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## To What Extent Did Blood Transfusion Systems and Technologies Modernize During World War II?

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# To what extent did blood transfusion systems and technology modernize during World War II?

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## **Section A: Plan of Investigation**

This investigation will explore changes in blood transfusion during World War II (1939-1945). Medical technology and collection systems for whole blood and blood plasma in particular will be examined. The focus of this investigation will be the United States, but Great Britain will also be mentioned due to its close blood transfusion-related interactions with the United States during this period. Additionally, blood transfusion prior to World War II and in modern times will also be considered in this investigation to provide context and to allow assessment of modernization during the war. However, artificial blood substitutes will not be considered, nor any other areas of medicine such as surgery or antibiotics.

Word Count: 110

## **Section B: Summary of Evidence**

### Scientific Background

- Whole blood is composed of four parts: red cells (45% of blood volume), platelets, white cells, and plasma (55% of blood volume combined).<sup>1</sup>
- Plasma is 92% water and 7% “vital proteins” such as albumin.<sup>2</sup>

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<sup>1</sup> “Blood Components” (American Red Cross), accessed 15 November 2015, <http://www.redcrossblood.org/learn-about-blood/blood-components>.

<sup>2</sup> Ibid.

- Plasma helps maintain blood pressure and volume, as well as carrying vital electrolytes and proteins.<sup>3</sup>

### Pre-WWII Blood Transfusion

- Prior to World War I, the only possible transfusion techniques were direct transfusion from donor to patient and transfusion of defibrinated<sup>4</sup> blood<sup>5</sup>, and until 1913 direct transfusion was the only technique used.<sup>6</sup>
- Before blood banking systems began in the 1930s, all blood was donated by “professional donors” or the family and friends of patients in hospitals.<sup>7</sup>
- During World War I and the period between World Wars I and II, it was generally accepted that “reduction in blood volume” was the most significant factor in the etiology<sup>8</sup> of shock<sup>9</sup>, and that hemoconcentration<sup>10</sup> also played a significant role.<sup>11</sup>
- Loss of red blood cells in hemorrhage was not considered an important factor in shock.<sup>12</sup>
- The first recorded use of plasma to save a life instead of whole blood was in 1934 by Dr. Max Strumia.<sup>13</sup>

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<sup>3</sup> David Steinert, “History of WWII Medicine”, April 5, 2002,

<http://www.mtaofnj.org/content/WWII%20Combat%20Medic%20-%20Dave%20Steinert/wwii.htm>.

<sup>4</sup> Blood with fibrinogen removed. Fibrinogen is a plasma protein that plays an important role in coagulation of blood. Removing it allowed blood to be stored for indirect transfusion without immediate coagulation.

<sup>5</sup> Anthony Harding, “A Brief History of Blood Transfusion”, *The Biomedical Scientist*, November 2005.

<sup>6</sup> Kendrick, Douglas, “Blood Program in World War II,” *Medical Department, United States Army*, 1989, 4.

<sup>7</sup> Kara W. Swanson, “Banking on the Body: The Market in Blood, Milk, and Sperm in Modern America,” *The Belknap Press*, 2014, 49.

<sup>8</sup> Etiology: cause of a condition or disease

<sup>9</sup> Kendrick, Douglas, “Blood Program in World War II,” *Medical Department, United States Army*, 1989, 30.

<sup>10</sup> Hemoconcentration: an increase in concentration of red blood cells as a result of a decrease in plasma volume.

<sup>11</sup> Ibid. 51.

<sup>12</sup> Ibid. 51.

<sup>13</sup> Charles Ellis and Robert Thompson, “Your Blood Goes To War,” *The Saturday Evening Post*, May 2, 1942, 44.

## Whole Blood

- “Supplying whole blood to the Armed Forces in the quantities likely to be needed, together with its safe storage and transportation, presented logistic problems of enormous proportions.”<sup>14</sup>
- Whole blood was “the agent of choice” in treatment of battlefield shock, and the only treatment that could prepare the seriously wounded for life-saving surgery.<sup>15</sup>
- Due to difficulty in transporting whole blood to the front lines, whole blood was collected locally on the fronts themselves for much of the war.<sup>16</sup>

## Plasma

- Use of dried plasma solved the problems of whole blood preservation and transportation, as it required no refrigeration and was not damaged by extreme temperatures.<sup>17</sup>
- Plasma transfusions did not require blood type matching.
- Dried plasma was “easily, safely, and quickly produced commercially in...large quantities.”<sup>18</sup>
- Plasma transfusions helped increase blood volume, serving to reverse the severe drop in blood pressure associated with shock.

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<sup>14</sup> Kendrick, Douglas, “Blood Program in World War II,” *Medical Department, United States Army*, 1989, 52.

<sup>15</sup> Ibid. 57.

<sup>16</sup> Ibid. 57.

<sup>17</sup> Kendrick, Douglas, “Blood Program in World War II,” *Medical Department, United States Army*, 1989, 268-269.

<sup>18</sup> Ibid. 269.

- Near “the end of the war,” serum albumin<sup>19</sup> started to replace plasma in transfusions, helping to “draw water into the blood vessels from the tissues.”<sup>20</sup>
- Plasma was viewed as “the foremost lifesaver,” “magical,” and “the outstanding medical discovery of the war.”<sup>21</sup>
- Plasma was not as effective as whole blood in the treatment of shock, but “the early enthusiasm that accompanied its development” often overwhelmed “sound clinical judgment” surrounding its use.<sup>22</sup>
- Plasma transfusions helped patients “recover” from shock, but often could not prepare them for “major surgery” that may have been necessary for full recovery.<sup>23</sup>
- “Of the 13 million pints of blood collected during the wartime blood program, about 75 percent was turned into plasma.”<sup>24</sup>
- Plasma and serum albumin transfusions are used today in critical care settings and during surgery.<sup>25</sup>
- Dried plasma helps solve blood shortages in “developing countries” today.<sup>26</sup>

### Donation and Collection

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<sup>19</sup> Serum refers to plasma which has been defibrinated (had its fibrinogen removed). Albumin is the most abundant protein in plasma.

<sup>20</sup> Charles Ellis and Robert Thompson, “Your Blood Goes To War,” *The Saturday Evening Post*, May 2, 1942, 49.

<sup>21</sup> Anastasia Kirby Lundquist, “Out for Blood: The Pursuit of Life for the Wounded on the Fighting Fronts of World War II,” *Createspace*, 2014.

<sup>22</sup> Kendrick, Douglas, “Blood Program in World War II,” *Medical Department, United States Army*, 1989, 56.

<sup>23</sup> *Ibid.* 56.

<sup>24</sup> Kara W. Swanson, “Banking on the Body: The Market in Blood, Milk, and Sperm in Modern America,” *The Belknap Press*, 2014, 73.

<sup>25</sup> “WWII “Critical Care” Battlefield Therapy Still Saving Lives”, accessed 28 October 2015, <http://www.politico.com/ppta/wwii-critical-care.html>.

<sup>26</sup> PB Isarangkura et al., “Fresh Dried Plasma: A Solution for the Shortage of Blood Products in Developing Countries”, *La Ricerca in Clinica E in Laboratorio*. 4, no. 17 (October 1, 1987), <http://www.ncbi.nlm.nih.gov/pubmed/3438669>.

- The Blood for Britain program began in 1940 to send plasma collected from donors in America to Great Britain, representing “the first effort in the United States to collect large amounts of blood from voluntary civilian donors for military use.”<sup>27</sup>
- The American Red Cross collaborated with independent organizations to carry out the Blood for Britain program<sup>28</sup> and later assisted with organization and blood collection in the American military’s own blood program.<sup>29</sup>
- “During the war the domestic collection of blood for the American armed forces was...the largest organized medical effort ever undertaken in the United States.”  
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- Blood collection for Blood for Britain and the Red Cross depended on unpaid volunteers, both as donors and to work at collection centers.
- The Red Cross recruited donors by appealing to “patriotism”<sup>31</sup> through various means<sup>32</sup> and making donation as comfortable as possible.<sup>33</sup>
- The Red Cross standardized the collection process and created criteria that donors had to meet.<sup>34</sup>

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<sup>27</sup> Kendrick, Douglas, “Blood Program in World War II,” *Medical Department, United States Army*, 1989, 13.

<sup>28</sup> “WWII Specialized War-Time Services | American Red Cross” (American Red Cross), accessed 29 October 2015,

<http://www.redcross.org/about-us/history/red-cross-american-history/WWII/specialized-services>.

<sup>29</sup> David Steinert, “History of WWII Medicine”, April 5, 2002,

<http://www.mtaofnj.org/content/WWII%20Combat%20Medic%20-%20Dave%20Steinert/wwii.htm>.

<sup>30</sup> Kara W. Swanson, “Banking on the Body: The Market in Blood, Milk, and Sperm in Modern America,” *The Belknap Press*, 2014, 68.

<sup>31</sup> *Ibid.* 74.

<sup>32</sup> These means included “posters, leaflets, car cards, pamphlets, motion pictures, photographs, radio transcriptions and announcements, recruiting plans, and publicity kits” *Ibid.* 80.

<sup>33</sup> *Ibid.* 79.

<sup>34</sup> *Ibid.* 79.



Word Count: 613

### **Section C: Evaluation of Sources**

Source 1: "Your Blood Goes To War," May 2, 1942 issue of *The Saturday Evening Post* by Charles H. Ellis, Jr. and Robert E. S. Thompson<sup>35</sup>

This article was published in *The Saturday Evening Post* on May 2, 1942 by Charles H. Ellis, Jr. and Robert E. S. Thompson. It was written to inform its readers about dried plasma transfusions, and to document the authors' experiences donating blood at an American Red Cross donation center. It is valuable to this investigation because it was written during the war by civilians, and is therefore a primary source that offers insight into the general populace's view of blood and plasma during the war. Furthermore, the article describes the development of dried plasma collection, processing, and transfusion techniques in detail, as well as providing a first-hand account of blood donation during the war. It also gives insight into the rhetoric used to create popular support for America's blood program in wartime. However, as an article written during the war, this source provides no information about the way blood transfusion did or did not develop into a more modern system during the war -- it has no capability for hindsight. Additionally, the limitations of medical knowledge at the time and the fact that neither author has a scientific background make the article an unreliable source for scientific information. The article was written to

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<sup>35</sup> Charles Ellis and Robert Thompson, "Your Blood Goes To War," *The Saturday Evening Post*, May 2, 1942.

create popular support for America's wartime blood program, and therefore is sensationalized and may have sacrificed accuracy to inspire its readers.

Source 2: *Blood Program in World War II* by Brigadier General Douglas B. Kendrick<sup>36</sup>

This book was written by Douglas B. Kendrick, a brigadier general in the United States military, and published by the U.S. Army Medical Department in 1989.

It was created to document the United States military's blood programs during World War II and the Korean War. This book is valuable because it was written long after the war ended by someone directly involved in the wartime blood program. This allows analysis of the wartime development of blood transfusion and its effects on later transfusion, and provides the perspective of the military during the war. In addition, source is a comprehensive account of all aspects of the American military's blood program during World War II. As the book is not intended as propaganda or meant to inspire support for the blood program, it acknowledges the mistakes made in the blood program during the war. This book has very few limitations as a source - it provides both hindsight and the perspective of someone directly involved in the blood program.

However, it is unable to provide the perspectives of civilians, such as how the general populace felt about the blood program. Despite being published by the United States military about its own blood program, it attempts to provide an objective view of its success and failures. Nevertheless, the author is likely to have some bias inherent in his

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<sup>36</sup> Kendrick, Douglas, "Blood Program in World War II," *Medical Department, United States Army*, 1989.

writing in favor of the military as a military officer, despite stating his intentions to remain objective.

Word Count: 465

### **Section D: Analysis**

Dried plasma was considered by many to be the “outstanding medical discovery of the war” and seen as the single most important factor in saving the lives of wounded American soldiers.<sup>37</sup> It solved all the logistical problems presented by the use of liquid blood and plasma (mainly transportation without spoilage), and didn’t require time-consuming additional procedures like blood type matching that would delay treatment or weren’t available on the front lines.<sup>38</sup> Furthermore, it fit perfectly into the accepted theory of shock at the time: it increased blood volume, and therefore blood pressure, and reduced hemoconcentration by adding more volume without adding red blood cells. However, while the use of plasma certainly saved many lives during the war, it is difficult to assert that its usage was modern. We now have a different understanding of shock than we did during World War II; one based much more in inadequate circulation of oxygen than in hemoconcentration. Additionally, Douglas Kendrick writes that “the early enthusiasm that accompanied its development had pushed aside sound clinical judgment,” leading to use when it would not be effective

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<sup>37</sup> Anastasia Kirby Lundquist, “Out for Blood: The Pursuit of Life for the Wounded on the Fighting Fronts of World War II,” *Createspace*, 2014.

<sup>38</sup> Kendrick, Douglas, “Blood Program in World War II,” *Medical Department, United States Army*, 1989, 268-269.

and creating the belief that patients' conditions, once treated with plasma, were more stable than they actually were.<sup>39</sup> In modern times, plasma is still used<sup>40</sup> in similar situations to those in World War II: in critical care,<sup>41</sup> and in areas where liquid blood part transfusions are not feasible.<sup>42</sup> However, it is no longer seen as a panacea -- its usage is limited to areas where it is most effective. Therefore, while the the actual real-life usage of plasma in World War II may not have been modern, the concept behind it is still used today.

The systems of blood donation and collection that were developed during World War II can perhaps, out of all the changes that occurred in the field of blood transfusion, be best described as "modern" when compared to those in use today. The Blood for Britain program (which actually sent plasma to Britain, not whole blood as its name implies), created in 1940, was "the first effort in the United States to collect large amount of blood from civilian donors."<sup>43</sup> The program also marked the point at which the American Red Cross became involved with a national system of blood collection, a role that it still plays in the modern United States, albeit without its wartime military involvement. After the conclusion of Blood for Britain, the American Red Cross became a part of with the United States military's own blood program, a system that David

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<sup>39</sup> Ibid. 56.

<sup>40</sup> Much of today's plasma transfusion is actually serum albumin, a blood product consisting of protein processed from plasma. Serum albumin was used toward the end of World War II, but is being included in the overarching idea of plasma transfusion in the war for the sake of concision in this investigation.

<sup>41</sup> "WWII "Critical Care" Battlefield Therapy Still Saving Lives", accessed 28 October 2015, <http://www.politico.com/ppta/wwii-critical-care.html>.

<sup>42</sup> PB Isarangkura et al., "Fresh Dried Plasma: A Solution for the Shortage of Blood Products in Developing Countries", *La Ricerca in Clinica E in Laboratorio*. 4, no. 17 (October 1, 1987), <http://www.ncbi.nlm.nih.gov/pubmed/3438669>.

<sup>43</sup> Kendrick, Douglas, "Blood Program in World War II," *Medical Department, United States Army*, 1989, 13.

Steinert describes as “a model for today’s volunteer blood donation programs.”<sup>44</sup> Many aspects of both the Blood for Britain and the US military blood programs are indeed reflected in modern blood donation. For instance, the Red Cross depended heavily on volunteers, both for donation and collection. They used propaganda to inspire a patriotic desire to donate blood<sup>45</sup> -- today focused less on patriotism and more on the direct effects of blood donation<sup>46</sup> -- and created a standardized way of donating blood. Just like at modern blood drives, there were certain ways donation centers had to be set up, and specific criteria that each donor had to meet in order to donate. Donor restrictions are of course different today than they were during World War II - their rules were limited by their knowledge of bloodborne disease - but the basic idea is the same. In sum, much of the foundation for modern blood donation in the United States was laid during World War II by the American Red Cross through Blood for Britain and the military blood program.

Word Count: 593

## **Section E: Conclusion**

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<sup>44</sup> David Steinert, “History of WWII Medicine”, April 5, 2002, <http://www.mtaofnj.org/content/WWII%20Combat%20Medic%20-%20Dave%20Steinert/wwii.htm>.

<sup>45</sup> Kara W. Swanson, “Banking on the Body: The Market in Blood, Milk, and Sperm in Modern America,” *The Belknap Press*, 2014, 68.

<sup>46</sup> For example, prior to blood drives at high schools, the American Red Cross puts up posters that say how many lives a donor can save with one donation.

It is undeniable that World War II was a period of great change in the field of blood transfusion. Concepts developed before the war, such as the idea of using plasma instead of whole blood<sup>47</sup> and the theory of shock as developed during World War I, were implemented. Transfusion changed from a direct vessel-to-vessel procedure<sup>48</sup> to something that could be carried out thousands of miles and months away from the initial collection point. Perhaps more importantly, unpaid volunteer blood donation in the United States became a national phenomenon, representing a significant shift from the decentralized, patient-by-patient system of the professional donors and direct transfusions. In the case of blood donation and collection, World War II was very much a period of modernization: the establishment of national blood programs to support the war laid the foundation for modern blood systems. However, hematology was still very much limited by medical knowledge at the time, as demonstrated by the use of plasma as a miraculous cure-all for shock. Thus, while the actual implementation of some aspects of blood transfusion may not be considered modern in hindsight, the fundamental concepts behind them - the use of plasma in medical treatment, the use of volunteer donors in a standardized, centralized blood collection system - laid the groundwork for many aspects of blood transfusion today.

Word Count: 217

## **Section F: Sources and Word Limit**

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<sup>47</sup> Charles Ellis and Robert Thompson, "Your Blood Goes To War," *The Saturday Evening Post*, May 2, 1942, 44.

<sup>48</sup> Kendrick, Douglas, "Blood Program in World War II," *Medical Department, United States Army*, 1989, 4.

Word Count: 1,998 excluding section headings, titles, footnotes, and citations

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