fentanyl for labor analgesia. *Anesthesia and Analgesia* 1996; **83**: 1229–33.
9 Chadwick HS, Ready LB. Intrathecal and epidural morphine sulphate for post-caesarean analgesia: a clinical comparison. *Anesthesiology* 1988; **68**: 925–9.
10 Pert CB, Snyder SH. Opiate receptor: demonstration in nervous tissue. *Science* 1973; **179**: 1011–14.
11 Ballantyne JC, Loach AB, Carr DB. Itching after epidural and spinal opiates. *Pain* 1988; **33**: 149–60.
12 Bromage PR, Camporesi EM, Durant PAC, Nielsen CH. Rostral spread of epidural morphine. *Anesthesiology* 1982; **56**: 431–6.
13 Bromage PR, Camporesi EH, Durant PAC, Nielsen CH. Non-respiratory side-effects of epidural morphine. *Anesthesia and Analgesia* 1982; **61**: 490–5.
14 Cousins MJ, Mather LE. Intrathecal and epidural administration of opioids. *Anesthesiology* 1984; **61**: 276–310.
15 Davies J, Dray A. Effects of enkephalin and morphine on Renshaw cells in feline spinal cord. *Nature (London)* 1976; **262**: 603–4.
16 Thomas DA, Williams GM, Iwata K *et al.* The medullary dorsal horn: a site of action of morphine in producing facial scratching in monkeys. *Anesthesiology* 1993; **79**: 54.
17 Scott PV, Fischer HBJ. Spinal opiate analgesia and facial pruritus: a neural theory. *Postgraduate Medical Journal* 1982; **58**: 531–5.
18 Rieselbach RE, DiChiro G, Freireich EJ, Rall DP. Subarachnoid distribution of drugs after lumbar injection. *New England Journal of Medicine* 1962; **267**: 1273–8.
19 DiChiro G. Observations on the circulation of the cerebrospinal fluid. *Acta Radiological Diagnosis* 1966; **5**: 988–1002.
20 Oyama T, Matsuki A, Taneichi T, Ling N, Guillemin R. Beta-endorphin in obstetric analgesia. *American Journal of Obstetrics and Gynecology* 1980; **137**: 613–16.
21 Baraka A, Noueihid R, Hajj S. Intrathecal injection of morphine for obstetric analgesia. *Anesthesiology* 1981; **54**: 136–40.
22 Vella LM, Willatts DG, Knott C, Lintin DJ, Justins DM, Reynolds F. Epidural fentanyl in labour. *Anaesthesia* 1985; **40**: 741–7.
23 Tejwani GA, Rattan AK, McDonald JS. Role of spinal opioid receptors in the antinociceptive interactions between intrathecal morphine and bupivacaine. *Anesthesia and Analgesia* 1992; **74**: 726–34.
24 Ackerman W, Juneja M, Kaczorowski D, Colclough G. A comparison of the incidence of pruritus following epidural opioid administration in the parturients. *Canadian Journal of Anaesthesia* 1989; **36**: 388–91.

FORUM

Reducing red blood cell transfusion in elective surgical patients: the role of audit and practice guidelines

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Summary

In 1996, we prospectively audited peri-operative transfusion practice in elective surgical patients over a 3-month period. Two-unit transfusions represented 60% of all transfusions. Haemoglobin was measured infrequently prior to transfusion and the main 'trigger' for transfusion was an estimated blood loss in excess of 500 ml. Transfusion guidelines that required the haemoglobin level to be measured immediately before transfusion were introduced. The audit was repeated in 1998; transfusion 'triggers' and the number of transfusions for the two periods were compared. In the second audit, the total number of transfusions decreased by 43%. The mean estimated blood loss associated with a 2-unit transfusion had increased from 608 (373) ml to 1320 (644) ml ($p < 0.01$) and the estimated haemoglobin concentration after transfusion had decreased from 12.4 (1.8) $g.dl^{-1}$ to 9.9 (2.4) $g.dl^{-1}$ ($p < 0.01$). These results suggest that transfusion guidelines can have a significant impact on clinical practice.

Keywords *Transfusion*: guidelines; audit.

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Accepted: 26 March 2000

Considerable variability in transfusion practice exists, both between and within institutions [1–3]. The SANGUIS study, which examined blood product use in 43 European hospitals, found that transfusion rates depend more on physicians than on type of procedure, patient population or hospital [4]. Studies reviewing the appropriateness of red-cell transfusion, based on a variety of criteria, estimate that the proportion of unnecessary transfusions ranges from 4 to 66% [5]. Reasons for the large variability in transfusion practice remain elusive, but clinicians' practices and attitudes may be entrenched and slow to change [6]. Many clinicians continue routinely to transfuse patients to haemoglobin levels > 10 g.dl^{-1} [7, 8], despite little scientific evidence to support this practice [9–11].

Blood transfusion is not entirely risk free. The risks of allogeneic transfusions include viral transmission and immunomodulation with implications for tumour recurrence and postoperative infection [12–14]. Operational transfusion errors are a significant cause of morbidity and mortality [15]. Inappropriate blood transfusions expose patients to unnecessary risk and have a considerable economic impact [16]. Up to 70% of all red-cell transfusions are administered to surgical patients during the peri-operative period [17]. Anaesthetists and surgeons are responsible for the decision to transfuse in over two-thirds of hospital inpatients. The basis on which they make these decisions is therefore of fundamental importance in determining the use and administration of blood within the NHS.

The aim of our study was to audit peri-operative transfusion practice in elective surgical patients, to determine which 'triggers' were being used to initiate red-cell transfusion and identify opportunities for reducing unnecessary transfusions. Departmental transfusion guidelines were introduced following the first audit and their impact was measured in a repeat audit 1 year later.

Methods

In 1996, we undertook a survey of all medical staff ($n = 50$) within the Department of Anaesthesia in a large teaching hospital to ascertain their views concerning red-cell transfusion and the 'triggers' used to initiate transfusion during the peri-operative period. This was followed by a prospective 3-month audit of peri-operative red-cell transfusions in all elective surgical patients, excluding day-case and cardiac surgical patients. Data collected included patient weight (Wt), operative procedure, pre-operative haemoglobin level (Hb_{start}), haemoglobin (Hb) level at the time of transfusion (if known), estimated blood loss (EBL) recorded by the anaesthetist and number of red cell units transfused. Estimated blood volume (EBV) was calculated as 70 ml.kg^{-1} body weight. Estimated haemoglobin balance following transfusion was calculated using the formula:

$$\mathrm{Hb} = \mathrm{Hb}_{start} + [(\text{units transfused} \times 70)/\mathrm{Wt}] - [(\mathrm{EBL} \times \mathrm{Hb}_{start})/(\mathrm{Wt} \times 70)]$$

assuming that 1 unit of red cells increases the Hb level by 1 g.dl^{-1} in a 70-kg adult [18]. While this formula is somewhat simplistic and assumes linearity of Hb change with blood loss or red-cell transfusion, it is probably valid over the range of transfusions studied (1–2 units). The

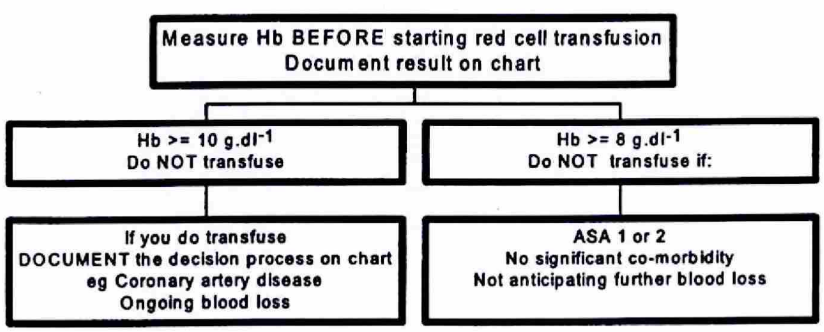

Figure 1 Guidelines for peri-operative red-cell transfusion.

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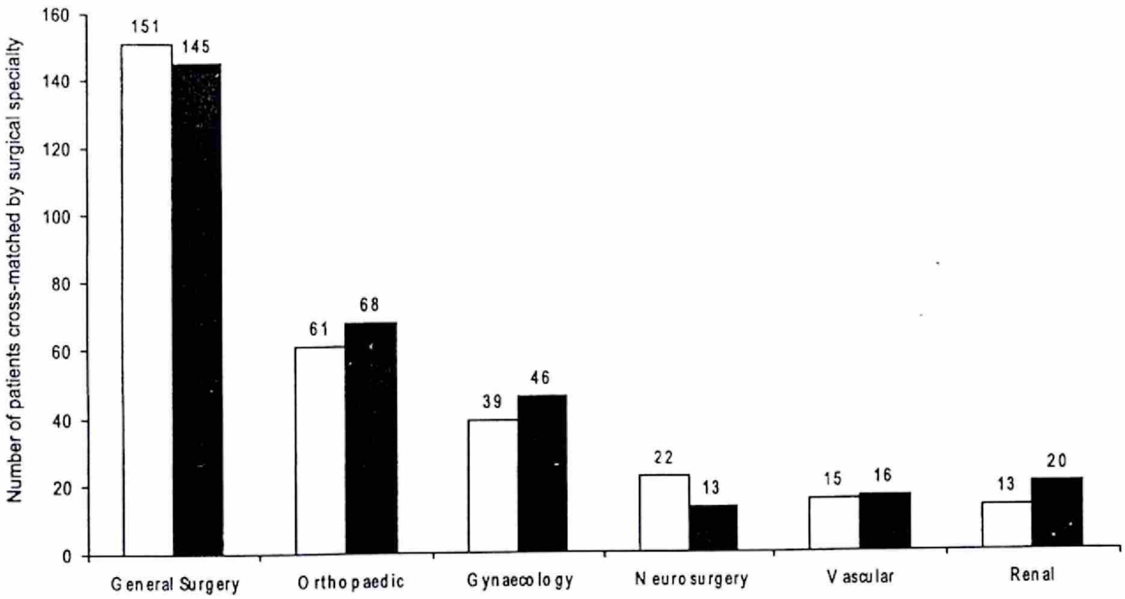

Figure 2 Number of elective surgical patients cross-matched and their surgical specialty over 3-month periods in 1996 (open) and 1998 (solid). General surgery includes gastrointestinal, colorectal, hepatobiliary and plastic surgery.

blood bank provided data on transfusion to cross-match ratios (defined as the number of units transfused in any given inpatient episode to number of cross-matches). Cross-match requests for elective surgical cases were based on the published maximum blood-ordering schedule.

Following the 1996 audit, departmental guidelines were introduced (Fig. 1). The only mandatory requirement was that the Hb concentration was measured immediately before starting a transfusion and documented on the anaesthetic chart. To facilitate patient testing, four Hemocues® (HemoCue AB, Ängelholm,

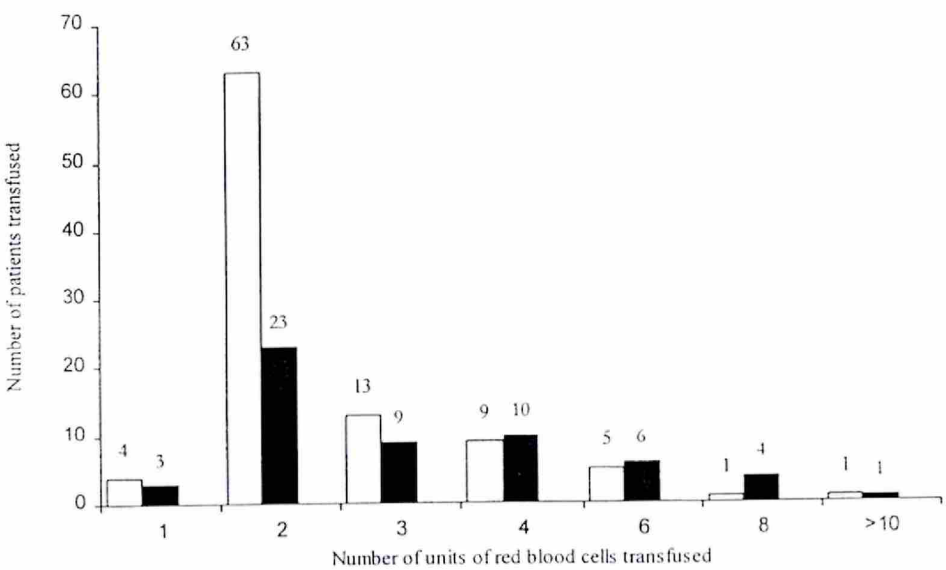

Figure 3 Number of transfusion episodes and number of units transfused during the 1996 (open) and 1998 (solid) audits.

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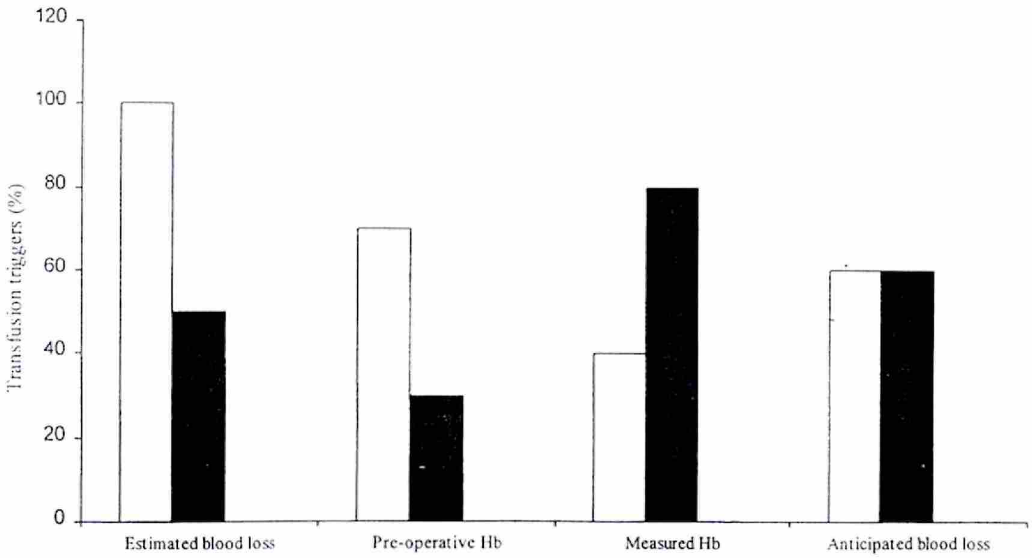

Figure 4 Detail from the survey of transfusion practice: the main transfusion triggers used by anaesthetists in determining whether to initiate a peri-operative red cell transfusion in 1996 (open) and 1998 (solid).

Sweden) were placed in the operating theatres. Advice was given on transfusion thresholds, but there was no formal policing of compliance with the guidelines. As new medical staff joined the department, guidelines were reinforced. In 1998, we repeated the audit, again over a 3-month period. We decided to specifically target 1- and 2-unit transfusions for scrutiny, as they represented the majority of transfusions and would be the group most likely to alter as a result of changes in transfusion practice. This group had the greatest potential for unnecessary transfusion. The Student's *t*-test was used for statistical analysis of data. Summary statistics are given as means and standard deviations (SD).

Results

In 1996, there were 1771 elective surgical patients during the 3-month period. Seventeen per cent of these patients had been cross-matched ($n = 301$) and a total of 96 patients (32%) received a transfusion. Two-thirds of all transfusions comprised 2 units ($n = 63$). In the second audit, there were 1783 elective surgical cases of which 308 cases were cross-matched. Surgical case mix was similar for the audits (Fig. 2).

There was a decrease in transfusions in 1998 compared with 1996, with only 18% of cross-matched patients receiving a transfusion ($n = 56$). This reduction was due almost entirely to fewer 2-unit transfusions ($n = 23$; Fig. 3). The number of three or more unit transfusions

Table 1 Patient demographics and details of intra-operative blood loss and haemoglobin balance following one and two unit red cell transfusions. All values are shown as mean (SD)

	1996 $n = 67$	1998 $n = 26$
Weight; kg	64.5 (14)	69.9 (13)
Pre-operative Hb; g.dl^{-1}	12.0 (2.27)	11.6 (1.90)
EBV; ml	4514 (1017)	4895 (995)
EBL; ml	609 (374)	1317 (644)*
Blood loss as percentage of EBV	13.5 (7.9)	27.8 (14.7)*
Estimated decrease in Hb as a result of blood loss; g.dl^{-1}	1.66 (1.04)	3.18 (1.90)*
Haemoglobin balance following surgical blood loss and blood transfusion; g.dl^{-1}	Positive +0.42 (1.3)	Negative −1.21 (1.7)*
Estimated Hb after peri-operative transfusion episode; g.dl^{-1}	12.4 (1.8)	9.9 (2.4)*

*$p < 0.01$.

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Table 2 Comparison of cross-match to transfusion ratios

Procedure	1996	1998
All surgical procedures (elective and emergency)	2.9	3.3
Craniotomy	4.8	6.0
Total hip replacement	3.4	3.4
Total knee replacement	3.4	4.8
Transurethral prostatectomy	2.8	3.3
Total abdominal hysterectomy	4.7	9.0

remained similar in both periods. Only two patients who had not been cross-matched (one in 1996 and one in 1998) received a red-cell transfusion.

One and 2-unit red-cell transfusions

Single-unit transfusions were uncommon (< 5% of all transfusion episodes in 1996 and 1998). Two-unit transfusions represented 66% of all transfusion episodes in 1996 and 41% in 1998. There was no significant difference in patient demographics in the two periods. Patients' weights, estimated blood volumes and pre-operative Hb levels are shown in Table 1. The estimated blood loss (EBL) associated with a 2-unit transfusion increased significantly from a mean of 609 (374) ml in 1996 to 1317 (644) ml in 1998 ($p < 0.01$). In 1996, there was a net increase in Hb following surgical blood loss and peri-operative transfusion of red cells, from a pre-operative value of 12.0 (2.27) $g.dl^{-1}$ to a final estimated Hb of 12.4 (1.8) $g.dl^{-1}$. In 1998, after the introduction of the transfusion guidelines, the same calculation demonstrated a net decrease in Hb from a mean pre-operative value of 11.6 (1.90) $g.dl^{-1}$ to 9.9 (2.4) $g.dl^{-1}$ ($p < 0.01$).

Survey of attitudes to transfusion

There was little change in attitude within the anaesthetic department between 1996 and 1998 concerning the Hb concentration (8–9 $g.dl^{-1}$) perceived as acceptable in a healthy adult. Also, there was no change in attitude to 1-unit transfusions, with 70% of the department indicating that they felt that a 1-unit transfusion was never justified. In both surveys, 80% indicated that 1 unit of packed red cells would increase the Hb in an average adult by ≈ 1 $g.dl^{-1}$; however, 20% incorrectly thought the Hb would increase by only 0.5 $g.dl^{-1}$. There was a much greater inclination to measure the patient's Hb before starting a red-cell transfusion in 1998 (80 vs. 40%). Also, there were clear differences in 'transfusion triggers'. In the second survey, measured Hb concentration was the primary transfusion trigger, whereas estimated blood loss was the main trigger in the first survey. Anticipated or ongoing blood loss was considered equally important in both surveys as a transfusion trigger (Fig. 4).

Table 3 Projected demand for units of blood compared to actual use

Financial year	Contract target (£)	Actually used	Difference (£)	%
1996/97	20 000	20 059	+ 59	+ 0.3%
1998/99	20 964*	18 764	– 2200	– 10.5%

*Small increase in target to accommodate expansion of existing services and new surgical developments.

Transfusion to cross-match ratios and financial data

Data from the blood bank demonstrated that transfusion in all surgical patients (elective and emergency) decreased from 1996 to 1998, with a corresponding increase in the transfusion to cross-match ratio over the 2 years (2.9–3.3). Certain surgical specialties had significant increases in the transfusion to cross-match ratio (Table 2). In 1998, the annual blood bank budget for red cells was underspent by £55,500, 10% of the budget. This was equivalent to 2200 units of red blood cells (Table 3).

Discussion

Our results demonstrate a significant change in transfusion practice, with a reduction in the total number of transfusions administered peri-operatively over the two periods studied. In 1996, 32% of cross-matched patients were transfused, giving a transfusion to cross-match ratio of 3.0. However, of those patients transfused, 63% received a 2-unit transfusion and more than half of these were transfused to a Hb that was equal to or higher than their pre-operative Hb. In the first audit, the primary trigger for initiating red-cell transfusion was an estimated blood loss > 500 ml. This threshold was fairly consistent and was not influenced significantly by either the patient's estimated blood volume or their pre-operative Hb. It would appear that without objective criteria (Hb measurement) on which to base the transfusion decision, clinicians act on the basis of clinical experience, with a natural tendency to err on the side of caution and replace all or most of the lost red cells.

The second audit took place 18 months after the guidelines had been established. There was a demonstrable reduction in the total number of red-cell transfusions (transfusion to cross-match ratio 5.5), which was due almost entirely to a reduction in 2-unit transfusions. The triggers for transfusion appeared to be more appropriate as the mean estimated Hb following transfusion was significantly lower than in 1996 (9.9 $g.dl^{-1}$). This difference may be explained in part by clinicians adopting a more cautious approach to red-cell transfusion. However, the results of the survey of transfusion practice show that there

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was little change in the perceived acceptable Hb level (8–9 g.dl^{-1}). The audited changes would appear to be related to the more frequent measurement of the patient's Hb before starting a red-cell transfusion.

However, in order to modify peri-operative transfusion practice, point of care testing is essential [19]. Acquiring laboratory results can take in excess of 60 min and so are of little value in the acute situation. The HemoCue® produces results comparable with the laboratory-based Coulter® counter provided standard operating procedures are used and quality control is monitored [20]. The availability of such equipment in operating theatres allows transfusion decisions to be based on objective criteria.

Although our guidelines require prior Hb measurement, the transfusion thresholds themselves are advisory, in order to allow flexibility to account for individual circumstances. Factors such as the surgical procedure, continuing blood loss, co-existing morbidity and physiological reserve all influence the transfusion decision [10]. The indications for transfusion should always be documented as this has been shown to improve compliance with guidelines for red-cell transfusion and reduce the number of transfusions given [21]. It is notable that single-unit transfusions accounted for < 5% of all transfusion episodes in both our audits. The survey of transfusion practice showed a consensus that if transfusion is necessary, then it is always worth giving 2 units. However, a single-unit red-cell transfusion may be adequate to achieve the target Hb. Where quality improvement programmes for red-cell transfusion are implemented, it is common to find that the use of single-unit transfusions increases significantly. One institution recently reported that single-unit transfusions now represent 77% of all transfusion episodes [22].

Transfusion to cross-match figures from the blood bank showed a less impressive reduction when compared with the data for peri-operative transfusions. Transfusion to cross-match ratios are based on transfusions for the entire inpatient episode and although the guidelines have altered practice in the operating theatre, postoperative transfusions on the wards have remained entirely at the discretion of the surgical team. Nevertheless, transfusion to cross-match ratios for many surgical procedures have increased, indicating that the use of top-up transfusions in the postoperative period is decreasing. The high transfusion to cross-match ratios have since led to a review of the maximum blood-ordering schedule with fewer units routinely cross-matched for some elective procedures.

Improving clinician awareness and education on transfusion issues is an important component of the strategies available to reduce the use of allogeneic blood [23, 24]. Autologous transfusion methods (pre-operative deposit, isovolaemic haemodilution and cell salvage) do have an important role, but they also have cost and logistic pressures and are not necessarily suitable for all types of surgery. Lowering the trigger and target Hb thresholds for red cell transfusion has a significant effect on the use of allogeneic blood without compromising patient outcome [11, 25–27]. However, our results, and also those from other centres [7, 8, 28], show that it is still fairly common practice for surgical patients to be transfused to Hb levels > 10 g.dl^{-1}. There is no evidence in patients undergoing elective surgery that this practice reduces morbidity or mortality [29, 30], or that moderate degrees of anaemia (8–10 g.dl^{-1}) are necessarily harmful as long as normovolaemia is maintained [31, 32]. Indeed, transfusion of allogeneic red cells may be independently associated with longer hospital stays, an increased incidence of postoperative infection and higher hospital costs [27, 33].

This study demonstrates that it is possible to change clinical practice through audit and the use of simple transfusion guidelines, achieving significant reductions in the amount of allogeneic blood transfused in elective surgical patients. The elimination of unnecessary red-cell transfusion has many potential advantages in terms of patient safety, provides economic benefits for the institution concerned and reduces demand for a scarce and precious resource.

References

1 Pinkerton PH, Coovadia AS, Seigel C. Audit of the use of packed red cells in association with seven common surgical procedures. *Transfusion Medicine* 1992; **2**: 231–4.

2 Goodnough LT, Johnston MF, Toy PT. The variability in transfusion practice in coronary artery bypass surgery. *Journal of the American Medical Association* 1991; **265**: 86–90.

3 Stover EP, Siegel LC, Parks R, *et al.* Variability in transfusion practice for coronary artery disease persists despite national consensus guidelines: a 24 institution study. *Anesthesiology* 1998; **88**: 327–33.

4 Baele P, DeBruyere M, Deneys V, *et al.* The SANGUIS study in Belgium: an overview of methods and results. Safe and good use of blood in surgery. *Acta Chirurgica Belgica* 1994; **94**: 69–74.

5 Hebert PC, Schweitzer I, Calder L, *et al.* Review of the clinical practice literature on allogeneic red cell transfusion. *Canadian Medical Association Journal* 1997; **156**: S9–26.

6 Salem-Schatz SR, Aworn J, Soumerai SB. Influence of clinical knowledge, organizational context, and practice style on transfusion decision making: implications for practice change strategies. *Journal of the American Medical Association* 1990; **264**: 476–83.

7 Sudhindran S. Perioperative blood transfusion: a plea for guidelines. *Annals of the Royal College of Surgeons of England* 1997; **79**: 299–302.

8 Garrioch M, Sandbach J, McIlrenney S. Current transfusion practice in three large British teaching hospitals. *British Journal of Anaesthesia* 1999; **82** (Suppl.): A266.

9 Stehling L, Luban NLC, Anderson KC, *et al.* Guidelines for blood utilization review. *Transfusion* 1994; **34**: 438–48.

NHBT0086594_003_0006

10 American Society of Anesthesiologists Task Force on Blood Component Therapy. Practice guidelines for blood component therapy. *Anesthesiology* 1996; **84**: 732–47.

11 Carson JL, Duff A, Berlin JA, *et al.* Perioperative blood transfusion and postoperative mortality. *Journal of the American Medical Association* 1998; **279**: 199–205.

12 Dodd RY. The risk of transfusion transmitted infection. *New England Journal of Medicine* 1992; **327**: 419–20.

13 Vamvakaas E, Moore SB. Perioperative blood transfusion and colorectal cancer recurrence. A qualitative statistical overview and meta-analysis. *Transfusion* 1993; **33**: 754–65.

14 Waymark JP, Yurt RW. The effect of blood transfusions on immune function. V. The effect on the inflammatory response to bacterial infection. *Journal of Surgical Research* 1990; **48**: 147–53.

15 Williamson LM, Lowe S, Love EM, *et al.* Serious hazards of transfusion (SHOT) initiative: analysis of the first two annual reports. *British Medical Journal* 1999; **19**: 16–19.

16 Goodnough LT, Soegiarso RW, Birkmeyer JD, Welch HG. Economic impact of inappropriate blood transfusions in coronary artery graft surgery. *American Journal of Medicine* 1993; **94**: 509–14.

17 Chiaavetta JA, Herst R, Freedman J, Axcell TJ, Wall AJ, van Rooy SC. A survey of red cell use in 45 hospitals in central Ontario, Canada. *Transfusion* 1996; **36**: 699–706.

18 Wiesen AR, Hospenthal DR, Byrd JC, Glass KL, Howard RS, Diehl LF. Equilibrium of haemoglobin concentration after transfusion in medical patients not actively bleeding. *Annals of Internal Medicine* 1994; **121**: 278–80.

19 Goodnough LT, Despotis GJ. Establishing practice guidelines for surgical blood management. *American Journal of Surgery* 1995; **170** (Suppl.): 16S–20S.

20 Lardi AM, Hirst C, Mortimer AJ, McCollum CN. Evaluation of the HemoCue® for measuring intra-operative haemoglobin concentrations: a comparison with the Coulter Max-M®. *Anaesthesia* 1998; **53**: 349–52.

21 Brandis K, Richards B, Ghent A, Weinstein S. A strategy to reduce red blood cell transfusion. *Medical Journal of Australia* 1994; **160**: 721–2.

22 Audet AM, Andrzejewski C, Popovosky M. Improving the appropriateness of red cell transfusions in patients undergoing orthopaedic surgery. *Evaluation and the Health Professions* 1998; **21**: 487–501.

23 Soumerai SB, Salem-Schatz S, Avorn J, Casteris CS, Ross-Deguan D, Popovosky MA. A controlled trial of educational outreach to improve transfusion practice. *Journal of the American Medical Association* 1993; **270**: 961–6.

24 Rehm JP, Otto PS, West WW, *et al.* Hospital-wide educational program decreases red blood cell transfusions. *Journal of Surgical Research* 1998; **75**: 183–6.

25 Bracey AW, Radovancevic R, Riggs SA, *et al.* Lowering the haemoglobin threshold for transfusion in coronary artery bypass procedures: effect on patient outcome. *Transfusion* 1999; **39**: 1070–7.

26 Bush RL, Pevec WC, Holcroft JWA. Prospective, randomised trial limiting perioperative red cell transfusions in vascular patients. *American Journal of Surgery* 1997; **174**: 143–8.

27 Hebert PC, Wells G, Blajchman MA, *et al.* A Multicentre, randomised, controlled clinical trial of transfusion requirements in critical care. *New England Journal of Medicine* 1999; **340**: 409–17.

28 Joshi G, McCarroll M, O'Rourke P, Coffey F. Role of quality assessment in improving red blood cell transfusion practice. *Irish Journal of Medical Science* 1997; **166**: 16–19.

29 Kim DA, Brecher ME, Estes TJ, Morrey BF. Relationship of haemoglobin and duration of hospitalization after total hip arthroplasty: implications for the transfusion target. *Mayo Clinic Proceedings* 1993; **68**: 37–41.

30 Jonsson K, Jensen JA, Goodson WH, Scheuenstuhl H, West J, Hopf HW. Tissue oxygenation, anaemia and perfusion in relation to wound healing in surgical patients. *Annals of Surgery* 1991; **214**: 605–13.

31 Viele MK, Weiskopf RB. What can we learn about the need for transfusion from patients that refuse blood?: the experience of Jehovah's Witnesses. *Transfusion* 1994; **34**: 396–401.

32 Kitchens CS. Are transfusions overrated? Surgical outcome of Jehovah's Witnesses. *American Journal of Medicine* 1993; **94**: 117–19.

33 Vamvakas EC, Carven JH. Allogeneic blood transfusion, hospital charges, and length of hospitalization: a study of 487 consecutive patients undergoing colorectal cancer resection. *Archives of Pathology and Laboratory Medicine* 1998; **122**: 145–51.