With few exceptions, injuries to airmen, infantrymen, and sailors are similar surgically and are treated in the same way. Why should there not be a medical corps for the armed services, instead of three separate organizations with duplication of hospitals, supplies, and personnel? The only reason, it seemed to me, was the selfish desires of men to establish their own empires.

Lo y aL Da v i s

Surgeons deployed to a combat zone face numerous unique challenges. The work environment represents perhaps the greatest stressor—facing the frequent influx of new casualties often with extreme injuries in the setting of a completely new surgical practice consisting of inexperienced support staff and equipment that is likely to have been selected by a supply officer. Add to this the challenge of ordering replacement supplies through a logistics chain designed to deliver tanks and mortars to the front lines, and you can begin to appreciate the mindset of Loyal Davis in his service as a combat consultant in neurosurgery during World War II.

All biographical accounts of this great surgeon note the important contributions he made in the areas of frostbite care and protective headgear as well as his survey of the Soviet military medical system. These contributions were unfortunately colored by the extreme frustration he experienced working within the monolithic bureaucracy of the Army. This frustration notwithstanding, Davis continued his efforts to improve combat casualty care even after he hung up his uniform, by using his influence as a prominent academic surgeon. Although over 65 years have passed since Davis’s service, his military experience and contributions to combat casualty care hold valuable lessons for modern combat surgeons. This article details the experiences that shaped Davis prior to and during his service as a combat consultant and then discusses his postdeployment contributions and their relevance to combat casualty care today. Recent examples of similar contributions by combat surgeons are also discussed along with applications for surgeons in today’s military.

Abbreviations used in this paper: ACS = American College of Surgeons; JTTS = Joint Theater Trauma System; MEDCOM = US Army Medical Command; SOS = Services of Supply; USCENTCOM = US Central Command.

Combat surgeons before, during, and after war: the legacy of Loyal Davis

JEREMY W. CANNON, M.D., S.M.,1 AND RICHARD J. TEFF, M.D.2

1Department of Surgery, Wilford Hall Medical Center; and 2Division of Neurosurgery, Brooke Army Medical Center, San Antonio, Texas

By 1942, Loyal Davis had firmly established himself as a preeminent civilian neurosurgeon. With military operations rapidly escalating, he was recruited to serve in the European Theater of Operations as a consultant to the Surgeon General. Davis brought tremendous experience, insight, and leadership to this position; however, he found the military system in which he was suddenly immersed inefficient and impassive. His requests for even basic equipment became mired in endless bureaucracy even as his communiqués to the Chief Surgeon in the European Theater and to the Surgeon General’s staff in Washington seemed to fall short of their intended recipients. Then, when he attempted to vent his frustrations to his academic colleagues, he was nearly court-martialed. Notwithstanding, Davis became the first to formally recognize high-altitude frostbite and also developed protective headgear for airmen, and later in his service, he joined a contingent of senior medical leaders who visited the Soviet Union to study their system of combat casualty care. Subsequent to his service on active duty, Davis returned to his academic practice at Northwestern where he used his position as editor of Surgery, Gynecology, and Obstetrics to advocate for change within the military medical corps. Others like Davis have contributed greatly to the advancement of combat casualty care both during active service and long after their time in uniform. This paper examines the lessons from Davis’s experiences as a military neurosurgeon and his continued advocacy for change in the medical corps along with additional recent examples of change effected by former military surgeons. For those currently serving, these lessons illustrate the value of contributing wherever a need is recognized, and for those who have served in the past, they demonstrate the importance of having a continued voice with junior combat surgeons and the military leadership. (DOI: 10.3171/2010.2.FOCUS1024)

KEY WORDS • Loyal Davis • military neurosurgery • combat casualty care • surgical consultant • lessons learned
Academic Career

Many biographical works have expertly chronicled the remarkable career of Loyal Davis, including an entire issue (Volume 157, 1983) of *Surgery, Gynecology, and Obstetrics* (now *Journal of the American College of Surgeons*), which honored the long-time editor upon his death. The son of a railroad engineer from a small town in Illinois, Davis graduated from Northwestern University Medical School in 1918 even as the US involvement in the Great War was escalating. Following graduation, Davis undertook graduate studies in neuroanatomy that led to his being awarded the first doctor of philosophy degree from Northwestern University Medical School.

During this time, he was trained in surgery by Alan B. Kanavel who famously described the physical signs associated with flexor tenosynovitis. Kanavel had come to Northwestern in 1908 and was the chief of the Division of Surgery. He had arranged Davis’s graduate work in neuroscience and encouraged his young protégé to undertake further clinical training under Harvey Cushing. So, in 1923, Davis traveled to Boston where he worked as an associate to Cushing both observing and assisting on a number of neurosurgical procedures. Cushing had served in World War I as a volunteer surgeon, as the director of Base Hospital No. 5, and as the senior consultant in neurosurgery to the American Expeditionary Force, and he ran his neurosurgical service at the Peter Bent Brigham with military discipline. Cushing’s pursuit of excellence in every endeavor profoundly influenced Davis who emulated “the big boy” in many respects throughout his surgical career.

Upon his return to Chicago, Davis established the first neurosurgical service in the city and organized a formal department of surgery at Northwestern of which he became the chairman in 1932. During this time, Davis was appointed associate editor of *Surgery, Gynecology, and Obstetrics* by his mentor Kanavel. He then rose to editor-in-chief in 1938, a position he held until 1982.

During this time, he authored *Principles of Neurological Surgery* and maintained an active research laboratory in partnership with his colleague Lewis Pollock. Despite these numerous clinical and administrative responsibilities, Davis faithfully taught the Northwestern medical students and mentored numerous young surgeons, many of whom served in the 12th General Hospital based first in North Africa and then in Italy during World War II.

In the European Theater of Operations

On July 5, 1942, Davis met with the chief surgical consultant to the Surgeon General, Fred W. Rankin, who recruited him to join the staff of expert consultants in the European Theater. On August 20, Davis was commissioned a lieutenant colonel in the US Army (Fig. 1), and on September 6, he joined the staff of medical consultants in Cheltenham, England, with other prominent figures in American surgery including the chief consultant in surgery, Elliott Cutler. Like the other consultants recently commissioned from civilian practice, Davis was given no clear direction but rather defined his own role.

He felt compelled to mentor junior surgeons who had been tasked with caring for neurosurgical injuries and to survey the state of combat casualty care.

During the first 3 months of his service, Davis made a series of recommendations regarding hospital staffing and the need for critical equipment in the general hospitals including suction devices for the operating rooms. None of these recommendations seemed to reach the chief surgeon, Paul Hawley, who worked for the Services of Supply (SOS) and could effect such changes. Instead, Davis’s recommendations “were passed back and forth or conveniently filed by a personally hostile medical officer who openly boasted that he would put the new lieutenant colonel specialist consultants in their place.” In a series of events reminiscent of Joseph Heller’s *Catch 22*, Davis compiled his memoranda from the previous 3 months and addressed them to General Fred Rankin in Washington DC; J. Roscoe Miller, dean of Northwestern University Medical School and later president of the university; and Howard Naffziger, chairman of the Department of Neurological Surgery at the University of California, who had a close relationship with the National Research Council (R. Davis, personal communication, 2010). These packages were intercepted by censors who charged Davis with attempting to circumvent the channels of military communication and with violating the rules that allowed him to censor his own mail. He was notified of his imminent
court-martial on Christmas Eve, 1942. Ironically, these charges resulted in a short-order face-to-face meeting with Chief Surgeon Hawley, in which Davis was assured that a court-martial would not be convened. Hawley ultimately implemented changes within his staff that subsequently permitted more effective communication with his consultants, and Davis went on to make important contributions in the diagnosis and management of frostbite injuries in aircrew members and in the development of protective headgear for aviators.

**Frostbite and Aircrew Helmets**

At the time, frostbite was a well-known medical scourge among ground troops. However, frostbite had never been identified as an injury to which aircrews were vulnerable. Davis was one of the first to pick up on this novel mechanism of injury by taking the time to carefully interview one aircrew member whose hands initially were thought to have been blistered from a cabin fire. In fact, on further questioning, this crewman related that he had not been burned when his aircraft crashed. Prior to the crash, he had actually taken off one of his electrically warmed gloves to relieve himself at altitude, and his hand was almost instantly frozen.

After describing this injury mechanism, Davis began to carefully document a number of similar cases. He also began to question the standard treatment for these injuries. At the time, frostbite was treated either by rubbing the extremity with ice or snow as originally advocated by the French surgeon Baron Lerray or by other means of continued cooling including placing the affected extremity in a CO₂ “therapeutic refrigerator.” Davis postulated that warming the affected extremity to room temperature was a superior approach. To clarify this controversial issue, he devised a case-control study to evaluate these
Disparate treatment approaches, and in fact, one of his patients even served as his own control given his bilateral, symmetric injuries. His results showed that patients treated with passive warming to room temperature had less pain and subsequent tissue loss than those treated with the widely accepted approach of continued cooling.

Davis’s findings ultimately shifted the therapeutic paradigm from cooling to rewarming, which ultimately gave way to rapid, active rewarming based on further work by Fuhrman and others. Interestingly, peoples of the Himalaya had been treating frostbite with active rewarming for many years despite the efforts of Westerners to discourage this practice. When Davis attempted to alert the Army Air Corps to this injury mechanism and his recommended treatment, he met resistance. Malcom Grow adamantly denied the possibility of this problem and even acknowledged this problem and even claimed to have discontinued treatment, he met resistance. Malcom Grow had commissioned a British armorer to develop a protective suit of metal for use by the aircrews, having rejected Davis’s plastic liner on the grounds that it was inadequate. When the suit was presented to the aircrews, they reportedly objected vehemently, suggesting that General Grow be required to bail out over the North Sea in the suit himself. In a series of presentations made to the Surgeon General of the Army, Norman Kirk, and his staff in the fall of 1943, Davis was ultimately able to gain the support he required to care for both high-altitude frostbite injuries and to further develop protective helmets for aircrew members.

**Mission to the Soviet Union**

In June 1943, Davis embarked on a mission to the Soviet Union with Elliott Cutler, Wilder Penfield, and 4 British professors of surgery (Fig. 3). The mission objective was to study the Soviet system of combat casualty care to glean information about important advances that could be applied in our own military hospitals. At the time, there was a general feeling of trust and camaraderie toward our Soviet allies, who were perceived as practicing highly advanced surgical care, and the mission members were eager to observe first-hand the management of the numerous casualties on the eastern front. The mission found that in contrast to popular opinion, with regard to neurosurgery, the techniques used by the Soviets were from World War I and that Soviet researchers at the Institute for Neurological Surgery had likely fabricated overly optimistic clinical results on formalin-fixed nerve grafts for peripheral nerve injuries. In his report on the activities of the consultants, Davis frankly observed that their Soviet hosts “appeared to be like 10-year-old American boys who brag about the size of their houses and chimneys and recklessly claim that their fathers can lick anyone.”

On a more positive note, Davis commented that “when organization alone was considered, the Soviet plans were efficient and superior.” In the Red Army, the Surgeon General answered directly to the People’s Commissariat for Defense and the chief of staff of the Army without any intermediaries. Within this system, the Surgeon General was made aware of each planned combat operation and could theoretically prepare for the medical requirements with the authority and resources at his disposal to make such preparations. Davis later admonished the American military medical corps to adopt a similar streamlined structure in a thinly veiled commentary on the bureaucratic quagmire all of his previous recommendations had encountered.

For his faithful service and remarkable contributions to the care of injured soldiers, Davis was awarded the Le...
Combat surgery: the legacy of Loyal Davis

gion of Merit. In the spring of 1944, Davis returned to his position as chairmain of the Department of Surgery at Northwestern, and in the ensuing years, he became widely recognized as one of the most important figures in American surgery. He held the presidency of the American Surgical Association (1957) and the American College of Surgeons (1962–63), served as Chairman of the Board of Regents of the American College of Surgeons (1960), and was a founding member of the American Board of Surgery and the American Board of Neurosurgery. In fact, in the introductory remarks of the special issue of *Surgery, Gynecology, and Obstetrics* dedicated to his life, Davis was labeled the “20th Century American Crown Prince of Surgery.”

Encore Recommendations in the Civilian Medical Literature

In his position as editor of *Surgery, Gynecology, and Obstetrics*, Davis was in a unique position to make ongoing contributions to the Medical Department of the Army following his active-duty service. In this capacity, Davis chose to comment on what he perceived as the root cause of the many difficulties he faced during his service: the organizational complexities and inefficiencies in the US Army Medical Corps. In a series of 2 editorials aimed at addressing this problem, Davis marveled that “the Medical Department of the United States Army performed its tasks in an outstanding manner in this War against almost insuperable difficulties, handicaps, and obstacles which were placed in its way by a complex organization.”

In stark contrast to the vertical command structure of the Red Army medical organization, the US Army Medical Corps was burdened by decentralized inefficiency. Since 1918, the US Army chief surgeon was headquartered in the SOS and served essentially as an advisor to the field general, who ultimately “owned” all medical assets. Davis charged an apathetic cadre of civilian surgeons after World War I as partly responsible for the persistence of this convoluted, decentralized organization: “They universally recognized the errors in organization of the Medical Department committed in World War I, but upon their return home they were anxious to forget their tribulations of war and eager to resume their professional lives.” Furthermore, the national academic surgical organizations “made no attempt to learn of the problems and plans of the Medical Department in case of war...” Consequently, “… any criticism of … the Medical Department … should not be directed at the Surgeon General of the U.S. Army or his staff. The fault lies in the fundamental anomalous relation of his office to the General Staff and the Army as a whole, which can be corrected only by the War Department.”

Davis advocated a structure in which the Surgeon General has the ultimate control over all matters related to combat casualty care, with a close, direct relationship with the chief of staff of the Army. Nearly 50 years later, Army medicine underwent a series of reorganizations that nearly approximated this structure. In October 1994, the US Army Medical Command (MEDCOM) was officially established under the leadership of the Surgeon General of the Army. This unprecedented unification gave ultimate command authority over all nondeployed Army medical assets to the Surgeon General, who is supervised by the chief of staff of the Army and is responsible to the Secretary of the Army. Lieutenant General Eric B. Schoomaker, M.D., Ph.D., became the fifth MEDCOM commander on December 13, 2007.

Although this structure is significantly streamlined relative to the command structure against which Davis railed, the MEDCOM commander does not control deployed medical assets. This authority still rests with the line of the Army. In the case of Operation Iraqi Freedom and Operation Enduring Freedom, the US Central Command (USCENTCOM) commander, General David Petraeus, controls all medical personnel, facilities, equipment, and supplies. Among medical officers, the highest ranking are the colonels serving as hospital commanders who in every instance report to their respective nonmedical base commander.

Although the line still officially controls deployed medical personnel, equipment, and supplies, medical care and practice policy is established by a new program, the Joint Theater Trauma System (JTTS). The JTTS was created with the support of the Surgeons General of the Armed Forces, USCENTCOM, the Army Institute of Surgical Research, and the ACS Committee on Trauma with the stated mission of getting “the right patient to the right place at the right time.” This system is led by an in-theater senior trauma surgeon similar to the consultants of Davis’s era. This individual and a small support staff visit the various medical facilities in theater with the goal of disseminating the best current practices of combat casualty care. Simultaneously, the stateside JTTS director develops clinical practice guidelines, which attempt to standardize in-theater medical care using the current best practice. Within this system, one author (R.J.T.) was able to directly impact the training of forward surgeons by teaching them to perform emergency, life-saving neurosurgical procedures under austere conditions. However, even with the JTTS, implementing lasting policy changes, obtaining essential equipment, and changing staffing levels as the tactical situation changes still present challenges and frustrations reminiscent of Davis’s experiences.

The Importance of a Continued Voice

Like Davis in the editorials he authored following his active-duty service, others have made important encore contributions that have changed our combat casualty care for the better by shining a spotlight on the underbelly of the military system. Although in Loyal Davis’s day an undertone of antipathy existed between the so-called regular Army Medical Corps and the newly minted lieutenant colonel and colonel consultants, there is little room for such pretension in today’s military. The vast majority of active-duty surgeons begin their military service directly upon completing residency training and have relatively short commitments, resulting in a significant number of junior surgeons who turn over frequently (Ragel BT, Sholes AH, Taggard DA, Liu JM, Klimo P Jr: Effect of surgeon turnover and deployments on neurosurgical case management. Neurosurg Focus / Volume 28 / May 2010 5
volume at a military hospital. Paper presented at the 58th Annual Congress of Neurological Surgeons. Orlando, Florida, September 20–25, 2009). In addition, with the current operations tempo, many of these surgeons deploy for the first time shortly after entering their first staff position. As a result, the active-duty surgeons in today’s military are generally receptive to the potential contributions and invaluable mentorship that more senior surgeons with combat and civilian trauma experience can provide.

Several recent examples of such contributions bear discussion.

The first example of an essential contribution by a former active-duty surgeon is the scathing article by Dr. Donald Trunkey after the Gulf War titled “Lessons Learned.” In many ways, the medical response during Desert Storm was a shambles. The myriad problems with patient movement, hospital facilities, and predeployment training were detailed in a series of retrospective reports by the General Accounting Office.

Trunkey was activated from the reserves while he was chairman of the Department of Surgery at the Oregon Health & Science University to serve on the staff of the 50th General Hospital during Desert Storm. In his critique of this combat experience, he corroborated the General Accounting Office findings that physician rosters were unfilled, supplies inadequate, patient transport challenges unanticipated, and the medical command and control suboptimal. Furthermore, he confirmed that medical research had not been allowed to be conducted in theater by the command. Trunkey implicated a lack of high-ranking medical officials within the command structure and advocated for a general officer with bona-fide medical experience in theater as capable of addressing both the patient evacuation issues and the absence of research teams. To keep active-duty surgeons and other medical staff current in our military hospitals, he advocated for the establishment of active-duty trauma centers that would accept and care for civilian trauma victims. He also suggested that by forming reserve medical units with a mix of academic and community staff affiliated with academic trauma centers, deployment taskings could be filled with qualified personnel without severely compromising the entire hospital staff during a deployment. In closing, like Davis, Trunkey admonished “representatives from military medicine and the American College of Surgeons” to “jointly devise trauma training programs that would benefit both the civilian and military community.”

Subsequent to the publication of Trunkey’s article, a number of changes were implemented largely from a grass-roots effort to address these shortcomings, and these changes are largely responsible for the great successes of our current system of combat casualty care. Pre-deployment training for surgeons, nurses, and medics is now conducted in collaboration with civilian trauma centers; in-theater transport routes have been dramatically simplified; subspecialty surgical requirements are clearly defined and filled by experienced surgeons; patient care guidelines are established by a consensus of experts and broadly disseminated; civilian consultant surgeons have been called upon to review our process of care; and surgical research teams are now actively engaged in collecting data in the field. To further validate these improvements, the ACS Committee on Trauma recently conducted a site visit to the Landstuhl Regional Medical Center. Led by Trunkey and other senior civilian surgeons, this verification review resulted in Landstuhl Regional Medical Center being granted status as the first ACS Level 2 trauma center outside the US.

Many additional examples of such contributions exist. Norman Rich’s establishment of the combat vascular registry in Vietnam, and his continued service to the Surgical Department of the Uniformed Services University of the Health Sciences has directly saved innumerable lives and inspired a generation of military vascular surgeons. Gerald Grant’s work in traumatic brain injury that began in the Air Force Theater Hospital in Balad, Iraq, now continues in the Department of Neurosurgery at Duke University and promises to better the lives of numerous combat casualty victims. One author (R.J.T.) served for an entire year in Iraq and has since joined the faculty as a civilian surgeon at Brooke Army Medical Center, which will soon be renamed the San Antonio Military Medical Center as it merges with Wilford Hall Medical Center to become the largest military treatment facility and the only Level 1 trauma center in the Department of Defense.

Conclusions

Loyal Davis left his academic post for nearly 2 years to serve in the US Army, during which time he made landmark contributions in the recognition and prevention of frostbite and head injuries among airmen. He struggled mightily with the inefficiencies he faced in attempting to implement change; however, his contributions were ultimately recognized and acted upon. Furthermore, he used his significant influence as a prominent academic surgeon to suggest changes in the military medical structure that have been recently implemented.

Surgeons from modern conflicts have also contributed significantly to the current practice of combat casualty care both in uniform and after their entry or reentry into civilian practice. The insights of these surgeons have proven invaluable in elevating the quality of our combat casualty care and in creating a safe and efficient system of care. Nonetheless, our military system of care remains extraordinarily complex. Within this system, frustrations still arise, and lessons learned have been and will again be forgotten to the detriment of our fellow men and women in uniform. For this reason, there will always be room for those in the mold of Davis who observe and act on opportunities to improve our system of care and who remember long after their active service that, as the French diplomat Clemenceau once said, “War is too serious a matter to entrust to military men.”

Disclosure

The opinions contained in this article are solely the authors’ private ones and are not to be construed as official or reflecting the views of the United States Air Force, the United States Army, or the Department of Defense.

The authors report no conflict of interest concerning the mate-
Combat surgery: the legacy of Loyal Davis

rials 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: Cannon. Acquisition of data: both authors. Drafting the article: Cannon. Critically revising the article: both authors. Reviewed final version of the manuscript and approved it for submission: both authors.

Acknowledgments

The authors thank Ron Sims, special collections librarian in the Galter Health Sciences Library, Northwestern University, for providing the formal portrait of Lt Col Davis, and Dr. Richard A. Davis, son of Lt Col Davis, who provided important historic commentary, photographs, and original artwork which greatly enriched this project.

References
