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Tailoring transfusion strategy using thromboelastogram in goal-directed massive transfusion: Impact on transfusion requirements and clinical outcomes

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Abstract:

BACKGROUND AND OBJECTIVE: We compared the overall clinical outcome in formula-based protocol (1:1:1) and thromboelastogram (TEG)-guided goal-based massive transfusion (MT) in the resuscitation of patients with hemorrhagic shock.

MATERIALS AND METHODS: This was a retro-prospective case–control study conducted over a period of 2 years among the patients who received MT using a 1:1:1 fixed ratio protocol (controls, Group A) and goal-based protocol (cases, Group B) guided through TEG. Patients were matched for the type and severity of the clinical conditions. Utilization of blood components, clinical outcomes, transfusion-related complications, and total mortality rates were compared between the groups.

RESULTS: There were 113 patients in the formula-based group and 109 patients in the goal-based transfusion group who were matched for injury severity scores. The total blood components utilized were 1867 and 1560, respectively, with a 17.7% reduction associated with the use of TEG. Patients were divided into normal, hypo, and hypercoagulable based on TEG, and a higher transfusion rate was associated with hypocoagulable TEG (942 vs. 610). The prothrombin time, activated partial thromboplastin time, R time, and K time had a significant positive correlation with the need to transfuse more than 20 blood components, whereas platelet count, base excess, alpha angle, MA, and CI had a negative correlation ($r = 0.268$, $P < 0.001$). At the end of goal-directed transfusion, 75% of the patients were free of transfusion support (vs. 65.4%) and only 6.9% of the patients had coagulopathy (vs. 31.8%) compared to formula-based resuscitation with a 10% reduction in mortality.

CONCLUSION: TEG-guided goal-based approach helped to reduce blood component utilization with a reduced incidence of coagulopathy at the end of the MT while improving patient survival.

Keywords:

Blood utilization, goal-directed massive transfusion, hemorrhagic shock, massive transfusion, thromboelastogram

Introduction

Hemorrhage secondary to trauma, cardiac surgeries, postpartum, and surgical causes which require massive transfusion (MT) is still a major cause of preventable death.[1-4] Managing patients with MT is often challenging and requires a multidisciplinary approach including clinicians, nurses, and laboratory and transfusion medicine specialists.[4,5] This multidisciplinary approach can be implemented by the concept of MT protocols (MTPs) which outlay all the concerned departments and the duties.

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MTPs have helped to reduce the early hospital mortality over the years along with improvements in prehospital care, injury preventive measures, regionalized trauma care system, interdepartmental communications, and damage control resuscitation.[6,7] Availability of transfusion medicine clinicians also played a role in developing and implementing MTPs in acute care settings in our country.

Early transfusion of plasma and platelets in a fixed ratio with packed red blood cells (PRBCs) in a 1:1:1 fixed ratio is associated with better patient outcomes.[8] Fixed ratio MT (FRMT) provides hassle-free transfusion support to necessary patients; however, this does not address the needs of individual patients in various clinical settings.[9] Goal-based MT individualizes the patient care by utilizing viscoelastic tests such as thromboelastogram (TEG) or rotational thromboelastometry in the MT support and addresses the needs of individual patients. This helps in early identification of the coagulopathy in each patient and correcting them in a timely manner.[8,9] Goal-based MTP does not follow a fixed ratio of component transfusion and hence the patient receives the required blood components at the appropriate time.[10,11] We intended to analyze the blood transfusion practice between FRMT and the newly implemented TEG-guided approach in various clinical conditions that required MT in our center.

Materials and Methods

We conducted a retro-prospective case–control, single-centered study in a 2032 bed level I trauma center attached to a tertiary care referral center. The study was approved by the institutional ethics committee (IEC: 494/2018, for the study period of 2 years). The retrospective data collection was done between January and December 2018, and the prospective data were collected between January and December 2019.

Study population

The study population was divided into the retrospective group (Group A; controls) and the prospective group (Group B; cases). The retrospective group (controls) included the population who received MT as per a prefixed 1:1:1 ratio of blood component transfusion protocol and was assigned as Group A. The prospective group (cases) included the population who received goal-based MT using TEG and was assigned as Group B. Citrated Kaolin TEG-5000 (Haemonetics, USA) was performed in the transfusion medicine department, and blood components were issued based on the clinical and TEG-based assessment of individual patients. We have included formula-based transfusion from retrospective data because the practice was to transfuse a 1:1:1 ratio of MT packs. The prospective group was taken after TEG was introduced into clinical management. The retrospective group was considered controls, and the prospective group was considered cases for this study.

Inclusion criteria and exclusion criteria

All the patients over the age of 18 years requiring MT (due to various causes such as trauma, obstetric hemorrhage, surgical bleeding, and medical causes such as upper gastrointestinal [UGI] bleeding) were included in the study. Patients with missing data, expired within the 1st h of admission, Revised Trauma Score (RTS) <3, and neonatal and pediatric transfusions were excluded from the study. MT was defined as either transfusion of >4 PRBC concentrates in 1 h or transfusion of >10 PRBCs in 24 h for the study purpose.

Recruitment and data collection

The patients were broadly categorized based on the diagnosis into trauma, massive obstetric hemorrhage (MOH) or postpartum hemorrhage (PPH), UGI bleeding, surgical causes, and others. The patients were further subclassified based on the severity of the injury, the need for MT (Trauma-Associated Severe Hemorrhage [TASH] score for trauma patients, Rockall scoring for UGI bleed patients, and shock index for obstetric hemorrhage), and survival probability (RTS). To minimize the confounding factors, the case and control groups were matched for the demographic variables and the clinical severity. The flowchart of the proposed goal-based MT algorithm is depicted in Figure 1. The data of the patients were collected from medical records and laboratory software. The data collection, as well as sample collection, happened in two time frames: one at the beginning of a MT and one at the end of the MT which was labeled as 24 h post MT. Laboratory parameters collected were hemoglobin, hematocrit, platelet count, pH, acid-base excess, prothrombin time (PT), activated partial thromboplastin time (aPTT), and fibrinogen levels. Transfusion details were collected from blood bank software and entered into Excel sheets. Prospective data were collected in real time as the resuscitation was going on. Coagulopathy was defined as either elevated PT INR more than 1.5 times, aPTT more than 1.5 times of normal range, or fibrinogen levels <100 mg/dL based on conventional tests. Prolonged R time more than 8 min, K time more than 3 min, reduced alpha angle <49°, reduced MA <50 mm, and presence of Ly30 more than 9% were used to define hypocoagulable state based on TEG. Whereas, shortened R or K, increased angle, and MA were used to define hypercoagulable state based on TEG. Based on the TEG findings, the cases were categorized as having normal, hypocoagulable, and hypercoagulable status.

Massive transfusion

Formula-based transfusion packs were used in the retrospective group (1:1:1). The packs were designed to

<table>
<tr><td>Series</td><td colspan="4">Blood components</td><td>Inv 1-
ABG, CBC, PT, aPTT, TEG
Blood grouping, Crossmatching</td></tr>
<tr><td>Pack series 1</td><td colspan="4">Pack 1 –
2 O neg PRBC and 2 AB FFP or ABO compatible PRBC/ FFP</td></tr>
<tr><td colspan="6">Based on Investigations1</td></tr>
<tr><td></td><td>Hb- low
Platelet-N
Coagulation screen - N</td><td>Hb-low
Platelet-low
Coagulation profile - N</td><td>Hb-low
Platelet-N
Coagulopathy-present</td><td>Hb-low
Platelet-low
Coagulopathy-present</td><td></td></tr>
<tr><td>Pack Series 2</td><td>Pack 2A
2 PRBCs and 2 FFPs</td><td>Pack 2B
2 PRBCs, 2 FFPs, 4 RDPs/ 1 SDP</td><td>Pack 2C
2 PRBC, 2 FFPs, 10 Cryoprecipitate</td><td>Pack 2D
2 PRBCs, 2 FFPs, 4 RDPs and 10 Cryoprecipitate.</td><td>Inv 2 –
ABG, CBC, PT, aPTT, TEG</td></tr>
<tr><td colspan="6">Based on Investigations 2</td></tr>
<tr><td rowspan="2">Pack Series 3</td><td>Hb- low
Platelet-N
Coagulation screen - N</td><td>Hb-low
Platelet-low
Coagulation profile - N</td><td>Hb-low
Platelet-N
Coagulopathy-present</td><td>Hb-low
Platelet-low
Coagulopathy-present</td><td>Continue Series 2</td></tr>
<tr><td>Pack 3A
2 PRBCs and 2 FFPS</td><td>Pack 3B
2 PRBCs, 2 FFPs, 4 RDPs/ 1 SDP</td><td>Pack 3C
2 PRBC, 2 FFPs, 10 Cryoprecipitate</td><td>Pack 3D
2 PRBCs, 2 FFPs, 4 RDPs and 10 Cryoprecipitate.</td><td></td></tr>
</table>

Figure 1: Goal-based massive transfusion algorithm that was implemented to manage massive haemorrhage

deliver the components in a 1:1:1 ratio irrespective of the clinico-laboratory profile of the patient (retrospective group). Goal-based transfusion algorithm was used in the prospective group to manage the patients when MTP was activated. Transfusion was guided based on clinical status as well as laboratory TEG parameters[6] in the prospective arm which was communicated to the bedside [Figure 1]. The endpoint was defined as either stabilization of the patient or attaining hemostasis or death, and values were recorded 24 h after stopping MT. The decision to stop MT was made by the treating physician once the patient was stabilized. Patients were subdivided into whether or not requiring more than 20 blood components within 24 h of admission and analyzed the factors that correlated with an increase in blood utilization.

Statistical analysis

The data were entered in Microsoft Excel, and analysis was done using SPSS version 21 (IBM, West Maddison street, Chicago, USA). Statistical tools used for analysis were measures of central tendency, correlation, Chi-square analysis, one-way analysis of variance, and linear regression. The sample size was estimated based on the historical data available as 6–11 MT per month and converted into a time-bound data collection over a period of 2 years (1 year for retrospective and 1 year for prospective).

Results

A total of 113 patients were enrolled in Group A and 109 patients were enrolled in Group B, as demonstrated in Figure 2. The groups were compared based on the type of disease and the severity of the disease, and both were comparable in terms of the severity of the disease at the time of admission. The patients were compared for severity using TASH scoring, RTS scoring for trauma, and Rockall scoring for UGI bleed. The overall indications for initiating the MT were trauma 100 (45.05%), UGI bleed 46 (20.72%), obstetric hemorrhage 34 (15.32%), surgical causes 34 (15.32%), and other causes 8 (3.6%) [Figure 2]. The baseline characteristics as well as the severity scores were comparable upon admission in both the groups, and hence, we were able to compare the clinical outcome [Table 1] and transfusion requirements [Table 2]. The median time taken to release blood components from the blood center was 7 and 8 min for Groups A and B, respectively.

The total transfusion requirement in the study population was 1867 blood components in Group A and 1560 blood components in Group B resulting in an overall reduction of 17.7% blood utilization. We have observed a reduction in the total number of blood components utilized in the TEG-guided algorithm [Table 2]. PRBC, FFP, Platelets and cryoprecipitate utilisation was reduced by 20%, 16.2%, 9.4% and 22.5% respectively in the prospective group [Figure 3]. The reduction in blood utilization was also evident in diagnosis-based management as the data shown in Table 2. In the prospective arm based on TEG, a total of 942 components were transfused in hypercoagulable patients based on TEG whereas patients in normal and hypercoagulable TEG stages received 559 and 51 units, respectively. The majority of the transfusion events occurred in the hypocoagulable stage with significant use of cryoprecipitate (245 units vs. 82 in normal and 13 in hypercoagulable). PRBC Transfusions in retrospective controls were significantly correlated with pH (-0.241, P=<0.001), strong correlation was observed between PT, aPTT and pH (0.445, 0.355 and -0.305, P<0.001 respectively) with FFP transfusion. Whereas, in prospective study group, K timeewas strongly associated with the PRBC and FFP requirements (0.356, 0.347 respectively, P<0.001) and MA had a coefficient of 0.281 (P=0.04) with platelet transfusions.

The details of the TEG and interpretation are depicted in Figure 3. Patients were subdivided based on TEG into normal, hypo, or hypercoagulable status. The

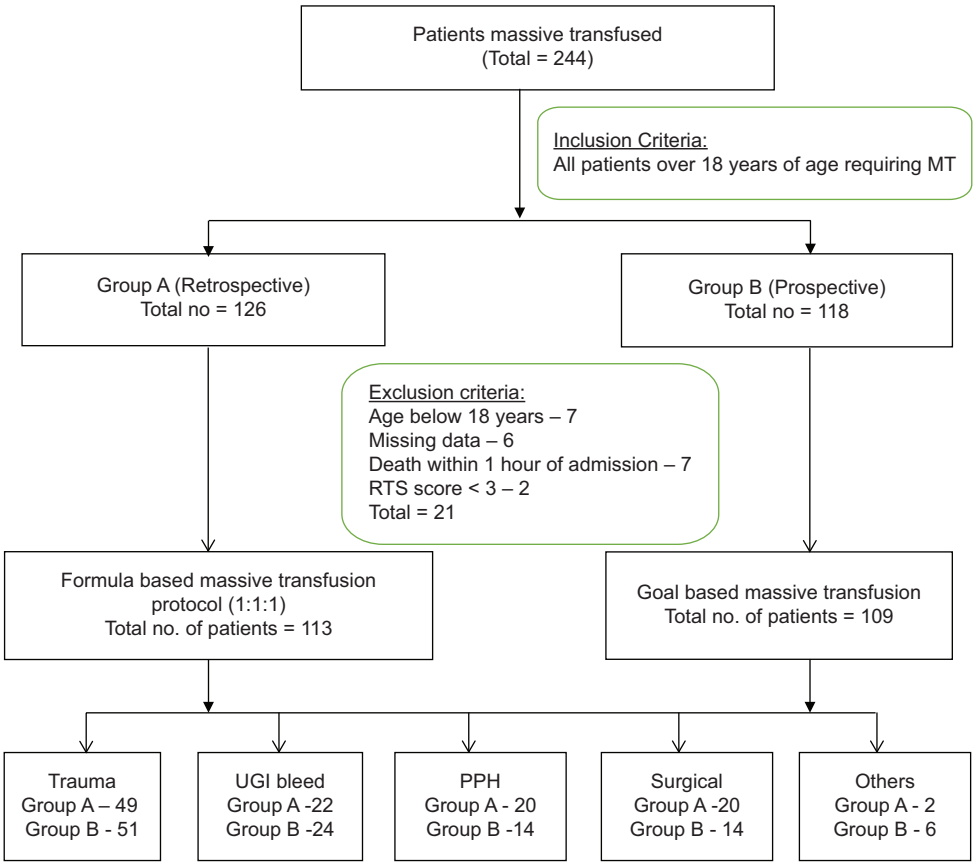

Figure 2: Study participants recruitment method

majority of the patients had either a normal coagulation status or hypocoagulable picture during the early resuscitation phase. The mean TEG values are expressed in Table 3 compared to the age-matched in-house reference range. The most common abnormality noted was increased fibrinolysis activity followed by a low maximum amplitude level and angle and K and R time. A primary fibrinolysis activity was seen in 28.4% of the patients along with either a normal or hypocoagulable TEG picture. Trauma and MOH were most commonly associated with primary fibrinolysis. Analyzing the transfusion requirement of more than 20 units requirement with laboratory parameters of all the patients at the time of admission, we found that PT, aPTT, R time, and K time had a significant positive correlation (0.325, 0.360, 0.282, and 0.311, respectively, $P < 0.001$) whereas platelet count, base excess, alpha angle, MA, and CI had a negative correlation (–0.201, –0.218, –0.235, –0.219, and –0.430, respectively, $P < 0.005$). Blood requirement >20 units had a significant regression coefficient with TEG parameters ($r = 0.268$, $P < 0.001$) as well and a blood requirement of more than 15 units at the time of admission was significantly correlated to poor outcome (correlation coefficient: –0.368, $P = 0.0056$).

Post MT status of the patients was analyzed to know the effect of goal-based MT on the patients, and we

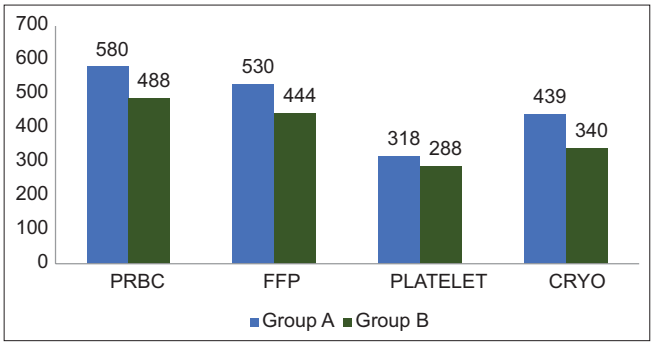

Figure 3: Patterns of blood component utilisation among cases (Group B) and controls (Group A)

have observed a significant improvement in the coagulation status of the patients compared to the time of admission as well as to the retrospective group [$P = 0.03$, Table 4]. The changes in the presence of acidosis and hypocalcemia were similar in patients managed with two different MT protocols. TEG-guided management resulted in a 10% reduction (55 vs. 42) in the overall mortality rate [Table 4]. After 24 h of MTP, 65.4% and 75.2% of the patients were free of transfusion support in Groups A and B, respectively, meaning the goal-based management helped in achieving hemostasis better.

Table 1: Clinical profile of patients at the time of admission/at the onset of massive transfusion and after massive transfusion compared between retrospective controls (Group A) and thromboelastography-guided transfusion support group (Group B)

	Normal values	Overall	At the time of admission			Postmassive transfusion		
			Group A	Group B	*P*	Group A	Group B	*P*
Demographic details								
Age, mean±SD		42.7±16.3	43.7±16.9	41.7±15.7	0.37			
Male (%)		14565.3	7566.3	7064.2	0.42			
Female (%)		7734.7	3833.6	3935.7				
Hypotension (mmHg) (%)	SBP <90, DBP <60	11350.9	6456.6	4945	0.05			
Tachycardia (beats/min) (%)	HR >100	10346.3	5548.7	4844	0.08			
Hematologic parameters, mean±SD								
Hemoglobin (g/dL)	13–17	9.04±2.7	9.05±2.7	9.03±2.9	0.57	9.07±1.8	9.98±2.5	0.007
Hematocrit (%)	40–50	27.5±9.3	27.1±8.1	27.8±10.4	0.29	26.2±5.4	29.3±8.05	0.003
Platelet count (/µL)	150000–450000	206235±127166	206281±121592	206188±133219	0.23	147000±122858	119865±63029	0.08
WBC (/µL)	4000–1000	16299±9194	16919±9209	15672±9184	0.92	13108±6230	14835±22087	0.54
Biochemistry parameter, mean±SD								
pH	7.35–7.46	7.19±0.22	7.10±0.23	7.27±0.17	0.01	7.14±0.19	7.27±0.18	<0.001
Na^+ (mmol/L)	136–146	137.1±7.3	136.2±7.9	138±6.6	0.06	136.6±7.4	137.5±12.8	0.58
K^+ (mmol/L)	3.4–4.5	4.14±0.23	4.1±0.9	4.1±1	0.75	3.9±1	4.3±1.69	0.09
$HCO3^-$ (mmol/L)	23–29	16.47±5.2	15.6±5.7	17.2±4.6	0.05	17.41±7.4	17.41±5.2	0.99
Cl^- (mmol/L)	98–106	103.7±6.8	103.7±8.7	103.7±5.1	0.98	105.9±9.5	102.4±13.6	0.10
$Ca2^+$ (mmol/L)	2.2–2.7	0.9±0.1	0.8±0.1	1.0±0.1	0.72	0.86±0.2	1.09±0.50	0.10
Base excess (mmol/L)	−3–+3	−10.41±7.46	−11±8.31	−9.2±6.3	0.04	−9.4±7.4	−7.9±7.1	0.35
Coagulation parameters, mean±SD								
PT (s)	9.6–12.5	22.7±24.8	23.6±25.9	22±24	0.55	14.7±7.2	15.07±6.29	0.82
aPTT (s)	26.8–33.2	45.3±30.9	45.5±30.7	45±31.1	0.94	38.2±22.6	35.9±18.7	0.56
Fibrinogen (mg/dL)	200–400	126±107.9	122.2±133.4	128.8±87.5	0.15	219±161.7	267.1±160.7	0.31

SD=Standard deviation, WBC=White blood cells, aPTT=Activated partial thromboplastin time, PT=Prothrombin time, DBP=Diastolic blood pressure, SBP=Systolic blood pressure

Table 2: Utilization of blood components in both the groups categorized according to diagnosis

Group (number)	Trauma		UGI Bleed		Obstetric		Surgical		Others		Total units		Percentage change in component utilization	*P* (ANOVA)*
	A49	B51	A22	B24	A20	B14	A20	B14	A2	B6	A	B		
PRBC														
Median (IQR)	5 (3)	4 (4)	3 (3)	3.5 (3.25)	5 (4)	5 (2.75)	5 (2)	5 (2)	4 (0.25)	4 (1)	610	488	−20	0.014
Units	292	219	85	94	125	77	99	75	9	23				
P	0.01		0.937		0.55		0.5		ND					
FFP														
Median (IQR)	4 (2)	3.5 (4)	2 (4)	4 (2.25)	6 (4)	4 (3.5)	4 (4)	4 (4)	4 (1)	4 (1)	530	444	−16.20	0.07
Units	249	211	78	87	112	67	87	57	4	22				
P	0.104		0.87		0.4		0.9		ND					
Platelets														
Median (IQR)	5 (0)	5 (0)	5 (1)	5 (1)	5 (2)	4.5 (1)	5 (0)	7.5 (3.25)	6 (0)	5 (0)	318	288	−9.40	<0.001
Units	176	135	26	58	56	41	60	43	0	11				
P	0.71		0.3		0.26		0.01		ND					
Cryoprecipitate														
Median (IQR)	6 (10)	10 (0)	6 (2)	10 (0)	10 (4)	16 (4.75)	5 (13)	10 (4)	10 (0)	10 (0)	439	340	−22.50	<0.001
Units	142	67	24	50	234	125	39	70	0	28				
P	0.5		0.02		0.8		0.4		ND					
Total														
Units	859	632	213	289	527	310	285	245	13	84	1897	1560	−17.76	<0.01
P	0.32		0.59		0.6		0.4		ND					

PRBC: Packed rec blood cells, FFP: Fresh frozen plasma, ANOVA: Analysis of variance, IQR: Inter quartile range, ND: Not done

Table 3: Thromboelastography parameters in massively transfused patients on admission during the initial phase of massive transfusion (Group B)

	R (min)	K (min)	Angle (degree)	MA (mm)	G (dynes/s)	EPL (%)	LY30 (%)
Normal range	3.8–10.6	1.2–3.1	44.9–72	41.2–64.5	4.6K–10.9K	0–15	0–9.9
Mean±SD	5.08±8.8	2.4±3.6	62.7±14.9	51.8±14	6±2.7	14.74±20.7	14.7±20.7
Number of Patients with abnormal results (%)	6 (11.1)	11 (10)	19 (18.2)	40 (38)	29 (27.3)	33 (31.1)	43 (40.5)

SD: Standard deviation, MA: Maximum amplitude, EPL: Estimated percentage of lysis, LY30: Lysis at 30 minutes

Table 4: Comparing the clinical profile of patients between groups after massive transfusion

	Group A (*n*=113)	Group B (*n*=109)	*P*
Metabolic acidosis	52.5% (32, *n*=61)	51.9% (28, *n*=54)	0.54
Hypocalcemia	74.2% (49, *n*=66)	72.5% (29, *n*=40)	0.50
Coagulopathy	31.8% (21, *n*=66)	6.9% (6, *n*=87)	<0.05
LOHS (days)	12.07±12.28)	14.39±16.19)	0.24
Free of transfusion at the end of 24 h post-MT	74 (65.4%)	82 (75.22%)	0.14
Mortality within 24 h of MT	17 (15%)	12 (11%)	0.42
Patient outcome after 24 h of MT			
Survival	68 (60.1%)	73 (66.9%)	0.29
Expired	38 (33.6%)	30 (27.5%)	
Overall mortality	55 (48.67%)	42 (38.53%)	0.15

7 patients in group A and 6 in group B were discharged against medical advice and were excluded from statistical analysis. MT: Massive transfusion, LOHS: Length of hospital stay

Discussion

In the present case–control study, we compared the protocol and goal-based approach in managing patients with massive hemorrhage and studied the blood component utilization pattern and effect on the overall clinical outcome. The two groups were clinically comparable, as shown in Table 1. We have observed a 17.7% reduction in the blood components transfused after the introduction of TEG and a reduction in individual component usage by 20% in PRBCs, 16.2% in FFPs, 9.4% in platelets, and 22.5% in cryoprecipitate transfused in the goal-directed group, as shown in Table 1. The reduction in the PRBC in the TEG-based group was statistically significant (P = 0.01). The decreased use of blood components prevents unnecessary exposure to donors and the infectious and noninfectious complications associated with transfusion. This reduction in component utilisation also reduce the financial burden on the patients.[7,12] The added advantage of the blood center is that it helps in inventory management as more units will be available for other patients. A meta-analysis on viscoelastic-guided transfusion protocol revealed that fewer PRBCs and FFPs were used in the MT in the trial arm with similar outcomes.[10] The TEG guided interventions may result in an earlier achievement of haemostasis could be one of the reasons for the reduced requirement of blood components.[13]

We have also observed a reduction of blood component usage in trauma, MOH, and surgical causes except UGI bleed which alone was associated with a greater number of transfusions. The usage of individual components in each diagnostic category was also lesser. Early administration of cryoprecipitate is needed while managing postpartum hemorrhage to prevent DIC.[14] The utilization of cryoprecipitate was much reduced with TEG without leading to the development of DIC [Tables 1 and 3] in PPH cases. An abnormal K time and alpha angle indicates a fibrinogen deficiency and cryoprecipitate should be the choice of component in such cases.[11,15-17] Early identification of clot formation and dynamics of clot formation may help in correcting the existing coagulopathy by appropriate blood components.

The mean parameters of the 109 citrated kaolin TEG performed were in the normal range, however, often the patients were distributed among normal and hypocoagulable status. Hypocoagulable status explains that patients were already in coagulopathy and its correction by proper transfusion practice is of utmost importance in the resuscitation of such patients. 45.87% of patients presented with a hypocoagulable TEG picture [Figure 4]. A hyperfibrinolysis activity was the most common abnormality observed among the patients. A hyperfibrinolysis is associated with poor outcome and death in trauma, and our findings are in accordance with the published literature.[6,7] Fibrinolysis and fibrinogen depletion also play a major role in PPH and hence antifibrinolytics is advised in the early resuscitation phase of such cases.[18,19] TEG is a viscoelastic assay which helps us to diagnose fibrinolytic activity in the patient even when their clot initiation (R time) and acceleration (K time and α angle) happen to be normal. The timely intervention helps to arrest this early coagulopathy to progress into an overt consumptive coagulopathy.[20,21] The extensive tissue damage exposes all the membrane lipids mediating endothelial-driven fibrinolysis hyperactivity, and this

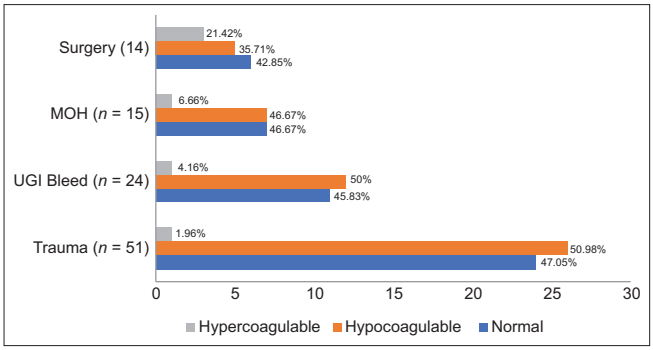

Figure 4: Coagulation status based on TEG according to the diagnosis of the patients. MOH: Massive obstetric haemorrhage, UGI bleed: Upper gastro intestinal bleeding

hyperfibrinolysis indirectly leads to a low MA in TEG tracing with a normal platelet count.

The coagulopathy associated with hemorrhagic shock is characteristically driven by multiple host factors including coagulation pathways, complement system, and inflammatory mechanisms. The coagulopathy typically presents with a hypocoagulable condition arising from either the pathophysiology of the injury or the loss of coagulation factors due to bleeding or both.[22-25] We have observed that majority of our patient population had a hypocoagulable or normal coagulation status on admission based on TEG and major proportion of transfusion occurred in these two groups. Patients with a hypocoagulable TEG tracing received more cryoprecipitate transfusion compared to either normal or hypercoagulable TEG. This early intervention in the form of cryoprecipitate transfusion might have helped to correct the coagulopathy at an earlier phase. There was a significant correlation between TEG parameters and utilization of more than 20 blood components within 24 h. This suggests that monitoring massively bleeding patient's coagulation status with TEG will help us to evaluate the need of blood component needed in resuscitation program.

Coagulopathy and acidosis are factors which regulate each other. Refractory acidosis in hemorrhagic shock leads to severe consumptive coagulopathy which is very difficult to treat.[11,26] The current study revealed that TEG-guided management has lead to a significant improvement improvement of coagulopathy post MT. This will also help to reduce the transfusions in the later phase which may otherwise occur because of coagulopathy. The fact that there was better achievement of hemostasis with lesser number of blood components in goal-directed arm and a reduction in mortality rate suggests a significant improvement in patient management in resource-limited scenarios. A goal based individualized transfusion support requires a multidisciplinary team consisting of treating physician, transfusion medicine specialists, clinical hematologists, pathologists and critical care specialists.[27,28]

In summary, goal-directed MT suggests a positive direction in the early resuscitation of hemorrhage. Early identification and intervention of fibrinolysis helps to prevent overt consumptive coagulopathy. TEG helps to attain complete hemostasis with a lesser number of blood products. Reduction in the transfusion requirement also reduces the risk of infectious and noninfectious complications associated with blood transfusion. More components will be available for blood centres which help in efficient inventory management. In resource-limited scenarios like ours, the factors thus far mentioned play a significant role in easing the financial burden on patients. The goal-based MT improves patient outcomes compared to formula-driven protocol. The development and implementation of goal-based MTP is a multidisciplinary approach tailored to provide individualized patient care.

The study limitations were that it was conducted as a single-center retro-prospective study. In the retrospective arm irrespective of the cause of massive hemorrhage, the uniform protocol was used for managing the adult patients. Even though the study showed a promising result, we would like to do a prospective randomized multicentric trial in our population to establish the role of TEG in MT to evaluate the utility of TEG. Another limitation we faced during the study frame was we had to recruit patients with diverse clinical scenario requiring MT which we have compared with respective severity scores applicable in each etiopathology.

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Conflicts of interest
There are no conflicts of interest.

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