

Preoperative Prediction of Intra and Postoperative Red Blood Cell Transfusion in Surgical Patients

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Abstract

Anaesthetists were asked to predict the need for intra and postoperative red blood cell transfusion in 1706 patients before surgery. Each prediction was made using only the individual patient's medical history and physical examination, the results of routine preoperative laboratory investigations, and knowledge of the proposed surgical procedure. Only 159 patients (9.3%) received red blood cell transfusion. The sensitivity and specificity of this preoperative prediction were 85.5% and 96.6% respectively, whereas the positive and negative predictive values were 72.3% and 98.5% respectively. Using a stepwise logistic regression model, preoperative haemoglobin concentration, Surgical Table of the procedure, and age of patients were found to significantly determine the need for intra and postoperative red blood cell transfusion. It is recommended that type and screen should replace group and crossmatch procedures in surgical patients where no intra and postoperative red blood cell transfusion is predicted as necessary.

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Key words: Age, Anaesthetists, Preoperative haemoglobin concentration, Surgical Table

Introduction

Accurate preoperative prediction of the individual patient's needs for intra and postoperative red blood cell transfusion is an important aspect of patient care. Since red blood cell transfusion is associated with a small but definite risk of morbidity,¹ accurate preoperative prediction will allow anaesthetists and surgeons to improve the informed consent, better assess the risk-benefit ratio of the proposed surgical procedure, and choose a more appropriate intraoperative surgical, anaesthetic or monitoring technique. Accurate prediction also allows advanced preparation and prevents hold-up of blood products at the blood banks. Since about two-thirds of all red blood cell transfusions are given in the perioperative period,² and anaesthetists are involved in more than half of such transfusions,³ we conducted this study among anaesthetists in the Singapore General Hospital (SGH). Our objective was to determine how accurately anaesthetists could predict individual patient's need for intra and postoperative red blood cell transfusion; using only the patient's medical history and physical examination, the results of routine preoperative laboratory investigations (e.g. full blood count, prothrombin time and partial thromboplastin time, serum urea, electrolytes and creatinine, chest X-ray, resting 12-lead electrocardiogram, and liver function

tests) when available, and knowledge of the proposed surgical procedure.

Materials and Methods

This study was approved by the administrative authority of the SGH, and supported by the Department of Anaesthesia and Surgical Intensive Care. It was conducted over 5 weeks in major operating theatres (OTs) of the SGH between February and March 1995. There was no change in the perioperative management of the patients during the study period. To avoid bias, all predicting anaesthetists were kept ignorant of the nature of the study during the entire 5-week period, and the names of the predicting anaesthetists were not revealed. The seniority of the predicting anaesthetists was however documented. Medical officers and anaesthetic trainees were considered as junior anaesthetic staff; while registrars, senior registrars and consultants were considered as senior anaesthetic staff. The patient's age, sex, and American Society of Anesthesiologists (ASA) classification of physical status (Table I)⁴ were recorded. Patients belonging to ASA 3 or more were considered as suffering from major medical illnesses, and patients who were older than 60 years were considered as elderly patients. The nature of the surgery (elective or emergency), duration of surgery, and Surgical Table of the

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TABLE 1: THE AMERICAN SOCIETY OF ANESTHESIOLOGISTS (ASA) CLASSIFICATION OF PHYSICAL STATUS⁴

1	A normal healthy patient.
2	A patient with a mild systemic disease.
3	A patient with a severe systemic disease that limits activity, but is not incapacitating.
4	A patient with an incapacitating systemic disease that is a constant threat to life.
5	A moribund patient not expected to survive 24 hours with or without operation.
E	In the event of emergency operation, precede the number with an E.

procedure (i.e. classification according to the complexity of the procedure) were also recorded, with the latter following the Ministry of Health's Surgical Operation Fee Tables.⁵ Operations belonging to Surgical Table 5 or more (e.g. total knee replacement, laminectomy/fenestration with discectomy, partial or subtotal gastrectomy, cholecystectomy with exploration of the common bile duct, hemicolectomy, and transurethral resection of >30 g of prostate gland) were considered major surgical procedures in our study. The above data were recorded by anaesthetic staff nurses in the OTs.

All consecutive patients undergoing surgical operations in the major OTs were admitted into the study except the following:

- 1) Patients not under the care of anaesthetists in the major OTs during surgery (i.e. patients who underwent surgery under local anaesthesia administered by the surgeons).
- 2) Patients undergoing open heart surgery, repeated surgery, or who suffered from major multiple trauma with one or more episodes of hypotension, because intra and postoperative red blood cell transfusion is usually necessary in these groups of patients.
- 3) Patients scheduled for eye surgery because intra and postoperative red blood cell transfusion is hardly ever necessary in these patients.
- 4) Paediatric (<12 years old) patients.
- 5) Patients who died within 72 hours postoperatively.
- 6) Patients receiving red blood cell transfusion due to a disease not directly related to the proposed surgery (e.g. red blood cell transfusion for bleeding from the upper gastrointestinal tract in patients who had undergone orthopaedic surgery).

Each patient selected was first assessed by his or her anaesthetist who would then predict the patient's need for intra and postoperative (up to 72 hours) red blood cell transfusion. Seventy-two hours was chosen because all grouped and matched blood products were reserved for the respective patients for 24 to 48 hours after surgery, and the risk of primary and reactionary surgical haemorrhage decreased significantly after 48 hours.⁶ In order to simulate our day-to-day clinical practice, preoperative prediction of red blood cell transfusion was based on each individual patient's history and

physical examination, the results of routine preoperative laboratory investigations, and knowledge of the proposed surgical procedure. One of the investigators (OAH) followed up each patient's clinical course to determine whether red blood cell transfusion was given at the end of the 72-hour period. No attempt was made to determine the amount of intraoperative blood loss nor the amount of homologous red blood cell transfused intra and postoperatively. The decision to transfuse red blood cell was made at the discretion of the clinicians (anaesthetist or surgeon) looking after the patient, with the main objective being to achieve optimal oxygen delivery.⁷ Since non-haemoglobin factors are also important determinants of perioperative red blood cell transfusion,* we considered specifying the minimum haemoglobin (Hb) concentration level for red blood cell transfusion in all surgical patients as inappropriate.

Definitions

In this study, red blood cell transfusion was defined as an intravenous infusion of packed red blood cells or whole blood. Sensitivity was defined as the percentage of patients predicted to require and were given red blood cell transfusion, out of the total number of patients who received red blood cell transfusion. Specificity was defined as the percentage of patients predicted not to require and were not given red blood cell transfusion, out of the total number of patients who did not receive red blood cell transfusion. Positive predictive value was defined as the percentage of patients predicted to require and were given red blood cell transfusion, out of the total number of patients predicted to require red blood cell transfusion. Negative predictive value was defined as the percentage of patients predicted not to require and were not given red blood cell transfusion, out of the total number of patients predicted not to require red blood cell transfusion.

Statistical Analysis

All statistical analyses were accomplished using SPSS statistical data analysis software (SPSS Inc, Chicago, IL). t-tests and chi-square tests were applied where appropriate. All values were expressed as mean $\pm$ standard deviation (SD) and percentage (%). Pearson and Spearman correlation coefficients (r) were used to study linear correlations among the variables where appropriate. We used stepwise logistic regression to determine the factors that might significantly increase the need for red blood cell transfusion. A P value of less than 0.05 was considered as statistically significant.

Results

Patient Characteristics

One thousand seven hundred and six consecutive cases from 11 surgical disciplines of SGH were entered

into the study. The mean age of the study population was 45 ± 16 years, with a slight female preponderance (936 or 55% females). Eighty per cent of patients (1369) underwent elective surgery. Ninety-two per cent (1572) belonged to ASA classes 1 or 2 (i.e. no major medical illnesses), and 85% (1444) had surgery lasting less than 120 minutes. Seventy-six per cent (1297) of the operations belonged to Surgical Table 4 or less (Fig. 1). The mean preoperative Hb concentration was 12.7 ± 1.9 g/dl. Only 9.3% (159) of the study population received intra and postoperative red blood cell transfusion. When red blood cell transfusion was required, 86% (137) was transfused in the OT and 13% (21) in the surgical wards. One patient received red blood cell transfusion in both the OT and ward. Compared to those who received no transfusion

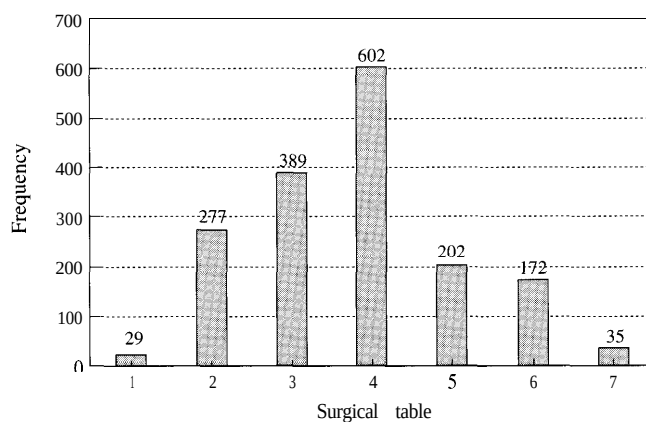


Fig. 1. Distribution of patient population ($n = 1706$) according to Surgical Tables.

TABLEII: CHARACTERISTICS OF PATIENTS WITH AND WITHOUT INTRA AND POSTOPERATIVE RED BLOOD CELL TRANSFUSION

Risk Factor	Patients with red blood cell blood transfusion ($n = 159$)	Patients without red blood cell transfusion ($n = 1547$)	<i>P</i> values
Preoperative Hb (g/dl)	10.4 ± 2.1	12.9 ± 1.7	$P < 0.001$
Age	52.1 ± 18.4	44.6 ± 16.5	$P < 0.001$
Surgical Tables (%)			
≤4	4.0	96.0	$P < 0.001$
≥5	26.2	73.8	
Duration of surgery (min)	164 ± 114	73 ± 60	$P < 0.001$
Sex (%)			
Male	7.2	92.8	$P < 0.01$
Female	11.1	88.9	
ASA (%)			
≤2	7.5	92.5	$P < 0.001$
≥3	31.1	68.9	
Nature of surgery (%)			
Emergency	9.8	90.2	NS
Elective	9.2	90.8	

NS: not significant; Hb: haemoglobin

(Table II), patients who received red blood cell transfusion were significantly older, and had significantly lower preoperative haemoglobin (Hb) concentration. They also underwent significantly more complex and longer surgical procedures. In addition, a significantly greater proportion of female patients and patients suffering from major medical illnesses received red blood cell transfusion.

Multivariate Risk Factor Analysis

In our study, preoperative Hb concentration, Surgical Table, age and sex of the patient, nature of surgery, and ASA classification of physical status were the 6 important variables that might determine the need for intra and postoperative red blood cell transfusion. There were weak linear correlations between age and ASA ($r = 0.46$), and ASA and preoperative Hb concentration ($r = -0.27$). We included these 6 variables into a stepwise logistic regression model. Only 3 factors (preoperative Hb concentration, Surgical Table and age) were found to significantly determine the need for intra and postoperative red blood cell transfusion (Table III).

The Anaesthetists

Sixty-eight per cent of the predictions (1157) were made by junior anaesthetic staff. Table IV shows the sensitivity, specificity, positive and negative predictive values of the preoperative prediction by the anaesthetists. The overall sensitivity and specificity were 85.5% and 96.6% respectively, while the overall positive and negative predictive values were 72.3% and 98.5% respectively. Numerically, senior anaesthetists had a slightly better positive predictive value.

Discussion

Accurate preoperative prediction of the individual patient's need for intra and postoperative red blood cell transfusion not only improves patient care, but it also allows advanced preparation and prevents hold-up of blood products at the blood banks. In our study, each preoperative prediction of red blood cell transfusion was made only with the patient's medical history and physical examination, the results of his or her routine

TABLEIII: MULTIVARIATE RELATIONSHIP BETWEEN RED BLOOD CELL TRANSFUSION AND THE CLINICAL FACTORS ($n = 1660$, 46 cases were rejected because of missing data)

Factor	Odd ratio	<i>P</i> values	95% Confidence interval
Preoperative haemoglobin (g/dl)	0.43	< 0.001	0.375, 0.489
Surgical Tables (14 or 25)	4.9	< 0.001	3.065, 7.941
Age	1.02	< 0.05	1.003, 1.028

TABLE IV: THE SENSITIVITY, SPECIFICITY, POSITIVE AND NEGATIVE PREDICTIVE VALUES OF SENIOR AND JUNIOR ANAESTHETISTS

	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
Senior anaesthetists (n = 549)	90.8	94.7	73.4	98.5
Junior anaesthetists (n = 1157)	80.7	97.5	71.3	98.5
Overall results (n = 1706)	85.5	96.6	72.3	98.5

preoperative laboratory tests, and knowledge of the proposed surgical procedure to simulate our day-to-day practice. To the best of our knowledge, there has not been a similar reported study. Our study showed that while the positive predictive value was 72.3%, the negative predictive value was 98.5% (i.e. for those who were predicted not to require intra and postoperative red blood cell transfusion, only 1.5% actually received red blood cell transfusion). Our results also demonstrated that anaesthetists in SGH could achieve very accurate negative predictive value.

We observed that preoperative red blood cell transfusion requests in SGH were often in great excess of the number of units of red blood cell actually transfused during both elective and emergency surgical procedures. One reason is the belief that preoperative red blood cell transfusion requests should be large enough even to cover the very unlikely eventuality of haemorrhage.⁸ The idea is to prepare matched red blood cell units for patients undergoing surgery to avoid medico-legal complications, resulting in the 1994 average crossmatch-transfusion ratio of 3.3:1 in the government hospitals and 2.1: 1 in the government-restructured hospitals.⁹ Such excessive blood requests have led to an increased workload to the OT staff and the transfusion laboratory technicians, a higher percentage of out-dated unused blood units, and straining the ever limited blood supply in the blood banks.¹⁰ Ong et al⁸ suggested that type and screen procedures were suitable for operative procedures listed under the Surgical Table 2 and below. Our results, however, suggest that type and screen should replace group and crossmatch for surgical cases predicted not to require intra and postoperative red blood cell transfusion, even if the surgical procedures belong to the Surgical Table 3 and above. Based on the results of these 2 studies, it is reasonable to suggest a review of the maximum surgical blood orders by the hospital blood transfusion committee to maximize blood usage and avoid wastage.

While there are many other possible known (e.g. seniority of surgeon and duration of surgery) or unknown

factors that might influence the need for intra and post-operative red blood cell transfusion, we included only 6 common predictive variables for multivariate risk factor analysis. Our results suggest that preoperative Hb concentration, Surgical Table of the procedure, and age are important predictive variables that significantly determine the need for intra and postoperative red blood cell transfusion in surgical patients, whereas ASA physical status, sex and the emergent or elective nature of the surgery did not. The seniority of the surgeon was not included because team approach to a surgical case in the operating room was unavoidable in a teaching institution like the SGH. Duration of surgery was also not included because it was not a preoperative predictive variable. Not surprisingly, preoperative Hb concentration was significant because it represented the oxygen carrying capacity of the patient's blood. It was also the single most commonly used indicator for red blood cell transfusion.^{2,7,11} Complicated surgical procedures were represented by higher Surgical Tables with longer duration of surgery, resulting in a higher chance of intra and postoperative red blood cell transfusion. The threshold for intra and postoperative red blood cell transfusion was lower in elderly patients (>60 years) and medically-compromised patients.⁷ Such non-haemoglobin considerations were probably the reasons resulting in age being a significant factor affecting the need for intra and postoperative red blood cell transfusion. In contrast, we were unable to demonstrate that ASA physical status was a significant factor. This is probably because it is a non-specific indicator of physical health and physiologic reserve.

There are two limitations in this study. Firstly, we did not specify the Hb concentration below which red blood cell transfusion should be given. Because of serious complications which may be associated with red blood cell transfusion, 'non-haemoglobin factors have become more important determinants of red blood cell transfusion than before.'^{2,7} There is no absolute level of Hb above which increased patient safety can be demonstrated or below which the risks of anaesthesia and surgery are increased." A previous survey demonstrated wide variations in transfusion practices among anaesthetists, such practices being based on habit rather than scientific data.¹² Therefore, we consider specifying the minimum Hb level for red blood cell transfusion in all surgical patients as inappropriate. Secondly, the predicting anaesthetists might be biased. While as far as possible, the anaesthetists under survey were not told of the nature or purpose of the study, they might however attempt self-fulfillment of their own prophecies. Although we consider such a practice a possibility, the fact that only 22 patients were given red blood cell transfusion in the surgical wards indicates that this practice would not have significantly affected the negative predictive value.

In the major OTs of the SGH, we routinely use an intravenous administration set with a 200 µm filter (Sangofix® Air, B Braun, Mel Sungen AG, W Germany) for every patient receiving perioperative intravenous fluid. The main function of the filter is to remove clot and debris present in stored bank blood. Since our results show that only 1.5% of surgical patients predicted not to require intra and postoperative red blood cell transfusion actually received red blood cell transfusion, the routine use of such intravenous administration sets with filters for perioperative intravenous fluid administration in patients predicted not to require intra and postoperative red blood cell transfusion is not necessary. Rather, intravenous administration sets without filters should be used routinely, and those with filters only when blood transfusion is anticipated. If we extrapolate our results to all the government hospitals, government-restructured hospitals, and all the ambulatory surgical OTs, we may anticipate substantial cost saving although only detailed analysis of the cost-benefit ratio of such a change in policy can provide a definitive answer.

In conclusion, the anaesthetists in the SGH were able to achieve very good (98.5%) negative predictive value of intra and postoperative red blood cell transfusion. Such preoperative predictions were made using only the patient's medical history and physical examination, the results of routine preoperative laboratory investigations, and knowledge of the proposed surgical procedure.

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