Optimizing Preoperative Blood Ordering with Data Acquired from an Anesthesia Information Management System

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ABSTRACT

Background: The maximum surgical blood order schedule (MSBOS) is used to determine preoperative blood orders for specific surgical procedures. Because the list was developed in the late 1970s, many new surgical procedures have been introduced and others improved upon, making the original MSBOS obsolete. The authors describe methods to create an updated, institution-specific MSBOS to guide preoperative blood ordering.

Methods: Blood utilization data for 53,526 patients undergoing 1,632 different surgical procedures were gathered from an anesthesia information management system. A novel algorithm based on previously defined criteria was used to create an MSBOS for each surgical specialty. The economic implications were calculated based on the number of blood orders placed, but not indicated, according to the MSBOS.

Results: Among 27,825 surgical cases that did not require preoperative blood orders as determined by the MSBOS, 9,099 (32.7%) had a type and screen, and 2,643 (9.5%) had a crossmatch ordered. Of 4,644 cases determined to require only a type and screen, 1,509 (32.5%) had a type and crossmatch ordered. By using the MSBOS to eliminate unnecessary blood orders, the authors calculated a potential reduction in hospital charges and actual costs of $211,448 and $43,135 per year, respectively, or $8.89 and $1.81 per surgical patient, respectively.

Conclusions: An institution-specific MSBOS can be created, using blood utilization data extracted from an anesthesia information management system along with our proposed algorithm. Using these methods to optimize the process of preoperative blood ordering can potentially improve operating room efficiency, increase patient safety, and decrease costs.

What We Already Know about This Topic

- Blood orders for various operations are not based on current use and are rarely institution-specific

What This Article Tells Us That Is New

- The investigators developed a system to create an institution-specific maximum surgical blood order schedule from electronic medical record data
- Institutions can use this system to develop specific data-driven protocols for ordering blood for various procedures
- Blood orders based on institution-specific data will presumably reduce unnecessary blood preparation and its associated cost

THE decision to order blood typing and red cell antibody screening (T/S) or a type and crossmatch (T/C) before surgery can be controversial, especially for cases with a low or intermediate likelihood of transfusion. Several variables must be considered when making this decision, including the anticipated blood loss for a given procedure, the preoperative hemoglobin concentration, and the relative risk of transfusing emergency-release type-O blood during unexpected hemorrhage when preoperative T/S or T/C are unavailable. Previous investigations have led to proposed blood ordering protocols, but often, these protocols are designed for a single type of surgical procedure.[1–7] Ideally, a blood order algorithm could be developed, which would cover most types of procedure.

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A recommended maximum surgical blood order schedule (MSBOS) for common surgical procedures was published more than 30 yr ago by Freidman,[8] but many new procedures have since been introduced, and surgical techniques have evolved such that blood loss is now less common. Ideally, blood ordering protocols should be based on institution-specific, recent historical blood utilization data, which can be difficult to obtain. We have previously described methods for collecting such data with an anesthesia information management system (AIMS),[9] and two recent publications by Cheng *et al.*[10] and Dexter *et al.*[11] have proposed using AIMS-acquired data to guide preoperative blood ordering based on specific criteria. However, neither of these studies developed an MSBOS based on their recommended criteria, nor did they define criteria specific enough to create an MSBOS.

The purpose of the current study was to create an institution-specific MSBOS by using AIMS-acquired data along with a blood order algorithm. In addition, we sought to identify specific low–blood-loss procedures, for which we could eliminate blood orders, and thereby substantially reduce costs.

Materials and Methods

After receiving Institutional Review Board approval (The Johns Hopkins Medical Institutions, Baltimore, Maryland), we extracted and analyzed data from our institution's AIMS (Metavision; iMdSoft, Needham, MA) to assess transfusion requirements and preoperative blood orders. We collected data from a 27-month period (January, 2010–March, 2012) that included 76,106 patients having 1,909 types of surgical procedures. A detailed account of our methods for data extraction from the AIMS system, as well as data validation, have been described previously.[9]

We excluded 22,586 cases, in which patients were under 18 yr old or had ophthalmic surgery, leaving 53,526 surgical patients having 1,632 types of surgical procedures for the analysis. We excluded pediatric patients because in children, blood is often transfused according to body mass (ml/kg) and is not measured in units transfused. Therefore, transfusion data from adults and children are not comparable. Ophthalmic surgery was excluded because these patients never receive blood transfusions.

Each surgical procedure was then grouped into one of 135 different procedure categories determined by surgical subspecialty and relevant anatomical operative site. For patients having combined procedures, the primary posted procedure was used for categorization purposes. For the purposes of grouping procedures into categories, we considered the percentage of patients transfused for procedures that could potentially fall under more than one category. Procedures with similar transfusion rates (±5%) were grouped together; otherwise a new procedure category was created. Two investigators (Drs. Frank and Rothschild) carried out the grouping process. Details of category assignments for every procedure, for each of the nine surgical services, can be accessed electronically (see Supplemental Digital Content 1, http://links.lww.com/ALN/A924, which is a table outlining the categorization of all surgical procedures).

For each procedure category, we analyzed the following variables: number of patients transfused with erythrocytes; number of units of erythrocytes transfused; median estimated blood loss (EBL); and transfusion index[3,12] (total number of erythrocyte units transfused divided by the total number of patients having a particular procedure). The number of patients who had a preoperative T/S and/or T/C ordered was also recorded. The T/C–to–transfusion ratio was calculated as the number of patients who had a T/C ordered, divided by the number of patients who were transfused with erythrocytes. The T/S–to–transfusion ratio was calculated as the number of patients who had a T/S or T/C ordered, divided by the number of patients who were transfused with erythrocytes. We used this definition because every T/C includes a T/S as well.

Using previously proposed criteria, we developed an algorithm (fig. 1) to determine the appropriate preoperative blood order for each procedure category. These criteria included: 5% or more of patients transfused with erythrocytes;[11,13,14] median EBL more than 50 ml;[11] and a transfusion index 0.3 or more.[15] An additional parameter, which we called "risk of major bleeding," was assigned to each procedure category as either "yes" or "no" for the purposes of the algorithm. This risk was determined by consensus among the investigators after discussion with surgeons by considering the proximity of surgery to large blood vessels, and thus, the potential for major surgical bleeding. A detailed description of the computer code used to create and execute this algorithm can be accessed electronically (see Supplemental Digital Content 2, http://links.lww.com/ALN/A925, which outlines the specific computer code used in the algorithm).

The three primary blood orders determined by the algorithm were "no T/S or T/C", "T/S", and "T/C". The minimum number of T/C units was two (2 U). If four or more units of erythrocytes were transfused in more than 10% of patients, then the recommendation was a T/C for four units (4 U), and for the category of procedures considered to be "major vascular or transplant," the recommendation was a T/C of six to 15 units (6–15 U). For example, this category included liver transplants and thoracoabdominal aortic aneurysms.

The value for EBL was missing for 53% of cases in the anesthesia record. For these cases, a value of zero was assumed, as described and justified by Dexter *et al.*[11] These investigators explain in detail that this method is valid because most cases with missing values are those in which blood loss was minimal and transfusion did not occur. Because AIMSs do not allow text entries in a numeric field (*e.g.,* minimal), most providers choose not to enter a value when blood loss is very low. Furthermore, because EBL is known to be a somewhat unreliable measurement,[16] we included the parameters transfusion index and percentage of patients transfused in the algorithm. EBL is not routinely measured in cardiac surgery

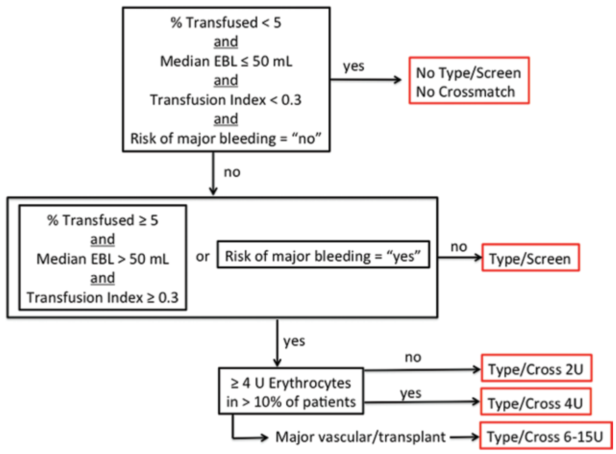

Fig. 1. The algorithm used to derive the maximum surgical blood order schedule. The thresholds in the algorithm for percentage of patients transfused, median estimated blood loss (EBL), and transfusion index (mean number erythrocyte units transfused per patient) are derived from previous studies.[11,13–15] "Risk of major bleeding" was determined to be "yes" or "no" for each surgical procedure category based on the proximity of the surgical field to large vascular structures. RBC = erythrocytes; U = units.

cases, and all patients who undergo cardiac surgery are at risk for major bleeding. Therefore, we omitted EBL in the analysis and assigned all cardiac surgery procedures, except for automatic implantable cardiac defibrillator/pacemaker placement, to the T/C group, according to the algorithm (fig. 1).

We compared the T/C–to–transfusion ratio and the T/S–to–transfusion ratio among the nine surgical services to identify services with the highest rates of overordering. We also performed an analysis to calculate the reduction in hospital charges, as well as actual cost savings that could be achieved by eliminating all T/S and T/C tests that were ordered at our institution for patients having procedures determined by the algorithm to be in the "no T/S or T/C" category, and by eliminating any T/C tests that were ordered for cases assigned to the "T/S" category. We used the current laboratory charge at our institution for T/S and T/C, which were $37 and $52, respectively. Actual costs for these tests, taking into account reagents, technician time, laboratory equipment maintenance, and depreciation were calculated to be $7.56 and $10.61 for each T/S and T/C, respectively. Hospital charge and actual cost reductions were proportionally adjusted for the 27-month period of data collection, to determine these values in U.S. dollars per year. The two-tailed hypothesis tested was that blood ordering guided by the MSBOS would have a financial impact as measured by patient charges and actual costs.

Statistical Analysis

All data were processed and analyzed with the software programs Excel, v. 14.1.0 (Microsoft Inc., Redmond, WA) and JMP, v. 9.0.0 (SAS Institute, Cary, NC). Comparisons were made by ANOVA and chi-square tests where appropriate. Nonparametric data were compared by the Kruskal–Wallis test. The blood order algorithm was constructed using JMP. Data are given as mean ± SD or median (interquartile range) as appropriate. P value less than 0.05 defined significance.

Results

The 135 categories of surgical procedures were assigned to one of five blood order groups, according to the algorithm outlined in figure 1, and the results of these assignments are shown in table 1. Fifty two percent of patients had surgical procedures that met criteria for the "no T/S or T/C" recommendation, 8.7% had procedures that met criteria for the "T/S" recommendation, 33.9% had procedures that met criteria for the "T/C 2U" recommendation, 5.2% had procedures that met criteria for the "T/C 4U" recommendation, and 0.2% had procedures that met criteria for the "T/C 6-15U" recommendation. The percentage of patients transfused, median EBL, and transfusion index were all greater in the "T/C" groups than in the "T/S" group, and greater in the "T/S" group than in the "no T/S or T/C" group (P < 0.01 for all differences among the groups for these parameters).

Table 1. Comparison of Blood Order Recommendation Categories

Blood Order Recommendation Category	No. of Patients (%)	% Transfused*	Median EBL (ml)†	Transfusion Index (Erythrocyte Units/ Patient)‡	% T/S§*	% T/C§*
No T/S or T/C	27,825 (52.0%)	1.2%	0 (0–10)	0.03 ± 0.04	32.7	9.5
T/S	4,644 (8.7%)	5.8%	100 (50–150)	0.12 ± 0.1	49.7	32.5
T/C 2 U	18,123 (33.9%)	15.9%	125 (50–275)	0.39 ± 0.32	31.4	54.1
T/C 4 U	2,814 (5.2%)	53.9%	650 (500–1,325)	2.6 ± 1.78	7.2	87.4
T/C 6–15 U	120 (0.2%)	86.2%	3,000 (900–4,500)	6.3 ± 0.99	4.0	92.6

The five blood order recommendation categories are compared to illustrate differences among groups. Transfusion index = total number of erythrocyte units transfused divided by total number of patients.

* P < 0.001 for differences among blood order categories by chi-square test. † Data given as median (interquartile range), P < 0.01 for differences among blood order categories by Kruskal–Wallis. ‡ P < 0.01 for differences among blood order categories by ANOVA. § The percentage of cases for which these tests were actually ordered.

EBL = estimated blood loss; T/C = type and crossmatch; T/S = type and screen; U = units.

Of 27,825 patients who were determined as not requiring any blood orders, 9,099 (32.7%) had a T/S ordered, and 2,643 (9.5%) had a T/C ordered (table 1). Of 4,644 patients that were determined to need a T/S only, 1,509 (32.5%) had a T/C ordered.

The 135 categories of surgical procedures and the associated blood order recommendations, along with detailed transfusion data, are shown in appendix 1, tables 2–10. Each of these tables represents the MSBOS for a particular surgical service. Surgical procedures that were noted to have extremely low transfusion rates and very high T/C– and T/S–to–transfusion ratios were: breast procedures, thyroid/parathyroid procedures, cerebrospinal fluid shunt procedures, cystoscopy/ureter/urethral procedures, robotic prostate/kidney/adrenal procedures, robotic or laparoscopic uterus/ovary procedures, open shoulder procedures, and peripheral nerve procedures.

We compared the T/S–to–transfusion ratios and the T/C–to–transfusion ratios among the nine surgical services (fig. 2). The services with the highest ratios were those that potentially had the greatest number of unnecessary preoperative blood orders. All surgical services, except for cardiac and vascular/transplant, had T/C–to–transfusion ratios of 3 or greater. A ratio of 2 has been proposed as optimal.[3,17]

The economic implications of following the recommended blood orders are shown in figure 3. The greatest potential savings would be realized by the general surgery, otolaryngology, neurosurgery, and urology services. By using the MSBOS to eliminate unnecessary blood orders, we calculated a potential reduction in hospital charges and actual costs of $211,448 and $43,135 per year, respectively. When calculated for all surgical patients as the denominator, this change in practice would reduce hospital charges and actual costs by $8.89 and $1.81 per patient, respectively.

A summary of the recommended preoperative blood orders for each surgical procedure category organized by surgical service, is shown in appendix 2 (fig. 4). These recommendations are derived from data in appendix 1, tables 2–10, and represents our institution-specific surgical blood order schedule, which has been implemented into practice.

Discussion

Using AIMS-acquired data, we were able to collect detailed information on transfusion requirements for a large number of surgical procedures, while taking into account institution-specific factors. Before the adoption of the current AIMS at our institution, the development of an MSBOS based on detailed and accurate blood utilization data would have been prohibitive. However, with the AIMS, we were able to apply an algorithm based on previously published parameters[3,11,13–15] to create an institution-specific MSBOS. We then were able to identify specific procedures with very low transfusion rates, for which preoperative blood orders for T/S and T/C were considered unnecessary. If these blood orders were eliminated, significant reduction in charges and costs would be achieved. In addition, it is likely that following the MSBOS recommendations would improve operating room efficiency and patient safety because the blood bank staff often faces the challenge to process multiple blood samples simultaneously on the day of surgery. As a result, the start of cases can be delayed,[18] and/or surgical cases begin without blood available,[18] a practice which is contrary to the Joint Commission (JCAHO) recommended guidelines.[19] Furthermore, patients who truly require blood readily available would also benefit from MSBOS-guided blood ordering.

Creating an MSBOS is much more complex than it was three decades ago. Procedures now have many more variations, often with differing bleeding risks and transfusion

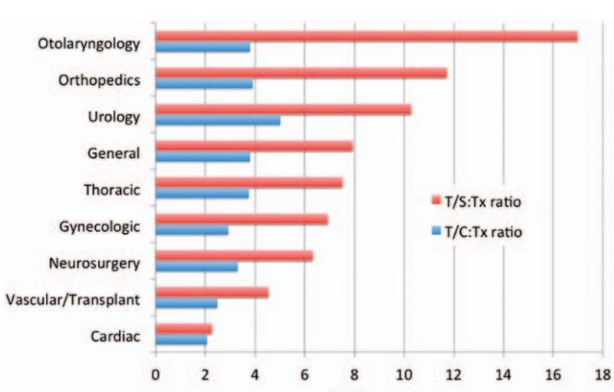

Fig. 2. The type-and-crossmatch–to–transfusion ratio and type-and-screen–to–transfusion ratio were compared among surgical services. The likelihood that blood would be ordered but never transfused was assessed according to these ratios, and compared between services. An ideal type-and-crossmatch–to–transfusion ratio has been described as 2:1.[3,4,17]

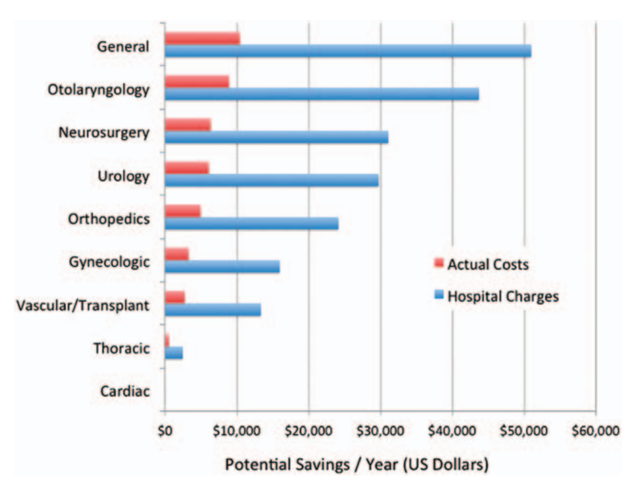

Fig. 3. The nine surgical services were compared regarding potential hospital charges and actual cost savings per year, if nonindicated, blood orders were eliminated. The total reduction in hospital charges for all surgical services combined would be $211,448 per year, and the reduction in actual costs to perform these tests would be $43,135 per year.

requirements. The complexity of creating a modern, universal MSBOS list is evident when one considers that 1,909 different surgical procedures were performed at our institution in the past 3 yr, in contrast to the 63 procedures from Friedman 1979 MSBOS list.[8] The original MSBOS was released before the advent of laparoscopic and robotic techniques, which as shown by our data, are clearly associated with lower transfusion requirements than traditional surgical techniques. The increased use of cell salvage, hemostatic agents, and new methods of cautery for certain procedures has also decreased transfusion requirements.[20,21] Although the original MSBOS was derived by collecting transfusion data from multiple institutions,[8] our opinion is that blood ordering decisions should be institution-specific, procedure-specific, and perhaps even surgeon-specific, all of which are possible using AIMS-acquired data.

Dexter *et al.*[11] and Cheng *et al.*[10] have recently described using AIMS-acquired data to guide the process of preoperative blood ordering. However, our methods differ from theirs. In their "letter to the editor", Cheng *et al.* used the transfusion index (average number of erythrocyte units transfused per patient) as the sole criterion for determining whether a procedure warrants a T/C. If the transfusion index was 0.5 or more, they recommended a T/C, and if not, they recommended a T/S. Using these criteria, even procedures that are rarely or never transfused would have unnecessary T/S tests ordered. In the study by Dexter *et al.*,[11] two parameters were used to determine whether a T/S was necessary—median EBL and percentage of patients transfused. EBL is known to be relatively inaccurate,[16,22] but was one of the primary determinates in their study. Our algorithm is based on a greater number of measured parameters and includes indications not just for T/S, but for T/C as well.

On the basis of MSBOS recommendations, we found that a substantial number of preoperative blood orders were unnecessary. One explanation for the overordering of blood products for surgery is that many providers are unfamiliar with certain procedures and the associated blood requirements. Another reason for overordering may be that multiple providers are allowed to order blood (surgeons, anesthesia providers, and advance practice nurses). If any one of these individuals ascribes to the "better-safe-than-sorry" approach, it is likely that blood will be ordered unnecessarily. An estimated reduction in hospital charges of over $200,000 per year at our institution would be achieved if unnecessary blood orders were eliminated. Because the actual costs of performing these tests are known to differ from hospital charges,[23] we calculated the true cost savings that could be recognized, which was approximately 20% of the hospital charges.

Another indication of excessive blood ordering is the T/C–to–transfusion ratio. The ideal ratio has been described as 2:1,[3,4,17] and a ratio above this is thought to represent excessive blood ordering. In our institution, only the cardiac surgery service was close to the ideal ratio, and the ratios for the other services were between 3:1 and 5:1. In addition to this ratio, we assessed the T/S–to–transfusion ratio, which has not been previously reported. When considering unnecessary blood orders, we believe this ratio is also useful for estimating utilization of blood bank resources. These ratios can also be used to modify subsequent releases of the MSBOS as surgical procedures are refined and changes in transfusion rates are recognized. Another advantage of using AIMS-acquired data is the ability to compare surgical services, or even individual medical providers, to determine where efforts should be focused to reduce excessive blood orders.

An issue that is rarely discussed is the relative safety of using emergency-release type-O blood as a backup plan when unexpected bleeding is encountered and no blood products are available. The risk of a major, acute, ABO group hemolytic reaction should be zero, barring clerical error and the wrong unit being given (which would be the same risk as for crossmatched units).[24,25] Dutton *et al.*[26] reported no acute hemolytic reactions in 161 patients given 581 units of uncrossmatched, type-O erythrocytes. The risk of a delayed, slower onset reaction has been described as one in 1,000 units of emergency-release blood.[27] This type of reaction is usually mild, slower in onset (4–21 days), associated with a mild increase in bilirubin, and often goes undetected. Thus, if a given case (thyroidectomy for example) has a two in 1,000 chance of transfusion, the calculated risk of a mild delayed reaction would be approximately two in a million (2:1,000 × 1:1,000) in the typical patient presenting for this procedure without blood orders.

Patient blood management has seen an increased level of attention in the past few years.[28–30] Although much focus has been on reducing the incidence of unnecessary transfusion, reducing unnecessary preoperative blood orders is also part of the effort to conserve blood. Blood management encompasses allocating resources appropriately and decreasing the unnecessary use of those resources. Using AIMS-acquired data to create an institution-specific MSBOS is an example of patient blood management, which we believe should be incorporated into a hospital's blood management program. The utility of AIMS-acquired data for guiding a blood management program has also been described in our previous study, where providers were compared with their peers in terms of blood utilization and hemoglobin transfusion triggers, an exercise that has proven useful in our institution.[9]

One factor not accounted for in our algorithm is the preoperative hemoglobin concentration. Previous studies have accounted for preoperative hemoglobin, when describing surgical blood order equations[1,7] and other transfusion predictors,[5,13,14] which are used to determine the need for T/C. Hemoglobin concentration should be considered, and our MSBOS can be modified for patients with anemia. Ideally, multiple factors should be considered when ordering blood—the preoperative hemoglobin, the planned surgical procedure, and medical need to transfuse based on coexisting conditions, such as cardiovascular disease.

Our study has certain limitations that should be recognized. First, some common surgical procedures are infrequently performed in our hospital because they are performed at an affiliated hospital where an AIMS is not used. Hip and knee arthroplasty, both primary and revision, are such procedures that are underrepresented in our database. Most physicians, however, would agree that these orthopedic procedures do require a T/C, except for perhaps the primary total knee arthroplasty, which our algorithm assigned to the T/S category. Second, the blood order algorithm is based solely on intraoperative transfusion requirements and does not account for postoperative transfusions. Certain procedures (hip arthroplasty and multilevel lumbar spine fusions) are associated with significant postoperative blood loss that would justify the T/C, despite the intraoperative blood requirements. Because these types of cases were determined as requiring a T/C, the results would be unchanged, if we accounted for postoperative bleeding. Lastly, we report data from only one institution, which may or may not represent blood requirements in other institutions. However, any center with an AIMS could use our algorithm to create an institution-specific MSBOS, similar to ours in appendix 2, figure 4.

In conclusion, we have shown that an MSBOS created with AIMS-acquired data can be used to optimize the process of preoperative blood ordering. As a result of this analysis, we plan to implement preoperative blood ordering protocols that eliminate or decrease unnecessary blood orders. In addition, these protocols should reduce the number of cases with missing blood orders, when these orders are truly indicated. Implementing the algorithm and the MSBOS that we have described offers the potential to improve operating room efficiency, enhance patient safety, and reduce costs.

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References

1. Nuttall GA, Horlocker TT, Santrach PJ, Oliver WC Jr, Dekutoski MB, Bryant S: Use of the surgical blood order equation in spinal instrumentation and fusion surgery. Spine 2000; 25:602–5
2. Kajja I, Bimenya GS, Eindhoven GB, ten Duis HJ, Sibinga CT: Surgical blood order equation in femoral fracture surgery. Transfus Med 2011; 21:7–12
3. Mahadevan D, Challand C, Clarke A, Keenan J: Maximum surgical blood ordering schedules for revision lower limb arthroplasty. Arch Orthop Trauma Surg 2011; 131:663–7
4. Nuttall GA, Santrach PJ, Oliver WC Jr, Horlocker TT, Shaughnessy WJ, Cabanela ME, Bryant S: The predictors of red cell transfusions in total hip arthroplasties. Transfusion 1996; 36:144–9
5. Krupp NL, Weinstein G, Chalian A, Berlin JA, Wolf P, Weber RS: Validation of a transfusion prediction model in head and neck cancer surgery. Arch Otolaryngol Head Neck Surg 2003; 129:1297–302
6. Usal H, Nabagiez J, Sayad P, Ferzli GS: Cost effectiveness of routine type and screen testing before laparoscopic cholecystectomy. Surg Endosc 1999; 13:146–7
7. Nuttall GA, Santrach PJ, Oliver WC Jr, Ereth MH, Horlocker TT, Cabanela ME, Trousdale RT, Bryant S, Currie TW: A prospective randomized trial of the surgical blood order equation for ordering red cells for total hip arthroplasty patients. Transfusion 1998; 38:828–33
8. Friedman BA: An analysis of surgical blood use in United States hospitals with application to the maximum surgical blood order schedule. Transfusion 1979; 19:268–78
9. Frank SM, Savage WJ, Rothschild JA, Rivers RJ, Ness PM, Paul SL, Ulatowski JA: Variability in blood and blood component utilization as assessed by an anesthesia information management system. Anesthesiology 2012; 117:99–106
10. Cheng CK, Trethewey D, Brousseau P, Sadek I: Creation of a maximum surgical blood ordering schedule *via* novel low-overhead database method. Transfusion 2008; 48:2268–9
11. Dexter F, Ledolter J, Davis E, Witkowski TA, Herman JH, Epstein RH: Systematic criteria for type and screen based on procedure's probability of erythrocyte transfusion. Anesthesiology 2012; 116:768–78
12. Juma T, Baraka A, Abu-Lisan M, Asfar SK: Blood ordering habits for elective surgery: Time for change. J R Soc Med 1990; 83:368–70
13. van Klei WA, Moons KG, Rheineck-Leyssius AT, Kalkman CJ, Rutten CL, Knape JT, Grobbee DE: Validation of a clinical prediction rule to reduce preoperative type and screen procedures. Br J Anaesth 2002; 89:221–5
14. van Klei WA, Moons KG, Leyssius AT, Knape JT, Rutten CL, Grobbee DE: A reduction in type and screen: Preoperative prediction of RBC transfusions in surgery procedures with intermediate transfusion risks. Br J Anaesth 2001; 87:250–7
15. Jayaranee S, Prathiba R, Vasanthi N, Lopez CG: An analysis of blood utilization for elective surgery in a tertiary medical centre in Malaysia. Malays J Pathol 2002; 24:59–66
16. Bose P, Regan F, Paterson-Brown S: Improving the accuracy of estimated blood loss at obstetric haemorrhage using clinical reconstructions. BJOG 2006; 113:919–24
17. Vibhute M, Kamath SK, Shetty A: Blood utilisation in elective general surgery cases: Requirements, ordering and transfusion practices. J Postgrad Med 2000; 46:13–7
18. McWilliams B, Yazer MH, Cramer J, Triulzi DJ, Waters JH: Incomplete pretransfusion testing leads to surgical delays. Transfusion 2012; 52:2139–44; quiz 2145
19. Gammon HM, Waters JH, Watt A, Loeb JM, Donini-Lenhoff A: Developing performance measures for patient blood management. Transfusion 2011; 51:2500–9
20. Waters JH, Lee JS, Karafa MT: A mathematical model of cell salvage efficiency. Anesth Analg 2002; 95:1312–7
21. Huët C, Salmi LR, Fergusson D, Koopman-van Gemert AW, Rubens F, Laupacis A: A meta-analysis of the effectiveness of cell salvage to minimize perioperative allogeneic blood transfusion in cardiac and orthopedic surgery. International Study of Perioperative Transfusion (ISPOT) Investigators. Anesth Analg 1999; 89:861–9
22. McConnell JS, Fox TJ, Josson JP, Subramanian A: "About a cupful"—A prospective study into accuracy of volume

estimation by medical and nursing staff. Accid Emerg Nurs 2007; 15:101–5
23. Ramsey G, Desley C, Ross K, Peck K, Spennachio J, Blumberg N: The type and screen: Are patient charges a valid measure of cost reduction? Ann Clin Lab Sci 1983; 13:55–8
24. Blumberg N, Bove JR: Un-cross-matched blood for emergency transfusion. One year's experience in a civilian setting. JAMA 1978; 240:2057–9
25. Lefebre J, McLellan BA, Coovadia AS: Seven years experience with group O unmatched packed red blood cells in a regional trauma unit. Ann Emerg Med 1987; 16:1344–9
26. Dutton RP, Shih D, Edelman BB, Hess J, Scalea TM: Safety of uncrossmatched type-O red cells for resuscitation from hemorrhagic shock. J Trauma 2005; 59:1445–9
27. Goodell PP, Uhl L, Mohammed M, Powers AA: Risk of hemolytic transfusion reactions following emergency-release RBC transfusion. Am J Clin Pathol 2010; 134:202–6
28. Waters JH, Ness PM: Patient blood management: A growing challenge and opportunity. Transfusion 2011; 51:902–3
29. Goodnough LT, Shander A: Patient blood management. Anesthesiology 2012; 116:1367–76
30. Yazer MH, Waters JH: How do I implement a hospital-based blood management program? Transfusion 2012; 52:1640–5

Appendix 1: Maximum Surgical Blood Order Schedules (MSBOS) for the Nine Surgical Services

Using data acquired from the anesthesia information management system and the algorithm shown in figure 1, the following MSBOS lists were created.

An MSBOS list was generated for each surgical specialty service, and recommendations were given for preoperative blood orders for each category of surgical procedure.

Table 2. Cardiac Surgery: Recommendations for Preoperative Blood Orders and Erythrocyte Transfusion Data

Case Category	Recommendation	n	% Transfused	Median EBL	Transfusion Index (Erythrocyte Units/Patient)	Risk of Major Bleeding	T/C to Tx Ratio	T/S to Tx Ratio
Heart or lung transplant	T/C 4 U	81	81.5	NM	4.3	Yes	1.2	1.2
Minimally invasive valve	T/C 4 U	108	37.0	NM	1.29	Yes	2.5	2.6
Revision sternotomy	T/C 4 U	83	67.5	NM	3.46	Yes	1.4	1.5
CABG/valve	T/C 4 U	99	60.6	NM	2	Yes	1.5	1.6
Open heart surgery	T/C 4 U	581	42.7	NM	1.3	Yes	2.0	2.2
Assist device	T/C 4 U	123	48.0	NM	2.21	Yes	1.7	1.9
Cardiac/major vascular	T/C 4 U	334	44.3	NM	2.87	Yes	1.8	2.0
Open ventricle	T/C 4 U	7	42.9	NM	1.14	Yes	2.0	2.0
CABG	T/C 2 U	744	43.0	NM	1.05	Yes	2.2	2.2
Cardiac wound surgery	T/C 2 U	313	31.9	NM	0.94	Yes	2.3	2.8
Percutaneous cardiac	T/C 2 U	136	0.0	NM	0	Yes		
Pericardium	T/C 2 U	41	22.0	NM	0.46	Yes	3.6	4.1
Lead extraction	T/C 2 U	101	5.9	NM	0.14	Yes	12.1	13.7
AICD/pacemaker placement	T/S	58	10.3	NM	0.31	No	6.0	8.7

Transfusion index = Total number of erythrocyte units transfused divided by total number of patients.

AICD = automatic implantable cardiac defibrillator; CABG = coronary artery bypass grafting; EBL = estimated blood loss; NM = not measured; T/C = type and crossmatch; T/S = type and screen; Tx = transfusion.

Table 3. General Surgery: Recommendations for Preoperative Blood Orders and Erythrocyte Transfusion Data

Case Category	Recommendations	n	% Transfused	Median EBL	Transfusion Index (Erythrocyte Units/Patient)	Risk of Major Bleeding	T/C to Tx Ratio	T/S to Tx Ratio
AP resection	T/C 2 U	37	43.2	425	1.13	Yes	1.6	2.1
Intraabdominal GI	T/C 2 U	3,581	16.7	150	0.483	Yes	3.1	5.1
Whipple or pancreatic	T/C 2 U	851	26.5	470	0.5	Yes	3.9	4.8
Liver resection—major	T/C 2 U	347	12.1	300	0.55	Yes	7.4	8.0
Retroperitoneal	T/C 2 U	170	11.2	100	0.36	Yes	5.8	8.4
Liver resection—minor	T/C 2 U	41	0.0	50	0	Yes		
Substernal	T/C 2 U	51	0.0	0	0	Yes		
Bone marrow harvest	T/S	275	4.4	900	0.065	No	14.3	20.6
Appendectomy	No T/S or T/C	130	0.8	0	0.015	No	9.0	83.0
Abdomen/chest/ extremity superficial	No T/S or T/C	836	2.2	0	0.042	No	4.9	19.6
Laparoscopic or open cholecystectomy	No T/S or T/C	519	1.3	10	0.016	No	7.9	51.7
Thyroid/parathyroid	No T/S or T/C	1,605	0.2	0	0.002	No	16.3	226.7
Central venous access	No T/S or T/C	22	0.0	0	0	No		
Breast procedure	No T/S or T/C	2,627	0.4	50	0.007	No	5.9	66.5

Transfusion index = Total number of erythrocyte units transfused divided by total number of patients.

AP = abdominal peritoneal; EBL = estimated blood loss; GI = gastrointestinal; T/C = type and crossmatch; T/S = type and screen; Tx = transfusion.

Table 4. Gynecologic Surgery: Recommendations for Preoperative Blood Orders and Erythrocyte Transfusion Data

Case Category	Recommendation	n	% Transfused	Median EBL	Transfusion Index (Erythrocyte Units/Patient)	Risk of Major Bleeding	T/C to Tx Ratio	T/S to Tx Ratio
Uterus open	T/C 2 U	123	16.5	300	0.32	Yes	2.8	5.7
Open pelvic	T/C 2 U	2,681	9.5	100	0.561	Yes	2.5	4.8
Uterus/ovary Laparoscopic/robotic	T/S	760	1.7	100	0.032	No	11.9	46.0
Total vaginal hysterectomy	T/S	17	0.0	75	0	No		
Cystectomy robotic-assisted	T/S	17	0.0	75	0	No		
Cystoscopy	No T/S or T/C	816	2.9	0	0.017	No	4.6	22.6
External genitalia	No T/S or T/C	692	1.5	0	0.03	No	4.2	22.0
GYN cervix	No T/S or T/C	1,146	0.7	0	0.022	No	4.4	26.9
Hysteroscopy	No T/S or T/C	213	0.0	0	0	No		
Superficial wound	No T/S or T/C	105	0.0	0	0.095	No	6.3	11.1

Transfusion index = Total number of erythrocyte units transfused divided by total number of patients.

GYN = gynecologic; EBL = estimated blood loss; T/C = type and crossmatch; T/S = type and screen; Tx = transfusion.

Table 5. Neurosurgery: Recommendations for Preoperative Blood Orders and Erythrocyte Transfusion Data

Case Category	Recommendation	n	% Transfused	Median EBL	Transfusion Index (Erythrocyte Units/ Patient)	Risk of Major Bleeding	T/C to Tx Ratio	T/S to Tx Ratio
T/L/S fusion	T/C 4 U	1,087	45.1	650	1.56	Yes	1.8	2.1
Spine tumor	T/C 2 U	113	7.96	200	0.24	Yes	7.9	12.3
Posterior cervical spine fusion	T/C 2 U	250	18.8	200	0.32	No	3.3	5.1
Spine I and D	T/C 2 U	93	16.1	100	0.33	Yes	2.3	4.8
Intracranial	T/C 2 U	1,538	7.8	200	0.18	Yes	7.2	11.9
Laminectomy/discectomy	T/S	572	10.1	150	0.26	No	4.0	8.8
Spine hardware removal/biopsy	T/S	61	6.6	75	0.1	No	7.5	13.5
ACDF	No T/S or T/C	421	1.9	50	0.033	No	16.0	48.0
Extracranial	No T/S or T/C	375	3.7	25	0.065	No	5.1	18.9
Nerve procedure	No T/S or T/C	1,488	0.27	0	0.006	No	13.8	97.5
CSF/shunt procedure	No T/S or T/C	542	0.37	0	0.004	No	20.5	180.0

Transfusion index = total number of erythrocyte units transfused divided by total number of patients.

ACDF = anterior cervical discectomy and fusion; CSF = cerebrospinal fluid; EBL = estimated blood loss; I and D = incision and drainage; T/C = type and crossmatch; T/L/S = thoracic, lumbar, or sacral; T/S = type and screen; Tx = transfusion.

Table 6. Orthopedic Surgery: Recommendations for Preoperative Blood Orders and Erythrocyte Transfusion Data

Case Category	Recommendation	n	% Transfused	Median EBL	Transfusion Index (Erythrocyte Units/ Patient)	Risk of Major Bleeding	T/C to Tx Ratio	T/S to Tx Ratio
Pelvic orthopedic	T/C 4 U	59	32.2	500	1.41	Yes	2.0	2.8
Open hip	T/C 2 U	119	22.7	350	0.487	Yes	2.7	3.9
Femur open	T/C 2 U	202	18.8	200	0.4	Yes	2.4	4.6
Above knee amputation	T/C 2 U	31	25.81	100	0.39	No	1.8	3.4
Humerus open	T/S	172	7.56	0	0.13	No	2.6	9.5
Fasciotomy	T/S	33	12.1	0	0.21	No	2.0	5.5
Shoulder I and D	T/S	24	8.3	60	0.083	No	1.5	8.0
Tibial/fibular	T/S	260	7.7	100	0.13	No	4.4	10.6
Total knee replacement	T/S	32	3.1	200	0.16	No	19.0	31.0
Below knee amputation	T/S	93	17.2	100	0.24	No	2.8	5.3
Shoulder open	T/S	240	0.42	200	0.008	No	70.0	202.0
Knee open	T/S	71	1.41	0	0.056	No	9.0	25.0
Thigh soft tissue	No T/S or T/C	179	2.23	0	0.04	No	4.0	18.5
Ortho external fixation	No T/S or T/C	59	1.7	0	0.017	No	5.0	31.0
Peripheral nerve/tendon	No T/S or T/C	244	0.82	0	0.016	No	6.0	39.5
Lower extremity I and D	No T/S or T/C	187	4.81	0	0.094	No	4.9	14.3
Hip I and D	No T/S or T/C	24	4.2	0	0.042	No	7.0	17.0
Hand orthopedic	No T/S or T/C	812	0.25	0	0.005	No	3.5	31.0
Upper extremity arthroscopy	No T/S or T/C	38	0	0	0	No		
Upper extremity open	No T/S or T/C	160	1.25	0	0.167	No	8.0	50.0
Foot bone	No T/S or T/C	397	0.5	0	0.005	No	21.5	117.0
Hip closed/percutaneous	No T/S or T/C	32	0	10	0	No		
Lower extremity arthroscopic	No T/S or T/C	449	0.22	0	0.002	No	3.0	28.0
Shoulder closed	No T/S or T/C	344	0	0	0	No		
Tibial/fibular closed	No T/S or T/C	70	2.9	25	0.086	No	8.0	22.5

Transfusion index = total number of erythrocyte units transfused divided by total number of patients.

EBL = estimated blood loss; I and D = incision and drainage; T/C = type and crossmatch; T/S = type and screen; Tx = transfusion.

Table 7. Otolaryngology: Recommendations for Preoperative Blood Orders and Erythrocyte Transfusion Data

Case Category	Recommend	n	% Transfused	Median EBL	Transfusion Index (Erythrocyte Units/ Patient)	Risk of Major Bleeding	T/C to Tx Ratio	T/S to Tx Ratio
Laryngectomy	T/C 2 U	63	24.6	150	0.4	Yes	2.0	3.6
Facial reconstruction	T/C 2 U	97	20.3	100	0.289	Yes	1.9	3.9
Cranial surgery	T/C 2 U	253	6.4	150	0.146	Yes	5.5	9.5
Radical neck dissection	T/C 2 U	199	4.4	50	0.12	Yes	4.8	17.9
Carotid body tumor	T/C 2 U	8	0.0	200	0	Yes		
Mandibular surgery	T/S	171	12.6	50	0.23	No	2.3	6.5
Neck dissection	T/S	345	4.3	0	0.3	No	2.2	8.6
Mastoidectomy	No T/S or T/C	108	4.5	0	0.12	No	3.0	7.0
Parotidectomy	No T/S or T/C	194	3.9	50	0.076	No	3.7	18.3
Facial plastic	No T/S or T/C	2,632	2.6	0	0.036	No	3.0	15.2
Oral surgery	No T/S or T/C	747	2.1	50	0.032	No	4.6	17.4
Sinus surgery	No T/S or T/C	762	0.6	45	0.024	No	4.1	23.4
Thyroidectomy/ parathyroidectomy	No T/S or T/C	1,605	0.5	0	0.0025	No	15.7	228.3
Suspension laryngoscopy	No T/S or T/C	416	0.5	0	0.0072	No	7.0	46.5
Bronchoscopy	No T/S or T/C	427	0.0	0	0	No		
Cochlear implant	No T/S or T/C	282	0.0	0	0	No		
EGD	No T/S or T/C	316	0.0	0	0.016	No	9.5	48.0
External ear	No T/S or T/C	113	0.0	0	0	No		
Inner ear	No T/S or T/C	186	0.0	0	0	No		
Tonsillectomy and adenoidectomy	No T/S or T/C	173	0.0	0	0	No		
Tympanomastoid	No T/S or T/C	270	0.0	0	0	No		

Transfusion index = total number of erythrocyte units transfused divided by total number of patients.

EBL = estimated blood loss; EGD = esophagogastroduodenoscopy; T/C = type and crossmatch; T/S = type and screen; Tx = transfusion.

Table 8. Thoracic Surgery: Recommendations for Preoperative Blood Orders and Erythrocyte Transfusion Data

Case Category	Recommendation	n	% Transfused	Median EBL	Transfusion Index (Erythrocyte Units/ Patient)	Risk of Major Bleeding	T/C to Tx Ratio	T/S to Tx Ratio
Esophageal open	T/C 2 U	69	13	250	0.298	Yes	6.0	7.1
Sternal procedure	T/C 2 U	164	23.2	150	0.494	Yes	3.2	3.9
Chest wall	T/C 2 U	70	5.7	100	0.13	Yes	3.8	11.3
Thoracotomy	T/C 2 U	424	11.1	50	0.54	Yes	2.4	6.4
Pectus repair	T/C 2 U	31	0	25	0	Yes		
VATS	T/S	270	7.04	100	0.155	No	6.7	12.5
Mediastinoscopy	T/S	18	5.6	50	0.22	No	4.0	14.0
EGD/FOB	No T/S or T/C	441	2.3	10	0.052	No	3.6	12.5
Central venous access	No T/S or T/C	69	0	5	0	No		

Transfusion index = total number of erythrocyte units transfused divided by total number of patients.

EBL = estimated blood loss; EGD/FOB = esophagogastroduodenoscopy or fiberoptic bronchoscopy; T/C = type and crossmatch; T/S = type and screen; Tx = transfusion; VATS = video-assisted thoracoscopic surgery.

Table 9. Urology: Recommendations for Preoperative Blood Orders and Erythrocyte Transfusion Data

Case Category	Recommendation	n	% Transfused	Median EBL	Transfusion Index (Erythrocyte Units/ Patient)	Risk of Major Bleeding	T/C to Tx Ratio	T/S to Tx Ratio
Cystoprostatectomy	T/C 2 U	136	27.2	530	0.600	Yes	2.7	3.5
Urology open	T/C 2 U	1,696	22.6	100	0.790	Yes	2.3	3.8
Nephrectomy	T/C 2 U	117	17.1	300	1.150	Yes	4.4	5.5
Lap kidney/adrenal	T/C 2 U	766	4.6	50	0.140	Yes	7.6	17.4
RRP	T/C 2 U	1,257	1.7	400	0.027	Yes	33.1	53.2
Robotic RRP/kidney/ adrenal	T/S	934	0.1	150	0.002	No	431.0	864.0
Percutaneous nephrolithotomy	No T/S or T/C	70	2.9	0	0.057	No	2.5	21.5
External genitalia	No T/S or T/C	1,230	1.2	0	0.025	No	3.9	23.9
TURP	No T/S or T/C	106	0.9	0	0.009	No	9.0	79.0
Cysto/ureter/urethra	No T/S or T/C	1,811	0.6	0	0.010	No	7.7	56.5
TURBT	No T/S or T/C	346	0.0	0	0.000	No		

Transfusion index = total number of erythrocyte units transfused divided by total number of patients.

EBL = estimated blood loss; Lap = laparoscopic; RRP = radical retropubic prostatectomy; T/C = type and crossmatch; T/S = type and screen; TURBT = transurethral bladder tumor resection; TURP = transurethral prostatectomy; Tx = transfusion.

Table 10. Vascular Transplant Surgery: Recommendations for Preoperative Blood Orders and Erythrocyte Transfusion Data

Case Category	Recommendation	n	% Transfused	Median EBL	Transfusion Index (Erythrocyte Units/ Patient)	Risk of Major Bleeding	T/C to Tx Ratio	T/S to Tx Ratio
Liver transplant	T/C 15 U	92	79.4	1,325	7	Yes	1.2	1.2
Thoracoabdominal aortic	T/C 15 U	28	92.9	5,100	5.6	Yes	1.0	1.0
Major liver	T/C 4 U	7	28.6	500	0.86	Yes	3.5	3.5
Major vascular	T/C 4 U	165	55.2	800	2	Yes	1.5	1.7
Exploratory laparotomy vascular	T/C 4 U	80	51.3	200	1.96	Yes	1.6	1.8
Kidney pancreas transplant	T/C 2 U	15	66.7	900	1.3	Yes	1.2	1.5
Major endovascular	T/C 2 U	104	31.7	300	0.63	Yes	2.7	3.1
Above/below knee amputation	T/C 2 U	96	20.8	100	0.31	No	2.3	4.4
Nephrectomy/kidney transplant	T/C 2 U	616	18.0	200	0.21	Yes	3.5	5.3
Organ procurement	T/C 2 U	21	4.8	400	0.095	Yes	3.0	10.9
Peripheral vascular	T/C 2 U	158	22.8	200	0.47	No	2.7	4.0
Vascular wound I and D	T/C 2 U	32	18.8	100	0.41	No	2.5	5.0
Carotid vascular	T/S	115	2.6	100	0.09	No	22.4	36.1
AV fistula	T/S	100	6.0	50	0.13	No	3.8	14.7
Peripheral endovascular	No T/S or T/C	449	2.9	50	0.07	No	6.0	26.7
Peripheral wound I and D	No T/S or T/C	34	2.9	50	0.029	No	7.1	23.3
First rib resection/thoracic outlet	No T/S or T/C	132	0.0	50	0	No		
Superficial or skin	No T/S or T/C	112	1.8	25	0.15	No	6.4	28.3
Vascular foot amputation/ debridement	No T/S or T/C	158	1.3	30	0.013	No	7.8	47.7
Central venous access	No T/S or T/C	3	0.0	10	0	No		

Transfusion index = total number of erythrocyte units transfused divided by total number of patients.

AV = arterial-venous; EBL = estimated blood loss; I and D = incision and drainage; T/C = type and crossmatch; T/S = type and screen; Tx = transfusion.

Appendix 2

SURGICAL BLOOD ORDER SCHEDULE

Cardiac Surgery

Case Category	Rec
Heart or lung transplant	T/C 4U
Minimally invasive valve	T/C 4U
Revision sternotomy	T/C 4U
CABG/valve	T/C 4U
Open heart surgery	T/C 4U
Assist device	T/C 4U
Cardiac/major vascular	T/C 4U
Open ventricle	T/C 4U
CABG	T/C 2U
Cardiac wound surgery	T/C 2U
Percutaneous cardiac	T/C 2U
Pericardium	T/C 2U
Lead extraction	T/C 2U
AICD/pacemaker placement	T/S

General Surgery

Case Category	Rec
AP resection	T/C 2U
Intra-abdominal GI	T/C 2U
Whipple or pancreatic	T/C 2U
Liver resection	T/C 2U
Retroperitoneal	T/C 2U
Substernal	T/C 2U
Bone marrow harvest	T/S
Hernia – Ventral/Incisional	T/S
Hernia – Inguinal/Umbilical	No Sample
Appendectomy	No Sample
Abdomen/chest/soft tissue	No Sample
Lap. or open cholecystectomy	No Sample
Thyroid/parathyroid	No Sample
Central venous access	No Sample
Any Breast – except w/flaps	No Sample

Gynecological Surgery

Case Category	Rec
Uterus open	T/C 2U
Open pelvic	T/C 2U
Uterus/ovary	T/S
Total vaginal hysterectomy	T/S
Cystectomy robotic assisted	T/S
Cystoscopy	No Sample
External genitalia	No Sample
GYN cervix	No Sample
Hysteroscopy	No Sample
Superficial wound	No Sample

Neurosurgery

Case Category	Rec
Thoracic/Lumbar/Sacral fusion	T/C 4U
Spine tumor	T/C 2U
Posterior cervical spine fusion	T/C 2U
Spine Incision and Drainage	T/C 2U
Intracranial tumor / aneurysm	T/C 2U
Laminectomy/discectomy	T/S
Spine hardware removal/biopsy	T/S
ACDF	T/S
Extracranial	No Sample
Nerve procedure	No Sample
CSF/shunt procedure	No Sample

Orthopedic Surgery

Case Category	Rec
Thoracic/Lumbar/Sacral fusion	T/C 4U
Pelvic orthopedic	T/C 4U
Open hip	T/C 2U
Femur open	T/C 2U
Above/below knee amputation	T/C 2U
Humerus open	T/S
Fasciotomy	T/S
Shoulder Incision & Drainage	T/S
Tibial/fibular	T/S
Total knee replacement	T/S
Shoulder open	T/S
Knee open	T/S
Thigh soft tissue	No Sample
Ortho external fixation	No Sample
Peripheral nerve/tendon	No Sample
Lower extremity I&D	No Sample
Hand orthopedic	No Sample
Upper extremity arthroscopy	No Sample
Upper extremity open	No Sample
Podiatry/Foot	No Sample
Hip closed/percutaneous	No Sample
Lower extremity arthroscopic	No Sample
Shoulder closed	No Sample
Tibial/fibular closed	No Sample

Otolaryngology Surgery

Case Category	Rec
Laryngectomy	T/C 2U
Facial reconstruction	T/C 2U
Cranial surgery	T/C 2U
Radical neck dissection	T/C 2U
Carotid body tumor	T/C 2U
Mandibular surgery	T/S
Neck dissection	T/S
Mastoidectomy	No Sample
Parotidectomy	No Sample
Facial plastic	No Sample
Oral surgery	No Sample
Sinus surgery	No Sample
Thyroid/parathyroidectomy	No Sample
Suspension laryngoscopy	No Sample
Bronchoscopy	No Sample
Cochlear implant	No Sample
EGD	No Sample
External ear	No Sample
Inner ear	No Sample
Tonsillectomy/adenoidectomy	No Sample
Tympanomastoid	No Sample

Thoracic Surgery

Case Category	Rec
Esophageal open	T/C 2U
Sternal procedure	T/C 2U
Chest wall	T/C 2U
Thoracotomy	T/C 2U
Pectus repair	T/C 2U
VATS	T/S
Mediastinoscopy	T/S
EGD/FOB	No Sample
Central venous access	No Sample

Urology

Case Category	Rec
Cystoprostatectomy	T/C 2U
Urology open	T/C 2U
Nephrectomy	T/C 2U
Lap/Robotic kidney/adrenal	T/S
RRP	T/S
Percutaneous nephrolithotomy	T/S
Robotic RRP	No Sample
External genitalia/Penile	No Sample
TURP	No Sample
Cysto/ureter/urethra	No Sample
TURBT	No Sample

Vascular/Transplant Surgery

Case Category	Rec
Liver transplant	T/C 15U
Thoracoabdominal aortic	T/C 15U
Major liver resection	T/C 4U
Major vascular	T/C 4U
Exploratory lap. vascular	T/C 4U
Kidney pancreas transplant	T/C 2U
Major endovascular	T/C 2U
Above/below knee amputation	T/C 2U
Nephrectomy/kidney transplant	T/C 2U
Organ procurement	T/C 2U
Peripheral vascular	T/C 2U
Vascular wound I and D	T/C 2U
Carotid vascular	T/S
AV fistula	T/S
Peripheral endovascular	T/S
Angio/Arteriogram	No Sample
Peripheral wound I&D	No Sample
1st rib resection/thoracic outlet	No Sample
Superficial or skin	No Sample
Foot/toe amputation/debride	No Sample
Central venous access	No Sample

If the procedure you are looking for is not on this list, then choose the procedure that most closely resembles that procedure.

***Emergency Release blood is available for ALL cases, and carries a risk of minor transfusion reaction of 1 in 1,000 cases.**

Fig. 4. The surgical blood order schedule that has been implemented at Johns Hopkins Hospital. These recommended preoperative blood orders are derived from data in appendix 1, and are specific to our institution. ACDF = anterior cervical discectomy/fusion; AICD = automated implantable cardiac defibrillator; AP = anterior-posterior; AV = arterial-venous; CABG = coronary artery bypass grafting; CSF = cerebral-spinal fluid; D&C = dilatation and curettage; D&E = dilatation and evacuation; EGD = esophagogastroduodenoscopy; FOB = fiberoptic bronchoscopy; GI = gastrointestinal; GYN = gynecological; I and D = incision and drainage; Lap = laparoscopic; No sample = no type and screen or type and crossmatch needed; Rec = recommendation; RRP = radical retropubic prostatectomy; T/C = type and crossmatch; T/S = type and screen; TURBT = transurethral bladder tumor; TURP = transurethral prostatectomy; U = units of erythrocytes; VATS = video-assisted thoracoscopic surgery.