TABLE II Composition of irrigation fluid

Heparin sulphate	2 mg
10% Sodium citrate	10 ml
10% Poloxamer-188 (Pleuronic F-68)*	40 ml
Ampicillin†	2 g
Physiological saline‡	1000 ml

*Used in 22 cases but excluded now.
†After July, 1984.
‡Substituted by 6% Hetastarch ("Hespan") in 0.9% saline.

et al.[10] demonstrated that malignant cells could not be separated satisfactorily. Very little data have been published on the cytocidal effect of anticancerous drugs *in vitro*. We conducted a number of investigations (unpublished) in our laboratory to determine whether a limited exposure to mitomycin-C (MMC) could kill human cancer cells. In addition, we implanted cancer cells treated in this way into laboratory mice to verify the results *in vivo*. Our investigations have led us to use a concentration of 300 $\mu g \cdot ml^{-1}$ of MMC in the centrifuge bowl for a period of 20 minutes (using the Haemonetics Cell Saver) during cancer surgery. The MMC is added after the initial packing of red cells in the centrifuge but before rinsing.

To date, this procedure has been used in nine patients. Microscopic examinations of the erythrocyte concentrate were performed, and a few enlarged ghost cells suspected to be of malignant origin were found in two cases. We have not seen any generalized dissemination of malignant neoplasma. During three years of follow-up one of the nine patients died of myocardial infarction and one of local recurrence. Autopsies did not reveal distant metastases. Therefore, although the use of SAT during cancer surgery is considered contraindicated, our experience suggests that the use of MMC mixed with the concentrated red cells in the centrifuge bowl may kill malignant cells.

References

1 *Takaori M, Safar P.* Critical point in progressive hemodilution with hydroxyethyl starch. Kawasaki Medical Journal 1976; 2: 212–22.
2 *Takaori M, Safar P.* Treatment of massive hemorrhage with colloid and crystalloid solutions. JAMA 1967; 199: 297–302.
3 *Yoshida H.* Effect of hemodilution on distribution of ventilation-perfusion ratio. Japan Journal of Anesthesiology 1988; 37: 1351–8.
4 *Lewis JH, Szeto ILF, Bayer WL, Takaori M, Safar P.* Severe hemodilution with hydroxyethyl starch and dextrans. Arch Surg 1966; 93: 941–50.
5 *Mishler JM IV.* Synthetic plasma volume expanders – their pharmacology, safety and clinical efficacy. Clin Haematol 1984; 13: 75–92.
6 *Burrows L, Tartter P.* Effects of blood transfusions on colonic malignancy recurrence rate. Lancet 1982; 2: 662.
7 *Kaneda M, Horimi T, Ninomiya M et al.* Adverse effect of blood transfusion on survival of patients with gastric cancer. Transfusion 1987; 27: 375–7.
8 *Heal JM, Chuang C, Blumberg N.* Perioperative blood transfusions and prostate cancer recurrence and survival. Am J Surg 1988; 156: 374–79.
9 *Fujimoto H, Okamoto E, Yamanaka W et al.* Autotransfusion for liver resection – advantage and pitfall. Autotransfusion 1989; 2: 62–5.
10 *Dale RF, Kipling RM, Smith MF, Collier D St J, Smith PJ.* Separation of malignant cells during autotransfusion. Br J Surg 1988; 75: 581.

Safety of blood transfusion: risks and use of predonation, the Canadian experience

Noel A. Buskard MD FRCPC
Canadian Red Cross Society, Blood Transfusion Service and Department of Medicine, University of British Columbia, Vancouver, British Columbia

A variety of measures has been introduced in Canada to improve the safety of the blood supply. An autologous blood transfusion pilot study in British Columbia indicated that this form of transfusion is well tolerated and accepted in low-risk patients undergoing elective breast reconstructive surgery. While the use of autologous blood in Canada is not common at present, with broad donor criteria and increased concern about the hazards of homologous blood transfusion autologous transfusion is likely to increase in Canada in the future.

Plusieurs mesures ont été prises afin d'améliorer la sûreté des stocks sanguins au Canada. En Colombie-Britannique, une étude préliminaire a démontré que la transfusion de sang autologue est bien tolérée par les patientes présentant peu de risques lors de reconstructions mammaires électives. L'usage de sang autologue est peu répandu au Canada pour l'instant toutefois, l'élargissement des critères d'éligibilité et l'inquié-

tude grandissante quant aux risques associés aux transfusions de sang homologue sont susceptibles d'en promouvoir la popularité.

The safety of the blood supply in Canada remains extremely high. The major concern with respect to safety continues to be the transmission of infectious agents, and the impetus for developing autologous blood transfusion programs world-wide has been concern about infectious agents, especially the AIDS virus (HIV). At present, in Canada, the possibility of acquiring AIDS through a blood transfusion is remote (estimated to be about one in one million or less) but there has been no recipient follow-up to establish the exact risk. The chance of acquiring a serious infection from a blood transfusion in Canada has been reduced with the recent incorporation of Hepatitis C virus and anti-HTLV-1 testing.

Various strategies have been developed to reduce the potential for transmitting infectious agents:

1 Augmented donor screening by the nursing staff of the Canadian Red Cross Society Blood Transfusion Service (CRCSBTS) including education and self-exclusion.
2 Increased emphasis on education of medical and technical personnel, and the appropriate use of blood products.
3 Testing of all donor specimens for: (a) HBV (HBsAG); (b) HCV; (c) HIV; (d) HTLV-1; (e) syphilis. Each new infectious marker test reduces the chance of receiving blood containing one of the other infectious markers. For example, AIDS patients not only have HIV but often have evidence of infection with other agents.
4 Methods are being developed to inactivate viruses in blood and blood products and these include steam heat treatment of factor concentrates, physical removal (CMV), radiation, physical agents and photodynamic inactivation.
5 The production of blood substitutes may reduce the need for natural products. Blood substitutes currently under investigation include recombinant DNA products such as Factor VIII and Factor IX and Antithrombin III.
6 Finally, the development of an autologous blood program will reduce the infectious risks for those patients involved.[1-3] The advantages and disadvantages of an autologous blood program are outlined in Tables I and II respectively.[4] Directed donations are not accepted within the CRCSBTS and there is no evidence at the present time that these preparations are safer alternatives. The experience with autologous transfusions in British Columbia and Canada is discussed.

TABLE I Advantages of autologous transfusions

- eliminates risk of alloimmunization to red cells, white cells, platelets or plasma proteins
- eliminates risk of disease transmission including hepatitis B, and C (non A non B hepatitis), HIV, HTLV-1, cytomegalovirus (CMV), etc.
- eliminates risk of febrile, allergic or haemolytic transfusion reactions
- predeposit donations enhance erythropoiesis by "priming" the bone marrow
- haemodilution improves tissue perfusion by decreasing blood viscosity
- reduces the demand on the homologous or volunteer blood supply
- provides psychological benefits to the patient by participation in their own treatment

TABLE II Disadvantages of autologous transfusions

- complex logistics for collection, storage and transfusion of the correct unit to the appropriate patient
- increased expense due to the additional labour and paperwork
- usefulness restricted to specific clinical situations
- reinforcement of the misguided impression that volunteer donations are unsafe
- outdating of liquid stored blood if elective surgery is cancelled
- autologous transfusion option may be overused by patients who would not otherwise have needed transfusion
- risk to those persons who handle a potentially infective donor unit and increased wastage if that unit is discarded when donor criteria are not met
- haemodilution and intraoperative blood salvage require specially trained staff and/or special equipment

Autologous transfusion in breast reconstructive surgery – British Columbia experience

The Vancouver Centre of the CRCSBTS has carried out a feasibility study of low-risk donors to determine the cost, logistics, utilization rates and patterns of autologous blood use. One hundred and thirty-one women between 18 and 60 years of age (mean 32 yr) donated one (31 patients), or two (99 patients) units of blood. In 11 patients there was insufficient time for donation of two units of blood and only one was available; other reasons for donation of only one unit of blood included symptoms of light-headedness, dizziness, or fainting (four donors), haematocrit of less than 34% (five patients), poor venous access or less than the standard donation volume (nine donors), and minor illnesses (four patients). An average decrease of $10\ g \cdot L^{-1}$ in haemoglobin was noted following each donation.

All autologous donations were processed into packed red blood cells (PRBC) and a total of 230 units was prepared. Sixty-five per cent of these units were used in 91 of the donors, giving a utilization rate of 69%. Only one patient in this group required additional homologous blood (three units PRBCs).

The appropriateness of transfusions is illustrated in Table III. The preoperative haemoglobin concentration was lower in the transfused than in the untransfused group

TABLE III Haemoglobin levels in patients donating autologous blood (g/L^{-1})

	Transfused	*Not transfused*	
Pre-op Hb	112 ± 1.03	121 ± 1.5	$P < 0.01$
Post-op Hb	102 ± 1.50	102 ± 2.9	$P < 0.05$

($P < 0.01$). This suggested that the decision to transfuse was triggered partly by the preoperative haemoglobin, and partly by the intraoperative blood loss. There was no difference in the postoperative haemoglobins between the two groups.

Questionnaires to donors were returned by 73% of participants, and these questionnaires indicated that 39% of the respondents had previously been Red Cross whole blood donors. When asked if they would consider being a volunteer donor in the future, 79% were affirmative. The majority of the participants stated that they were happy about being permitted to take part in the study and would recommend it to others.

The unpublished study, although limited, indicates that autologous transfusion in patients undergoing reconstructive breast surgery could be carried out safely. The utilization rate was high, and with strict donor criteria and with the release of units not used into the general blood supply, there may be a cost saving in this type of program. At present there is no such crossover.

Autologous blood transfusion in Canada – April 1989–March 1990

For the year ending March 31, 1990, 4,045 units of autologous blood were collected for 1,934 donors. The donor ages varied considerably but the largest number were in the 17 to 45 yr age group. In all age categories females outnumbered males. With respect to the type of surgical program requesting autologous blood, orthopaedic and plastic surgery predominated. Donors were unable to complete their series of autologous blood collections for reasons similar to those found in the Vancouver study reported above. Two donors were noted to be HIV positive, one male and one female. The majority of autologous blood was donated in Montreal, Ottawa, Toronto, Hamilton and Vancouver.

Utilization rates are important to substantiate the effectiveness of autologous blood transfusion. The transfusion rates for whole blood are highest at 61% followed by red cell concentrates at 56% and plasma at 10%. A high proportion of plasma collected is discarded. Less red cell concentrates are discarded while only 26% of the whole blood collected is discarded. Currently only small amounts of blood products not used by the donor are released to the general blood supply. This is because of concern about increased infectious risks with autologous blood donation. Thus homologous use of autologous units is discouraged in Canada.

TABLE IV Autologous blood transfusion program

Donor eligibility criteria

A Age 17–71 years

B Haematocrit
- 1st donation >34
- subsequent donation >32

C General health criteria – more relaxed than homologous blood donors, e.g., recent inoculations, past history of cancer, medications, etc.

D Confirmed HBV (HBsAg), HCV, anti-HIV OR anti-HTLV-I antibody positive individuals are not eligible.

E In case of doubts about the eligibility, acceptance of the patient is at the discretion of the centre medical director

The autologous blood transfusion program of the CRCSBTS has been in operation for over two years.[5] Our objective of a high utilization rate of collected units has not yet been met, as we would like to see a rate of >80% rather than the current rate of 60%. Apart from symptoms during blood removal, no untoward effects of low circulating blood volume or low haemoglobin have been documented, although these have not been searched for specifically. It is anticipated that the relatively small proportion of autologous blood collection in Canada (<1% of all units donated) will increase in Canada in the future. This may be particularly important as the introduction of new infectious marker testing such as HCV and anti-HTLV-I will further reduce the donor base by as much as 1%. At present, autologous blood transfusion is more expensive than the use of homologous blood, by about $25 per unit. It has not been found to be economically viable for a private company to undertake autologous blood transfusion in Canada. The autologous donor criteria listed in Table IV permit a broad population to be eligible for this program, and this plus the other factors cited above mean that more patients will donate for themselves in the future.

In summary, a variety of measures has been introduced in Canada to improve the safety of the blood supply. An autologous blood transfusion pilot study in British Columbia indicated that this form of transfusion is well tolerated and accepted in low-risk patients undergoing elective breast reconstructive surgery. While the use of autologous blood in Canada is not common at present, with broad donor criteria and increased concern about the hazards of homologous blood transfusions, autologous transfusion is likely to increase in Canada in the future.

Acknowledgements

I am indebted to Dr. Roger Perrault and his staff at the

National Office of the Canadian Red Cross Society for their assistance in the preparation of the manuscript. Also, to Vangie Viebe for the typing it.

References

1 *Kay LA*. The need for autologous blood transfusion. BMJ, 1987; 294: 137–9.
2 British Committee for Standardization in Haematology Blood Transfusion Task Force: Guidelines for autologous transfusion. Clin Lab Haematol 1988; 10: 193–201.
3 *Slater JL*. Autologous transfusion: its role in transfusion medicine in Canada. Ann RCPSC 1988; 21: 209–12.
4 *Edwards E*. Autologous blood transfusion. British Columbia Medical Journal 1989; 31: 230–2.
5 *Gilmore A*. Red Cross gets go-ahead for autologous blood service. Can Med Assoc J 1988; 138: 157–9.

Safety of blood transfusion: the Japanese experience

Hisami Ikeda MD
Hokkaido Red Cross Blood Center, Yamanote 2-2, Nishi-ku Sapporo 063, Japan

There are eight million blood donors in Japan. Blood is donated in units of 200 ml or 400 ml and by haemapheresis. The major problems are concerned with the transmission of infection, particularly with HIV and HTL-1 viral infections, and this leads to rejection of about 8% of donated blood. Recent emphasis has been placed on the automated screening of blood at the time of donation and the more widespread use of patient records to eliminate infected blood.

Au Japon, huit millions de personnes donnent de leur sang que l'on prélève par hémophérèse à raison de 200 ou 400 ml. On s'inquiète des risques de transmission infectieuse et plus particulièrement du HIV et du HTL-1, ce qui entraîne le rejet de 8% des unités. On a récemment mis l'accent sur le dépistage automatique lors du don de sang et sur un plus grand recours aux dossiers des patients afin réduire le risque d'infection.

The Japanese blood program

In 1988, about eight million people (6.5% of Japanese population) donated blood. Of the three types of blood donation (200 ml, 400 ml and haemapheresis), 200 ml is the most common. The 400 ml and haemapheresis donations began in 1986, and are increasing (Table I). Japan is self-sufficient for red cells which are supplied exclusively through the Japanese Red Cross but many plasma products are imported. Imported virus-contaminated anti-haemophilic factor (AHF) concentrates have caused HIV in Japanese haemophiliacs, and the Government and the Red Cross have decided that AHF concentrates will be made from blood donated here so that Japan will be self-sufficient by 1992.

Predonation testing

Serological tests before donation to exclude virus carriers may be beneficial to avoid inappropriate blood collection. The tests should be simple and reliable as donors should not be kept for a long time at collection sites awaiting results. For transfusion safety, however, all collected blood units should be examined. Inappropriate blood collection may also be reduced by referral to the previous records of donors 80% of whom are repeat donors. Direct computer access to these records from donation sites will help to avoid collection from hepatitis B virus (HBV), human T-cell lymphotrophic virus (HTLV-I), hepatitis C virus (HCV) or human immunodeficiency virus (HIV-1) carriers.

Serological tests are not performed before donation to exclude virus carriers although predonation tests for haemapheresis donors would help because haemapheresis is time-consuming and expensive. This would be particularly advantageous for HLA-matched or cytomegalovirus (CMV) free platelets which must be supplied rapidly, and where alternative registered donors must be contacted as soon as possible.

Blood donor screening

About 8% of donated blood units are rejected in our blood center (Table II). The main reason is virus infection particularly with HBV and HTLV-I infection.

The HBV carrier rate of the general population is estimated to be higher than that of blood donors. The major route of the HBV transmission in Japanese is mother to infant.[1] Since vaccination of affected infants is highly effective, the carrier rate should decrease in the future. Residual cases of transfusion-associated hepatitis B are probably due to the low sensitivity of the screening method of hepatitis B surface antigen (HBsAg). They should decrease following the recent adoption of anti-hepatitis B core antigen (HBc) screening.

Japan is an endemic area for HTLV-I infection. The Japanese Red Cross started HTLV-I seroscreening in 1986. Healthy HTLV-I carriers are found in 1–2% of Japanese blood donors.[2] A higher prevalences (8%) is seen in Kyushu, southwestern Japan. A high HTLV-I seroconversion rate (>50%) was observed among the