Bridgeport Hospital Autologous Blood Donation Experience from 1992 to 1996

Larry H. Bernstein\textsuperscript{a}, Maxime Coles\textsuperscript{b} and Nicholas Viner\textsuperscript{c}

Departments of \textsuperscript{a}Pathology and Laboratory Medicine, Sections of \textsuperscript{b}Orthopedics and \textsuperscript{c}Urology, Department of Surgery, Bridgeport Hospital, Bridgeport, Connecticut

(Received April 4, 1995; sent for revision June 26, 1995; accepted July 10, 1995)

The safety of the blood supply, an issue in the 1970s and 1980s, created an increased need to screen the blood supply for HIV-1 and hepatitis C virus infections. The possibility exists that other contamination could again affect the blood supply. This has resulted in the increased use of strategies to minimize the transfusion of allogeneic blood, such as autologous blood predeposit for elective surgical procedures. Many studies indicate, however, that autologous blood donation is overutilized so that half of the blood withdrawn for autologous use is discarded. Cost-effectiveness studies have indicated that autologous blood donation has little benefit compared with many medical procedures, from which one might conclude that the procedure could be eliminated. Alternatively, the benefit could be improved by reducing the wastage of autologous donated blood. This wastage must occur only because of a premise that autologous blood is obtained to ensure avoidance of a homologous transfusion. This results in an amount of blood withdrawn that is more than is used in an uncomplicated procedure. We examined the transfusion requirements in surgical procedures for which there is autologous blood donation to establish the optimum amount of blood to be taken based on expected blood use.

The transfusion records of 493 patients who donated blood preoperatively (340 orthopedic, 69 urological and 83 gynecological, in the years 1992 and 1993) were audited to determine the characteristics of the transfusion procedures associated with the surgical procedures.

The study sample underwent 182 total knee and 123 total hip arthroplasties, 33 laminectomies with fusion and three without, 83 hysterectomies and myectomies, 59 radical retropubic prostatectomies and 10 nephrectomies and lymph node resections. Data used for evaluation were age, sex, units donated and transfused, predonation hemoglobin concentration, initial and final hemoglobin concentration, surgical procedure and surgical blood loss.

The study suggests that autologous predeposit is not indicated for hysterectomies because of the low likelihood of transfusion. Even when a transfusion is likely according to the surgical blood order schedule, predonation is greater than actual use. Use of predonation hemoglobin could facilitate better efficiency of use for procedures where use is anticipated, thereby significantly reducing a wastage near 50 percent.

INTRODUCTION

Preoperative autologous deposit has increased as a method for reducing the risk of receiving a unit of allogeneic blood, the most significant of which is hepatitis C virus infection (1:3,300), now that the risk of HIV-1 virus infection is of the order 1:300,000.

\textsuperscript{a}To whom all correspondence should be addressed: Larry H. Bernstein, M.D., Department of Pathology and Laboratory Medicine, Bridgeport Hospital, 267 Grant Street, P.O. Box 5000, Bridgeport, CT 06610. Tel: 203-384-3155; Fax: (203) 384-3237; E-mail: lbernsl@ix.netcom.com.

\textsuperscript{b}Abbreviations: TKA, total knee arthroplasties; THA, total hip arthroplasties; LAM, laminectomies with fusion; HYS, hysterectomies; RRP, radical retropubic prostatectomies; Hbf, predonation hemoglobin concentration; Hb\textsubscript{f}, initial predonation hemoglobin concentration; EBL, surgical blood loss.
There is also the as yet uncalculated risk of postoperative infection from immune modulation [1-3], most likely from the transfusion of allogeneic leukocytes [4, 5]. The method is used mostly for elective surgical procedures (i.e., knee and hip arthroplasties, radical retropubic prostatectomies) for which transfusion is likely as a result of predictable blood loss intra- and/or post-operatively [6-7]. In other cases, such as gynecological procedures, the blood loss is minimal, but the perceived downside risk of an allogeneic transfusion by the patient is a motivating factor and contributes to a significant wastage of autologous predonated blood. This perception exists despite an exceptional need for transfusion and a substantially reduced risk of HIV and hepatitis transmission by transfusion of allogeneic blood. Of course, there are other and sufficient reasons to minimize using allogeneic blood for transfusions. None of them mandate avoidance of allogeneic transfusion.

Factors that may contribute to over- and under-utilization of autologous donation include: predonation anemia that does not allow donation of the required units and blood donation orders in excess of actual need [8]. The ability to donate is, indeed, determined by sex, bone marrow reserve and initial hemoglobin concentration [9]. Moreover, the phlebotomy for autologous donation is a medical procedure requiring more than an hour of patient and staff time and which has significant hemodynamic effects on the donor population. The failure to transfuse the units obtained invariably results in wastage of units. Consequently, autologous blood predonation has been viewed as not cost-effective compared with other medical procedures. This is largely because of a wastage of unused units at nearly 50 percent, since unused units are not crossed-over into the general blood supply. These units do not meet the same criteria for transfusion as blood donated for homologous use. Therefore, the predeposit of autologously donated blood may be viewed as unnecessary, since its estimated value is largely determined by its use. An alternative approach is to realize the optimum use of the procedure based on surgical blood loss and need for transfusion, thereby minimizing the amount of blood wastage. The approach envisioned is based on a substantial reduction rather than an absolute avoidance of homologous transfusion.

We, therefore, reviewed the transfusion records of 493 patients who donated blood preoperatively (340 orthopedic, 69 urological and 83 gynecological, in the years 1992 and 1993) to determine the characteristics of the transfusion practices associated with the surgical procedures.

**STUDY SAMPLE AND METHODS**

The study sample underwent 182 total knee (TKA) and 123 total hip (THA) arthroplasties, 33 laminectomies with fusion (LAM) and three without, 83 hysterectomies and myomectomies (HYS), 59 radical retropubic prostatectomies (RRP) and 10 nephrectomies and lymph node resections. Data used for evaluation were age, sex, units donated and transfused, predonation hemoglobin concentration (Hbd), initial (Hbi) and final (Hbf) hemoglobin concentration, surgical procedure, and surgical blood loss (EBL). The data were analyzed using Statgraphics™ software (Rockville, MD) on an IBM compatible computer. Statistical analyses included: histograms, linear regression analysis with step-wise variable selection, one-way analysis of variance (ANOVA1) and Kruskal-Wallis one-way analysis by ranks. We use a new nonlinear probabilistic model that presents a graphical display of odds ratio to illustrate the probabilistic representation of effects (Statistical Innovations, Belmont, MA) [10, 11].

**RESULTS**

Table 1 shows the means and standard error of EBL (ml), transfused, donated, Hbd, Hbi (mg/dl) for the listed procedures.
Table 1. Means and standard errors by procedure for estimated blood loss, units transfused
and donated and hemoglobin concentrations.

| Procedure | EBL    | Transfused | Donated | Hbd  | Hb1  |
|-----------|--------|------------|---------|------|------|
| THA       | 950 (45)| 2.32 (.11) | 2.46 (.06)| 13.8 (.12) | 9.4 (.16) |
| TKA       | 272 (37)| 1.14 (.09) | 2.07 (.05)| 13.9 (.10) | 10.5 (.13) |
| LAM       | 588 (87)| 1.55 (.22) | 2.21 (.11)| 14.6 (.23) | 12.0 (.32) |
| RRP       | 1441 (353)| 2.39 (.16) | 2.78 (.08)| 15.2 (.17) | 10.7 (.24) |
| HYS       | 417 (55)| 0.46 (.14) | 1.18 (.07)| 13.3 (.14) | 11.7 (.20) |

ANOVA1 F (p): 40.2 (E-5) 19.9 (E-5) 36 (E-5) 11.3 (E-5) 14.5 (E-5)

It is reasonable to conclude from this that blood loss in units or grams hemoglobin in descending order is RRP: 3; THA: 2; LAM, TKA and HYS: 1. The transfusion of more units than the operative blood loss for THA and TKA is related to additional loss postoperatively, compared to all the loss for RRP in the operative period. Further, less than the blood loss is transfused in RRP, which has a Hbd of 15, expected of all men donors. A preoperative Hb of 11 g/dl might result in a postoperative Hb of 7 g/dl if only intravenous support was provided during the procedure with a risk of volume overload from transfusion later. The use of 1.5 unit and usual donation of two units for LAM is not explained by the Hbd of 15 g/dl and Hb1 of 12 g/dl, unless the operative and postoperative loss is 2-3 g and the preoperative Hb concentration is 12 or 13 g/dl. The 12 g/dl Hbd after a 13 g/dl Hb1 reflects an imposed one-unit limit for HYS and is associated with a high discard rate associated with non-transfusion. The final hemoglobin is 10 g/dl, irrespective of procedure. However, the Hb1 (which does not distinguish pretransfusion from nontransfusion) does not always indicate that a transfusion trigger of 10 g/dl is “used” because the hemoglobin is allowed to decrease by two g/dl for many procedures without transfusion.

One-way analysis of variance was carried out assuming parametric distribution and Kruskal-Wallis analysis by ranks (non-parametric test) to examine the effect on units transfused of other variables. ANOVA1 and Kruskal-Wallis for EBL, Hb1 and donated units, respectively, by transfusion were significant: F = 34.5, 44.2, 17.1; t = 155, 233, 135; p < E-5. The units transfused is related to blood loss and inversely related to hemoglobin concentration.

Low blood loss procedures (< 500 ml) are knee arthroplasty, laminectomy, nephrectomy and hysterectomy. High blood loss procedures (> 500 ml) are hip arthroplasty, radical retropubic prostatectomy and pelvic lymph node dissection (ANOVA1, F = 48.2, p < .00001). Except for hip and knee arthroplasties, with significant postoperative blood loss, Hb1 concentrations are at or above 10 g/dl. Only hip arthroplasty and radical retropubic prostatectomy require two or more red cell unit transfusions (Figure 1). Stepwise linear regression analysis showed that EBL (F = 158) and Hb1 (F = 156) are critical variables associated with transfusion (r2 = .5288, p = .00001). Units transfused increase with blood loss above 500 ml (1 g) and occurs at Hb1 near 10 g/dl. Units donated also has an effect on units transfused (F = 32, p < .001). Nonparametric Spearman rank correlations were analyzed to correct for distribution effects. The rank correlation coefficients for transfusion, Hb1, blood loss, donated units and procedure are shown in Table 2.

Bridgeport Hospital participated in a voluntary collaborative quality improvement (QI) project within six months of the above study. The study, “The Red Blood Cell Transfusion in Selected Elective Surgical Procedures Project,” was part of a multi-state collaborative QI project coordinated by the Kerr L. White Health Policy Institute. The
Table 2. Spearman rank correlations between variables affecting transfusion.

|                        | Transfused units | Hb | Blood loss | Donated units | Surgery |
|------------------------|------------------|----|------------|---------------|---------|
| n = 493                |                  |    |            |               |         |
| Number units           | 1.000            | -0.6037 | 0.5325   | 0.4918       | -0.3071 |
| Initial Hb             | -0.6037          | 1.000   | -0.2303   | -0.2194      | 0.4202  |
| Blood loss             | 0.5325           | -0.2303 | 1.000     | 0.3721       | -0.1600 |
| Donated units          | 0.4918           | -0.2194 | 0.3721    | 1.000        | -0.3602 |
| Surgery                | -0.3071          | 0.4202   | -0.1600   | -0.3602      | 1.000   |

Table 3.

| Finding                                | Bridgeport | All  |
|----------------------------------------|------------|------|
| Admission Hb obtained                  | 100%       | 96.7%|
| Appropriateness per ACP guidelines     | 18.4%      | 12.5%|
| Overutilization adjusted for comorbidity | 57.1%     | 63.6%|
| RBC transfusion adjusted for blood loss | 19.5%     | 31.3%|
| Unused autologous RBC units            | 46.5%      | 35.5%|
| Hip                                    | 32.9%      | 26.0%|
| Knee                                   | 54.7%      | 41.2%|
| Unused crossmatch RBC units            | 72.6%      | 50.4%|
| Calculated C/T ratio                   | 1.38       | 1.98 |
| Hysterectomy                           | 3.00       | 2.32 |
| Hip                                    | 1.33       | 1.79 |
| Knee                                   | 1.40       | 2.18 |

primary goal was to assess current inter-state practice variations for autologous and homologous blood utilization.

In the first phase of the project, a study panel evaluated the record abstraction instrument developed by the Medical Society of Virginia Review Organization for use in the project and modified it for the Connecticut review process. The panel raised specific concerns that the ACP guidelines were too narrow in scope and did not take into account the clinical judgement used in transfusion decisions. Changes made in the abstraction tool adjusted for clinical conditions, such as a pulse rate greater than 110. The study encompassed three procedures for the Medicare population: hysterectomy, total hip replacement and total knee replacement.

The study found (Table 3) that the ACP guidelines are not followed in 81 percent of transfusions at Bridgeport Hospital or in 88 percent of transfusions in ALL participating hospitals, justifying the adoption of a conservative standard. However, there is a 57 percent overutilization of red cell transfusions by Bridgeport Hospital and 63.6 percent by all participants for the identified procedures using the conservative adjusted guidelines. It is only when blood loss is taken into consideration that overutilization is of the order of 19.5 percent by Bridgeport Hospital and 31.4 percent by all participants. The overutilization is not significant for homologous units, except for hysterectomies. The C/T ratio for homologous use in hysterectomy was high (3:1). The problem would be immediately corrected by only carrying out immediate spin crossmatch for transfusion when blood is needed for hysterectomy and not setting up units in the immediate preoperative period.

The mean units use in orthopedics was as before: 1.04 for 65 total knee arthroplasties and 2.4 for 40 total hip arthroplasties. The overutilization in orthopedics was mainly in total knee arthroplasties and only in autologous transfusions with overutilization rates of 33 percent for hip and 55 percent for knee procedures. The MSBOS of three units for hip and two
Figure 1. Means and standard error of means (adjusted for unequal variance) for units transfused by procedure: hip, knee, fusion, prostate resection, hysterectomy and other.
units for knee was changed to two units and one unit, respectively, and a homologous unit is not set up for these procedures since an immediate spin crossmatch can be done to meet the needs of any case. The overutilization rate was brought down to 25 percent for hip and for knee procedures within eight months of the changes. Figure 2 is a GOLDminer™ plot of odds-ratios for units transfused by TKA and THA showing that use exceeding one unit is exceptional for a TKA but not for a THA.

**DISCUSSION**

There is nearly 50 percent wastage of autologous blood taken [12]. The blood cannot be converted to allogeneic donation if not transfused. The procedure requires an hour and may result in significant hypotension in some of the donor population.

Transfusions are dependent largely on a one or more unit blood loss intra- or post-operatively. Transfusions are initiated at a Hb concentration near 10 g/dl. Hb above that for hysterectomies and laminectomies is associated with a high discard rate [13]. This suggests that autologous transfusions are not only affected by donation (the blood would be

**Table 4. Adjusted maximum surgical blood order schedule by procedure.**

| Procedure | Blood order | Adjusted order |
|-----------|-------------|---------------|
| THA       | 3 (or 4)    | 2 (or 3)      |
| TKA       | 2 (or 3)    | 1 (or 2)      |
| LAM       | 2           | 1 or none     |
| RRP       | 4           | 3 or 2        |
| HYS       | 1           | none          |
discarded) but also that they are not necessarily based on unstable hemodynamics (which is the recommended practice guideline) [6, 7].

Considering the cost of autodonation and the significant wastage involved, it would be best to autodonate only for procedures for which significant blood loss is likely [14]. Hysterectomies would rarely qualify [13]. It is also desirable to follow a conservative approach to transfusion and to adjust the amount predeposited to the donation Hb concentration, especially for patients with a Hb exceeding 15 g/dl.

Table 4 shows a recommended autologous donation schedule based on our findings. The requirement for total hip arthroplasty (add one for reoperation) and radical retropubic prostatectomy is three units donation. This requirement should be reduced by one unit for a Hb4 above 15 g/dl and by two for a Hb4 above 17 g/dl.

Hysterectomy has been a type and screen procedure because the likelihood of transfusion is only five percent, which at low hemoglobin transfusion and preoperative concentrations would not allow autologous predeposit. Predeposit for hysterectomies is not indicated for Hb1 above 13 g/dl since transfusion is unlikely.

Total knee arthroplasty is considered a 1.5 unit procedure, which results in a standing order of two units with a significant wastage. The second unit can be deferred if the Hb1 exceeds 15 g/dl.

REFERENCES

1. Tarrter, P.I., Quintero, S., and Barron, D.M. Perioperative blood transfusion associated with infectious complications after colorectal cancer operations. Am. J. Surg. 152:479-482, 1986.
2. Tarrter, P.I. Blood transfusion and infectious complications following colorectal cancer surgery. Brit. J. Surg. 75:789-792, 1988.
3. Murphy, P., Heal, J.M., and Blumberg, N. Infection or suspected infection after hip replacement surgery with autologous or homologous blood transfusions. Transfusion 31:212-217, 1991.
4. Gianotti, L., Pyles, T., Alexander, J.W., Fukushima, R., and Babcock, G.F. Identification of the blood component responsible for increased susceptibility to gut-derived infection. Transfusion 33:458-465, 1993.
5. Brunson, M.E. and Alexander, J.W. Mechanisms of transfusion-induced immunosuppression. Transfusion 30:651-658, 1990.
6. Welch, I.G., Meehan, K.R., and Goodnough, L.T. Prudent strategies for elective red blood cell transfusion. Ann. Int. Med. 116:393-402, 1992.
7. National Blood Resource Education Program Expert Panel. The use of autologous blood. JAMA 263:414-417, 1990.
8. Goodnough, L.T., Vizmeg, K., and Verbrugge, D. The impact of autologous blood ordering and blood procurement practices on allogeneic blood exposure in elective orthopedic surgery patients. Am. J. Clin. Pathol. 101:354-357, 1994.
9. McVay, P.A., Hoag, M.S., Lee, S.J., and Toy, P.T.C.Y. Factors associated with successful autologous blood donation for elective surgery. Am. J. Clin. Pathol. 97:304-308, 1992.
10. Magidson, J. Introducing a new graphical model for the analysis of an ordered categorical response, part I. J. Targeting Measurement Analysis Marketing 4:133-148, 1995.
11. Magidson, J. Maximum likelihood assessment of clinical trials based on an ordered categorical response. Drug Inf. J. 30:143-170, 1996.
12. Renner, S.W., Howanitz, P.J., and Bachner, P. Preoperative autologous blood donation in 612 hospitals. Arch. Pathol. Lab. Med. 116: 613-619, 1992.
13. Goodnough, L.T., Saha, P., Hirschler, N., and Yomtovian, R. Autologous blood donation in non-orthopaedic surgery as a blood conservation strategy. Vox Sang. 63:90-95, 1992.
14. Birkmeyer, J.D., Goodnough, L.T., AuBuchon, J.P., Noordsh, P.G., and Littenberg, B. The cost-effectiveness of preoperative autologous blood donation for total hip and knee replacement. Transfusion 33:544-551, 1993.