Changing patterns of transfusion practice in a tertiary care hospital from 1977 to 1984

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Patterns of blood transfusion practice over an eight-year-period (1977–1984) are described. Use of blood and blood products increased annually as did the number of patients crossmatched and transfused. Programs such as the "Blood Group & Antibody Screen" and the "Maximum Surgical Blood Order Schedule" were important in improving transfusion practices. There was improvment in blood use by all subspecialties; the overall C:T (crossmatched:transfused blood) ratio declined from 4.4 to 2.8. Approximately a quarter of both crossmatches performed and transfusions of red cells were associated with cardiac surgery. Incidence of outdated units of blood declined markedly (2.6 per cent in 1984), as did requests for and administration of single unit transfusions. Seven per cent of patients received one unit of blood during hospitalization; since 85 per cent of these were associated with surgery (57 per cent cardiac surgery), it is suggested that single unit transfusions may sometimes be more appropriate than inappropriate. Two per cent of patients had clinically significant alloantibodies. About two per cent of patients had positive direct antiglobulin tests; nine per cent of the sera of these patients contained both auto and alloantibodies. Such data are important for transfusion quality assurance as well as for optimal logistical use of facilities both at hospital Blood Bank and blood collection agency levels.

Key words

TRANSFUSION: stored blood, blood utilization, blood order; BLOOD: blood group antibodies.

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Recently much attention has been given to improvements in Blood Bank techniques designed to enhance the safety of blood transfusions. New approaches to pretransfusion testing have also been developed in an attempt to enhance cost-efficiency. The progressively increasing requirement for blood and blood products for transfusion necessitates also the analysis of blood transfusion ordering and utilization practices, in order to ensure optimal availability and use of donated blood. This report describes changes and trends in blood ordering and utilization practices from 1977 to 1984 in a large teaching hospital. The report indicates the effects of some particular policy and procedural changes on overall transfusion practice. Such information is important for quality assurance of clinical transfusion.

The Institution and its programs

This 700-bed downtown university-affiliated tertiary care general hosptial provides a comprehensive range of clinical services. The hospital has no paediatric service. In addition to usual medical and surgical services, active specialty services include cardiac surgery, orthopaedics, neurosurgery, and renal transplantation. Recently developed clinical programs in the institution affecting blood utilization include automated therapeutic apheresis (1981), regional adult haemophiliac Comprehensive Care Centre (1983), and designation of the hospital as a trauma centre (1984).

Blood Bank practices were in accord with established procedures.[1,2] The routine for the "Blood Group and Antibody Screen" (BGAS; "Type and Screen") and the "Maximum Surgical Blood Order Schedule" (MSBOS) orders initiated in 1977 was similar to that described by others.[3,4] The Trans-

TABLE I Blood and blood products used 1977–1984

	1977	*1978*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*
Total red cells*	8,958	8,236	8,819	9,934	10,449	10,320	12,084	12,588
Whole blood*	3,756	2,338	1,259	576	146	139	0	3
Red cell concentrates*	5,202	5,898	7,560	9,358	10,303	10,181	12,084	12,585
Granulocytes*	0	0	29	14	18	12	4	8
Platelets*	1,618	2,014	2,459	3,008	2,873	3,156	3,618	4,032
Fresh frozen plasma*	1,710	2,669	2,705	4,049	4,777	4,926	2,523	1,192
Frozen plasma*	0	0	0	0	0	400	824	1,745
Stored plasma*	30	46	170	471	2,142	1,630	2,169	2,381
Albumin†	780	614	610	624	717	1,009	1,129	858

*Units.
†Equivalents of 5% albumin in ml × 10^3.

fusion Review Committee formed in 1976 reviews blood utilization practices and directs follow up of unusual or inappropriate practices.

All blood and blood products were obtained from the Toronto Centre of the Canadian Red Cross Society Blood Transfusion Service; more specific descriptions of blood components and products have been given elsewhere.[5] Statisics on all blood orders, transfusions and Blood Bank investigations were kept manually on an ongoing daily basis, reviewed and summarized monthly and annually.

Results

Blood and blood products 1977–1984

As shown in Table I, the use of red cells for transfusion increased 1.4-fold from 1977 to 1984. Whereas only 58 per cent of red cell transfusions were given as red cell concentrates (packed cells) in 1977, in 1984 red cell concentrates accounted for 99.98 per cent of all red cell transfusions. Transfusions of granulocytes (obtained by apheresis) were given only sporadically, despite an approximate 50 per cent increase in the number of leukemics and oncology patients seen throughout this period. The use of platelet concentrates (all random donor) increased 2.5-fold from 1977 to 1984.

There was a 3.1-fold increase in the use of plasma throughout the study period (Table I). In 1984, 45 per cent of plasma transfused was in the form of stored liquid plasma (SP), 22 per cent as fresh frozen plasma (FFP; frozen within 12 hours of donation) and 33 per cent as frozen plasma (FP; frozen within 24 hours of donation). Coagulation factor products transfused increased markedly over the past two years: 88 units of cryoprecipitate were administered in 1982, 1525 in 1984; 116,500 units of factor VIII (as concentrate) in 1982, 1,171,000 in 1984; no factor IX in 1982, 108,500 units (as concentrate) in 1984.

In 1977, nine per cent of units of blood became outdated prior to use (Table II). The reduced incidence of outdated blood units was related primarily to more careful attention to inventory management. Extension of red cell shelf-life to 35 days in 1982 (blood collected into CPD-A_1), reduced the number of blood units outdated to 2.6 per cent (1984).

Blood ordering and transfusion practices

There was no increase in the number of hospital beds (700) over the study period. As shown in Table II, there was also no increase in the number of patients admitted to hospital annually. Nonetheless the number of patients tested and number of pretransfusion tests performed annually increased 56 and 106 per cent respectively from 1977 to 1984). Overall 40.7 ± 2.8 per cent (mean ± SD) of patients admitted to hospital were crossmatched; overall 9.9 ± 1.6 per cent of hospitalized patients were transfused. The proportion of hospitalized patients for whom crossmatched blood was requested was not significantly different in the 1977–1980 period than in 1981–1984. The proportion of hospitalized patients who were transfused, however, increased significantly from 1977–1980 (8.6 per cent) to 1981–1984 (11.2 per cent).

In 1977 only 21.4 per cent of the patients who

TABLE II Blood (red cells) crossmatched and transfused

	1977	*1978*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*
No. patients hospitalized	23,225	22,862	21,697	22,469	22,892	23,465	24,979	23,814
No. patients tested	8,840	10,742	9,456	10,813	11,597	11,989	12,760	13,821
No. pretransfusion tests	9,100	9,970	12,160	13,629	14,857	16,876	17,303	18,749
No. units blood crossmatched	34,987	35,963	24,696	26,616	27,528	28,896	33,060	34,188
No. patients crossmatched	8,820	9,970	8,100	8,892	9,048	9,528	10,104	11,028
No. units blood transfused	8,958	8,236	8,819	9,934	10,449	10,320	12,084	12,588
No. patients transfused	1,884	1,656	1,992	2,196	2,448	2,604	2,724	2,904
C:T ratio*	3.91	4.37	2.80	2.68	2.63	2.80	2.74	2.72
Units per patient transfused	4.75	4.97	4.43	4.56	4.27	3.96	4.44	4.34
Per cent units outdated	8.7	9.1	6.8	8.4	8.5	8.4	2.9	2.6

*Ratio of crossmatched to transfused units of red cells.

TABLE III Requests for and transfusion of blood (red cells) by hospital service analyzed over the same three-month period (Sept., Oct., Nov.) in 1977 and 1984

	Percent of all cross-matched		*Per cent of all blood used*		*C:T ratio*	
	1977	*1984*	*1977*	*1984*	*1977*	*1984*
Obstetrics/Gynecology	23	16	9	7	10.1	5.6
General surgery	19	24	19	26	4.0	2.8
Cardiac surgery	21	21	34	26	2.5	1.4
Orthopaedics	8	6	7	4	4.2	2.3
Urology	8	5	5	5	5.3	2.6
Emergency/trauma	3	6	3	8	3.3	3.2
General medicine	11	14	14	13	3.0	2.1
Haematology	3	6	7	9	1.7	1.2
Other	4	2	2	2	3.1	2.4

were crossmatched and 25.6 per cent of units of blood that was crossmatched were transfused (Table II). Programs advocating the use of the BGAS and the MSBOS orders were instituted in 1977. Marked reduction was observed in the number of patients for whom crossmatched blood was requested and also in the number of crossmatched units of blood requested (Table II). Since 1979 a small but steady annual increase has occurred in the number of patients for whom crossmatched blood has been requested and there has been a corresponding annual increase in the number of units of blood crossmatched. In 1984 26.3 per cent of patients for whom crossmatched blood had been requested did receive blood; 36.8 per cent of crossmatched units of blood were transfused.

The C:T ratio (units crossmatched:units transfused) fell from 4.4 in 1978 to 2.8 in 1979 and has remained at approximately that level since (Table II). The C:T ratio was generally highest in January and June–July, when new house staff are rotated to the institution. The number of units of red cells administered per transfused patient remained unchanged throughout the eight year period (Table II). Table III shows blood ordering and utilization practices by individual hospital departments. Requests from general surgery and cardiac surgery accounted for about one half of all crossmatches performed and about a half of all red cells transfused. There was a significant reduction in the C:T ratio from 1977 to 1984 in almost all subspecialties. Despite improvement, Obstetrics and Gynecology continued to have a C:T ratio more than twice the average.

From 1977 to 1981 the use of the BGAS order (for patients who may, but are likely not to, require

TABLE IV Blood group and antibody screen (BGAS) and single unit transfusions

	1977	*1978*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*
BGAS requests	501	1,040	1,389	1,908	2,288	2,380	2,424	2,496
BGAS subsequently crossmatched	N/A*	N/A	102	157	118	118	118	116
BGAS subsequently transfused	N/A	N/A	34	60	43	43	54	46
1 unit requests	336	N/A	26	10	2	3	0	2
1 unit transfused	359	222	333	172	186	192	204	203
1 unit as % of blood used	4.0	2.7	2.7	1.7	1.8	1.9	1.7	1.6
1 unit as % of pts transfused	19.0	13.4	11.8	7.8	7.6	7.4	7.5	7.0

*Data not available.

blood) increased up until 1981 and then stabilized (Table IV). In about five per cent of patients for whom BGAS was initially ordered, crossmatched blood was subsequently requested; of the five per cent a third were transfused. We estimate that the use of the BGAS order instead of crossmatch has reduced work volume in the Blood Bank by about ten per cent.

There has been marked reduction in requests for the crossmatch of a single unit of blood for transfusion (Table IV). In 1984, about 85 per cent of occasions where a patient was transfused with only one unit of blood occurred in association with surgery; in 1977 32 per cent, and in 1984 57 per cent, of such patients had cardiac surgery. In 1984 11 per cent of one unit transfusions were given for preoperative and 17 per cent for postoperative haemoglobin replacement in patients with mild anaemia, 58 per cent were given during surgery or in the recovery room, and 14 per cent were given for a variety of non-surgical conditions.

About a quarter of all crossmatches and all transfusions of red cells were in association with cardiac surgery. The annual number of patients who had "open-heart" surgery increased (452 in 1977, 778 in 1984). Overall, 93 per cent of patients having "open-heart" surgery were transfused with red cells; the average number of red cells used per patient did not change significantly during this period (4.0 ± 0.29 units). In 1977 44 per cent of cardiac surgery patients received plasma (average three units each); in 1984 49 per cent received plasma (average 6.5 units each). In 1977 seven per cent received platelets (average ten units each); in 1984 11 per cent received platelets (average 14 units each). The data on transfusion in patients undergoing cardiac surgery include blood utilization throughout the entire hospital stay of the patient, i.e., preoperative, at surgery, and in the recovery phase. There was no collection of autologous blood prior to surgery for auto-transfusion and, except for one three-month trial period, a "cell saver" was not used at surgery. The short randomized trial failed to show significant reduction in donor blood used for the 30 patients on whom the cell saver was employed compared to an equal number matched for type of surgery in whom the cell saver was not used. The extracorporeal circulation device was generally primed with crystalloid.

In 1984, >6 units of red cells at a time where requested for 182 patients. These 182 patients represented 1.7 per cent of all patients for whom blood was requested. Cardiac surgery cases accounted for 38 per cent and trauma cases for 45 per cent of all such requests. The remaining 17 per cent of patients for whom >6 units at a time were requested either had gastrointestinal bleeding or the blood was requested during surgery. Ninety-four per cent of the patients having cardiac surgery for whom >6 units were requested (representing nine per cent of all cardiac surgery cases in 1984) were indeed transfused; in these patients the C:T ratio was 1.35 and they used an average 14.5 units of red cells, 8.1 units of platelets and 9.3 units of plasma each. Only 54 per cent of "trauma patients" for whom >6 units were requested were transfused; for those who were transfused, the C:T ratio was 1.9 and they received an average of 9.4 units of red cells, 3.4 units of platelets and 0.02 units of plasma each. Overall, in 1984, individual requests for >6 units of blood accounted for 6.9 per cent of all crossmatches performed and for 12.5 per cent of all red cells transfused.

TABLE V Antibody (Ab) detection

	1977	*1978*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*
Total antibodies	441	535	469	482	784	777	872	894
Antibody detection rate*	.050	.054	.039	.035	.053	.046	.050	.048
"Clinically significant" Abs	156	202	172	191	256	201	295	307

*Antibodies detected per number of antibody detection tests performed.

Staffing and workload

The number of Canadian Dominion Bureau of Statistics work units performed annually in the Blood Bank approximately doubled over the past eight years. There was no change in the method of calculating work units over this period (a number of units are assigned to individual tests on the basis of one unit per minute required for optimal performance of the test). The Blood Bank provided 24 hour a day coverage, seven days a week. In 1977, there were nine Blood Bank technologists, including a chief and a charge technologist. The number of technologists increased to 13 by 1984, but there was an average 21 per cent increase in work units performed by each technologist from 1977 to 1984.

Antibody detection

From 1977 to 1984, 90,018 patients were tested. Excluding patients with a positive direct antiglobulin test (DAT), 5254 antibodies were detected (Table V). Overall, 4936 (5.5 per cent) patients tested had one or more antibodies in their serum. "Clinically significant" antibodies (i.e., reacting at 37° C) were detected in two per cent of all patients tested. Sixty-nine per cent of patients in whom antibodies were detected were female. Anti-K and anti-D were the most frequently detected clinically significant alloantibodies (18 and 16 per cent of clinically significant antibodies respectively). Table VI shows examples of the changing antibody frequency patterns. Similarly, haemolytic disease of the newborn due to $Rh_o(D)$ incompatibility occurred in 2 cases/1000 births in 1977, whereas in 1984 it was observed in 0.8 cases/1000 births; in 1977 haemolytic disease of the newborn was due to anti-D in 8/15 cases, in 1984 it was due to anti-D in 3/15 cases.

Overall, 6.7 per cent of all antibody-containing sera demonstrated more than one antibody specificity. Of clinically significant antibodies detected in 1984, 19 per cent were multiple antibodies detected in single patients. Of these, 73 per cent were examples of serum antibodies with two specificities, 16 per cent with three specificities, and in six per cent four specificities were present. Five antibody specificities were detected in three per cent and six or more specificities in two per cent of the cases in which multiple antibodies were present.

TABLE VI Changing incidence of anti-D and anti-K antibodies

	anti-D		*anti-K*	
Per cent of:	*1977*	*1984*	*1977*	*1984*
All antibodies	9.1	3.2	2.6	8.8
Significant antibodies	25.6	9.4	7.5	25.7

Between 1977 and 1984, 75 patients developed a positive DAT following transfusion, in the absence of overt haemolysis. Antibody eluted from the sensitized (DAT-positive) red cells most commonly showed specificity within the Rh system (anti-E (23), -e (5), -c (4), and -D (2)). Antibody specificities within the Kidd (anti-Jk^a (18)), Kell (anti-K (15)) and Duffy (anti-Fy^a (4) and -Fy^b (2)) blood group systems were also frequently responsible for the post-transfusion positive DAT. In one case the antibody was panagglutinating and in one no antibody was detected in the eluate. These patients were asymptomatic and recognition of the development of antibody was due only to observation of a positive DAT within 3–4 weeks post-transfusion. In nine other patients who developed a positive DAT post-transfusion there was mild haemolysis and mild renal dysfunction and a diagnosis of delayed haemolytic transfusion reaction (HTR) was made; antibody specificities in these cases were anti-Jk^a (3), -E (3), -c (1), -e (1) and -K (1). An additional patient with delayed HTR, due to anti-Jk^a, developed moderately severe haemolysis and renal failure but recovered completely. Over the eight-year period four cases of immediate HTR

were recognized. Three were associated with mild haemolysis and were due to ABO incompatibility (one due to patient misidentification at the bedside resulting in group O packed cells given to a group B recipient, one due to blood bank error in issuing group O plasma to a group A patient, and one in blood group A haemophiliac following large dose factor VIII concentrate). The fourth patient with an immediate HTR had a negative DAT and no antibodies detected on extensive testing, but she had a clinically clear-cut HTR with severe intravascular haemolysis and renal failure and markedly shortened survival of crossmatch-compatible red cells (^{51}Cr T_{50} < 10 minutes). No deaths were attributed to HTR over the eight-year period.

A positive DAT attributed to drugs was detected in 267 patients over the eight-year period. This represented 0.3 per cent of all patients tested and accounted for 15.7 per cent of all positive DATs detected. Drug-induced positive DAT was attributed to methyldopa in 87 per cent, cephalosporins in seven per cent, penicillin in six per cent and other drugs in less than one per cent of cases.

Discussion

Developments particularly affecting blood use in our institution over the past eight years have included increased surgery, particularly an increase in the number of cardiac operations. The increase in proportion of hospitalized patients who were transfused (8.1% and 12.2% in 1977 and 1984 respectively), increased platelet transfusions, etc., support a clinical impression that patients admitted over recent years have tended to be sicker, more often requiring transfusion. The development of an automated therapeutic apheresis program in 1981 contributed to subsequent increased use of plasma and albumin. The establishment in 1983 of a regional Comprehensive Care Center for adult haemophiliacs resulted in marked increase in use of factor VIII and IX replacement products. A particular increase in number of trauma cases tested occurred in 1984 when the hospital was designated a "trauma centre."

General patterns of ordering and transfusing blood changed over the study period. The C:T ratio is a recognized parameter for evaluation of blood transfusion practice.[6–12] Introduction of the MSBOS and BGAS programs resulted in an improved C:T ratio in almost all subspecialties. The optimal C:T ratio is largely determined by the diseases of the patients, and the C:T ratio of about 2.7 obtained from 1979 to 1984 is consistent with that which might be considered reasonable.[6–12] In 1984, for the 23 hospitals in Toronto, the average C:T ratio was 2.96 ranging from 1.34 (in an oncology institute) to 4.54 (in a general hospital with designated high-risk obstetric service). Our institution transfused the third highest number of patients and had the sixth lowest C:T ratio among the 23 hospitals (1984 Annual Report of the Toronto Centre of the Canadian Red Cross Blood Transfusion Service). Efficacy of the BGAS approach is demonstrated by the lack of incrase in number of crossmatches performed annually despite increase in number of units of blood transfused and in number of patients transfused. We are not aware of a single instance during the study period in which it was detrimental to the patient to have had the BGAS initially requested, even when the patient subsequently required blood transfusion.

It was evident during the period of study that the Blood Transfusion Review Committee had a significant role to play in improving and maintaining blood transfusion practices and that "blitz" education drives resulted in improved (although often only temporarily) practices. Blood Bank personnel played a role in significantly reducing the incidence of outdated units of blood (2.6 per cent in 1984); some authors have indicated the feasibility of achieving an outdating rate of less than one per cent.[13]

Considerable change was observed in incidence of requests for, and transfusion of, a single unit of blood during the course of a patient's hospitalization. The data show a plateau in the percentage of blood given as single unit transfusions and of patients receiving single unit transfusions. Since currently most single units transfused are administered to patients bleeding at surgery, we do not anticipate significant reduction in this area. Administration of one unit of blood has been regarded as inappropriate and incidence of single unit transfusions has been used as a measure of overall transfusion practice. This measure has probably been overemphasised and administration of one unit of blood may sometimes be more appropriate than inappropriate.[14]

Blood use in patients undergoing cardiac surgery compared favourably with previously published

data for non-autotransfused patients, e.g., four units versus an average of 6.3 units red cells transfused per case in six reports from 1973–1982.[15–20] Although there has been an emphasis in recent years to transfuse red cell concentrates plus other components rather than whole blood (in order to permit preparation of other needed components and blood products), the findings suggest that in some patients requiring large volume transfusion, e.g., those with trauma or those having cardiac surgery, it may be more efficient to utilize, at least partially, whole blood transfusions.

Although alloantibodies were detected in the serum of 5.5 per cent of patients in pretransfusion testing, in only two per cent were the antibodies clinically significant. Anti-D was detected much less often (16 per cent of all clinically significant antibodies) than the 49–81 per cent reported in studies from 1973–1977;[21–24] this may be a reflection of reduced development of anti-D subsequent to routine use of Rh Immune Globulin. It is likely that this trend will continue and, with increasing transfusions, more clinically significant antibodies with specificities other than anti-D will be observed; this may result in compatible blood being more difficult to find. The presence of multiple specificities in the sera of 6.7 per cent of patients with alloantibodies may result in delay in providing appropriate blood for transfusion; such delays might be reduced by a program of pre-admission antibody screening tests for surgical patients.

Accumulation of statistics related to transfusion is often a rather tedious process. It is rewarding to be able to document improvements in the ordering and use of blood components and products, but the data obtained are more important in indicating areas where further improvement needs to be achieved: e.g., C:T ratio, outdating of blood. Documented statistics have been particularly useful to the Transfusion Review Committee in persuading clinicians of the appropriateness of approaches such as BGAS, MSBOS and appropriate use of single unit transfusions. Evaluation of blood utilization may also be helpful for determining the effect other hospital programs may have on the Blood Bank. For example, if cardiac surgery currently accounts for a known percentage of all crossmatches and blood used, and this proportion is fairly constant, one may then relatively reliably assess the effect on the Blood Bank of the addition of another cardiac surgeon or an incrase in operating room time devoted to cardiac surgery. The information regarding incidence and frequencies of antibodies has allowed Blood Bank staff to evaluate efficacy and appropriateness of Blood Bank policies and techniques; it may be useful for local Blood Bank evaluation and planning; e.g., number of technologists, inventory. Information regarding blood component and product utilization trends should also be important to blood collection agencies for optimal logistical planning.

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Résumé

Les indications et la pratique de transfusion pour une période de huit ans (1977–1984) sont décrites. L'utilisation du sang ainsi que ses dérivés a augmenté chaque année avec l'augmentation du nombre de patients qui ont été groupés et transfusés. Des programmes tels que "Blood Group et Antibody Screen" et le "Maximum Surgical Blood Order Schedule" ont amélioré d'une façon significative la pratique des transfusions. Il y avait une amélioration dans l'utilisation du sang par toutes les sous-spécialités: en général le taux C:T (patients groupés sur quantité de sang transfusé) a diminué de 4.4 à 2.8. Approximativement le quart des patients groupés et du sang transfusé étaient reliés à la chirurgie cardiaque. L'incidence d'unité de sang dont la date est expirée a diminuée remarquablement (2.6 pour cent en 1984), il en est ainsi des demandes pour l'administration d'une seule unité de sang. Sept pour cent des patients ont reçu une unité de sang lors de l'hospitalisation; puisque 85 pour cent de ceux là étaient associés avec la chirurgie (57 pour cent pour la chirurgie cardiaque), il est suggéré que la transfusion d'une seule unité de sang peut des fois être plus appropriée qu'inappropriée. Deux pour cent des patients ont présenté des alloanticorps cliniquement significatifs. A peu près deux pour cent des patients présentaient un test positif aux anti-globulines directes: neuf pour cent du sérum de ces patients contenait des autoanticorps ainsi que des alloanticorps. De telles données sont importantes afin d'assurer une bonne qualité de transfusion ainsi qu'une bonne utilisation optimale des services des banques de sang hospitaliers ainsi que de la Croix Rouge.