Evaluation of the Effectiveness of Preoperative Blood Ordering Guideline in Elective Spine, Knee Replacement, and Hip Replacement Surgery

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Background: *Preoperative blood ordering is necessary in most of the major orthopedic operations. However, over-crossmatching 200 units/day results in technician workload and compromises blood stock for other patients at Siriraj Hospital.*
Objective: *To evaluate the effectiveness of a new blood ordering guideline in spine and arthroplasty surgery at Siriraj Hospital by comparing the quantity of blood ordering between pre-guideline and guideline groups.*
Material and Method: *The guideline was developed from data of 456 patients who underwent spine or arthroplasty surgery between January 2013 and December 2013 at Siriraj Hospital. To evaluate the effectiveness of the guideline, blood order, and use in 89 patients who received specific orthopedic surgical procedures between December 2014 and March 2015 were compared to blood order and use in pre-guideline patients.*
Results: *Five hundred forty five patients were included. Mean age of subjects was 58 years and 71.49% were females. Mean cross-matched units between the pre-guideline group (1.81 units; 95% CI 1.70 to 1.92) and the guideline group (1.34 units; 95% CI 1.13 to 1.55) was significantly different ($p<0.001$).*
Conclusion: *The blood ordering guideline does increase effectiveness of preoperative blood reservation, reduce unnecessary cost, and does not compromise patient safety. Consistent use and frequent evaluation of this guideline are encouraged.*

Keywords: *Blood transfusion, Blood grouping and crossmatching, Blood loss, Surgical, Orthopedic procedures, Length of stay*

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The majority of major orthopedic procedures result in significant blood loss and blood transfusion is required. Previous investigators found that an unacceptably high proportion of preoperatively ordered blood was not utilized, resulting in the loss of those blood components[1-3].

Between 2011 and 2012, many units of packed red cells (PRC) went unused daily at Siriraj Hospital, especially PRC group O (200 to 250 units/day). For all blood groups, a range of between 2,638 to 3,379 units were requested monthly, but only 817 to 1,133 of these units were transfused. This translated into a crossmatching to transfusion ratio (C:T ratio) of 3.7.

In order to reduce excessive blood ordering, crossmatching workload, and wastage due to out-dating of blood component, guidelines for preoperative blood ordering (maximum surgical blood order schedule: MSBOS) have been developed and implemented in several institutions[4-10]. However, our institution and our department have never set up the preoperative blood ordering guideline for orthopedic procedures. Hence, the amount of blood ordered for spine and joint replacement surgery is varied in wide range (Table 1)

Table 1. Blood ordered for spine and joint replacement surgery before implementation of the guideline

Operations	Number of blood ordered
1 or 2 level ACDF	PRC 0 to 2 units
1 or 2 level PLF	PRC 0 to 2 units
PSF (scoliosis)	PRC 1 to 3 units
TKA	PRC 1 to 2 units
Hemiarthroplasty of the hip	PRC 1 to 3 units
THA	PRC 1 to 4 units

ACDF = anterior cervical discectomy and fusion; PLF = posterolateral fusion; PSF = posterior spinal fusion; PRC = packed red cells; TKA = total knee arthroplasty; THA = total hip arthroplasty

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and this might be an important cause of over-crossmatching.

Therefore, we established a blood ordering guideline for commonly performed orthopedic surgical procedures. Accordingly, the objective of this study was to evaluate the effectiveness of a new blood ordering guideline in spine and arthroplasty surgery at Siriraj Hospital by comparing blood ordering and use between pre-guideline and guideline groups.

Material and Method

The guideline (Table 2) evaluated in this study was developed from data gathered from medical charts of 456 patients who underwent spine or arthroplasty surgery between January 2013 and December 2013 at Siriraj Hospital, Thailand's largest university-based national tertiary care center. The protocol for this study was approved by the Siriraj Institutional Review Board (SIRB).

Elective cases of primary 1 or 2 level anterior cervical discectomy and fusion, 1 or 2 level posterior lumbar fusion, posterior fusion in scoliosis, total knee arthroplasty, total hip arthroplasty, and hemiarthroplasty was included. Patients having any one or more of the following criteria were excluded: the American Society of Anesthesiologists (ASA) physical status III, IV; revision surgery; and/or associated trauma or tumor condition. We analyzed all relevant clinical data, especially blood units ordered, blood units used, and excess blood units. Opinions of each subspecialty staff were also collected and analyzed. All relevant data were presented in a faculty meeting for the purpose of establishing a departmental consensus before implementing the guideline.

To evaluate the effectiveness of the guideline, blood order and use data of 89 patients who received specific orthopedic surgical procedures between December 2014 and March 2015 were compared to blood order and use data of pre-guideline patients.

Table 2. Pre-operative blood ordering guideline

Operations	Recommended blood order
1 or 2 level ACDF	Type & screen
1 or 2 level PLF	Type & screen
PSF (scoliosis)	PRC 2 units
TKA	None
Hemiarthroplasty of the hip	PRC 2 units
THA	PRC 2 units

Sample size was calculated using data from previous study and our pilot study, with a sample size result of 89 patients per group. Two groups were compared, as follows: group 1, consisting of 456 patients who received orthopedic procedures during the pre-implementation period; and group 2, consisting of 89 patients who received orthopedic procedures in which the new blood ordering guideline was used.

Data were analyzed using SPSS Statistic version 18 (SPSS Inc., Chicago, IL, USA) and reported using descriptive statistics, including mean and 95% confidence interval, variance, and range. Student's t-test, Mann-Whitney U test, and Chi-square test were used to compare continuous and categorical data, respectively. A *p*-value of less than 0.05 was regarded as being statistically significant.

The calculated indices include a crossmatch to transfusion ratio (C:T ratio), transfusion probability (%T) and transfusion index (Ti), all of which were used to develop the blood ordering guideline.

The C:T ratio represents proper crossmatching and usage:

$$\text{C:T ratio} = \frac{\text{Number of units crossmatched}}{\text{Number of units transfused}}$$

The transfusion probability represents significant blood usage for an operation:

$$\text{Transfusion probability (\%T)} = \frac{\text{Number of patients transfused} \times 100}{\text{Number of patients crossmatched}}$$

The transfusion index represents the average number of units of blood for a procedure.

$$\text{Transfusion index (Ti)} = \frac{\text{Number of units transfused}}{\text{Number of patients crossmatched}}$$

A realistic objective for C:T ratio is between 1 and 2. A C:T ratio <2.0 and Ti >0.5 are considered to be indicative of significant blood utilization, and transfusion probability >30 is considered to be indicative of significant blood usage.

General criteria for the transfusion of RBCs in this study consisted of any one or more of the followings[11-13].

1. Hemoglobin <8 g/dl in an otherwise healthy patient
2. Hemoglobin <11 g/dl in patients with increased risk of ischemia
3. Acute blood loss, as evidenced by any one of the following:
   - Decrease in blood volume by ≥15%
   - Diastolic blood pressure <60 mmHg
   - Systolic blood pressure decrease >30 mmHg
   - Tachycardia
   - Oliguria

4. Symptomatic anemia resulting in tachycardia, mental status changes, cardiac ischemia, orthostatic dizziness, or dyspnea.

Results

Five hundred forty five patients were included in this study. These patients underwent any one of six common elective orthopedic surgical procedures at Siriraj Hospital.

There were no statistically significant differences between the pre-guideline and guideline groups for epidemiology or patient characteristics, including gender, age, body weight, height, preoperative hematocrit, preoperative platelet, operative time, estimated blood loss, and postoperative hematocrit. Although hospital length of stay was significantly different between groups, no clinical difference was observed (Table 3). Mean crossmatched units between the pre-guideline group (1.81 units; 95% CI 1.70 to 1.92) and the guideline group (1.34 units; 95% CI 1.13 to 1.55) was significantly different ($p<0.001$).

No statistically significant difference was observed for mean inadequate crossmatched units between groups ($p = 0.67$). Inadequate crossmatching was mostly attributed to prolonged operation and uncontrolled bleeding. There were no complications that resulted from inadequate blood ordering. Of the 545 included patients, 89 (16.3%) patients were treated using the new blood management guideline (Table 4) and 74% of 89 patients were followed the guideline.

Discussion

The results of this study showed a significant reduction in reserved blood using the new blood ordering guideline, with an average decrease of 0.5 unit/patient. In addition to decreased waste of blood components, the costs associated with preparation of unneeded blood were also reduced. Of the 456 patients in the pre-guideline group, 339 patients (74%) had preoperative crossmatched units that exceeded the number prescribed in the guideline. The number of units ordered in excess of the guideline was 329. At an estimated cost of 570 THB per unit, the estimated loss or potential savings was 187,530 THB. Translated another way, a reduction in the use of those 329 units makes this invaluable and lifesaving resource available for use by other patients.

Table 3. Demographic and clinical data of study participants

Parameters	Group 1: before guideline (n = 456)	Group 2: after guideline (n = 89)	*p*-value
Gender (%)			
Male	28.51	32.58	0.439
Female	71.49	67.42	
Age (year)	59.30	50.14	0.171
Weight (kg)	50.69	51.85	0.585
Height (cm)	154.72	154.77	0.835
Hematocrit (%)	35.05	36.76	0.813
Platelet (cell/mm^3)	270,814	302,954	0.632
Pre-transfusion hematocrit (%)	26.74	27.20	0.693
Estimate blood loss (ml)	824.63	704.32	0.160
Operative time (hour)	2.38	3.23	0.930
Length of stay	11.39	9.59	0.038

Data presented as mean; Gender tested by Pearson's Chi-square test; Age, Height, Platelet, Estimate blood loss, Operative time, and Length of stay tested by Mann-Whitney U test; Weight, Hematocrit, and Pre-transfusion hematocrit tested by independent t-test

Table 4. Blood ordered and blood used before and after implementation of the new guideline

Parameters	Group 1: before guideline (n = 456)	Group 2: after guideline (n = 89)	*p*-value*
Crossmatching (unit)	1.812	1.340	0.001
Transfusion (unit)	0.280	0.430	0.059
Inadequate crossmatching (unit)	0.035	0.023	0.671

Data presented as mean; * *p*-value calculated using Mann-Whitney U test

It is a standard practice in orthopedic surgery, as in other surgical specialties, to order typing and crossmatching of blood for elective surgical procedures. The purpose of crossmatching is to have blood readily available for any remote possibility of serious intra-operative bleeding. Upon receiving a request for cross matching of blood for a certain number of units, a blood bank technologist first determines the patient's blood type (ABO and Rh). Next, the patient's serum is incubated with a panel of red cells containing most of the common red cell antigens to screen the patient's serum for presence of any irregular antibodies. The last step is the actual crossmatching procedure in which the patient's serum is incubated with donor red cells to test compatibility by ensuring complete absence of red cell agglutination or hemolysis. Once the requested units are crossmatched for a specific patient, those units are reserved and are not available for any other patient until the requesting physician releases the blood or the reserved status period exceeds the maximum allowable time established by the blood bank (usually 24 to 48 hours). If blood is not used, it may become outdated during this holding period.

For the type and screen (T&S) procedure, the patient's blood is typed (ABO and Rh) and the serum is screened for antibodies; however, the last crossmatching step (incubating patient's serum with donor's red cells) is not performed. The blood bank maintains an inventory of type-specific units (also screened for antibodies) to cover anticipated needs. As such, if blood is required, a type-specific unit is immediately available from the blood bank. For T&S processed blood products, no specific units are held in reserve for any specific patient, thus allowing this blood supply to be available to any patient who needs it. The T&S procedure can be substituted for routine crossmatching for a large number of elective surgical procedures for which blood is seldom used[14-17].

The blood ordering guideline evaluated in this study was based on data that described how much blood had been historically used in a specific procedure. That data was then used to guide how much blood should be crossmatched preoperatively for the same procedure in future procedures. For procedures that only rarely require stand-by blood, T&S is recommended. Type-compatible blood and screened blood are both safe from risk of incompatible transfusion. Based on the results of this study, implementation of a preoperative blood ordering guideline is likely to reduce excessive crossmatching and outdating of blood. Implementation of this protocol will also have other carry-over benefits like decreased patient care costs, reduced technician workload, and improved preservation and availability of blood, a limited and essential lifesaving clinical resource. This guideline is recommended for implementation among primary and secondary healthcare centers to the extent that it can be managed safely and compatibly in each center.

Conclusion

The new blood ordering guideline has increased the effectiveness, efficiency, and accuracy of preoperative blood ordering. This guideline also reduces unnecessary costs without compromising patient safety. Consistent use and frequent evaluation of this guideline are encouraged. However, this guideline is not recommended for use in the following settings or conditions: patients with ASA physical status III-IV, revision surgery, associated trauma, or tumor condition.

What is already known on this topic?

Guidelines for preoperative blood ordering (MSBOS) can reduce excessive blood ordering, crossmatching workload and wastage due to out-dating of blood component.

What this study adds?

The guideline can be successfully implemented in the teaching hospital and tertiary healthcare center. Consistent use and frequent evaluation of this guideline are crucial.

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Potential conflicts of interest

None.

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การศึกษาประสิทธิภาพของการใช้แนวปฏิบัติสำหรับการจองเลือดเพื่อการผ่าตัดกระดูกสันหลัง และการผ่าตัดเปลี่ยนข้อเข่าและข้อสะโพกเทียม

สุระ นริสศิริกุล, สุรินทร์ ธนพิพัฒนศิริ, บวรรัฐ วนดุรงค์วรรณ

ภูมิหลัง: *การผ่าตัดใหญ่ทางออร์โธปิดิกส์ส่วนใหญ่จำเป็นต้องเตรียมเลือดเพื่อให้ทดแทนการเสียเลือดระหว่างการผ่าตัดและหลังผ่าตัด การจองเลือดไว้จำนวนมากเกินความจำเป็นทำให้เกิดค่าใช้จ่ายสูญเปล่าในการเตรียมเลือด และจำนวนเลือดสำรองสำหรับจัดสรรให้แก่ผู้ป่วยที่จำเป็นรายอื่นมีน้อยลงหรือขาดแคลน*

วัตถุประสงค์: *เพื่อศึกษาประสิทธิภาพของการใช้แนวทางปฏิบัติสำหรับการจองเลือดเพื่อการผ่าตัดกระดูกสันหลัง การผ่าตัดเปลี่ยนข้อเข่าและการผ่าตัดเปลี่ยนข้อสะโพก โดยเปรียบเทียบความแตกต่างของจำนวนเลือดที่จองแต่ไม่ได้ใช้ในผู้ป่วยที่มารับการผ่าตัดระหว่างกลุ่มที่อาศัยแนวทางและไม่อาศัยแนวทางการจองเลือด*

วัสดุและวิธีการ: *ศึกษาข้อมูลในผู้ป่วยที่รับการผ่าตัดกระดูกสันหลังระดับคอหรือเอว เพื่อแก้ไขการกดทับของเส้นประสาทและไขสันหลัง รวมถึงผ่าตัดแก้ไขกระดูกสันหลังคดชนิดไม่ทราบสาเหตุ การผ่าตัดเปลี่ยนข้อเข่าเทียมแบบทั้งข้อ การผ่าตัดเปลี่ยนข้อสะโพกเทียมแบบทั้งข้อและบางส่วน โดยแบ่งเป็นกลุ่มผู้ป่วยที่ได้รับการผ่าตัดก่อนนำเสนอแนวทางการจองเลือด มีจำนวนผู้ป่วยที่สอดคล้องกับเงื่อนไขของการศึกษา 456 ราย และกลุ่มผู้ป่วยที่ได้รับการผ่าตัดภายหลังนำเสนอแนวทางการจองเลือดมีจำนวน 89 ราย ทำการเก็บข้อมูลทั้งสองกลุ่มมาวิเคราะห์ทางสถิติ*

ผลการศึกษา: *ผู้ป่วยทั้งสองกลุ่มไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติในเรื่องเพศ อายุ น้ำหนัก ส่วนสูง ระดับความเข้มข้นเลือดก่อนผ่าตัด ปริมาณเลือดที่สูญเสียระหว่างการผ่าตัด และระยะเวลาผ่าตัด(operative time) พบว่าการจองเลือดแบบ blood grouping and crossmatching (G/M) หลังใช้แนวทางการจองเลือดมีค่าเฉลี่ย 1.34 ยูนิตต่อราย (95% CI = 1.13-1.55) ซึ่งลดลงอย่างมีนัยสำคัญทางสถิติ (p = 0.001) เมื่อเปรียบเทียบกับก่อนใช้แนวทางการจองเลือดที่มีการจองเลือดแบบ G/M เฉลี่ย 1.81 ยูนิตต่อราย (95% CI = 1.70-1.92) โดยที่จำนวนเลือดที่จองไว้ก่อนผ่าตัดไม่เพียงพอของทั้งสองกลุ่มไม่แตกต่างกันอย่างมีนัยสำคัญทางสถิติ (p = 0.67) และผู้ป่วย 339 ราย จาก 456 ราย ของผู้ป่วยกลุ่มแรกมีการจองเลือดมากเกินกว่าจำนวนของแนวทางการจองเลือด 329 ยูนิต ทำให้สูญเสียค่าใช้จ่ายที่ไม่จำเป็น 187,530 บาท และจำนวนเลือดสำรองสำหรับจัดสรรให้แก่ผู้ป่วยที่จำเป็นรายอื่นมีน้อยลงหรือขาดแคลน*

สรุป: *การนำแนวทางการจองเลือดมาใช้ทำให้เพิ่มประสิทธิภาพการจองเลือด และมีความปลอดภัย และต้องอาศัยความร่วมมือของทีมผู้ให้การรักษา พร้อมกับการประเมินผลเป็นระยะ ๆ ต่อไป*