The deep roots of military service in neurological surgery: an academic genealogical analysis of the founding generation

Michael S. Rallo, BS, and Gavin P. Dunn, MD, PhD

Throughout human history, advancements in medicine have evolved out of periods of war. The carnage of battlefield injuries provided wartime surgeons an unprecedented opportunity to study anatomy, develop novel techniques, and improve systems of care. As a specialty that was established and evolved during the first half of the 20th century, neurological surgery was heavily influenced by the experiences of its founders during the World Wars I and II. Utilizing the published Neurosurgery Tree, the authors conducted an academic genealogical analysis to systematically define the influence of wartime service on neurosurgery’s earliest generations. Through review of the literature and military records, the authors determined that at least 60% of American neurosurgical founders and early leaders served during World Wars I and/or II. Inspired by the call to serve their nation as forces for good, these individuals were heralded as expert clinicians, innovative systems thinkers, and prolific researchers. Importantly, the service of these early leaders helped highlight the viability of neurosurgery as a distinct specialty and provided a framework for early neurosurgical education and expansion. The equipment, techniques, and guidelines that were developed during these wars, such as management of craniocerebral trauma, peripheral nerve repair, and hemostasis, set the foundation for modern neurosurgical practice.

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KEYWORDS Harvey Cushing; Wilder Penfield; military neurosurgery; war; head injury

So let us strive till war’s foul, gloomy portal,  
Has vanished into space, like ships at night  
Bringing to us that peace which is immortal,  
A newer, fresher Earth of radiant light.  
— Captain G. Horrax,  
lines written 1 year after leaving America

Recognition of the vulnerability of the head and its contents has long rendered it a target for incapacitating adversaries in combat. Battlefield injuries have been a central focus of surgeons aiming to understand the mysteries of the brain and refine care for the injured. Indeed, medical and surgical luminaries throughout history have reflected on the way in which medical techniques are cultivated and rapidly evolve during wartime. In fact, Hippocrates is famously quoted as stating, “He who desires to practice surgery must go to war.”

The neurosciences, and neurosurgery in particular, illustrate that scientific advancements have been gleaned throughout the centuries from the tragedy of war. We now know that ancient Egyptian physicians had a relatively contemporary understanding of the pathogenesis underlying spine trauma owing to their experiences with war wounds and construction injuries. Galen of Pergamon, a Greek physician in the Roman empire, revolutionized contemporary understanding of anatomy through his expert animal dissections and experience treating injured gladiators. He advocated for trephination to relieve intracranial pressure and for repair of depressed skull fractures, and he encouraged his pupils to study the bodies of slain soldiers and gladiators to advance anatomical knowledge. The battlefield remains a catalyst for modern advancements in neurosurgical care. Indeed, many advancements in neurosurgical hemostasis and infection control that are still in use today arose directly from experiences with craniocerebral injuries during World War I (WWI) and World War II (WWII).
War has provided nearly unlimited opportunities to develop and improve approaches to the treatment of injuries. Although the military services of various neurosurgeons have been memorialized in the literature, a unified appreciation of the influence of military service is lacking, particularly on the founding generation. In this academic genealogical analysis, we explored the prevalence and impact of wartime service among several influential neurosurgical titans who shaped the origins of the field, with an emphasis on Harvey Cushing, William Mixter, Charles Frazier, Charles Elsberg, Ernest Sachs, Alfred Adson, and their respective lineages. We aimed to highlight the contributions of these individuals who used their wartime experiences to advance the field of neurological surgery, and in doing so, we illustrate the powerful ways that our field has served humanity even in its darkest hours.

Methods
Academic genealogy involves mapping mentoring relationships among scientists and scholars into a “family tree.” The practice has been mainstreamed through the success of various initiatives such as the Mathematics Genealogy Project, Chemical Genealogy, and Neurotree, as well as its broader successor Academic Family Tree. These trees typically define lineage on the basis of the scholars’ thesis advisors. Utilizing Academic Family Tree, a Neurosurgery Tree was produced in 2019 that identified 6 lineages for department chairs in the US. These lineages were defined on the basis of the department chair or division chief during the neurosurgeon’s most formative training experience. Cushing, Mixter, Frazier, Elsberg, Sachs, and Adson are therefore termed the founders from whom American neurosurgery grew.

To determine the prevalence and impact of military service among neurosurgical founders, we reviewed the published literature, military records and documents, and internet sources for 2 generations of members from each of the 6 lineages represented in the Neurosurgery Tree. Founders were defined on the basis of the department chair or division chief during the neurosurgeon’s most formative training experience. Cushing, Mixter, Frazier, Elsberg, Sachs, and Adson are therefore termed the founders from whom American neurosurgery grew.

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Results
Details of each neurosurgeon’s military records, including their branch of service, rank, conflict, and activities, are summarized by lineage in Tables 1–6. The largest lineage was that of Cushing, who directly trained 23 future neurosurgical department chairs or division chiefs, followed by Adson (6 trainees), Frazier (5), Mixter (3), Elsberg (2), and Sachs (2). Notably, each of these 6 founders had verifiable evidence of military service during the period of WWI as members of the US Army Medical Corps. Harvey Cushing attained the highest rank among the original founders and was honorably discharged as a colonel (O-6). In total, of the 41 first-generation descendants from the founders, 25 (61.0%) had verifiable service in the military, including all individuals in the Mixter and Elsberg lineages. The US Army was the most common branch of service: 20 trainees were affiliated with the Army Medical Corps, 3 with the US Navy, 1 (Wilder Penfield) with the Royal Canadian Army, as well as 1 who served in both the Army Infantry and Navy Medical Corps. It is important to note that the predecessor of the US Air Force was a branch of the Army prior to 1947. Winchell M. Craig, a Navy neurosurgeon who served during WWII, attained the highest rank when he was discharged as a rear admiral (O-7).

The definition of neurological surgery as a distinct specialty in the early to mid-20th century meant that its founders and early leaders were subjected to the influences of global war twice in a quarter century. To the best of our knowledge, this is the first report to systematically examine the involvement of the founding neurosurgical generation in military service and wartime. Several common themes emerged from the experiences of military neurosurgeons, including 1) a common sentiment of altruism and pride in service, which has been referred to as medical patriotism; 2) decorated leadership and a desire to improve military systems of care; and 3) an emphasis on research and innovation as a means of driving forward neurosurgical progress.

Discussion
Medical Patriotism During Total War
As the Greatest Generation ages, the concept of total war—one in which both military and civilian resources are mobilized on a massive scale—has gradually faded from our national memory. The call to service during WWI and WWII did not target just industrial resources but extended into healthcare, including the budding field of neurosurgery. In fact, several American neurosurgeons were engaged in war efforts even before the US formally entered WWI. This included, perhaps most famously, Harvey Cushing, who served as the second leader of Ambulance Américaine after the tenure of the unit’s inaugural surgeon-in-chief, George Crile, who was cofounder of the Cleveland Clinic. Cushing took this opportunity to interact with surgeons from across Europe and explore approaches to management of wartime injuries. Similarly, a young Wilder Penfield, then a Rhodes scholar at Oxford University who was desperately seeking to aid in the war effort, spent his vacations between terms dressing wounds in an American hospital in Paris. He was injured himself when the SS Sussex, the ship carrying him to duty in France in March 1916, was struck by a German torpedo in the English Channel.

As American involvement in WWI became more inevitable, volunteer surgeons shared their frontline experiences as vocal advocates for military medical preparedness, often challenging the nation’s neutral stance. Crile lamented that US neutrality could be detrimental to the readiness of the armed forces due to limitations placed on medical officers traveling abroad for training. To combat such ill preparedness, he conceptualized a novel civilian-military partnership in which well-trained personnel from American universities would staff base hospitals in the event of US entry into the war. This concept was well received by Army Surgeon General William Gorgas, who ultimately selected Crile and Cushing to develop and lead model base hospital units from Cleveland’s Lakeside Hos-
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<tr>
<th>Authors &amp; Year</th>
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<th>Name</th>
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<th>Rank</th>
<th>Conflict</th>
<th>Notes</th>
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</table>
| Cushing, 1936 | Proband    | Harvey W. Cushing (1869–1939) | Peter Brigham Hospital, Harvard University | US Army Medical Corps | Colonel | WWI | • Served as a volunteer surgeon w/ Ambulance Américaine in France prior to the US entering WWI.  
• Directed Base Hospital No. 5 ("Harvard Unit") and appointed as senior consultant in neurosurgery to the American Expeditionary Force.  
• Wrote extensively on management of cranio-cerebral injuries, including use of electromagnetism to remove projectiles.  
• Awarded US Army Distinguished Service Medal & Companion of the Order of Bath. |
| Carey, 2014   | Descendant | Carl W. Rand (1886–1972) | Los Angeles County General Hospital, University of Southern California Medical Center | US Army Medical Corps | Lieutenant (O-2) | WWII | • Assigned to Surgical Team No. 578, which was active during the Argonne offensive of the fall of 1918.  
• Operated on 64 patients w/ cranial injuries in austere conditions lacking antibiotics, blood transfusion, & electrocautery. Mortality rate maintained at <20%. |
| Lindskog, 1979 | Descendant | Samuel Harvey (1886–1953) | New Haven Hospital, Yale University School of Medicine | US Army Medical Corps | Major (O-4) | WWII | • Resident w/ Cushing at onset of WWI, traveled as a member of Base Hospital No. 5 for service in France.  
• Assigned to Evacuation Hospital No. 7 during the Argonne offensive. |
| Cushing, 1936 | Descendant | Wilder Penfield (1891–1976) | Montreal Neurological Institute, McGill University | Royal Canadian Army Medical Corps | Colonel | WWII | • Volunteered as a dresser in American Red Cross Hospital during WWII.  
• Mobilized resources of Montreal Neurological Institute to war-relevant research projects, including studies on brain, spine, & peripheral nerve injuries; antimicrobial therapy; pilot blackout; & sea sickness.  
• Honored w/ American & French service distinctions. |
| Keller, 2002  | Descendant | Howard Naffziger (1884–1961) | University of California Medical School, University of California, San Francisco | US Army Medical Corps | Lieutenant colonel | WWII | • Served in military facilities in South Carolina & New Jersey before deployment to Europe.  
• Assigned to Base Hospital No. 115—a primary neurosurgical center—in Vichy, France.  
• Continued service "in mufti" as a consultant to the Navy during WWII & the Army during Korean War. |
| Smith, 1962   |            | William P. van Wagenen (1897–1961) | University of Rochester Medical Center | US Army Medical Corps | Lieutenant colonel | WWII & WWII | • Served briefly in Army during WWI prior to matriculation at Harvard Medical School.  
• Assigned to Lawson General Hospital & Cushing General Hospital during WWII.  
• Published "Cushing General Hospital Regime for Treatment of Peripheral Nerve Injuries" w/ Dr. Frederick Lewey. |
• Served as acting senior consultant during Colonel Davis's mission to the USSR.  
• Worked w/ Davis on the prevention of high-altitude frostbite & head injuries in airmen. |

CONTINUED ON PAGE 4 »
### TABLE 1. Summary of military service among early neurosurgical leaders trained under Harvey Cushing

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<tr>
<th>Authors &amp; Year</th>
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<th>Rank</th>
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<th>Notes</th>
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<tbody>
<tr>
<td>Cannon &amp; Telf, 2010</td>
<td>Loyal Davis (1896–1982)</td>
<td>Descendant</td>
<td>Northwestern University Medical School</td>
<td>US Army Medical Corps</td>
<td>Colonel</td>
<td>WWII</td>
<td>Served as senior consultant in neurosurgery to the European Theater of Operations, where he was instrumental in developing systems for neurosurgical care, and instrumental in developing emergency management of head injuries. Awarded Legion of Merit.</td>
</tr>
<tr>
<td>Loyal Davis (1896–1982)</td>
<td>Semmes-Murphey Clinic, University of Tennessee College of Medicine</td>
<td>Yes</td>
<td>US Army Medical Corps</td>
<td>Captain</td>
<td>WWI</td>
<td>• Served in a 1000-bed hospital through meningococcal meningitis &amp; influenza outbreaks. • Led prevention efforts against high-altitude frostbite &amp; head injuries in airmen. • Awarded Legion of Merit, Bronze Star, &amp; American Campaign Medal.</td>
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</tr>
<tr>
<td>Rallo &amp; Dunn, 2010</td>
<td>Raphael E. Semmes (1894–1968)</td>
<td>Descendant</td>
<td>University of Louisville</td>
<td>US Army Medical Corps</td>
<td>Lieutenant Colonel</td>
<td>WWII</td>
<td>Appointed as assistant chief of surgery at Walter Reed Hospital, transferred to the US Army Medical Service as a neurosurgical consultant in 1944, recalled to Europe in December 1945 to care for General Patton after the car accident that resulted in his death. Awarded Legion of Merit, Bronze Star, &amp; American Campaign Medal.</td>
</tr>
<tr>
<td>Rallo &amp; Dunn, 2010</td>
<td>Charles E. Dowman Sr. (1882–1931)</td>
<td>Descendant</td>
<td>Emory University School of Medicine</td>
<td>US Army Medical Corps</td>
<td>Major</td>
<td>WWI</td>
<td>• Served as chief of neurosurgical team in a mobile hospital unit during the St. Mihiel &amp; Argonne offensives. • Received Unit Citation for Meritorious Service.</td>
</tr>
<tr>
<td>Rallo &amp; Dunn, 2010</td>
<td>Leo M. Davidoff (1896–1957)</td>
<td>Descendant</td>
<td>Albert Einstein College of Medicine</td>
<td>US Army Medical Corps</td>
<td>Major</td>
<td>WWI</td>
<td>• Served in the student Army Training Corps while a student at Harvard Medical School. • Headed the Brain Surgery Section at the start of WWII, assigned to Base Hospital No. 87 in France. • Surgical resident of Cushing’s at the start of WWI, assigned to Base Hospital No. 5 in France. Later stationed at No. 46 Casualty Clearing Station at Mendinghem, from which he described his experience managing head injuries nearest to the front.</td>
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NA = not applicable; USSR = Union of Soviet Socialist Republics.
Although Cushing entered into volunteer service at Ambulance Américaine with hesitation, in subsequent letters to Crile he describes his service with great positivity: "It was one of the most extraordinary of experiences and I not only would not have missed it for a great deal, but had things not been as they were here, with the need of my presence, I unquestionably should have stayed over for the rest of the summer."  

Cushing’s experiences as a volunteer surgeon and his subsequent service in the US Army Medical Corps Base Hospital No. 5 (Fig. 1) are documented in exquisite detail in his diary, *From a Surgeon’s Journal*. His painstaking work to save the lives of soldiers reflects the pride he took in his service and surgical craft. He mourned the losses of his comrades, most acutely that of Revere Osler, son of his mentor and friend Sir William Osler. Often in silence, he honored the memories of the fallen with his tireless efforts to improve upon the care he delivered at the front lines.  

While America once again sought to remain out of another European conflict in the years preceding WWII, the spirit of altruism motivated physicians and surgeons to support Allied forces overseas. For example, Henry Heyl (a Mixter trainee), who was inspired to public service by his father’s participation on the Hoover Commission for Relief of War Victims, delivered neurosurgical services in England for a year as a volunteer with the British War Relief Society. In this capacity, he is credited with restoring the speech of a young boy who sustained a skull fracture after a German bombing raid on London. When the US was thrust into WWII after the attack on Pearl Harbor in December 1941, Heyl accepted a commission as a captain in the Army Medical Corps and went on to become the chief neurosurgeon with the Massachusetts General Hospital Unit as part of the revived US Army Affiliated Hospitals.

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<th>Rank</th>
<th>Conflict</th>
<th>Notes</th>
<th>Wartime Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>White, 1958</td>
<td>Proband</td>
<td>William J. Mixter</td>
<td>Massachusetts General Hospital</td>
<td>US Army Medical Corps</td>
<td>Major (O-4)</td>
<td>WWI &amp; WWII</td>
<td>• Served as volunteer surgeon w/ the Ambulance Américaine in France prior to US entering WWI. • Returned as an army officer w/ Base Hospital No. 6 located in Talence, France. • Commanded Camp Hospital 35 &amp; later Base Hospital 204 in England. • During WWII, served as senior consultant in neurosurgery to the surgeon general.</td>
<td>Cranial &amp; spinal trauma</td>
</tr>
<tr>
<td>Parisien &amp; Ball, 1998</td>
<td>Descendant</td>
<td>James C. White</td>
<td>Massachusetts General Hospital</td>
<td>US Navy &amp; US Navy Medical Corps</td>
<td>Captain (O-6)</td>
<td>WWI &amp; WWII</td>
<td>• Served as watch &amp; division officer on a light cruiser during WWI prior to earning medical degree. • Spent 5 yrs in the Naval Medical Corps as chief of neurosurgery at US naval hospitals in Chelsea, Massachusetts, and St. Albans, New York, during WWII. • Remained in the naval reserve until 1953 while also supporting the Veterans Administration in New England. • Reported 13 cases of causalgia after peripheral nerve injuries, including a case of postamputation phantom limb.</td>
<td>Cranial trauma &amp; peripheral nerve injury</td>
</tr>
<tr>
<td>Wang et al., 2021</td>
<td></td>
<td>William B. Scoville</td>
<td>Hartford Hospital, University of Connecticut Health Center</td>
<td>US Army Medical Corps</td>
<td>Major (O-4)</td>
<td>WWII</td>
<td>• Stationed initially at Walter Reed General Hospital, followed by McCaw General Hospital in Washington &amp; finally Cushing General Hospital in Massachusetts. • Assigned to manage the paraplegic service &amp; became heavily involved in organizing rehabilitation efforts, even after the war.</td>
<td>NA</td>
</tr>
<tr>
<td>Pool, 1975</td>
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<td>Henry L. Heyl</td>
<td>Hitchcock Clinic, Dartmouth Medical School</td>
<td>US Army Medical Corps</td>
<td>Captain (O-3)</td>
<td>WWII</td>
<td>• Volunteered w/ British War Relief Society at the beginning of WWII. • Served as the chief of neurosurgery for the 6th General Hospital in North Africa. • Contracted tuberculosis requiring his return to the US.</td>
<td>NA</td>
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TABLE 3. Summary of military service among early neurosurgical leaders trained under Charles Frazier

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<th>Authors &amp; Year</th>
<th>Generation</th>
<th>Name</th>
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<th>Rank</th>
<th>Conflict</th>
<th>Notes</th>
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</thead>
</table>
| Hanigan, 2003  | Proband    | Charles H. Frazier (1870–1936) | University of Pennsylvania | Yes            | US Army Medical Corps | Lieutenant colonel (O-5) | WWII     | • Directed the Army Neurosurgical School of Instruction in Philadelphia.  
  • Chief of neurosurgery at General Hospital No. 11, w/ a focus on peripheral nerve injuries.  
  • Served in surgeon general's office & joined the Peripheral Nerve Commission. |
  • Described the incidence & management of infections related to gunshot wounds to the head. |
  • Joined the US Navy during WWII; this led to his interest in cranial wounds.  
  • Owing to his military experience, he developed several novel devices, including the clinical G-suit to combat hypotension. |

TABLE 4. Summary of military service among early neurosurgical leaders trained under Charles Elsberg

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<tr>
<th>Authors &amp; Year</th>
<th>Generation</th>
<th>Name</th>
<th>Primary Affiliation</th>
<th>Military Branch</th>
<th>Rank</th>
<th>Conflict</th>
<th>Description of Service</th>
</tr>
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</table>
  • Extensively involved in the care of patients w/ peripheral nerve injuries at General Hospital No. 1. |
| Scarff, 1967 | Descendant | Byron Stookey (1887–1966) | Neurological Institute of New York, Columbia University | Yes            | US Army Medical Corps | Major (O-4) | WWII      | • Assigned to study at the Neurosurgical Training School in New York under Drs. Elsberg, Tinley, & Strong.  
  • Chief of neurosurgical service at General Hospital No. 2, Fort McHenry, Maryland. Supervised 200 beds & gained expertise in peripheral nerve injuries. |
| Hanigan, 2010 | Proband    | Ira Cohen (1887–1957) | Mount Sinai Hospital      | Yes            | US Army Medical Corps | Major (O-4) | WWII     | • Served at the Base Hospital No. 3 in France & tasked w/ establishing a new hospital at Le Braun.  
  • Having sustained a skull fracture & dural tear, he is said to have supervised the debridement & repair w/ a mirror. |
| Oppenheim, 1994 | Proband    | Ira Cohen (1887–1957) | Mount Sinai Hospital      | Yes            | US Army Medical Corps | Major (O-4) | WWII     | NA                                                                                                                                             |
### TABLE 5. Summary of military service among early neurosurgical leaders trained under Ernest Sachs

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<tr>
<th>Authors &amp; Year</th>
<th>Generation</th>
<th>Name</th>
<th>Primary Affiliation</th>
<th>Military</th>
<th>Branch</th>
<th>Rank</th>
<th>Conflict</th>
<th>Description of Service</th>
<th>Wartime Research</th>
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</thead>
<tbody>
<tr>
<td>Tilney &amp; Jelliffe, 1924⁶⁶</td>
<td>Proband</td>
<td>Ernest Sachs (1879–1958)</td>
<td>Barnes Hospital, Washington University in St. Louis</td>
<td>Yes</td>
<td>US Army Medical Reserve Corps</td>
<td>Major (O-4)</td>
<td>WWI</td>
<td>• Directed the Military Neurosurgical Training School in St. Louis.</td>
<td>NA</td>
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<tr>
<td>Smolik, 1959⁶⁹</td>
<td>Descendant</td>
<td>Henry G. Schwartz (1908–1998)</td>
<td>Barnes Hospital, Washington University in St. Louis</td>
<td>Yes</td>
<td>US Army Medical Corps</td>
<td>Lieutenant colonel (O-5)</td>
<td>WWII</td>
<td>• Served w/ the 21st General Hospital in North Africa, Italy, &amp; France.</td>
<td>Cranial trauma, peripheral nerve injury, &amp; systems of care</td>
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</table>

### TABLE 6. Summary of military service among early neurosurgical leaders trained under Alfred Adson

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<tr>
<th>Authors &amp; Year</th>
<th>Generation</th>
<th>Name</th>
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<th>Rank</th>
<th>Conflict</th>
<th>Description of Service</th>
<th>Wartime Research</th>
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<tbody>
<tr>
<td>Adson, 1919⁷¹</td>
<td>Proband</td>
<td>Alfred W. Adson (1887–1951)</td>
<td>Mayo Clinic</td>
<td>Yes</td>
<td>US Army Medical Reserve Corps</td>
<td>Major (O-4)</td>
<td>WWI</td>
<td>• Served a first lieutenant in the Medical Reserve Corps during WWI.</td>
<td>Peripheral nerve injury</td>
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<tr>
<td>Military Surgeon, 1926⁷²</td>
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<td></td>
<td>• Assigned to 56th Surgical Hospital &amp; 66th Evacuation Hospital as assistant chief of surgical service in the Seventh Corps Area.</td>
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<td>MacCarty interview¹⁵</td>
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<td></td>
<td>• Served as a neurosurgeon at Great Lakes Naval Hospital, Illinois, &amp; Bethesda Naval Hospital, Maryland, where he served as chief of staff in 1946.</td>
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<tr>
<td>Oklahoma Hall of Fame⁷⁴</td>
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<td>Chief of surgery at the 382nd Station Hospital from 1947 to 1949.</td>
<td>NA</td>
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<tr>
<td>Spurling, 1960¹⁵</td>
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<td></td>
<td>• Served as chief of surgical service at Bethesda Naval Hospital.</td>
<td>Cranial trauma, spinal trauma, peripheral nerve injury, &amp; systems of care</td>
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<td></td>
<td>• Appointed chief consultant in neurosurgery &amp; served as an unofficial adviser to Surgeon General Admiral Ross T. McIntire.</td>
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<td></td>
<td></td>
<td></td>
<td>• Awarded Legion of Merit &amp; Bronze Star.</td>
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Program. He served honorably in the North African theater until a bout of tuberculosis required his return home. The desire to serve the nation during WWII was a common sentiment shared by young men and women across the US. This is perhaps most earnestly represented in the words of Collin S. MacCarty (as he discussed embarking on his neurosurgical training at Mayo Clinic under Adson): “What I wanted was to do neurosurgery, and to get it done as fast as I could so I could get into the war, which was imminent.”

MacCarty would hold true to those words, completing his neurosurgical training while a naval officer in 1943 before serving at the Great Lakes and Bethesda Naval Hospitals until 1946. The commitment to service is further exemplified by the continued involvement of several neurosurgical leaders, including Henry G. Schwartz (a Sachs trainee) (Fig. 2), Howard Naffziger (Cushing trainee), and James C. White (Mixter trainee), in the military and Veterans Administration systems.

**Systems Thinkers, Problem Solvers, and Decorated Leaders**

Although a patriotic and altruistic desire to serve was common among the early neurosurgical leaders, several expressed frustrations with the armed forces’ ill preparedness preceding the wars. Throughout their military careers, these individuals worked to develop or improve systems of care.

As noted above, under the guidance of Surgeon General Gorgas, Crile and Cushing were among the first to assemble a model for military-civilian partnership that would become the US Army Affiliated Hospitals Program. Although this was an important step to ensuring the availability of experienced surgical teams to care for the injured, a system for educating surgeons in basic neurosurgical skills was essential to combatting the burden of head, spine, and peripheral nerve injuries resulting from this new form of industrialized war. Indeed, Gorgas estimated that at least 100 trained neurosurgeons would be required to staff the
Army’s planned battlefield hospitals. When advised by his neurosurgical consultants that there were not even 100 neurosurgeons in the world, he replied “That doesn’t interest me! It’s up to you to furnish the men!” During a meeting on August 24, 1917, the concept of training general surgeons in the basics of neurology and neurosurgery was proposed by Major Charles Bagley and senior neurosurgical consultants, including Charles Frazier, Dean Lewis, Ernest Sachs, and Allen Kanavel. In what could be considered the first formalized system of neurosurgical education in the world, these consultants developed US Army Neurosurgical Training Schools in Philadelphia, Chicago, New York City, St. Louis, and Camp Greenleaf, Georgia. These programs spanned approximately 10 weeks and included exposure to neuroanatomy, neurological examination, and surgical techniques. Several prominent contemporary neurosurgeons served as faculty or military directors for these schools, including Charles Frazier, Dean Lewis, Charles Elsberg, Ernest Sachs, and Claude Coleman. A review of the curriculum from the School of Neurosurgery at Camp Greenleaf demonstrated that didactic education in neuroanatomy was complemented by participation in several days of dissection on live dogs and human cadavers. Although the so-called “70-day brain surgeons” who graduated from these courses served an important purpose in augmenting the wartime workforce, the majority returned to their general surgery practices at the end of the war. Only 3—Charles Dowman, Raphael Semmes, and Frank Teachnor—continued neurosurgical careers.

Despite the growth of the neurosurgery-capable workforce, systemic problems requiring intervention persisted throughout US involvement in WWI. In a report commissioned by then Surgeon General Merritte Ireland nearly 10 years after the war, Cushing described these organizational and logistical concerns in detail. Most pressing was the limited ability to provide care in the forward hospitals closest to the front. This was in part due to the emphasis placed on treating a high volume of wounded, therefore deferring more time-consuming procedures such as those undertaken for neurological injuries to larger base hospitals. Additionally, there were several examples of surgeons with neurological training who were misappropriated into roles such as triage, thereby limiting the neurosurgical capabilities of forward operating facilities. Cushing felt that this was incredibly detrimental to the survivability of patients with cranial injuries. He postulated that the mortality rate could be reduced by 50% if surgical intervention was undertaken closer to the front. Neurosurgical capacity was also limited by the availability of instruments and equipment required for such interventions. While reviewing the medical equipment chests prior to deployment, Cushing noted that many of the instruments were antiquated, with some even dating back to the Civil War. After some delay, he was able to acquire the essential tools, including perforators, drills, and rongeurs, from French manufacturers.

WWI represented a significant step forward for the field of neurological surgery. In fact, the US Army was the first organization to recognize the need for, and viability of, neurosurgical specialists. It should not be surprising that the first academic recognition of neurosurgery—William Mayo’s proclamation of “the birth of a new specialty” in 1919—came just a year after the signing of the armistice. In the subsequent 2 decades, neurosurgery would be logistically defined with the establishment of academic societies, creation of training programs, and approval of the American Board of Neurological Surgery (ABNS) by the Advisory Board for Medical Specialties in 1940. Standing on the brink of global war once again, American neurosurgery, it would seem, was better prepared to answer the nation’s call. This turned out to be true in several ways. The civilian-affiliated hospitals program established under Crile and Cushing provided a framework for deploying highly experienced surgical teams into combat settings. However, by the time of US entry into WWII, there were only 30 ABNS-certified neurosurgeons in the country who were adequately prepared to be deployed. Once again, short-term neurosurgical schools provided a pathway for training experienced general surgeons in the basic surgical management of neurological injuries. Notably, these programs expanded the curriculum from those of their WWII predecessors and included approximately 30 days of didactic lectures and anatomical dissections followed by 60 to 90 days of clinical rotations at US Army neurosurgical centers. Each class consisted of 24 to 30 young medical officers with strong general surgery backgrounds and some degree of exposure to neurosurgery. While the experienced neurosurgeons were attached to larger general hospitals outside of the combat zone, these newly trained “working neurosurgeons”—designated 313IC—were assigned to evacuation hospitals close to the front. This model, informed by Cushing’s experience and data, was meant to ensure earlier access to neurosurgical stabilization prior to evacuation to facilities capable of definitive treatment. Ultimately, these programs, which were held at the University of Illinois and Columbia University before being transferred to the University of Pennsylvania, graduated nearly 200 wartime neurosurgeons. However, only a handful, including Eben Alexander Jr., Donald Matson, Joseph Ransohoff, Ludwig Segerberg, and Bert Selverstone, remained in neurosurgery after their separation from the armed forces.

Unfortunately, equipment-related recommendations stemming from WWI failed to be implemented prior to the advent of WWII. Loyal Davis, who established the first neurological service in Chicago after his training with Cushing, emerged as a heroic systems thinker who challenged the slow-moving bureaucracy of the US Army Medical Corps early in the war. In his role as senior neurosurgical consultant to the chief surgeon, Davis conducted a situational assessment of neurosurgical capabilities across the European theater throughout 1942. This “get-acquainted tour” left Davis frustrated by the inadequacy or complete lack of instruments required for neurological surgery. He described his efforts in securing equipment from British surgical instrument houses as “unproductive... because those instruments available were completely out-modeled; the field of neurological surgery and its appliances and instruments had been developed in the US. It was, however, a demonstration, many times repeated, of the facts that the Army could put supplies into a depot but could not get them out.”
Davis wrote voraciously of the need for adequate equipment and a system for transferring neurologically injured patients to neurosurgery-capable facilities. His frustration was compounded by the feeling that his recommendations were “passed back and forth or conveniently filed” without ever reaching the necessary audience. This desperation led him to compile, in chronological order, his previous memorandums and forward them directly to the chief consultant in surgery, Brigadier General Fred W. Rankin.34 Although this circumvention of the chain of command risked disciplinary action, it ultimately garnered him a desired meeting with Chief Surgeon Hawley. Not only was this meeting successful in relaying Davis’s concerns, but it started a lifelong friendship between the two.8 Davis’s service continued to be marked with distinction owing to his efforts to mitigate head injuries and frostbite among men; he was ultimately honored with the Legion of Merit in 1945.35 Just as Cushing relied on the shared experiences of British and French colleagues 20 years earlier, neurosurgeons in the European theater regularly engaged with their British and Canadian counterparts. Indeed, these Allied facilities represented the only sites for active training of US neurosurgical personnel from 1942 through the landing at Normandy in June 1944.32 Davis himself was even afforded the opportunity to survey the medical system of the Soviet Union, which at the time was considered highly proficient in battlefield surgery.35

Winchell M. Craig, who was activated from the US Navy Reserve immediately after the bombing of Pearl Harbor, served a similarly important role in the initiation and augmentation of naval neurosurgical care. Craig was first assigned to the naval hospital in Corona, California, where he established the first neurosurgical center for wounded sailors and marines. After his appointment as chief of the surgical service at Bethesda Naval Hospital, Craig became an unofficial adviser to Admiral Ross T. McIntire, surgeon general of the Navy, and was eventually promoted to chief consultant in neurosurgery.15 In this role, he helped develop a neurosurgical flying unit at the National Naval Medical Center that would become capable of deployment across the East Coast in the event of an attack on US soil.16 Owing to his strong working relationship with Admiral McIntire, he often represented the surgeon general’s office at assignments across the globe.15 His distinguished tenure was recognized by promotion to the rank of rear admiral (O-7), the highest rank ever conferred upon a naval reserve medical officer at the time and the highest rank identified among the military neurosurgeons in this analysis.37 He was also awarded the Legion of Merit and Bronze Star for his meritorious service.15

Pushing Boundaries Through Research and Innovation

Volumes could be written, and in many cases have been already, on the clinical neurosurgery advancements developed in the laboratory of war. Indeed, the first volume of the Journal of Neurosurgery, issued in 1944, is filled with wartime innovations such as novel hemostatic agents,6,38 a headrest for use in austere hospitals,39 antimicrobial therapy regimens for cranioencephalic injury,40 and new approaches to cranioplasty.41 Research contributions, including the areas of focus of military neurosurgeons, are summarized in Tables 1–6. Notably, significant advancements were made in detailing the pathology and management of peripheral nerve injuries.42,43

Conclusions

Early neurosurgical leaders were incredibly important contributors to military medical preparedness and response during WWI and WWII. Motivated by the spirits of altruism and patriotism, these individuals served honorably and became valuable systems leaders, prolific researchers, and forward-thinking innovators. The high incidence rate of neurological injury during these conflicts and the value offered by frontline neurosurgical providers helped to elevate the nascent specialty. Upon return to their civilian institutions, these early leaders were prepared to institute a golden age of neurosurgery marked by prolific growth in training programs, rapid advancement in surgical technique, and groundbreaking insights into the workings of the human brain that laid the foundation we still feel today.

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References

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