thoracic duct) were performed after initial failure of attempts to divert CSF into the venous system. Ingraham's results were not promising, though CSF diversion to the pleural space seemed better than to the thoracic duct.23,26

Ingraham's contribution to the management of brain tumors is marked by multiple clinical series; 56 cases of medulloblastoma cerebelli,15 16 cases of craniopharyngioma,25 and 15 cases of cystic teratoma and teratoid tumor.13 Additional reports included cases of fibrosarcoma of the dura mater and blood vessel hyperplasia masking glioblastoma multiforme.8

Academic and Nonacademic Appointments

Ingraham received numerous accolades and served in many honorary positions of national importance before his death at the age of 67. From 1941 to 1946, he was treasurer of the Harvard Medical School Alumni Association. He served on the executive committee of the Board of Trustees of the Countway Library of Medicine (Fig. 4). His hospital appointments, in addition to that of neurosurgeon-in-chief at BCH, included attending neurosurgeon at PBBH and consulting neurosurgeon at many additional hospitals, particularly Beverly Hospital, near his summer home in Manchester, Massachusetts. He served for 6 years as a member of the American Board of Neurological Surgery. He was on the Study Section of the National Institute of Nervous Diseases and Blindness.
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He was a member of the editorial board of the Journal of Neurosurgery. From 1944 to 1946, Ingraham was president of the Harvey Cushing Society, which would later become the American Association of Neurological Surgeons. He was active in numerous other professional societies in neurosurgery, surgery, neurology, and pediatrics. His local esteem was recognized by a term as president of the Boston Surgical Society. Ingraham was also a respected member of the Society of British Neurological Surgeons and the Scandinavian Neurosurgical Society. He had many professional friends abroad. Both Sir Hugh Cairns of Oxford and Professor Jean Morelle of Louvain referred to Ingraham as “best friend.”

Professional Relationships

Ingraham had tremendous respect for Cushing and considered him a great teacher. Ingraham’s daughter Alice recalls that her father always spoke of Cushing with awe and admiration. Similarly, Ingraham had a warm relationship with Matson both personally and professionally. Matson was godfather for Ingraham’s daughter, Alice, and was always a kind friend to both Alice and her brother Timothy (A. W. Ingraham, personal communication, 2012).

There is a long list of residents and visiting fellows who trained under Ingraham as a part of the combined neurosurgery program of BCH and PBH (Table 1). Many of his disciples became legendary neurosurgeons.29,33,36

Henry Heyl, who worked with Ingraham, later went on to become editor-in-chief of the Journal of Neurosurgery.

TABLE 1: Alumni of the combined BCH-PBH neurosurgery program, 1939–1964

<table>
<thead>
<tr>
<th>Name</th>
<th>Year(s) of Residency or Fellowship</th>
</tr>
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<tbody>
<tr>
<td>Eben Alexander Jr., M.D.</td>
<td>1939–1942</td>
</tr>
<tr>
<td>Albert Farley, M.D.</td>
<td>1949–1950</td>
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<tr>
<td>Edgar A. Bering, M.D.</td>
<td>1949–1952</td>
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<tr>
<td>Anthony Susen, M.D.</td>
<td>1949–1953</td>
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<tr>
<td>Robert L. McLaurin, M.D.</td>
<td>1950–1951</td>
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<td>E. Bruce Hendrick, M.D.</td>
<td>1953–1954</td>
</tr>
<tr>
<td>Hal Tucker, M.D.</td>
<td>1954–1955</td>
</tr>
<tr>
<td>Fred D. Fowler, M.D.</td>
<td>1955–1956</td>
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<tr>
<td>John Shillito Jr., M.D.</td>
<td>1955–1957</td>
</tr>
<tr>
<td>Ernest S. Matthews, M.D.</td>
<td>1956–1959</td>
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<tr>
<td>Walter C. Cotter, M.D.</td>
<td>1957–1958</td>
</tr>
<tr>
<td>Francis X. Rockett, M.D.</td>
<td>1960–1964</td>
</tr>
<tr>
<td>August W. Geise, M.D.</td>
<td>1961</td>
</tr>
<tr>
<td>David L. Kelly, M.D.</td>
<td>1962–1963</td>
</tr>
<tr>
<td>Erich S. Wisiol, M.D.</td>
<td>1962–1963</td>
</tr>
<tr>
<td>Larry K. Page, M.D.</td>
<td>1962–1966</td>
</tr>
<tr>
<td>Ronald Birkenfeld, M.D.</td>
<td>1963</td>
</tr>
<tr>
<td>Michael J. Jerva, M.D.</td>
<td>1963–1965</td>
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Personal Life

Ingraham was a modest and shy individual. At all times he remained gentle, soft-spoken, and dignified. He was unusually considerate and was therefore a great favorite of nurses, technicians, orderlies, volunteers, and hospital workers.29

He was a man of many hobbies, which he pursued with great enthusiasm. He had a profound interest in photography and took delight in taking good photographs in and out of the operating room, even buying cameras for others so they could share his pleasure.29 The services of an artist were not always readily available for making permanent records of operative steps, and sterility concerns made photography difficult. Ingraham cleverly managed to take photographic pictures of operations without compromising the sterility of the field by inserting cameras into a sterile cover.18

Ingraham was also something of an artist. He began painting when he and his wife spent a year in Arizona, shortly after their marriage. At the time, Ingraham was recuperating from a bad bout of bronchial asthma that had almost taken his life. Ingraham had a great sense of humor. One of his notable paintings from that time, now in the possession of his daughter Alice, captured a group of pigs dressed in fancy clothes. It was titled, Indigestion of the Opera (A. W. Ingraham, personal communication, 2012).

As his own children grew up, Ingraham also became interested in magic, a hobby that led him to membership in the Society of American Magicians. He was an avid sports fan and became very focused on Harvard hockey. He enjoyed small-boat sailing and coastal cruising in his early years, a pleasure that gave way later to piloting motor boats for his children along with water skiing and scuba diving. Ingraham was also an accomplished musician. He enjoyed classical music and played cello and piano duets on the radio with his friend Vernon Williams, a Boston psychiatrist. He spent many weekends with friends and residents at his summer home at Gales Point in Manchester, Massachusetts.

Ingraham’s trademark was the astrocyte. He used it time and again. The astrocyte was the signature engraving on his office china. He even gave his trainees silk neckties with an astrocyte design (A. W. Ingraham, personal communication, 2012).

Conclusions

Franc Ingraham was a gifted diagnostician, bold neurosurgeon, dedicated educator, creative researcher, and compassionate advocate for his young patients (Fig. 5). Despite his prolific 36-year academic neurosurgical career, Ingraham was still an associate professor at Harvard at the time of retirement. It is likely that the interruption of his professional life by recurrent illness prevented him from rising to the rank of full professor. In the recognition of his major contributions to neurosurgery, Harvard
announced the establishment of an endowed chair in his name on July 21, 1967, and Donald Matson, his disciple, became the first Franc Ingraham Professor of Neurosurgery at Harvard Medical School (Fig. 6).36

Ingraham was a pioneer in the development of pediatric neurosurgery by virtue of his imagination, intelligence, and ability to lead and inspire others to join him. Although modest and soft-spoken, he was able—like Cushing—to recruit and develop a number of extraordinarily talented trainees. Although he did not enjoy talking to large groups, his sophisticated humor at the bedside and his quick perception of complex consultative problems made him a teacher of great ability and inspiration, both in the operating room and on the ward.

Harvey Cushing is widely considered to be the founder of neurosurgery. It is fair to conclude that his protégé, Franc Ingraham, is the founder of pediatric neurosurgery.

Disclosure
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Cohen. Acquisition of data: Lohani. Analysis and interpretation of data: Cohen. Drafting the article: Lohani. Critically revising the article: both authors. Reviewed submitted version of manuscript: both authors. Approved the final version of the manuscript on behalf of both authors: Cohen. Administrative/technical/material support: Cohen.

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