PIONEERS AND PATHFINDERS

Blood Transfusion in World War I: The Roles of Lawrence Bruce Robertson and Oswald Hope Robertson in the "Most Important Medical Advance of the War"

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The demonstration and acceptance of the life-saving potential of blood transfusion in the resuscitation of combat casualties came in two parts. First, Canadian surgeon Major Lawrence Bruce Robertson showed that direct transfusion of uncrossmatched blood from the veins of a donor to a patient could save the lives of many moribund casualties, even if a few died of acute hemolytic reactions. Second, US Army Captain Oswald Hope Robertson showed that stored, syphilis-tested, universal donor whole blood could be given quickly and safely in forward medical units. With these demonstrations, the Royal Army Medical Corps adopted transfusion and declared it the most important medical advance of the war.

IN HIS OTHERWISE fine history of hematology, *Blood Pure and Eloquent*, Maxwell Wintrobe conflated the two most important figures in the development of transfusion in World War I.[1] He wrote, "A Canadian Army medical officer, O. H. Robertson, introduced the use of a citrate-glucose solution…." The two figures confused in this account are Canadian Major Lawrence Bruce Robertson and American Captain Oswald Hope Robertson.

The Canadian Major Lawrence Bruce Robertson, a surgeon, used uncrossmatched whole blood transfused by syringe directly from donor to recipient to demonstrate the life-saving potential of transfusion and the need to resuscitate the badly injured with something more than normal saline.[2] He served on the Western Front in Canadian Corps of the British Third Army from October 1915 to the end of 1917 and wrote four articles describing series of cases of transfusion.[3-6] He was returned to Canada as an invalid before the war ended and died at the age of 38 in 1923.

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The American Captain O.H. Robertson, a medical officer with special training in blood storage from the Rockefeller Institute, came to France with the Harvard Medical Unit in May of 1917 and served until the end of the War.[7] He developed the transfusion bottle, demonstrated the use and safety of stored universal donor or crossmatched blood, wrote two important articles, and served as head of the US Army's transfusion school during the last months of the war.[8,9] After the war, he had a long successful academic career and received the Landsteiner Award of the AABB in 1958.

Keeping the wartime stories of the two Robertsons straight can be difficult because they even served in some of the same units at the same time. This occurred because the American Robertson had been forwarded to the British Third Army to conduct his most important work on the transfusion of stored blood. His patients in this work were largely Canadian soldiers.

This article will briefly recount the service of the two Robertsons and their contributions to the spread of blood transfusion in the Great War. The importance of their respective contributions will be highlighted.

LAWRENCE BRUCE ROBERTSON

The medical and military career of L.B. Robertson has been well documented in two excellent reviews by Peter Pinkerton, most recently in this journal 2 years ago.[2,10] These reviews draw on official records from the Canadian War Office, Robertson's personal papers in the Ontario

archives, the writings of colleagues, Robertson's medical papers, and the work of historian Kim Pelis.[11] The short version given here is largely taken from Pinkerton, although the authors have copies of Dr Pelis' historic photographs, timelines, and some notes (Fig 1).

L.B. Robertson graduated in medicine from the University of Toronto in 1909 and served 1 year as an intern at the Hospital for Sick Children in Toronto, 18 months at the Bellevue Hospital in New York, and 6 months at Boston Childrens' Hospital before returning to Canada in 1913. He learned the syringe technique of direct transfusion from Lindeman at Bellevue and performed the first transfusions in Canada on his return. He was in active surgical practice at the Hospital for Sick Children, and one of his articles from that time described transfusions in 27 children.[2,12] Only one of the transfusions appeared to have been crossmatched. L.B. Robertson emphasized the safety of the procedure and the lack of transfusion reactions despite cross-reactivity on preliminary testing.

L.B. Robertson volunteered and was commissioned in the Canadian Army Medical Corps at the outbreak of the War in September of 1914 but was left in place at the Hospital for Sick Children for 6 months while the Canadian Army organized. He was shipped to England in April 1915 and then to France in September 1915, and immediately seconded to a British base station hospital for 4 months. At this time, transfusion was not well regarded in the British medical hierarchy. That disdain is clear in a review in 1907 in the *British Medical Journal* of an article by American surgeon and transfusion pioneer G.W. Crile, "Excellent results were certainly obtained in some cases of shock, but in the treatment of this condition, and indeed, of all others in which intravascular infusion of some kind is clearly indicated, surgeons, we imagine, will find no good reasons given here for abandoning the safe and simple method of saline injection."[13] However, during this period at the British base station hospital, L.B. Robertson preformed four transfusions described in his June 1916 article in the *British Medical Journal*, "The transfusion of whole blood: a suggestion for its more frequent employment in war surgery."[3] Again, he performed no crossmatching, experienced one death from acute hemolysis, and wrote that the desperation of the situations and visible benefit in some justified the actions. It was the first article on wartime blood transfusion published in the 20th century.[3]

Fig 1. Lawrence Bruce Robertson, Major, Canadian Army Medical Corps, served in France 1915-1917.

L.B. Robertson returned to the Second Canadian Casualty Clearing Station in early 1916, and in February, he built a resuscitation ward. However, the Flanders Theater was relatively quiet that year with the major fighting taking place to the east on the Somme and at Verdun. Nevertheless, they were immediately behind the front and were receiving primary casualties who had spent hours lying wounded and being evacuated out of the trenches. L.B. Robertson put together a series of these primary resuscitation transfusions and published them twice in the *British Medical Journal* in November 1917 and in the *Annals of Surgery* in January 1918.[4,5] The reports are, with a few word changes, the same article, describing the same 36 cases, including three fatal hemolytic transfusion reactions, with each patient identified by rank, initials, and admission date. Both versions ended with the same note by Gordon Watson, consultant surgeon to the British Expeditionary Force. It appears that the British Army Medical Corp's "conversion" to blood transfusion was so sudden that the *British Medical Journal* picked up the

already accepted *Annals of Surgery* article and prepublished it 5 weeks ahead of its appearance as the lead article in the *Annals of Surgery*. This unusual double publication was a gratifying vindication of the observations and practice of a junior surgeon from the "colonies."

In June of 1918, after he had returned to Toronto, L.B. Robertson published a fourth article describing methods and results of transfusion in war surgery in *The Lancet*. Separately, he published an appendix of his transfused cases, listing the previously published 40 patients and 28 more.[6] It is a historically useful article, but it was already obsolete when it was written.

OSWALD HOPE ROBERTSON

Oswald Hope Robertson's life has been described in six medical articles, and his military career can be traced in the three books written about personal experiences in the Harvard Medical Unit: Harvey Cushing's *From a Surgeon's Journal* and Roger Lee's *Letters of Roger I. Lee* and *The Happy Life of a Doctor*.[3,14-20] The records of the Fifth Base Station Hospital are in the US National Archives, and O.H. Robertson's sons Don and Dr. Alan Robertson provided the authors with a copy of their father's World War I diary. O. H. Robertson wrote two articles about transfusion and two long reports on transfusion for the Medical Research Council (Fig 2).[8,9]

O.H. Robertson was born in Great Britain, but his family immigrated to the United States when he was 2. He graduated from the University of California in 1910 and received a Master's degree in Microbiology in 1911 before going to Harvard Medical School. At Harvard, he did research on urobilinogen in the laboratories of Roger Lee and Beth Vincent and was involved in their blood transfusion work as well.[21] During O.H. Robertson's last year as a medical student, Vincent went to the American volunteer hospital in Paris, the Ambulance Americaine, and there performed the first recorded transfusion of the war on April 23, 1915.[18] After his graduation in 1915, O.H. Robertson went to the Rockefeller Institute to work with Peyton Rous at a time when Rous was publishing work on blood typing and red cell storage.[22-24] In 1917, O.H. Robertson returned to Harvard to join the Harvard Medical Unit at Roger Lee's request. This American military medical group, therefore, was skilled in and committed to blood typing as in integral part of transfusion.

Fig 2. Oswald Hope Robertson, Captain, US Army Medical Officer Reserve Corps, served in France 1917-1918.

The US entered World War I in April 1917, and the Harvard Medical Unit sailed in early May. The unit spent 2 weeks in England and then moved to France and directly into position behind the line in Flanders. Because they were the first American Army unit in theater, they were assigned to the British Army for command and supply and carried joint designations as the 5th US Base Station Hospital and the 13th British Expeditionary Force Hospital. By July, Lee had set up a system of identifying potential blood donors each day and posting their names and blood types on the operating room doors. During this time, O.H. Robertson had developed a transfusion bottle using the Rous-Turner solution of citrate and glucose.[8,25]

Later that summer, Sir George Makins, the Surgeon General of the British Expeditionary Force, asked Lee to look into the practice of uncrossmatched blood transfusion in the British Expeditionary Force.[19] Specifically, he was worried about the use of uncrossmatched blood and the reported deaths. Lee responded by sending O.H.

Robertson to the British Third Army to demonstrate transfusion of universal donor stored blood in the casualty clearing stations. By December, the safety and ease of using typed, syphilis-tested, and stored blood had been widely demonstrated, and training in the new methods and serologic quality control became an increasing part of O.H. Robertson's duties. By the time he published his two articles in the *British Medical Journal* in April and June of 1918, his methods were already in wide use. In 1922, Geoffrey Keynes, a distinguished surgeon and author of a major textbook on blood transfusion as well as other books on the history of science and literature, wrote, "The first transfusion of citrated blood was performed by Professor L. Agote of Buenos Aires on November 14th 1914, but despite this, transfusion of blood was considered to be too difficult and unsuited for the stress of war conditions until 1917 when the Royal Army Medical Corps was reinforced by doctors from the United States of America and the knowledge that blood could be safely transfused spread throughout the Armies."[26]

GLORY ENOUGH FOR ALL

The joint demonstrations of the efficacy of whole blood and of the combined safety and ease of use of stored blood led to wide use and acceptance of transfusion in the final year of World War I. Harvey Cushing noted in October of 1918 that "good hospitals are performing 50 transfusions a day."[18] The work that led to this advance was crushing. Oswald H. Robertson described a day, November 30, 1917, in his diary:

> "By noon, the wounded began to arrive, then more and more till there was a solid string of ambulances extending down the road almost as far as you could see. We were simply deluged. We couldn't operate [on] more than a small fraction of the cases; we couldn't get rid of them as the ambulance trains were hung up several miles away—couldn't get thru because ammunition trains had the right of way. They piled up and piled up. The resuscitation ward was a veritable chamber of horrors—worse than anything before. Men were horribly mutilated—many were dying when brought in, an occasional one had already died by the time he reached the ward. The beds were filled and we began putting stretchers on the floor. Hemorrhage, hemorrhage, hemorrhage—blood everywhere—clothes soaked in the blood, pools of blood in the stretchers, streams of blood dropping from the stretchers to the floor. I was blood up to my elbows and my rubber apron was one solid red smear. All we could do was to stop the bleeding and get the patients as comfortable as possible. The two sisters were wonderful. I never saw nurses work harder or to better effect. How they stood the orgy I don't know. Men were dying on all sides—as many as 6 dead in the ward at once. They were dying faster than we could get them out. We had to lay the corpses on the floor as we needed the beds for new wounded. We worked on and on. I could transfuse an occasional one but the majority had to take their chance without much treatment and go thru operation as best they could provided there was any possibility at all of their standing operation. I lost all track of time. The night sisters came on. One of the day sisters left but the other stayed till midnight. The seven tables in the operating theatre were going every minute. By 3 or 4 AM I began to sag and as there seemed every prospect that the rush was to continue, I thought I'd better call it off. … was practically moribund (the next) morning when my batman came to wake me. The thought of going back to the resuscitation ward nauseated me. The ward was still full. Many of the faces I remembered last night were no longer there and new faces had taken their place. Learned that we had taken in 1800 patients during the last 24 hours!" [Roberston OH, unpublished WWI diaries]

The work went on throughout the autumn of 1917 as the battle of Passchendaele finally exhausted itself in the winter mud with half a million casualties recorded.

Some time after this, Bruce L. Robertson's health broke, and at the end of the year, he was invalided home. Lee arranged for Oswald H. Robertson to spend 2 weeks of rest and recuperation on the

French Riviera in January 1918 and then he returned to work.

In their Medical History of the Great War, the Royal Army Medical Department acknowledged the development of blood banking and transfusion as the "most important medical advance of the war."[27] Lawrence Bruce Robertson and Oswald Hope Robertson brought insight and care to one of the great clinical horrors of the 20th century. We continue to live in both of their debt.

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