

HISTORY

Battling for Blood: World War Two and the Evolution of Blood Transfusion in Australia¹

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INTRODUCTION

HIPPOCRATES ADVISED, “he who would become a surgeon should join an army and follow it”.¹

Acceleration of scientific development and advances in methodology and practices often result from the exigencies of war, and can be demonstrated in the impact that involvement in conflicts, particularly the Second World War, had on medicine in Australia. An examination of the specific area of blood transfusion will highlight not only the legacy that war conferred in this area but will also underscore the theoretical issues underlying such development. The term ‘blood transfusion’, for the purposes of this paper, should be taken as a blanket term that includes the transfusion of whole blood, including blood related products including serum or plasma, unless a specific product is otherwise identified. The term ‘serum’ is used as it was in the original reference and may include items, which are in actuality plasma.

By drawing on the work of Thomas Kuhn² in which he attributes the development and utilisation of scientific theory to a ‘paradigm shift’ in practitioners’ knowledge rather than an accumulation of ‘facts’, this examination will acknowledge the role of non-scientific factors in this process. Rather than considering the incorporation of blood transfusion into treatment regimens as being a progressive, incremental process based on the accretion of individual discoveries and inventions, this paper will seek to identify other factors that lead to its universal acceptance after World War II. A brief overview of the history of blood transfusion makes evident the theoretical knowledge that had been developed, but not exploited, over a 300-year period. This overview will provide a background to the identification of some indicative factors operating in World War II which enabled the imposition of new paradigms of scientific knowledge, facilitated technological diffusion and provided opportunities to exten-

sively experientially test accumulated theoretical knowledge. The factors examined include the experience of medical officers working with mass casualties and in desperate circumstances such as a Prisoner of War (POW) hospital; the ways in which information was promulgated; and the training which medical officers serving in the military received. The impact of exposure both within the military and on the home front to blood transfusion as practitioners, donors and recipients during the war years, and the post-war expectations that this exposure engendered are also considered.

The literature concerning the relationship between war and medicine has been overwhelmingly dominated by practitioner-centered accounts of how medicine has benefited from and been advanced by war³. A review of the Australian literature that addresses the confluence of war and medical advances shows, not surprisingly, that writers who are both medical practitioners and military personnel dominate the field.

Various articles addressing the issue have appeared in the *Medical Journal of Australia* in the period between 1919 to 1951, authored by personnel of the Australian military medical services as wartime or post-war pieces and by Allan Walker, the official Second World War medical historian.⁴⁻⁹ The former Surgeon General of the Australian Defence Force, Major-General John Pearn has published a book on the subject¹⁰ and recently made it the focus of an address to the US Uniformed Services University of Health Sciences¹¹. Additionally, the issue has been addressed either obliquely as a part of a wider theme in various publications, such as the official war histories, biographies and histories of specific subjects such as microbiology, malaria, or blood transfusion.¹²⁻²⁵ Some of the studies would fall under the category of medical antiquarianism rather than that of the history of medicine.

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Taking blood transfusion as a specific issue, there has been little published which tackles, in an Australian context, the topic from a theoretical rather than a technical or narrative point of view. In a 1999 article, Mark Cortiula, Fellow at the Unit for the History and Philosophy of Science at the University of Sydney, states that historiography of transfusion medicine and blood banking in Australia is underdeveloped and what is available are "...whiggish and rather hagiographic examinations".²⁷ Cortiula has begun the work of redressing this deficit²⁸, with several articles in print and with recently published book.²⁹ Pamela Sampson, at Flinders University, has based her soon-to-be-submitted history doctorate on the issue of blood transfusion.³⁰ Being informed by the discipline of history rather than that of medicine, these contributions to the topic of blood transfusion promise to extend the parameters and focus of the history of medicine. Continuing this approach, this paper, using a theoretical underpinning, seeks to add another dimension. It will begin the task of exploring the issue of blood transfusion in World War II and its subsequent acceptance into the canon of remedial and therapeutic treatment regimes. The approach will examine the development of blood transfusion services and will focus on the way in which the war environment lead to the establishment of new paradigms of medical knowledge, in the sense of Kuhn's theory.² The technicalities of the process will only be dealt with in so far as they pertain to the understanding of the wider issues.

HISTORICAL BACKGROUND

A brief overview of the global history of blood transfusion will provide a background for understanding the progression of the acceptance of blood as a means of remedial and therapeutic treatment within Australia. The vital importance of blood has been realized from the earliest recorded history. The Old Testament, the classical writers of Greek and Rome, and the writings of the ancient Egyptians all contain references to blood, but relate to its mystical qualities rather than its medicinal value³¹. Ancient civilisations such as the Aztecs employed the shedding of blood as part of sacrificial rituals³². Bloodletting was depicted in

Egyptian tomb paintings as early as 2500 BC; as a form of therapy phlebotomy continued well into the twentieth century³³. However, the therapeutic value of the transfer of blood from one creature to another was first noted in the writings of Pliny the Elder (A.D.23-79) in which he describes the drinking of blood of the gladiators in the arena as a remedy for epilepsy³⁴. The 1615 writings of Libavuis of Halle contain one of the earliest references to the actual transfer of blood from person to person; however there is no evidence that the procedure was any more than an idea³¹. When the first human transfusion occurred has been the subject of debate: it has, on occasion, been attributed to a Jewish physician in 1492, when the blood of three youths was alleged to be transfused into the veins of Pope Innocent VIII. However, both Keynes³¹ and Titmuss³⁵ argue that this was a misinterpretation of the facts and that the boys were bled to death to produce a draught for the aging Pope.

It was not until after William Harvey's theory of the circulation of blood was published in 1628³ and provided the underpinning concept for the development of the practice of blood transfusion, that further reference to blood transfusion has been noted in the literature. Francesco Folli, a Florentine physician, claimed to have performed human blood transfusion in 1654,³⁴ but Keynes³¹ contends that there is no confirmation of this in the writings of others. In 1659, Richard Lower, at the suggestion of Dr. (Sir) Christopher Wren, transfused the blood of one animal to another³¹. However, a variety of authoritative evidence for the first human blood transfusion attributes the honour to Jean-Baptiste Denis (Denys), a French physician, who in 1667, transfused the blood of a lamb into a human thus performing the first medical transfusion.^{31,33,34,36,37} Concurrent experimentation was being carried out in France, England and in Italy but it was curtailed firstly, by a ruling of the Supreme Court in France under which the Faculty of Medicine of Paris (which was opposed to blood transfusion) had to approve all transfusions³¹ and ironically, in 1678, by a Papal edict which forbade any transfusional surgery³⁴. The fatal consequences of the incompatibility of animal and human blood and human blood of different types would have also contributed to the disrepute

3. Edwin Clarke defines 'medical antiquarianism' as '... uncritical, repetitive, biographical, institutional and anecdotal writing.'²⁶

into which this procedure fell. The possibilities engendered by blood transfusion hence fell into neglect for over a hundred years, with only isolated references in the literature³¹.

Not until the nineteenth century did James Blundell, a noted physician, establish through his animal experimentation the incompatibility of the blood of different species^{31,38}. Blundell performed the first human-to-human blood transfusion, injecting the blood of several donors with a syringe in 1818³¹. The next half-century was dedicated to experimentation with a variety of apparatuses and anticoagulants. The independent discovery in 1901 of agglutinins and isoagglutinins in blood by Landsteiner and Shattock in Vienna and London respectively lead to the identification of the initial four blood groups by Jansky in Prague in 1907 and by Moss in America in 1910^{31,39}. Blood grouping techniques enabled the further development of blood transfusion procedures but the problem of clotting outside the vein still posed considerable difficulties except through direct transfusion, which presented innumerable difficulties of its own. An indirect method, which depended on coating the vessel into which the blood was drawn with paraffin wax, was used with some success during World War I³⁷.

Nonetheless, although transfusion using sodium citrate as an anticoagulant had been successfully carried out in 1914, it was not until 1917 that the citrate method was used in military hospitals in France³¹. While military surgeons recognized the effectiveness of transfused blood as a therapy, the system of delivery needed development⁴⁰. Dr J Powers, in a paper presented to the Queensland Branch of the British Medical Association in 1920, described the methods of blood transfusion carried out at the 2 Australian General Hospital and specifically mentions the use of citrated blood transfusion. He also hypothesized that, given the benefits derived from transfusion in war surgery, that there must be scope for this procedure in civil life⁴¹. While work on blood transfusion did continue, research was desultory. Hanigan, in his treatise on blood transfusion in World War I, identifies that abandonment of wartime research by clinical investigators after the war was a common reaction. He attributes such abandonment to either the unique characteristics of the clinical problem or the "associated misery"⁷⁴⁰.

As a corollary to discoveries about the properties of blood, blood transfusion equipment also underwent

development. The coagulating property of blood required apparatus that enabled transfer of blood directly. Quills and silver tubes were used by Lower in his experiments; Blundell's combined pump and funnel called an 'impellor' and his 'gravitator', which as the name implies, used gravity as the motive force were his solutions for infusing blood. Roussel's apparatus for direct transfusion was in use during the Franco-Prussian War of 1870-71³¹ and Australian Dr. Julian Smith demonstrated a vastly improved rotary pump for the same purpose at a symposium held at the Royal Australian College of Surgeons in April 1942.⁴² This apparatus was used for experimental work in malarial transmission in the Malaria Research Unit in Cairns for the rapid transference of unaltered blood from donor to recipient²². The Kimpton-Brown tube, developed in 1913, was one of the vessels coated with paraffin wax used for indirect transfusion until the citrate method, was more commonly used³¹. In the battlefields of France in 1917, Canadian Oswald Robertson adapted apparatus developed by American Lewisohn in 1913 to assist in the process of mixing the blood with the citrate⁴⁰. In contrast to the application of new knowledge, advances in equipment were a necessary adjunct to innovation in technique and perhaps most support a technologically determinist view.

In the period between the Wars, blood transfusion contributed a small part to the repertoire of the medical practitioner. The synergies created by World War II, however, lead to blood transfusion becoming a routine protocol in remedial and therapeutic treatment. In the intervening period, blood transfusion spasmodically enlivened the discourse in the *Medical Journal of Australia*, indicating that while there was an ongoing interest in blood transfusion, it was not widely practiced or understood.

The relatively low demand for blood meant that, prior to World War II, there was no national blood service operating in Australia. The Spanish Civil War of 1936-39 however, provided a rehearsal for what was to come for the rest of the world in the Second World War. The Barcelona Blood Transfusion Service under the direction of Federico Duran-Jorda is credited with proving conclusively the practicability of supplying wounded men in forward medical institutions with stored blood from civilian donors^{43,44}. Responding to the lessons learned in that conflict, a national blood transfusion service was established in 1939, expanding

the rudimentary Red Cross Blood Banks that had been established in Melbourne in 1929 and in Western Australia in 1935⁴⁵. This followed a meeting between Red Cross and the Defence Department, with the State blood banks remaining autonomous but being overseen nationally. To address the anticipated demand for blood, the Australian Army Medical Service organised blood collecting centres in each of the capital cities, staffed by specially trained army medical officers, orderlies and Red Cross volunteers²¹. During World War II, the Red Cross Blood Transfusion Service, working in close association with the 2nd Australian Blood and Serum Preparation Unit, commanded by Robert J. Walsh, supplied blood and serum to every unit of the Australian Military Forces, the US Army in the Southwest Pacific area and the British Pacific Fleet of the Royal Navy^{29,46}. By October 1945, 96,620 donors had been enrolled and 114,120 litres of serum and 35,722 litres of whole blood had been distributed to both the military and civilian community²². The blood services had demonstrated a capacity to respond to not only the war demands but to civilian requirements as well.

Finally, since Landsteiner's original discovery of blood groups at the turn of the century, many more sub-groups had been added to the original four. In 1940, Landsteiner and Weiner extended the understanding of blood typing with the discovery of the Rhesus agglutinin. In the same year, Moureau in France independently demonstrated the same finding, but his discovery was not passed on to the British or Americans because of the war⁴⁷. The significance of the discovery of the Rhesus blood group is that it overcame one of the last obstacles to safe blood transfusion by identifying the additional component which could render blood incompatible for transfusion.

The numerous technical problems to be overcome in order to render blood transfusion safe are evident in the brief outline above. They included the prevention of blood clotting after removal from the body; the storage of blood; blood grouping, testing and cross matching; and methods and techniques of transfusion therapy including equipment³⁵. Nevertheless, given the potential contribution of blood transfusion to the reduction of morbidity and mortality, the prerequisite technical and scientific investigation lacked impetus. Its development as an effective remedial and therapeutic treatment in the

post-World War II period took close to 300 years from the first authenticated transfusion, and it was more than one hundred years from the Harvey's publication of his discovery of blood circulation in 1628 to the acceptance of blood transfusion as routine practice.

THE IMPETUS FOR TRANSFUSION

Many histories of medicine are concerned with technological determinism and 'progress'. A technologically determinist view, that is, that changes in society are the product of changes in tools and techniques,⁴⁸ has some validity and certainly blood transfusion could not have been carried out successfully and safely without advances in blood grouping, methods of transfusion and storage of blood. However, technologies are not value-neutral and technological change is not inevitable. Social processes are also involved in the uptake of innovations and economic and political factors govern the acceptance and absorption of scientific discovery and usually, the concepts and the practices that contribute to the advance develop interactively.⁴⁹ Consequently, there were periods when knowledge was available but there appeared to be reluctance on the part of medical practitioners and researchers to employ the new techniques. In 1918, a *Lancet* editorial declared that up until four years prior, surgeons were unwilling to perform "the operation" of transfusion⁴⁴. Indeed, by the end of World War I, many of the obstacles to transfusion had been overcome, with the identification of the Rhesus factor the major undiscovered complication. It appears then that what stood in the way of its acceptance was the practitioner's will to use it.

Application of Thomas Kuhn's theory provides a possible explanation as to why blood transfusion had not been accepted as a routine medical protocol prior to World War II. According to Kuhn's theory, scientific development, rather than being an incremental process, an accumulation of individual discoveries and inventions, is the result of 'scientific revolutions' which require a paradigm shift in thinking. 'Paradigm' in this context refers to "universally recognised scientific achievements that for a time provide model problems and solutions to a community of practitioners"². Much as the acceptance of germ theory required a paradigm shift in practitioners' thinking to become inculcated into normal practice, so too with blood transfusion. In the case of blood transfusion, the expe-

rience of World War II was the catalyst through which it gained general acceptance by the medical fraternity and by which it was introduced into the treatment regimen of everyday medical practice. As Diana Dyason argues in her article relating to William Gilbee and the issue of consent to the principles of germ theory at the turn of the twentieth century at the Melbourne Hospital, there is a need to “examine the non-scientific factors in the development, evaluation and utilisation of scientific theory.”⁵⁰ In the case of blood transfusion, the advent of war is the major non-scientific factor that led to blood transfusion’s incorporation into the medical practitioner’s repertoire as a routine procedure. Along with the necessary impetus to research in particular directions in order to solve specific problems, as Dyason says, “the mere existence of knowledge is no guarantee that it will be applied”.⁵⁰

As has been shown, the knowledge pertaining to blood transfusion was available, but was not yet being widely used. A further catalytic impetus was required. The working environments, both intellectual and applied, engendered by World War II facilitated this necessary evolution in thinking. An examination of a selection of non-scientific factors will illustrate the way in which that occurred. Foremost among these factors was the powerful demonstration offered by the successful treatment of mass casualties with blood and blood products. Even the prisoner of war camps offered examples of the efficacy of blood transfusion under the most primitive of conditions. The ability of the blood transfusion service to respond to the demand for blood was a complementary factor in the equation and the effectiveness and practicability of blood banking services was also established in meeting this requirement. A system of training in blood

transfusion techniques and the provision of guidelines and instructions to medical officers serving in the military during the war ensured consistency and standardisation of procedures that enabled wide diffusion of a corpus of knowledge. Furthermore, as well as establishing the practicalities of blood transfusion, personal experience in World War II of medical practitioners, donors and recipients created expectations of a post-war blood transfusion service that was equivalent to or exceeded that available during the war. While not complete, examples such as these, which will be elaborated further, clearly identify alternative factors to a simplistic explanation that focuses on technological advances as to why such a paradigm shift in thinking and practice occurred.

In 1947, Doctor Lucy Bryce, Honourary Director of the Red Cross Blood Transfusion Service, commenced an article published in the *Medical Journal of Australia* with the statement: “Since the use of human blood and its derivatives as therapeutic agents... has increased so greatly during the past few years, the maintenance of adequate donor panels must be accepted as an essential feature of modern medical practice”.⁵¹

Blood transfusion was used to great effect in Japanese POW camps. Captain J. Markowitz wrote in a report written from Nakom Paton POW Hospital in Thailand in 1945: “[T]eams trained and supervised by the author performed 3800 transfusions, and in addition, as MO’s got to know about it, it was used successfully up and down Thailand by others. The author feels therefore that the method has distinct value as an emergency measure.”

The statement clearly demonstrates how knowledge pertaining to blood transfusion was diffused during the war, even in the deprived environment of a POW camp. Markowitz goes on to say: “Care was required in our early transfusions to conform with the Hippocratic maxim *primo non nocere* (sic). The theoretical objections to it in practice do not operate.”

His report makes clear that the medical conditions encountered in the camp, where prisoners “died in droves” prompted the extensive use of blood transfusion to combat malaria, bacillary dysentery, tropical ulcers, pellagra, beri-beri and starvation. The dire conditions in the POW hospital created a circumstance where the benefits to be accrued from blood transfusion far outweighed the risks involved. That blood transfusion was used in such a multitude of ways with

Figure 1: Sketch of Transfusion in Prisoner of War Camp, Thailand (from the NH Fairley papers, 65/14/1, Basser Library, AAS, Canberra)



such a high degree of success and a low rate of reaction (“13%, and much of that was contributed to malaria”) with the most rudimentary equipment provided strong empirical evidence for its efficacy.⁵⁵

The military doctrinal system was also the ideal vehicle for the promulgation of standardised technical information to medical officers in the field, which could then be incorporated into civilian practice at the conclusion of the war. For example, the Army Medical Technical Instruction²² “Soluvac Solutions and Wet Serum” issued in 1941 promulgated information on the subject of the abnormalities of appearance of glucose solutions.⁵⁶ The Royal Australian Navy issued Technical Instruction No. 7 and the Royal Australian Airforce Medical Technical Instruction No. 10 which provided those Services with details on blood banking techniques and the preparation, assembly and use of transfusion apparatuses.²² The Services’ bureaucratic systems ensured that medical officers were receiving identical information and that procedural techniques were uniform. As a result, there was a cadre of medical practitioners in post-war practice that had been trained and indoctrinated in a standard way. Even before the end of the war, a chapter in a *Medical Journal of Australia Supplement* published in 1943, entitled ‘War Medicine and Surgery’, extolled the importance of blood transfusion in these fields. The supplement promulgated information in respect of the supply and use of blood and blood substitutes not only to medical practitioners serving in the military, but to all *Medical Journal of Australia* subscribers.⁵⁷ The benchmarks that this standardisation provided facilitated the practices and ideas to become more universally accepted.

As early as 1943, there was recognition that an expanded blood transfusion service was necessary for the civilian population. In 1944, Lucy Bryce wrote a report on post-War organisation of blood transfusion services that laid the foundation for the development of a peacetime Service, with the Red Cross Blood Transfusion Service continuing and adapting its wartime role.⁵⁸ The use of blood transfusion in treating wounded soldiers demonstrated its life-saving benefits and the lessons learnt from wartime experience could be applied to the treatment of civilian sick and wounded. Prior to the war, blood transfusions, using small amounts of blood and fraught with technical difficulties, were performed in hospitals only on rare

occasions⁴⁶. A small number of donors were called on to donate blood on an as-required basis, and were often the friends and relatives of the patient. There was insufficient demand at individual hospitals to warrant collection and storage of quantities of blood and the delay in obtaining blood often meant that the patient died in the interim.

Apart from the experiences of war providing empirical evidence of the value of blood transfusion, civilian medical practitioners recruited from around the country were often introduced to the techniques of blood transfusion through their military service. Before deploying overseas, medical officers gained experience in blood transfusion in civil hospitals using army equipment and training continued on deployment. The Red Cross produced a 16 millimetre training film that was shown in overseas units. Australian medical officers also visited British transfusion units and received help and advice from them²². Military service also gave general practitioners the opportunity to work with some of the pioneers of blood transfusion research within Australia such as Dr. Ian Wood and Dr. Cyril Fortune, who had also been recruited. The invaluable experience and learning thus gained could be carried over into post-war civilian practice.

The experience gained in wartime could be applied on the home-front and provided remedial treatment for blood loss not just due to industrial and road accidents, during operations and for treating burns, anaemia and infection but also for blood loss due to childbirth. This meant that blood was required in large quantities and that serum, unavailable prior to the war, was also in demand: medical practitioners, particularly those who had served in the armed forces, had become accustomed to routinely having access to blood and serum⁴⁶. In 1949, Cabinet approved Commonwealth financing of a cooperative venture of blood fractionation between the Commonwealth Serum Laboratories and the Australian Red Cross Society⁵⁹ and in 1954, financial support for the Red Cross Blood Transfusion Service itself.⁶⁰ In 1953, a *MJA* editorial commented that procedures of blood transfusion had proved so beneficial during World War II that the resultant increased demand for blood of tenfold ‘would have seemed fantastic in 1943’.⁶¹ In 2000, an *MJA* editorial reported that the Australian Red Cross Blood Service recorded over one million donations in 1998-99.⁶²

The change to thinking about blood transfusion brought about by war service extended beyond the medical fraternity. From very early in the War, the Director-General of Medical Services – Army, Major General Rupert Downes, introduced the blanket blood group testing of Defence Force recruits.¹³ The procedure, which was unique among the Commonwealth Forces, no doubt contributed to the universal ready acceptance by Australian servicemen and women to the idea of blood transfusion and blood donation that carried over into post-war attitudes towards it²². In a study conducted in the United Kingdom in 1967, five percent of donors, when questioned about their motivations in donating blood, stated they first became donors as members of the services during World War II and 6.7 percent of donors said that they began donating blood as a contribution to the war effort³⁵. While comparable statistics are not available for Australia, given the similarities of the two blood services, it is likely that the British response would be at least indicative of the Australian response and that perhaps higher response rates for these categories could be expected in the Australian context.

The Australian community, as well as responding to war needs as donors also experienced the significance of blood transfusion at a local level. While within Australia, transfusion services were not needed in response to enemy action, the techniques and organisation which had been set up to cope with such an eventuality provided a rapid response capability to anticipated burn injuries in widespread bushfires in Victoria in 1944²². Contingency planning for war was thus translated into a response to an emergency situation applicable in peacetime and provided an illustration of how the new knowledge and techniques could be of benefit to the community.

CONCLUSION

The history of blood transfusion spans more than three centuries. An examination of that history shows that using a technologically determinist approach to explaining why blood transfusion had not been accepted as a routine medical protocol prior to World War II is insufficient. Application of Thomas Kuhn's theory, that a paradigm shift in thinking is required, does however provide a possible explanation for the relatively late acceptance of the practice of blood transfusion into medical protocols. Selection of some

indicative factors operating in World War II demonstrates the way in which new paradigms of scientific knowledge were imposed, technological diffusion was facilitated and opportunities to extensively experientially test accumulated theoretical knowledge was provided in relation to blood transfusion. The factors examined here include how the experience of medical officers working with mass casualties, both on the battlefield and in POW hospitals, established blood transfusion as a formidable addition to the medical practitioner's treatment regimen. The bureaucratic standardisation of procedures and training which medical officers serving in the military received also contributed to the acceptance of blood transfusion as a routine procedure by providing benchmarks and uniformity of practice. Exposure within both the military and civilian communities to blood transfusion as practitioners, donors and recipients during the war years lead to post-war expectations that such a service should be available to the entire community and predicated the maintenance and expansion of blood transfusion services. The examination has focused on the way in which the war environment lead, in the sense of Kuhn's theory, to the establishment of new paradigms of medical knowledge and that in the case of blood transfusion, that the advent of war is the major non-scientific factor which lead to its incorporation into the canon of medical doctrine. The arguments presented here provide a persuasive account of how Kuhn's dictum "As in manufacture, so in science – retooling is an extravagance to be reserved for the occasion that demands it. Crises are a necessary precondition"² can be applied. World War II provided such a crisis in the medical field and changed the way in which medicine utilised the "tool" of blood transfusion.

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