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Case Report

Evaluation of Blood Utilization in Elective Surgery-Requirement, Ordering and Transfusion Practices

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ABSTRACT

Aims and Objectives:

- To evaluate utilization of blood in different surgical procedures.
- To study average requirement of blood in different surgical procedures.
- To formulate maximum surgical blood order schedule (MSBOS).

Methodology: In this study 319 patients were included which admitted in Krishna Hospital from Feb. 2013-Jan. 2014, who undergone different surgical procedures for whom a preoperative cross-match was requested. The cases were studied in special performa which includes preoperative data of previous history of blood transfusion, patient's Wt., blood group and no. of blood units cross-matched and no. of units transfused for the procedure. Intraoperative data regarding blood loss notified.

Result: Analysis was done based on criteria like Cross matched to transfusion ratio(C/T ratio), Transfusion Probability, Transfusion Index, MSBOS.

Conclusion: Based on this study there is gross over ordering of blood for many procedures which can be minimized by T & S procedure. MSBOS should be done before any major surgical procedure in which blood transfusion required.

Key words: Maximum surgical blood order schedule(MSBOS), Transfusion Index, Transfusion Probability.

INTRODUCTION

Recently there has been a growing demand for blood and its derivatives. Elective surgery demands large quantity of blood each day out of which little is ultimately used. In emergency surgery large amount of blood and blood products are used. The present study is planned to evaluate transfusion practice in our hospital and identify surgical procedure where complete cross-match could be replaced by Type and Screen (T & S) and to formulate MSBOS for those procedures where a complete cross-match appears mandatory.

METHODS

The present series is a study of 319 cases admitted in Krishna hospital, Karad and undergone different surgical procedures during the period of FEB.-2013 to JAN.-2014.

All the patients undergoing surgery for whom a preoperative cross-match was requested are included in this study. About 18 different surgical procedures from general surgery, oncosurgery, urosurgery are included in this series. The cases were studied according to a definite plan which includes

Preoperative data:-

Data is collected under brief history of present illness.

Past history of bleeding diathesis, Anticoagulation therapy, Previous surgery in the area to be operated upon, Previous history of blood transfusion were noted.

The hematological investigations:- Total leukocyte count, differential leukocyte count, platelet count, bleeding times, clotting time, prothrombin time if done for that patients were recorded. Blood group of patient and Wt. of patient was noted.

Total blood volume was calculated using the physiological formula.

For male – 66ml/Kg

For women – 75ml/Kg

Intraoperative data

In the absence of any sophisticated techniques to measure the intraoperative blood loss, a subjective assessment by the anesthetist was used, as it is he or she who decides the need for the intraopeative and immediate postoperative transfusion.

Blood loss is calculated after taking in consideration the number of mops soaked, weight of mops and amount of blood in suction apparatus and weight of blood clots removed from operative field.

Intraoperative occurrence of hypotension and tachycardia due to surgical blood loss were recorded.

RESULT

The patients were grouped under 18 different procedures(Table I). Under each procedure the number of patients, number of units ordered, number of units cross-matched and number of patients cross-matched were tabulated.

The numbers of units transfused and number of patients transfused and range of transfused units for each procedure were obtained.

The following indices were calculated for each procedure.

1. Cross matched to transfusion ratio (C/T ratio)

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

A ratio <2.5 was considered indicative of significant blood usage.

2. Transfusion probability (%T)

$$\%T = \frac{\text{No. of patients transfused}}{\text{No. of patients cross-matched}}$$

A value of >30 was considered indicative of significant blood usage.

3. Transfusion index (Ti)

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

A value >0.5 was considered indicative of significant blood usage.

4. Maximum surgical blood order schedule(MSBOS)

For the procedure which are showing significant blood uses based on above three indices maximum surgical blood order schedule is calculated.

For calculating maximum surgical blood order schedule Mead's criterion is taken into consideration.

$$MSBOS = 1.5 \times TI$$

Where,

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

Mead's criteria provides 1.5 times the average number of units transfused per transfused patients for the procedure.

The above criteria are applied to the percentage of blood loss.

Different groups were formed according to percentage of blood loss. The cross-matched transfusion ratio, transfusion probability and transfusion index were calculated for each group. The average units of blood transfused for each group were determined and MSBOS is determined for each group arranged according to percentage of blood loss.

The procedures which require average blood <0.5 units or procedures for which the above indicators like C/T ratio, transfusion probability or the Transfusion Index shows no significant blood usage were recommended for Type and Screen(T&S) instead of complete cross-match and the other procedures where the significant blood usage is present, MSBOS in calculated using Mead's criteria.

Table No.I. PROCEDURE –WISE DISTRIBUTION OF PATIENTS.

S.No.	PROCEDURE	(n)	%
1	Oesophagectomy	11	3.4
2	Splenectomy	8	2.6
3	Splenectomy Emergency	9	2.8
4	Small & large bowel resection. (Elective)	16	5.1
5	Small & large bowel resection. (Emergency)	28	8.8
6	Nephrectomy	9	2.8
7	Pyelolithotomy-ureterolithotomy	13	4.1
8	TURP	37	11.5
9	Thyroidectomy	12	3.7
10	DU perforation closure	73	22.8
11	Intraabdominal soft tissue tumour excision	9	2.8
12	Colostomy/colostomy closure	14	4.4
13	MRM	22	6.9
14	Surgery on oral malignancy	29	9.1
15	Incisional hernia repair	9	2.8
16	Cholecystectomy	8	2.6
17	Cholecystectomy with CBD exploration	6	1.9
18	Biliary enteric bypass	6	1.9
		319	100

Table No.II. BLOOD-ORDERING AND CROSS-MATCHING PATTERN OF PATIENTS.

S.No.	PROCEDURE	BLOOD TRANSFUSED		CROSS MATCHED	
		PATIENTS	UNITS	PATIENTS	UNITS
1	Oesophagectomy	11	29	11	35
2	Splenectomy	8	25	8	26
3	Splenectomy Emergency	9	19	9	20
4	Small & large bowel resection. (Elective)	14	19	16	31
5	Small & large bowel resection. (Emergency)	23	31	27	47
6	Nephrectomy	4	7	9	17
7	Pyelolithotomy-ureterolithotomy	2	2	12	13
8	TURP	9	9	36	51
9	Thyroidectomy	3	4	12	15
10	DU perforation closure	10	12	49	66
11	Intraabdominal soft tissue tumour excision	7	15	9	25
12	Colostomy/colostomy closure	2	2	12	13
13	MRM	12	13	21	24
14	Surgery on oral malignancy	21	35	27	46
15	Incisional hernia repair	1	1	5	5
16	Cholecystectomy	2	2	6	10
17	Cholecystectomy with CBD exploration	6	7	6	15
18	Biliary enteric bypass	6	11	6	16
		150	243	281	475

Table No.III. TRANSFUSION PROFILE.

S.No.	PROCEDURE	PATIENT TRANSFUSED	PATIENT CROSS-MATCHED	UNITS TRANSFUSED	AVARAGE (TI)	RANGE (UNITS)
1	Oesophagectomy	11	11	29	2.6	2-3
2	Splenectomy	8	8	25	3.1	2-4
3	Splenectomy Emergency	9	9	19	2.1	1-3
4	Small & large bowel resection. (Elective)	14	16	19	1.3	0-2
5	Small & large bowel resection. (Emergency)	23	27	31	1.3	0-4
6	Nephrectomy	4	9	7	1.7	0-2
7	Pyelolithotomy-ureterolithotomy	2	12	2	1.0	0-1
8	TURP	9	36	9	1.0	0-1
9	Thyroidectomy	3	12	4	1.3	0-2
10	DU perforation closure	10	49	12	1.2	0-2
11	Intraabdominal soft tissue tumour excision	7	9	15	2.1	0-4
12	Colostomy/colostomy closure	2	12	2	1.0	0-1
13	MRM	12	21	13	1.08	0-2
14	Surgery on oral malignancy	21	27	35	1.6	0-3
15	Incisional hernia repair	1	5	1	1.0	0-1
16	Cholecystectomy	2	6	2	1.0	0-1
17	Cholecystectomy with CBD exploration	6	6	7	1.16	0-3
18	Biliary enteric bypass	6	6	11	1.83	1-3
	TOTAL	150	281	243	1.62	

TABEL NO.IV. CROSSS-MATCHED TO TRANSFUSED RATIO (C/T RATIO)

$$\text{C/T RATIO NO} = \frac{\text{No of units cross matched}}{\text{No of units transfused}}$$

S.No.	PROCEDURE	UNITS CROSS MATCHED	UNITS TRANSFUSED	C/T RATIO
1	Oesophagectomy	35	29	1.2
2	Splenectomy	26	25	1.04
3	Splenectomy Emergency	20	19	1.05
4	Small & large bowel resection. (Elective)	31	19	1.63
5	Small & large bowel resection. (Emergency)	47	31	1.51
6	Nephrectomy	17	7	2.4
7	Pyelolithotomy-uretrolithotomy	13	2	6.5
8	TURP	51	9	5.6
9	Thyroidectomy	15	4	3.75
10	DU perforation closure	66	12	5.5
11	Intraabdominal soft tissue tumour excision	25	15	1.6
12	Colostomy/colostomy closure	13	2	6.5
13	MRM	24	13	1.8
14	Surgery on oral malignancy	46	35	1.3
15	Incisional hernia repair	5	1	5.0
16	Cholecystectomy	10	2	5.0
17	Cholecystectomy with CBD exploration	15	7	2.1
18	Biliary enteric bypass	16	11	1.4
	TOTAL	475	243	1.95

TABLE NO.V. TRANSFUSED PROBABILITY (%T).

$$\%\ T = \frac{\text{No. of units transfused}}{\text{No. of units cross matched}} \times 100$$

S.No.	PROCEDURE	PATIENTS TRANSFUSED	PATIETS CROSS MATCHED	%T
1	Oesophagectomy	11	11	100
2	Splenectomy	8	8	100
3	Splenectomy Emergency	9	9	100
4	Small & large bowel resection. (Elective)	14	16	87.5
5	Small & large bowel resection. (Emergency)	23	27	85.1

TABLE NO.V. *Continued…* TRANSFUSED PROBABILITY (%T).				
6	Nephrectomy	4	9	44.4
7	Pyelolithotomy-ureterolithotomy	2	12	16.6
8	TURP	9	36	25.0
9	Thyroidectomy	3	12	8.33
10	DU perforation closure	10	49	20.4
11	Intraabdominal soft tissue tumour excision	7	9	77.7
12	Colostomy/colostomy closure	2	12	16.6
13	MRM	12	21	57.1
14	Surgery on oral malignancy	21	27	77.1
15	Incisional hernia repair	1	5	20.0
16	Cholecystectomy	2	6	33.3
17	Cholecystectomy with CBD exploration	6	6	100
18	Biliary enteric bypass	6	6	100

TABEL NO.VI. TRANSFUSION INDEX (Ti)

$$Ti = \frac{\text{No. of units transfused}}{\text{No. of units cross matched}}$$

S.No.	PROCEDURE	PATIENTS TRANSFUSED	PATIETS CROSS MATCHED	Ti
1	Oesophagectomy	29	11	2.6
2	Splenectomy	25	8	3.1
3	Splenectomy Emergency	19	9	2.1
4	Small & large bowel resection. (Elective)	19	16	1.21
5	Small & large bowel resection. (Emergency)	31	27	1.14
6	Nephrectomy	7	9	0.8
7	Pyelolithotomy-ureterolithotomy	2	12	0.16
8	TURP	9	36	0.25
9	Thyroidectomy	4	12	0.33
10	DU perforation closure	12	49	0.24
11	Intraabdominal soft tissue tumour excision	15	9	1.66
12	Colostomy/colostomy closure	2	12	0.16
13	MRM	13	21	0.6
14	Surgery on oral malignancy	35	27	1.29
15	Incisional hernia repair	1	5	0.20
16	Cholecystectomy	2	6	0.3
17	Cholecystectomy with CBD exploration	7	6	1.16
18	Biliary enteric bypass	11	6	1.83

TABLE NO :VII

No	Percentage of blood loss	No of Patients	Percentage	Blood crosshatched		Blood transfused		Average	CT ratio	%T	Ti
				Patients	Units	Patients	Units				
1	0-5	122	38.2	92	127	16	19	1.1	6.6	17.3	0.2
2	5.1-10	92	28.8	86	126	38	44	1.15	2.8	44.1	0.5
3	10.1-15	51	15.9	49	67	42	60	1.4	1.1	85.7	1.2
4	15.1-20	16	5.0	15	36	14	27	1.9	1.3	93.3	1.8
5	20.1-35	11	3.4	10	27	10	23	2.3	1.17	100	2.3
6	25.1-30	8	2.5	8	20	8	19	2.37	1.05	100	2.37
7	30.1-35	7	2.1	7	18	7	17	2.4	1.0	100	2.4
8	35.1-40	-	-	-	-	-	-	-	-	-	-
9	40.1-45	3	0.9	3	10	3	9	3.0	1.1	100	3.0
10	>45	8	2.5	8	27	8	26	3.25	1.03	100	3.25

TABLE No.VIII. MSBOS for procedures with significant blood usage.

Sr No.	Procedure	TI	MSBOS
1	Oesophagectomy	2.6	3.9
2	Splenectomy (Emergency)	3.1	4.65
3	Splenectomy (Elective)	2.1	3.15
4	Small & large bowel resection (Emergency)	1.3	1.95
5	Small & large bowel resection (Elective)	1.3	1.95
6	Nephrectomy	1.7	2.89
7	Intraabdominal soft tissue resection	2.1	3.15
8	Modified radical mastectomy	1.08	1.62
9	Surgery on oral malignancy	1.6	2.4
10	Cholecystectomy with CBD exploration	1.16	1.74
11	Biliary enteric bypass	1.83	2.7

Table No. IX

S.No.	Procedure	Recommendation
1	Pyelolithotomy - ureterolithotomy	T&S
2	Trans urethral resection of prostate	T&S
3	Thyroidectomy	T&S
4	Colostomy/ colostomy closure	T&S
5	Cholecystectomy	T&S
6	Incisional hernia repair	T&S
7	Closure of duodenal ulcer perforation	T&S

DISCUSSION

The limited shelf life of a unit of blood stand as a constant challenge to all those that are concerned with the intelligent use of this valuable resource. The outdating of a unit of blood serve as a constant reminder that many of the subtleties of blood bank inventory control have not yet been mastered.

There is however an approach to one aspect of blood bank inventory control immediately available to any hospital blood bank officer which can quickly and effectively reduce the outdating of blood by increasing its relative availability. This method of blood bank inventory control is Maximum Surgical Blood Order Schedule(MSBOS).

The MSBOS is a list of commonly performed surgical procedure with the maximum number of units of blood, which will be cross matched for each of the procedure. [2]

A strategy commonly employed by surgeons and anesthesiologists is to request more units of blood than they anticipate transfusing intraoperatively, in order to provide a margin of safety for their patients in the event of unexpected blood loss. It is questionable whether the ready availability of small number of cross matched units of blood is of great value when massive hemorrhage is encountered during an operation. Additional units of blood will be ordered and transfused. Under such circumstances, often utilizing and emergency cross match technique. The ready availability of one or two cross matched units of blood in the operating room may even serve as a stimulus for unnecessary blood transfusion in some cases. [2] And it is documented and proved that single units blood transfusion is unnecessary and without any beneficial effect but it increases the chances of transmission of diseases which are transmitted through blood. [8,10,12]

From the perspective of hospital blood bank personnel, excessive cross matching results in both increased blood outdating and increased patient care costs. Cross-matched units of blood are placed on reserved status and are unavailable under most circumstances for transfusion to other patients. The number of units of blood in an uncross-matched status must be held relatively constant in hospital blood bank in order to meet any unexpected demand. The higher the ratio of total inventory to transfusion activity, the higher the outdate rate and blood wastage.

Friedman et al [9] addressed this nagging problem associated with surgical blood use, and excessive preoperative cross matching. When they advocated the hospital to establish a MSBOS which places limit on preoperative blood orders for the common surgical procedures. The primary goal of MSBOS is to make preoperative blood ordersmore closely coincide with the number of unit of blood which will actually be transfused to patient.

It is uncommon to encounter severe hemorrhage during operative procedures prior to which only a T &S was performed. Secondly an override mechanism of the

MSBOS is that given surgeons and anesthetist, privilege to order 1.5 times the average units used for the particular procedure, which will cover the additional blood loss.

And lastly a techniques like immediate spin cross match can be used to provide additional blood within minutes for hemorrhaging patients. If cross – matched blood is not available, in patients with negative preoperative antibody screen, the cross-match is completed, through the indirect anti globulin phase after the blood is released from blood bank for transfusion. The above work was supported by Boyd et al [5] stating that the Type and screen has been successfully and safely used for elective surgery patients who are unlikely to require transfusion, but for whom blood should be available on demand in needed for an unexpected hemorrhage. The T&S is a safe, resource conserving, practical alternative to more expensive traditional two units cross-match for surgical procedures which usually do not require blood transfusion.

The above studies have shown that the Type and Screen evolved from a realization of facts in blood utilization.

1) Blood resources annually grow scarcer relative to the increasing demand for blood and blood products by surgical patients.
2) There is an excessive cross match to transfusion ratio for certain surgical procedures, requiring that more cross-matched blood units be held in reserve for 24 to 48 hrs for a specific patient. This practice generates higher charges to patients and contributes to outdating of blood units.
3) T & S has been proved to be effective and safe alternative to full cross-match in certain surgical procedures. [3-5]

All these studies were carried out outside India, until 1997 when S.G. Bhutiaet al [6] published their study on blood utilization in elective surgery. In their study they have shown that blood was over ordered for majority of procedures which is causing drain on blood bank resources and patient cost. They concluded that implementation of the recommended MSBOS for those procedures where a complete cross-match appears mandatory and introduction of T & S for eligible surgical procedures is a safe, effective and economic solution too verordering of blood.

In view of these facts and inspired by these studies we evaluated the preoperative blood ordering and transfusion practices for common surgical procedures carried out at our hospital. The study period was of one year between FEB.2013 to JAN.2014.

We aimed to identify the surgical procedures for whom a complete cross-match could be replaced by T&Sand to MSBOS for those procedures where a complete cross match preoperatively appears to be mandatory.

Within the study period of one year 319 patients undergoing 18 different common surgical procedures were studies where the preoperative cross matching of blood is done or intraoperative transfusion of blood is anticipated.

In our study, it was seen that maximum number of patients are from closure of duodenal ulcer perforation and minimum number is from cholecystectomy with CBD exploration and biliary enteric bypass.

The procedures under which at least more than five patients are there are taken into consideration; the other procedures are excluded from the study.

Blood ordering and cross matching pattern of patient is studied in Table No.II.

For total of 281 patients 475 units of blood was cross-matched preoperatively. The

average was 1.6 units of blood cross-matching for each patient.
Of the total 475 units cross-matched 243 units of blood were transfused to 150 patients.

Routine one to two units of blood were cross-matched for procedures like closure of duodenal ulcer perforation, transurethral resection of prostate(TURP), pylolithotomy or uretolithotomy, nephrectomy or colostomy closure, thyroidectomy and incisional hernia repair.
For the procedure like oesophagectomy , intra-abdominal soft tissue tumour excision, spleenectomy emergency or elective, and small and large bowel resection more than two units are cross-matched in an average.
In the group of closure of duodenal ulcer perforation out of 73 patients 49 patients were cross-matched and 10 patients received transfusion. Out of 66 units of blood cross-matched only 12 units of blood were transfused.
In case of transurethral resection of prostate(TURP) out of 37 patients, 36 patients were cross-matched of which only 9 patients received transfusion. Out of total 51 units of blood, cross-matched only 9 units of blood were transfused.
Whereas the procedure like oesophagectomy, splenectomy elective or emergency, billiary enteric bypass and cholecystectomy with CBD exploration every patient cross-matched has received blood transfusion.

The Table no.III describes the transfusion profile of this study.
In this table for all 18 different procedures number of patients cross-matched, number of patients transfused. It gives amount of or number of units transfused per patient who has received transfusion for the particular procedure.
Range of unit transfused for each procedure is noted.
In procedures like thyroidectomy, closure of duodenal ulcer perforation, TURP, cholecystectomy, pyelolithotomy and ureterolithotomy, incisional hernia repair and colostomy or closure of colostomy, very few patients received blood transfusion as compared to the number of patients cross-matched and for these procedures the average blood transfusion is also low. That is one unit of blood per transfused patient. The range of units of blood transfused is between 0 to 2. While for procedures like oesophagectomy, spleenectomy(elective and emergency), small and large bowel resection elective and emergency, nephrectomy, modified radical mastectomy, surgery for oral malignancy, intraabdominal soft tissue tumour excision, biliary entric bypass and cholecystectomy with CBD exploration the average is above 1 units of blood transfusion per transfused patient. Elective spleenectomy has a maximum average of 3.1 units of blood followed by oesophagectomy with 2.6 units of blood. For oesophagectomy it is 2 to 3 units and for biliary entric bypass between 1 to 3 units and so on.
Over all 150 patients received transfusion of 243 units of blood with average of 1.62 units of blood for each transfused patient .the overall range was between 0 to 4 units of blood transfusion.
This Table no.III gives the overall idea about transfusion pattern & the average (TI) calculated for each procedure is used afterwads for calculation MSBOS for procedure which shows significant blood usage.

Table no. IV describes the cross matched to transfusion ratio for individual procedure.
C/T ratio =No of unit cross matched/No of unit transfused
Boral & Henry first suggested the use of cross match to transfusion ratio (C/T) in 1975. [3] A retrospective study conducted by

Boral & Henry showed that cross matched to transfused ratio to be about 2.5:1 for elective surgery, that is 2.5 units are cross matched for single unit blood transfused. This overburden the blood bank &these units of blood become unavailable to other patients for at least 24 to 48 hours.

A C/T ratio of <2.5 was suggested as indicative of significant blood uses for particular procedure [1,4,17,18] C/T ratio of less than 2.5 indicates that more than 40% of cross matched blood is transfused & denote satisfactory blood use.
A C/T ratio of >2.5 is suggestive of less than 40% of cross matched blood is transfused & denote over ordering.

In our study procedures like oesophagectomy, spleenectomy(emergency or elective),small & large bowel resection, nephrectomy, intra abdominal soft tissue tumor excision, modified radical mastectomy, surgery for oral malignancy, cholecystectomy with CBD exploration & biliary entric bypass the cross match to transfusion ratio(C/T) was less than 2.5 showing significant biood usage for these procedures.

Procedures like pylolithotomy with ureterolithotomy, TURP, thyroidectomy, closure of duodenal ulcer perforation, incisional hernia repair, colostomy or colostomy closure & cholecystectomy had a cross match to transfusion ratio of more than 2.5. This suggests that significant over ordering is done.

To overcome the drawbacks of the cross match to transfusion ratio (C/T) other indicators are introduced. These indicators were transfusion probability & transfusion index. We have considered all these indicators together to get to conclusion whether the blood utilization for given procedures are significant or there is over ordering of blood. Table no.V is prepared to show thetransfusion probability(%T) for the procedures studied.

The transfusion probability(%T) was first suggested by Mead et al in 1980 as an indicator of significant blood usage. [13]
The transfusion probability is the probability with which the cross matched patient receives blood transfusion.
Transfusion probability = No. of pt received transfusion/No. of patients cross-matched.
The transfusion probability of more than 30% is considered to be indicative of significant blood usage.
The transfusion probability of less than 30% is considered as indicator of insignificant blood usage or over ordering.

In our study procedures like oesophagectomy, spleenectomy(elective or emergency), biliary entric bypass & cholecystectomy with CBD exploration had transfusion probability of 100%. This shows that for these procedures, each cross matched patient has received blood transfusion of at least one unit of blood intraoperatively.
While other procedures like small & large bowel resection, modified radical mastectomy &surgery for oral malignancy have a transfusion probability of less than 30% which is insignificant.

The remaining procedures like pylolithotomy&ureterolithotomy, TURP, closure of duodenal ulcer perforation, incisional hernia repair, colostomy or colostomy closure have transfusion probability of less than 30% denoting insignificant blood usage for these procedures. Cholecystectomy has a transfusion probability of 33.3%, which is just above the lower unit of 30% so it is considered to be insignificant blood use.

The third indicator the transfusion index (Ti) is discussed in Table no.VI.
The average no of units of blood used per patient cross matched is indicated by Transfusion Index (Ti). It differs from

average (TI) in which patients transfused is taken into consideration instead of patient cross matched.

The transfusion index(Ti) signifies the appropriateness of no of units ordered. [6]

In our study Transfusion index(Ti) is calculated for all procedures. Ti was above 0.5 for procedures like oesophagectomy, spleenectomy, small and large bowel resection, nephrectomy, intra-abdominal soft tissue tumour excision, modified radical mastectomy,Biliaryentric bypass and cholecystectomy with CBD exploration. This showed that for these procedures utilization of blood is significant and preoperative cross-match is required.

The remaining procedures like pylolithotomy, ureterolithotomy, TURP, thyroidectomy, closure of duodenal ulcer perforation, colostomy or colostomy closure, incisional hernia repair, cholecystectomy are having Ti of less than 0.5 which is insignificant.

We have studied these three indicators for each procedure in details namely Cross-matched to transfusion ratio, Transfusion probability, Transfusion index.

For procedures like oesophagectomy, spleenectomy, large and small bowel resection, nephrectomy, intra-abdominal soft tissue tumour excision, modified radical mastectomy, surgery for oral malignancy, biliary entric bypass and cholecystectomy with CBD exploration there is significant blood usage in all three indicators.

Other procedures like thyroidectomy, TURP, pylolithotomy and ureterolithotomy, closure of duodenal ulcer perforation, colostomy and colostomy closure and repair of incisional hernia are showing in all three indicators, insignificant blood usage.

The only exception is cholecystectomy, which is showing insignificant blood usage in cross-match transfusion ratio and transfusion index but showing significant blood usage according to transfusion probability. In the end it is considered to be insignificant.

The above finding obtained from our study matches to the other studies conducted prior both in India and outside.

The values are for thyroidectomy, C/T ratio of 3.75 and transfusion index of 0.33 and for TURP C/T ratio of 5.6 and transfusion index of 0.25.

The study conducted in India by Bhutia et al, [6] is also showing insignificant blood usage and over ordering for these procedures with values for thyroidectomy C/T ratio of 30.5 and transfusion index 0.03.

In our study, for oesophagectomy C/T ratio is 1.2, the transfusion probability of 100% and transfusion index of 2.6 which is significant in all the three indicators.

These values well match with the values calculated in study conducted by Bhutia et al. in his study values are C/T ratio 1.0, transfusion probability of 95.6% and transfusion index of 2.13.

The same is for biliary entric bypass procedure where values are C/T ratio of 2.04, transfusion probability of 60% and transfusion index of 0.88 while in our study for biliary entric bypass procedures C/T ratio is 1.4, transfusion probability of 100% and transfusion index of 1.83. In both of these studies it is significant.

Percentage of blood loss gets the major role in deciding the intraoperative or immediate post operative blood transfusion.

The above three indicators cross-match transfusion ratio, transfusion probability and transfusion index is calculated according to percentage of blood loss. Table no.VII is prepared so that 10 groups are made according to percentage of blood loss. Under each group, number of patients, the cross-match and transfusion pattern is noted.

The average, C/T ratio, transfusion probability and transfusion index calculated using the same formula.

The percentage of blood loss is calculated for each patient for each procedure. The total blood volume of that patient is calculated using the physiological formula.

For female-75ml/Kg

For male-66ml/Kg

The total blood loss is estimated by taking subjective analysis by anesthetist of intraoperative blood loss and finally percentage of blood loss calculated by using the formula.

$$\text{Percentage of blood loss} = \frac{\text{Blood Loss}}{\text{Total blood volume}} \times 100$$

The Table no.VII gives all detailed information about the study using the percentage of blood loss.

For group 1 and 2 all the three transfusion indicators are showing insignificant blood usage except for transfusion probability for group 2 which is 44.4%.

All other groups are showing significant blood usage as indicated by all these indicators.

The transfusion probability is 100% for all patients who had blood loss of more than 20% of their total blood volume. All patients with above 20% of blood loss received blood transfusion.

In our study, group 1 and 2 comprise of about 224 patients out of 319 patients. This shows that patient with blood loss of less than 10% are 70% of total patients. For these groups about 253 units of blood were cross-matched out of total 458 units. This comes to about 55.2% of total cross matched blood. As seen earlier, these patients do not require a routine cross match, thus, 55.2% of cross matches are unnecessary and these are creating a significant load over blood bank.

Out of 253 units cross-matched only 63 units of blood was transfused to the patients in this group, that means only 25% of blood is transfused the rest 75% units are held in reserve for at least 48 hours. This might have been caused outdating and wastage of blood.

The procedures where blood loss is anticipated to be less than 10% of total blood volume of the patient a routine cross-match should not be done.

While for procedure where blood loss is expected to be more than 10% in usual instance then routine preoperative cross-match is mandatory.

For instance in our study the closure of duodenal ulcer perforation the average blood loss was below 10% with only one patient where it has touched the 10% mark so it can be stated that for duodenal ulcer perforation patients preoperative blood cross-matching is not required.

Two solutions have been advocated to reduce the over ordering of blood. [3,6,10,13]

1. Formulation of MSBOS for procedures showing significant blood usage.
2. Substitution of a full cross-match by T&S for procedures with insignificant blood usage.

Our study has shown that out of 18 procedures, 11 procedures require significant blood usage. That is oesophagectomy, spleenectomy, small and large bowel resection, nephrectomy, intra-abdominal soft tissue tumour excision, modified radical mastectomy, surgery for oral malignancy, biliary entric bypass and cholecystectomy with CBD exploration.

Mead [13] suggested the criteria called Mead's criteria of 1.5, that is providing 1.5times the average amount of blood units per transfused patient for a procedure as maximum requirement.

The Maximum Surgical Blood Order Schedule (MSBOS) calculated using formula.

$$\text{MSBOS} = 1.5 \times Ti$$

$$\text{Where } Ti = \frac{\text{Number of unit transfused}}{\text{Number of patients transfused}}$$

The MSBOS as calculated for the 11 procedures that had shown significant blood usage in this study is tabulated in Table no.VIII.

The MSBOS suggested in this study well match with the other studies that conducted elsewhere by various authors. [2,6,13,14,19]

The MSBOS of 2 units of blood for modified radical mastectomy well matches with the study conducted in India by Bhutia et al and in abroad. [9,13]

The three to four units of preoperative blood cross match for oesophagectomy well matches with the reports of Bhutia and Napier. [6,14]

Surgery for oral malignancy having MSBOS of 2.4 in this study is comparable to the study by Bhutia [6] where MSBOS is of 2.2 and outside studies. [14,16]

Maximum surgical blood requirement of 1.95 for small and large bowel resection in this study also matches with MSBOS of 1.8 in study by Bhutiaet al [6] and Napier. [14]

The second solution for the reduction of over ordering of blood is substitution of a full cross-match by Type and Screen for procedures with insignificant blood usage.

The T&S involves the typing of patients of blood by grouping it for ABO and Rh(d) factors. [2,4,6,10,17] And the screening of patients serum for presence of any unusual antibodies. [2,5,6,10,15] If such an antibody is detected in the patient's serum then the serum is further tested against a panel of red cells.The antibody is identified and its titer determined.

If no antibodies are found in patients serum then no blood is kept in reserve. [4,6,10,12,15]

In the event of such patient while undergoing surgery experience excess blood loss, blood can be arranged accordingly. In case of severe hemorrhage the Type and Screened blood is made available immediately with an acceptable risk of minor incompatibility of 1:10000. [7,11]

In less severe need, emergency cross-match can be performed within 30-35 minutes while patient is maintained on plasma expanders. Even though blood is issued with the T&S, full cross-match is carried out over the issued blood and patient blood sample for further confirmation.

In our series the procedures which are recommended for the Type and Screen are listed in Table no.IX.

The procedures, which have been recommended for Type and Screen(T&S), shared 173 units of cross-matched blood, which comes to about 36% of 473 unit's cross-matched in total. If we should have avoided these numbers of units and replaced by T&S significant amount of load on the blood bank could have been reduced and the overall cross-matched to transfusion ratio which is of 1.9 would have been reduced to 1.4, which is highly desirable.

For proper implementation of T&S and MSBOS there should be close cooperation between blood bank officer, surgeons and anesthetist. The surgeon and anesthetist should be convinced that Type and Screen is a safe and effective method and in an emergency, the blood would be available on demand.

The blood bank needs to keep adequate stock of blood of patients group which has been Type and Screened only.

The MSBOS should be flexible and it should never be applied too rigidly. The clinical judgement of surgeon and anesthetist in anticipating blood loss should be given due consideration.

CONCLUSION

From this study following conclusions can be drawn

1) In a number of surgical procedures, there is gross over ordering of blood
2) Most of these procedures can be managed if the patients sample is subjected to Type and Screen(T&S)

procedure instead of a full cross match.

3) Type and Screen is a safe effective and economic solution to the strain put on blood banks by routine cross match of all cases with a consequence blockage of blood bottles of other patients.
4) In major surgical procedures routinely requiring blood transfusion, MSBOS should be calculated and followed since this gives a margin of 50% over the average blood loss/replacement thus safety margin in cases of unexpected hemorrhage.
5) Single unit transfusion should be avoided as far as possible, since, here the likely of transfusion complications are more than the benefits.
6) Blood fractionation with use of components will optimize the use of this precious commodity.

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