Original Article

Thromboelastography in Different Mechanisms of Injuries/ Organ Injuries in Traumatized Patients in Southern Thailand

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Abstract

Background: Trauma is the second most common cause of death in Thailand, relatively with massive blood loss. Coagulopathy plays a role in blood loss. Differences in mechanisms and organs injured can affect coagulopathy stage and blood loss. Thromboelastometry is a measuring instrument for accurate and rapid detection of coagulopathy. We hypothesized that thromboelastometry in traumatized patients who require surgery in Songklanagarind Hospital will help with early detection of coagulopathy and assess anticipated blood loss. **Methods:** After approval from the Institutional Ethics Committee, patients aged above 18 years who had American Society of Anesthesiologists Physical Status (ASA) IE–VE, activated by trauma team and sent for emergency surgery. Anesthesia was induced and maintained, and invasive procedures were done as anesthesiologist's consideration. Thromboelastometry, prothrombin time (PT), partial thromboplastin time (PTT), complete blood count, platelets, arterial blood gas, lactate, and base deficit were assessed and recorded at the emergency room and after Massive Transfusion Protocol (MTP) was activated at 1 and 2 MTP, respectively. **Results:** Most traumatized patients who were operated on in Songklanagarind Hospital during the study period were male, the most common cause of their injuries was a motorcycle accident, and the most common organ associated with massive blood loss and blood transfusion was the head. After the patients received PRCs of 5 and 11 units, the hematocrit level and platelet count decreased from baseline, while PT and PTT were prolonged. pH, base deficit, and lactate were worse. Clot formation time (CFT), A10, and maximum clot firmness (MCF) of EXTEM were statistically significantly different among the three time periods. Clotting times, CFT, A10, and MCF of INTEM were statistically significantly different among three time periods. A10 and MCF of FIBTEM were statistically significantly different among three time periods. **Conclusion:** Most baseline laboratory tests in the traumatized patients who received massive blood transfusion and underwent surgery were worse after they received 1 and 2 MTP. These parameters including thromboelastometry could be guided for preparing proper blood components for patients requiring massive transfusion.

Keywords: Mechanism of injuries, organ injuries, thromboelastography, traumatized patients

Introduction

Trauma is the second most common cause of death in Thailand,[1,2] and the trauma mortality rate around the world increased by 10.7% from 4.3 million in 1990 to 4.8 million in 2013.[3] The major cause of death in traumatized patients is massive bleeding and head injury.[4] The main mechanism of massive bleeding is coagulopathy[5] which is associated with high mortality rates.

Coagulopathy in traumatized patients have high risk for coagulopathy stage and bleeding more than other kinds of patients with bleeding.[6] The risk of bleeding in traumatized patients arises from hyperfibrinolysis which

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is attributed to activated protein C-mediated inactivation of plasminogen activator inhibitor-1. In trauma patients with many serious injuries including massive bleeding, standard coagulopathy testing may be delayed. Rotational thromboelastometry (ROTEM)[7] is a measuring instrument that can detect coagulopathy more rapidly than the standard test and thus help physicians to predict impending coagulopathy and prepare the required blood components until the termination of blood transfusion for trauma patients.

The component of ROTEM consists of EXTEM to predict the extrinsic pathway of the coagulation cascade, INTEM for the intrinsic pathway of the coagulation cascade, FIBTEM for measuring the fibrinogen level, and APTEM for measuring the aprotinin level and platelet function. Each of the ROTEM tests affects the decision to choose blood components, which a different from standard practice which gives blood components by clinical decision, which is the risk to allergic reaction from blood component, side effects of massive blood transfusion, and waste value.

One retrospective study which included patients admitted to the AUVA Trauma Center, Salzburg, Austria,[8] with injury severity score (ISS) ≥16 found that clotting time (CT) and clot formation time (CFT) of EXTEM and INTEM were significantly prolonged and maximum clot firmness (MCF) of FIBTEM was significant lower in massive transfusion group versus nonmassive transfusion group.

This study is to describe the thromboelastography pattern in traumatized patients. We also describe the traumatized patient characteristics, causes of injuries, and organ of injuries in Songklanagarind Hospital.

Methods

After approval from the institutional ethics committee, patients aged above 18 years who had American Society of Anesthesiologists Physical Status IE–VE, activated by trauma team, and sent for emergency surgery in the operating theater from November 2015–October 2016 in Songklanagarind Hospital, were enrolled in the study. Our institution is a level 1 trauma center, an 856-bedded medical center in Hat Yai, Songkhla, Thailand, which is affiliated with Prince of Songkla University.

Traumatized patients who arrived emergency department of Songklanagarind Hospital and were activated by trauma team followed these criteria: developed hypotension or went into shock (systolic blood pressure [SBP] <90 mmHg or 100 mmHg in hypertension), mechanism of injury was penetrating trauma (gunshot wound, stab wound), developed cardiac arrest, respiratory rate <12/min or >30/min, tachycardia (pulse rate >120 beat per min), and as emergency department physician opinion. The patients who had the following problems on antiplatelet, chronic liver disease, burn, or pregnancy were excluded from this study. The massive transfusion protocol (MTP) of our institution was used which is a 1:1:1 ratio of packed red cells (PRC), fresh frozen plasma (FFP), and platelets, which includes 4 units of PRCs, 4 units of FFP, and 1 unit of platelet pheresis or 6 units of platelets. Informed consent was waived due to the emergency status of the patients.

At the emergency department, after initial treatment and resuscitation were done, standard laboratory tests were done, including complete blood count (CBC), prothrombin time (PT), partial thromboplastin time (PTT), arterial blood gas (ABG), lactate, and thromboelastometry. At the operating room, demographic data, SBP, heart rate, body temperature, mechanism of injury, injured organs, Glasgow coma scale score, and ISS were recorded by the nurse anesthetists. After standard monitoring was applied, invasive monitoring and induction agents were considered by the anesthesiologists. After the patients became apneic and had loss of eyelash reflex, an appropriate-sized endotracheal tube was inserted. Keeping a patient anesthetized depends on the patient's condition and the anesthesiologist's assessment. After transfusion of PRC 5 units (1 MTP) and 11 units (2 MTP), blood samples were sent to assess CBC, platelets, PT, PTT, ABG, lactate, base deficit, and thromboelastometry. The blood samples were collected via an A-line or central venous catheter after 5 mL of blood was tested. Blood for thromboelastometry was sent in a 3.2% sodium citrate tube. Intraoperative blood loss, intravenous fluid, inotropic drug use, and blood components were recorded. After the operation, the patients were transferred to the postanesthetic care unit or the intensive care unit (ICU). Postoperative 24-h mortality was recorded.

The sample size was calculated using a correlation coefficient from a previous study, and the number of patients required for this study was 75.

Statistical analysis was performed using R software version 2.14.1 R Foundation for (Statistical Computing, Vienna, Austria). The Shapiro–Wilk normality test was used to assess the normality of the findings. Continuous variables are presented as means and standard deviations. Categorical variables are presented as numbers of patients and percentages. Continuous variables were analyzed using paired *t*-test or Wilcoxon rank-sum test. A $P < 0.05$ was considered statistically significant.

Results

Seventy-five patients were enrolled from November 2015 to October 2016. Three patients were excluded from the study due to technical error. The patient demographic data are shown in Table 1.

The most common cause of admission to the emergency room (ER) was motorcycle accident (42.7%), followed by motor vehicle accident (17.3%) and penetrating trauma (17.3%) [Figure 1]. The most common injury sites were head (60%), chest (48%), extremities (48%), abdomen (44%), and face (8%) as shown in Figure 2. All patients received crystalloid and some patients received colloid intravenously (gelofusine 64.9% and voluven 24.7%). Sixty patients (80%) received PRC transfusion, 53 (70.7%) patients received FFP, 26 (31.5%) patients received platelets, and four patients (5.4%) received cryoprecipitate intraoperatively, as shown in Table 2. Laboratory tests were done at the emergency department as baseline and then repeated after the patient received 5 units and 11 units of PRC [Table 3]. There were statistically significant differences in Hb, platelet counts, PT, aPTT, pH, base deficit, and lactate between the group which received 5 units of PRC transfusion and the group which received 11 units of PRC transfusion group.

The recorded thromboelastometry (EXTEM, INTEM, and FIBTEM) values at the emergency department, after receiving their different PRCs of 5 units and 11 units, are shown in Figure 3.

For EXTEM, there were statistically significant differences of CFT, A10, and MCF among ER group, after 5 units of PRC transfusion group and 11 units of PRC transfusion group. For the INTEM readings, there were statistically significant differences in CT, CFT, A10, and MCF among ER group, after 5 units of PRC transfusion group and 11 units of PRC transfusion group. For FIBTEM, there were statistically significant differences in A10 and MCF, among ER group, after 5 units of PRC transfusion group and 11 units of PRC transfusion group.

Table 1: Patient demographic data, shown as *n* (%) and mean±standard deviation

Patient characteristics	*n* (%) or mean±SD
Sex, *n* (%)	
Male	60 (80)
Female	15 (20)
Age (year)	37.90±15.00
SBP (mmHg)	121.60±30.40
HR (bpm)	100±25
Temperature (°C)	36.4±1.2
GCS	10±5
ISS	22±10
ASA, *n* (%)	
II	5 (6.7)
III	28 (37.3)
IV	39 (52)
V	3 (4)
24-h mortality, *n* (%)	5 (6.7)
Cause of accident	
Road traffic	47 (62.8)
Penetrating trauma	13 (17.3)
Fall from height >1 m	6 (8)
Terrorism/war	4 (5.3)
Accident due to natural and environment	1 (1.3)
Others	4 (5.3)

HR: Heart rate, SBP: Systolic blood pressure, GCS: Glasgow coma scale score, ISS: Injury severity score, ASA: American Society of Anesthesiologists

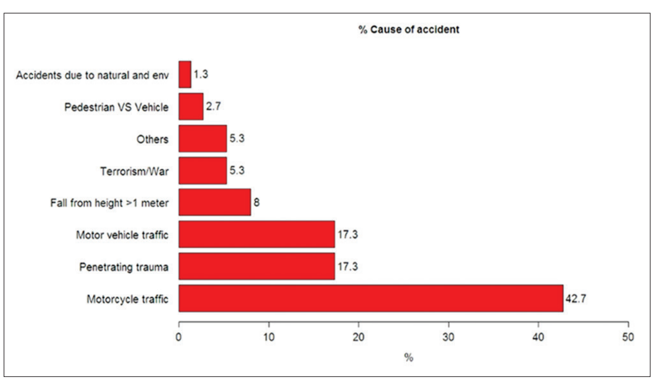

Figure 1: Cause of accident

Discussion

Stroke is the leading cause of death in Thailand (10.7%), followed by ischemic heart disease (7.8%) and HIV/AIDS (7.4%). Other leading causes are road traffic accidents (males) and diabetes mellitus (females).[9] Trauma and massive transfusion are associated with coagulopathy secondary to tissue injury, hypoperfusion, dilution, and consumption of clotting factors and platelets,[6] resulting in high mortality rates. Each year, Songklanagarind Hospital, the major tertiary care and referral center in Southern Thailand, receives approximately 1200 traumatized patients, of whom approximately 10% are severe cases who need emergency surgery and frequently have massive bleeding leading to a high mortality rate. Standard laboratory tests require a period of time to detect coagulopathy, and we suspected that thromboelastometry could help to predict coagulopathy stage and alert ER doctors to the need to prepare blood components in a timely way if likely to be needed.

Thromboelastometry is a whole-blood viscoelastic test measuring CTs (CT and CFT), clotting dynamics (CFT and a-angle), clot firmness (A5, A10, A15, and MCF), and clot stability over time (CLI30, CLI45, CLI60, maximum lysis, and lysis onset time).[10] ROTEM can be used as a mobile point-of-care device in the operating theater or the ICU. ROTEM includes an extrinsically activated assay with tissue factor (EXTEM), an intrinsically activated test using kaolin (INTEM), and an extrinsically activated test with tissue factor and the platelet inhibitor cytochalasin D (FIBTEM).[11]

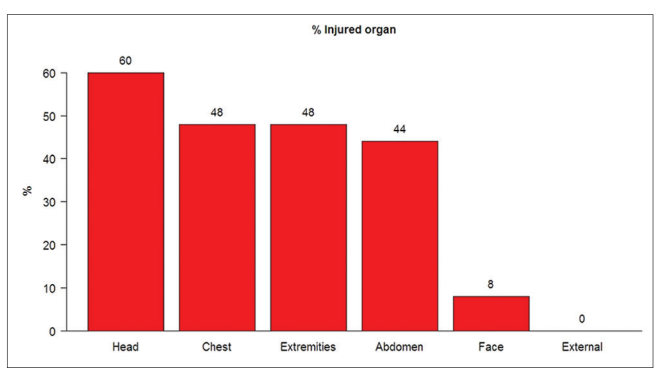

Figure 2: Injured organ

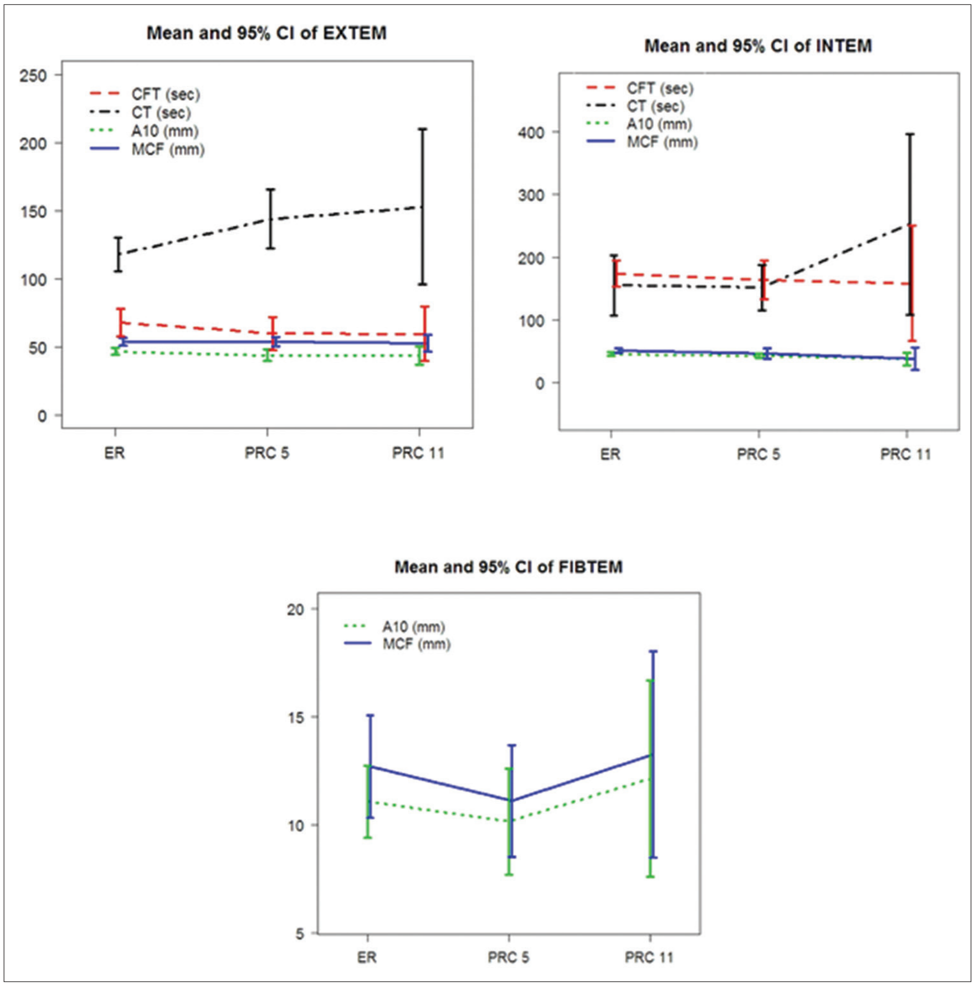

Figure 3: Mean and 95% confidence interval of EXTEM, INTEM, and FIBTEM. ER: Emergency room, PRC 5: 5 units of packed red cell, PRC 11: 11 units of packed red cell

Table 2: Blood component and fluids consumption, shown as *n* (%) and mean±standard deviation or median (interquartile range)

Blood component and fluid (ml)	*n* (%)	Mean±SD
Normal saline solution	75 (100)	3078.00±2539.47
Pack red cell	60 (80)	1585.91±1593.71
FFP	53 (70.7)	1532.52±1640.86
Gelofusine	48 (64.9)	791.67±311.03
Platelet	26 (31.5)	533.24±332.61
Voluven	18 (24.7)	846.15±240.19
Lactated ringer solution	2 (2.7)	1525.00±671.75
Acetar	3 (4.1)	1000.00±0
Cryoprecipitate	4 (5.4)	35.00

FFP: Fresh frozen plasma, SD: Standard deviation

In Songklanagarind Hospital, the reference ranges for EXTEM are CT (38–79 s), CFT (34–159 s), A10 (43–65 mm), and MCF (50–72 mm); for INTEM are CT (100–240 s), CFT (30–110 s), A10 (44–66 mm), and MCF (50–72 mm); and for FIBTEM are A10 (7–23 mm) and MCF (9–25 mm). In this study, CFT INTEM was prolonged at the ER, 5 units of PRC transfusion, and 11 units of PRC transfusion (177.238 + 240.89, 166.357 + 87.56, and 275.714 + 172.83, respectively).

In this study, we found that Hb and platelet count were decreased from baseline, and PT and PTT were prolonged, which we suspect were from massive blood loss and delays in blood transfusion.

Trauma-induced coagulopathy (TIC) affects 25%–34% of all trauma patients. TIC increases the risk of the need for massive transfusion which is associated with mortality rates up to 54%.[11] A previous study by Schöchl *et al*.[12] reported that EXTEM and INTEM CT and CFT were significantly prolonged and MCF was significantly lower in the massive transfusion group versus the nonmassive transfusion group ($P < 0.0001$ for all comparisons). In this present study, we found that INTEM CFT between ER group and 5 units of PRC transfusion was statistically significant ($P = 0.040$).

A previous retrospective analysis study in trauma patients by Schöchl *et al*.[13] reported that when using ROTEM®-guided hemostatic therapy, with fibrinogen concentrate as the first-line hemostatic therapy and additional prothrombin complex

Table 3: Laboratory test, shown as mean±standard deviation

Laboratory	ER (*n*=75)	After 5 units of PRC transfusion (*n*=18)	After 11 units of PRC transfusion (*n*=7)	*P*
Hemoglobin	12.7±2.4	9.5±2.2	9.2±2.1	0.05
Platelet count	269.9±88.2	131.4±51.5	104±27.1	<0.05
PT	13.8±2.2	16.3±1.9	15.8±2	0.04
aPTT	28.3±7.3	35.1±9.4	37.4±12.7	0.03
pH	7.3±0.1	7.3±0.1	7.3±0.1	<0.05
Base deficit	−6.2±4.2	−7.3±4	−5.9±4.2	0.01
Lactate	3.5±2.2	3.7±2.5	4.4±2.8	<0.05
EXTEM				
CT	68±43.3	59.8±27	59.6±25.9	0.07
CFT	118±50.7	144±47.9	153±74.4	<0.05
A10	46.5±10.6	44±8.7	43.6±8.9	<0.05
MCF	54±12.4	53.7±7.6	52.6±7.9	<0.05
INTEM				
CT	158.7±99.1	164.6±65.9	174.1±87.4	<0.05
CFT	155.2±198.9	151.8±78.2	252.8±172.7	<0.05
A10	45.6±11.8	42.8±7.6	37.9±11.5	<0.05
MCF	51.3±15.2	46.6±17.4	38.2±21.5	<0.05
FIBTEM				
A10	11.1±6.8	12.1±5.4	21.4±5.9	<0.05
MCF	12.7±9.7	11.1±5.7	13.2±5.7	<0.05

CT: Clotting times, CFT: Clot formation times, MCF: Maximum clot firmness, PT: Prothrombin time, aPTT: Activated partial thromboplastin time, ER: Emergency room, PRC: Packed red cell

concentrate (PCC), the mortality rate was lower than trauma ISS and revised injury severity classification group. Fibrinogen concentrate and PCC correct coagulopathy effectively and rapidly.[14]

The target fibrinogen concentration in the European guidelines for managing trauma is 1.5–2 g/L.[15] Songklanagarind Hospital does not have fibrinogen concentration; we use cryoprecipitate in patients who need fibrinogen transfusion.

In this study, we found that none of the traumatized patients received fibrinogen concentrate in the operating room, only one patient (2%) received cryoprecipitate (cryoprecipitate consists of factor VIIIc 80–100 unit, fibrinogen 225 mg, and von Willebrand factor; cryoprecipitate 20–50 mL per body weight 5 kg will increase fibrinogen 75 mg/dL[16]), and A10 and MCF of FIBTEM were in normal range.

Conclusion

In this study, we found that most of the traumatized patients who were operated on in Songklanagarind Hospital were male, the most common cause of injury was a motorcycle accident, and the area most commonly associated with massive blood loss and requiring blood transfusion was the head. There were statistically significant differences in terms of Hb, platelet counts, PT, and CFT of INTEM between the ER group and after received 5 units of PRC transfusion group. Coagulation status should be monitored because we found that CFT of INTEM after a patient received 5 units of PRC transfusion was prolonged compared with baseline.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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