The Assassination of Abraham Lincoln and the Evolution of Neuro-Trauma Care: Would the 16th President Have Survived in the Modern Era?

Sandra C. Yan, Timothy R. Smith, Wenya Linda Bi, Ryan Brewster, William B. Gormley, Ian F. Dunn, Edward R. Laws Jr

Key words
- Abraham Lincoln
- Elevated intracranial pressure
- Gunshot wound
- Penetrating brain injury
- Trauma care

Abbreviations and Acronyms
CSF: Cerebrospinal fluid
GCS: Glasgow Coma Scale
ICP: Intracranial pressure
PBI: Penetrating brain injury
WWI: World War I
WWII: World War II

Department of Neurosurgery, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts, USA

To whom correspondence should be addressed: Timothy R. Smith, M.D., Ph.D., M.P.H. [E-mail: trsmith@partners.org]

Citation: World Neurosurg. (2015) 84, 5:1453-1457.
http://dx.doi.org/10.1016/j.wneu.2015.06.011

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

1878-8750/$ - see front matter

Abraham Lincoln was the 16th President of the United States of America. On April 14, 1865, shortly after his re-election and the conclusion of the Civil War, Lincoln was shot and killed by John Wilkes Booth. Although numerous physicians tended to the President shortly after his injury, he passed away the next morning. Today, we recognize Lincoln as one of the greatest Presidents in American history. His assassination profoundly influenced the future of the United States, especially as the country was coming back together again following the Civil War. Testaments to his lasting legacy can be seen in many places, from the stone carving of him on Mount Rushmore to his image gracing the $5 bill.

What if the President had survived his injury? Would he have had a different outcome utilizing current critical care treatment? Neurotrauma care in 1865 was not yet developed, and head wounds such as the one Lincoln sustained were almost always fatal. The medical attention he received is considered by historians and physicians today to be excellent for that time. We look at the evolution of neurotrauma care during the last 150 years in the US. Particular focus is paid to the advancement of care for penetrating brain injuries in modern trauma centers.

INTRODUCTION

Abraham Lincoln was elected President in 1860 and served as the 16th President of the United States from 1861 until 1865. During that time, he led the United States through the Civil War and helped pass the 13th Amendment, which officially abolished slavery. On April 9, 1865, General Robert E. Lee formally surrendered to General Ulysses S. Grant at Appomattox Court House, thus ending the Civil War, the deadliest war in American history (1). Less than 1 week later, President Abraham Lincoln would be assassinated by John Wilkes Booth, an actor and known Confederate sympathizer, while he attended a showing of the play, *Our American Cousin*, at Ford's Theater (**Figure 1**). Shortly after 10 PM on April 14, 1865, Booth shot the President in the head at point-blank range before escaping the scene (**Figure 2**) (21).

Lincoln's assassination was "the cause of such mighty changes in the world's history as we may perhaps never realize," lamented Dr. Edward Curtis, an Army surgeon who assisted with Lincoln's autopsy (21). His death had lasting repercussions on the economic, racial, and social landscape of the United States at the time, especially as the nation looked to move forward from the Civil War.

LINCOLN'S EVALUATION AND TREATMENT

The first physician on the scene was Dr. Charles Leale, a young Army general surgeon in attendance that night. Dr. Leale noted that the President was paralyzed, had great difficulty breathing, and had no discernible pulse (30). Dr. Leale had seen Booth wielding a bloody knife, which had earlier been used to stab Major Rathbone, and because of this, initially believed that the President had been stabbed. However, he noticed that Lincoln had a dilated right pupil, which increased his suspicion of head injury, and quickly discovered a bullet entrance wound at the back of the head. Dr. Charles Taft, another Army surgeon who arrived at the scene shortly after, also noted that Lincoln's right eye was protuberant and ecchymotic; both feared that the wound was most certainly fatal (12).

Lincoln was transported expeditiously to the Petersen House (across the street from Ford's Theater), where his personal physician, Dr. Robert Stone, assumed control of the care (2). Stone, and others, astutely observed 2 effects of manual disimpaction of blood clots and brain debris on the President's condition. First, the hemorrhage would reinvigorate, and second, the President was able to temporarily breathe again. At approximately 1 AM, it was noted that he experienced uncontrolled spasms. Both his pupils became fixed and dilated, and it is now generally accepted that he was brain-dead at this time (2). At around 2 AM, Dr. Joseph Barnes, the Surgeon General of the US Army, introduced a blunt probe into the wound in an unsuccessful attempt to locate the missile. Around 6 AM, President Lincoln was suffering sustained bradycardia and extreme dyspnea. The President was declared dead at approximately 7:30 AM on the morning of April 15, 1865.

The autopsy was conducted by Army surgeon Dr. Joseph Woodward, who was assisted by Dr. Curtis. Dr. Woodward


THE NEW YORK HERALD.
IMPORTANT.
THE REBELS.
EXTRA.
DEATH
THE PRESIDENT.

Figure 1. The headline of *The New York Herald* on the morning of April 15, 1865, shortly after President Lincoln's assassination. Available at: http://etc.usf.edu/clippix/picture/lincoln-assassination-newspaper-headline.html. Accessed July 10, 2015.

reported that the lead ball had entered President Lincoln's occipital bone around an inch to the left of the midline. It entered just above the left transverse sinus, which was subsequently opened. After penetrating the dura mater, it passed through the left posterior occipital and parietal lobes of the cerebrum before entering the left lateral ventricle. It finally lodged in centrum semiovale just superior to the left anterior corpus striatum (Figure 3) (21).

There remains much controversy over the path of the bullet, with notes from the various physicians detailing different paths. Dr. Woodward and Dr. Stone believed the bullet was lodged on the left-hand side, while Dr. Barnes and Dr. Taft thought the ball ended up on the right side (12). This discrepancy could be attributable to the emotional duress and sleep deprivation experienced by the physicians, as well as the fact that the bullet fell accidentally from the skull as the brain was removed from the calvarium. As Dr. Curtis noted in a letter to his mother, "not finding [the bullet] readily, we proceeded to remove the entire brain, when, as I was lifting the latter from the cavity of the skull, suddenly the bullet dropped out through my fingers and fell, breaking the solemn silence of the room with its clatter, into an empty basin that was standing beneath" (21). Many medical historians today, however, believe that the bullet crossed the midline and lodged in the posterior right orbit. The observed right orbital ecchymosis and protuberance support this conclusion (25).

Additionally, the bullet fractured both orbital plates of the frontal bone and retropulsed some of these fragments into the frontal lobes, which led to hemorrhagic accumulation within the bilateral orbits. The bullet track was flanked by multiple large hematomas and bone fragments. Intraventricular hemorrhage, laceration of the left cerebral hemisphere, and bilateral holohemispheric subdural hematomas also were discovered at autopsy.

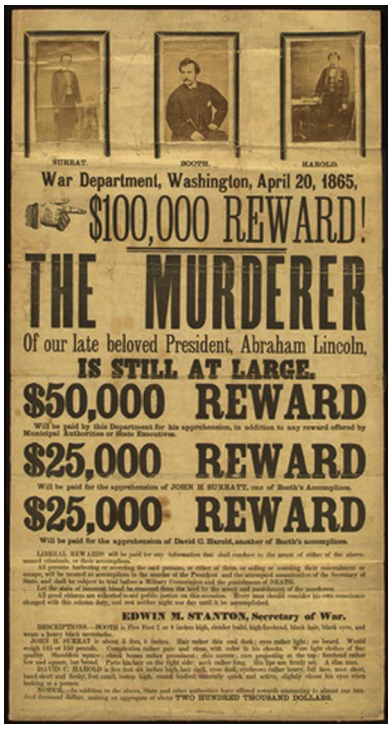
War Department, Washington, April 20, 1865.
$100,000 REWARD!
THE MURDERER
Of our late beloved President, Abraham Lincoln,
IS STILL AT LARGE.
$50,000 REWARD
$25,000 REWARD
$25,000 REWARD
EDWIN M. STANTON, Secretary of War.

Figure 2. A poster from the War Department announcing a reward for the capture of President Lincoln's assassin, John Wilkes Booth, and Booth's accomplices. Available at: http://www.loc.gov/exhibits/treasures/trm075.html. Accessed July 10, 2015.

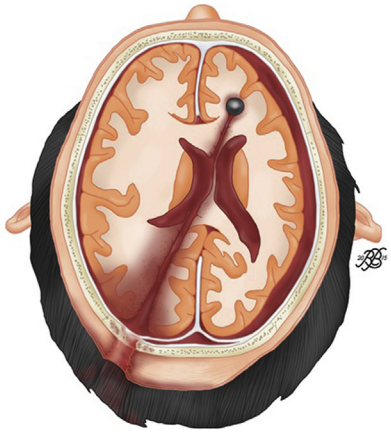

Figure 3. A reconstruction of the projected bullet pathway.

HISTORICAL HEAD INJURY IN MODERN TERMS

President Lincoln's massive subdural, intraparenchymal, and intraventricular hemorrhages, coupled with inadequate oxygenation secondary to bradycardia and irregular breathing, would have produced significant elevations in intracranial pressure (ICP). Contemporary management of increased ICP includes ventriculostomy and placement of an external drain to measure and alleviate intracranial hypertension. Hematoma obstruction of President Lincoln's traumatic "ventriculostomy" track likely exacerbated the increased ICP, leading to transtentorial herniation and brainstem compression, with the consequent sequelae of labored breathing and bradycardia (Figure 4). Mechanical removal of these clots allowed the ventriculostomy track to be reopened, ICP to decrease, and respiration to transiently improve. Although removal of the blood clot at the bedside transiently decreased ICP, it also led to increased blood loss and contributed to traumatic shock. It is generally accepted that Lincoln died as a result of cerebral herniation and shock (31).

The amount of mechanical and thermal injury caused by a missile is directly related to its kinetic energy (kinetic energy = $^1/_2$[mass][velocity]^2). Booth's weapon was a .44-caliber single-shot Derringer (Figure 5) (21). It was a low-velocity weapon, and the ball traveled at roughly 400 ft/s (25). To put that into perspective, arrows usually have a velocity of 120–250 ft/s, while the muskets used in the Civil War had a velocity of 1400 ft/s. The rifle President John F. Kennedy was assassinated with had a velocity of roughly 2500 ft/s (30, 33). With low-velocity gunshot wounds, the primary mechanism of damage is mechanical tissue disruption. Occasionally, there are secondary missiles (bone or bullet fragments) that can also move radially through brain tissue and cause collateral damage, although this secondary damage is more prevalent with high-velocity bullets (typically greater than 2000 ft/s). High-velocity missiles also produce