Blood transfusion services in the UK

The National Blood Transfusion Service of England and Wales (NBTS) celebrates its fiftieth anniversary in 1996. Although the NBTS and the Scottish National Blood Transfusion Service can be regarded as the direct successors of blood depots set up during the Second World War, there was an important antecedent in the British Red Cross Blood Transfusion Service. Founded in 1921, it set a standard for the world’s transfusion services by insisting that blood donors should always offer their blood free of charge.

The First World War as an impetus to blood transfusion

Although it is tempting to assume that the discovery of blood groups [1] and of citrate anticoagulants [2–4] increased the use of transfusion, the assumption would almost certainly be incorrect. The real stimulus was the need to save the lives of soldiers during the First World War.

At the beginning of the twentieth century blood transfusion was used infrequently in Europe but was much more popular in America, where it was regarded as a panacea for a whole variety of ills [5]. Even though America did not officially enter the war until 1917, American surgeons were working with the allies in France from as early as December 1914, teaching transfusion techniques to British and French doctors. An English surgeon, Geoffrey Keynes, recalls that in 1916, whilst visiting a casualty clearing station staffed by men from Harvard, he learnt what was to him the new technique of blood transfusion [6]. Using citrated blood, Keynes found that in an emergency he could both give the transfusion and operate single-handedly. The official inducement to donate blood, namely a fortnight’s extra leave in ‘Blighty’, emphasised the novelty of the procedure, especially since the donor was usually a soldier who was only lightly injured.

Military surgeons quickly learnt to appreciate the life-saving properties of blood transfusion, but on the home front attitudes were very different. In fact, the medical profession’s disregard for the value of blood transfusion was emphasised by the lack of response to an editorial in the Lancet, which stated ‘We doubt whether any surgeon in this country could have been found to perform the operation of blood transfusion even so recently as four years ago’ [7]. The only challenge came from Sir Berkeley Moynihan (later Lord Moynihan), Professor of Surgery in Leeds.

During a visit to America in the early 1900s, he had learnt the difficult (surgical) procedure of arm-to-arm transfusion from George Crile of Cleveland, Ohio. The complexity of the procedure, together with the need to recruit a donor prepared to sacrifice an artery, rendered the technique unsuited for use in an emergency.

Crile knew nothing of Karl Landsteiner’s work (carried out in Vienna and published in German) on blood groups until 1907. Even then, he expressed the view that it was ‘better to run the rare and relative risk of haemolytic accidents than to allow the patient to die of haemorrhage’. Throughout the war, many military surgeons continued to show scant regard for blood grouping and for compatibility tests which had been described a few years earlier [8]. A Canadian surgeon working with the British army was aware of potential problems with donor blood, but even though he advocated the use of haemolysis tests in order to check for compatibility, and of a Wassermann test in order to exclude syphilis in the donor, he admitted that there was rarely time for these refinements [9].

The introduction of citrate anticoagulation made pre-transfusion testing a more realistic proposition, particularly after Moss had shown that with standardised typing sera, blood could be grouped in two to five minutes [10]. Moss designated the four blood groups I(AB), II(A), III(B) and IV(O), being unaware of the paper written in Czech, by Jansky, in which the groups had been labeled differently, ie I(O), II(A), III(B) and IV(AB) [11]. It was inevitable that the discrepancy between the two nomenclatures would be responsible for some unfortunate accidents.

Throughout the war, most transfusions were of blood anticoagulated with sodium citrate and used immediately, although work done for the American army at the Rockefeller Institute had shown that citrated blood could be stored for up to three weeks with only minimal haemolysis if glucose was added to the anticoagulant [12]. An American surgeon, credited as the first person to set up a blood bank, used this Rous-Turner glucose-citrate anticoagulant to store blood in field stations behind the Allied lines in Northern France [13].

Transfusion in Britain, 1918–1939

In the Lancet article referred to earlier [7], the author expressed the view that although blood transfusion had been of value to battle casualties it was unlikely to be of much use in civilian hospitals. Keynes did not agree. On returning to England he was disappointed to find little enthusiasm amongst his colleagues for a
therapy which had proved so effective in preventing surgical shock. The prevailing view of senior surgeons was that a blood transfusion, given whilst they were operating, would hinder their activities. Consequently, Keynes was strongly discouraged from organising an official donor panel at St Bartholomew’s Hospital, where he had been appointed consultant surgeon. Whenever blood was needed, it was customary to give it after the operation was over and it was provided by one of the patient’s relations, by a friend or even by a professional donor. But this situation was most unsatisfactory. Keynes complained that:

‘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’ [14].

But by the time his complaint was published, an independent voluntary blood donor service had already been founded by a most imaginative and public-spirited man, Percy Lane Oliver.

The London Blood Transfusion Service

Oliver, who had no connection with the medical profession and who worked in the finance department of Camberwell Borough Council, had helped to found the local division of the Red Cross and was its Honorary Secretary. In October 1921, during a divisional meeting, the members received a request from King’s College Hospital for a blood donor. Oliver was amongst those who volunteered and although it was not his blood which was used, he was most impressed by the outcome of the transfusion. Realising that many patients had neither relations nor friends who could, should the need arise, give them blood, he set about building up a voluntary blood donor panel. Local hospitals, which saw themselves as beneficiaries of the service, agreed to group the blood of volunteers free of charge. Many of the early volunteers were recruited from the local Red Cross division but other voluntary organisations, like the Toc H and the Rover Scouts, helped to swell the numbers. The service, known as The London Blood Transfusion Service, was run from Oliver’s home and was funded entirely by voluntary contributions.

Involvement of the British Red Cross

The British Red Cross became involved with the transfusion service in 1926. During the winter of 1925–6 Oliver was ill. One of his assistants, realising that the transfusion service would founder if not established on a more formal basis, appealed to Red Cross Headquarters for help with administration. By coincidence, at about the same time, the London Regional Medical Committee had invited the British Red Cross to organise a permanent transfusion service to serve the whole capital. A multi-disciplinary committee was formed, with Oliver as Honorary Secretary, and the organisation given the official title of The British Red Cross Blood Transfusion Service. Keynes was invited to join the committee as medical advisor. Members of the committee, in particular Oliver himself, henceforth devoted a large part of their spare time to publicising the service throughout the country.

Competition between professional and unpaid donor services

It was very difficult to set up voluntary unpaid donor panels in towns and cities where a professional panel was already in operation. The Manchester and Salford Transfusion Service, run by the Red Cross was in competition with a professional service organised by the Manchester Public Health Department. The latter paid 10s 6d for a donation and 5s 0d to potential donors attending for a blood test. The fee increased considerably and by 1950, was three guineas for each donation. In other towns the fees were even higher (Table 1).

Establishing standards for donor care

In order to draw attention to the poor organisation of some professional services, Oliver cited the case of a man who had been called to donate 12 times in less than 10 months by different surgeons. The regular blood tests carried out on Red Cross donors led to the advice that men should not donate more than four times, and women not more than three times in a year.

In another effort to improve the well-being of donors, Oliver gave lectures on how to take blood whilst preserving the vein for future use: as a consequence of the destructive practice of cutting down on veins, by 1925 all the original volunteers had left the panel. Doctors resented being given instructions by a

Table 1. Fees paid to professional donors in the UK (1921–38)

| Town or district | Year | Fee   |
|------------------|------|-------|
| Sheffield        | 1921 | £5 5s 0d |
| Melton Mowbray   | 1928 | 2 2 0 |
| Norwich          | 1928 | 4 4 0 |
| Manchester       | 1930 | 3 3 0 |
| Glasgow          | 1930 | 1 1 0 |
| Essex            | 1931 | 1 1 0 |
| Swansea          | 1934 | 1 1 0 |
| Leicester        | 1936 | 4 4 0 |
| Nottingham       | 1938 | 3 3 0 |
| Kings Lynn       | 1938 | 1 1 0 |

(Information supplied by Mr F Hanley JP, President of the Oliver Memorial Fund and Chairman of the Greater London Red Cross Blood Transfusion Service 1962–86.)
layman but Oliver was fortunate in having some support from within the profession [15].

**Advantage of voluntary unpaid blood donors**

The hallmark of Oliver’s donor service had always been that blood should be given free of charge—indeed any person who was suspected of accepting money for a donation was struck off the panel. Oliver presumably thought that those who needed to make money by selling their blood belonged to a group whose health and hygiene were suboptimal. If he needed support for this view, it came from countries where professional donation was the rule and where as many as 30% of donors had to be rejected because they had syphilis. Syphilis was very rare amongst members of the Red Cross donor panel and, when it occurred, was usually of the congenital variety.

**Problems with grouping blood**

When excessive demands were made for universal (group O) donors, Oliver pointed out that the distribution of blood groups was likely to be the same amongst donors and patients (Table 2). Hospitals were instructed to group patients before placing their request and not merely to demand a group O donor. However, grouping sera were expensive—some hospitals tried to solve the problem by producing their own anti-sera using the blood of staff members, but with unpredictable results. In these non-standardised sera, the antibodies to A and B antigens were often very weak. In 1929 the problem was brought to a head when a patient at Queen Charlotte’s Hospital died during the transfusion of blood donated by a Red Cross donor, whilst the donor was still on the premises. The donor’s blood had been designated group III (B) at the Westminster Hospital but, on regrouping, was shown to be group II (A). The subsequent inquiry revealed that similar grouping errors had occurred in other hospitals.

The problem was eventually solved when the Medical Research Council awarded a four-year grant to cover the salary of a part-time assistant who would be responsible for donor care and blood grouping. Keynes recommended that the post be filled by Dr H F Brewer, consultant pathologist at St. Bartholomew’s Hospital. Brewer’s appointment in 1932 marked the beginning of a long association between the Red Cross donor service and St Bartholomew’s Hospital.

Burroughs Wellcome, the only commercial supplier of grouping serum, charged 4s 0d for a quantity sufficient to group only one specimen. Brewer persuaded the firm to package serum from Red Cross donors known to have high antibody concentrations. The serum, sealed into pairs of capillary tubes, one containing anti-A and the other anti-B, was sold to hospitals affiliated to the donor service for the bargain price of 6s 0d (30p) for a dozen pairs of tubes. Non-affiliated hospitals were charged 12s 0d.

**The British Red Cross Blood Transfusion Service Quarterly Circular**

By 1933 Oliver had retired from his post at Camberwell Town Hall. With more time to devote to his ‘hobby’, he determined to publish a bulletin, with the aim of binding Service members more closely together. *The British Red Cross Blood Transfusion Service Quarterly Circular* was used to educate donors on subjects like blood group inheritance, to inform them about lectures on transfusion-related topics and about the Society’s donor statistics.

Donors were invited to contribute items of interest to the Circular which, in 1937, included the account of a visit to the Leningrad Blood Bank made by a woman during her summer holiday the previous year. She observed that citrated blood was stored for up to 14 days before being used to resuscitate accident victims. A later edition of the Circular contained a very different account of the benefits of blood banking which was being used in northern Spain during the Civil War.

**The Spanish Civil War (1936–9) and blood banking**

When the Civil War broke out in Spain, F Duran Jorda, a communist and republican sympathiser, set up a blood bank in Barcelona in order to succour both army and civilian casualties; his inspiration came from the blood banks already operating in many large Russian cities. In April 1937 he made a fund-raising trip to England and, in a lecture to the British Red Cross, described the benefits of stored blood in time of war. There is no record of whether help for the Barcelona Blood Bank was forthcoming but Oliver was left in no doubt that the Red Cross Transfusion Service panel members disliked the idea of banking blood. They wished to retain their close ties with hospitals and to be informed as to how their donation

---

*Table 2. Blood groups of 99 donors used over a 3 month period in 1926*

| Blood group | Number of donors supplied | Percentage |
|-------------|---------------------------|------------|
| I AB        | 3                         | 3.3        |
| II A        | 24                        | 26.6       |
| III B       | 10                        | 11.1       |
| IV O        | 62                        | 68.8       |

In his unpublished Report on the work of the London Blood Transfusion Service c. 1937, Oliver documented the distribution of ABO groups in 4,786 Red Cross donors as: AB-3.5%, A-42.6%, B-8.6%, O-45.3%.
was used (Fig 1). The donors were supported by a large proportion of the British medical establishment who disliked the idea of using blood which was not freshly donated.

Oliver was impressed by Jorda’s work and staged an exhibition illustrating methods of storing blood as practised in the Barcelona blood bank. At about the same time, following his return from the Second International Blood Transfusion Congress in Paris (1937), he reported that much of the discussion had been on blood banking. There had been particular emphasis on the need to have stocks of blood available for civilian casualties, should a war occur. Donors were nonetheless assured that their very personal services would always be needed because ‘English surgeons would continue to demand high quality fresh blood for their patients’.

Donor attitudes changed considerably during the next few months. Blood transfusion was being used more frequently and, by January 1938, the donors themselves were asking for blood banks to be established within hospitals so that they would not be called away from work so frequently. By October of the same year, with the threat of war hanging over the country, the Service could no longer meet the increasing demands for typing serum. Oliver, realising it would be impossible to continue the system of summoning individual donors, set about organising a blood bank. His efforts were overtaken by events; the Red Cross blood bank never became operational and was supplanted by a government organised transfusion service.

At the outbreak of war, Oliver joined Brewer who became medical director of the newly-formed Luton Blood Depot. Oliver’s task was to organise the donor panel but he found the work unsatisfying and returned to London to work with the Red Cross Service until his death in 1944.

Throughout the war the British Red Cross Transfusion Service continued to function nationwide, and remained active in London until 1985 as the Greater London Red Cross Blood Transfusion Service. The obligatory immediate pre-transfusion testing for HIV infection then made walk-in donation quite impractical. Statistics from the London Service show that it was at the peak of its activity in the years immediately before the war (Fig 2).

Oliver died when the Second World War was fast nearing its conclusion, which probably explains why there was no official obituary. His contributions to blood transfusion were, however, recognised during his lifetime. A Belgian delegate to the first International Blood Transfusion Conference in 1935 praised Oliver, saying:

---

Fig 1. Report on the results of a transfusion given to a patient suffering from pernicious anaemia
'It is to the Red Cross in London that the honour is due to having been the first, in 1921, to solve the problem (of the blood donor) by organising a transfusion service . . . This society, whose encouraging experiences were watched by Red Cross societies of other nations, served both as a model and an inspiration for the organisation of similar services in seven other countries' (Quarterly Circular, Oct. 1936).

The Second World War and blood banking in Britain

During the Spanish Civil War Dr Janet Vaughan (later Dame Janet) was a member of the Committee for Medical Aid to the Republican Government and, naturally, she knew Jorda. When it became clear that the fascists would win the war, Jorda escaped to England and persuaded Vaughan that stored blood would be essential for the resuscitation of casualties, should Britain go to war with Germany. Accepting his advice, Vaughan and her colleagues at the Hammermith Hospital set about comparing the relative therapeutic value of stored and freshly donated blood. Blood stored for several days was shown to cause no more reactions than that drawn into the same anticoagulant and used immediately [16]. Viewed from the perspective of the late twentieth century, this may seem like an insignificant step forward but, at the time, the issue of fresh versus stored blood was very much alive [17,18].

It was obvious that war with Germany was imminent, so during an informal meeting held at Vaughan’s home on 5 April 1939, a scheme was drawn up to provide London with blood for civilian casualties. This scheme, involving the creation of four blood storage depots, was submitted to Professor Topley who was responsible to the government for organising emergency medical services. The plans were presented to the Cabinet, adopted officially on 20 April and then put into effect.

The Medical Research Council and the London depots

The Medical Research Council (MRC), realising that blood transfusion would open up a field for applied and basic scientific research, agreed to administer the depots on behalf of the Ministry of Health. The four depots, situated at Sutton in Surrey, Maidstone, Slough and Luton, were in areas where donors were available and were as close to the main concentration of hospitals as possible whilst being as far away from the centre of London as was practicable.

By August 1939, Professor Payling Wright, Chairman of the MRC Transfusion Committee, was able to report that all essential equipment was in place at the depots and when, on 3 September, war was declared, the directors received telegrams instructing them to bleed donors. At about this time the Army established its own blood depot in a ward of Southmeads Hospital, Bristol.

Initially, little blood was transfused and each depot was able to bleed donors in excess of local needs in order to produce plasma (Table 3). The first occasion on which blood was used in considerable quantity was between 20 May and 4 June 1940, when about 340,000 troops were evacuated from the Dunkirk beaches. Blood was sent from the Maidstone depot to the south coast ports for those casualties in greatest need. The other three depots supplied blood and plasma for many more wounded men who were transferred in conveyos to the London hospitals.

The regional depots

Dr A N Drury (later Sir Alan), now in overall charge of the London depots, realised that the situation regarding

| Table 3. Statistics from the four London depots, June 1940 |
|-----------------------------------------------------------|
| **Donor panel** | **Output bottles/week** | **Normal civilian demands/week** |
| NE depot | 12,500 | 400 | 100 |
| SE depot | 33,000 | 600 | 150 |
| SW depot | 38,000 | 600 | 150 |
| NW depot | 30,000 | 600 | 100 |
| **Totals** | **113,500** | **2,200** | **500** |
| Excess donations over civilian requirements—more than 1,000 bottles. |
provision of blood outside London was most unsatisfactory. In June 1940, he and Sir Philip Panton, consultant in pathology to the Ministry of Health, drew up a scheme for establishing a regional transfusion service. Nine depots, similar to those in London, were built close to either teaching hospitals or large district hospitals. Two small subunits to support the depots were added at Maidstone and Sutton.

From September 1940 London was bombed uninterruptedly for three months, then, together with most of the large provincial cities, intermittently until 1942. During this period the transfusion service was rapidly expanded in order to meet the needs of injured civilians and also to provide plasma for the armed forces. Mobile transfusion teams were established in association with the Luton and Nottingham depots to support the Royal Air Force, while the Army depot extended its area of activity to include the whole of south-west England.

Transfusion-related research projects
The Blood Transfusion Research Committee, set up in December 1939 by the MRC, decided that the most pressing problems were improving red cell preservation and developing better techniques for processing plasma. The Committee also decided that three young medical officers attached to the Sutton depot, AC Dornhorst (later Professor), PL Mollison (later Director, MRC Blood Transfusion Research Unit) and DG MacQuaide should make observations on casualties of their response to blood transfusion.

Red cell preservation
London depot directors decided to use a simple citrate saline anticoagulant which was easy to make and to sterilise: they were aware that red cells were better preserved if stored in a glucose-citrate solution, but that glucose caramelised when the mixture was autoclaved. However, studies at the South London depot showed not only that citrate alone was a poor red cell preservative [19] but also that a glucose-citrate solution, if acidified, could be autoclaved without caramelisation [20]. A further modification produced acid-citrate-dextrose (ACD), which enabled red cells to be stored for up to three weeks [21]; it became the standard anticoagulant in worldwide use until the introduction of citrate-phosphate dextrose in 1957.

Processing plasma
A large amount of unprocessed plasma was successfully transfused at the time of Dunkirk although bacterial contamination posed a serious problem. Drury was aware that Dr R I N Greaves had developed a freeze-drying technique for preparing tetanus toxin. Since it was known that bacteria did not survive in the final product, Drury asked Greaves to adapt his technique to freeze-drying plasma and serum. When the process proved successful, the MRC established a plasma drying unit at Cambridge, with Greaves as director. The freeze-dried product had the advantages of being stable under all climatic conditions and of having a long shelf-life.

In the summer of 1941 Drs A S McFarlane and R A Kekwick, working in the biophysics division of the Lister Institute, produced a clear, high-quality liquid plasma product. Their approach was quite different from any used before and involved ether precipitation of fibrinogen [22,23]. Although the product was successfully used in clinical trials and continued to be produced in small amounts until the early 1970s, large scale production was never possible because of the hazards posed by the use of ether. The MRC had, moreover, received confidential reports from the United States about Cohn’s procedure for fractionating plasma by alcohol extraction. In spite of the obvious advantages of presenting plasma in fluid form, it was impossible to put Cohn’s technique into operation in war-time Britain because alcohol was then needed for the manufacture of nitroglycerine.

Transmission of hepatitis
The Blood Transfusion Research Committee realised that there was a potential danger in transfusing pooled human plasma. In 1937 several people had died of acute hepatic necrosis following an injection of pooled plasma for measles prophylaxis. Concrete evidence of the connection between hepatitis and transfusion became available in 1942; it was noticed that a series of patients had developed jaundice 50–60 days after receiving serum; furthermore, that several people became infected following transfusions from the same batch of serum. Plasma pools were thereafter limited to ten donations.

Blood group research
Throughout the war, Borroughs Wellcome continued to supply hospitals with grouping sera but it was felt that the blood depots should be able to provide their own material. The task of producing standardised high-titre grouping sera was given to the Galton Serum Unit which had moved to Cambridge just before the war. The unit, directed by Dr G L Taylor, initially obtained most of its sera from recruits at a nearby Royal Air Force base. The results of grouping the blood of 200,000 airmen provided useful data on the distribution of blood groups in the United Kingdom.

Following publication of the discovery of Rh (D) [24], many serum samples were tested from women who had delivered babies with erythroblastosis fetalis. The Americans’ results were confirmed and high-titre sera selected for use as reagents. Subsequent work done at the Galton serum unit defined a whole series
of Rh factors. In early 1944, Professor R A Fisher proposed the theory that three closely linked loci, with at least two allelic genes, were responsible for Rh groups [25].

Planning the post-war transfusion service

On 3 June 1943, at a meeting between the Chief Medical Officer, Drury and the four London depot directors, plans were made for a post-war transfusion service. The volume of work was now so great that it was impossible to revert to the pre-war hospital based donor service. The rational solution seemed to be a nationwide transfusion service, controlled centrally by the Ministry of Health and based on the existing blood depots. Everyone agreed that blood donors should continue to be unpaid, but that some charges might have to be made to hospitals in order to cover the costs of processing blood. At the same meeting, Drury outlined his plans for the future MRC transfusion-related research units. Discussions continued throughout the next 18 months and in a letter dated 11 May 1945, the Treasury accepted the principle, expressed in the Health Service Bill, that the Ministry of Health should take power to provide a National Blood Transfusion Service.

During the next fifty years, the NBTS was subject to many changes. In the early days of the service, the emphasis in transfusion medicine was on blood group serology, but this gradually changed to preventing the transmission of infection. In 1946 it was decided that the transfusion centres should be funded through the local health authorities and, as there was no central executive body, management was in the hands of the individual transfusion centre directors. There were some unfortunate consequences. The virtual autonomy of transfusion centres resulted in a very patchy service, with some parts of the country faring much better than others. Some of the directors were less sympathetic to clinical needs than others and were slow to institute changes which would improve patient services. What is more, some local health authorities ascribed so little importance to blood transfusion that they refused to make funds available for new and more effective equipment. A good example was the slow introduction of plastic transfusion equipment.

By 1970, the transfusion centre directors themselves realised that the situation was most unsatisfactory and, knowing that the Department of Health and Social Security was preparing to reorganise the NHS, asked that consideration be given to returning the NBTS to the centrally organised service of the war years. But not until 1993 did the Department of Health finally agree to establish a National Blood Authority.

From April 1991, regional transfusion centres were obliged to cover their operating costs by claiming handling fees from their client hospitals. The overall impression was that hospitals, if given the freedom to do so, would be able to ‘buy’ blood and blood components less expensively from one centre than from another, an impression which was simply untrue. Any difference in charges merely reflected variable input from regional centres to centrally organised schemes, varying degrees of continued support for the transfusion centres from regional health authorities and the variety of different costing systems. One particular scheme, the Management Information System (MIS), which was identified as essential by the DHSS Management Consultancy Services, made possible the transfer of blood and blood products from regions where there was an excess to those where there were shortages. When charges were introduced, some centres were reluctant to draw on supplies from other regions and preferred to risk the adverse publicity of postponed surgery if blood were in short supply.

It was quickly realised that, without central management it was impossible to budget for successful initiatives like quality assurance and for the payment of the MIS. Adequate funding for them was only assured when the National Blood Authority was founded in 1993.

Although expenditure on blood products represents only a small percentage of a hospital’s total budget, problems arise if new services are introduced which require more support from the transfusion service. Clinicians still have problems in thinking about finance for this essentially ‘free’ service but the organisational difficulties are gradually resolving and people working within the service feel that it can only get better.

Acknowledgements

The author would like to express her thanks to Professor W Schneider, Indiana University, for information on blood transfusion in America at the turn of the century and for access to his, as yet, unpublished paper Blood transfusion in peace and war, 1900–1950; Mr F Hanley Jr, Chairman of the Oliver Memorial Fund, for information on the Red Cross Transfusion Service and for access to his private archives; Professor P L Mollison, formerly director of the MRC Blood Transfusion Research Unit, for information on the Second World War blood depots and for assistance in editing the text.

Additional material, relevant to blood transfusion during the Second World War, was obtained from the Maycock and the MRC Archives, Public Records Office, Kew and the Drury Archives, Wellcome Institute for the History of Medicine, London. Needless to say, all the mistakes that remain are made by the author.

References

1 Landsteiner K. Über Agglutinationsersecheinungen normalen menschlichen Blutes. Wiener Klin Wochenschr 1901;1:5–8. English translation in Transfusion 1961;1:1132–4.
2. Hustin A. Principe d'une nouvelle méthode de transfusion muqueuse. J med Brux 1914;12:436-9.
3. Agote L. Nuevo procedimiento para la transfusión de sangre. An Inst Modelo Clin méd (Buenos Aires) 1915;1:25.
4. Lewisohn R. Blood transfusion by the citrate method. Surg Gynecol Obstet 1915;21:37-47.
5. Crile G. Hemorrhage and Transfusion. New York: Appleton, 1909.
6. Keynes G. The Gates of Memory. Oxford: Oxford University Press, 1983.
7. Editorial. Transfusion of blood in military and civilian practice. Lancet 1918;i:773-4.
8. Ottenberg R. Transfusion and arterial anastomosis. Ann Surg 1908;47:486-505.
9. Robertson LB. Results of blood transfusion in war surgery. Br Med J 1918;i:691-5.
10. Moss WL. Studies on isoagglutinins and isohemolysins. Bull Johns Hopkins Hosp 1910;21:63-70.
11. Jansky J. Haematologické, studie u. psychotiku. Sb Klin Praze 1906-7;8:85-139.
12. Rous P, Turner JR. The preservation of living red blood cells. J Exp Med 1916;23:219-48.
13. Robertson OH. Transfusion with preserved red blood cells. Br Med J 1918;i:691-5.
14. Keynes G. Blood donors. Br Med J 1924;i:613-4.
15. Gibson PC. A technique of blood transfusion. Lancet 1926;i:375-7.
16. Elliott GA, Macfarlane RG, Vaughan JM. The use of stored blood for transfusion. Lancet 1939;i:384-7.
17. Riddell VH. Blood Transfusion. Ed, H Milford. London: Oxford University Press, 1939.
18. Wain SL. The controversy of unmodified versus citrated blood transfusion in the early 20th century. Transfusion 1984;24:404-7.
19. Mollison PL, Young JM. Failure of in vitro tests as a guide to the value of stored blood. Br Med J 1941;i:797-800.
20. Loutit JF, Mollison PL, Young I Maureen. Citric acid-sodium citrate-glucose mixtures for blood storage. Q J Exp Physiol 1943;32:183-202.
21. Loutit JF, Mollison PL. Advantages of a disodium-citrate-glucose mixture as a blood preservative. Br Med J 1943;i:744.
22. McFarlane AS (letter). Behavior of lipoids in human serum. Nature 1942;149:439.
23. Keckwick RA, Mackay M, Record BR. Fractionation of human plasma with ether. Nature 1946;157:629.
24. Landsteiner K, Wiener AS. Agglutinable factor in human blood recognized by immune sera for Rhesus blood. Proc Soc Exp Biol Med 1940;43:223.
25. Fisher RA, cited by Race RR. The Rh genotypes and Fisher's theory. Blood 1948;3(Suppl2):27-42.

Address for correspondence: Dr H Dodsworth, 56 King Henry's Road, London NW3 3RP.