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“Improving clinicians’ knowledge of Thromboelastography: A quality improvement project”

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Abstract

Surgical bleeding is a significant complication of surgery. Achieving homeostasis is key to maintaining perfusion and oxygenation to vital organs. Blood product transfusion is part of the management of surgical bleeding; however, if the underlying cause is not addressed, bleeding can reoccur or become worse. Thromboelastography (TEG) is a non-invasive, point-of-care test that measures the ability of whole blood to form a clot. TEG-guided blood product transfusion has shown promising results in cardiac, obstetric, and trauma surgery as well as in patients with cirrhosis. TEG-guided transfusion strategy can provide a more accurate and precise method to reflect coagulopathy leading to significantly lower use of blood products when compared to standard practice. Although TEG is key to the management of surgical bleeding, there is a gap in its utilization in clinical practice which could be associated with a lack of clinicians' knowledge and competency of TEG. This quality improvement project aimed to improve clinicians' knowledge of TEG interpretation and promote the application of TEG in clinical practice.

Introduction/Problem Statement/Significance

Problem identification

Perioperative bleeding is a significant problem nationwide leading to increased patient morbidity and mortality rates [1(p3)]. Blood product transfusion therapy is not a benign management, there are risk associated with it such as bloodborne infections, dilution coagulopathy, citrate toxicity, and transfusion related acute lung injury.[3] Empiric blood transfusion has contributed to the blood product shortage nationwide. In 2015, 11.3 million packed red blood cell (PRBC) units were transfused, 2.1 million platelet, and 3.6 million plasmas [2]. The average cost for blood is $ 204 for (PRBC), $ 524 for platelet, and $ 52 for fresh frozen plasma[3]. It was found that the costs for acquisition, screening, and transfusion augmented

exponentially over the past 5 years and that blood shortage is a significant problem nationwide.[3] In cardiac surgery, bleeding occurs in nearly 7% of cases [4]. In trauma patients, uncontrolled bleeding is the reason for 30%-40% of all trauma-related deaths [4(p10)]. Patients undergoing surgical procedures with expected significant blood loss would benefit from a precise assessment of the hematologic system to deliver optimum care while providing cost-effective replacement of only the needed blood components. Hemorrhage is an essential topic to the field of anesthesia because Certified Registered Nurses Anesthetists (CRNA) are responsible for managing the patient's hemodynamic parameters during surgical procedures. Thromboelastography (TEG) is a promising diagnostic tool to assess coagulation deficiencies and guide clinicians to manage bleeding during surgery with the appropriate blood product. Although (TEG) is highly valuable to guide patient therapy, (TEG) is currently underutilized at many hospitals due to a lack of knowledge of interpretation and techniques [5]. Furthermore, there is a need for standardization and extensive clinical studies about (TEG) [5]. It is crucial to enhance the knowledge of (TEG) among clinicians. This project aims to expand the knowledge of anesthesia clinicians about (TEG) as a diagnostic instrument for the management of intraoperative bleeding.

Background

Hemostasis is critical to control bleeding and prevent blood loss. A balance between pro-coagulation factors, anticoagulants, and fibrinolysis is necessary to maintain adequate homeostasis[1(p22)]. The intrinsic and extrinsic pathways are the main pathways involved in the coagulation cascade [1(p22)]. The extrinsic pathway is triggered through tissue factors released by endothelial cells after an outside injury, while the intrinsic pathway is initiated through exposed endothelial collagen[1(p22)]. The intrinsic pathway is faster than the extrinsic pathway to achieve

homeostasis[1 (p22)]. Homeostasis is achieved when a platelet plug is formed and reinforced with fibrin threads that act as bond [1 (p22)].

Surgeries associated with the highest risk for disturbance in homeostasis include vascular, cardiothoracic, trauma, liver, and obstetrics[1 (p23)]. Multiples factors contribute to bleeding, such as trauma, acquired congenital coagulopathies, hemodilution, hypothermia, and activation of inflammatory pathways [1(p22)]. Unresolved bleeding can lead to consumption of clotting factors and acidosis, which further exacerbates the clotting cascade and worsens the problem by creating a vicious cycle [1(p22)]. Some hemostatic agents used to treat bleeding include aprotinin, tranexamic acid, and desmopressin [1(p22)]. The transfusion of red blood cells, platelets, fresh frozen plasma, and cryoprecipitate are used to restore the blood components lost during hemorrhage. The effective management of coagulopathies during surgery will allow the surgeon to visualize the anatomy and repair the source of bleeding. Anesthesia clinicians are responsible for maintaining the patients' hemodynamic parameters during surgical bleeding (TEG) can provide clinicians with valuable information about the hematologic system and any deficiencies that need to be replaced.

Scope of the problem

The scope of the problem is poor management of surgical bleeding and lack utilization of TEG as a guide for blood product transfusion. Bleeding can be managed successfully through early assessment and diagnosis. Inadequate provider competence about (TEG) contributes to the significant problem of uncontrolled bleeding during surgery. According to the World Health Organization (WHO), injuries associated with bleeding are responsible for about 30% to 40% of deaths worldwide [6(p22)]. In a sample of 25,000 patients, a sizable proportion of patients had

uncontrolled surgical bleeding despite current hemostat use, with rates ranging from 32% to 68% [6(p25)]. Furthermore, healthcare resource utilization, including Intensive Care Unit (ICU) stay, ventilator use, length of hospital stays, operation time, and reoperation, were often greater in patients with uncontrolled bleeding [6(p22)]. These findings revealed that healthcare cost is higher when bleeding is uncontrolled during surgery[6 (p22)].

Additionally, the type of surgery plays a significant role in the risk of bleeding. Cardiac surgeries are associated with a high incidence of bleeding due to the proximity to large vessels such as the aorta [6(p23)]. During cardiopulmonary bypass, hemodilution and loss of clotting factors can occur because of heparin administration [1(p22)]. For example, a prolonged time during cardiopulmonary bypass can produce consumptive coagulopathy [1(p22)]. Numerous congenital disorders associated with a coagulation factor insufficiency, such as hemophilia A or B, Von Willebrand disease, may worsen bleeding even with minor injuries or surgeries[6]. Furthermore, prescribed antiplatelet medications and anticoagulants increase the risk for coagulopathies, leading to excessive hemorrhage associated with trauma or medical procedures [7 (p22)]. Therefore, the anesthesia provider must perform a careful hematologic assessment to identify patients at risk for surgical bleeding and take precautions to decrease the incidence for blood loss.

Consequences of the problem

Some of the consequences associated with uncontrolled perioperative bleeding and blood product transfusion are increased patient morbidity and mortality. The lack of provider competency of (TEG) utilization can have negative patient outcomes. For example, inadequate provider assessment of the hematologic system or failure to recognize patient risk factors for bleeding might lead to uncontrolled bleeding, empiric blood products administration, and increased patient exposure to blood pathogens. There are major risks associated with blood

products transfusion, including infections such as hepatitis B, C, Human Immunodeficiency Virus (HIV), ABO incompatibility and transfusion-related acute lung injury [8]. In addition, platelet transfusions were associated with stroke and death during cardiopulmonary bypass in cardiothoracic surgery [8(p22)]. The administration of antifibrinolytic agents used to prevent bleeding carry risk factors as well. For example, high doses of tranexamic acid are associated with an increased risk of postoperative seizures [8(p23)]. Furthermore, conservation of blood product use is expected to come at significant cost savings of $5,000 per patient savings [6(p22)]. If a solution is not found to this problem, patients would receive inappropriate treatment for bleeding and have an increased risk of complications associated with blood product transfusions and uncontrolled bleeding. Without utilizing (TEG), patients might receive excessive blood products that do not target the specific coagulation problem that is causing the bleeding.

Knowledge Gap

While the National Institute for Health and Care Excellence recommends (TEG) as a tool for hemostatic management during surgery, it is not yet the standard of clinical guidelines due to a lack of high-quality research and awareness about the technique, interpretation, and implications [8(p23)]. There is a knowledge deficit among clinicians about utilizing (TEG) in clinical practice [8(p23)]. Clinicians must understand the (TEG) value results to diagnose coagulopathies that might arise during surgery. Researchers acknowledge a lack of evidence of (TEG) to detect Von Willebrand disease despite it being the most predominant congenital hemostatic disorder [10]. Furthermore, researchers discussed a lack of awareness about the poor correlation between (TEG) and INR in patients taking Warfarin [5(p22)]. Also, there is insufficient data to compare the exactitude of (TEG) against PT/INR in trauma-induced coagulopathies[10].

Additionally, the existing evidence of (TEG) does not measure the effect of antiplatelet therapy; therefore, future research is needed on this topic[7(p11)]. Moreover, there is limited research on platelet mapping with (TEG), and it must be evaluated to improve patient care and appropriate laboratory utilization [5(p11)].

(TEG) is a point of care test that can guide the anesthesia provider to treat numerous coagulopathies that occur during surgery. (TEG) provides a global assessment of the dynamics of clot development, maintenance, and termination[7(p10)]. With the utilization of (TEG), a hemostatic assessment can be done from the initial platelet-fibrin interaction through platelet aggregation, clot strengthening, fibrin cross-linkage, and eventually clot lysis[7(p11)].

The results reveal a graph tracing, and corresponding values allow clinicians to determine the specific blood component required to treat coagulopathies[8(p10)]. The (R) parameter represents the reactive time from the blood placed in the machine until the initial fibrin development [9]. (K) means the clots' formation time from the beginning until stable strength is achieved [9(p22)]. Angle measures the speed of clot strengthening. Maximum amplitude measures the ultimate strength of the clot [9 (p19)]. Finally, the LY30 parameter measures clot lysis [9(p19)]. When the reactive time (R) parameter is prolonged, administration of fresh frozen plasma may be warranted [9(p19)]. A prolongation in clotting time (K) would indicate a lack of fibrinogen[9 (p20)]. A decrease in the angle parameter suggests a lack of fibrinogen or cryoprecipitate [9(p20)]. A decreased in maximum amplitude necessitates the administration of platelets [9(p20)]. On the other hand, an increase in LY30 indicates rapid fibrinolysis, which will warrant an antifibrinolytic agent [9(p20)].

Several researchers have demonstrated the benefits of (TEG) to diagnose and manage deficiencies in coagulation factors and decreased the need for unnecessary transfusion of blood products. Furthermore, (TEG) can help distinguish from surgical and coagulopathic bleeding

[6(p22)]. Additionally, (TEG) can help determine primary from secondary fibrinolysis [6(p22)]. Also, platelet functions can be assessed through (TEG) [6(p22)]. Therefore, to close the knowledge gap, an intervention must be made to increase provider education about the technique, considerations, and benefits of (TEG) on patient outcomes.

Proposal solution

The implementation of an educational module for clinicians would increase awareness about the technique, implications, and benefits of (TEG). Learning is a continuous process that promotes knowledge growth and development. The delivery of high-quality continuing education to healthcare professionals stimulates excellence in healthcare performance. The primary goal of the proposed solution is to prevent and manage bleeding complications effectively through the utilization of (TEG). (TEG) can help identify risk factors for bleeding, which is essential to diminish patient morbidity, mortality and improve patient outcomes. The standardization of (TEG) in clinical practice can decrease healthcare costs by reducing excessive blood product transfusions. Reducing unnecessary transfusions would decrease complications associated with blood transfusions such as anaphylactic shock, infections, and transfusion-related acute lung injury. Expanding provider understanding about (TEG) might motivate healthcare providers to conduct future research about (TEG) utilization in other areas such as the Intensive Care Units. An educational module nationwide would promote the application of (TEG) in clinical practice guidelines and evidence-based practice.

In conclusion, blood loss is a major complication of surgery nationwide. Effective measures are necessary to manage hemostasis during surgery. Blood component transfusion is the mainstay treatment for bleeding. However, it is crucial to choose the specific blood product

needed to achieve optimum patient outcomes. (TEG) is a promising tool that measures all the phases of the coagulation cascade. (TEG) can assist clinicians in identifying the exact blood product necessary to maintain homeostasis. Furthermore, the application of (TEG) can distinguish surgical versus coagulopathic bleeding. However, there is a knowledge gap among clinicians, limiting the applications of TEG in clinician practice. Surgical bleeding is a significant problem that must be addressed. The implementation of an educational module as part of a QI project can assist in closing the knowledge gap while supporting evidence-based practice and improving patient outcomes.

Methodology of literature review

An extensive literature review was done utilizing CINAHL, Pub med, and MEDLINE databases. The search criteria included recent research studies within the past five years to ensure current data. The goal was to find studies that evaluate the utilization of (TEG) in clinical practice. Furthermore, this project aims to find any knowledge gaps of (TEG). Keyword used in the search includes thromboelastographic, cardiac surgery, cirrhosis patients, obstetric hemorrhage, anticoagulation therapy, deep vein thrombosis (DVT), trauma, antifibrinolytics, and orthopedic surgery. Boolean phrases used were “TEG and cardiac surgery, TEG and cirrhosis, TEG and obstetric hemorrhage, TEG and trauma, TEG and DVT, TEG and antifibrinolytics”. Exclusion criteria included the studies older than seven years, pediatric patients, neonates, narrative reviews, expert opinions, and case studies. A total of 15 articles were found, however only 8 were randomized controlled trials and were selected for the study. After a careful analysis of the literature findings, six research studies were identified that investigate the application of (TEG) in clinical practice. The six articles selected were randomized controlled trials to ensure

the highest level of evidence. The search terms used included (TEG), surgical bleeding, clinicians' knowledge, patient outcomes, and nurse anesthesia.

Introduction

Surgical bleeding is defined as a site of bleeding that is limited exclusively to the operative site[1]. Perioperative bleeding is a significant complication of surgery that leads to increased patient morbidity and mortality rates. [11(p3)] In 2015, 11.3 million packed red blood cell (PRBC) units were transfused, 2.1 million platelet, and 3.6 million plasma. [12] The average cost for blood is $ 204 for (PRBC), $ 524 for platelet, and $ 52 for fresh frozen plasma.[13] It was found that the prices for acquisition, screening, and transfusion augmented exponentially over the past five years and that blood shortage is a significant problem nationwide.[13] It is evident that blood product transfusion is costly, and measures must be taken to reduce unnecessary blood component transfusion. The type of surgery and patient factors predisposing factors to surgical bleeding and blood product transfusion. Some procedures associated with a high risk of bleeding include cardiac, trauma, neuraxial anesthesia, obstetrics. Other patient factors that increase the risk of bleeding are liver disease and pregnancy. Venous thromboembolism can result from venous stasis secondary to immobilization and disruption of homeostasis during surgery. TEG is a valuable assessment tool because it measures all stages of the coagulation cascade from clot formation to clot lysis. TEG can guide transfusion therapy for high-risk surgeries such as cardiac and trauma to determine the specific blood product needed with the goal of decreasing unnecessary blood transfusion.

Additionally, TEG could assist clinicians in diagnosing hypercoagulable state after surgery and direct effective dose for anticoagulation therapy. Homeostasis is an essential topic to the field of anesthesia because Certified Registered Nurses Anesthetists (CRNA) are responsible

for managing the patient's hemodynamic parameters during surgical procedures. Thus, Thromboelastographic (TEG) is a promising diagnostic tool to assess the clotting cascade and choose the specific blood product to manage and prevent bleeding during surgery and treat blood clotting disorders.

Rationale

Although (TEG) is highly valuable to guide patient therapy, (TEG) is currently underutilized at many hospitals due to a lack of knowledge of interpretation and techniques. [15] Furthermore, there is a need for standardization and extensive clinical studies about (TEG).[15] Therefore, it is crucial to enhance the knowledge of (TEG) among clinicians. This project aims to expand the knowledge of anesthesia clinicians about (TEG) as a diagnostic instrument for the management of intraoperative bleeding.

Literature review results

TEG utilization in cardiac surgery

Cardiac surgeries are associated with a high incidence of bleeding due to the proximity to large vessels such as the aorta.[2] In addition, during cardiopulmonary bypass, hemodilution and loss of clotting factors can occur due to heparin administration.[11(p22)] Therefore, careful consideration must be taken to reduce the incidence of bleeding associated with cardiac surgery. A randomized controlled trial evaluated the operation of (TEG) to guide blood component therapy after cardiac surgery. This randomized controlled trial aims to determine the effectiveness of TEG-guided blood component treatment for patients undergoing cardiac surgery. Cardiac surgery accounts for 20% of all national blood products utilization

nationwide.[13] Therefore, clinicians must select the appropriate blood product to prevent blood shortage nationwide while improving patient outcomes. Haensig at al[13]; found that a structured protocol that includes (TEG) has been proven to be more beneficial than the empiric treatment of surgical bleeding.[13 (p1)]

The study methods consisted of 104 patients scheduled for cardiac surgery. Patients were randomly assigned to a control group and an experimental group.[13 (p2)] The patients in the control group were treated based on standards coagulation testing, while the experimental group was treated using (TEG) blood component protocol.[13(p2)] Primary outcomes were transfusion requirements of red blood cells, platelets, plasma, fibrinogen, or clotting factors. The secondary results were 24 hours drainage loss, re-thoracotomy rate, and cost analysis of blood and coagulation products. To maintain consistency and improve accuracy in the study, all patients receive the same intraoperative care and management in the intensive care unit.[13(p2)] A power analysis was conducted and revealed that 30 patients per group would be needed to prove a 40% reduction in the use of allogeneic blood products.[13(p2)] The statistical analysis was performed using the software SPSS, version 24. Continuous variables are expressed as mean, standard deviation.[13(p2)] The authors utilized the two-tailed Student's t-test and the Mann-Whitney U-test to compare continuous variables.[13(p2)] Furthermore, a p-value of less than 0.05 was deemed statistically significant. [13(p2)] The clinicians performing the data analysis and statistical calculations were blinded to prevent biases analysis.[13(p2)] The authors found less bleeding within the first 24 hours in the (TEG) group when compared to the control group.[13(p5)] However, within 30 days, (2%) in the TEG group and (6%) in the control group suffered a stroke.[13(p6)] These findings might suggest that the use of unnecessary blood components might be associated with an increased risk of stroke.

Furthermore, the mortality rate was 8% in the control group, while the mortality rate in the (TEG) group was 2%.[13 (p5)] In addition, at five years, there was a mortality rate of 12% in control and 4% in the (TEG) group. [13 (p5)] These findings suggest that TEG is associated with better survival rates after cardiac surgery, lower patient mortality rate, and enhanced outcomes. Patients in the (TEG) group received fewer platelets concentrates and aprotinin, while the control patients needed less fibrinogen. [13 (p5)] In addition, the investigators found that the (TEG) experimental group experienced substantially less blood loss within the first 24 hours. [13 (p5)] These findings are significant because blood loss is associated with significant impairments to the homeostatic system and higher rates for re-thoracotomy. The study findings revealed cost savings because there was a decrease in unnecessary blood products; however, there was an additional cost for (TEG) testing. [13 (p5)]

Some study limitations included a small cohort of study participants and a lack of homogeneity. [13(p5)] Furthermore, there was limited evidence about the structure of the TEG algorithm, and platelet response was not evaluated in the study. [13 (p5)] The authors demonstrated not only a decrease in mortality with TEG-guided transfusion therapy but also revealed the risks associated with unnecessary blood transfusion products. The authors included some secondary sources to support their research study. The study is well-organized with an introduction, background, methodology, discussion, and conclusion. One limitation is that the hypothesis was not stated directly, but it was implied throughout the study. This research study supports the effectiveness of TEG to decrease unnecessary blood product transfusion and improve patient outcomes in cardiac surgery.

TEG to direct transfusion therapy in patients with cirrhosis

While Haensig et al [12] and colleagues focused on examining the application of TEG in cardiac surgery, Kumar et al [14] focus on the utilization of (TEG) in a patient with cirrhosis undergoing surgeries. Homeostasis is directly correlated to liver function because the liver synthesizes many coagulation factors. Therefore, patients with cirrhosis do not have vitamin-K-dependent coagulation factors such as II, VII, IX, and X, which increase the risk for surgical bleeding.[14 (p10)] Therefore, TEG is a valuable tool for this patient population due to their abnormal coagulopathies, which places them at a higher risk for bleeding during surgery. Kumar et al [14] and colleagues aim to assess the effectiveness of (TEG) in patients to diagnose coagulopathies in patients with liver impairment. [13 (p10)] The study consists of 100 patients who underwent percutaneous liver biopsy, trans jugular intrahepatic portosystemic shunt, and trans arterial chemoembolization. [13 (p10)]

A computer randomly assigned patients to the control or (TEG) experimental groups in a 1:1 ratio. [13 (p10)] The participants, investigator, data analysts, and clinician were blinded to improve accuracy and prevent biases. [13 (p10)] The data findings were managed using the software package SPSS version 20.0. [13 (p10)] The chi-square and Fisher's exact tests were utilized to establish a relationship. [13(p10)] To compare continuous variables, the student t-test and Mann-Whitney U test were used. [13(p10)] It was also noted that the P values were two-sided. A P value of less than 0.05 was considered significant. [14 (p10)] This study found that the blood component utilization was lower when using TEG to guide transfusion therapy. [13 (p10)] In the (TEG) group, only 26.5 % of patients were transfused with all types of blood components versus 87 % in the control group. [13(p10)]

Furthermore, it was discovered that TEG-guided transfusion reduces transfusion of FFP in patients undergoing liver transplantation, although it does not affect the 3-year survival rate. [13]

[13(p10)] Subsequently, the transfusion-related reaction was less in the TEG group than in the control group. [13 (p10)] Additionally, TEG is superior to the International Normalized Ratio (INR) or platelet count to estimate the risk for bleeding. [13(p10)] Transfusion-related acute lung injury (TRALI) is a significant complication of blood transfusion. [13(p10)] The authors found that patients with end-stage liver disease who received transfusion therapy developed (TRALI) more frequently than those without it. [13 (p10)] Therefore, it is crucial to prevent unnecessary blood product transfusion in this patient population with liver disease because they are at higher risk for transfusion-related reactions and complications. Additionally, more units of fresh frozen plasma were transfused using an (INR) of greater than 1.8 compared with the TEG R time of greater than 10 minutes. [13(p10)] Similarly, more platelets were transfused using standard platelet counts than with TEG MA less than 55 mm. [13(p10)]

One of the study weaknesses is that the coagulation levels were not measured during blood component transfusion to compare the findings and effectiveness of therapy. [13 (p10)] The study objective was clearly defined. The background, methodology, discussion, and conclusion were appropriate. Research findings were presented in a graph and discussion to compare the results. This study demonstrates the usefulness of TEG on patients with cirrhosis undergoing surgical procedures. Both Haensig et al [13] and Kumar et al [14] have similar sample sizes, and study participants were randomly selected, demonstrating comparable and accurate findings. Furthermore, both researchers discovered that TEG utilization improves patient outcomes while reducing blood products requirements during surgery. Both clinicians used SPSS software for statistical analysis, and a P value less than 0.005 was considered significant in these two studies.

TEG to guide transfusion therapy in obstetric hemorrhage

Haensig et al [13] evaluated the efficacy of TEG in cardiac surgery, while Kumar et al [14] assessed the application of TEG in patients with cirrhosis. Similarly, Karlsson et al [14] evaluate the application of TEG in obstetric hemorrhage.[14] Obstetric is associated with a high incidence of surgical bleeding due to coagulation disorders related to pregnancy, uterine atony, abnormal placenta placement, and retained placenta.[14(p13)] Subsequent disseminated intravascular coagulopathy (DIC) can occur, leading to consumption of clotting factors and further bleeding. [14(p13)] The objective of this study was to compare the efficacy of TEG with standard laboratory analysis to predict and manage bleeding. [14(p13)] Postpartum hemorrhage is the cause of 73% of all morbidity during pregnancy, and it is a common cause of intensive care admission in pregnant patients. [14(p13)] The study participants consisted of forty-five women with major obstetric hemorrhage and 49 women with blood loss <600 mL.[14(p13)] The parameters measured were (TEG-R), (TEG-K), (TEG-Angle), (TEG-MA), and (TEG-LY30) to compare with a standard parameter such as prothrombin time, fibrinogen, antithrombin, and d-dimer. [14(p13)] Results are presented as mean, standard deviation, and 95% confidence interval. [14(p13)] Pearson's correlation assessed the relationship between estimated blood loss, TEG variables, and hemostatic laboratory analysis. [14(p13)] A correlation coefficient > 0.5 and a P value less than 0.01 were found to be significant. [14(p13)] All data and statistical analysis were performed in SPSS version 19. [14(p13)]

The study clinicians found that homeostasis is impaired with major obstetric hemorrhage. [5(p13)] TEG is a valuable tool because it provides rapid and clinically significant information about hemostatic variations in obstetric hemorrhage. [14(p13)] Furthermore, TEG can assist clinicians in detecting coagulation deficiencies to determine the specific blood product therapy at an earlier point than traditional laboratory testing. [14(p13)] TEG showed faster initiation of blood clotting, less fibrin clot strength, and depressed fibrinolysis during major obstetric hemorrhage than

normal delivery.[14(p13)] Furthermore, TEG-LY30 was 75% lower in women with major obstetric hemorrhage, indicating impaired clot formation. [14(p13)]

The authors clearly stated the objectives of the study along with some background information to identify the problem. No research question was clearly stated, but it was implied during the study. One study's limitations are that there was no standardized transfusion strategy or consistent methods for transfusion and fluid management, which might have distorted the study outcomes. [14(p13)] Another study discrepancy is that some women were given tranexamic acid while others were given plasma to manage bleeding. [14(p13)] Finally, there was no analysis of hematocrit or capillary hemoglobin. [14(p13)] A final limitation is a possible inaccuracy of estimated blood loss (EBL). [14(p13)] Nevertheless, the study validates the feasibility of TEG in major obstetric. TEG is a point of care laboratory that can provide accurate and fast results during obstetric hemorrhage.

Haensig et al [13], Kumar et al [14] and Karlsson et al[14] had approximately 100 participants in the studies, indicating accurate mean values. Kumar et al [13] and Karlsson et al [14] and Haensig et al [13] established a comparison between TEG guided therapy versus stand coagulation laboratory results. Haensig et al [12] and Kumar et al [13] deemed significant a P value less than 0.05 while Karlsson et al [15] considered a P value less than 0.01 to be substantial, indicating substantial evidence against the null hypothesis. The previously mentioned studies were randomized controlled trials with around 100 study participants, ensuring the accuracy of study findings. Furthermore, the studies were conducted within the last seven years which guarantees current data. Karlsson et al [15] conducted the study in Sweden, while Haensig et al [13] conducted it in Germany. Studies conducted outside the United States have many implications because European countries might follow different guidelines, standards of care, and protocols.

TEG to guide anticoagulation therapy for thromboembolism (VTE)

Previous studies focus on the management of bleeding on cardiac and obstetric surgeries and patients with cirrhosis undergoing invasive procedures. On the other hand, Connelly et al [15] investigate the utilization of TEG decreases the risk of venous thromboembolism. The study is different from previous studies in that the Connelly et al [15] and colleagues test the effective dose of anticoagulation for Venous thromboembolism prophylaxis by using TEG. Venous thromboembolism (VTE) is a complication of surgery secondary to lack of immobilization and homeostasis impairment, leading to increase patient morbidity and mortality. [15] Prophylactic Enoxaparin is used to prevent venous thromboembolism (VTE) in patients at risk for (DVT). [15(p13)] Despite the utilization of Enoxaparin (DVT) is still a significant source of morbidity and mortality after surgery due to antithrombin III or anti–Factor Xa deficiencies or missed enoxaparin doses. [15 (p13)]

This study aims to assess the efficacy of TEG to determine the exact dosing of Enoxaparin to prevent (DVT). [15 (p13)] The study compared the usual dosing of 30 mg twice daily versus TEG-adjusted enoxaparin dosing, 35 mg twice daily for 185 surgical and trauma patients, a larger sample size than previously discussed studies. [15 (p13)] Surprisingly, the findings revealed that patients in the experimental group who received larger dosages of Enoxaparin guided by TEG did not have a significant difference in the incidence of (DVT). [15 (p13)] The authors suggest that missing one or more doses of Enoxaparin may offset any possible positive effects of dose adjustment in the experimental group. [15 (p13)] Additionally, the (TEG-R) parameter was associated with increased incidence (DVT) when it was less than 1 minute. [15 (p13)] The incidence of VTE was comparable 6.7% in the experimental vs 6.3% in the control group. [15 (p13)] To demonstrate statistical significance, 3212 total patients would be desirable. [15 (p13)] Therefore, a

small number of participants was one of the study's weaknesses. Secondly, several patients in each group missed at least of dose of the anticoagulant, which is a recognized risk factor for DVT.

Additionally, the physiologic effects of the dose adjustment were not observed until later in the study, which could lead to erroneous results. [15 (p13)] Finally, there were inconstant screening protocols at the participating institutions. [15 (p13)] It is recognized that TEG can assist clinicians in managing acute bleeding; however, there is limited research on how TEG can be used to determine the effective dose of anticoagulation with Enoxaparin. When compared to previous studies that demonstrate the efficacy of TEG in cardiac, obstetric, and patients with cirrhosis, this study did not validate that TEG-guided anticoagulation therapy can improve patient outcomes. However, some of the study inconsistencies might have affected the validity of this study. Therefore, further research is necessary to address the gaps and expand knowledge of TEG in clinical practice.

TEG to guide antifibrinolytic therapy

Whereas Connelly et al [15] focus on TEG-guided anticoagulation therapy to prevent (VTE), Xu et al [16] evaluate the application of TEG in determining best route of administration for antifibrinolytic therapy during hip surgery. Connelly et al [15] and Xu et al [16] focused on medication therapies to manage bleeding and (VTE). All studies are randomized controlled trials within the last six years which demonstrate accurate and current data. With an increased aging population, orthopedic surgeries are becoming more common. Orthopedic procedures are associated with a considerable amount of blood loss. [16] Among orthopedic surgeries, total hip arthroplasty has the highest risk for bleeding, with a mean of 1,500 ml of blood loss. [16 (p14)] Therefore, intraoperative blood management during hip arthroplasty is an essential topic for

anesthesia clinicians. To decrease blood product transfusion, Tranexamic acid (TXA) is commonly used in orthopedic surgery. TEG is a valuable tool for orthopedic surgery to assess the coagulation cascade and determine when antifibrinolytics are needed. For instance, an increase in LY30 indicates rapid fibrinolysis, which will warrant an antifibrinolytic agent. [16(p14)] Some clinicians investigated the implementation of thromboelastography to assess the effect of different administration methods of Tranexamic acid on coagulation cascade in total hip arthroplasty. [16 (p14)]

The randomized study consisted of 207 patients who had total hip arthroplasty. [16 (p14)] A computer program randomly assigned patients to three topical-TXA, IV-TXA, and control groups. [16 (p14)] The main results measured include the rate of DVT, blood loss, and transfusion rates. [16 (p14)] TEG was utilized to assess coagulation from preoperative to 7 days postoperative. [17(p14)] TEG results revealed that that intravenous injection (TXA) promotes a hypercoagulable state. On the other hand, the group that received topical-TXA and the control group did not increase the TEG-MA parameters. [16 (p14)] These findings demonstrate that topical TXA is not as effective as IV therapy for hip arthroplasty. [16(p14)] The topical-TXA group and IV-TXA group had less blood loss than the control group, with a P value of less than 0.05. [16 (p14)] The control group had higher blood loss because no TXA was used. [16 (p14)] The IV-TXA group IV-TXA group improved coagulation peak values ($P < 0.05$). [16(p14)] MA values increased steadily from preoperative levels to the seventh day postoperatively. [16(p14)] Nearly no meaningful changes were observed between topical-TXA and control groups. [16(p14)] The ANOVA was used to assess homogeneity and statistical significance between the groups. [16 (p14)] The analysis of qualitative variables was guided using Pearson's chi-square, Fisher's exact test. [16(p14)] Additionally, the SPSS

software version 19.0 was used for the statistical analysis. [16(p14)] Finally, a p-value < 0.05 was considered significant. [16(p14)]

Some of the study limitations include a small sample size. [16(p14)] A larger sample size is necessary to examine the effects of (TXA) on (TEG) parameters and obtain more broad and accurate findings. [16 (p14)] Secondly, longer postoperative monitoring is needed for TEG evaluation. [16 (p14)] Third, serum concentrations of TXA were not measured to evaluate the rate of systemic absorption of TXA. [16(p14)] This study reveals the usefulness of TEG in orthopedic surgery to guide antifibrinolytic therapy reducing blood transfusion. TEG can assist clinicians in determining the most effective route of antifibrinolytic therapy to decrease the risk of bleeding.

TEG utilization in trauma surgery

Previous studies revealed the successful application of TEG-guided therapy in cardiac and obstetric surgery and for an antifibrinolytic and anticoagulant effective dose. Similarly, Gonzalez E et al [17] investigated the role of TEG in guiding blood product transfusion during trauma-related coagulopathies. In trauma, the rapid loss of circulating blood volume can lead to shock and death, which increases patient morbidity and mortality. [17] The acute coagulopathy associated with trauma is a multifactorial process that occurs from an arrangement of shock, tissue injury leading to the activation of anticoagulant and fibrinolytic pathways, and thrombin generation. [17 (p11)] The coagulations can be worsened in certain conditions such as acidemia, dilution, hypoperfusion, and homeostasis factor consumptions. [17 (p11)] This randomized controlled trial reviews the utilization of TEG to guide hemostatic resuscitations of trauma-related coagulopathies. [17 (p11)] This investigation entails 101 participants who were injured from a level -1 trauma hospital. [17 (p12)] Patients were randomly assigned to be managed by a massive transfusion therapy (MTT) directed by conventional coagulation assays (CCA) such as

fibrinogen (INR) and platelet count or TEG. [17 (p12)] The PASS-11 software was used to calculate the sample size and power. [17 (p12)] It must be noted that a sample of 122 patients would be desirable to achieve 80% of power analysis and identify a 20% difference in the survival rate between the two groups. [17 (p12)] All tests were 2-tailed, and the significance was set at $P<0.05$. [18(p12)] The study finding revealed that the group that used TEG during massive transfusion therapy received less plasma and platelet when compared to conventional coagulation assays. [17 (p12)] Although the control group received more platelets and plasma transfusion, this did not improve the coagulation values in the (CCA) group. [17 (p12)] These findings demonstrate that more blood product utilization does not indeed lead to better results. [17(p12)]

Additionally, the TEG-guided (MTP) patients spent fewer days on the ventilator in the intensive care unit. [17(p12)] After trauma, plasma and platelet transfusion can lead to organ dysfunction, which can explain the TEG group's decreased number of intensive care unit (ICU) admission and ventilator days. [17(p12)] The TEG cohort had increased survival rates at 28 days and 6 hours from trauma. [17 (p12)] The difference in deaths secondary to bleeding was 23.4% in the (CCA) group compared with 7.8% in the TEG group. [17 (p11)] One weakness identified is that the study was not intended to test one coagulation assay but rather to represent a broad picture of how clinicians deliver care. [17 (p12)] The sample size was an additional weakness of this study. [17(p12)] A larger sample size would increase the power analysis and improve the accuracy of the survey. [17 (p12)] When compared to previous studies, this was a smaller sample size representation which might affect the exactitude of the study findings.

Discussion

The six research studies selected were randomized controlled trials which demonstrate the highest level of evidence. The investigators effectively showed the utilization of TEG in clinical practice. All studies were conducted within the last 6 years. Karlsson et al [15] and Haensig et al [13] conducted their studies in Sweden and Germany, while the rest were conducted in the United States. Research studies conducted abroad might have different regulatory and legal systems. The study participants were randomly assigned into a controlled and experimental group. To increase the accuracy, the clinicians were blinded during the statistical analysis. The number of study participants was similar in all the studies except for Gonzalez E et al [18], who had less than 200 participants.

A larger study would be ideal to obtain more reliable results with greater precision and power. All researchers used SPSS software for the statistical analysis. A P value < 0.05 was considered significant in most studies except for Karlsson et al [15], who deemed P-value < 0.01 substantial. All researchers used SPSS software for the statistical analysis. Thus, the research investigator provides sufficient evidence to validate the effective use of TEG in clinical practice. The authors had no conflict of interest in the study. Small sample size was a common limitation in all the studies. Haensig et al [13] report that there was considerable preoperative homogeneity regarding the incidence of von-Willebrand-Syndrome in the study. Gonzalez et al [18] conducted a prospective study where the participants were monitored for 28 days after the trauma for survival rate. Similarly, Haensing et al [13] monitored the patients for 30 days after cardiac surgery to assess the survival rate after TEG-guided transfusion versus stand coagulation parameters.

Summary of literature review

Surgical bleeding is a significant complication from surgery. (TEG) provides a global assessment of the dynamics of clot development, maintenance, and termination. [19(p10)] The literature review has proven multiple applications of (TEG) in clinical practice in different clinical settings. The utilization of (TEG) plays an essential role in cardiac surgery to decrease unnecessary blood products transfusion while improving survival rate.[12(p 20)] Additionally, TEG was found to be effective in guiding transfusion therapy in patients with cirrhosis.[13(p1)] This patient population is at higher risk for bleeding due to the inability of the liver to make clotting factors. Furthermore, TEG was utilized in obstetric hemorrhage and demonstrated faster results to guide transfusion therapy.[15(p10)] Moreover, the application of TEG was advantageous to determine the effective dose of Enoxaparin to reduce (DVT) incidence after surgery and trauma. [16(p12)] In addition, TEG has shown to be significant in evaluating the efficacy of different methods of (TXA) administration in orthopedic surgery to minimize blood product transfusion.[17(p10)] Finally, one of the studies proved that TEG can improve survival rate while decreasing morbidity and mortality in trauma patients by guiding blood transfusion therapy.[18(p10)] The literature review demonstrate that TEG is a valuable tool, therefore it must be incorporated into the standard of care to improve patient outcomes and survival rates.

An educational module to improve the knowledge of Thromboelastography among clinicians

Purpose/ PICO

Clinical Questions/Objectives

Population (P): Clinicians

Intervention (I): Intervention to improve the knowledge of Thromboelastography (TEG)

Comparison (C): None

Outcome (O): Improve clinician knowledge of Thromboelastography (TEG) to manage surgical bleeding.

Objective: to improve provider competency of TEG in clinical practice

Definition of Terms

Thromboelastography: TEG is a non-invasive test that quantitatively measures the ability of whole blood to form a clot. The principle of this *in vitro* test is to detect and quantify dynamic changes of the viscoelastic properties of a blood sample during clotting.[16 (12)]

Change: change is the transformation of tasks, processes, methods, structures, and/or relationships.[19]

Provider competency: Provider competence entails having and demonstrating the "knowledge, skills, abilities, and traits" to successfully and effectively delivery high-quality services. Competency can be built during pre-service education as well as in-service education and is not limited to technical knowledge.[20]

Evidence-based practice: evidence-based practice (EBP) focuses on growing an environment where evidence supports clinical and administrative decision-making to ensure the highest quality of care, promotes optimal outcomes, and creates a culture of critical thinking and accountability.[19(p59)]

Conceptual Underpinning and Theoretical Framework

Lippitt's model of change is an appropriate theoretical framework for this quality improvement project. Change to current practice in necessary promotes the utilization of TEG to guide blood component transfusion. Understanding and utilizing a theoretical framework can assist project managers in increasing the likelihood of project success. Lippitt explores the different stages of change within an organization.[16] Lippitt, Watson, and Westley built on the

work of Lewin's theory of organizational change.[16 (p66)] The seven steps of change are: 1 develop the need for change by diagnosing the difference, 2 Establish change relationship and assess the motivation and capacity to change, 3 clarify assessment for change and determine resources, 4 establish goals and intentions for an action plan, 5 examine alternatives, 6 transform intentions into actual change and maintain the change, 7 generalize and stabilize change and end the helping relationship of the change agent.[16(p67)] Lippitt's theory of change is similar to the nursing process because it entails an assessment, planning, implementation, and evaluation.[16(p67))]

Setting and participants

The setting for this project took place in a 1,013-bed level one trauma hospital with twenty-two operating rooms and a mixture of anesthesia providers. Providers include anesthesiologists, certified registered nurse anesthetists (CRNA), and anesthesiologist assistants (AA) with various experience levels. These providers perform anesthesia for multiple procedures, including orthopedics, vascular, thoracic, and trauma. Patients receiving care in this facility also suffer numerous comorbidities such as congestive heart failure, liver disease, obstetric complications, coronary artery disease, diabetes mellitus, and additional risk factors.

Recruitment and Participants

Recruitment was obtained via email invitation; surveys were be done virtually. An informational letter was sent to all anesthesia personnel in the operating room, inviting them to participate in the project. An anonymous link to the pre-intervention survey was included in the email. In addition, providers completed the pretest assessment survey on their mobile devices or computers via the Qualtrics survey platform. These protective measures ensured the safety of the data.

All participants who met the inclusion criteria were invited to participate in this voluntary educational module. Anesthesia providers working for other companies and hospital employees were excluded from participating in this educational module. Potential benefits to participants include improved knowledge of TEG, effective management of surgical bleeding, and application of TEG in blood transfusion protocol. The potential risk of participating in this educational module includes mild physical discomfort from sitting or standing for an extended period.

Intervention and Procedures

Bleeding remains a common occurrence during surgery. Inadequate surgical hemostasis can lead lactic acidosis, hypovolemic shock, disseminated intravascular coagulation and multi organ dysfunction. In addition, empiric blood transfusion has contributed to the blood product shortage nationwide.[3] Inadequate blood product transfusion therapy is not a benign management, there are risk associated with it such as bloodborne infections, dilution coagulopathy, citrate toxicity, and transfusion related acute lung injury.[3] Therefore, this problem must be addressed by educating anesthesia providers. Educational intervention is critical to gathering participation and support for utilizing thromboelastography to assess the etiology of surgical bleeding. The academic module educated participants on TEG values interpretation, risk factors for surgical bleeding, and the benefits of TEG application in clinical practice. A voiceover PowerPoint was provided with the module to explain the information and data further. The educational session included reflection questions to help learners assess their knowledge before and after the module and consolidate the knowledge acquired from the presentation.

An email was sent to the anesthesia providers inviting them to participate in this education module. An anonymous link was included in the email, allowing them to access the pretest, learning module, and post-test. The provider could complete these sections on their mobile devices or computers via the Qualtrics survey platform. No personal identifiers were captured, allowing for anonymity. Once the provider clicked on the given link, they were taken directly to the learning module. First, project partakers viewed an introductory letter explaining the procedure for participation, the voluntary nature of the project, contact information to the principal investigator, and consent for participation. Next, they were directed to a pretest questionnaire, followed by a voiceover presentation. Lastly, a post-test was provided.

Protection of Human Subjects

All data were collected anonymously. Institutional Review Boards (IRB) approval from Florida International University was obtained prior to launching the project. No identifiable private information was collected as part of the pretest and post-test surveys. Only investigators have access to the completed pretest and post-test surveys. There are no hard copy forms. Data collected from the pretest and post-test surveys will be tabulated anonymously to electronic spreadsheets, which will be maintained on a password-protected laptop computer. These measures further ensured the protection of participant identity.

Data Collection

The primary instruments utilized to collect data for this project included a 3-step process using the Qualtrics data collection system, including a pretest survey, a video-based educational module, and a post-test survey. The collected data will help to identify the anesthesia providers' knowledge of TEG to manage surgical bleeding. Once the data is collected, it will be imported into the SPSS statistics software to be analyzed.

Measurement and Analysis

The staff knowledge of TEG was measured before and after the educational module. The pretest and post-test included the same questions to directly assess change in knowledge on TEG to manage surgical bleeding and the effectiveness of the learning module. Both surveys contained eleven multiple-choice questions to evaluate clinicians' competency. The pretest included demographic questions regarding gender, race, age, position, and years of practice. Data collected from the Qualtrics pretest and post-test questionnaire was exported into SPSS statistics software. This allowed for analysis of each survey and the associated responses. In addition, a statistical analysis was conducted to determine if a change in knowledge occurred after viewing the educational module.

Results of quality improvement

Pretest and Posttest Sample

Upon original access to Qualtrics, the preintervention survey contained 30 participants. Of these, 30 participants, 21 did not receive a random ID number and did not answer the demographic questions asked. Six participants who logged onto the survey could not complete the study due to errors with the question display and random ID display. After evaluation, the post-intervention survey was also not completed by these 21 individuals. Therefore, the preintervention sample contained 9 participants. The participants varied in gender, race, position held, and the number of years in anesthesia practice. Of the pre-intervention participants, female participants dominated and only included two males. The participants' races varied, with Caucasian individuals serving as the largest group (n = 4), followed by Black/African American participants (n = 3). CRNAs made the largest group of participants in the educational module (n

= 9). Years of experience also varied; most participants had between 0- 5 years of experience (n = 7). The complete demographic breakdown of the preintervention sample is described in table 1. Nine (n = 7) of the original 31 participants participated in the educational module and completed the post-test survey. All seven of these participants were CRNAs (n = 7, 100%) and included 2 males (n = 2, 28.6 %) and 5 females (n = 5, 71.4 %). Age of those who completed the postintervention varied amongst these individuals. People between the ages of 25-35 dominated at (n = 4, 50%) followed by the 46-55 age group (n = 2, 25%). The data also represented a range of ethnicities: Hispanic (n = 1, 11 %), Caucasian (n = 4, 44 %), Black or African American (n = 3, 33%), Asian (n = 1, 11%). The data also represented people of varying years of experience in anesthesia practice: 0-2 years (n = 3, 37.5%), 3-5 years (n = 2, 25%), 6-10 years n = 1 12.5%), over 10 years (n =2, 25%). Table 4 displays the post-intervention demographics.

Demographics table

Demographic items Table 1	
Pre- test demographic N= 9	Post-test demographic N= 9
Gender Female: N=7 Male: N=2	Gender Female: N=7 Male: N=2

Race: Hispanic : N= 1, 11% Caucasian: N= 4 , 44% African American: N= 3 , 33% Asian: N=1, 11%	Race: Hispanic : N= 1, 11% Caucasian: N= 4 , 44% African American: N= 3 , 33% Asian: N=1, 11%
Education Master's degree: N=6 Doctorate: N=3	Education Master's degree: N=6 Doctorate: N=3
Years of experience: *0 -2 years,* (n = 3, 37.5%) 3-5 years (n = 2, 25%), 6-10 years n = 1 12.5%), over 10 years (n =2, 25%). Greater than 10 years: (n =2, 25%).	Years of experience: *0 -2 years,* (n = 3, 37.5%) 3-5 years (n = 2, 25%), 6-10 years n = 1 12.5%), over 10 years (n =2, 25%). Greater than 10 years: (n =2, 25%).

Pre-test knowledge

The pretest served to gather current knowledge about TEG interpretation as well as the application and benefits of TEG in clinical practice. Nine clinicians took the pretest and posttest. Table 2 displays the scores for subcategory 1 which measures clinicians' competency to interpret TEG values before the educational module. Table 2 illustrates the scores for subcategory 2 which evaluates provider's competency to understand TEG's application in clinical practice. The pretest showed the participants had limited knowledge of the interpretation of TEG and its application in clinical practice. It also demonstrated a lack of understanding regarding the benefits of TEG in trauma, cardiac, liver, and obstetric surgery. The participants scored the least when questioned about interpreting TEG parameters such as K value, R parameter, Maximum amplitude, and LY 30. Additionally, the study participants scored the least when asked about the accuracy of INR versus TEG in predicting the risk for bleeding in patients with cirrhosis (n=2,

35%). These findings demonstrate a deficiency in clinicians' knowledge of TEG values interpretation which can be related to its underutilization in clinical practice. The participants scored the highest when asked about the benefits of TEG in cardiac surgery to decrease the number of unnecessary blood product transfusions (n=9, 100%).

Results table

Table 2 **Difference in Pre-test and Pos-test Knowledge of TEG values interpretation Subcategory 1**	Pre-test	Post-test	Difference
Q1: Which blood product is appropriate when the R parameter is prolonged?	50 %	100%	+ 50%
Q2: A prolongation in clotting time (K) would indicate?	22%	100%	+ 78%
Q3: A decreased in maximum amplitude necessitate the administration of which blood product?	50%	87%	+37%
Q4: What does an increase in LY30 indicates?	67%	90%	+23%

Table 3 **Difference in Pre- test and Posttest knowledge of TEG application in clinical practice** **Subcategory 2**	Pre-test	Post-test	Difference
Q5: TEG has been proven to decrease unnecessary blood product transfusion after cardiac surgery true or false?	100%	100%	0%
Q6: Unnecessary blood product transfusion can lead to what?	66.7 %	100%	+33.3 %
Q7: In patients with cirrhosis, TEG is superior to international normalized ratio (INR), or platelet count to estimate the risk for bleeding, true or false?	87.5 %	100%	+12.5%
Q8: Obstetric hemorrhage can lead to what?	78%	100%	+22%
Q 9: Patients with end-stage liver disease who received transfusion therapy are at higher risk for?	35%	70%	+35%
Q10: True or false: TEG can detect coagulation deficiencies in obstetric hemorrhage at an earlier point compared with traditional laboratory testing?	55%	100%	+ 45%
Q11: TEG-guided transfusion protocol has shown to improve patient survival rates in trauma true or false?	90%	100%	+ 10%

Post-test

Table 2 and 3 displays the post-test results for the 2 main subcategories. After viewing the narrated educational module, some areas improved while others remained stagnant. The questions were categorized into two subgroups: subgroup 1 included questions about TEG values interpretation, while subgroup 2 incorporated questions about TEG application in clinical practice. There were four questions include in subcategory 1 and seven questions in subcategory 2. The average score in subcategory 1 pre-test was 48.5%, while the post-test was 94%. These results demonstrate a level of improvement of 45.75 % in staff's understanding of TEG values. In subcategory 2, the average score for the pre-test was 73 %, while the average score in the post-test was 95.7%. The findings demonstrate a level of improvement of 22% in clinicians'

knowledge base of TEG application in clinical practice. Some areas showed no change between the pre and post-test results. For instance, the participants scores did not change when asked about the utilization of TEG in cardiac surgery (n=9, 100%). Overall, there was a significant educational development in all subcategories after implementing a learning module. The outcomes demonstrate that clinicians had an existing basic understanding of TEG application in clinical practice; however, there was a greater knowledge deficiency in interpreting TEG values. The factors identified in the study attempt to explain the underutilization of TEG in clinical practice.

Summary of Data

Overall, a substantial change in knowledge did occur. The overall score of the pre-test was 67%, while the overall score of the post-test was 95% which demonstrate an improvement of 28%. There was no change in scores when clinicians were asked about the efficacy of TEG application in cardiac surgery, demonstrating an existing knowledge of TEG application in clinical practice. Still, it should be noted that one of the questions received a 100% pass rate in the pre-test, thus showing the participants did not change their answers. Some scores remain the same while others increase. However, none of the scores decreased. This quality improvement project identified knowledge gaps among anesthesia clinicians that must be addressed to increase the utilization of TEG in clinical practice.

Discussion of quality improvement

Limitations

This survey was distributed to 50 individuals via email; however, 30 individuals started the survey but did not finish it. Out of the total of participants who attempted the survey, only 9

participants completed the pre-intervention and post-intervention surveys. A limitation of this data is all the participants were CRNAs and did not represent the attitudes and knowledge of the various anesthesia providers at this site. However, the goal of this quality improvement project was to enhance clinician's knowledge of TEG interpretation and clinical application and not to make findings generalizable. The delivery method of this survey may also serve as a limitation, as this required self-direction, and it is possible participants were unable to set a specific time to focus on the information provided. Providing an in-person class would have ensured the participants viewed the narrated educational module and possibly yielded more reliable data. A total of 30 staff members started the module but did not complete it; therefore, these participants were excluded from the results. Only 9 participants completed the pre-test and post-test and watched the educational video, therefore these individuals were included in the data analysis. The participants' inability to complete the module could have been related to technical difficulties or time constraints.

Future Implications for Advanced Nursing Practice

Surgical bleeding is a complication associated with surgery. Blood product transfusion is not a benign intervention because it carries risks for the patients. Measures to reduce the incidence of empiric blood products must be implemented. The outcome of this study demonstrates a need for more information on TEG interpretation and application in clinical practice. The data collected shows that educational modules can effectively educate providers and change their attitudes regarding TEG application. This DNP project has beneficial implications for the advancement of nursing practice. The improvement in clinician competency of TEG demonstrates the effectiveness of an evidence-based educational intervention. Furthermore, this project potentially increased awareness of TEG among healthcare providers,

which can improve patient surgical outcomes. Also, this is valuable for the healthcare organization because it promotes evidence-based practice. Research confirms that patient outcomes improve when clinicians practice in an evidence-based manner. Additionally, unnecessary blood products transfusion and complications can be reduced, while diminishing healthcare costs, and improving blood product shortage.

Conclusion

Surgical bleeding is a medical risk impacting individuals undergoing anesthesia, and the anesthesia provider must understand the appropriate management. As the number of individuals with complex medical conditions undergoing anesthesia continues to increase, it is prudent for measures to utilize TEG as a tool to direct blood product transfusion therapy. Presently, TEG is not the standard of care for blood transfusion protocols in clinical practice. TEG This quality improvement project has demonstrated that educational interventions can increase provider knowledge of TEG and improve their likelihood of using this effective tool for surgeries and patients at high risk for bleeding.

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Appendix A

Institution Approval letter

Envision
PHYSICIAN SERVICES
February l , 2022

Charles Buscemi, PhD, APRN
Clinical Associate Professor,
Florida International University

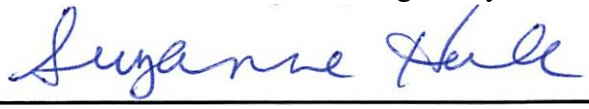
Dr. Buscemi,

Thank you for inviting Memorial Regional Hospital to participate in the Doctor of Nursing Practice (DNP) project conducted by Yanet Villa Milanes entitled "An education intervention to improve the knowledge of TEG: A Quality Improvement Project" in the Nicole Wertheim College of Nursing and Health Sciences, Department of Nurse Anesthetist Practice at Florida International University. I have warranted him permission to conduct the project using our providers.

Evidence-based practice's primary aim is to yield the best outcomes for patients by selecting interventions supported by the evidence. This project intends to evaluate if an educational intervention to improves the knowledge of TEG.

We understand that participation in the study is voluntary and carries no overt risk. All Anesthesiology providers are free to participate or withdraw from the study at any time. The educational intervention will be conveyed by a 15-minute virtual PowerPoint presentation, with a pretest and posttest questionnaire delivered by a URL link electronically via Qualtrics, an online survey product. Responses to pretest and posttest surveys are not linked to any participant. The collected information is reported as an aggregate, and there is no monetary compensation for participation. All collected material will be kept confidential, stored in a password-encrypted digital cloud, and only be accessible to the investigators of this study: Yanet Villa Milanes and Dr. Buscemi We expect that Yanet Villa Milanes will not interfere with normal hospital performance, behave in a professional manner and follow standards of care.

Prior to the implementation of this educational project, the Florida International University Institutional Review Board will evaluate and approve the procedures to conduct this project. Once the Institutional Review Board's approval is achieved, this scholarly project's execution will occur over two weeks. We support the participation of our Anesthesiology providers in this project and look forward to working with you.



Suzanne Hale, MSN, CRNA, ARNP
Advanced Practice Provider Director, Broward and Dade
Chief, Memorial Regional Hospital
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954-265-2044

3501 Johnson Street I Hollywood, FL 33021

Appendix B

IRB approval letter

FIU | FLORIDA INTERNATIONAL UNIVERSITY

Office of Research Integrity
Research Compliance, MARC 414

MEMORANDUM

To:	Dr. Charles Buscemi
CC:	Yanet Milanes Villa
From:	Elizabeth Juhasz, Ph.D., IRB Coordinator
Date:	March 28, 2022
Protocol Title:	**"Improve clinicians' knowledge of thromboelastography. A quality improvement project"**

The Florida International University Office of Research Integrity has reviewed your research study for the use of human subjects and deemed it Exempt via the **Exempt Review** process.

IRB Protocol Exemption #: IRB-22-0118 **IRB Exemption Date:** 03/28/22
TOPAZ Reference #: 111514

As a requirement of IRB Exemption you are required to:

1) Submit an IRB Exempt Amendment Form for all proposed additions or changes in the procedures involving human subjects. All additions and changes must be reviewed and approved prior to implementation.
2) Promptly submit an IRB Exempt Event Report Form for every serious or unusual or unanticipated adverse event, problems with the rights or welfare of the human subjects, and/or deviations from the approved protocol.
3) Submit an IRB Exempt Project Completion Report Form when the study is finished or discontinued.

Special Conditions: N/A

For further information, you may visit the IRB website at http://research.fiu.edu/irb.

Appendix C

Survey pre- and post-questions

1: When R parameter is prolonged?
A. administration of platelets is needed
B. administration of blood is necessary
C. administration of FFP is needed
D. administration of cryoprecipitate

2: A prolongation in clotting time (K) would indicate?
A: need for fibrinogen
B: need for cryoprecipitate
C: need RBC
D: need for cryoprecipitate

3: A decreased in maximum amplitude necessitate the administration of which blood product?
A: Albumin
B: Platelet
C: RBC
D: FFP

4: An increase in LY30 indicates?
A: it is normal values
B: coagulation factors are normal
C: indicates rapid fibrinolysis which will warrant an antifibrinolytic agent such as TXA
D: Indicate hemolytic anemia

5 : TEG has been proven to decrease unnecessary blood product transfusion after cardiac surgery true or false?

6: Unnecessary blood product transfusion can lead to?
A: Stroke, infections, and TRALI
B: blood product transfusion is benign
C: increased WBC, hyperkalemia, hyponatremia
D: Increase sensitivity reactions.

7: In patients with cirrhosis, TEG is superior to international normalized ratio (INR) or platelet count to estimate the risk for bleeding, true or false?

8: Obstetric hemorrhage can lead to:
A: deficiency of clotting factors
B: thrombocytopenia
C: hyperkalemia
D: hypervolemia

9: Patients with end-stage liver disease who received transfusion therapy
A: Transfusion related acute lung
B: Hepatitis C
C: Acute hemolytic anemia
D: Red man syndrome

10: True or false TEG can assist clinicians in detecting coagulation deficiencies in obstetric hemorrhage to determine the specific blood product therapy needed at an earlier point compared with traditional laboratory testing?

11: TEG-guided transfusion protocol has shown to improve patient survival rates in trauma true or false?