

Anne Miller

## The Advancement and Legacy of Battlefield Surgery During World War One

In the World War One era, medicine and surgical advancements were a crucial aspect of survival on the battlefield. During the war itself there were a total of 22,062,427 casualties giving World War One a reputation as one of the deadliest wars in history. In the United States alone 323,018 men were injured or killed between 1914 and 1917<sup>1</sup>. New brutality paired with more advanced technological forces led to a severe number of casualties that ultimately forced a change in the medical field. Surgery rapidly advanced and expanded during World War One producing a new era of medicine. The vast increase in seriously injured patients pushed surgeons, physicians, and many other medical specialists to utilize and often invent new ways to treat wounds. The need for new surgical techniques and methods on the World War One battlefield opened a path to the modern post-war world of medicine. The legacy of World War One medicine is one of the most influential to the medical world and the advancements improved conditions in many areas of expertise. Battlefield surgery during World War One helped significantly advance the field of medicine through the evolution of plastic surgery, the enhancement of the use of anesthesia, and the development of new surgical techniques.

World War One battlefield facial injuries, a result of the new brutality as well as the increased use of shrapnel, sparked the evolution of restorative plastic surgery and allowed for soldiers to more confidently reenter society after war. An advancement in weapons and technology resulted in a bloodier and overall significantly more dangerous war not only for the Americans, but for each participating nation. Unprepared and inexperienced, surgeons on the battlefield during the early stages of war attempted to treat soldiers with shattered faces and severe nose, lip, and eyelid injuries from explosions or gunshots<sup>2</sup>. Shrapnel, the cause of most

---

<sup>1</sup> "WWI Casualty and Death Tables." PBS. [http://www.pbs.org/greatwar/resources/casdeath\\_pop.html](http://www.pbs.org/greatwar/resources/casdeath_pop.html).

<sup>2</sup> Sharan, Sharma. "Clashes, Wars and Plastic Surgery." Journal of Young

facial injuries during the war, ripped through skin unlike bullets and tore severe gashes in soldiers' faces upon impact. The metal shards often left faces blown apart and deconstructed completely<sup>3</sup>. Along with shrapnel blast injuries many soldiers dealt with severe burns, explosions, or gunshot wounds<sup>4</sup>. Surgeons were forced to use what they had in medical tents to invent new ways of effectively constructing human faces for the thousands of soldiers with severe facial impairments. Plastic surgery masks, originally designed by Dr. Harold Gillies, became one of the most popular methods of treatment for victims of severe facial trauma in the early 1900s. Healing masks became increasingly important for many soldiers who wished to avoid more extensive surgery as well as for those who wished for a more permanent facial mask after plastic surgery. The masks were crafted individually to cover gunshot wounds, shrapnel blast injuries, or any other facial damage. Without masks, gaping facial wounds were exposed ultimately prohibiting soldiers from confidently re entering society; however, with customized masks soldiers had the opportunity to look as close to normal as possible<sup>5</sup>. Even though the extremely swollen skin that resulted initially from the plastic surgery was unattractive, the scars and swelling faded over time and could easily be covered by a healing mask<sup>6</sup>. Pictures of men with and without their masks reveal drastic differences in facial appearances as well as the surgeon's goals to replicate a soldier's facial features with precision<sup>7</sup>. World War

---

Investigators. <http://www.jyi.org/issue/clashes-wars-and-plastic-surgery/>.

<sup>3</sup> "How Do You Fix a Face That's Been Blown off by Shrapnel?" BBC.  
<http://www.bbc.co.uk/guides/zxw42hv>.

<sup>4</sup> "Pioneering plastic surgery records From First World War." The Telegraph.  
<http://www.telegraph.co.uk/history/9396435/>

[Pioneering-plastic-surgery-records-from-First-World-War-published.html](http://www.telegraph.co.uk/history/9396435/Pioneering-plastic-surgery-records-from-First-World-War-published.html).

<sup>5</sup> *A Healing and Harrowing Mask*. Photograph. *All That is Interesting*.  
<http://www.smithsonianmag.com/history-archaeology/mask.html>.

<sup>6</sup> "Pioneering plastic surgery records From First World War." The Telegraph.  
<http://www.telegraph.co.uk/history/9396435/>

[Pioneering-plastic-surgery-records-from-First-World-War-published.html](http://www.telegraph.co.uk/history/9396435/Pioneering-plastic-surgery-records-from-First-World-War-published.html).

<sup>7</sup> *World War One*. Photograph. Pinterest. <https://www.pinterest.com/pin/123426846013688418/>.

One had an immensely significant impact on the development of plastic surgery and the skills learned during the war formed the base of surgical techniques used in modern day medicine.

One of the most influential plastic surgeons during the World War One era, Dr. Harold Gillies developed many of the facial aesthetic techniques that led to the evolution and advancement of plastic surgery in the United States through his invention of the tube pedicle technique and his dedication to the soldiers. Though born in New Zealand and positioned in the British Army, Gillies invented many of the most prominent and effective techniques used in American plastic surgery during the war and still today. Treating 2,000 patients in the Battle of Somme alone, Gillies worked from a plastic surgery specific hospital in Sidcup, England. He strove to restore not only the soldiers' lost facial features but also their previous function. His commitment to the field significantly helped plastic surgery develop into a necessary rather than discretionary part of war altogether. The lack of antibiotics, however, made surgery on the battlefield a risk and forced Gillies to try new methods to prevent infection. Early in his time on the battlefield Gillies had major success healing Lieutenant William Spreckley's gunshot wound. The gunshot left a gaping hole in the center of Spreckley's face where his nose would be. Gillies intuitively attempted the process of taking cartilage from the rib and implanting it in the forehead knowing the tendency of rib cartilage to create new and useful skin cells. After a blood supply in the forehead formed, Gillies attached the cartilage into the nose position. After a few months of healing, Gillies removed the excess tissue, and Spreckley left the hospital with a new and healing nose. Gillies's technique of taking cartilage from the rib is one that advanced surgery and is a technique that surgeons often use in medicine today. Gillies also discovered that in plastic surgery, skin must be transferred in small amounts to decrease the risk of serious infection. Because of lack of antibiotics for infections, there were many failures in plastic surgery on the battlefield that often resulted in death. Gillies realized the risk of infection and knew that to be successful he must keep the skin alive by constantly having it connected to the place it originated. From past experiences with surgical failures because of infections, Gillies created

the tube pedicle technique. One of the most innovative surgical techniques of its time, the tube pedicle technique involved cutting a flap of skin and rolling it into a tube to be wrapped around to a desired location. Leaving one side of the roll attached to the skin and rolling the skin into a tube greatly prevented infections and gave the transferred skin a waterproof exterior. Gillies left the pedicle to heal for several months with less risk than previous methods, and once a blood supply formed he could manipulate the flesh into the desired position<sup>8</sup>. Even though soldiers often looked odd after the tube pedicle treatment it decreased the risk of plastic surgery and healed miraculously<sup>9</sup>. Because of his commitment to the soldiers, the medical world, and innovation Dr. Harold Gillies created new surgical techniques that advanced the way surgery was practiced on and off the battlefield.

During the World War One era, advancements in anesthesia developed quickly because of an increase in trauma surgery and a greater need for a more improved method of pain relief. Before World War One, anesthesia consisted of the simple method of completely saturating a sponge with ether alcohol and placing it over a patient's nose<sup>10</sup>. On the battlefield, physicians realized that because of the severe injuries and trauma faced by thousands of men, anesthesia needed to be more controlled, reliable, and effective. Although anesthesia was simple at first it still proved to be a dangerous tool, and only specific personnel were permitted to administer anesthesia to soldiers. In preparation for war the United States army "drafted dentists for anesthetic service, contracted for women physician anesthetists, and brought in nurse anesthetists to serve at base hospitals"<sup>11</sup>. The army realized the serious risk of the misuse of anesthesia and took precautions to decrease fatality. As the demand for medical personnel on

---

<sup>8</sup> "How Do You Fix a Face That's Been Blown off by Shrapnel?" BBC.

<http://www.bbc.co.uk/guides/zxw42hv>.

<sup>9</sup> *How World War One Invented Modern Plastic Surgery*. Photograph. Made From History. <http://madefrom.com/history/world-war-one/plastic-surgery-ww1/>.

<sup>10</sup> Condon-Rall, Mary Ellen. "A Brief History of Military Anesthesia."

[https://ke.army.mil/bordeninstitute/published\\_volumes/anesthesia/ANch31.pdf](https://ke.army.mil/bordeninstitute/published_volumes/anesthesia/ANch31.pdf).

<sup>11</sup> Condon-Rall, Mary Ellen. "A Brief History of Military Anesthesia."

[https://ke.army.mil/bordeninstitute/published\\_volumes/anesthesia/ANch31.pdf](https://ke.army.mil/bordeninstitute/published_volumes/anesthesia/ANch31.pdf).

the battlefield increased, the amount of people in America wanting to specialize in anesthesiology increased and “the nurse anesthetist programs grew in number in both civilian and military medicine”<sup>12</sup>.

In the early stages of the United States’s involvement in World War One anesthesia had progressed from its early stages; however, a need for a safe and more reliable administration led to the development of the nitrous oxide apparatus. The constant flow of gas was difficult to regulate and even with specialists operating the machines, many deaths came from the improper administration of anesthesia<sup>13</sup>. The anesthesia devices of the time period lacked proper pieces necessary for a safe sedation such as a heart rate monitor and a blood pressure gauge. However, many parts of the machine invented during the war still exist in machines today. The war sparked the development of a higher powered device with higher levels of nitrous oxide gas and that included a reservoir bag and face mask for inhalation<sup>14</sup>. Medics quickly realized that with the new severity of battlefield wounds the use of chloroform, ether, and ethyl chloride with inadequate machinery presented many difficulties. A need for more reliable anesthesia led to the development of the shipway nitrous oxide apparatus that harnessed nitrous oxide, commonly known as laughing gas, to be inhaled by the patient. The new apparatus provided a significantly more even flow of gas than the previous device as well as a more precise regulation of gas distribution<sup>15</sup>. It was important to receive an even distribution of gas during arduous surgery to ensure that the soldier experienced as little pain as possible. The increased demand for the nitrous oxide apparatus on the battlefield created a surge in the development of nitrous oxide plants in the United States on the home front. As physicians and surgeons became accustomed to using the new gas for anesthesia they often used it primarily

---

<sup>12</sup> Ibid

<sup>13</sup> Ibid

<sup>14</sup> *transportable anesthetic apparatus in carrying case and set up*. Photograph.  
<http://history.amedd.army.mil/booksdocs/wwii/surgeryinwwii/chapter3figure9.jpg>.

<sup>15</sup> Condon-Rall, Mary Ellen. "A Brief History of Military Anesthesia."  
[https://ke.army.mil/bordeninstitute/published\\_volumes/anesthesia/ANch31.pdf](https://ke.army.mil/bordeninstitute/published_volumes/anesthesia/ANch31.pdf).

while treating soldiers with gangrene, traumatic shock, amputations, and cerebral wounds<sup>16</sup>.

Because of the wartime atrocities the nitrous oxide gas apparatus was created and developed to give soldiers adequate pain relief and is the base for the modern day model of the machine.

New and more serious trauma injuries during World War One led to a reliance on the use of blood transfusions during demanding operations. During the war, doctors were constantly shocked with the severity of injuries and often the surgeons who came to help were not prepared to deal with the level of trauma that they faced. Blood transfusions quickly became one of the most important parts of battlefield surgery when treating soldiers in need of intense surgery. Because of insufficiencies in medical supplies, physicians stored blood to be used for transfusions when necessary. The extra blood from a transfusion significantly helped sustain a safe blood pressure during surgery, and if a soldier received blood the spinal anesthesia would not cause a sudden drop in blood pressure. Because it is important to keep a regular blood pressure during surgery, blood transfusions became increasingly useful and more popular<sup>17</sup>. The extra blood was also used to replace the blood lost because of a serious injury or during surgery itself. Blood transfusions proved to be one of the most influential medical advancements during World War One because of its ability to save lives and to make trauma surgery safer. The conservation and use of blood in World War One ultimately lead to the creation of modern day blood banks<sup>18</sup>. Because of the brutality of war the surgical world was forced to grow at a rapid pace, and even though there were many difficulties involving battlefield medicine, surgeons developed techniques that saved many lives of soldiers during the war.

Wound infections during the war and on the battlefield lead to a dramatic advancement in the surgical techniques of wound closure. Controlling infections and diseases was one of the most prominent goals of physicians once they realized the severe danger they produced. World War One pushed the early medical world into the modern age of medicine because “the number

---

<sup>16</sup> Ibid

<sup>17</sup> Ibid

<sup>18</sup> Ibid

and severity of wounds was on a scale that nobody had ever seen before. Even surgeons, being familiar with operations, were not prepared for the terrible wounds that they were expected to treat"<sup>19</sup>. Because the injuries became more advanced, surgeons knew their techniques must also advance at an ever-increasing rate. The military realized the need for doctors on the battlefield to be highly trained specialists who knew how to deal with the challenges that they faced. As a result, "to produce skilled combat surgeons, in 1918 the U.S. Army Medical Department's division of surgery arranged with some of the nation's finest medical schools to have medical officers receive intensive instruction in war surgery, including the treatment of wounds and the administering of anesthetic"<sup>20</sup>. With a more knowledgeable medical force in place on the battlefield, techniques developed in attempt to prevent fatal infections and diseases while still help the soldiers recover quickly. Surgeons realized that there was a much higher risk for infection if primary closure of a wound was performed. Primary closure refers to the method of sealing fresh wounds without clearing away debris or the excess dead skin. Doctors found that wound exploration and the debridement of wounds before sealing them significantly decreased the chances of infection. They realized that it was necessary to have a clean wound before sealing it to the inside of the skin. Because of the lack of antibiotics at the time, surgeons used the technique of debridement when treating new wounds and treated injuries with carbolic lotion and a bismuth iodoform paraffin paste to prevent further infections<sup>21</sup>. As injuries increased in severity, physicians learned how to treat them more effectively and found the advantages of wound exploration. They found that primary closure was a dangerous method and "Allied surgeons began using the open circular technique with better results". The open circular technique was significantly effective because it involved taking into account the

---

<sup>19</sup> "War Surgery." Brought to Life. <http://www.sciencemuseum.org.uk/broughttolife/techniques/warsurgery.aspx>.

<sup>20</sup> Condon-Rall, Mary Ellen. "A Brief History of Military Anesthesia." [https://ke.army.mil/bordeninstitute/published\\_volumes/anesthesia/ANch31.pdf](https://ke.army.mil/bordeninstitute/published_volumes/anesthesia/ANch31.pdf).

<sup>21</sup> Anderson, Julie. "Wounding in World War One." British Library. <http://www.bl.uk/world-war-one/articles/wounding-in-world-war-one>.

specific levels of harmful bacteria before closing a wound. Wounds were left open for twenty-four to forty-eight hours and bacterial counts were recorded. The wound was then closed if bacterial counts were low and the wound appeared not infected; however, if bacterial counts were high surgeons would douse the wound in Dakin's solution<sup>22</sup>. Dakin's solution, a hypochlorite solution, utilized chlorine's antiseptic nature to kill bacteria in wounds<sup>23</sup>. Battlefield surgery during World War One led to the discovery of the safest treatment of wounds and therefore saved many patients from diseases and infections.

Amputations, a common form of surgery during World War One, led to the development of alternate surgical remedies because of patients' extreme discomfort and more serious long-term problems. The amputation of infected or destroyed limbs was a method of surgery that often left soldiers crippled or incompetent. One of the major infections that led to foot amputation was trench foot. Soldier Harry Roberts recalled that the feet "swell to two or three times their normal size and go completely dead. You can stick a bayonet into them and not feel a thing...I have heard men cry and scream with pain and many have had to have their feet and legs amputated"<sup>24</sup>. Amputations caused severe pain because even though anesthesia was used it was not yet strong enough to mask the pain of an amputation and patients were awake during the surgery. Surgeons used different sizes of knives for various types of amputations. Small knives would be used for smaller extremities such as toes or fingers; however, large knives would be used for leg, arm, foot, and hand amputations<sup>25</sup>. Surgeons saw the intense pain that amputations caused patients and realized, especially after hearing the long-term effects of

---

<sup>22</sup> Manring, M. M., Alan Hawkk, Jason Calhoun, and Romney Andersen. "Treatment of War Wounds: A Historical Review." <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2706344/>.

<sup>23</sup> "Dakin's Solution." WebMD. <http://www.webmd.com/drugs/2/drug-62261/dakin's-misc/details>.

<sup>24</sup> Roberts, Harry. "Memoirs from the Trenches." History of Learning. [http://www.historylearningsite.co.uk/memories\\_from\\_the\\_trenches.htm](http://www.historylearningsite.co.uk/memories_from_the_trenches.htm).

<sup>25</sup> Watney, John. *Amputation saws for treating gangrene infections were part of the military doctor's field equipment*. Photograph. Human Diseases and Conditions. <http://www.humanillnesses.com/original/E-Ga/Gangrene.html>.

amputations, that there was a need for improved surgical methods. Years after World War One, many soldiers reported cases of phantom limb pain, or pain in the part of the body that was amputated because of nerve exposure. Consequently, many surgeons disliked amputation because it caused nerve exposure that led to stump pain and difficulties with prosthetics<sup>26</sup>. The desire to reduce pain created by amputations sparked the search for advancements in battlefield surgery that would have positive long-term effects on soldiers.

Dr. Harvey Cushing, acclaimed for his many contributions to the neurosurgery field during World War One, developed many of the most influential methods for surgical procedures that are used today. Before the start of World War One Cushing created the Harvard Medical Unit as an attempt to adequately prepare new surgeons for war. Once the United States joined the Allied forces in 1917 Cushing's army medical unit was the very first to serve overseas for the American forces. He spent most of the war in the United States, however, continuing to prepare new surgeons for battlefield surgery abroad. He also trained them to specialize in treatment of certain traumatic injuries with the theory that this method would produce better results for the soldiers<sup>27</sup>. On the home front Cushing designed the device used to measure blood pressure and was one of the first surgeons to use X-rays for diagnosis<sup>28</sup>. He contributed also to the advancement of battlefield surgery by developing methods including the "control of bleeding with silver clips, the development of electro-surgery and the development of technical methods for performing surgical operations"<sup>29</sup>. Cushing's development of bleeding control by using clips

---

<sup>26</sup> Wong, Sam. "WWI Surgeons Could do Little for Amputees' Pain." Imperial College London. [http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/newssummary/news\\_6-11-2014-14-8-7](http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/newssummary/news_6-11-2014-14-8-7).

<sup>27</sup> "Harvey Cushing Contributions to World War One." Tripod. <http://surgeons-journal.tripod.com/id11.html>.

<sup>28</sup> "Harvey Cushing." Neurosurgical Medical Clinic, Inc. <http://www.sd-neurosurgeon.com/providers-harvey-cushing.php>.

<sup>29</sup> Bliss, Michael. "Harvey Cushing: A Life in Surgery." NCBI. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2384244/>.

reduced blood loss in patients during surgery and allowed for a more detailed examination<sup>30</sup>. Cushing quickly became one of the most influential and innovative surgeons of his time and he often performed neurosurgery in an observational setting with many colleagues crowding around him to watch<sup>31</sup>. His developments such as bleeding control and devices for monitoring vital signs are ones still used regularly in modern day surgery. Because of Cushing's commitment to the care of soldiers and advancement of beneficial surgical procedures he created methods that saved countless lives on the battlefield and which make medicine what it is today.

Electrical treatment during World War One, used as means to help cure shell shock, allowed for the the development of revolutionized methods of treatment for emotionally distressed soldiers. On the battlefield physicians not only treated patients with physically traumatic wounds but also soldiers with severe mental injuries. Soldiers that were mentally affected from the brutality of war were diagnosed with shell shock, or the modern day post-traumatic stress disorder. Physicians were forced to take a different approach for treatment of soldiers with shell shock because of the uncertainty of the true cure<sup>32</sup>. In the early stages of war doctors began treating mentally disabled soldiers with electrical treatment before the discovery of the realistic effects of shell shock. Because of the initial belief that shell shock was a physical injury caused by close range explosions, physicians sought to use electrical treatment in the form of electric shock to cure soldiers. The general electrical treatment involved administering

---

<sup>30</sup> "Lateral Ventricular Puncture." Legacy of Harvey Cushing: Profiles of Patient Care. [https://books.google.com/books?id=QlJczB2\\_gkgC&pg=PA379&lpg=PA379&dq=dr+harvey+cushing+electrosurgery&source=bl&ots=2KYwsHk9ch&sig=HJJVQ4JBCtXUix9LT\\_SOkBlf9ns&hl=en&sa=X&ei=AK9XVbepL4KkNs ergcAO&ved=0CFQQ6AEwCA#v=onepage&q=dr%20harvey%20cushing%20electrosurgery&f=false](https://books.google.com/books?id=QlJczB2_gkgC&pg=PA379&lpg=PA379&dq=dr+harvey+cushing+electrosurgery&source=bl&ots=2KYwsHk9ch&sig=HJJVQ4JBCtXUix9LT_SOkBlf9ns&hl=en&sa=X&ei=AK9XVbepL4KkNs ergcAO&ved=0CFQQ6AEwCA#v=onepage&q=dr%20harvey%20cushing%20electrosurgery&f=false)

<sup>31</sup> *Dr. Harvey Cushing*. Photograph. Tripod. <http://l.murugan.tripod.com/Murugan/id22.html>.

<sup>32</sup> Harrison, Gordon. "Medical Treatment." World War One Journal Entries. <http://jonathan-jung.blogspot.com>

electric shock to soldiers sitting in the Bergonic chair<sup>33</sup>. Mentally disabled soldiers were strapped into the chair with metal plates wrapped around their legs and wires wrapped around their arms<sup>34</sup>. The electrical shock method proved not as effective as hoped and many surgeons, as well as neurologist Sigmund Freud, believed electrical treatment for soldiers with shell shock to be an unnecessary and brutal remedy. They believed psychoanalysis would produce better results in healing soldiers, and physicians began to view shell shock differently than before<sup>35</sup>. Later in the war psychiatrists began to believe that shell shock was actually the result of emotional injury during war rather than physical injury of the brain. The new view of shell shock was the initial step in the transition from electrical treatment to treatment by psychoanalysis and specific exercises<sup>36</sup>. The advancement in the knowledge of mental disabilities caused by war led to more beneficial methods of treatment during World War One as well as an improved understanding of the emotional distress caused by war.

The development and advances in plastic surgery, anesthesia, and specific surgical techniques that evolved during World War One contributed not only to medicine in the early 1900s but greatly impact medicine today. Many of the surgical techniques and devices used on the battlefield play important roles in the health of patients in modern medicine. Without the innovative surgeons who developed new techniques during the war the legacy of World War One would not have carried on to change the world of medicine in the following years, and surgery would not be as reliable as it is today. Because of World War One surgery, physicians discovered new forms of infection prevention and methods to keep patients safer during procedures. The war sparked a development of more detailed methods for wound recovery that made it easier for soldiers to return to society after war. The revolutionization of medicine on the

---

<sup>33</sup> Reeve. *Bergonic Chair*. Photograph. National Museum of Health and Medicine. <https://www.flickr.com/photos/medicalmuseum/3299318697>.

<sup>34</sup> *ibid*

<sup>35</sup> "World War One." History of PTSD. <https://historyofptsd.wordpress.com/world-war->

<sup>36</sup> *ibid*

World War One battlefield played one of the most influential roles in creating the advanced medical world of today.

#### Bibliography

Anderson, Julie. "Wounding in World War One." British Library. <http://www.bl.uk/world-war-one/articles/wounding-in-world-war-one>.

Bliss, Michael. "Harvey Cushing: A Life in Surgery." NCBI. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2384244/>.

Condon-Rall, Mary Ellen. "A Brief History of Military Anesthesia." [https://ke.army.mil/bordeninstitute/published\\_volumes/anesthesia/ANch31.pdf](https://ke.army.mil/bordeninstitute/published_volumes/anesthesia/ANch31.pdf).

"Dakin's Solution." WebMD. <http://www.webmd.com/drugs/2/drug-62261/dakin's-misc/details>.

*Dr. Harvey Cushing*. Photograph. Tripod. <http://l.murugan.tripod.com/Murugan/id22.html>.

*Faces of War*. Photograph. Smithsonian. com. <http://www.smithsonianmag.com/ist/?next=/history/faces-of-war-145799854/>.

Harrison, Gordon. "Medical Treatment." World War One Journal Entries. <http://jonathan-jung.blogspot.com>.

"Harvey Cushing." Neurosurgical Medical Clinic, Inc. <http://www.sd-neurosurgeon.com/providers-harvey-cushing.php>.

“Harvey Cushing Contributions to World War One.” Tripod. <http://surgeons-journal.tripod.com/id111.html>.

*A Healing and Harrowing Mask*. Photograph. *All That is Interesting*.  
<http://www.smithsonianmag.com/history-archaeology/mask.html>.

“How Do You Fix a Face That’s Been Blown off by Shrapnel?” BBC.  
<http://www.bbc.co.uk/guides/zxw42hv>.

*How World War One Invented Modern Plastic Surgery*. Photograph. Made From History.  
<http://madefrom.com/history/world-war-one/plastic-surgery-ww1/>.

“Lateral Ventricular Puncture.” Legacy of Harvey Cushing: Profiles of Patient Care.  
[https://books.google.com/books?id=QlJczB2\\_gkgC&pg=PA379&lpq=PA379&dq=dr+harvey+cushing+electrosurgery&source=bl&ots=2KYwsHk9ch&sig=HJJVQ4JBCtXUix9LT\\_SOkBlf9ns&hl=en&sa=X&ei=AK9XVbepL4KkNsergcAO&ved=0CFQQ6AEwCA#v=onepage&q=dr%20harvey%20cushing%20electrosurgery&f=false](https://books.google.com/books?id=QlJczB2_gkgC&pg=PA379&lpq=PA379&dq=dr+harvey+cushing+electrosurgery&source=bl&ots=2KYwsHk9ch&sig=HJJVQ4JBCtXUix9LT_SOkBlf9ns&hl=en&sa=X&ei=AK9XVbepL4KkNsergcAO&ved=0CFQQ6AEwCA#v=onepage&q=dr%20harvey%20cushing%20electrosurgery&f=false).

Manring, M. M., Alan Hawkk, Jason Calhoun, and Romney Andersen. “Treatment of War Wounds: A Historical Review.” <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2706344/>.

“Pioneering plastic surgery records From First World War.” The Telegraph.  
<http://www.telegraph.co.uk/history/9396435/Pioneering-plastic-surgery-records-from-First-World-War-published.html>.

Reeve. *Bergonic Chair*. Photograph. National Museum of Health and Medicine.  
<https://www.flickr.com/photos/medicalmuseum/3299318697>.

Roberts, Harry. “Memoirs from the Trenches.” History of Learning.  
[http://www.historylearningsite.co.uk/memories\\_from\\_the\\_trenches.htm](http://www.historylearningsite.co.uk/memories_from_the_trenches.htm).

Sharan, Sharma. “Clashes, Wars and Plastic Surgery.” Journal of Young Investigators.  
<http://www.jyi.org/issue/clashes-wars-and-plastic-surgery/>.

*transportable anesthetic apparatus in carrying case and set up*. Photograph.  
<http://history.amedd.army.mil/booksdocs/wwii/surgeryinwwii/chapter3figure9.jpg>.

“War Surgery.” Brought to Life.  
<http://www.sciencemuseum.org.uk/broughttolife/techniques/warsurgery.aspx>.

Watney, John. *Amputation saws for treating gangrene infections were part of the military doctor’s field equipment*. Photograph. Human Diseases and Conditions. <http://www.humanillnesses.com/original/E-Ga/Gangrene.html>.

Wong, Sam. “WWI Surgeons Could do Little for Amputees’ Pain.” Imperial College London.  
[http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/newssummary/news\\_6-11-2014-14-8-7](http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/newssummary/news_6-11-2014-14-8-7).

“World War One.” History of PTSD. <https://historyofptsd.wordpress.com/world-war-i/>.

*World War One*. Photograph. Pinterest. <https://www.pinterest.com/pin/123426846013688418/>.

“WWI Casualty and Death Tables.” PBS. [http://www.pbs.org/greatwar/resources/casdeath\\_pop.html](http://www.pbs.org/greatwar/resources/casdeath_pop.html).

*WWI War Nueroses*. Photograph. Daily Mail. <http://www.dailymail.co.uk/news/article-2229655/Disturbing-Pathe-footage-World-War-One-reveals-devastating-effects-shell-shock-soldiers-treated-pioneering-Devon-hospital.html>.