ABSTRACT
Excess ordering of blood and blood components is widely prevalent across the world, which, in turn, leads to overburdening of blood bank with unnecessary grouping, cross-matching of blood units that ultimately leads to gross mis-utilization of resources, reagents and wastage of blood units along with imposition of financial stress to the patients, particularly those from the economically weaker section of the society. In view of this, various options are being considered, with greater emphasis on judicious and rational usage of blood and blood products based on safety and minimization of wastage. Once such step is the development of Maximum Surgical Blood Ordering Schedule this is a criterion development from institutional usage statistics providing a figure for the number of units to be cross matched for any given surgical procedure. MSBOS is done by a team approach involving surgeons, anesthesiologist, hematologist and blood bank staff. MSBOS will be of greats use in improving rational and scientific blood utilization, maintaining blood safety standards without compromising patient welfare.

KEYWORDS: Type & Screen, Blood Transfusion, Maximum surgical blood ordering schedule.

According to the World Health Organization (WHO), the four cornerstones of a safe and effective blood donor service are a national system, volunteer donations, blood testing and avoidance of unnecessary transfusion. Each of these cornerstones poses challenges in developing countries, where infrastructure is limited; the cost of blood procurement, screening and storage is high; and blood donation is rare. In 2002, 5% to 10% of recently acquired HIV infections were related to infected blood transfusions[1] because of women of child bearing ages & children are the most likely recipients of blood in areas having high HIV endemic rates associated with shortages of safe blood supply.

Blood transfusion is one of the practices that is in vogue because it expands blood volume and purportedly improves the oxygen carrying capacity. In spite of the physiological benefits, paradoxically, both anaemia and transfusion are independently associated with organ injuries and high morbidities. Previously, routine blood transfusions were done to have adequate blood haemoglobin (Hb) and haematocrit (Hct) level. However, there is now a greater emphasis on interventions to reduce the use of transfusion as it is a scarce and expensive resource with many serious adverse effects.

Institutional Maximum Surgical Blood Ordering Schedule (MSBOS) algorithm developed with data analysis and consensus of surgeons, anaesthesiologists and blood banks can be a useful tool to promote judicious utilization of blood and blood components of blood and reduce the unnecessary wastage.[2]

In 1970s, Friedman and his colleagues proposed (MSBOS) as a way to limit outdated risk of blood stocks. MSBOS is a table of elective surgical procedures which lists the units of red cells routinely cross-matched for them pre-operatively.[6] MSBOS is basically designed to order enough blood for 85-90% of patients for each surgical procedure.[3]

One of the important factors for the establishment of MSBOS is identification of those procedures in which there is no requirement of a preoperative cross-match and these could be accommodated by a ‘Group and Screen’ procedure only.[1] This ensures that a patient would be blood typed and evaluated for presence of a typical red cell antibodies and in a rare event of a need for transfusion, red cells can be safely given. Approximately 60% cost reduction has been observed with implementations of MSBOS.[4]
The decision to transfuse red blood cell (RBCs) was based upon the ‘10/30 rule, to maintain blood haemoglobin (Hb) concentration above 10 g/dL and a haematocrit above 30%.[5]

Reports of several series of patients who refuse blood transfusion demonstrate that a variety of major operations are tolerated without apparent major morbidity or mortality.[6] The Agency for Healthcare Research and Quality reported that in 2007, blood transfusion were given in 1 in every 10 hospital admissions in which a procedure was performed leading to a huge increase of 140% from the level of 1997 in USA.[7]

The efficacy of transfused RBCs may be related to three mechanisms, circulatory (volume) effects, rheological effects (blood flow/viscosity) and effects on oxygen transportation.[5] Circulating volume expansion of RBC transfusions is immediate but is not usually recommended except for cases of trauma or surgical cases with massive blood loss as there is a risk of transfusion-associated circulatory overload.[5]

Rheological effect on blood viscosity is an important factor for maintaining microvascular circulation. High haematocrit will cause an increased in viscosity and may compromise the microcirculation.[5]

Oxygen (O2) delivery rises with the rise in Hb approximately 1 g/dL per unit of RBC transfused and is often viewed as the main reason for giving blood.[5]

The anaemia and blood transfusion in critical care (ABC) study, a large epidemiologic survey of 3534 patients in 146 western European intensive care units (ICS)s showed increased mortality rates (ICU and hospital) in transfused patients.[8]

In view of this data and lack of clarity of appropriate transfusion trigger, a single pre-specified transfusion criterion is not justified as an indication for RBC transfusion.[9] Different transfusion threshold have been studied in different patient population.[10] An appropriate transfusion trigger is defined as one which balances the benefit of treating anaemia and the risk of unnecessary transfusions. Generally accepted terminologies include ‘liberal strategy’ with transfusion threshold Hb of 9-10g/dL and ‘restrictive strategy, with transfusion Hb threshold of 7-8 g/dL.[11]

The findings of a Cochrane collaboration meta-analysis done in 2012[12] which included 19 trials with a total of 6264 patients were as follows. Restrictive transfusion strategies reduced the risk of receiving a RBC transfusion by 39% (risk ration [RR] 0.61, 95% confidence interval [CI] 0.52 to 0.72. The volume of RBCs transfused was reduced on average by 1.19 units (95% CI: 0.53-1.85 units).0.73.

Thus, this Cochrane meta-analysis[12] supports the use of restrictive transfusion triggers in most patients, including those with pre-existing cardiovascular disease.

In another meta-analysis[13] pooled results from three trials with 2364 participants were included. This meta – analysis showed that a restrictive Hb transfusion trigger of <7 g/dL resulted in reduced in-hospital mortalities, total mortalities, re-bleeding, acute coronary syndrome, pulmonary edema and bacterial infections compared with a more liberal strategy. Thus, in patients with critical illness of bleed, restricting blood transfusions by using Hb trigger of <7g/dL significantly reduces cardiac events, re-bleeding, bacterial infections and total mortalities.[13]

The following transfusion Indies are used to determine the blood utilization for each surgical procedures while designing MSOBS.[14]

1. The formula for cross-matched to transfusion: C:T ratio = No. of units cross-matched
   No. of units transfused
   A ratio of > 2 is considered indicative of significant blood wastage.

2. The formula for transfusion probability:
   Transfusion probability % = No. of patients transfused x100
   No. of patients cross-matched
   A value of < 30 was considered indicative of significant blood wastage.

3. The formula for Transfusion index: Transfusion index = No. of units transfused
   No. of patients cross-matched
   A value of <0.5 signifies no need for cross-match.[14]
   Ideally a C/T ration of 1:1 would be most desirable and most efficient, but it is never achievable.[14] Therefore a C/T ration of 2:1 for all procedure has been accepted as a reasonable goal. MSBOS is a viable option to avoid unnecessary, excessive cross matching of blood for elective surgical procedures.[14]

Mead et al[15] suggested that surgical procedures which would have a less than 30% probability of using blood be recommended for ‘T&S’. They also recommended that for procedure with a greater than 30% probability of transfusion, the cross match orders should not exceed 1.5 times the number of units transfused per patients. It is also pointed out that surgical blood estimates of three units or less were generally unreliable and for these procedures a ‘T&S’ approach was recommended. An estimate of greater than three units was more reliable and usually some blood was used, but even in these cases the C/T ratio was too high.[16]

One of the logical outcomes of MSBOS is the development of T & S approaches which has several
benefits including the reduction in the hospitalization charges for the patient, improved distribution of blood supplies and the more effective utilization of the time of the blood bank technologist if a T & S approach was adopted.[15]

One misplaced notion about T&S procedure is absence of cross matching blood during immediately required and reduced hospital blood inventory to successfully meet sudden disasters or major emergency conditions. In such situations immediate spin (IS) can be safely done and has been highlighted by Richardson et al[17] and Chawla et al.[18]

Vibhute et al[19], Mahadevan et al[20] and Iyer et al[21] has conclusively proved the MSBOS promotes judicious and rational use of blood and blood products eliminates the need to determine the number of blood component required for each surgery, reduces pre transfusion compatibility testing thereby reduction of unnecessary workload and avoids wastage of blood components.

According to Thabah et al[22], several factors affect the MSBOS recommendation of C/T ratio.

The first factor is the distance at which the blood bank is located and the ability of the blood bank to provide blood in emergency situations. Therefore, the distance and efficiency of blood bank affects the confidence of the surgeons and the anesthesiologists. Installation pneumatic tube system from various hospital wards to the blood bank for transporting patient blood samples could be a very useful step in ensuring uninterrupted supply of blood and blood components during emergencies. Hence, effort must be made in blood bank to promote automation, strict monitoring of turn around time (TAT) and ensure facilities for IS cross matching is readily available to meet emergency requirements.

Next, the patient’s pre-operative condition does affect the C/T ratio since the MSBOS algorithm uses the surgical procedures alone. Hence, co-morbid conditions such as hypertension, diabetes mellitus, hypothyroidism, electrolyte imbalance should be taken into consideration and the design of MSOBS should be flexible enough to accommodate all such conditions.

The final decision regarding utilization of blood arranged for in operable cases is left discretion of the operating surgeons. Hence, while designing MSOBS the opinion of surgeons should be given top priority.

In conclusion, blood wastage ultimately depends on the surgeons and the anesthesiologists. The surgeons, depending on their expertise may cause more or less blood loss for a particular surgery. Anesthesiologists on the other hand, would transfuse a patient in which no indication for transfusion could be found. Despite much studies and evidence based guidelines for transfusion, inappropriate transfusion still happens.

Although MSBOS has several advantages there are also few limitations as suggested by Nagarekha et al.[23] MSBOS fails to take into account the individual variations with regard to the request of blood and blood components. These factors include low preoperative Hb, low weight, elderly patients over the age of 65 years and female patients. In addition, the transfusion needs of patients with significant co-morbidities also differ from that of general population. Patients with ischaemic heart disease require a higher transfusion threshold because of a risk of anaemia – associated adverse outcomes postoperatively.

MSBOS is subjected to constant improvement and modification.[24] The treating clinicians, anesthetists, surgeons, nurses, along with the blood bank staff should all give their inputs an contribute for improving the transfusion practice. The hospital transfusion committee should be a source of guidance, provide support and conduct surveillance. Educational programs are fundamental and should be conducted regularly within the hospital for the sake of improved blood transfusion practices and provide a framework for conducting blood bank audits.[25]

Finally, the auditing of clinical practices is important in order to improve the quality of service, encourage team work and ensure high standard which has clinical as well as financial implications. The evidence based MSBOS, appropriately designed can make our transfusion services more efficient and logical with implementation of gold-standard C/T ratio.[26]

MSBOS is a list of common elective surgical procedure for which the maximum number of units of blood is cross-matched pre-operatively for each procedure.[26] It is basically designed to order enough blood for 85-90% of patients for each surgical procedure and C/T ratio should not exceed 2:1.[21] Although MSBOS have improved the efficiency of blood utilization in many institutions, there are certain drawbacks, the most significant one being the absence of accountability for individual differences in transfusion requirements between different persons undergoing the same surgical procedure. Surgical blood ordering equation (SBOE) is an extended MSBOS incorporating patient and surgical variable, such as pre- and post operative Hb levels of the patient and the amount of surgical blood loss during each surgical procedure. By establishing such an MSBOS, each surgical team can develop its own transfusion system and set its own transfusion limits. They can also audit the operative blood loss for each procedures.[26]

Sharma et al[27] and Basnet et al[28] showed that in most of the cases, particularly in the rural teaching hospitals, of developing countries blood ordering is done by Junior doctors who have a limited knowledge of blood and blood components and thereby adopted a “Safety First Policy” of ensuring that more, rather than less blood is available.
Such an unscientific and irrational system is wasteful because of multiple reasons including a) In a rural and resource constrains set up this system leads to “acute shortage of blood and blood components” b) This system also leads to increased rate of discard and wastage of blood and blood components. c) This system allows gross misuse of the scarce financial resources of the poor patients. d) Over burdening of the fragile rural health system with unnecessary cross-matching of blood and blood components.

Similar to Nagareekha et al\cite{23} we all agree that in order to reduce excessive cross matching “type, screen and hold” T&S procedure must be implemented. Under T&S blood is screened for antibodies a few days prior to the procedure. If no antibodies are detected, no blood will be cross-, matched. If need does arise for transfusion, cross matching may be accomplished in 8 to 10 minutes using the immediate spin (IS) method. If antibodies are detected in the antibody screening tests, suitable blood units lacking the corresponding antigen and compatible with the patient will have to be provided prior to surgery. Several studies have shown the T&S policy to be safe if done according recommended techniques. This technique proved to be 99.99% efficient in preventing incompatible blood transfusion.\cite{28}

**DESIGNING OF MSBOS**

**Step 1:**
Formation of Hospital Transfusion Committee with members of Medicine & Allied subjects, Surgery & allied subjects, Emergency Care Department & Nursing Department

**Step 2:**
Implementation of Hospital Audit regarding utilities of blood and blood components

**Step 3:**
Identify surgeries were only T&S required. Identify surgeries were cross-matched required

**Step 4:**
Evaluate the number of units transfused (T) and the number of units cross-matched C for specified elective surgical procedure C/T ration, transfusion probability and transfusion index for a specified elective surgical procedure is then determined.

**Step 5:**
Designing MSBOS draft schedule using retrospective data. Elective surgical procedures are allotted to the only group and screen category or to a group and cross-match category.

**Step 6:**
Pre-implementation consensus by stakeholders such as surgeons, anesthesiologist and blood bank is important to ensure ease of implementation. Draft has to be circulated to surgical and anesthesia teams.

**Step 7:**
Regular review and updating
Table 1: Shows various steps involved in designing of MSOBS.

<table>
<thead>
<tr>
<th>RED CELL TRANSFUSION TRIGGERS</th>
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<tbody>
<tr>
<td><strong>R1</strong></td>
<td>Acute Blood Loss: Transfusion with Red cells recommended for blood loss of 30-40% coupled along with following – Hb level &lt; 7g/dl in otherwise patients OR</td>
</tr>
<tr>
<td><strong>R2</strong></td>
<td>Anemia WITHOUT Risk Factors – Transfusion Trigger 7g/dl</td>
</tr>
<tr>
<td><strong>R3</strong></td>
<td>Anemia with risk factors-cardiovascular disease/elderly/DM/HT/Per. Vas diseases etc.Trigger 9g/dl</td>
</tr>
<tr>
<td><strong>R4</strong></td>
<td>Critical Care: Transfusion to maintain Hb &gt;7g/dl</td>
</tr>
<tr>
<td><strong>R5</strong></td>
<td>Post Chemotherapy- No Evidence based Gide. Suggested therhold:8-9/gdl</td>
</tr>
<tr>
<td><strong>R6</strong></td>
<td>Radiotherapy: Transfuse to maintain the Hb &gt;10g/dl</td>
</tr>
<tr>
<td><strong>R7</strong></td>
<td>Chronic Anemia (Ex CRF, Thalassemia)-Hb levels just above the theershold of symptomatic features(8g/dl)</td>
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<table>
<thead>
<tr>
<th>PLATELET TRANSFUSION TRIGGERS</th>
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<tbody>
<tr>
<td><strong>Dose-</strong> 15ml/kg body weight for children &lt;20kg. Therapeutic dose(5-6 units RDP or ISDP (apheresis) for adults and older children</td>
<td></td>
</tr>
<tr>
<td><strong>P1</strong></td>
<td>To prevent spontaneous bleeding (Ex. Dengue) When platelet count&lt;10,000/ul</td>
</tr>
<tr>
<td><strong>P2</strong></td>
<td>Presence of risk factors like sepsis (fever) or hemostatic abnormalities transfuse when platelet count &lt; 20,000/ul</td>
</tr>
<tr>
<td><strong>P3</strong></td>
<td>To prevent bleeding associated with invasion procedure. Raised to &gt; 50,000/ul (Ex Lumbar Puncture/liver biopsy) and &gt; 1 lakh in case Ophthalmic and Nuerosurgery</td>
</tr>
<tr>
<td><strong>P4</strong></td>
<td>Critical Care/Surgery</td>
</tr>
<tr>
<td><strong>P5</strong></td>
<td>Platelet dysfunction-following CABG, antiplatelet drugs (clopidigrel)</td>
</tr>
<tr>
<td><strong>P6</strong></td>
<td>Acute DIC In the presence of bleeding and severe thrombocytopenia</td>
</tr>
<tr>
<td><strong>P7</strong></td>
<td>Inherited platelet dysfunction e.g. Glanzmanns thrombastheia with bleeding of as prophylaxis before surgery.</td>
</tr>
</tbody>
</table>

Table 2: Adapted from British Committee for Standardization in Hematology (BCSH) Guidelines for blood Transfusion.

<table>
<thead>
<tr>
<th>FRESH FROZEN PLASMA (FFP) TRANSFUSIONS</th>
<th></th>
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<tbody>
<tr>
<td><strong>Dose-</strong> 4 units in the adult 10-15 ml/kg body weight in children</td>
<td></td>
</tr>
<tr>
<td><strong>F1</strong></td>
<td>Replacement of single factor-deficiencies when specific factor concentrates are unavailable</td>
</tr>
<tr>
<td><strong>F2</strong></td>
<td>Immediate reversal of warfarin effect, in the presence of bleeding</td>
</tr>
<tr>
<td><strong>F3</strong></td>
<td>Acute DIC associated with bleeding and/ or abnormal coagulation results</td>
</tr>
<tr>
<td><strong>F4</strong></td>
<td>TTP- Treated by Therapeutic Plasma exchange with Cryopoor plasma</td>
</tr>
<tr>
<td><strong>F5</strong></td>
<td>Massive transfusion and surgical bleeding (guided by abnormal PT/APTT)</td>
</tr>
<tr>
<td><strong>F6</strong></td>
<td>Liver Disease associated with bleeding /planned invasive procedure/surgery. WHEN INR&gt;105</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>CRYOPRECIPITATE</th>
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<tbody>
<tr>
<td><strong>Dose</strong> 12-15ml/kg body weight equivalent to 4 for an adult</td>
<td></td>
</tr>
<tr>
<td><strong>C1</strong></td>
<td>Acute DIC with continued bleeding and a Fibrinogen level &lt;1g/L</td>
</tr>
<tr>
<td><strong>C2</strong></td>
<td>Liver disease to correct bleeding or pri-opertively when Fibrinogen level, lg/L</td>
</tr>
<tr>
<td><strong>C3</strong></td>
<td>Bleeding with hypofibrinogenemia(&lt;lg/L) secondary top Thrombolytic therapy</td>
</tr>
<tr>
<td><strong>C4</strong></td>
<td>Hypofibrinogenemia(&lt;1g/L) secondary to massive transfusion</td>
</tr>
<tr>
<td><strong>C5</strong></td>
<td>Hepatic/Renal failure with abnormal bleeding and where DDAVP is contra-indicated or ineffective</td>
</tr>
</tbody>
</table>

Table 3: Proposed Transfusion Guidelines.

<table>
<thead>
<tr>
<th>Total abdominal/vaginal hysterectomy LSCS</th>
<th>Type and Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pregnancy with anaemia/sepsis PPH/APH</td>
<td>70% units demanded</td>
</tr>
<tr>
<td>Abdomino perineal repair</td>
<td>Type and Screen</td>
</tr>
<tr>
<td>Cesarean section</td>
<td>Type and Screen</td>
</tr>
<tr>
<td>Dilatation and curettage</td>
<td>Type and Screen</td>
</tr>
<tr>
<td>Hysterectomy abdominal</td>
<td>Type and Screen</td>
</tr>
<tr>
<td>Hysterectomy laparoscopic</td>
<td>Type and Screen</td>
</tr>
<tr>
<td>Radical hysterectomy</td>
<td>Type and Screen</td>
</tr>
<tr>
<td>Breast surgery</td>
<td>Type and Screen</td>
</tr>
<tr>
<td>Colon biopsy</td>
<td>2</td>
</tr>
<tr>
<td>Exploratory laparotomy</td>
<td>Type and Screen</td>
</tr>
<tr>
<td>Gastrectomy</td>
<td>2</td>
</tr>
<tr>
<td>Laryngectomy</td>
<td>2</td>
</tr>
</tbody>
</table>
**Mastectomy, radical** | Type and Screen  
**Pancreatectomy** | 4  
**Splenectomy** | 2  
**Thyroidectomy** | Type and Screen  
**Cardiothoracic**  
Aneurysm resection | 6  
Redo coronary artery bypass graft | 4  
Primary coronary artery bypass graft | 2  
Lobectomy | Type and Screen  
Lung biopsy | Type and Screen  
**Vascular**  
Aortic bypass with graft | 4  
Endarterectomy | T/S  
Femoral noplileal bypass with graft | 2  

**CONCLUSION**  
The demand for large quantities of blood for elective surgeries, of which little is utilized results in exhaustion of valuable supplies and resources both in terms of technician time and reagents. This adds to the financial burden of the patients.

MSBOS provides guidelines for frequently performed elective surgical procedures by recommending the maximum number of units of blood to be cross matched preoperatively.

Blood Transfusion is recognized as one of the eight essential component of comprehensive emergency obstetric care which has been shown to reduce the maternal mortality.[11] In developing country like India, efforts must be made to make blood transfusion services well maintained and readily available to reduce maternal morbidities and mortalities.[22]

Hence it is quite necessary to streamline the blood usage by incorporating blood ordering schedule for such procedures which decreases over-ordering of blood, unnecessary compatibility testing, returning of unused blood & wastage due to outdating. As suggested by Setia et al.[29], MSBOS promoting T & S policy is highly beneficial, particularly tertiary care hospital as it provides enough time for the immunohematology laboratory to complete the workups to confirm the alloantibody and also to arrange compatible units for transfusion. It also allows the treating physicians and transfusion medicine specialist to discuss the best transfusion strategies in case the antibody is not identified or when compatible blood is not available. This policy also forms the base for the newer concept of computer cross-match for which this policy is mandatory.

Similar to Thabah et al.[22] we have also observed, excess of blood units are cross-matched each day for patients who are most unlikely to require transfusion. Thus, each hospital can have a schedule of expected blood usage for each surgical procedure produced by analyzing their respective hospital data. However, it is necessary to analyze data retrospectively over a period of six months and collect a sufficient number of each procedure to give a meaningful assessment. In drawing up the “schedule” attention must be paid to factors that would affect the speed of provision of compatible blood such as, the distance of the operating rooms from the blood bank and the availability of the transport facility. Thus, during the establishment of the schedule of MSBOS, emphasis should be laid on local circumstances, clinical practice and patients’ variable.

This schedule should be reviewed regularly and adjustment made as necessary for the schedule to be effective.[30]

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