Transfusion practices for elective orthopedic surgery

Research

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Brian G. Feagan,[*†] Cindy J. Wong,[*] William C. Johnston,[‡] Ramiro Arellano,[§] Nigel Colterjohn,[¶] Keyvan Karkouti,[**] Kim Turner[††]

From *the London Clinical Trials Research Group, John P. Robarts Research Institute, London, Ont.; †the Departments of Medicine and of Epidemiology and Biostatistics, University of Western Ontario, London, Ont.; ‡the Department of Orthopedics, University of Alberta Hospital, University of Alberta, Edmonton, Alta.; §the Department of Anaesthesia, Queen Elizabeth II Health Sciences Centre, Dalhousie University, Halifax, NS; ¶the Department of Surgery, Hamilton Health Sciences Corporation, McMaster University, Hamilton, Ont.; **the Department of Anaesthesia, Toronto General Hospital, University of Toronto, Toronto, Ont.; and ††the Department of Anaesthesia, Queen's University, Kingston, Ont.

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Abstract

Background: Use of blood conservation techniques in elective surgery reduces the risk of infection and transfusion reactions that result from using allogeneic blood products. We examined the transfusion practice and blood conservation strategies for elective orthopedic procedures in 19 Canadian hospitals.

Methods: We reviewed the medical records of patients who underwent total hip or knee joint arthroplasty between June 1998 and January 1999 in a convenience sample of 19 hospitals to determine the pre- and postoperative hemoglobin concentrations, concurrent medical conditions, participation status in an autologous blood donation program, use of other blood conservation techniques, and occurrence of allogeneic and autologous transfusions. Patients were considered eligible for autologous blood donation if they weighed at least 25 kg, were in good general health without major cardiac conditions and had a hemoglobin concentration of at least 110 g/L.

Results: We reviewed 4535 medical records. Of the 4422 patients whose eligibility status was known, 2561 (57.9%) were eligible to participate in an autologous blood donation program. Only 842 (18.6%) of the patients predonated blood. Patients who did not predonate blood were older (mean age 70.1 v. 63.8 years) and were more likely to have concomitant medical conditions (60.3% v. 37.9%) than those who did predonate. Overall, 30.6% (95% confidence interval [CI] 29.1%–32.1%) of the patients who did not predonate blood received allogeneic transfusions. For patients who predonated, the rate of allogeneic transfusion was 14.1% (95% CI 11.8%–16.5%). The frequency with which blood conservation techniques other than autologous blood donation were used was minimal (in 2.4% of all cases).

Interpretation: The use of blood conservation techniques among hospitals in Canada remains low. Only a minority of eligible patients participated in an autologous blood donation program.

Total joint arthroplasty is a highly effective procedure that is frequently performed in elderly patients.[1] Substantial perioperative blood loss is common, and patients often become anemic following surgery.[2,3] As well, elderly patients have a high prevalence of ischemic heart disease, and consequently many who undergo total joint arthroplasty are at increased risk of cardiovascular complications.[4,5] Although the transfusion of allogeneic blood is an effective solution, this intervention is now considered undesirable by many patients and health care providers.[6] Concern about transmission of viral infection[7,8] has led to attempts to avoid allogeneic transfusion. The most widely accepted procedure is autologous blood donation (ABD). Patients bank 2 to 3 units of their own blood for use during the perioperative period if required.[9] For patients who are ineligible for ABD, other interventions such as acute normovolemic hemodilution,[10] the use of red blood cell salvage devices[11] or the administration of erythropoietin[12] or aprotinin[13] are options.

In 1995/96 we performed a retrospective chart review of patients undergoing total hip and knee arthroplasty at 9 hospitals in Canada to assess transfusion practices.[2]

We selected these procedures because they are common and often result in substantial blood loss. Of 2233 charts evaluated, only 8% indicated participation in an ABD program even though 64% of the patients were eligible. Of patients who predonated blood, 9% received an allogeneic transfusion; conversely, of those who did not predonate, 24% received a transfusion. Although ABD is the most widely advocated method in Canada for avoiding allogeneic transfusion, our study showed that it was underutilized.

The Commission of Inquiry on the Blood System in Canada (Krever Commission) was established in 1993 to make recommendations to ensure an efficient, effective and safe blood system. Its final report was released in 1997.[14] One of the key recommendations was that "the operator of the blood supply system promote appropriate use of, and alternatives to, blood components and blood products." This recommendation has important implications for health care providers who must develop and implement

Table 1: Characteristics of patients who did and did not participate in autologous blood donation (ABD) program before elective orthopedic surgery

	Predonated blood *n = 842*		Did not predonate blood *n = 3693*	
Characteristic	% of patients*	95% CI	% of patients*	95% CI
Mean age (and SD), yr	63.8 (11.8)	63.0–64.6	70.1 (11.7)	69.7–70.5
% male	42.1	38.8–45.5	40.1	38.6–41.7
Type of procedure				
Hip, primary	48.4	45.0–51.8	42.0	40.4–43.6
Hip, revision	8.2	6.3–10.1	8.1	7.2–9.0
Knee, primary	39.0	35.7–42.3	44.3	42.7–45.9
Knee, revision	4.4	3.0–5.8	5.6	4.8–6.3
Mean weight (and SD), kg	83.0 (18.5)	81.7–84.2	80.3 (18.7)	79.7–80.9
Concomitant medical condition				
Cardiovascular disease	17.0	14.4–19.5	37.8	36.2–39.3
Diabetes mellitus	8.6	6.7–10.4	13.2	12.1–14.3
Pulmonary disease	8.2	6.3–10.0	12.5	11.5–13.6
Hematologic disease or cancer	4.8	3.3–6.2	8.0	7.2–8.9
Rheumatoid arthritis	5.6	4.0–7.1	7.2	6.4–8.0
Kidney disease	1.7	0.8–2.5	2.9	2.4–3.5
Gastrointestinal bleeds	2.1	1.2–3.1	1.7	1.2–2.1
Seizure disorder	0.5	0.0–0.9	1.3	0.9–1.6
Liver disease	1.2	0.5–1.9	1.1	0.7–1.4
No significant condition	62.1	58.8–65.4	39.7	38.1–41.3
Preoperative hemoglobin concentration ≤ 130 g/L	65.2	61.7–68.7	40.3	38.7–41.9
Mean preoperative hemoglobin concentration (and SD), g/L	125.2 (14.3)	124.1–126.2	133.6 (15.0)	133.1–134.1
Hip surgery	124.7 (14.7)	123.3–126.1	132.0 (15.4)	131.3–132.7
Knee surgery	125.7 (13.6)	124.2–127.2	135.2 (14.4)	134.6–135.9
Postoperative hemoglobin concentration† < 90 g/L	54.8	51.4–58.2	44.2	42.5–45.8
Mean postoperative hemoglobin concentration† (and SD), g/L	89.1 (13.0)	88.2–90.0	93.0 (15.6)	92.5–93.5
Hip surgery	87.9 (13.1)	86.7–89.1	91.0 (14.8)	90.4–91.7
Knee surgery	90.6 (12.7)	89.3–92.0	94.9 (16.1)	94.2–95.7
Eligible for ABD‡	100.0		48.0	46.4–49.7
Mean hemoglobin concentration before autologous donation (and SD), g/L	135.7 (12.1)	134.6–136.9	–	–
Mean no. of units donated (and SD)	2.1 (0.6)	2.1–2.2	–	–

Note: SD = standard deviation, CI = confidence interval.
*Unless otherwise stated.
†Postoperative hemoglobin concentration is the lowest concentration recorded during the postoperative period before hospital discharge.
‡Patients were considered eligible for ABD if they weighed at least 25 kg, had no cardiovascular illnesses and had a hemoglobin concentration of at least 110 g/L.

transfusion policies and provide access to blood conservation techniques.[15]

Whether the Krever Commission has influenced the use of blood conservation and transfusion practices at Canadian institutions is unknown. We conducted the current study to further assess this issue.

Methods

A convenience sample of 19 Canadian hospitals participated in the study. Seven of the institutions had participated in our 1995/96 study.[2] Ethics approval was obtained from the institutional review board at the University of Western Ontario. We asked the hospitals to review medical records of patients undergoing primary or revision hip or knee joint arthroplasty between June 1998 and January 1999.

Predefined criteria were used to record demographic variables, the type of procedure, concurrent medical conditions, the pre- and postoperative hemoglobin concentrations, participation status in an ABD program, use of other blood conservation techniques, and occurrence of allogeneic and autologous transfusions. Although access to ABD varied among the institutions, in Canada eligible patients must weigh at least 25 kg, be in good general health without major cardiac conditions and have a hemoglobin concentration of at least 110 g/L.[16] Patients over 80 years old are considered eligible only under exceptional circumstances.

We summarized the data using descriptive statistical methods. The autologous and allogeneic blood transfusion rates and corresponding 95% confidence intervals (CIs) were calculated according to the type of surgery and ABD participation status.

Results

Each hospital attempted to review all medical records of consecutive patients during 1998/99 and provided data for a minimum period of 8 months. We identified a total of 4535 cases at the 19 hospitals. Of the 4422 patients whose ABD eligibility status was known, 2561 (57.9%) were eligible for ABD. Only 842 (18.6%) of the patients predonated blood. The rate of ABD participation varied greatly among the institutions, from 1.3% to 66.0%.

Patient characteristics, stratified by ABD participation status, are shown in Table 1. Similar to our findings from the 1995/96 study, patients who did not predonate blood were older, were more likely to have undergone primary hip surgery and were more likely to have a concomitant medical illness than those who did predonate. Patients who predonated blood had lower pre- and postoperative hemoglobin concentrations than those who did not predonate. Their mean hemoglobin concentration before donation was 135.7 (standard deviation 12.1) g/L, and they banked 2.2 units of blood on average.

The transfusion rates, according to type of surgical procedure and ABD participation status, are shown in Table 2. Among patients who did not predonate blood, those who underwent revision hip surgery had the highest allogeneic transfusion rate (65.7%), requiring 3.8 units of blood on average. In the group of patients who did predonate blood, the rate of allogeneic transfusion was also highest among those who underwent revision hip surgery (27.5%). The overall rate of allogeneic transfusion was 30.6% among the patients who did not predonate, as compared with 14.1% among those who predonated blood. However, the proportion of patients receiving any transfusion was highest if autologous blood was available. Alternatively, allogeneic transfusion rates were relatively low among the patients who predonated. For example, 11.1% of patients who underwent a primary hip procedure required allogeneic transfusion.

Table 2: Transfusion requirements by procedure and ABD participation

	Predonated blood			Did not predonate blood		
Procedure; type of transfusion	No. of patients*	% who received transfusion (and 95% CI)	Mean no. of units (and SD)	No. of patients*	% who received transfusion (and 95% CI)	Mean no. of units (and SD)
Hip, primary	407			1544		
Allogeneic		11.1 (8.0–14.1)	1.8 (1.4)		30.4 (28.1–32.7)	2.4 (1.3)
Autologous		68.1 (63.5–72.6)	2.0 (0.6)		–	–
Hip, revision	69			297		
Allogeneic		27.5 (17.0–38.1)	2.0 (1.5)		65.7 (60.3–71.1)	3.8 (2.6)
Autologous		81.2 (71.9–90.4)	2.0 (0.7)		–	–
Knee, primary	328			1629		
Allogeneic		15.3 (11.4–19.2)	2.0 (1.3)		24.5 (22.4–26.6)	2.3 (1.2)
Autologous		72.2 (67.3–77.0)	1.9 (0.6)		–	–
Knee, revision	37			204		
Allogeneic		13.5 (2.5–24.5)	2.0 (1.4)		31.5 (25.1–37.9)	2.7 (1.3)
Autologous		54.1 (38.0–70.1)	1.7 (0.5)		–	–
All	842			3693		
Allogeneic		14.1 (11.8–16.5)	1.9 (1.4)		30.6 (29.1–32.1)	2.6 (1.7)
Autologous		70.0 (66.9–73.1)	1.9 (0.6)		–	–

*Totals may vary because of missing values.

Data from the 1995/96 study are presented in Table 3 along with the results of the current study. The rate of participation in an ABD program was lower in the earlier study than in the current one (8.4% v. 18.6%), although the proportion of patients who were eligible for ABD was higher in the earlier study (63.9% v. 57.9%). The rate of allogeneic transfusion was higher in 1998/99 than in 1995/96: 14.1% v. 9.0% among patients who predonated blood and 30.6% v. 24.1% among those who did not predonate.

Data from the 7 institutions that participated in both surveys appear in Table 3. Although the proportion of patients eligible for ABD decreased, from 66.0% to 52.4%, their participation rate increased slightly, from 15.7% to 19.2%. Thus, the overall participation rate remained at about 10% (10.4% in 1995/96 and 10.0% in 1998/99). The overall rate of allogeneic transfusion among patients who did not predonate blood increased, from 26.1% to 32.6%; this increase was similar to that observed for the total sample.

The use of blood conservation strategies other than ABD was low (in 2.4% [107/4508] of cases); normovolemic hemodilution was used in 74% of the 107 cases and a red blood cell salvage device in the remaining cases. No other blood conservation techniques were identified. However, we did not obtain data on the use of intraoperative blood conservation strategies and hypotensive anesthesia.

Table 3: Transfusion practices for elective orthopedic surgery in 1995/96[2] and 1998/99

	Chart review period	
Variable	1995/96	1998/99
All hospitals		
No. of hospitals	9	19
No. of patients	2233	4535
Mean age (and SD), yr	69 (11)	69 (12)
Revision procedure, % of patients	8.3	13.4
Cardiovascular illness, % of patients	26.3	33.9
Eligible for ABD, % of patients	63.9	57.9
ABD participation rate, %		
All patients	8.4	18.6
Patients eligible for ABD	13.4	32.9
Allogeneic transfusion rate, %		
Patients who predonated blood	9.0	14.1
Patients who did not predonate blood	24.1	30.6
Hospitals included in both surveys		
No. of hospitals	7	7
No. of patients	1728	1637
Mean age (and SD), yr	68 (11)	69 (11)
Revision procedure, % of patients	7.7	14.7
Cardiovascular illness, % of patients	24.3	38.9
Eligible for ABD, % of patients	66.0	52.4
ABD participation rate, %		
All patients	10.4	10.0
Patients eligible for ABD	15.7	19.2
Allogeneic transfusion rate, %		
Patients who predonated blood	9.0	8.6
Patients who did not predonate blood	26.1	32.6

Interpretation

We conducted 2 large-scale studies of transfusion practices in Canada covering the periods 1995/96 and 1998/99. Although both studies were retrospective and not based on a random sample of Canadian hospitals, they provide data for over 6700 patients who underwent 4 clearly defined surgical procedures at a large number of geographically representative institutions. The most important outcomes evaluated — transfusion status and the use of blood conservation strategies — were objective and thus insensitive to bias. Therefore, we believe our observations accurately reflect transfusion practices at the institutions surveyed.

Our previous study[2] showed that only 8.4% of patients participated in an ABD program in 1995/96. Although the rate of ABD participation was higher in 1998/99 (18.6%), this figure is still low given that 57.9% of the patients were eligible for participation. Moreover, minimal use was made of red blood cell salvage devices and acute normovolemic hemodilution. No erythropoietin or aprotinin use was reported.

ABD is the main blood conservation technique used in Canada. The predonation of autologous blood eliminates the risk of viral transmission; however, there are other risks. Although rare, bacterial contamination of stored autologous units can cause sepsis or death.[8,17] Similarly, major transfusion reactions due to clerical errors can occur.[18] Predonation of blood also increases the prevalence of postoperative anemia.[2] In the 1998/99 survey, 54.8% of the patients who predonated blood had a postoperative hemoglobin concentration below 90 g/L, as compared with 44.2% of those who did not predonate.

Not surprisingly, more revision procedures were performed and more patients had cardiovascular illnesses in 1998/99 than in 1995/96 (Table 3). This observation likely reflects both the demographic trend toward a more aged population and the more frequent use of orthopedic surgery in older, sicker individuals. Although we surveyed different hospitals in the 2 studies, this observation was consistent in the 7 hospitals included in both surveys. If in future more high-risk patients undergo surgery, then a greater proportion of patients will be ineligible for ABD and the risk of allogeneic transfusion will increase. Thus, expanded use of blood conservation techniques other than ABD must be introduced. The virtually nonexistent use of alternative strategies documented in our study clearly identifies a problem.

Our main finding was that the use of blood conservation techniques in Canada remains low despite the strong directive of the Krever Commission. Several explanations may exist. First, the 1998/99 survey was performed just 1 year after the report was issued. However, the "blood crisis" began in the early 1990s, and thus the impetus to reduce ex-

posure to allogeneic blood antedated publication of the Krever Commission recommendations by several years. Other possible reasons for our findings include insufficient resources for blood conservation techniques, the reluctance of providers to change traditional behaviours or the failure of institutions to coordinate preoperative management.

If exposure to allogeneic blood is to be reduced, comprehensive blood conservation programs must be developed. Current eligibility criteria for predonation of autologous blood are broad, and the use of ABD may not be appropriate for all eligible patients. Specifically, we speculate that people with a low hemoglobin concentration may be better served by other blood conservation techniques. Evidence-based guidelines for identifying which patients will benefit from ABD and other blood conservation techniques should be developed. Since support for comprehensive programs has important resource implications, the cost-effectiveness of these initiatives should also be studied.

Competing interests: None declared for Cindy Wong and William Johnston. Brian Feagan received speaker fees from Ortho Biotech (Canada) for presentations on anemia management. Ramiro Arellano received speaker fees and travel assistance from Ortho Biotech for a presentation on blood conservation to the Society of Obstetricians and Gynaecologists of Canada. Nigel Colterjohn received speaker fees, an educational grant and travel assistance from Ortho Biotech for presentations and research on the topic of perioperative blood conservation. Keyvan Karkouti received speaker fees and educational grants from Ortho Biotech in support of the perioperative blood conservation program at the University Health Network, Toronto. Kim Turner has received travel assistance from Ortho Biotech to attend a continuing medical education event on chronic pain.

Contributors: Brian Feagan and Cindy Wong were responsible for the conception and design of the study, the interpretation of the data and the drafting and revision of the manuscript. They were also responsible for data acquisition and analysis respectively. Bill Johnston, Ramiro Arellano, Nigel Colterjohn, Keyvan Karkouti and Kim Turner were responsible for data acquisition and revision of the manuscript. All authors approved the final version of the manuscript.

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References

1. Brady OH, Masri BA, Garbuz DS, Duncan CP. Rheumatology: 10. Joint replacement of the hip and knee — when to refer and what to expect. *CMAJ* 2000;163(10):1285-91. Available: www.cma.ca/cmaj/vol-163/issue-10/1285.htm
2. Feagan BG, Wong CJ, Lau CY, Wheeler SL, Sue-A-Quan G, Kirkley A. Transfusion practice in elective orthopaedic surgery. *Transfus Med* 2001;11:87-95.
3. Borghi B, Casati A. Incidence and risk factors for allogenic blood transfusion during major joint replacement using an integrated autotransfusion regimen. The Rizzoli Study Group on Orthopaedic Anaesthesia. *Eur J Anaesthesiol* 2000;17:411-7.
4. Neill F, Sear JW, French G, Lam H, Kemp M, Hooper RJ, et al. Increases in serum concentrations of cardiac proteins and the prediction of early postoperative cardiovascular complications in noncardiac surgery patients. *Anaesthesia* 2000;55:641-7.
5. Hogue CWJ, Goodnough LT, Monk TG. Perioperative myocardial ischemic episodes are related to hematocrit level in patients undergoing radical prostatectomy. *Transfusion* 1998;39:657-60.
6. Lee SJ, Liljas B, Churchill WH, Popovsky MA, Stowell CP, Cannon ME, et al. Perceptions and preferences of autologous blood donors. *Transfusion* 1998; 38:757-63.
7. Legler TJ, Riggert J, Simson G, Wolf C, Humpe A, Munzel U, et al. Testing of individual blood donations for HCV RNA reduces the residual risk of transfusion-transmitted HCV infection. *Transfusion* 2000;40:1192-7.
8. Dodd RY. The risk of transfusion-transmitted infection. *N Engl J Med* 1992; 327:419-21.
9. Goodnough LT, Brecher ME. Autologous blood transfusion. *Intern Med* 1998;37:238-45.
10. Monk TG, Goodnough LT. Acute normovolemic hemodilution. *Clin Orthop* 1998;357:74-81.
11. Cross MH. Cell salvage and leucodepletion. *Perfusion* 2001;16:61-6.
12. Feagan BG, Wong CJ, Kirkley A, Johnston DWC, Smith FC, Whitsitt MD, et al. Erythropoietin with iron supplementation to prevent allogeneic blood transfusion in total hip joint arthroplasty. *Ann Intern Med* 2000;133:845-54.
13. Murkin JM, Haig GM, Beer KJ, Cicutti N, McCutchen J, Comunale ME, et al. Aprotinin decreases exposure to allogeneic blood during primary unilateral total hip replacement. *J Bone Joint Surg [Am]* 2000;82:675-84.
14. *Commission of Inquiry on the Blood System in Canada: final report (Krever Commission)*. Ottawa: Canadian Government Publishing; 1997. Cat no CP32-62-3-1997E.
15. Hoey J. The sensibility of safety: reflections on the Krever inquiry's final report [editorial]. *CMAJ* 1998;158:(1)59-60. Available: www.cma.ca/cmaj/vol-158/issue-1/0059.htm
16. Innes G. Guidelines for red blood cells and plasma transfusion for adults and children: an emergency physician's overview of the 1997 Canadian blood transfusion guidelines. Part 1: red blood cell transfusion. Canadian Medical Association Expert Working Group. *J Emerg Med* 1998;16(1):129-31.
17. Roth VR, Arduino MJ, Nobiletti J, Holt SC, Carson LA, Wolf CF, et al. Transfusion-related sepsis due to serratia liquifaciens in the United States. *Transfusion* 2000;40:931-5.
18. Domen RE. Adverse reactions associated with autologous blood transfusion: evaluation and incidence at a large academic hospital. *Transfusion* 1998;38: 296-300.

Correspondence to: *Dr. Brian G. Feagan, Professor of Medicine, Department of Epidemiology and Biostatistics, Director, London Clinical Trials Research Group, John P. Robarts Research Institute, PO Box 5015, 100 Perth Dr., London ON N6A 5K8*