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Preoperative cross-matching in major head and neck surgery: a study of a department's current practice and eligibility for electronic cross-matching*

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Objective. The maximum surgical blood ordering schedule (MSBOS) has reduced but not eliminated the over-ordering and wastage of blood products. Electronic cross-matching (ECM) may be a suitable alternative method to provide blood on demand in eligible cases. The purpose of this study was to assess the department's current blood ordering policy and to identify patients eligible for ECM.
Study Design. This was a retrospective observational study of 88 consecutive maxillofacial surgical oncology patients.
Results. A total of 383 units of blood were cross-matched, of which 43% were not transfused. Of these, 38% were reallocated and 5% discarded. Of all cross-matched blood, 82% was eligible for ECM; 18% was not eligible, 6% because of the presence of antibodies and 12% because of lack of a second historical sample.
Conclusions. ECM is recommended as a safe method for elective surgery. Blood can be provided on demand, reducing workload and costs for transfusion services and minimizing wastage. (Oral Surg Oral Med Oral Pathol Oral Radiol 2013;116:534-539)

BLOOD SUPPLY CONSIDERATIONS

Blood donation is voluntary in the United Kingdom, with only 4% of the eligible population donating blood regularly.[1] Blood transfusion services are challenged to maintain a fine balance between the supply of this limited resource and an increasing demand. Wastage of blood products due to nonutilization and expiration is not only expensive but also can produce shortages in stock levels at times of peak need.[2]

The maximum surgical blood order schedule (MSBOS) was designed to aid control of blood bank inventory stock by improving the efficiency of ordering blood for use in elective surgery.[3,4] The MSBOS is a table of elective surgical procedures that provides the recommended number of units of blood to be cross-matched.[5] The figures are derived from local analyses of the amount of blood transfused during individual surgical procedures. It aims for blood to be ordered and reserved for patients scheduled for surgical procedures according to a locally-agreed tariff of expected blood usage.[5] This practice has helped to decrease, but unfortunately has not eliminated, unnecessary preoperative cross-matching resulting in over-ordering of blood.[6]

The British Committee for Standards in Haematology (BCSH) has produced guidelines for pretransfusion compatibility testing to ensure quality and safety in blood transfusion.[7,8] Compatibility testing involves 4 stages: a review of the patient's transfusion history, ABO and Rh grouping, antibody screening, and the cross-match itself.[9,10] The degree of importance of each stage for determining compatibility has changed over the last decade, with a shift in focus from the serologic cross-match to the antibody screen.[9,10]

Cross-matching methods available

Full cross-matching involves a number of techniques to exclude incompatibility between recipient and donor.

Statement of Clinical Relevance

Electronic cross-matching could be used as a method to provide blood within minutes of request and to avoid unnecessary preoperative cross-matching in eligible cases, thus reducing work and costs for transfusion services and minimizing wastage from expiration of blood products.

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These include an indirect antiglobulin test, where the patient's serum is incubated with red cells from the donor unit intended for transfusion. The indirect antiglobulin test takes approximately 20 to 30 minutes and in the past was required for every unit of donor blood to be transfused.[11] Blood units that are conventionally cross-matched by this method preoperatively are allocated and reserved solely for the patient and cannot be accessed for use in other patients until the postoperative period, by which time units are less fresh and may have expired.

In recent years it has been shown that patients with a negative antibody screen and no historical record of cell antibodies do not require the full conventional cross-match test.[12] Instead, a group-and-save technique (G&S, type and screen) can be used, and this has been widely adopted for surgical procedures for which the MSBOS shows that blood is rarely transfused.[12] The G&S includes blood grouping, an antibody screen, and saving. If the antibody screen is positive, then a full cross-match is required; however, if the antibody screen is negative, the antiglobulin phase of the cross-match can be omitted.[10,12] These patients can safely have any ABO- and Rh-compatible blood "off the shelf" if transfusion is required, with the compatibility of the donor unit confirmed rapidly on demand by an abbreviated cross-match test.[9]

There are 2 methods for abbreviated cross-match testing: the immediate spin cross-match (ISCM) and the electronic cross-match (ECM, also known as computer CM).

ISCM detects major ABO incompatibility between donor and recipient by incubation of patient serum and donor red cells for 5 minutes at room temperature. ABO compatibility is indicated by the absence of agglutination. ISCM makes blood available to patients faster and is more cost-effective than the conventional cross-match technique, but it does not always detect ABO incompatibility, and there is no standardized procedure for its use.[8-10,13]

ECM is an alternative abbreviated cross-match performed by computer verification of ABO/Rh compatibility of donor and recipient without any serologic testing.[8-10,13] Using a validated computer system and bar code readers, a program analyzes the ABO of the patient, confirming the results of a current sample versus historical results.[8,9] The selected donor unit's individual bar code is scanned, and if compatibility is verified, a label will be printed, allowing assignment to the patient. ECM also enables the potential for remote issue of blood release outside the laboratory, which can further shorten the turnaround. One example of this is in a center in Hong Kong that established a self-service electronic issue system with operating room refrigerators performing as vending machines to increase the turnaround time.[14]

Requirements of the ECM include: (1) two corresponding results of the patient's ABO/Rh status must be on record, one from the current sample and the other from a historical sample; (2) no clinically significant antibodies can be detected in the patient's serum, either from the current sample or historically; (3) the computer system and all critical elements of the ECM, such as bar code readers, must be validated on-site; (4) procedures must be in place to verify that the data entered are correct before the release of blood units; and (5) the system must prevent the release or assignment of ABO-incompatible blood. [9,10,13,15]

The disadvantages of ECM include its failure to detect weak antibodies and the need for extensive computer validation, employee training, and competency testing. Potential and unexpected computer downtime is also a risk, and thus a manual backup contingency system is critical.[10] In addition to its rapid turnaround time, ECM's advantages include reduced laboratory workload, lower reagent costs, more reliability in detection of ABO-incompatible units, improved quality control, and reduced expiration and wastage of blood units.[9]

ECM is currently used in the United Kingdom, Ireland, France, Denmark, Italy, Sweden, North America, Hong Kong, Japan, New Zealand, and Australia.[16] There are 2 sets of guidelines published for ECM, one from the American Association of Blood Banks and the other from the Blood Transfusion Task Force of the BCSH, which are used in their respective countries of origin.[9,10,15] The BCSH guidelines, in contrast to those of the American Association of Blood Banks, do not require the ABO of the donor blood to be serologically confirmed once it has been labeled, instead accepting the guarantee of its accuracy from the blood supplier. The BCSH guidelines also require that historical results are not displayed on screen if current test results are entered manually.[15]

Objectives of previous studies and the present study

Previous studies have investigated models for predicting transfusion requirements in their respective surgical disciplines.[17-20] These studies have looked at individual patient variables to estimate more accurately a patient's transfusion requirements, but they have only provided a guide to blood ordering, failing to indicate how more blood could be ordered quickly and efficiently if there were a need for further transfusions to cover unexpected extensive tumor spread or intraoperative or postoperative complications.[18,21-23]

The main aim of this study was to supplement previous research and propose ECM as a method to ensure rapid and effective ordering of blood, which will, at the same time, help reduce any over-ordering and wastage of nonutilized blood. This study was

undertaken to compare the number of units of blood cross-matched to the actual numbers transfused during elective maxillofacial oncology surgery. It set out to assess whether it was possible to reduce the number of units of blood unnecessarily cross-matched and to determine the safety and practicality of replacing the preoperative cross-match with a G&S-only policy for all head and neck cancer surgery patients.

MATERIALS AND METHODS

This retrospective study was undertaken at the University Hospital of Wales, Cardiff. Before its start, agreement was obtained from the hospital's Clinical Governance Department. The study included all patients who received elective maxillofacial oncology surgery at the University Hospital of Wales over a 12-month period. Data were collected from the patients' medical records and anesthetic charts and from the hematology and blood transfusion laboratory computer database. Any patients who required emergency surgery or received transfusion preoperatively were excluded.

Computerized data were recorded relating to age; gender; pre- and postoperative hemoglobin concentrations; pre- and postoperative blood requirements, including those cross-matched, transfused, and returned to the blood bank; and type of surgery. The database was checked for accuracy by different observers and has been successfully used in previous studies.[22,23]

All patients had postoperative blood checks. The hemoglobin threshold for transfusion for these patients was set at 80 g/L according to a locally agreed protocol.

Blood utilization in elective operative procedures can be evaluated using various indices, such as the cross-match to transfusion ratio (C:T) and the transfusion index (TI).[5]

These indices were calculated using the following formulas:

$$\text{C : T ratio} = \frac{\text{No. of units cross-matched}}{\text{No. of units transfused}}$$

$$\text{TI} = \frac{\text{No. of units transfused}}{\text{No. of patients cross-matched}}$$

RESULTS

A total of 88 consecutive maxillofacial oncology patients who underwent major surgery (52 male and 36 female patients) were investigated. All data values were available and complete for all patients. The surgical procedures included neck dissection (n = 7); excision of tumor and neck dissection (n = 13); excision of tumor, neck dissection, and free flap (n = 49); and excision of tumor, neck dissection, and pedicle flap (n = 19). The two procedures involving flap reconstruction required composite resection (commando procedure) to achieve clear surgical margins (n = 68).

The mean preoperative hemoglobin level was 129 g/L; levels for both male and female patients were within the normal range. The mean 48-hour postoperative hemoglobin level was 97 g/L (range, 60-148 g/L).

Blood transfusion was required for 57 patients intraoperatively to replace blood lost to hemorrhage. A total of 16 patients were transfused postoperatively with a mean hemoglobin level of 70 g/L (range, 60-77 g/L), below the locally agreed hemoglobin threshold for transfusion of 80 g/L. Of these patients, 9 were transfused 1 day postoperatively, 6 were transfused 2 days postoperatively, and one was transfused 3 days postoperatively.

Table I shows the surgical procedures undertaken, the number of units of preoperative cross-matched blood, the number of patients transfused, the number of units transfused, the C:T ratio, and the TI. Ideally the C:T ratio would be 1.0; any higher value means that more blood is being cross-matched than is being used.[5] It has been suggested that a C:T ratio up to 2.5 is more practical.[24,25] A C:T ratio over 2.5 would suggest that under 40% of cross-matched blood is being transfused, an indication that blood is being cross-matched excessively.[24-26]

The TI reveals the average number of units cross-matched per procedure. A TI of 0.5 or greater suggests efficient usage of blood.[25,27,28] The need for transfusion for each procedure can be inferred from the TI; the higher the value, the more blood transfused per procedure, and therefore the higher the perceived need for transfusion. If the TI value is less than 0.5, it suggests that cross-matching blood is unnecessary and a G&S policy should be adopted instead.[25]

The C:T ratio for patients undergoing excision of tumor, neck dissection, and free flap is 2.6, indicating over-ordering of blood for this procedure. The TI value is 2.0, however, which confirms blood is required for the procedure. The C:T ratios for the neck dissection alone; excision of tumor and neck dissection; and excision of tumor, neck dissection, and pedicle flap are all less than 2.5, suggesting that the correct amount of blood was being ordered. This is supported by the TI values for the 3 surgical procedures, which are 1.9, 4.2, and 2.9, respectively, suggesting efficient usage of blood. The excision of tumor and neck dissection procedure has the highest TI value, indicating the highest need for transfusion.

Out of all the cross-matched blood, the eligibility for ECM was as follows:

- 82% of units were potentially eligible for ECM
- 6% had a positive antibody screen and hence were not eligible for ECM
- 12% were not eligible as they had only one sample taken despite having a negative antibody screen (no second historical sample was available)

Table I. Head and neck surgical procedures and blood transfusion requirements

Surgical procedure	*Number of procedures/ patients cross-matched (n = 88)*	*Units of blood cross-matched (range per patient)*	*Number of patients transfused*	*Units of blood transfused*	*C:T ratio*	*TI*
Neck dissection	7	15 (2-4)	6	13	1.2	1.9
Excision of tumor and neck dissection	13	59 (2-6)	11	54	1.1	4.2
Excision of tumor, neck dissection, and free flap	49	245 (2-6)	37	96	2.6	2.0
Excision of tumor, neck dissection, and pedicle flap	19	64 (2-6)	19	55	1.2	2.9
Total	88	383	73	218	1.8	2.5

C:T ratio, cross-match to transfusion ratio; *TI*, transfusion index.

The number of units of blood requested and cross-matched in 12 months for the 88 patients totalled 383 units. The total amount of cross-matched units for each blood component requested over the 12-month period is demonstrated in Table II.

The total number of units transfused was 57% (n = 218). The remaining 43% (n = 165) were not transfused. Of these, 38% (n = 147) were reallocated and 5% (n = 18) were discarded due to expiration.

The cost of each of the blood components per unit, at the time of this study, was as follows:

Red blood cells (RBCs): £151.86
Fresh frozen plasma (FFP): £39.16
Platelets: £251.46
Cryoprecipitate: £219.66

From this information, we calculated the total cost of the expired blood products. Wasted FFP totaled £156.64; wasted RBCs, £2126.04. This illustrates the financial implication of blood wastage and reinforces the usefulness of ECM to order blood on demand.

DISCUSSION

Any procedure that can significantly reduce blood wastage and cost has clear benefits for the patient, the trust, and blood banks. There are many studies that suggest the potential for safe and cost-effective blood ordering by adopting the G&S method in place of the routine cross-match if the C:T and TI indices indicate cross-matched blood is not being transfused.[6,24,25,28-30] However, no studies have reported on the proposed effectiveness of ECM in head and neck surgery.

The results of this study show that the practice over-ordered cross-matched blood for the excision of tumor with neck dissection and free flap procedure. The neck dissection alone, excision of tumor and neck dissection, and excision of tumor with neck dissection and pedicle flap procedures all had TI figures greater than 0.5 and C:T ratios less than 2.5, indicating that blood transfusion was required and the correct amount of blood was ordered in all 4 procedures.

Table II. The total amount of blood requested, transfused, reallocated, and discarded, in units

	RBCs	*FFP*	*Platelets*	*Cryoprecipitate*	*Total (%)*
Requested	353	25	3	2	383
Transfused	192	21	3	2	218 (57)
Reallocated	147	0	0	0	147 (38)
Discarded	14	4	0	0	18 (5)

RBCs, red blood cells; *FFP*, fresh frozen plasma.

These results contradict results published by Fordyce et al. in 1998,[28] which showed that for neck dissection alone their C:T ratio was very high at 12.5 and their TI score low at 0.21; therefore, those authors advised a G&S policy for this procedure. This divergence in results highlights that the MSBOS is a local tariff and results are not transferrable to other units.[31]

The use of autologous blood and erythropoietin preoperatively has been suggested by a number of authors as another alternative to reduce wastage.[18,20,23,31] This has the benefit of a potential reduction in the risk of transmission of blood-borne viruses. Interest in these methods has been heightened in light of conflicting reports that allogeneic blood transfusions may increase cancer recurrence and postoperative infection due to immunomodulation.[34] Despite the benefit of avoiding allogeneic blood, autologous transfusions may not be suitable for use in maxillofacial oncology patients due to the short time between the diagnosis and surgery, and the expense of recombinant erythropoietin makes its use for every patient impractical.[20]

Although the C:T and TI indices in the current study are in line with the continued use of conventional cross-match, the present study has shown that 43% of blood cross-matched and reserved was not actually transfused and 38% of the cross-matched blood was reallocated. Reallocation of blood compromises its freshness for transfusion. The effect of the duration of storage of blood on morbidity has been debated, with evidence presented on both sides.[32] A large-scale clinical trial is currently being performed in the United States to assess the effect of the age of red cells on clinical outcomes

and should provide more information on whether the duration of storage of blood affects treatment success.[33] More pressing is the fact that of all the cross-matched blood, 5% was discarded due to expiration. Avoiding this wastage would have lessened the chances of canceled surgical procedures due to shortages of blood.[28]

To save blood and make better use of it, our results suggest that ECM could be adopted in place of the conventional cross-match with a preoperative G&S policy for all patients. As blood was required for all 4 procedures in this study, the minimal amount of blood required based on a local MSBOS could be ordered using ECM in-theater at the start of the procedure. Further blood could then be ordered on demand when required. This protocol would have worked for the patients screened in the current study, given that 82% were eligible for ECM. Our results thus support the conclusion of Walsh et al.,[35] who reported that readily available hospital transfusion support could eliminate the need for preoperative conventional cross-matching. However, there remains a need for further study of the effect of ECM on blood conservation that compares blood utilization, costs, and wastage before and after ECM implementation.

CONCLUSION

This study has proposed that ECM for head and neck surgical procedures could aid the reduction of blood wastage and procedural costs. The authors recommend the introduction of ECM for ordering blood for patients undergoing elective major head and neck surgery, because it is shown to be a safe and practical method for verifying the compatibility of blood on demand.

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