# Blood Utilization for Elective Orthopaedic Surgeries at Maharat Nakhon Ratchasima Hospital

**Jumpotpong Wong-Aek, MD, Supphamard Lewsirirat, MD, Urawit Piyapromdee, MD**

*Department of Orthopaedic Surgery, Maharat Nakhon Ratchasima Hospital,*

*Nakhon Ratchasima, Thailand*

---

***Background:*** *Elective orthopaedic surgeries incur unavoidable blood loss and may need blood replacement. Over preoperative blood requesting results in unnecessary crossmatching.*
***Aim:*** *To audit blood ordering and utilization in elective orthopaedic surgeries at Maharat Nakhon Ratchasima hospital for a one year period and recommend guidelines for blood orders.*
***Materials and Methods:*** *A 1 year retrospective analysis of patients who underwent elective orthopaedic surgeries. Patients' age, sex, type of operative procedure, pre- and postoperative hematocrit (Hct) levels, number of units crossmatched, transfusion, crossmatch to transfusion ratio (C:T), transfusion probability, transfusion indices, and the actual and predicted fall in Hct were reviewed and a blood ordering schedule proposed based on a surgical blood ordering equation.*
***Results:*** *1,417 patients underwent 25 kinds of elective orthopaedic procedures. 1987 units of blood were cross-matched, but only 296 units were transfused. Transfusions were never used in seven procedures. All of the 25 procedures had C:T >2.0. Nineteen of the 25 procedures had transfusion probabilities of <30 percent. Twenty from 25 procedures had a low transfusion index (Ti<0.5). The results demonstrated that the majority of preoperative blood orders were unnecessary. Seven of the 25 elective surgical procedures did not require preoperative blood orders. This study recommends blood ordering guidelines based on patients and surgical variables which leads to the maximum utilization of blood.*

***Key words:*** *blood ordering schedule, elective orthopaedic surgeries, surgical blood ordering equation, blood utilization*

***The Thai Journal of Orthopaedic Surgery: 39 No.1-2: 17-24***
***Full text. e journal:*** *http://www.rcost.or.th, http://thailand.digitaljournals.org/index.php/JRCOST*

---

## Introduction

Many elective orthopaedic surgeries often inevitably lead to excess blood loss during the procedure which as a result requires transfusion. The Orthopaedic Department at Maharat Nakhon Ratchasima Hospital has many elective surgeries as well as blood ordering. In the year 2012, the amount of cross-matched blood was 9,324 units[1], but the number of units transfused was only 3,180 units (30 percent) and the cost of this was around 7,372,800 baht. The preoperative assessment of blood requirements is often an over assumption as shown by blood bank registers. The consequences of such misuse include the outdating of blood, overburdening of blood bank personnel, depletion of blood bank resources, and wastage of time.

Many hospitals experience over blood ordering in which high cross-matched to transfusion ratios (C:T ratio) are more than 2.0 to 97.56 percent[2-7]. The guidelines for proper cross-matched blood ordering for surgeons (maximum surgical blood order schedule: MSBOS) can decrease costs by around 60 percent[8,9], the C:T ratio will reduce from 3.6 to 2.6[10-13], and it will also reduce the work load for the blood bank which as a result gives benefits for emergency conditions.

The maximum surgical blood ordering schedule (MSBOS) is the list of common elective surgical procedures for which the maximum number of units of blood are cross-matched preoperatively for each procedure[14,15]. It is designed to help surgeons to order enough blood for patients for each operation with 85 percent–90 percent accuracy. Although MSBOS has improved the efficiency of blood utilization, there are also certain drawbacks. The most significant drawback is the absence of accountability for individual differences in transfusion requirements between different persons undergoing the same surgical procedure[16].

The surgical blood ordering equation (SBOE) is calculated using incorporating patient and surgical variables, such as pre- and

*Correspondence to: Lewsirirat S, Department of Orthopaedic surgery, Maharat Nakhon Ratchasima hospital, Nakhon Ratchasima, 30000, Thailand*
*E-mail: supphamard@hotmail.com*

postoperative hematocrit (Hct) levels of the patient and the amount of surgical blood loss during each surgical procedure[17,18]. Surgical teams can develop the transfusion system and set transfusion limits by using the SBOE.

Hence, this study aims to improve the efficiency of blood utilization in the trauma care blood bank and reduce unnecessary cross-matching. The primary objective is to audit the blood utilization in elective orthopaedic surgeries and to recommend a blood ordering schedule.

## Materials and Methods

The medical records of patients who underwent elective orthopaedic surgeries were reviewed. A retrospective analysis of data for a period of 1 year from January to December 2012 was performed. Data of the patient age < 15 yrs, patients with hematologic disease and pre-operative Hct below 30 percent, and patients who underwent multiple operations were excluded.

Patient and surgical parameters include age and gender, type of surgical procedure, pre- and postoperative Hct levels, estimated blood loss for each surgical procedure, and the predicted fall in Hct. The transfusion parameters, such as the number of units transfused and crossmatched, were collected. The calculated indices include the cross-match to transfusion ratio (C:T ratio), transfusion probability (%T), and transfusion index (Ti).

***C:T ratio***

$$= \frac{\text{Number of units cross matched}}{\text{Number of units transfused}}$$

The C:T ratio represents proper cross-matching and usage.

***Transfusion probability (%T)***

$$= \left\{\frac{\text{Number of patients transfused}}{\text{Number of patients cross-matched}}\right\} \times 100$$

The transfusion probability represents significant blood usage for an operation.

***Transfusion index (Ti)***

$$= \frac{\text{Number of units transfused}}{\text{Number of patients cross-matched}}$$

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

A realistic objective for C:T ratio is between 1:1 and 2:1. A C:T ratio < 2.0 and Ti > 0.5 is considered as indicative of significant blood utilization, and %T > 30 is considered as indicative of significant blood usage[19-22].

These parameters are used to calculate a blood ordering schedule using the SBOE. Many such SBOEs are in use; however, this study calculated blood ordering to create a guideline by using an equation modified from Nuttall et al[23,24] for the purpose of simplicity.

***Number of packed red blood cell units required***

$$= \frac{[\text{predicted Hct fall}(\%) - \text{patient Hct capacity}(\%)]}{3}$$

The predicted Hct fall is calculated based on the amount of blood lost during each surgical procedure and in the first 24 hour postoperative period to reduce the risk of severe blood loss and developing shock after surgery, assuming by the difference between preoperative and postoperative Hct that is taken at 24 hours post-surgery. The difference in the mean preoperative and mean postoperative Hct levels of the patients for each procedure gives the predicted Hct fall for any surgical procedure. The patient's Hct capacity is calculated based on postoperative Hct which should not be less than the normal threshold at 33 percent[25], so the differential between preoperative Hct and 33 is a capacity of the amount of blood loss from the surgical procedure. For example, the preoperative Hct is 36, so the capacity of the amount of blood loss from the surgical procedure is 3 percent. If the predicted Hct fall is 6 percent, the number of packed red blood cell (PRC) units required = [6 – 3]/3 which equals one unit.

## Result

A total of 1,417 patients were included in this study with 1,065 patients cross-matched. These patients underwent 25 common different elective procedures of orthopaedic surgery at Maharat Nakhon Ratchasima hospital. There were 646 males (60.7 percent) and 419 females (39.4 percent). The mean age was 46.9 years old. Out of the total 1,987 PRC units crossmatched from 1,065 cases, only 296 units (14.9 percent) were transfused to 243 patients. This means 85.1 percent of the total crossmatched units were not transfused. The number of patients and units cross-matched and transfused is tabulated in Table 1.

A majority of the patients (75.2 percent) underwent elective operations with cross-matching (1,065 patients cross-matched from 1,417 cases). The C:T ratio, transfusion probability, and transfusion index were formulated for each of the elective procedures and are shown in Table 2.

The overall C:T ratio was 6.7 (1,987/296 units). Seven out of the 25 elective procedures namely, lumbar discectomy, forearm and ankle plating, patella tension band wiring (TBW), below knee amputation (BKA), knee, and shoulder arthroscopy never had blood transfused and these cannot be used to calculate the C:T ratio. None of the 25 elective procedures had C:T ratio < 2; the lowest C:T ratio was for posterolateral interbody fusion (PLIF) with a C:T ratio of 2.3. The highest C:T ratio was for anterior cervical discectomy and fusion (ACDF) with a C:T ratio of 61.5.

The overall transfusion probability was only 22.8 percent. There were eight procedures with significant blood usage in which the transfusion probability was > 30 percent, namely posterior lumbar fusion (PLF) 1-2 levels, PLF 3-4 levels, PLIF 1-2 levels, PLIF 3-4 levels, femoral cephalomedullary nailing, femoral plating, acetabular fixation, and distal femoral plating. However, the transfusion index was > 0.5 in PLF 3-4 levels, PLIF 1-2 levels, PLIF 3-4 levels, acetabulum fixation, and distal femoral plating.

Many elective operations were performed with meticulous care of bleeding or were quickly completed and so resulted in minimal or uncountable blood loss during surgery. However, postoperative bleeding is unavoidable and may cause the fall in postoperative Hct until a need for blood infusion was necessary after surgery. The amount of Hct loss between preoperative and postoperative measurements of each procedure was calculated in Table 3.

There is an accepted guideline for postoperative infusions at Maharat Nakhon Ratchasima Hospital to infuse blood if Hct drops below 30 percent[25]. The predicted Hct fall is indicated the blood consumption and it should be the amount of units of blood prepared for a procedure and can be a protocol for preoperative cross-matched or surgical blood operative schedules (SBOS). However, patients with Hct levels which are high preoperatively and remain normal after the surgery was performed do not need the blood infusion and the preoperative cross-matching is wasted. Therefore, if the difference between preoperative Hct and the predicted Hct fall was more than 30 percent the preoperative cross-matching is unnecessary. The SBOS was drafted based on the SBOE. When the number of units calculated is less than 0.9 units, a type and screen (T&S) policy is recommended. When it is more than 0.9 units, the number of PRC units is rounded off to the nearest integer. The Hct capacity, predicted Hct loss, and the SBOS are tabulated in Table 4.

**Table 1** Blood cross-matched and transfusion patterns for different elective orthopedic surgeries

| Operation Type | Patients(n) | Crossmatched | | Transfused | |
|---|---|---|---|---|---|
| | | Patients(n) | Units(n) | Patients(n) | Units(n) |
| Anterior cervical discectomy and fusion 1 level | 42 | 42 | 87 | 2 | 2 |
| Anterior cervical discectomy and fusion 2 levels | 14 | 14 | 27 | 0 | 0 |
| Anterior cervical discectomy and fusion 3 levels | 4 | 4 | 9 | 0 | 0 |
| Corpectomy | 10 | 10 | 21 | 2 | 2 |
| Lumbar discectomy | 48 | 48 | 66 | 0 | 0 |
| Posterior lumbar fusion 1-2 levels | 73 | 73 | 147 | 23 | 26 |
| Posterior lumbar fusion 3-4 levels | 40 | 40 | 103 | 24 | 35 |
| Posterior lumbar interbody fusion 1-2 levels | 23 | 23 | 56 | 14 | 23 |
| Posterior lumbar interbody fusion 3-4 levels | 5 | 5 | 14 | 4 | 6 |
| Arthroscopic knee | 105 | 2 | 2 | 0 | 0 |
| Arthroscopic shoulder | 12 | 1 | 0 | 0 | 0 |
| Total hip arthroplasty | 92 | 92 | 182 | 27 | 31 |
| Total knee arthroplasty | 91 | 91 | 182 | 5 | 5 |
| Hip hemiarthroplasty | 68 | 68 | 136 | 20 | 22 |
| Plate and screw humerus | 30 | 30 | 49 | 8 | 11 |
| Plate and screw forearm | 170 | 48 | 63 | 0 | 0 |
| Multiple screw neck femur | 12 | 12 | 17 | 1 | 1 |
| Dynamic hip screw | 80 | 79 | 146 | 18 | 18 |
| Cephalomedullary nail femur | 61 | 61 | 115 | 21 | 22 |
| Intramedullary nail femur | 56 | 56 | 111 | 15 | 20 |
| Kuncher nail femur | 8 | 8 | 16 | 1 | 1 |
| Distal plate femur | 22 | 22 | 53 | 15 | 18 |
| Plate and screw femur | 72 | 72 | 150 | 27 | 31 |
| Intramedullary nail tibia | 65 | 48 | 56 | 4 | 4 |
| Plate and screw tibia | 92 | 61 | 88 | 4 | 4 |
| Plate and screw ankle | 62 | 18 | 21 | 0 | 0 |
| Acetabulum fixation | 15 | 15 | 44 | 8 | 14 |
| Patella tension band wiring | 37 | 10 | 13 | 0 | 0 |
| Below knee amputation | 8 | 12 | 13 | 0 | 0 |
| **Total** | **1,417** | **1,065** | **1,987** | **243** | **296** |

**Table 2** Blood utilization for different elective orthopedic operations

| Operation Type | C:T ratio | %T | Ti |
|---|---|---|---|
| Anterior cervical discectomy and fusion | 61.5 | 3.3 | 0.03 |
| Corpectomy | 11 | 20 | 0.2 |
| Lumbar discectomy * | - | - | - |
| Posterior lumbar fusion 1-2 | 5.7 | 31.5 | 0.36 |
| Posterior lumbar fusion 3-4 | 2.9 | 60 | 0.88 |
| Posterior lumbar interbody fusion 1-2 | 2.4 | 60.8 | 1 |
| Posterior lumbar interbody fusion 3-4 | 2.3 | 80 | 1.2 |
| Arthroscopic knee * | - | - | - |
| Arthroscopic shoulder * | - | - | - |
| Total hip arthroplasty | 5.9 | 29.3 | 0.34 |
| Total knee arthroplasty | 36 | 5.49 | 0.05 |
| Hip hemiarthroplasty | 6.2 | 29.4 | 0.32 |
| Plate and screw humerus | 4.5 | 26.7 | 0.37 |
| Plate and screw forearm * | - | - | - |
| Multiple screw neck femur | 17 | 8.3 | 0.08 |
| Dynamic hip screw | 8.1 | 22.8 | 0.22 |
| Cephalomedullary nail femur | 5.2 | 34.4 | 0.36 |
| Intramedullary nail femur | 5.6 | 26.8 | 0.36 |
| Kuncher nail femur | 16 | 12.5 | 0.13 |
| Distal plate femur | 2.9 | 68.2 | 0.82 |
| Plate and screw femur | 4.8 | 37.5 | 0.43 |
| Intramedullary nail tibia | 14 | 8.33 | 0.08 |
| Plate and screw tibia | 22 | 6.55 | 0.07 |
| Plate and screw ankle * | - | - | - |
| Acetabulum fixation | 3.1 | 53.3 | 0.93 |
| Patella tension band wiring * | - | - | - |
| Below knee amputation * | - | - | - |

*Packed red blood cells (PRC) was not transfused in this procedure

**Table 3** Predicted hematocrit loss for different orthopaedic procedures

| Type of surgery | Predicted hematocrit loss (percent) |
|---|---|
| Plate and screw forearm | 0.47 |
| Plate and screw ankle | 0.4 |
| Patella tension band wiring | 0.4 |
| Multiple screw neck femur | 1.95 |
| Plate and screw tibia | 2.31 |
| Below knee amputation | 1.57 |
| Dynamic hip screw | 3.37 |
| Cephalomedullary nail femur | 2.91 |
| Plate and screw humerus | 3.53 |
| Intramedullary nail femur | 3.7 |
| Intramedullary nail tibia | 3.63 |
| Distal plate femur | 5.14 |
| Plate and screw femur | 5.31 |
| Kuncher nail femur | 6.28 |
| Acetabulum fixation | 7.28 |
| Arthroscopic shoulder | 0.3 |
| Arthroscopic knee | 0 |
| Anterior cervical discectomy and fusion | 1.99 |
| Lumbar discectomy | 2.12 |
| Total knee arthroplasty | 3.18 |
| Hip hemiarthroplasty | 3.01 |
| Corpectomy | 4.06 |
| Total hip arthroplasty | 5.57 |
| Posterior lumbar fusion 1-2 | 4.65 |
| Posterior lumbar interbody fusion 1-2 | 7.85 |
| Posterior lumbar fusion 3-4 | 7 |
| Posterior lumbar interbody fusion 3-4 | 12.24 |

**Table 4** Predicted hematocrit loss and surgical blood ordering schedule

| Type of surgery | Predicted Hct loss | Preoperative hematocrit (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| Plate and screw forearm | - | - | - | - | - | - | - | - | - | - | - | - |
| Plate and screw ankle | - | - | - | - | - | - | - | - | - | - | - | - |
| Patella tension band wiring | - | - | - | - | - | - | - | - | - | - | - | - |
| Arthroscopic shoulder | - | - | - | - | - | - | - | - | - | - | - | - |
| Arthroscopic knee | - | - | - | - | - | - | - | - | - | - | - | - |
| Multiple screw neck femur | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S | T&S | T&S | T&S |
| Plate and screw tibia | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S | T&S | T&S | T&S |
| Below knee amputation | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S | T&S | T&S | T&S |
| Anterior cervical discectomy and fusion | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S | T&S | T&S | T&S |
| Lumbar discectomy | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S | T&S | T&S | T&S |
| Dynamic hip screw | 3 | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S | T&S | T&S |
| Cephalomedullary nail femur | 3 | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S | T&S | T&S |
| Total knee arthroplasty | 3 | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S | T&S | T&S |
| Hip hemiarthroplasty | 3 | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S | T&S | T&S |
| Plate and screw humerus | 4 | 2 | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S | T&S |
| Intramedullary nail femur | 4 | 2 | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S | T&S |
| Intramedullary nail tibia | 4 | 2 | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S | T&S |
| Corpectomy | 4 | 2 | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S | T&S |
| distal plate femur | 5 | 2 | 2 | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S |
| Plate and screw femur | 5 | 2 | 2 | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S |
| Posterior lumbar fusion 1-2 | 5 | 2 | 2 | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S | T&S |
| Kuncher nail femur | 6 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S |
| Total hip arthroplasty | 6 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | T&S | T&S | T&S | T&S |
| Acetabulum fixation | 7 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | T&S | T&S | T&S |
| Posterior lumbar interbody fusion 1-2 | 7 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | T&S | T&S | T&S |
| Posterior lumbar fusion 3-4 | 8 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | T&S | T&S |
| Posterior lumbar interbody fusion 3-4 | 12 | 5 | 4 | 4 | 4 | 3 | 3 | 3 | 2 | 2 | 2 | 1 |

## Discussion

Blood is a valuable commodity and its proper usage certainly promotes the management efficiency of the blood bank resource and hospital. The results from the present study shows highly improper blood ordering in this hospital according to the overall C:T ratio, transfusion probability, and transfusion index, and that some operations, namely, lumbar discectomy, forearm and ankle plating, patella tension band wiring, below knee amputation, knee, and shoulder arthroscopy, never needed blood infusions at all . So the C:T ratio parameter could not be calculated due to dividing by zero.

Many operative procedures in this study have a low risk for intraoperative bleeding because of the use of a tourniquet for bleeding control, but bleeding still might continue in the postoperative period. Therefore, the surgeons cannot predict the necessary preoperative cross-matching because the surgeons might not have the estimate data for the amount of blood to be used or blood loss which leads to improper blood ordering. The elective orthopedic procedures in which the tourniquet was used intraoperatively, but still had a postoperative Hct loss of more than 3 percent were total knee arthroplasty and intramedullary nailing tibia. However, these procedures showed the insignificant blood usage with transfusion probabilities of 5.49 and 8.33, respectively.

There are some operative procedures in which the tourniquet cannot be used. The routine preoperative cross-matching without the guideline for this group had never been reviewed and might lead to improper blood ordering. In the present study, none of the 48 patients who underwent lumbar discectomy used any blood that was crossmatched. Also, only 2 ACDF patients recieved infusions out of the total 60 patients.

The operations which used significant amounts of blood as calculated by the transfusion probability were PLIF, PLF, acetabulum fixation, femur and distal femoral plating, and femoral cephalomedullary nailing. Although these procedures had significant blood usage the C:T ratio was still high. It means that the preoperative cross-matching was much higher than what was actually needed. The appropriate blood usage can be achieved by a blood ordering schedule which will result in a decreased fee from unnecessary cross-matching[26,27]. The appropriate blood ordering can be achieved by using guidelines or schedules and many schedules have been developed for this purpose. Bhutia et al.[28] evaluated the preoperative blood ordering and transfusion practices for common elective general surgical procedures and found that 40 percent of the cross-matches performed were unnecessary. Vibhute et al.[19] used MSBOS to analyze the blood evaluation and transfusion practices for 500 elective general surgical procedures. It was shown that MSBOS definitely improved the blood utilization and reduced the wastage rate. However, it does not take into consideration the individual differences in transfusion needs between different patients undergoing the same surgery. The SBOE is created from this concern. The risk factors have been analyzed and found to be useful in predicting blood transfusions[17,18]. Some of them include low preoperative Hb/hematocrit, surgical blood loss, and the type of surgery. This study drafted the schedule which was formulated using the modified SBOE from Nuttall et al.[23] and operations with less bleeding, but the patients had low hematocrit capacity, preoperative cross-matching in this situation might or might not be necessary. The concept of type and screen will then be used by performing grouping and screening antibodies without cross-matching. Type and screen is suggested to be 99 percent effective in preventing incompatible transfusions[29-31]. This is due to the high efficacy of antibody screening in the detection of potentially clinically significant antibodies. According to the American Association of Blood Banks' recommendations[25], if the antibody screening is negative and there are no previous records of detecting such antibodies, serological testing to detect ABO incompatibility is adequate and antiglobulin testing is performed, crossmatching may be skipped. Benefits of a type and screen (T&S) include reduced costs of reagents (used for crossmatching), improved turnaround time, and decreased workload of the laboratory personnel. Most importantly, it helps reduce unnecessary loss of blood supply due to the outdating of blood.

However, the necessity of crossmatched infusions of some patients cannot be achieved by using the ratio. The surgical team needs to assess the need of crossmatching by assessing the rapidity of blood loss and the sign indications of blood loss. However, sometimes it appears that the amount of hematocrit is not high enough to fall into the blood replacement need category. In addition, the use of hematocrit may be varied due to other factors such as dehydration or technical errors in the sample collecting process which can lead to an inaccuracy in the interpretation of the results.

There are many factors that are associated with blood loss during and after each surgical procedure regardless of the kind of procedure. Hence, the results obtained from this study are meant to be a guideline rather than a rule. People associated with the use of this guideline need to determine the appropriateness of its use. Nevertheless, the implementation of such schedules requires a careful assessment of blood utilization practices of the hospital and regular reviews to improve the accuracy of the guideline.

## Conclusion

Blood is a valuable resource. There is the cost associated with the supply and the storage process of blood. An excess ordering of blood burdens in a significant waste of time, resources, and money. However, a proper and an appropriate amount of blood ordering is difficult to determine and there is a significant risk to patients. The assessment of blood ordering and utilization can be performed by a quantitative review and reflected in the form of C:T ratios, transfusion probabilities and transfusion indexes.

If the result is higher than the mean, the surgical team should consider the case because it can lead to an improvement of the utilization. The guideline and the follow up of the guideline's result can lead to a more accurate guideline. This will lead to a reduction in the waste of crossmatching, costs associated with the over ordering of crossmatching and the time consumed in the ordering process of the blood bank. Most importantly, it will reduce the risk of insufficient blood supply for the patient in the necessary situation or emergency surgical procedure.

## References

1. Haswatee S. The blood utilization and usage at Maharat Nakhon Ratchasima hospital. Department of laboratory and blood bank; 2012
2. Prichard RS, O'Keefe M, McLaughlin R, Malone C, Sweeney KJ, Kerin M J. A study of pre-operative type and screen in breast surgery: improved efficiency and cost saving. Ir J Med Sci 2011; 180: 513-6.
3. Gombotz H, Rehak PH, Shander A, Hofmann A. Blood use in elective surgery: the Austrian benchmark study. Transfusion 2007; 47: 1468-80.
4. Chawla T, Kakepoto GN, Khan MA. An audit of blood cross-match ordering practices at the Aga Khan University Hospital: first step towards a Maximum Surgical Blood Ordering Schedule. J Pak Med Assoc 2001; 51: 251-4.
5. Chow E. The impact of the type and screen test policy on hospital transfusion practice. HKMJ 1999; 5: 275-9
6. Palmer T, Wahr JA, O'Reilly M, Greenfield ML. Reducing unnecessary cross-matching: a patient-specific blood ordering system is more accurate in predicting who will receive a blood transfusion than the maximum blood ordering system. Anesth Analg 2003; 96: 369-75.

7. Singh JK, Singh P. Routine pre-operative cross-match for elective colorectal resections: An appropriate use of resources? The Surgeon 2011; 9: 8-12.
8. Voak D, Napier JAF, Boulton FE, Cann R, Finney RD, Fraser ID, et al. British Committee for Standards in haematology blood transfusion task force guidelines for implementation of a maximum surgical blood order schedule. Clin Lab Haematol 1990; 12: 321-7.
9. 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.
10. Komatsu H, Mitsuhata H, Hasegawa J, Matsumoto S. Evaluation of efficacy of maximum surgical blood order schedule (MSBOS) in the operating room. Masui 1992; 41: 914-8.
11. Mahattanobon S, Sunpaweravong S. Blood order guideline for elective surgery: impact of a guideline. Songkla Med J 2008; 26: 491-500.
12. Wanasuwannakul T, Vasinanukorn M, Lim A. Appropriate blood order for elective surgical procedures in Songklanagarind hospital. Thai J Anesthesiol 2005; 31: 271-80.
13. Sakurai Y, Okada C. Comparison by simulation of the efficiency of surgical blood order equation with that of maximum surgical blood order schedule. Masui 2001; 50: 69-75.
14. Friedman BA, Oberdman HA, Chandnick AR, Kingdon KI. The maximum surgical blood order schedule and surgical blood use in United States. Transfusion 1976; 16: 380-7.
15. 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.
16. Murphy WG, Phillips P, Gray A, Heatley L, Palmer J, Hopkins D, et al. Blood use for surgical patients: a study of Scottish hospital transfusion practices. J R Coll Surg Edinb 1995; 40: 10-3.
17. Bierbaum BE, Callaghan JJ, Galante JO, Rubash HE, Tooms RE, Welch RB. An analysis of blood management in patients having a total hip or knee arthroplasty. J Bone Joint Surg Am 1999; 81: 2-10.
18. Use of blood products for elective surgery in 43 European hospitals. The Sanguis Study Group. Transfus Med 1994; 4: 251-68.
19. Vibhute M, Kamath SK, Shetty A. Blood utilization in elective general surgery cases: Requirements, ordering and transfusion practices. J Postgrad Med 2000; 46: 13-4.
20. Guidelines for implementation of a maximum surgical blood order system schedule. The British Committee for Standards in Haematology Blood Transfusion Task Force. Clin Lab Haematol 1990; 12: 321-7.
21. Mead JH, Anthony CD, Sattler M. Hemotherapy in elective surgery: an incidence report, review of literature and alternatives for guideline appraisal. Am J Clin Path 1980; 74: 223-7.
22. Knowles S. Blood transfusion**:** challenges and limitations. TransfusAlternTransfus Med 2007; 9: 2-9.
23. Nuttall GA, Santrach PJ, Oliver WC, Ereth MH, Horlocker TT, Cabanela ME, et al. Possible guidelines for autologous red blood cell donations before total hip arthroplasty based on the surgical blood order equation. Mayo Clin Poc 2000; 75: 10-7.
24. Nuttall GA, Horlocker TT, Santrach PJ, Oliver WC, Dekutoski MB, Bryant S. Use of the surgical blood order equation in spinal instrumentation and fusion surgery. Spine (Phila Pa 1976) 2000; 25: 602-5.
25. Petrides M, Stack G. Practical guide to transfusion medicine. Bethesda, Maryland: American Association of Blood Banks; 2001.
26. ผกาวรรณชนะชัยสุวรรณ. Blood Utilization in Elective Surgery at Police General Hospital. วารสารโลหิตวิทยาและเวชศาสตร์บริการโลหิต 2553; 20: 93-104.
27. Chawla T, Kakepoto GN, Khan MA. An audit of blood cross-match ordering practices at the Aga Khan University Hospital: first step towards a Maximum Surgical Blood Ordering Schedule. J Pak Med Assoc 2001; 51: 251-4.
28. Bhutia SG, Srinivasan K, Ananthakrishnan N, Jayanthi S, RavishankarM.Blood utilization in elective surgery–requirements, ordering and transfusionpractices. Natl Med J India 1997; 10: 164-8.
29. Wong L, Cheng G. Type and screen of blood units at a teaching hospital. Hong Kong Med J 1995; 1: 27-30.
30. Boral LI, Henry JB. The type and screen: a safe alternative and supplement in selected surgical procedures. Transfusion 1977; 17: 163-8.
31. Subramanian A, Rangarajan K, Kumar S, Sharma V, Farooque K, Chandra MM. Reviewing the blood ordering schedule for elective orthopedic surgeries at a level one trauma care center. J Emerg Trauma Shock. 2010; 3: 225-30.

***การศึกษาความคุ้มค่าของการจองเลือดสำหรับผ่าตัดทางออร์โธปิดิกส์ที่ไม่ฉุกเฉินของโรงพยาบาลมหาราชนครราชสีมา***

***จุมภฏพงษ์ วงษ์เอก, พบ, ศุภมาศ ลิ่วศิริรัตน์, พบ, อุรวิศ ปิยะพรมดี, พบ***

***หลักการและวัตถุประสงค์:*** *การจองเลือดก่อนการผ่าตัดที่เกินการใช้ ทำให้เกิดผลเสียและค่าใช้จ่ายที่ไม่จำเป็น จากรายงานของคลังเลือดระหว่างปี 2553-2555 พบว่าอัตราส่วนของการจองเลือดก่อนผ่าตัดกับการใช้เลือดจริง(C/T ratio) ไม่เหมาะสม คิดเป็น 2.58, 2.82, 3.02 วัตถุประสงค์ของการศึกษานี้เพื่อศึกษาความคุ้มค่าในการเตรียมเลือดเพื่อการผ่าตัดทางกระดูกและข้อกรณีไม่ฉุกเฉินและจัดทำแนวทางการจองเลือดที่เหมาะสม*

***วิธีการศึกษา:*** *เป็นการศึกษาเชิงพรรณนาแบบย้อนหลังโดยเก็บข้อมูลการเตรียมเลือดและใช้เลือดจริงของการผ่าตัดกระดูกและข้อที่ไม่ฉุกเฉินในระยะเวลา 12 เดือน โดยเก็บข้อมูล อายุ, เพศ, ชนิดการผ่าตัด, ฮีมาโตคริตก่อนและหลังผ่าตัด, ระดับฮีมาโตคริตที่ลดลงจริงของชนิดการผ่าตัด จำนวนเลือดที่เตรียมและใช้ และคำนวณตัวชี้วัดความคุ้มค่า (C:T ratio, Transfusion probability, Transfusion index) และจัดทำแนวทางการจองเลือดจากสูตร*

***ผลการศึกษา:*** *พบผู้ป่วยที่เข้ารับการผ่าตัด 1,417 ราย จากการผ่าตัด 25 ชนิด ได้รับการเตรียมเลือด 1,987 ยูนิต ใช้เพียง 296 ยูนิต มีการผ่าตัด 7 ชนิด ที่ไม่มีการใช้เลือดทั้ง 25 ชนิด การผ่าตัดมี C:Tratio มากกว่า 2 การผ่าตัด 19 ชนิด มี transfusion probability <30 และการผ่าตัด 20 ชนิด มี transfusion index ต่ำกว่า 0.5*

***สรุป:*** *การเตรียมเลือดสำหรับผ่าตัดมีมากเกินความจำเป็นในทุกชนิดการผ่าตัดที่ศึกษาและ 7 ชนิดการผ่าตัดไม่ได้ใช้เลือดที่เตรียม จากการศึกษาได้คำนวณและจัดทำแนวทางการจองเลือดของแต่ละชนิดการผ่าตัดเพื่อให้เกิดความคุ้มค่าเหมาะสม*