Rotational Thromboelastometry Predicts Increased Bleeding After Off-Pump Coronary Bypass Surgery

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Background. We aimed to investigate the ability of rotational thromboelastometry (ROTEM) thresholds for coagulopathy to predict increased perioperative blood loss in off-pump coronary artery bypass graft surgery (OPCABG) and its association with transfusion requirement.

Methods. The data of 303 patients undergoing OPCABG were retrospectively analyzed. Perioperative blood loss and transfusion requirement were compared according to the presence of abnormal ROTEM thresholds, which were tested after anesthesia induction and heparin reversal. Logistic regression analyses were performed to predict significant perioperative blood loss (more than 20% of estimated blood volume).

Results. After graft completion, 92 patients (30%) exhibited abnormal ROTEM thresholds and showed significantly higher perioperative blood loss (median 840 mL [interquartile range: 646 to 1,102 mL] versus median 690 [interquartile range: 530 to 850 mL], $p < 0.001$) and greater transfusion requirement (both in the number of patients receiving transfusion and the median number of transfused units) of packed erythrocytes and fresh frozen plasma than patients exhibiting no ROTEM thresholds. After multivariate analysis of preoperative anemia, postoperative international normalized ratio greater than 1.3, and ROTEM thresholds, only ROTEM threshold (odds ratio 3.45, 95% confidence interval: 2.00 to 5.97, $p < 0.001$) remained an independent predictor of significant perioperative blood loss, which occurred in 79 patients (26%).

Conclusions. Abnormal ROTEM thresholds after heparin reversal were found to be associated with significant perioperative bleeding and transfusion requirement in OPCABG. Rotational thromboelastometry may allow timely hemostatic interventions to reduce blood loss and transfusion in OPCABG.

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Cardiac surgery is accompanied by a considerable amount of perioperative blood loss, resulting in the need for an algorithm-based transfusion strategy [1, 2]. For the hemostatic management of nonsurgical bleeding, however, fresh frozen plasma (FFP) or platelets were given to patients rather empirically based on conventional coagulation tests, including prothrombin time (PT) or international normalized ratio (INR), activated partial thromboplastin time (aPTT), and platelet counts [3]. Yet these tests are well known for their inherent flaws of a long turnaround time and limited predictability on coagulopathy or blood loss [4].

Recently, the role of viscoelastic tests such as thromboelastography or rotational thromboelastometry (ROTEM) in the hemostatic management of bleeding patients has gained much interest for its fast turnaround time and ability to assess global clot formation and dissolution in whole blood [5, 6]. Indeed, accumulating evidence suggests the beneficial influence of ROTEM- or thromboelastography-guided transfusion algorithms in terms of postoperative blood loss and transfusion requirement in cardiac surgery [7–9]. Nevertheless, controversies exist because these viscoelastic tests exhibited low predictive values on bleeding after cardiac surgery [10]. Furthermore, a recent review argued against their accuracies for diagnosing trauma-induced coagulopathy [11]. Therefore, the role of these viscoelastic tests on hemostasis seems to be surgery specific, and dependent on the nature of bleeding or coagulopathy.

Despite avoiding cardiopulmonary bypass, a major contributor to coagulopathy, off-pump coronary artery bypass graft surgery (OPCABG) is also accompanied by substantial perioperative blood loss, with a reported incidence of hemostatic reoperation of 1% to 3%, similar to that with the on-pump technique [12, 13]. Before now, however, no comprehensive data exist on the changes in viscoelastic test variables and their association with perioperative blood loss or transfusion requirement in OPCABG.

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Abbreviations and Acronyms

ACT = activated clotting time
aPTT = activated partial thromboplastin time
CT = clot time
EXTEM = extrinsically activated tests of ROTEM assays activated with tissue factor
FFP = fresh frozen plasma
FIBTEM = extrinsically activated tests of ROTEM assays activated with cytochalasin D followed by tissue factor
INR = international normalized ratio
INTEM = intrinsically activated test of ROTEM assays activated with phospholipid and ellagic acid
MCF = maximum clot firmness
OPCABG = off-pump coronary artery bypass graft surgery
pRBC = packed red blood cells
PT = prothrombin time
ROTEM = rotational thromboelastometry

The primary aim of this retrospective study was to investigate the ability of abnormal ROTEM thresholds for coagulopathy in predicting increased perioperative blood loss in patients undergoing multivessel OPCABG. The secondary aims were to assess changes in the ROTEM variables during the course of OPCABG, and their association with transfusion requirement.

Patients and Methods

Patients

This study was a retrospective review of data from a cohort of patients who underwent elective multivessel OPCABG from March 2011 to January 2015. After obtaining approval from the Institutional Review Board, the electronic medical records of 303 patients whose coagulation was assessed by using a ROTEM test were reviewed. The need to obtain written informed consent from the patients was waived by the Institutional Review Board. Patients with missed ROTEM test and patients having emergent conversion to on-pump technique were excluded (Fig 1).

ROTEM Test and Abnormal Thresholds for Coagulopathy

In all patients, the ROTEM test (TEM Systems, Munich, Germany) was performed in the operating room, immediately before surgery and 15 minutes after heparin reversal with protamine, after the completion of grafting. Adequate heparin reversal was confirmed by activated clotting time (ACT). Among the commercially available ROTEM assays, two extrinsically activated tests (ROTEM assays activated with tissue factor [EXTEM] and ROTEM assays activated with cytochalasin D followed by tissue factor [FIBTEM]) and one intrinsically activated test (ROTEM assays activated with phospholipid and ellagic acid [INTEM]) were used in a routine manner.

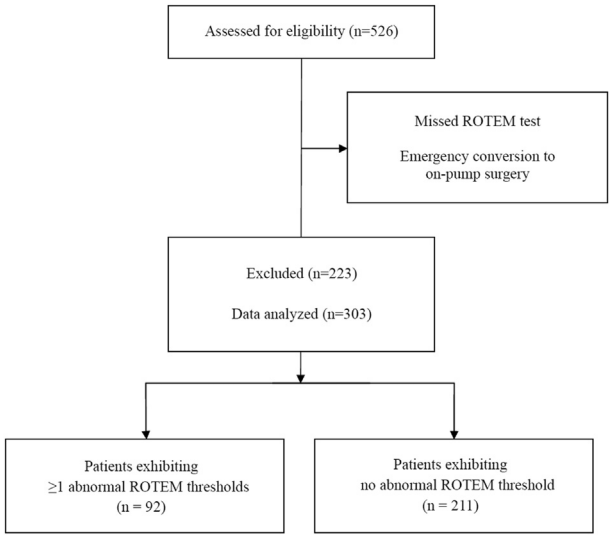

Fig 1. Patient enrollment into the study. (ROTEM = rotational thromboelastometry.)

The clot time (CT) represents the time from the start of measurement to the initiation of clotting, and maximum clot firmness (MCF) represents the clot strength. As the ROTEM thresholds for hemostatic intervention, we selected INTEM-CT greater than 240 seconds, EXTEM-CT greater than 100 seconds, EXTEM-MCF less than 45 mm, and FIBTEM-MCF less than 8 mm. The tested thresholds of ROTEM variables were chosen because the reference ranges of ROTEM variables were firmly established and they reflect the hypocoagulable state, and these have been tested in many of the previous studies involving cardiac surgical patients [6, 8]. These four ROTEM abnormalities could be checked within 30 minutes, and patients with at least one of the four ROTEM abnormalities were considered as having an abnormal ROTEM threshold.

Clinical Management

Institutional standardized anesthetic and surgical management was provided to all patients, as reported previously [14]. In brief, 80 IU/kg heparin was administered before grafting to achieve a target ACT greater than 250 seconds. After the completion of grafting, protamine sulphate (0.5 mg/150 IU heparin) was administered. Hematocrit was maintained above 25% with transfusion of packed erythrocytes (packed red blood cells [pRBC]) throughout the study period. Salvaged blood from a cell salvage device during surgery was reinfused to the patients before the end of surgery. In case of persistent bleeding after adequate surgical hemostasis and heparin reversal confirmed by ACT, FFP or platelets were