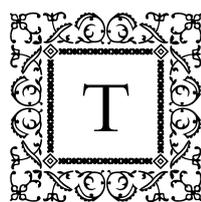


Blood Transfusion Between the Wars

WILLIAM H. SCHNEIDER

ABSTRACT: This article examines the introduction of blood transfusion into general practice from the end of the First World War to the Second World War. Developments during most of this period were not the result of new discoveries but rather the spread of ideas and the establishment of donor organizations to secure an adequate blood supply. The identification, testing, and organization of potential donors were done in a wide variety of settings that reflected differences in political and cultural experiences. At the end of the 1930s, with war approaching, the resolution of problems with storage of blood and the discovery of new techniques for separating and storing plasma dramatically changed transfusion practice. Thus, the innovations of the Second World War were very much based on the development of broad donor organizations plus the new technical discoveries that had occurred during the interwar period. **KEYWORDS:** blood, transfusion, donor, plasma, interwar.



THE heroic age of blood transfusion occurred in the first fifty years of the twentieth century. During this time, the replacement of lost blood became a routine procedure that saved so many lives that it has been called, along with the discovery of germ infection and anesthesia, one of the three most important developments in modern medicine.¹ Although in hindsight, transfusion seems obvious, the main elements took some time to be adopted and varied considerably from place to place.

Because of its importance, blood transfusion has been the subject of a number of histories, most of which have concentrated on the discovery of new techniques.² The process was a complicated one,

1. John Keegan, "Introduction," in Richard A. Gabriel and Karen S. Metz, eds., *A History of Military Medicine* (New York: Greenwood Press, 1992), 1, xi–xiii.

2. Among more recent scholarship on Britain is Harold H. Gunson and Helen Dodsworth, "Fifty Years of Blood Transfusion," *Transfus. Med.*, 1996 6(Suppl. 1), 1–88; and Kim Pelis, "Transfusion with Teeth," in Robert Bud, Bernard Finn, and Helmuth Trischler, eds.,

however, requiring organizational innovation and reflecting cultural differences, not to mention the tumultuous historical changes that occurred between 1900 and 1950. This history can be divided into three periods for the sake of understanding the main developments. The first period (1900–1918) witnessed both a revolution in techniques to withdraw and inject blood safely, plus an opportunity to apply them much more rapidly and on a wider scale than otherwise would have been possible, thanks to the First World War.³

The second period, from the end of the First World War to the mid-1930s, saw the widespread introduction of transfusion into general practice. The main developments, in addition to spreading the word about the techniques used during wartime, involved identification, testing, and organization of potential donors. This had to be done in peacetime circumstances and in a wide variety of settings that reflected differences in political and cultural experiences. Donor organizations held international meetings to exchange ideas and experiences, but there remained significant differences.

The final period in this heroic age of transfusion began in the mid-1930s and continued through the Second World War when a combination of developments brought dramatic new changes in practice. One was a group of new discoveries that produced unprecedented technical possibilities. These included resolution of the problem of contamination that hindered widespread use of anticoagulants for whole blood storage, as well as techniques for separating and storing plasma. Another development beginning in the mid-1930s, with the rise of fascist regimes in Italy and Germany plus the outbreak of the Spanish Civil War, was the realization that a general war was again likely.

Manifesting Medicine: Bodies and Machines (Amsterdam: Harwood, 1999), pp. 1–29; and Pelis, “Blood Clots: The Nineteenth Century Debate Over the Substance and Means of Transfusion in Britain,” *Ann. Sci.*, 1997, 54, 331–60. Douglas Starr recently completed a popular account, *Blood: An Epic History of Medicine and Commerce* (New York: Knopf, 1998) with a number of chapters on the period up to 1945. On Germany, a beginning is Thomas Schlich, “‘Welche Macht über Tod und Leben!’ Die Etablierung der Bluttransfusion im Ersten Weltkrieg,” in Wolfgang U. Eckart and Christoph Gradmann, eds., *Die Medizin und Der Erster Weltkrieg* (Pfaffenweiler: Centaurus-Verlagsgesellschaft, 1996), pp. 109–30. On France, see Jean-François Picard and William H. Schneider, “L’histoire de la transfusion sanguine dans sa relation à la recherche médicale,” *Vingtième siècle*, 1996, 49, 3–17; and Marie-Angèle Hermitte, *Le sang et le droit* (Paris: Editions du Seuil, 1996).

3. See Schneider, “Blood Transfusion in Peace and War, 1900–1918,” *Soc. Hist. Med.*, 1997, 10, 105–26. See also, Kim Pelis, “Taking Credit: The Canadian Army Medical Corps

Although the Second World War is usually thought of as the period of most significant changes in blood transfusion, this article shows that they were very much based on developments between the wars. Because Europeans and Americans had ample warning of the need for preparations (including medical), planning for blood transfusion on a much larger scale than ever before was already underway by the time conflict began. These plans were based on the broad donor organizations plus the new technical discoveries of storage and separation of blood products that had occurred during the interwar period.

THE TRANSITION FROM WARTIME TO CIVILIAN PRACTICE

Until the start of the twentieth century, curiosity about blood, its condition, and loss was common in many societies, but only after Harvey's discovery of the circulatory system in the first part of the seventeenth century were there sustained attempts in Western countries to replace blood using a variety of liquids and techniques for transfusion. Few of these demonstrated success worth repeating; but, beginning around 1900 and continuing until 1914, a number of new techniques were discovered that marked a dramatic change in the history of transfusion. By the outbreak of the First World War, at least some doctors in all Western countries had practiced or were aware of the miraculous benefits of replacing blood with blood. There was even an initial understanding of the importance of testing blood group compatibility (discovered in 1901) and the value of anticoagulants. The fact that the latter was discovered almost simultaneously in 1914 by researchers in Argentina, Britain, and Belgium shows how widely the information about transfusion had spread.

The wartime period from 1914–1918 ended this first phase in the establishment and increased use of blood transfusion. The most obvious, if tragically unfortunate, reason was the need to replace lost blood from casualties produced by the new technologies of killing. Above all, it was the duration of the war that permitted time for trial of the various transfusion discoveries and techniques developed since the beginning of the century. The results spread by various means, including reports in the medical literature that established a record of the

and the British Conversion to Blood Transfusion in WWI," *J. Hist. Med. Allied Sci.*, 2001, 56, 238–77.

adoption of various techniques.⁴ It is difficult to determine exactly how frequently transfusion was practiced during the conflict; but, by war's end, one can say with confidence that transfusion on the Western front was no longer a rare and desperate act to rejuvenate life, although how routine and expected a procedure it was for soldiers suffering blood loss depended on the war sector.⁵

If the most important change in blood transfusion during the First World War was the refinement and increased use of the technique, then the most significant development during the interwar period was adapting these procedures to a peacetime setting. The great increase in use of transfusion during the First World War relied on the extraordinary mobilization of whole countries for combat. Having proven its value in wartime, transfusion techniques required relatively little change; the most immediate need was to teach and train people. As the practice spread, however, a much bigger problem arose: finding sufficient sources of blood for transfusion. Without large numbers of soldiers already mobilized and motivated to be donors, civilian practice required the development of whole new organizations to provide blood for transfusion.

In one obvious sense, the purposes for transfusion changed the most at war's end because the combat ceased. There was an immediate shift to other kinds of injuries and conditions of the civilian population for which transfusion could be of great benefit. One of the most common uses was for women in childbirth, quite a contrast to young male soldiers suffering war injuries. The first problem was not finding applications, but teaching the techniques to new practitioners. The timing and manner by which doctors obtained this information varied, depending on the state of medical practice in a given country. In the case of France, for example, less than a handful of reports on transfusion appeared in the French medical literature between 1900 and 1914. In contrast, more than thirty articles on transfusion appeared

4. This ranged from word of mouth to a four-day Interallied Surgical Conference on transfusion held in March 1918 in Paris. Among other places, the proceedings of the conference were published in *Arch. Méd. Pharm. Mil.*, 1918, 70, 121–85.

5. There were many accounts of medical practice in the postwar histories of the conflict. For descriptions of transfusion in "official" histories, see "Collective Surgical Experiences at the Front and at the Base," in *Medical Department of the United States Army in the World War. Vol. IX: Surgery* (Washington, D.C., 1920), 9, 163 ff; Chapter 5 "Blood Transfusion" in W. G. MacPherson et al., eds. *Medical Services Surgery of the War* (London, 1922), 1, 108–33; and A. Mignon, *Le service de santé pendant la guerre de 1914–1918* (Paris: Masson, 1926), 4, 601 ff.

in French journals in the last year of the war and first postwar year.⁶ In 1920, the Fifth International Congress of Surgery met in Paris, from which four papers were published on transfusion.⁷ The annual meeting of the Congrès français de chirurgie held an extraordinary session in 1923 devoted entirely to transfusion. Likewise, in Germany, two of the leading medical journals, the *Münchener medizinische Wochenschrift* and *Deutsche medizinische Wochenschrift*, published a dozen articles each year on blood transfusion immediately following the war.⁸ There was also a special session on transfusion in 1920 at the first postwar meeting of the Deutsche Gesellschaft für Chirurgie. In Britain, however, it was not until 1926 that the British Medical Association held a special session with several talks on blood transfusion.⁹

This increased interest was largely in what was then called the “indirect” transfusion techniques pioneered just before the war. During the conflict, they had largely replaced the direct “arm-to-arm” method developed in the years after the turn of the century, which required the attachment of a donor’s artery to the patient’s vein. For transfusion to be used under wartime circumstances, however, an alternative was obviously needed; in response, doctors adopted simpler and more rapid techniques that withdrew blood from the donor and then introduced it into the patient as separate operations, hence the nomenclature of “indirect.” The most widely used of these techniques used a syringe, first developed by Edward Lindeman in the United States, or a temporary storage bottle with a pointed glass end that could be inserted into a vein first to draw blood from a donor and then to introduce it into the patient. The Kimpton tube, developed in 1913, whose interior was coated with paraffin to prevent coagulation, was especially popular with English and American surgeons.

These methods (or modifications of them)—using needles, syringes, and temporary storage bottles or ampoules—remained the com-

6. For a bibliography of articles between 1914 and 1923, see Emile Jeanbrau, “Transfusion Sanguine,” *Congrès français de chirurgie. XXXII. Paris (8 octobre 1923) Procès-verbaux, mémoires et discussions*, 1923, 32, 117–32.

7. They were by the Belgian authors A. Depage and P. Govaerts, the American Charles Goodman, as well as Emile Jeanbrau and M. R. Picqué from France. See *Rapports, procès verbaux, et discussions. Ve congrès de la société internationale de chirurgie, Paris, 19–23 juillet 1920* (Bruxelles: M. Hayez, 1921), 243–80; 409–24; 756–71; 789–92.

8. Schlich, “Welche Macht,” pp. 116–17.

9. These were published as, “Discussion on Blood Transfusion in the Treatment of Disease,” *Br. Med. J.*, 1926, ii, 969–83.

mon techniques for transferring blood throughout most of the 1920s and 1930s. The only additional development of note was the use of sodium citrate to prevent coagulation of blood exposed to the air during transfer, a technique first developed in 1914. At the time this prompted an extensive debate and a new way to classify transfusion techniques: those using citrated or “modified” blood, and those using “unmodified” or “pure” blood. For example, in the former category was a flask-shaped vessel developed by the British surgeon Geoffrey Keynes (brother of the economist) that used sodium citrate and added a tube with a needle to eliminate the need to expose the vein or insert the glass end of the tube.

The rapid increase in use of transfusion after the war involved no dramatically new techniques, but rather small, incremental changes that were adopted and modified by transfusion specialists in different countries. This was helped by a free flow of ideas and information through the medical literature with few or no reports of disputed claims of priority. Nonetheless, certain apparatuses became widely used with individuals’ names attached to them. In France for example, Auguste Becart developed a variation of the paraffin-coated Kimpton tube, but more widespread were changes in the syringe techniques that avoided exposure to the air. One of the earliest and simplest was developed by Jubé, but the syringe developed by Arnault Tzanck was the most widely used in France. In Germany, the most frequently used techniques for transfusion between the wars were developed by a Hamburg surgeon Friedrich Oehlecker who used a dual-valve syringe similar to that of Tzanck, and the Kiel surgeon A. Beck who devised one of the first hand-cranked pumps in 1926 to speed the operation.¹⁰ The earliest multiple stopcock syringe had been developed before the war by the American surgeon Lester Unger. It became the most widespread transfusion technique in the United States during the 1920s and early 1930s, along with variation of the citrated blood method, first developed by Richard Lewisohn in 1915.

Important changes in transfusion techniques only occurred at the end of the interwar period. These included the use of anticoagulants for extended storage and the use of plasma without red blood cells that diminished the problem of blood group incompatibility. The

10. See F. Oehlecker, “Weitere Erfahrungen aus über 400 direkten Bluttransfusionen von Vene zu Vene,” *Zentral. Chir.*, 1924, 51, 2346–47; and A. Beck, “Über Bluttransfusion,” *Münch. Med. Wochenschr.*, 1925, 72, 1232–36.

first experiments with plasma given to humans came in the late 1930s, hence the perfection and wide implementation belong more to changes connected with the Second World War. In contrast, the anticoagulant sodium citrate became widely known during the First World War as a means of temporarily preserving blood exposed to the air. This, in turn, prompted at least one serious experiment with extended storage during the war, as well as testing of other anticoagulants.¹¹ The main reason this was not immediately developed further was the occurrence of fever and chills that sometimes accompanied use of sodium citrate. Widespread use of stored blood, therefore, did not occur until the problem was resolved in the mid-1930s.

SELECTION AND ORGANIZATION OF DONORS

Of all the developments in blood transfusion between the wars, the greatest change was in the selection and organization of donors. Above all, the loss of a large, mobilized source of donors—as existed in wartime—meant that new means had to be developed to motivate and organize individuals who would give their blood.¹² Among other things, this meant that the general public learned about blood transfusion, not in reports of modern medical success, but also as part of campaigns to elicit potential donors. Thus, the selection of donors was the primary mechanism by which broader segments of society became involved in this new medical technique. Many of the issues and themes that emerged at the time have continued to this day, such as payment versus altruism as a motivation for blood donation and the safety of the blood supply.

The shift from wartime to peacetime meant that the social base for mobilization of donors varied greatly from country to country.

11. The experiment was based on the discovery of citration for extended storage of blood by Peyton Rous and J. R. Turner at the Rockefeller Institute in 1916. The field test was done by Oswald H. Robertson, a former Rockefeller lab assistant who volunteered for the war. He eventually set up refrigerated storage of several dozen bottles of blood stored for 10–14 days which he could use in times of crisis during attacks on the Western front. Robertson published his results in, “Transfusion with Preserved Red Blood Cells,” *Br. Med. J.*, 1918, *i*, 691–95. For details on Robertson’s accomplishments, see William C. Hanigan and Stuart C. King, “Cold Blood and Clinical Research During World War I,” *Mil. Med.*, 1996, *161*, 392–400. For an example of continuing postwar interest in anticoagulants other than citrate see, O. Flandin, Arnault Tzanck, and Jean Roberti, “Un nouveau procédé de transfusion du sang par utilisation des propriétés anti-coagulantes de arséno-benzène,” *Bull. Mem. Soc. Méd. Hôp. Paris*, 1921, *29*, 1373.

12. Starr, *Blood*, pp. 53–57, alludes to this mobilization in the title of his chapter on the interwar period, “Blood on the Hoof.”

One common development, however, was an increase in the use of testing for blood type. Before and during most of the war, testing for compatibility was considered a luxury by many surgeons. In fact, one of the most common but erroneous assumptions about the history of twentieth century medicine is that Landsteiner's discovery of the blood groups in 1901 was responsible for the new era in blood transfusion. Despite the coincidence in timing, the developments in blood transfusion after 1900 were initially unaffected by Landsteiner's discovery. For example, the most important pioneer of blood transfusion in the United States, George Crile, rarely tested for blood type before giving transfusions. One of the practical reasons for this was the time it took for testing blood type (at least three hours), as well as the question of reliability. Many surgeons developed an alternate, if rough, safeguard by transfusing a small amount of blood at first and waiting to see if there was any reaction. Thus, although testing for blood group compatibility was generally known and even valued by most surgeons when the First World War began, it was often ignored in view of the potential delay and dire condition of many of the wounded.¹³ After 1918, with the removal of wartime exigencies and development during the war of testing for blood type that was more rapid and simple—as well as more reliable—the avoidance of delay was no longer an excuse to forego testing. Even more important, transfusion accidents were much more visible in peacetime, because they were less likely to be masked by other complications from war injuries, nor could they be dismissed as unfortunate by-products of wartime conditions.

This greater concern with testing for compatibility was reinforced by a general interest among medical and scientific researchers after the war in more fundamental questions about blood groups, their function, and distribution. For example, a prewar suggestion that human blood types were inherited according to Mendelian laws of heredity was quickly confirmed by Emile von Dungern and Ludwig Hirsfeld in Heidelberg. Although this had grown out of the experience of choosing blood donors from family members and concerns with incompatibility, it opened up other possibilities of research using blood groups as “genetic markers” (i.e., links to other presumably inherited traits, such as race or disease). The basic method of research

13. Schneider, “Blood Transfusion in Peace and War,” pp. 120–24.

was to test for the ABO blood type distribution in the population under study.¹⁴

The most important implication of these discoveries for transfusions was better predictability of the likelihood of hemolysis from randomly chosen donors. As an extreme example, the chances of selecting a donor of blood type B was found to be only 6% in the English population, but more than 30% in those from subcontinent India. Native American populations were found to have as high as 90% blood type O with virtually no one of blood type B. The net effect was to bolster interest in the blood groups because the chances of selecting an incompatible donor could vary greatly, depending on the distribution of blood types in the donor's population of origin.

Even with better knowledge about blood types, the more immediate question faced by practitioners was where to find donors. Quite simply, army troops no longer provided a large number of already mobilized, readily available, and highly motivated potential donors. During the war, surgeons may not always have had time to test for blood type before transfusion, but at least they could always find donors among the lightly wounded in sick beds or recovery wards. When necessary, as the British surgeon Keynes recalled after the war, "an unofficial reward of a fortnight's leave in England proved a potent inducement."¹⁵ Family members were still a possible source of donors in civilian transfusion, as they had been before the war, but the increased use of transfusion required the assurance of a greater quantity of blood, as well as a more careful eye toward quality than had existed before. New testing procedures would help solve the latter problem, but the increased demand for transfusion, especially on short notice, required whole new systems of organization.

Until the mid-1920s, for patients in civilian hospitals, donors were found much as they had been before and during the war. Surgeons made arrangements for individual donors as needed from family members, hospital patients, and staff. For example, two doctors in Paris worked out an arrangement at a private Catholic hospital such that as soon as patients were admitted for an important operation

14. For background see the special issue entitled "The First Genetic Marker: Blood Group Research, Race and Disease, 1900-1950," of *Hist. Philos. Life Sci.*, 1996, 18, 273-362. See also Schneider, "Blood Group Research in Great Britain, France and the United States between the World Wars," *Yearb. Phys. Anthropol.*, 1995, 38, 77-104.

15. Geoffrey Keynes, *Blood Transfusion* (Oxford: Oxford University Press, 1922), p. 98.

likely to require transfusion, they were asked to bring relatives and friends. Everyone's blood was typed to know whom to call as an eventual donor.¹⁶ There were problems with most of these groups, however, that were exacerbated as the practice of transfusion became more common. Family members, for example, were not always numerous enough to provide compatible blood type or to be available in an emergency. In addition, most doctors with experience in transfusion had stories about family members who unexpectedly refused to give blood to their relatives. Arnault Tzanck described one such incident in which the family member told him later in private that he refused to donate blood because he knew he had contracted syphilis but did not want his family to know.¹⁷

Volunteers in the hospitals offered a larger group from which to draw, but the number and quality of donors varied a great deal. For example, staff and medical students were so overworked as to present potential health problems, which was also the case with many from the public who responded to appeals and were paid for blood donations. In 1923 Keynes, a leading proponent and author of a text on transfusion, complained, "This prevailing uncertainty as to how or where to obtain a blood donor often results in the postponement of the decision to transfuse until the patient has passed from the category of hopeful to that of hopeless."¹⁸ An article in the *Lancet* described similar complaints about using medical students and staff at Guy's and St. Bartholomew's hospitals, concluding with the modest hope, "if the house surgeon responsible for dealing with emergencies were to make a point of always knowing of at least one suitable donor among the patients, their blood could be obtained with the minimum of delay."¹⁹

As the practice of transfusion became more routine, it was easier to recruit donors, not only because of publicity, but also because they were more likely to return because the experience became more comfortable. For example, even though still called "indirect," almost all of the transfusion techniques initially still required that the donor and patient be in close proximity to one another. Numerous diagrams appeared in the literature to illustrate the best positions for the transfu-

16. F. Honoré, "La transfusion du sang," *Illustration*, 21 August 1926, p. 172.

17. Arnault Tzanck, *Problèmes théoriques et pratiques de la transfusion sanguine* (Paris: Masson, 1933), p. 125.

18. Keynes, "Blood Donors," *Br. Med. J.*, 1924, *ii*, 613-14.

19. "Blood Donors," *Lancet*, 1921, 1123.

sion room.²⁰ There were clear advantages and disadvantages to this requirement. For example, the donor could see the patient and gain some satisfaction from knowing face to face the person they were helping. On the other hand, it placed more demands on the donor, such as the requirement to be present at a certain time and to act in such a manner as to give confidence to the patient. As syringes and pumps became more efficient and doctors gained confidence in the use of anticoagulants, there was more flexibility in the placement of donor and patient. The result was less an atmosphere of an operating room.

Not surprisingly, publicity was given to some exceptional individuals who responded admirably to the call for their service. A certain Bertie Dibble of London was honored by the British Minister of Health in 1925 for having donated blood fifty times. An article in the *British Medical Journal* also noted he “always refused the usual payment of five guineas a time for blood transfusions.”²¹ In France, Ramon Briez was an employee of *Illustration* who, the weekly magazine bragged, gave blood 24 times in one year (250 ml per donation).²² Gradually, hospitals established lists of such donors who could be tested in advance, both for disease and blood type, so they could be called on short notice when needed. By 1923, the Mayo Clinic had a list of 1,000 people, 200 of whom were considered “active” donors, and one of which had donated blood 35 times. Similar arrangements were made by hospitals in most large cities of Europe and North and South America.²³

A TALE OF THREE CITIES: TRANSFUSION SERVICES IN LONDON, NEW YORK, AND PARIS

There were a number of responses to the problem of securing adequate supplies of blood for transfusion after the First World War. They ranged

20. For a graphic illustration, see Robert A. Kilduffe, *The Blood Bank and the Technique and Therapeutics of Transfusions* (St. Louis: C. V. Mosby, 1942), p. 449.

21. “Blood Transfusion: Public Recognition of a Donor,” *Br. Med. J.*, 1925, *ii*, 249.

22. F. Honoré, “La transfusion du sang,” p. 172.

23. Herbert Z. Giffin and Samuel F. Haines, “A Review of a Group of Professional Donors,” *J. Am. Med. Assoc.*, 1923, *81*, 532–33. For a broad contemporary survey, see Fritz Schiff, *Die Blutgruppen und ihren Anwendungsgebiete* (Berlin: Springer, 1933), pp. 75–77. On London, Paris, and New York, see below; for the Soviet Union, see E. Burceva, “Blutspenderorganisation in der USSR,” *Arch. Klin. Chir.*, 1935, *181*, 193–208. For examples from central Europe, see Albert Corvin, “Die Regelung des Blutspenderwesens in Wien,” *Wien. Klin. Wochenschr.*, 1934, *47*, 266–67 and Karl-Ad. Seggel, “Der Leipziger Blutspender-

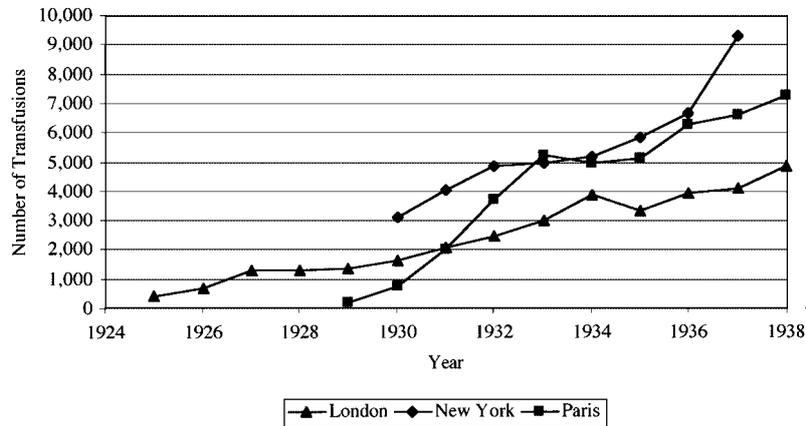


FIG. 1. Transfusion services in London, Paris, and New York, 1925–1938. Source: Schiff, *Die Blutgruppen*, p. 76; Stetten, “The Blood Transfusion Betterment Association,” p. 1251; procès verbaux of *Transfusion sanguine d’urgence*, 1930–33, 1935–36; “Note remise par Madame P. Sime,” unpublished manuscript, 1938, in archives of Assistance publique et hôpitaux de Paris; Keynes, “Technique of Blood Transfusion and the Organization of a Public Transfusion Service [with responses from H. F. Brewer and P. L. Oliver],” *J. State Med.*, 1933, 41, 685–707; *Report of British Red Cross Society for 1937*, as cited in William DeKleine, “Red Cross Blood Transfusion Projects,” *J. Am. Med. Assoc.*, 1938, 111, 2101–02; and Keynes, *Blood Transfusion*, p. 348.

from wide open, free-market payment schemes to altruistic individuals giving the gift of life, and mixtures of government regulation in between. To show this variety, as well as some of the common features that eventually became part of a more organized blood supply, it is useful to compare the three largest blood donor organizations that were established between the wars in London, New York, and Paris (Fig. 1). Their sheer size and influence also made them models for most organizations that followed. These services were established in the mid- to late 1920s, and the number of blood transfusions rapidly

nachweis II. Erfahrungen aus dem 2. Jahr seines Bestehens,” *Münch. Med. Wochenschr.*, 1936, 83, 1129–31. For an example in Buenos Aires see Alberto Peralta Ramos and Constanicio Largaia Escobar, “Transfusion de la sangre y organización práctica de un servicio de dadores,” *Sem. Med.*, 1928, 35, 186–95; and in China see C. Y. Chue and S. H. Wang, “System for Obtaining Chinese Donors,” *China Med. J.*, 1932, 46, 31–42.

rose to a comparable magnitude in all three cities. There were other similarities, but also significant differences in the specific practices of these services that require a closer examination of both accidental and cultural influences in the three countries.

In response to the problems and expenses of securing blood donors in London after the war, as early as 1924 Geoffrey Keynes concluded, "a properly organized supply of volunteer blood donors must therefore be found outside the hospital among healthy individuals who will not be subjected to any undue moral suasion. I would suggest that the various organizations of Red Cross workers throughout the country may perhaps afford one of the best solutions of the problem."²⁴ The local organization that best responded to these possibilities was the London Blood Transfusion Service organized by Percy L. Oliver under the aegis of the British Red Cross Society.

Oliver began his Red Cross service in the London borough of Camberwell in 1910. During the war, the Camberwell Division developed close ties with local hospitals, so it was only natural for members to respond in 1920 to a call for volunteers to donate blood for transfusion.²⁵ Two features of Oliver's work in shaping the response had repercussions on all subsequent blood donor organizations. First was the system of screened donors on call, which he developed beginning in October 1921 when Camberwell members were organized for blood donation in such a way that hospitals increasingly took advantage of their services. Oliver's volunteers agreed to be tested ahead of time and respond to calls day and night to go to the hospital on short notice. Not surprisingly, the hospitals welcomed the volunteers that Oliver sent, which soon included those from other organizations, such as the police and the Rover Scouts. For his part, Oliver, along with his wife, worked indefatigably recruiting new volunteers, keeping records, passing messages, and arranging transportation for donors. By 1926, the Camberwell service had grown to such an extent that the British Red Cross Society gave it a more official status, moved its operations, and renamed it the London Blood

24. Keynes, "Blood Donors," p. 614.

25. Minute Book, Camberwell Division, Red Cross Archives, Barnett Hill (U.K.), acc 932, 3 December 1920. The following is summarized from Gunson and Dodsworth "Fifty Years of Blood Transfusion," pp. 4-12, plus material from an unpublished manuscript kindly supplied by Kim Pelis who is working on a history of blood transfusion in England.

Transfusion Service with a correspondingly larger service area. In 1931, its scope was widened even further in an attempt to meet the needs of England and Wales.

The second feature of Oliver's organization that made it a model for others was his insistence that donation of blood be voluntary, that is, unpaid. As the service grew, so, too, did this practice to the extent that eventually transfusion in Britain became synonymous with unpaid voluntary donation of blood. Although some have suggested this was a reflection of British "national character," in fact it was much more an accident of Oliver's personal sensibilities.²⁶ There were numerous examples of payment for blood donation in Britain after the First World War. In 1923, several London hospitals offered up to £10 for transfusion donations. Moreover, despite Oliver's insistence on voluntary donation, there continued to be many regional transfusion services in other cities, such as Manchester, Swansea, and Sheffield, that paid donors, much to Oliver's consternation. It was only the combination of Oliver's preferences coupled with the success and growth of his organization (obviously the high quality and lack of cost for the service made it preferable to reliance on paid donors) that permitted the establishment of this voluntary model of blood donation. By 1926, the London service had a list of 350 volunteers who provided 737 transfusions, and within five years the annual number of transfusions had grown to 2,078. By the end of 1936, more than 200 hospitals in London were served by the organization that estimated it had provided 20,000 transfusions since its beginning.²⁷

If the British became associated, rightly or wrongly, with the model of voluntary, unpaid blood donation, the American model came to be known as "blood for sale." There is good reason for this characterization, given the historical record of the 1920s and 1930s, but as the New York City example demonstrates, the reality included government control and regulation. At first, American hospitals, like their

26. Richard M. Titmuss, *The Gift Relationship: From Human Blood to Social Policy* (London: Allen and Unwin, 1970), was especially critical of payment for blood in the United States. See Jane Piliavin et al., *Giving Blood: The Development of an Altruistic Identity* (Baltimore: Johns Hopkins University Press, 1991), for a social scientific study of motivation for blood donation. I am grateful to Kim Pelis for suggesting this and sharing an unpublished manuscript, "The Virtue of Giving: Making the Voluntary Blood Donor in Inter-war Britain."

27. "An Appeal for Volunteers," *Br. Med. J.*, 1927, *i*, 551; Schiff, *Die Blutgruppen*, p. 76; Keynes, "Blood Transfusion," *Practitioner*, 1931, 127, 425; P. L. Oliver, "British Red Cross Transfusion Service," *Guy's Hospital Gazette*, 1935, 49, 108-113; and Oliver, "Plea for a National Blood Transfusion Conference," *Br. Med. J.*, 1936, *ii*, 1032-33.

counterparts elsewhere around the world, made arrangements to find donors for transfusion however they could. The Mayo Clinic list of donors was only one of the better organized services. Elsewhere, stories in popular magazine and newspaper accounts told of college students, firemen, and the general public who were recruited by advertising and other means, including payment, to supply blood.²⁸ In New York and other American cities, independent private agencies arose as middlemen who kept “professional” donor lists and referred individuals to hospitals where they would give their blood. Problems could develop with this “free market” approach, such as when donors organized and drove up prices to as high as \$100 for a pint of blood, threatening the ability of hospitals to recover the costs of transfusion from all patients.²⁹

The noted Cornell University immunologist Arthur F. Coca led an effort to resolve the problems with professional donors by creating the Cooperative Blood Donors Bureau. In 1929 it was reorganized with funding from John D. Rockefeller and renamed the Blood Transfusion Betterment Association of New York City. The service enjoyed the cooperation of the New York Academy of Medicine and the City Health Department, but it was a private organization with its own board of trustees, including Karl Landsteiner himself who had moved to the Rockefeller Institute in the early twenties. The City Health Department’s cooperation was crucial in the success of the bureau, because it required all donors to obtain a license and carry a passbook indicating where and when blood donations had been given. This was done in the name of monitoring quality at a time when the Depression brought large numbers of donors from the unemployed who wished to make frequent donations to support themselves. From the donor’s viewpoint, it eliminated some of the competition, but greatly restricted the frequency of donation; then, in 1932, the bureau lowered the price paid for a pint of blood from \$50 to \$35. This risked decreasing the economic incentive for giving blood (from 1932 to 1934 the annual number of transfusions rose

28. For other examples, see Starr, *Blood*, pp. 57–58. I am also grateful to Susan E. Lederer for sharing a paper, “Blood Work: Blood Selling as a Profession in Early Twentieth-Century America,” given at the Wellcome Institute (London), 15 May 1998.

29. Schiff, *Die Blutgruppen*, p. 77. For a first-hand account by a professional donor, see Charles V. Nemo, “I Sell Blood,” *Am. Mercury* 1934, 31, 194–203. Eventually, the American Federation of Labor granted a charter for a union of blood donors; see *New York Times*, 15 September 1938, p. 27; and 25 September 1938, p. 8.

from 4,852 to barely more than 5,200) but by 1937, the number had grown to more than 9,000.³⁰

Almost simultaneous with the beginning of the New York organization was the creation in December 1928 of the Transfusion Sanguine d'Urgence (TSU) in Paris. The idea had originated with Arnault Tzanck at the Saint-Antoine Hospital, who approached the Directeur général of the Paris Assistance Publique (hospital administration). Tzanck was accompanied by the director of the Maternity Service at Saint-Antoine, E. Levy-Solal, and A. Gosset from Salpêtrière Hospital. In 1925, Tzanck and Levy-Solal began informally pooling the names of their donors and then added those from a half-dozen other Paris doctors. This combined list permitted them to draw from a larger group of possible donors, as well as to respond to a limited number of requests from additional doctors. The demand had grown so great in three years that they now proposed to the Assistance Publique to supplement, in emergency cases, the existing transfusion services they had already arranged.³¹

The model was similar to other such organizations. A list of potential donors was established, with individuals tested in advance for disease and blood type who were available on short notice to give blood for transfusions. The transfusion techniques, which required the donor to be in close proximity to the patient, also influenced the selection of potential donors. In addition to health, availability, and having veins appropriate for donating blood, the donor was expected to have a demeanor that inspired confidence or at least was not a hindrance

30. The "official" history of the New York organization can be found in De Witt Stetten, "The Blood Transfusion Betterment Association of New York City," *J. Am. Med. Assoc.*, 1938, 110, 1248–52. For more on Coca, who was a founding editor of the *Journal of Immunology*, see "Historical Notes: Arthur F. Coca, M.D.," *N. Engl. Reg. Allergy Proc.*, 1985, 6, 278–305. See Nemo, "I Sell Blood," for a view from the donor's perspective and Corvin, "Die Regelung," for how Vienna responded to these problems during the Depression in a similar way. It should be noted that New York was not the first city-wide organization of blood donors in the United States. In 1926, the Community Council of St. Louis followed the lead of the London Blood Transfusion Service. See Elwood Street, "Life Blood," *The Survey*, 1926, 56, p. 380.

31. "Procès-verbal de l'assemblée générale (5 février 1930)," *Transfusion sanguine d'urgence*, 1930, p. 16. The most widely available description of the service is found in Tzanck, *Problèmes*, pp. 119–46. For biographical information on Tzanck, see Hermitte, *Le Sang et le droit*, pp. 77–84; M. Lechelle, "Notice nécrologique sur M. Tzanck," *Bull. Mem. Soc. Méd. Hôp. Paris*, 1954, 70, 175–77, and a special issue on Tzanck of *Rev. Hist. Med. Heb.*, 1955, 8, 67–112.

to the procedure. As Tzanck put it, “at the time of transfusion, the donor must have a good personal appearance and be calm.”³²

After only one year, the TSU reported arranging transfusions for 24 hospitals in the Paris region. More important than these numbers, Tzanck boasted that fatalities in the maternity ward of Saint-Antoine declined from five in 1928 to zero in 1929.³³ In subsequent years, the demand rose as dramatically as in London and New York. The TSU reported more than 2,000 transfusions in 1931, more than 5,000 in 1933, and more than 7,000 in 1938. To meet this growing demand for blood donors, Tzanck demonstrated remarkable marketing skills. He quickly moved from early reliance on hospital personnel to other large groups of public employees. In 1930, he convinced the Prefect of the Paris Police to authorize appeals for donors at police stations in the city. The Paris firemen were quick to follow.³⁴

One problem with the Paris TSU was a high demand for “universal” donors of type O blood. Tzanck reported that this was the result of misunderstanding and preference of those giving transfusions who did not match the ABO blood type for every transfusion. In a 1933 report, Tzanck said that type O blood donors were supplied “regularly” and type A and B only “intermittently.”³⁵ This problem was not unique. Oliver faced a similar problem in London, where hospitals routinely requested type O donors because they were not willing or able to test their patients in need of transfusions. The long-term solution came in 1932 when the Medical Research Council funded a position at St. Bartholomew’s Hospital to expand and improve blood testing at London hospitals.³⁶ Coca reported in 1937 at an international transfusion congress that the New York bureau provided type O donors for patients with blood type B, and type A donors for type AB patients, presumably because of scarcity of donors with those blood types. Thanks to educating hospital personnel about blood testing, Coca stated that, from 1931 to 1937, there had been

32. Tzanck, *Problèmes*, p. 128.

33. *Ibid.*, p. 122.

34. Michèle Loubet, “L’oeuvre de la Transfusion sanguine d’urgence de 1928 à 1938” (Thèse de Médecine, Tours, 1983), p. 67.

35. Tzanck, *Problèmes*, p. 127.

36. Gunson and Dodsworth, “Fifty Years of Blood Transfusion,” p. 8. H. F. Brewer was the first to hold the appointment that eventually grew into the Blood Group Reference Laboratory.

only 418 transfusions from donors of type O to patients not of O blood type, out of a total of more than 40,000 transfusions.³⁷

Unlike the British who relied on the Red Cross, or the Americans who had created their own private service, the TSU cooperated much more closely with the French government through the Assistance Publique, the government hospital service, which provided almost half of the funds necessary to run the service. A typical budget (for 1930) showed income of 25,000 francs from dues, 57,000 francs from gifts (usually from families of patients who were asked for contributions that closely resembled fees for the service), and 59,000 francs from the Assistance Publique.³⁸ Initially, most of the expenses went to pay donors (200 francs per call). As the number of transfusions grew, however, the total of payments to donors rose quickly. In 1932 more than 325,000 francs were paid, of which Assistance Publique contributed more than 250,000 francs. The following year, the government agency began making all payments directly to donors and eliminated its subsidy through the TSU whose expenses were greatly reduced (to 75,827 francs on 1933).

Even after the Assistance Publique took over responsibility for direct compensation of donors, the TSU continued to have difficulty in finding resources to pay for the remaining administrative and laboratory expenses. Although the Paris Municipal Council made regular contributions, the amount fluctuated greatly as the impact of the Great Depression hit France after 1931. Dues and gifts were the only other regular source of income, but these also fluctuated, depending on the conditions of the economic crisis. As a result, the TSU resorted to some extraordinary fund-raising schemes that took advantage of the social and political influence of its patrons. For example, in May 1931, the "Comité de Propagande" organized a gala evening at the Theatre des Champs Elysées, whose honorary patrons included the President of the Republic, the Minister of Health, and the President of the Paris Municipal Council. The leading singers of the Paris Opera performed and a film was shown. The event raised 114,000 francs. Late in 1933 the committee obtained the right to hold another

37. Arthur F. Coca, "On the Selections of Donors for Blood Transfusion with Special Reference to the Use of 'Universal Donors' and Other Substitutions," *Ile Congrès international de la transfusion sanguine, 29 septembre-2 octobre 1937. Paris* (Paris: J.-B. Ballière, 1939), 2, 82.

38. "Procès-verbal de l'assemblée générale (4 février 1931)," *Transfusion sanguine d'urgence*, 1931, p. 12.

fund-raising event: a lottery. Thanks to generous subscriptions from such enterprises as Galeries Lafayette, the Compagnie Générale Transatlantique, and several pharmaceutical firms, more than 65,000 francs was raised by the event. This represented more than half the income of the TSU in 1934.³⁹

The involvement of the French government also extended, according to a report at the 1937 international congress on transfusion, to regulation of payment for donating blood. Legislation as early as 25 October 1922 (modified in 1927) set payment at 50 francs for the first 150 ml and 50 francs for each additional 100 ml of blood. The government was sensitive to potential charges of buying blood; hence, it took pains to explain that payments were made only when necessary and not as “the price of blood.” It was to compensate donors, in the words of the government, “for their loss of time, travel expense and the possible fatigue they might suffer afterward.”⁴⁰ Tzanck had to defend this practice in 1935 at the first International Blood Transfusion Congress in Rome, where he complained of “those who wish to oppose our donors to ‘Blood Volunteers’ in certain countries. Nothing is less justified.” In response, he maintained, “Our donors are all volunteers. And the minimal compensation which we give them is only a slight remuneration for lost time, numerous visits needed for safety checks, and not at all a payment for the blood which is generously offered.”⁴¹

The TSU never aimed at serving more than the Paris region, which was a practical necessity given the limited mobility of donors. Soon, however, it inspired other organizations in the provinces, such as one started by Emile Jeanbrau in Montpellier and Georges Jeanneney in Bordeaux.⁴² The government showed no interest in coordinating or even regulating this expansion. According to the report at the 1937 international transfusion congress, for example, many of the regional and municipal organizations refused to pay donors, as the Paris organization had done.

39. See Loubet, “L’oeuvre de la Transfusion,” pp. 104–10 and the annual financial reports of the TSU.

40. Dr. Braillon, “Réglementation des donneurs pour la transfusion du sang,” *Ile Congrès international de la transfusion sanguine, 29 septembre–2 octobre 1937. Paris* (Paris: J.-B. Ballière, 1939), 2, 409–10.

41. Reprinted in *Transfusion sanguine d’urgence*, 1936, 19.

42. A. Tzanck and P. Cazal, “Le professeur Emile Jeanbrau (1873–1950),” *Rev. Hematol.*, 1950, 5, 509; Georges Jeanneney and C. Ringenbach, “Transfusion du sang conservé,”

One reflection of the worldwide experience in securing an adequate and safe blood supply can be found in the reports of the Second International Blood Transfusion Congress held in Paris in the fall of 1937.⁴³ The congress itself was a testimony to the widespread adoption of the medical procedure. One of the four commissions of the Congress was devoted to "Organization of Transfusion," with 23 papers presented from directors of blood transfusion services in eleven different countries. Some of these services approached the size of those in London, New York, and Paris. They also used a variety of donors from existing organizations, such as the Danish Scouts or the Dutch and Belgian Red Cross (Table 1).

A final indicator of the status of transfusion by the end of the interwar period was a survey of American hospitals published in the *Journal of the American Medical Association* by Philip Levine and Eugene Katzin in 1938. After the 1937 international transfusion congress, the American Medical Association (AMA) decided to conduct a survey of transfusion practices in the United States. The New York Blood Transfusion Betterment Association drew up a questionnaire that was sent to all hospitals approved for internships by the AMA (approximately 700), of which half responded. The Americans' use of transfusion was probably the most extensive in the world, and therefore the results cannot be taken as typical of practices everywhere. From the beginning of the twentieth century, however, the United States was a model for others to emulate and thus serves as a bellwether. Responses to the questions reveal, for example, that 157 of the 345 hospitals responding still used their own lists of donors who were called for transfusions. Of the rest, 53 hospitals used commercial agencies, and only 8 hospitals used noncommercial agencies operated by boards of health or medical societies. Virtually all hospitals (310 of 345 reporting) did blood group testing before transfusion, but only 178 did their own Wassermann test for syphilis. (Some of the remainder relied on tests done by donor agencies.) Most hospitals (254) indicated they had moved away from the use of universal (type

Médecine, 1939, 20, 38–39. For an example of an idiosyncratic organization in Toulouse, see Hermitte, *Sang et droit*, p. 83.

43. The first international congress held in Rome in 1935 drew relatively few attendees and published only six reports from the sessions. See *Atti del Primo Congresso Internazionale della Trasfusione del Sangue, Roma, 26–29 Settembre 1935* (Milan: A. Colombo, 1935). The results of the second congress were published in three volumes, *Ille Congrès international de la transfusion sanguine*.

TABLE I

Reports of Transfusions by Donor Organizations, 1935-1936

Year	Location	Transfusions	Donors	Notes
1936	Copenhagen	2,000		515 by unpaid donors (scouts)
1935	Holland	978	2,500	Unpaid Red Cross donors
1936	Berlin	2,204		At Virchow City Hospital
1936	Belgium	648	527	From 6 Red Cross services
1936	London	3,957		Red Cross Transfusion Service
1936	New York	6,686		Blood Transfusion Betterment Association
1936	Paris	6,298		Transfusion Sanguine d'Urgence

Source: *Ile Congrès international de la transfusion sanguine* (Paris: J.-B. Ballière, 1939): Ib Freuchen, "Freiwilliger Donordienst in Dänemark und Blutgruppenbestimmung in der Armée," 2, 454; Van Dyk, "Organisation des services de transfusions aux Pays-Bas," 2, 519; Dr. Forssmann, "Bluttransfusion in Notfällen und ihre Organisation in Deutschland," 2, 441-49; and Dr. Anet et al., "Les services de transfusion sanguine de la Croix Rouge de Belgique," 2, 381-91.

O) donors for all transfusions, preferring to match ABO blood type. About 70 hospitals reported using the O donors either moderately or frequently. An indication of the great concern attached to blood compatibility in the interwar years was the small number of accidents (36) reported from incompatibility. It is equally telling that the authors of the article referred to these as "numerous avoidable accidents."⁴⁴

THE WAY TO WAR: EUROPEAN PREPARATIONS FOR CONFLICT

The 1937 International Blood Transfusion Congress and the AMA survey offer a convenient and appropriate dividing line between developments in blood transfusion that followed the First World War

44. Philip Levine and Eugene M. Katzin, "Survey of Blood Transfusion in America," *J. Am. Med. Assoc.*, 1938, 110, 1243-48, p. 1248. The 1935 article by Burceva, "Blutspenderorganisationen," is based on a comparable survey in the Soviet Union.

and those that are better understood as part of the next phase in the utilization of blood transfusion: the prelude and conduct of the Second World War. Up until this time, doctors had been very successful in adapting the lessons learned in the trenches to civilian, peacetime uses. In the 1920s and the first half of the 1930s, these developments in transfusion had been influenced by external social conditions, especially in organizing donor services to ensure a blood supply, but there were few political and no military needs that affected these developments.

That changed abruptly because of the military and diplomatic events that immediately preceded the Second World War, especially the Spanish Civil War and the Munich Crisis of September 1938. The effect was to shock and frighten Europeans about the need for wider use of transfusions by the civilian population in the next war. Equally significant, although originally unconnected, was the implementation at the same time of two dramatic changes in transfusion techniques. One was blood storage or banking, begun on a large scale in the wartime setting of Spain in 1936 and adopted in civilian practice the following year. The other new technique was the use of plasma. The results of the first plasma trials were published in 1936 by John Elliott in North Carolina, and the first reports of freeze-drying appeared in 1935 and 1936 at the University of Pennsylvania, although the technique was not perfected until 1940.⁴⁵

The successful blood programs of the Second World War were not the result of building directly on the lessons learned during the earlier war. In fact, there was very little continuity in military medical organization generally and transfusion practice in particular from the earlier to the latter conflict. One of the reasons is that most of the medical personnel mobilized for the war took their expertise back with them to civilian practice after demobilization in 1919. Hence, the occasional calls for keeping up with changes in transfusion during the 1920s and 1930s were usually from outside the military. They typically fell on deaf ears, however, as was illustrated by the debate that arose in the 1930s over whether new military conscripts should be tested automatically for blood type.

45. John Elliott, "A Preliminary Report of a New Method of Blood Transfusion," *South. Med. Surg.*, 1936, 98, 643-45; Earl W. Florsdorf and Stuart Mudd, "Procedure and Apparatus for Preservation in 'Lyophile' Form of Serum and Other Biological Substances," *J. Immunol.*, 1935, 29, 389-425.

Such an idea would seem logical by the end of the First World War, but the practice was not generally adopted by European armies either during the conflict or in the years that followed. It was only in 1930, for example, that Tzanck and R. Weissman-Netter proposed to the French Minister of War that blood transfusion be reorganized in the army. This was prompted in part by what they learned from establishing the TSU, but also from Weissmann-Netter's own military service in which he saw first-hand the shortcomings of the French military medical organization. In addition to urging the acquisition of the latest in transfusion equipment and training of personnel, he called for determining the blood type of every recruit and marking it on the soldier's identification tags.⁴⁶

The French army's response was that the problem had been studied, and such large-scale testing was not necessary. Reflecting an ignorance of exactly the kind of problems in civilian hospitals that Tzanck's TSU was trying to solve, one army doctor blithely observed, "for the moment we anticipate that donors will be found especially among our nurses, assistants and all other health personnel."⁴⁷ On the eve of the outbreak of war in 1939, Georges Jeanneney, a professor at the Faculty of Medicine at Bordeaux, was still arguing against routine typing of all army recruits because such a practice "would clash with the practical difficulties involved in such a large organization and would be subject to errors (of homonym, and registration . . . not to mention the possible danger of contamination)." He preferred instead to use a combination of hospital personnel and storage of citrated blood.⁴⁸

The failure to adopt such measures in France might be expected, given the low morale in the French military after the First World War, but it was not very different elsewhere.⁴⁹ Most surprising is that, although the German army called for testing all army recruits as early

46. R. Weissmann-Netter, "Il faut organiser la transfusion sanguine aux armées," *Presse Méd.*, 1931, 139, 1661-62.

47. Response of Médecin-colonel Schickelé during a discussion after a talk by Tzanck, "La transfusion sanguine aux armées," *Bull. l'Union Fed. Méd. Reserves*, 1932, 23, 537. See also, Fargot and Balgaires, "Faut-il déterminer le groupe sanguin de tous les soldats," *Bull. Mens. Soc. Méd. Mil. Fr.*, 1935, 29, 293-306.

48. P.-J.-F.-R. Maissonnet, Georges Jeanneney, et al., "Transfusion du sang en temps de guerre," *Revue du Service de Santé Militaire*, 1939, 111, 937-38.

49. For a survey of transfusion policies in all European armies in 1935 see Adolf Ritter, "Bluttransfusion in den armeen," *Atti del primo Congresso Internazionale della Transfusione del Sangue* (Milan: Coloma, 1935), 39-85.

as 1935, practical problems of mass testing delayed its implementation. Testing of all Waffen-SS recruits only began at the end of 1937, and as late as June 1939 German military doctors still complained about some of the same technical problems in testing all army recruits as were stated by Jeanneney. Only after the war began was testing extended to all German soldiers whose blood type was then stamped on their identity tags. The order requiring all American military personnel to have their blood typed and recorded on their ID tags was issued in June 1941.⁵⁰

The warnings by those urging reform of military blood supply proved well founded as the experience of the Spanish Civil War unfolded. That conflict immediately put a strain on the use of blood transfusion because of the large numbers of wounded and the impossibility of using pretested individual donors on call for each transfusion. Therefore, as was the case in 1914, a wartime necessity provided an opportunity to try new approaches to securing an adequate blood supply, in this case stored blood. As indicated by the program of the international transfusion congress in Paris, the question of stored blood already attracted great attention by the middle of the 1930s.⁵¹ An example of the range of the alternatives considered at this time was the intriguing report from Soviet doctors about the use of blood from cadavers. Growing out of earlier experiments on preservation of body tissue by refrigeration after death, these transfusions began in 1930 and continued through the end of the decade, with doctors reporting more than 2,500 cases. Although it enjoyed a certain vogue, the procedure was dropped for both technical and psychological reasons.⁵²

50. Douglas B. Kendrick, *Blood Program in World War II* (Washington: Department of the Army, 1964), p. 233. For Germany, see W. Schreiber, "Zur Technik der Blutgruppenbestimmung bei Massenuntersuchungen," *Deutsche Militärarzt*, 1936, 1, 97-99; H.O. Hettche, "Neues Geräte und Verfahren zur Massenuntersuchung auf Blutgruppenzugehörigkeit," *Deutsche Mil.*, 1939, 4, 11-13; J. Mrugowsky and H. Bernhart, "Die Ausführung von massen Untersuchungen auf Blutgruppenzugehörigkeit und das Eintätowaren der aufgefundenen Blutgruppen," *Münch. Med. Wöchenschr.*, 1941, 88, 669-672; Franz Spath, "Die Bluttransfusion im Felde," *Münch. Med. Wöchenschr.*, 1940, 87, 369-93.

51. There were seven papers of the "Deuxième Commission: Le sang conservé" published in *Ile congrès international de la transfusion sanguine*, 2, 161-227.

52. One widely read account, was by S. S. Yudin, "Transfusion of Cadaver Blood," *J. Am. Med. Assoc.*, 1936, 106, 997-99. An early critic was Tzanck. "A propos de la transfusion du sang de cadavre," *Bull. Mem. Soc. Méd. Hôp. Paris*, 1933, 57, p. 341, who called the practice "a step backwards." The Spanish experimented with cadaver blood in the early years of their civil war, but rejected it as "useless when large quantities are needed." See F. Duran Jorda, "The Barcelona Blood-Transfusion Service," *Lancet*, 1939, p. 773.

The eventual solution was the storage of refrigerated, citrated blood. This came relatively late, considering the technique had first been reported by Oswald H. Robertson during the First World War.⁵³ The reason for the delay was the controversy surrounding the side effects of chills and fever that sometimes accompanied the use of sodium citrate. It was only in 1933 that the Americans Lewisohn and Rosenthal showed these symptoms to be caused by bacterial pyrogens originating from incompletely sterilized containers. Ironically, they found that the simplicity of the method was the root cause of the problem. Because less skilled personnel were required when citrated blood was used, less attention was paid to the absolute need for sterile conditions. The solution to the problem was strict sterilization of glassware and use of triple distilled water.⁵⁴ This important discovery plus the experience of surgeons in the Spanish Civil War led to a renewed interest in the use of storage and the first blood banks in 1937.

Even if the cause of side effects associated with stored blood had not been discovered, there would have been experimentation by doctors in the Spanish conflict. Just as in the First World War, the needs during combat greatly outweighed concerns about relatively rare side effects. Thus, among a variety of new approaches to transfusion, Spanish doctors began using stored blood on a far larger scale than ever before. Beginning in 1936, the Republican government established a transfusion service based on blood stored for up to two weeks. In the Barcelona service, almost 30,000 donors were used over a thirty-month period to furnish 9,000 liters of blood in 27,000 transfusions. The storage techniques used the sodium citrate method. In all of his writings, the director of the service, F. Duran Jorda, emphasized that the key to success was recruitment of sufficient potential donors.⁵⁵

The concept and name "blood bank" originated at the same time,

53. See Robertson, "Transfusion," and Hanigan and King, "Cold Blood."

54. "Prevention of Fever and Chills following Transfusion of Citrated Blood," *J. Am. Med. Assoc.* 1933, 100, 466-69. See also Richard E. Rosenfield, "Early Twentieth Century Origins of Modern Transfusion Therapy," *Mt. Sinai J. Med.*, 1974, 41, p. 629. For the progress of the debate, see Lewisohn, "Chills Following Transfusion of Blood," *J. Am. Med. Assoc.*, 1923, 80, 247-49; and "Citrated Method of Blood Transfusion after Ten Years," *Boston Med. Surg. J.*, 1924, 190, 733-42.

55. Duran Jorda and his colleagues first published an extensive account on their work in six articles that appeared in *Revista de Sanidad de Guerra*, 1937, 1, 329-57. His 1939 article on "The Barcelona Blood-Transfusion Service," in *Lancet* was the most widely cited English account of the Spanish experience. For lessons learned from the other side of the Spanish

albeit independently, in the United States. In 1937, Bernard Fantus of the Cook County (Illinois) Hospital proposed the creation of a central stock of stored blood to which donors could contribute when possible and from which blood for patients could be drawn as needed. The idea was reinforced by news of the experience in Spain and was immediately picked up by a number of hospitals around the world. In France, preserved blood was first used in Bordeaux in 1934, and in Nancy, Strasbourg, and Paris by 1938.⁵⁶

By the late 1930s, these debates became more than academic for the rest of Europe. One of the ominous new developments revealed in the Spanish Civil War was the air bombardment of civilian populations. During the Munich Crisis in September 1938, this led to a near panic among the inhabitants of Europe's large cities as the specter of war loomed overhead. Part of the governments' response was to plan for a dramatic increase in the supply of blood for transfusion. In Britain, for example, a mobilization was planned within the constraints of the two-week time limit of stored blood and the huge population center (and target) that London presented. According to an October 1938 report of the British Red Cross Society, during the height of the crisis in September, an ambulance station in London was designated to be a temporary blood storage depot. Refrigeration units and a large stock of obsolete milk bottles were located and a rubber cap was designed for storage. The 200 hospitals in London were notified to prepare for blood storage and to expand the list of possible donors. Press releases and BBC broadcasts for appeals were prepared, but held up awaiting the announcement of conflict for fear

Civil War, see Paolo Ravenna, "Brevi osservazioni sulle transfusioni di sangue in guerra," *Minerva Med.*, 1938, 29, 622–24. See Starr, *Blood*, pp. 78–83 for more about Duran Jorda, plus the curious transfusion service organized by Norman Bethune in the Spanish conflict.

56. On the first blood bank, see Bernard Fantus, "The Therapy of the Cook County Hospital," *J. Am. Med. Assoc.*, 1937, 109, 128–31. For examples of other blood banks, see P. B. Patton, "Blood Bank of Graduate Hospital of University of Pennsylvania," *Am. J. Clin. Pathol.*, 1938, tech. suppl. 2, 178–82; E. D. Plass, "Blood Bank," *J. Iowa Med. Soc.*, 1939, 29, 61–63; E. Giddings and A. W. Kruger, "Blood Banking at King's County Hospital," *Hospitals*, 1939, 13, 41–48. On Soviet experiments with preserved blood that began in 1932, see A. Bagdassarov, "Le problème de la transfusion du sang conservé," *Sang*, 1937, 11, 466–82; Charles Richard Drew, "The Role of Soviet Investigators in the Development of the Blood Bank," *Am. Rev. Soviet Med.*, 1943, 1, 360–69; and Starr, *Blood*, pp. 65–71; 116–19. For Argentina, see Juan Tenconi and Rodolfo Palazzo, "Transfusión de sangre conservada," *Sem. Med.*, 1934, 41, 766–68; 1179–93; and for France see G. Jeanneney, J. Viéroz, and L. Servantie, "Transfusion du sang conservé plusieurs jours, en pratique médico-chirurgicale courante," *J. Méd. Bordeaux*, 1934, 111, 685–86.

of creating a premature panic.⁵⁷ The apparatus developed by Janet Vaughan and used widely during the Second World War retained the simple milk bottle design.

After the Munich crisis subsided, the British and other European governments continued preparations for war based on the new developments in blood banking and storage, in combination with their experience with blood transfusion services in the 1920s and 1930s. The net effect was to begin the creation of wartime transfusion services even before the opening of hostilities in September 1939. In Britain, for example, at the end of 1938 and beginning of 1939 the *Lancet* ran a series of articles “on medical organisation and surgical practice in air attacks,” and the *British Medical Journal* published a series of “lectures on the treatment of war wounds and air raid casualties.”⁵⁸ This reflected a planning framework for the broader public that resulted, once war broke out, in the creation of four blood supply depots in the outer suburbs of London, and an Army Transfusion Service in the southwestern counties to arrange for storage and transportation of the blood from the supply depots. The service also conducted research that paralleled American work on the use of plasma and freeze-drying. An indication of the new scale of operations was the fact that, during the first two years of the war, the London blood supply depots recorded almost a twenty-fold increase over the highest annual total of donations for the London Red Cross service in the late 1930s.⁵⁹

In France, the organizers of the TSU (Gosset, Lévy-Solal, and Tzanck) responded to the Munich Crisis by abandoning their donor-list system in favor of a blood banking scheme. They announced a plan on 25 September 1938 to establish a fixed stock of stored, citrated blood at Saint-Antoine Hospital.⁶⁰ Rather than calling an approved donor for each transfusion, they would use blood from the stock as needed, which was continually renewed as demands were made on

57. “After the Crisis,” *British Red Cross Society Blood Transfusion Service Quarterly*, no. 21 (October 1938), 4–6.

58. P. H. Mitchiner, “Wound, Shock, Haemorrhage and Blood Transfusion,” *Lancet*, 1939, 228–31; Janet Vaughan, “Blood Transfusion,” *Br. Med. J.*, 1939, *i*, 933–36.

59. Geoffrey Keynes, ed., *Blood Transfusion* (Baltimore: Williams & Wilkins, 1949), p. 337.

60. A. Gosset, E. Lévy-Solal, and A. Tzanck, “Transfusion sanguine en temps de guerre,” *Bull. Acad. Natl. Med.*, 1939, *121*, 166–76; and Causeret and Jeanneney, “Note au sujet de l’organisation des centres militaires de transfusion sanguine de sang conservé,” *Bull. Acad. Natl. Med.*, 1939, *121*, 722–24.

it. This was intended to be more than a Paris version of the blood bank; the model was based on the Spanish system and applied to France as a whole during wartime. Tzanck and his collaborators made clear how much this represented a departure from the system used in the First World War, because blood would be drawn, “neither from combatants nor medical or nursing personnel who were themselves overwhelmed during [military] action. It must be supplied by the non-combatants from the interior.”⁶¹ The existence of regional centers would allow the system to function even if a part of French territory had to be evacuated. A coordinating agency would be necessary but only to help train personnel and ensure use of standardized equipment and storage methods.

The Tzanck plan, with some modifications, was adopted in France at the outbreak of war, and Saint-Antoine Hospital became the coordinator of stored, citrated blood drawn from provincial centers around the country.⁶² The recently created Centre National de Recherche Scientifique (CNRS) established a “Comité spécialisé pour l’étude des problèmes de la transfusion sanguine,” in spring of 1940 which included Col. L. Jame, who directed the only army blood laboratory in France at the Val de Grâce hospital in Paris. At the outbreak of war, Jame’s facility was designated to receive and distribute the blood collected by Tzanck’s organization at Saint-Antoine.⁶³ Although the committee began funding experiments with substitutes for whole blood, including plasma, the defeat of France in June 1940 stopped the research. Tzanck, a Jew, was forced to flee to Chile. Another center for research and production of blood transfusion products was created in Algiers in November 1942 under the direction of Professor Edmond Benhamou. It supplied whole blood and liquid plasma for French forces in the North African campaigns and trained specialists in transfusion.⁶⁴ After the Normandy landings and liberation of Paris, Tzanck returned to France where, along with the North African

61. Gosset et al., “Transfusion sanguine en temps de guerre,” p. 167.

62. J. Blomet, “La transfusion-reanimation aux armées,” *Rev. Corps Santé Armées Terre Mer Air*, 1966, 7, p. 877.

63. L. Jame, “Le rôle du laboratoire central de recherches bactériologiques et de sérologie de l’armée dans l’organisation de la transfusion sanguine dans les armées en campagne,” *Rev. Corps Santé Armées Terre Mer Air*, 1966, 7, p. 853.

64. Benhamou, “Notes pour servir à l’histoire de la transfusion sanguine dans l’armée française de 1942 à 1945 à partir de l’Afrique du Nord,” in *Rev. Corps Santé Armées Terre Mer Air*, 1966, 7, 859–62.

veterans, he reestablished a transfusion service in the capital, including a plasma facility.

The Germans were surprisingly poorly organized for their transfusion needs. Only a few of the largest cities had established donor organizations before the outbreak of war. One of the earliest of these was in Leipzig, where a little more than 500 transfusions were arranged in 1936. A similar organization in Berlin had only 128 registered donors as late as 1935, although a report at the 1937 transfusion congress gave a figure of 2,000 transfusions at the Virchow Hospital the previous year. This was at a time when donor organizations in London, Paris, and New York recorded 4,000–6,000 transfusions each year.⁶⁵ Victor Schilling of the German delegation to the Second International Blood Transfusion Congress in Paris in September 1937 admitted at the concluding session,

The organization of blood transfusion in Germany is much less well perfected than in France. As of now, it is practiced only in a few private and state clinics, but it is to be hoped that the organizations in Germany will be improved, and the example of the Transfusion Sanguine d'Urgence in Paris will be of the greatest benefit to the German delegation.⁶⁶

The situation in Germany had not improved much by the outbreak of the Second World War. In September 1939, there were no blood banks in Germany, and articles published in German medical journals reported experiments with preserved blood and plasma reminiscent of ad hoc trials during the First World War on the Western Front. Despite earlier plans, the testing of all military personnel had not begun, and guidelines for blood transfusion (much more rudimentary than in Britain and the United States) were only promulgated in March 1940.⁶⁷ U.S. Army reports during and after the war ridiculed German

65. Seggel, "Der Leipziger Blutspendernachweis," p. 1129; "Organization of Blood Donors in Germany," *J. Am. Med. Assoc.*, 1935, 105, 610–11.

66. "Séance de clôture," *Deuxième congrès international de la transfusion sanguine*, 2, 312. Schilling, a professor at Münster, later worked at the blood transfusion laboratory in Berlin during the war.

67. A frank admission of Germany's backward blood transfusion practices was published in June 1939 by H. Burkle-de la Camp, "Über die Bluttransfusion im Kriegsfall unter besonderer Berücksichtigung der Verwendung konservierten Blutes," *Deutsche Zeitschrift Chir.*, 1939, 252, 365–80. See also H. Junghanns, "Vorschlag zur reichseinheitlichen Regelung der Blutspenderzentralen," *Münch. Med. Wochenschr.*, 1939, 86, 1775–77. For the guidelines that merely called for testing for disease, blood type compatibility, and further research, see V. Schilling, "Ueber die Bedeutung der Richtlinien für die Einrichtung des Blutspenderwesens im Deutschen Reich," *Chirurgie*, 1941, 13, 561–68.

efforts to obtain “Aryan” blood and gave anecdotal evidence of continued use of direct arm-to-arm transfusions, use of Unger syringes, and reliance on type O “universal” donors. On the other hand, there was a concerted effort at developing mass methods of typing German soldiers, and there were reports of widespread use of plasma substitutes and heparin as an anticoagulant. Indeed, among the charges at the Nuremberg medical war crimes tribunal were allegations of experiments on concentration camp inmates with a blood coagulant, polygal, and old plasma and blood serum. Even if it is difficult to draw a firm conclusion from all this disparate evidence, the German practices were in marked contrast to the highly organized British and American efforts to meet transfusion needs.⁶⁸

POSTSCRIPT ON AMERICAN PREPARATIONS
FOR THE SECOND WORLD WAR

The history of blood transfusion during the Second World War has been the subject of lengthy studies.⁶⁹ Of primary interest in this article were the American preparations, once war broke out in Europe, not only for comparison sake, but also because of the innovations that were developed. The delay of more than two years before the Americans entered the conflict permitted researchers to work on such techniques as preservation and the use of plasma.

In the United States (and to a lesser extent in Britain), new scientific and technological discoveries brought significant changes in blood transfusion during the Second World War that went beyond simply

68. During the war, P. L. Mollison ridiculed the German transfusion practices, calling them 25 years out of date. Examples of his summaries of the German literature can be found in the *Bull. War Med.*, 1942, p. 301; 1943, p. 276 and pp. 392–93. For examples of “Aryan” blood reports, see *New York Times*, 1 March 1942 and 23 September 1942. For postwar reports, see Edward D. Churchill, *Surgeon to Soldiers* (Philadelphia: J. B. Lippincott, 1972), p. 379; Howard E. Snyder, *Surgery in World War Two: Activities of Surgical Consultants* (Washington, D.C.: Office of the Surgeon General: Department of the Army, 1962), 1, 457; and Kendrick, *Blood Program in World War II*, pp. 22–23. Starr, *Blood*, pp. 114–15, suggests that Nazi xenophobia blinded the Germans to the utility of transfusion. However, for evidence that experiments continued, see K. Lang and H. Schwiegk, “Erfahrungen mit den Serumkonserven und mit Plasma als Blutersatzmittel,” *Deutsche Mil.*, 1942, 7, 379–84; and E. Klees, “Erfahrungen mit ‘Periston’, einer Blutflüssigkeitsersatz,” *Münch. Med. Wochenschr.*, 1943, 90, 29–32. On the Nuremberg medical war crimes, see *Trials of War Criminals before the Nuernberg Military Tribunals* (Washington: Government Printing Office, 1952), 1, 517–18; 553–54; 669–70.

69. For the U.S., see Kendrick; *Blood Program in World War II*; for Britain, in addition to Gunson and Dodsworth, “Fifty Years of Blood Transfusion,” see *Medical History of the Second World War* (London: HMSO, 1953) pp. 97–103; and for France, see the special issue of *Rev. Corps Santé Armées Terre Mer Air*, 1966, 7.

using older discoveries to their fullest. One of these, the discovery in 1939 of what came to be known as the Rh blood group, was serendipitous, having nothing to do with the war. Rather it grew out of work on two seemingly unrelated problems: the death of infants from a disease eventually called *erythroblastosis fetalis*, whose symptoms included abnormal blood-making ability; and the occurrence of a number of transfusion reactions between individuals with apparently compatible blood types.⁷⁰ The discovery was of very little immediate importance to transfusion in the Second World War.

Of far greater consequence to the war effort was American work on the use of plasma and other blood fractionation products.⁷¹ Although plasma research had begun before the outbreak of war, it was quickly expanded and extended thanks to recognition by the Americans of the need for innovation arising in large measure from the geographical isolation of the United States. If blood could be prepared and supplied over long distances like other war materiel, it would greatly facilitate the Americans' ability to use their large resources in the conduct of a global, industrial-based war. Here was a case, unlike the Rh discovery, in which wartime necessities directly influenced scientific and technical research. As luck would have it, the Americans had an opportunity to test new organizational as well as technical approaches to these problems in the two years between the outbreak of European hostilities in 1939 and the entry of the United States into the war in December 1941.

The first of these opportunities was the "Blood for Britain" project conducted by the largest American donor organization, the New York Blood Transfusion Betterment Association. It grew out of a sug-

70. Philip Levine and R. E. Stetson, "An Unusual Case of Intragroup Agglutination," *J. Am. Med. Assoc.*, 1939, 113, 126-27; Karl Landsteiner and A. S. Wiener, "An Agglutinable Factor in Human Blood Recognized by Immune Sera for Rhesus Blood" *Proc. Soc. Exp. Biol. Med.*, 1940, 43, 223; and Philip Levine, E. M. Katzen, and L. Burnham, "Isoimmunization in Pregnancy, its Possible Bearing on the Etiology of Erythroblastosis foetalis," *J. Am. Med. Assoc.*, 1941, 116, 825-27. For an excellent account of the background, see David R. Zimmerman, *Rh: The Intimate History of a Disease and Its Conquest* (New York: Macmillan, 1973), pp. 20-47. Among anecdotal "recollections," see L. K. Diamond, "The Rh Problem through a Retrospective," *Am. J. Clin. Pathol.*, 1974, 62, 311-24; and Richard E. Rosenfield, "Who Discovered Rh? A Personal Glimpse of the Levine-Wiener Argument," *Transfusion*, 1989, 29, 355-57.

71. Among these was the discovery of blood fractionation by Edwin Cohn. For more, see Angela Creager, "Biotechnology and Blood: Edwin Cohn's Plasma Fractionation Project, 1940-1953," in Arnold Thackray, ed., *Private Science: Biotechnology and the Rise of the Molecular Sciences* (Philadelphia: University of Pennsylvania Press, 1998), pp. 39-62; and Starr, *Blood*, pp. 101-21.

gestion by Alexis Carrel, a native of France who emigrated to the United States in 1904, joined the new Rockefeller Institute for Medical Research, and won the Nobel Prize in Medicine in 1912.⁷² After a visit to France where he witnessed German forces advancing on Paris in May 1940, Carrel returned to New York and attended a meeting of the New York transfusion association on 12 June 1940, where he suggested the possibility of supplying blood to France and Britain.

Even though Carrel's main objective soon became moot when France signed an armistice with Germany ten days later, the attendance of others at the meeting indicates that this was to be more than a short-term, humanitarian effort. In addition to the trustees of the New York Blood Transfusion Betterment Association, there were representatives of Carrel's former employer the Rockefeller Institute, as well as the U.S. Army, the Navy, and the National Research Council (NRC).⁷³ The latter had been created by the National Academy of Sciences during the First World War to conduct scientific research in the national interest. These members of the committee clearly saw the Blood for Britain project as a testing laboratory for possible later American needs.⁷⁴

Those at the meeting quickly made a key decision to concentrate on supplying plasma rather than whole blood. The use of this part of blood was not a completely new idea but rather the culmination of the long-standing albeit intermittent interest in fluids other than whole blood that could be transfused.⁷⁵ There had been sporadic

72. Carrel is a highly controversial figure because of his research on *in vitro* cell cultivation between the wars and his activities in German occupied France during the Second World War. For a balanced account of Carrel's life and scientific work, see his entry in the *Dictionary of Scientific Biography*. Because of his skills in microsurgery, Carrel had performed one of the first blood transfusions in the twentieth century on the infant of a New York doctor. Publicity from the operation not only helped spread the word about new techniques of blood transfusion, it also brought Carrel to the attention of John D. Rockefeller.

73. Kendrick, *Blood Program in World War II*, p. 13. This was not the first such project. See "Blood Sent to Spain," *New York Times*, 16 April 1938, p. 4, for an earlier effort directed by Walter B. Cannon at Harvard.

74. For background on the NRC, see Rexmond C. Cochrane, *The National Academy of Sciences: The First Hundred Years* (Washington, D.C.: National Academy of Sciences, 1978); and for the Second World War, see George B. Darling, "How the National Research Council Streamlined Medical Research for War," in Morris Fishbein, ed. *Doctors at War* (New York: E. P. Dutton, 1945), pp. 363–98.

75. For an overview, see Charles A. Janeway, "Plasma, the Transport Fluid for Blood Cells and Humors," in Maxwell M. Wintrobe, ed., *Blood, Pure and Eloquent* (New York: McGraw-

research on human plasma in the 1920s and early 1930s, with few findings to recommend its wider use. In the late 1930s, however, John Elliott showed one distinct advantage of plasma over whole blood. Based on the results of 190 transfusions, he found that, if plasma was pooled from a sufficient number of donors, it would neutralize antibodies—which meant there was no need to type for compatibility. In addition, plasma was stable for a much longer time than citrated whole blood.⁷⁶

Even though, in hindsight, this pooling of sera carried with it the danger of a single donor contaminating a large number of transfusions, there was a precedent in the Spanish Civil War in which the Barcelona service routinely mixed whole blood from at least six donors of the same type to cancel out variations in titer and to solve occasional problems of incompatibility when using O type as a universal donor. The benefits of producing plasma on a large scale—storage for a long time and elimination of the need for typing—were thought to outweigh any potential of widespread contamination.⁷⁷

By August 1940, standardized practices were developed by John Scudder and Charles Drew at Columbia University for processing and storing plasma for the Britain project. Although promising new techniques for freeze-drying were being developed in the United States and Britain, there was no time to wait for them to be perfected. The New York chapter of the American Red Cross was enlisted in the project to help find donors who gave their blood at several New York hospitals. The plasma was separated by sedimentation and centri-

Hill, 1980), pp. 572–99. As far back as the First World War, Gordon Ward, “Correspondence: Transfusion of Plasma,” *Br. Med. J.* 1918, *i*, 301, had suggested the advantage of plasma not hemolyzing red blood cells. This line of research even revived the pre-twentieth century interest in fluids other than human blood. For example, bovine plasma—a product in large supply—briefly came under serious study by O. H. Wangensteen, a surgery professor at the University of Minnesota. See Wangensteen et al., “Intravenous Administration of Bovine and Human Plasma to Man: Proof of Usefulness,” *Proc. Soc. Exp. Biol. Med.*, 1940, *43*, 616–21. In France, similar suggestions were made for horse plasma. For Tzanck’s critical reaction, see A. Tzanck and M. Sureau, “Sang total ou plasma?” *Bull. Mem. Soc. Méd. Hôp. Paris*, 1940, *56*, 19–23. Despite the advantage of large supply, these projects were abandoned because of side effects and reactions.

76. Elliott, “A Preliminary Report.” He used eight different donors in his first pool. See also, W. L. Tatum, J. Elliott, and N. Nessel, “A Technique for the Preparation of a Substitute for Whole Blood Adaptable for Use During Wartime Conditions,” *Mil. Surg.*, 1939, *85*, 481–89.

77. Duran-Jorda, “Barcelona Blood Transfusion,” pp. 773–74, ignored the problem of contamination.

fuge, then flown in 1,000-ml bottles, six to a carton, by clipper airplanes to Britain. When the program ended in January 1941, 14,556 donors had furnished a total of 6,151 liters of plasma.⁷⁸

Despite these efforts, the project had very little impact in Britain. This was partly because many batches were infected by the time they crossed the Atlantic, but in addition, the amount of plasma shipped was small, compared with the enormous efforts of the British where at the climax of the Battle for France in the month of June 1940, the four London blood depots took donations from more than 113,000 donors.⁷⁹ The Americans, nonetheless, learned several lessons in this project. First was the advantage of using the Red Cross. Despite the success of the London transfusion service begun in the 1920s, American Red Cross chapters had only very lately become involved in blood collection programs.⁸⁰ The Blood for Britain project demonstrated that the Red Cross possessed the combination of local chapters and national organization that would be ideal for a national blood donation campaign. A second lesson was that collection of blood on a large scale had proven its feasibility. Plasma also proved its value because of its storage and lack of compatibility problems, although by the end of the program the advantages of dried plasma made it a preferable alternative quite simply because it could be stored much longer without contamination.⁸¹ Of most importance to the Americans was that the different civilian and military organizations had

78. DeWitt Stetten, "Blood Plasma for Great Britain Project," *Bull. N. Y. Acad. Med.*, 1941, 17, 27-38. For a popular contemporary account of the new use of plasma, see Edith Roberts, "The Miracle of Plasma," *Hygeia*, 1940, 18, 1070 ff. See also Starr, *Blood*, pp. 92-98.

79. Gunson and Dodsworth, "Fifty Years of Blood Transfusion," pp. 14-15; 38. Although the contamination was not widely reported, it was a recurring problem for the American military production of plasma and blood products. For the example of jaundice, see Kendrick, *Blood Program in World War II*, pp. 674-78.

80. See W. DeKleine, "Red Cross Transfusion Projects," *J. Am. Med. Assoc.* 1938, 111, 2101-03; American National Red Cross, *American Red Cross Blood Donor Service During World War II: Its Organization and Operation* (Washington: American National Red Cross, 1946). For background, see Foster Rhea Dulles, *The American Red Cross: A History* (New York: Harper and Brothers, 1950), pp. 412-23. To be fair, the Red Cross involvement in Britain was exceptional.

81. Experiments with drying techniques for immunological products dated from before the First World War, but there were problems of damage because of changes in concentration of components during drying. A novel solution by first freezing and then evacuation of vapor [freeze-drying] was first reported by Flosdorf and Mudd at the University of Pennsylvania in 1935. It was not until 1940, however, that they worked out a cost-efficient way of applying the technique on a large scale. In addition to Flosdorf and Mudd, "Procedure and Apparatus for Preservation," see Mudd, Flosdorf et al., "The Preservation and Concentration of Human

shown they could cooperate successfully to solve a large logistical problem.

On 31 May 1940, the NRC Committee on Transfusions held its first meeting and thereafter acted as research coordinator of subcommittees on shock, blood substitutes, and blood procurement.⁸² In June 1940, the Surgeon General of the U.S. Army asked the Red Cross to collect blood for experimentation (this was in addition to the Blood for Britain project), and by May 1941—seven months before U.S. entry into the war—formal agreement had been worked out between the NRC, the Army, and Navy for a national blood procurement program.⁸³

This does not mean that all potential problems of blood supply had been worked out. The establishment of a national program immediately raised the highly sensitive questions of race and blood. This issue of whether the blood of people from different races possessed different properties had been vigorously investigated by scientists very soon after the initial discovery of the blood groups.⁸⁴ Although the issue had not been resolved to everyone's satisfaction, there was no evidence of any negative reaction from transfusion with blood from a person from a different racial or ethnic group that was not attributable simply to difference in blood type. Despite this experience, there certainly persisted in the mind of most of the public the idea that such blood differences existed. These problems, part of the question of whose blood to transfuse, had previously been masked by the decentralized system of blood donors that existed in the United States. Hence, the New York Blood Transfusion Betterment Association made no note of the racial origin of blood donors, whereas the first blood bank in Chicago labeled blood by race, and hospitals in the south very definitely kept the blood of blacks and whites separate.⁸⁵

With the establishment of a national program, the War Department issued a directive that admitted this disparity between scientific and

Serums for Clinical Use," *J. Am. Med. Assoc.*, 1936, 107, 956–59; and Flosdorf, Stokes, and Mudd, "The 'Desivac' Process for Drying from the Frozen State," *J. Am. Med. Assoc.*, 1940, 115, 1095.

82. Kendrick, *Blood Program in World War II*, pp. 73–76.

83. *Ibid.*, pp. 101–37, has a detailed treatment of the American Red Cross war effort.

84. For more, see Schneider, "Chance and Social Setting," pp. 558–62.

85. For example, a 1939 article on a new blood bank at a Texas hospital reported, "Blood from colored donors is kept separate from that of whites and Mexicans and only used for transfusing colored patients." Donald G. Henderson, "Blood Bank at Jefferson Davis Hospital," *Hospitals*, 1939, 13, 60–62.

public perceptions. It said, "For reasons which are not biologically convincing but which are commonly recognized as psychologically important in America, it is not deemed advisable to collect and mix Caucasian and Negro blood indiscriminately for later administration to members of the military forces."⁸⁶ The Surgeon-General initially recommended an implementation policy that accepted blood only from white donors, with the proviso that, "where transfusions are required for Negro servicemen, they will be given normal transfusions from Negro donors if they do not desire the use of blood or plasma from white donors."⁸⁷

The Red Cross, with some misgivings, followed the policy, even though the medical supervisor of the plasma project, and former head of the Blood for Britain project, was of African-American ancestry, Charles Drew. Protests by the medical and black communities only resulted in a slight modification of the policy such that blacks as well as whites could donate blood to the Red Cross. The blood and subsequently derived blood products would continue to be segregated.⁸⁸ Drew resigned from the project in April 1941, but despite continuing protests and the bitter irony of accepting the Nazi premise of racial difference in blood, the Army and Red Cross policies continued until December 1950. Even then, the labeling and segregation of blood by race continued in several southern states until the Civil Rights Act of 1964.⁸⁹

86. As quoted in Robyn Mahone-Lonesome, *Charles Drew, Physician* (New York: Chelsea House, 1990), p. 77.

87. As quoted in P. McGuire, *He too Spoke for Democracy* (Westport, Conn.: Greenwood Press, 1988), pp. 73–74. See also, P. McGuire, "Judge Hastie, World War II, and the Army's Fear of Black Blood," *Rev. Afro-Am. Issues Culture*, 1979, 1, 134–49 and "Military Hemophobia," *The Researchers: A Journal of Interdisciplinary Studies*, 1985, 11, 1–7.

88. McGuire, *He Too*, pp. 74–77. A Red Cross publication of November 1941 entitled, *Teamwork from Publicity to Plasma* (Washington, D.C.: American Red Cross, 1941), p. 20, stated, "In obtaining blood plasma for use in the armed forces, the American Red Cross is acting pursuant to the requests and instructions of the army and navy and as of this time the Red Cross has been asked to supply only plasma from white donors." For examples of criticism, see "Use of Negro Blood for Blood Banks," *J. Am. Med. Assoc.*, 1942, 119, 307–308 and *Science*, 1942, 96, 8. For more on Drew, see W. Montague Cobb, "Charles Richard Drew, M.D., 1904–1950," *J. Natl. Med. Assoc.*, 1950, 42, 238–46; and Starr, *Blood*, pp. 96–100. For more recent scholarly work addressing the controversies surrounding Drew, see Charles S. Wyne, *Charles Richard Drew: The Man and the Myth* (Urbana: University of Illinois Press, 1988); and Spencie Love, *One Blood: The Death and Resurrection of Charles R. Drew* (Chapel Hill: UNC Press, 1996).

89. In Louisiana, it continued until 1969. See "Segregated Blood: A Backlash Backfires," *Hospital Practice*, 1969, 4, 21–25; 82–83. The Americans were not, however, the only ones who acceded to common prejudices that ran counter to scientific evidence. Not surprisingly,

CONCLUSION

The history of blood transfusion in the first half of the twentieth century shows that scientific and technological innovation was hardly a story of the inevitable march of progress. On the contrary, discoveries came in fits and starts, some of which were immediately adopted, whereas others, such as the discovery of blood groups and anticoagulants, lay unused for years until rapid tests and problems of contamination could be worked out. Likewise, other practices such as the use of “universal donors” and racial segregation of blood, persisted long after being recognized as having little or no scientific merit. Nonetheless, a quick, safe, and effective transfusion procedure was developed by mid-century that can be credited with saving in dramatic fashion hundreds of thousands of lives during war and peacetime.

The majority of developments in transfusion between the wars were not the result of new discoveries, but rather the spread of ideas and the establishment of donor organizations to permit widespread use. The discovery of techniques for the transfer of blood had been made in the first dozen years of the century, and the world war permitted a demonstration of their effectiveness on a large scale. But widespread adoption in normal civilian settings required very different organization, motivation, and safeguards than were possible under wartime conditions.

After the First World War, the procedures of blood transfusion and testing were relatively simple, which also helps explain why the practice quickly spread to all parts of the world. There was little difference in the instruments and techniques used for transfusion in France, Britain, Germany, and the United States, but there were great differ-

the Nazis made some attempts to screen for “Aryan” blood in transfusions. See *New York Times*, 1 March 1942, 13, 2 and 23 September 1942; 11, 1. Jean Dausset, French Nobel laureate, relates that during his service in the North African campaign, captured Germans who were wounded refused blood transfusions from Italians in the medical wards. Dausset interview, May 1994, and *Clin d’oeil de la vie* (Paris: Editions Odile Jacob, 1998), p. 43. At the outbreak of the war, one French surgeon found it surprising enough that the blood from African troops could be used in transfusions for white French troops that he wrote a special report for a government commission studying blood transfusion. “Note du Dr. Briault exposée au comité spécialisé pour l’étude des problèmes de la transfusion sanguine,” séance du 4 mai 1940. Archives of CNRS, CAC 80284, folder 34. Finally, Wynes, *Charles Richard Drew*, p. 67, states that even before the U.S. Army created its national program, the blood and plasma shipped to Britain in 1940 was labeled by race, supposedly to honor British wishes. The separate labeling, although not the motivation, is confirmed by Stetten, “Blood Plasma for Great Britain Project,” p. 43.

ences in how services were established to insure adequate and safe blood supplies. Among the variations that developed not just between countries but even by region within them were the size and geographical scope of the service, whether donors would be paid, who organized the service, and the degree of government involvement.

Two developments by the mid-1930s began the next phase of change in transfusion that carried into the Second World War. One was the resolution of problems with storage of blood and the discovery of new techniques for separating and storing plasma. The other was the impending war and realization of the need for transfusion on an unprecedented scale. Thus, in contrast to the outbreak of the First World War—which caught everyone by surprise, including medical support, the European countries, and especially the United States—there was ample warning of the conflict that came to be known as the Second World War. Among their preparations were new techniques for storing and transporting whole blood and blood products. But the belligerent countries also adapted and expanded civilian donor organizations that had developed between the wars.

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