The advancement of early neurosurgical innovations can be attributed to neurosurgery’s intense and intimate relationship to war. Dr. Harvey Cushing, regarded as the father of modern neurosurgery, served in World War I between 1915 and 1918.\(^1\)\(^2\) Using the knowledge and experiences of numerous military surgeons from before his time, including Sir Victor Horsley and Sir Emil Kocher, Dr. Cushing was instrumental in treating soldiers with injuries to the head, spine, and peripheral nerves.\(^3\)\(^4\) Cushing recognized the value of meticulous note-taking during the war, for the sake of historians, physicians, and scientists to come. In this article, we summarize his experience published in his war memoir, *From a Surgeon’s Journal, 1915-1918*.\(^3\)

Through analyzing Dr. Cushing’s perspective from his war memoir, *From a Surgeon’s Journal, 1915-1918*, the costly yet critical contributions he made to the field of neurosurgery during World War I are evident, and his pearls of knowledge can be used even today for neurosurgeons worldwide. Dr. Cushing’s motivation for publishing his notes from World War I was the improvement of neurosurgical care through meticulous documentation.

This impactful memoir begins on March 18, 1915, 8 months into the official start of World War I. Dr. Cushing was entering Paris, a refuge for injured soldiers at that time, and he witnessed the need for military hospitals and motor ambulance services to enable more efficient patient care among the mounting soldier casualties. His story is divided into 11 chapters that advance chronologically in real time as the war progressed. We selected excerpts from each chapter that highlight Dr. Cushing’s multifaceted experience in World War I, from the eyes of a passionate patriot, a resilient physician, and a pioneering neurological surgeon.

**Military Neurosurgery: From a Surgeon’s Journal, 1915-1918**

*Chapter 1: The Harvard Unit at the Ambulance Américaine*

Once Dr. Cushing received word of the outbreak of World War I, he was keen to volunteer his services. In late August 1914, a group of American residents in Paris organized a military hospital and motor ambulance service that was sponsored by the American ambassador, Robert Bacon, under the auspices of the American Hospital at Neuilly-sur-Seine. The French government also transformed Lycée Pasteur, a nearby school, into a hospital with 600 beds. This unit was collectively referred to as the “Ambulance Américaine,” *ambulance* being the French term for a military hospital (Fig. 1). The Ambulance Américaine received its first patients in September 1914 and was initially staffed by rotating personnel primarily from the College of Physicians and Surgeons in New York. By December, however, the Ambulance requested that American universities staff the hospital in 3-month stints. Case Western Reserve University (Cleveland, Ohio) was the first to volunteer in January 1915, led by Dr. George W. Crile. Harvard University followed in April 1915, led by Dr. Cushing and Dr. Robert B. Greenough.
On March 18, 1915, Dr. Cushing’s team set sail for Paris on the Canopic. Sea conditions were rough, and aboard they faced many challenges, including a rampant case of influenza. However, the time aboard was not a complete loss. Lectures were held, as well as a conference on gaseous infections. The crew focused on the pathology of emphysematous lesions and brainstormed therapies.

The Canopic arrived in Paris on April 1, 1915. Dr. Cushing was impressed by the courtyard filled with motor ambulances at the Ambulance Américaine. At that time, there were 164 beds at the hospital. Dr. Cushing’s first patient was a man with paralysis caused by a gunshot wound to the spinal cord. The remaining injury list included 11 upper-extremity and 2 lower-extremity nerve injuries, 3 facial paralyses, a cervical sympathetic paralysis secondary to a gunshot wound to the mouth, 2 spinal fractures secondary to a beam collapsing, and a serious head injury. All injuries that occurred in the central parts of Paris were directed to the Ambulance Américaine.

While on his first trip to Paris, Dr. Cushing was taken to see another large base hospital at Compiegne, the Hôpital Complémentaire 21. Here, Cushing remarked on the opportunities to study and improve wound care, impressed by “the suction treatment of suppurating wounds without dressings; the employment of irrigation with bactericidal fluids which are being worked out by Henry Dakin [and] methods of increasing resistance to pathogenic organisms by turpentine injections, etc, etc.”

Cushing believed that it was important to extract bullets and shrapnel when possible, and he described a magnet that was used by some surgeons at the Ambulance. In a famous excerpt, he bragged about the extraction of a shell casing from the sellar region of a patient using a magnet attached to a wire nail that was inserted along the bullet track:

I had taken off my gloves and put the nail down; but then—let’s try just once more! So I slipped the brutal thing again down the track, 3½ inches to the base of the brain, and again Cutler gingerly swung the big magnet down and made contact. The current was switched on and as before we slowly drew out the nail—and there it was, the little fragment of rough steel hanging on to its tip! Much emotion on all sides….

Chapter 2: With the Royal Army Medical Corps in Flanders

Dr. Cushing then proceeded to attend to No. 13 General Hospital in Boulogne, where he met with Sir Gordon Holmes, a neurologist, and Sir Percy Sargent, a neurosurgeon. Here, the census ranged from 500 to 900 patients, much larger than the Ambulance Américaine. These physicians shared their experiences with cranial and spinal cord injuries. Dr. Cushing was most captivated by injuries of the “longitudinal-sinus” from so-called “gutter wounds,” or wounds that resulted from soldiers’ heads being hit by projectiles as they emerged from the protection of a trench. These patients developed rigidity of all four extremities that, incredibly, spontaneously recovered.

Another group of injuries that Cushing had not previously seen were transections of the lower cervical spinal cord, rendering total paralysis, hypothermia, urinary retention, and often death. He remarked on the importance of the notes kept by the treating physicians on injuries to all levels of the spinal cord. In Boulogne, Cushing also described the horrors of soldiers who were victims of chlorine gas inhalation at Ypres.

The day before Cushing was scheduled to return to the US, May 7, 1915, the Lusitania, a British passenger ship, was torpedoed by a German submarine, claiming the lives of 1198 people, many of whom were civilians. Cushing was not deterred from returning to the US. As his ship passed through the “nearly twenty miles” of wreckage the following day, he recounted the horrific scene of floating chairs, boxes, overturned boats, and bodies, including those of a woman and a child seemingly tethered to an overturned collapsible boat.

Chapter 3: The Battle of Boston Common

Although Cushing returned to his previous responsibil-
itites at Harvard Medical School, he remained concerned that the US, in particular the medical professionals, was unprepared for entrance into World War I. He also believed that the US should take a more active stance in the war. He recounted his experiences to his colleagues at a meeting of the Harvard Medical Society, wrote an article for the *Boston Medical and Surgical Journal* about the Ambulance Américaine, and issued a pamphlet on the objectives of the Ambulance response to criticism from the Red Cross. He attempted to assemble groups of medical personnel at various universities that could be called on, if necessary, to return to Europe for medical service without having to go through the hurdle of enrolling in the Medical Reserve Corps. In order to bolster public support for medical relief efforts in the war, in 1917 he proposed to set up a typical base hospital unit in Boston Common. At the time, the US continued to pledge neutrality and Cushing’s proposal was met with profound opposition. He jokingly referred to this episode, as well as his struggles against isolationist politics to create a base hospital unit, as “the battle of Boston Common.”

Chapter 4: With the British Expeditionary Force

On May 30, 1917, Cushing returned to London with a crew of 26 officers, 185 enlisted men, 81 nurses, 1 dietician, and 3 secretaries. He continued on to Camiers, France, where he would spend the next 6 months at No. 11 General Hospital as an operating surgeon. He described it as a “shockingly dirty, unkempt camp,” expressing relief that half of the patients were evacuated prior to his team’s arrival, leaving only 500 to be tended to. Each physician was responsible for 100 patients.

Tensions boiled high with the impending doom of the Battle of Messines Ridge in June 1917, as plans were made for underground explosive devices to be detonated by the British Second Army. Preparations were being made in anticipation of 30,000 heavy casualties. Four army corps with 12 divisions were engaged in this battle, including 11 casualty clearing stations and 3 corps dressing stations. The fields were packed with soldiers, and the roads with machines and guns.

There were fewer casualties than expected, and the men who were unscathed proudly went to bed. On the other hand, the men and children who were injured were gathered into a tent and rapidly attended to. The medical team spoke with a young boy who had stopped to pick up a wounded soldier and in turn was wounded when gunshots struck his pelvis. He was in such bad shape that no surgical procedure could help him as a large portion of his pelvis was displaced. Another officer, was more fortunate, as a Bible in his upper pocket protected him from sustaining a chest wound. During his time in Camiers, Cushing also witnessed victims of phosgene and mustard gas, the former causing fulminant pulmonary edema and death by suffocation, often delayed 48 hours, and the latter causing extensive chemical burns.

Missile-induced cranial injuries were plentiful after the Battle of Messines Ridge. Cushing opined that the outward appearance of these wounds sometimes belied their severity. He described a young boy who sustained a bullet hole to his tin hat, resulting in what, at first glance, appeared to be a small injury. Further inspection revealed that the bullet had actually cut a strip of metal from his helmet “as though by a can opener,” which curved through the temporal bone over his ear, passing through the brain, and emerging posterior to the external angular process, on its way transecting the middle meningeal artery.

Chapter 5: The Passchendaele Battles

In July 2017, Cushing was moved from No. 11 General Hospital in Camiers to No. 46 Casualty Clearing Station in Proven, Flanders, in preparation for casualties of the Passchendaele battle, also known as the Third Battle of Ypres. The days were long. “Operating from 8.30 a.m. one day till 2.00 a.m. the next; standing in a pair of rubber boots, and periodically full of tea as a stimulant, is not healthy. It’s an awful business, probably the worst possible training in surgery for a young man, and ruinous for the carefully acquired technique of an older.” By mid-August, Cushing was performing seven to eight 2-hour cases per day.

Cushing began his craniotomies by removing a bone flap around the penetrating wound, and then inserting a Carrel syringe into the bullet track to both wash it and suction out bone and bullet fragments. He continued to use his nail-and-magnet contraption to retrieve metal fragments from the brain and ventricle; instilled dichloramine-T, an antiseptic, down the bullet track; and became convinced that primary closure of a cleansed cranial wound was far superior to delayed closure. These techniques were essential in the preantibiotic era, especially because of the dirty nature of shrapnel wounds and the amount of time that elapsed, sometimes up to a week, before soldiers received medical care. Cushing recounted one such gentleman, O. Butler, a rifleman from Banbury who was a bricklayer prior to the war. “He had an awful-looking, not to say evil-smelling, gutter wound” and had been lying for a week in a shell hole before he was found by soldiers from a subsequent attack wave. We do not know the fate of Mr. Butler, but Cushing felt confident he would survive.

On August 30, Cushing received a message that Sir William Osler’s son Edward Revere Osler had been severely wounded and Cushing’s presence was requested. Cushing immediately traveled to the boy, finding him with wounds through the chest, abdomen, and thigh. Despite emergency surgery, Revere died, but his parents were grateful that Cushing, with whom Revere was familiar, was with him in his last moments.

On September 6, Cushing received word that the American unit at Base Hospital No. 5 had been bombed and several colleagues had been killed. Cushing toured the site, noting that it had been hit by five “daisy-cutter” bombs, a type of bomb that explodes in the air just before impact, with the intent of maximizing destruction.

From August through October, the combination of craters formed by shelling and heavy rains turned the battlefields into muddy swamps and pools that were progressively difficult for troops to traverse. It was not uncommon for fallen men to drown in such craters before they could be extracted. As conditions worsened, fewer men and only those with minor injuries presented for care, leaving Cushing to surmise, “either we were driven back and left...”
our more serious wounded, or else only the walkers survived to get away and out of the mire.” The battles in these later months resulted in steeper losses with less ground gained. Finally, on October 31, after 4 months of service and witnessing 13 battles, Cushing was ordered to return to Boulogne. The 5th Army, with which Cushing served, sustained 140,000 casualties during his time in Flanders. Both the British and German armies sustained heavy casualties, numbering between 200,000 and 400,000 men on each side.

Chapter 6: In Winter Quarters: Boulogne

As the weeks passed, Dr. Cushing’s attention shifted toward improving soldier morale and enhancing nutrition. He stated, “my chief concern being to keep the group together … to induce a collection of war-weary individuals to live amicably together longer than six months is no light task....” On a nightly basis, Dr. Cushing cooked his own suppers, ranging from corned beef hash to Campbell’s soups, with dessert being a cup of hot cocoa. In an attempt to heighten morale, the hospital hired a bonne (maidservant), who helped with food preparation and general cleanup such as making the beds. While in Boulogne, Cushing first described the symptoms of what many have later thought was trench, noting “shivery sensations, aches, and a weaened brain.”

Although Cushing was no longer on the front lines, he was involved in educational programs and research to improve the care of the soldiers. Once a week, the medical staff held teaching conferences, often on the topic of wounds. Cushing was also involved in commissions formed to study trench fever (a louse-borne illness common during World War I) and gas gangrene and attended monthly Research Committee meetings in Paris.

Christmas soon approached, much to the pleasure of Dr. Cushing, who noted that the toll of the war was dragging on and affecting the emotional and physical well-being of the soldiers. Christmas dinner for the troops was a buffet supper with abundant turkey pie, followed by the distribution of presents by a soldier dressed as St. Nick and comedic skit performances that helped to lighten the mood (Fig. 2).

After the holiday, Cushing attended to the ailing Lieutenant Colonel Dr. John McCrae, the Canadian poet and physician who served as both a soldier and surgeon during World War I, penning the well-known poem “In Flanders Fields.” McCrae had developed an “atypical pneumonia” and died 3 days later of pneumococcal meningitis on January 28, 1918, at the age of 45 years.

Chapter 7: The German Spring Offensive

On March 21, 1918, Cushing and the others at Boulogne received word that the Germans had begun to attack just south of Arras, with the intention of driving their line toward Amiens, effectively creating a wedge between the French and British armies. As these battles carried on, Cushing traveled between several hospitals operating on patients with cranial injuries. Finally, he was transferred to a casualty clearing station near Pernes in anticipation of wounded troops. Arm and leg amputations, more gunshot wounds to the head, and rigid extremities due to spinal cord injuries were common. A critical attack threatening Hinges Bridge at Bethune left an aftermath of multiple severe brain injuries due to penetrating shells. Triage was incredibly important. Cushing received some criticism for performing operations more meticulously and slowly than colleagues; whereas his colleagues may have completed 15 to 20 procedures during a shift, he would often complete only 8 to 10, but he believed that it was not worth undertaking an operation unless it was done well with a reasonable...
chance of success, and his patients were more likely to have meaningful recoveries. Unfortunately, this also meant that several patients died of their injuries in his waiting rooms.5

Chapter 8: The German Offensive Continues

On May 17, 1918, Germany launched another attack across a 40-mile front between Soissons and Reims. The No. 1 Canadian General Hospital was bombed, resulting in 59 deaths, including 1 officer and 3 sisters, with another 99 wounded. Two weeks later, the No. 3 Canadian Stationary at Doullens incurred a direct hit, “absolutely in the center of a red cross painted on the roof.” The four-story building was completely demolished, taking with it a surgical team operating on an officer. Several other hospitals were bombed, and air raids terrorized the personnel at Cushing’s hospital in Boulogne, although they incurred no substantial damage. During this phase of the war, the French lost 30,000 hospital beds. If these attacks caused Cushing concern for his own safety, it is not mentioned in his journals. In June, Cushing was transferred to Paris by order of the American Expeditionary Forces to work as the senior consultant for neurological surgery.

Chapter 9: Stemming the Tide

The Second Battle of the Marne, the last major German offensive of World War I, ended on July 15, 1918. The Germans attempted to capture Reims and split the French army but were met with significant resistance by the French army, aided by British, American, and Italian armies. The offensive was called off on July 18, and the Allied troops began a counteroffensive, resulting in heavy losses by the Germans and retreat. During this time, Cushing worked primarily out of Neufchâteau but traveled to several different field hospitals, bemoaning their understocked and unprepared conditions (Fig. 3).

Although Dr. Cushing dedicated his wartime service to helping others, he fell victim himself to an illness that historians have attributed to trench fever. He first described a febrile episode in August 1918 along with “an acute 2-diplopia presbyopia which has rushed on me in a period of ten days, an accompaniment of the muscular enfeeblement of the grippe [a term commonly used for the Spanish flu, which spread in World War I].” He had a recurrence of his weakness in October, followed by numbness in the arms and legs that lasted 6 weeks, and then spontaneously recovered but kept him largely bedbound.

In an interesting trip at the end of August, Cushing recounted a meeting with neuropathologist Gustave Roussy to visit Salins, a hospital dedicated to treating patients with “psychoneuroses,” feigned contractures or paralyses intended to keep the sufferer from returning to active duty. At this facility, the patients were treated with a brief séance that sometimes cured them of their ailments. The cured were sent back to military service, while those with more refractory illness underwent additional treatment.

Chapter 10: Reducing the Saint-Mihiel Salient

The Allies gained ground, and the Germans continued to retreat. During this period, Cushing commented little on his operative load. He instead visited other hospitals and medical and military personnel with the intention of improving medical care for the wounded. On September 12, 1918, the US led a successful attack against a contingent of Germans in the Battle of Saint-Mihiel, resulting in their further retreat.

Chapter 11: The Meuse-Argonne Offensive

The Meuse-Argonne offensive was the largest operation of the American Expeditionary Forces in the war. Unfortunately, it was the deadliest campaign, with more than 26,000 American soldiers killed and 130,000 injured. Cushing traveled to Fleury, where he oversaw the treatment of neurosurgical patients at Mobile Hospital No. 6, remarking that he performed one cranial procedure “and

with the help of poor eyes did it very badly.” In early October, he traveled to Paris for his monthly Research Society meeting but was unable to return to Fleury due to the recurrence of the illness he had in August. It took Cushing 6 weeks to recover from this ailment, by which time World War I was over.

On November 11, 1918, the day of the armistice agreement that ended World War I, Cushing wrote:

La dynastie des Hohenzollerns a ete balancee [The Hohenzollern dynasty has ended]: but in this process some twenty millions of human beings have perished or been mutilated, and who is to be held responsible for this? The terms of the armistice were signed early this morning, though the signal to “cease fire” was not given until 72 hours were up, viz, at 11 am. In these last few hours many poor fellows must have needlessly fallen.

Cushing expressed relief at the end of the war, but also prescient apprehension that despite claims “that this was the war to end all wars … We wonder.” Certainly, he remarked, there was much rebuilding to do. The published diary ends on an encouraging note:

And these shall be no easy idle ears,

For only by the toil of stubborn men,

Of women toiling stubbornly with men,

Shall earth attain her heritage of dreams.

Challenges and Successes

Dr. Cushing’s contributions toward improved neurosurgical care in World War I were not obtained without struggles. He openly criticized British surgeons on numerous occasions, and he wrote a letter with such castigation that it was intercepted in the mail. This was viewed as a major military censorship violation as it could have given the enemy valuable information. It was recommended that because of his repeated infractions (4 major and at least 5 minor violations in a 9-month period), Dr. Cushing be sent to prison at Fort Leavenworth. He was fearful of any court-martial, and he was eventually granted a pardon given that his neurosurgical prowess was much needed during the war and the authorities believed he simply was not aware of the rules.

Although many details of Cushing’s neurosurgical techniques are not explicitly discussed in From a Surgeon’s Journal, he published four papers after the war that are often credited as laying the groundwork for the modern treatment of penetrating head injuries. Prior to his work, penetrating head wounds were often incompletely debrided, dressed, left open to drain, and treated with antiseptics and then closed secondarily. The mortality rate for this procedure was 44% to 60%. When Cushing began operating on penetrating head wounds, his mortality rate was similarly 55%, but it decreased to 29% by the third month of his work. He attributed his success to complete shaving of the head to identify all wounds, preoperative x-ray to identify bullet fragments, removing a bone flap surrounding the site of penetration, detecting and removing fragments of bone with suction applied through a soft rubber catheter, removal of “pulped” brain along the missile track by suction, instillation of the wound with dichloramine-T dissolved in oil along the missile track, removal of bullet fragments (by use of a magnetized nail) when possible, and primary closure. During the war, opening intact dura to remove underlying pulped brain was considered controversial, but Cushing advocated for this, likely preventing delayed herniation by creating space for the injured and swollen brain. These methods were the culmination of lessons he learned from his experiences and those of other wartime surgeons, and they significantly increased the survival of soldiers with cranial wounds. Several of these methods, apart from aggressive attempts to remove retained bullet or shrapnel fragments, are still used in surgery for penetrating head wounds today.

Conclusions

In many ways, World War I shaped the modern world, and neurosurgery is no exception. Dr. Cushing’s journal and postwar papers not only provided the neurosurgical community with practical advice regarding the surgical treatment of penetrating cranial trauma but also provide an intimate look into the thought processes of a brilliant, kind, and fearless man. It is by no accident that he is considered the father of our field, as he provided a model to which we all might aspire.

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Author Contributions

Conception and design: all authors. Acquisition of data: all authors. Analysis and interpretation of data: all authors. Drafting the article: all authors. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Kosty. Administrative/technical/material support: Kosty. Study supervision: Kosty.

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