International Journal of Open-Access, Interdisciplinary & New Educational Discoveries of ETCOR Educational Research Center (iJOINED ETCOR)

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org

iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577

The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Advances in Blood Coagulation Monitoring Using Point-of-Care Testing: Benefits, Drawbacks, and Applications

Anton Miguel Diaz*[1], Prince Zoe Econg[2], Vincent Raul Gandeza[3], Therese Mae Guerra[4], Jodine Guia Gutierrez[5], Agnes Marie Ignacio[6], Kristianne Lapuz[7], Dianne Licaros[8], Rio Lozada[9]
[1, 2, 3, 4, 5, 6, 7, 8, 9] University of Santo Tomas, España, Manila, Philippines
*Corresponding Author e-mail: *antonmiguel.diaz.pharma@ust.edu.ph*

Received: 05 April 2024 **Revised**: 06 May 2024 **Accepted**: 07 May 2024

Available Online: 07 May 2024

Volume III (2024), Issue 2, P-ISSN – 2984-7567; E-ISSN - 2945-3577

Abstract

Aim: The array of Point-Of-Care Tests (POCT) methods, from traditional prothrombin time to cutting-edge microfluidic and smartphone-based technologies, signifies a transformative shift toward convenient and efficient coagulation testing. This paper explores the dynamic landscape of blood coagulation disorder diagnosis, emphasizing the emerging pivotal role of POCT in rapidly assessing hemostasis.

Methodology: The article employed a mini-review methodology referencing recent and up-to-date peer-reviewed journals. Based on set criteria, 27 articles were deemed pertinent for the review.

Results: While less precise than laboratory counterparts, POCT's accessibility and user-friendliness empower non-laboratory personnel, especially in time-sensitive scenarios such as intraoperative care or critical illnesses. POCT has demonstrated significant benefits in surgical contexts, reducing blood product transfusions and postoperative complications. Beyond surgery, the relevance of POCT extends to addressing global challenges like the COVID-19 pandemic and high-altitude conditions.

Conclusion: The investigation into the various journals proves the dynamic landscape of POC coagulation testing, with a wide variety of methods for measuring these vital parameters. Point-of-care tests offer convenience and efficiency in coagulation testing, particularly in time-sensitive scenarios like intraoperative care and critical illnesses. However, its limitations and the need for robust quality assurance programs underscore the importance of careful implementation and oversight.

Keywords: Blood coagulation monitoring, Point-of-care-testing, Advancements, Applications

INTRODUCTION

Blood coagulation monitoring is a crucial aspect in cases of hemorrhages, anticoagulant drug development, hemostatic therapies, and more, which calls for advanced technologies to be employed in creating highly accurate, competent, and cost-effective point-of-care devices (Aria et al., 2019). Point-of-care tests (POCTs) allow for fast hemostasis assessment and, when provided with a factor-based coagulation algorithm, can serve as a gold standard in hemostatic resuscitation that can lead to decreased transfusion requirement and improved trauma outcomes for cardiac surgery or postpartum hemorrhage (Sahli et al., 2020). POCT is usually performed near the site of clinical care, providing improved turnaround time (TAT) to test results with smaller specimen volume requirements that are helpful for intraoperative patients, patients with immediate life-threatening illnesses, and outpatients with chronic diseases (Wool, 2019).

Aria et al. (2019) classify these POC devices into four bases: (1) POCT Based on Optical Measurements that study the viscoelastic properties of blood through optical properties by light scattering or transmission, (2) POCT based on Electromechanical Measurements using micro and nanoelectromechanical resonators (MEMS and NEMS) devices for blood coagulation parameters, (3) POCT Based on Photoacoustic Measurements on laser-induced acoustic vibrations to monitor real-time clot circulation and blood coagulation, (4) POCT based on Electrical and Electrochemical

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Measurements which applies the principle of electrical impedance. Commercial POCT Devices are also categorized into (a) Standard Diagnostic Blood Clotting tests for PT/INR and aPTT and, (b) Devices that measure the blood's viscoelastic properties.

As good as POCT appears to be, Wool (2019) argues that its precision is still lower than automated laboratory systems and may show bias as compared to laboratory-based assays, which should be noted, along with its cost per test, when opting for POC devices. Conventional Coagulation Tests (CCT) are said to be highly optimized through automated tests, bearing low reagent costs and high walkaway time, but take relatively longer to produce results, as compared to Viscoelastic Testing (VET) which requires hands-on time and costly reagents. In a side-by-side comparison, VETs target the areas where CCTs are less capable, such as when CCTs are unable to assess clot strength and hyperfibrinolysis, a feature that can be performed through VET. In trauma settings, hemorrhage protocol is difficult to do using CCTs as it has longer TAT, so targeted resuscitation approaches are better suited with VET. However, the higher cost per test of VETs remains an issue that can potentially be optimized with more research and development of accurate and easy-to-use POC devices for targeted replacement therapies and medication support (Cohen et al., 2020).

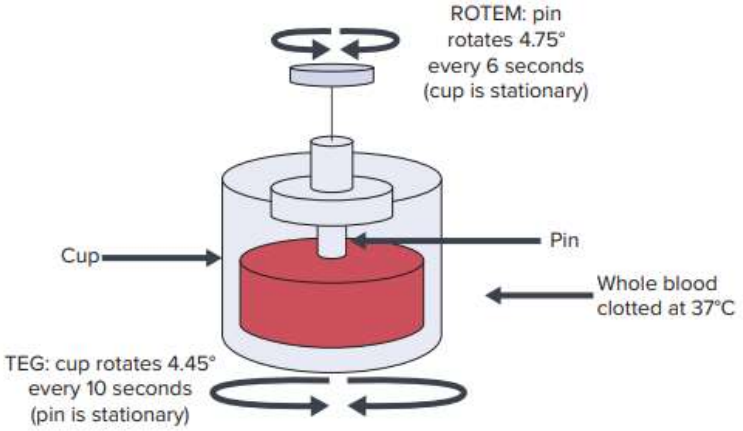


Figure 1. Illustration of the principle behind the preparation in Viscoelasticity testing and the difference between the classical thromboelastometry method (TEG) and the Rotational thromboelastometry (ROTEM) method.
Note: from Viscoelastic Haemostatic Assays in Cardiovascular Critical Care by Rali, 2021 https://www.cfrjournal.com/articles/viscoelastic-haemostatic-assays-cardiovascular-critical-care

Article Selection and Search Criteria

To ensure that the information presented in the paper is credible and up-to-date with the current advances in point-of-care coagulation testing, peer-reviewed journal articles published from 2018 to 2023 were used as references. These sources were gathered from reputable databases like Google Scholar and PubMed Central using the search terms "blood coagulation management," "anticoagulant monitoring," "hemostasis," "point-of-care testing," "point-of-care diagnostics," "POCT coagulation technologies," and "POCT vs. conventional coagulation studies" in order to limit the broad range of searches to what is relevant to this review article. Around 17,200 journal articles were screened following the set criteria for article selection, but only 27 were deemed pertinent for this mini-review.

Coagulation and Diagnosis of Blood Coagulation Disorders Using Laboratory-based Assays

Hemostasis maintains the fluidity of the blood, a complex process brought about by the delicate balance existing between thrombogenic and anti-thrombogenic mechanisms that, with the decrease or increase of one, may result in bleeding or clotting disorders (Palta *et al.*, 2014). To pinpoint such mechanisms that cause these disorders, we turn to laboratory tests for diagnosis.

Coagulation tests are functional assays that assess the clot formed after the coagulation cascade has been activated so as to detect whether the problem lies in the extrinsic, intrinsic, or final common pathways of the coagulation

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

cascade. Measurements of Prothrombin Time (PT) for extrinsic and common pathways, Activated Partial Thromboplastin Time (aPTT) for intrinsic and common pathways, Thrombin Time (TT), and Fibrinogen are used to evaluate disorders present in the secondary hemostasis. Specialized coagulation studies would follow if necessary, which include Mixing Studies for abnormally prolonged PT or aPTT, Factor Activity Assays for factor deficiencies, Factor Inhibitors, Specific Tests for Von Willebrand Disease, Anti-Xa Assay for heparin activity, Tests for Antiphospholipid Syndrome, Lupus Anticoagulant Testing, as well as monitoring for Direct-Acting and Novel Anticoagulants (Winter *et al.*, 2017). For coagulopathies and drug monitoring, PT, aPTT, and TT are most useful. PT investigates clotting from extrinsic and common pathways, notably Factors I, II, V, VII, and X; and aPTT assesses clotting factors in the intrinsic and common pathways and is sensitive to prekallikrein, high molecular weight kininogen (HMWK), Factors XII, XI, IX, and VIII. PT values are standardized using the International Normalized Ratio (INR), where the therapeutic INR falls between the 2.0-3.0 range. At the same time, levels above 4.9 are critical and show an increased risk of bleeding (Aria *et al.*, 2019).

Coagulation Tests at the Present

Coagulation tests are mainly done in central laboratories wherein patient blood tubes are submitted, with the turnaround time reaching an hour or more. Han *et al.* (2019) found feasibility in reducing in-hospital delay through the utilization of PT-INR point-of-care testing, with results being available in 9 minutes when POCT is done, in contrast to a 46-minute door-to-INR result when subjected to central laboratory processing. Presenting a 0.975 intraclass correlation coefficient at a 95% confidence interval between these two methods, Han *et al.* (2019) concluded that POCT was a quick and reliable method for expediting coagulation analysis.

Significant delays in providing coagulation test results can endanger patients, especially those involved in time-sensitive conditions such as trauma, post operation, critical care, and cardiovascular events. Circumstances such as these would necessitate rapid methods for coagulation testing, and POC assays and tests would play a key role in providing fast and accurate results for preserving these patients.

Principles and Recent Advancements of Point-of-Care Coagulation Testing

The use of POCT to monitor hemostasis permits quick evaluation of blood coagulation, thus reducing turn-around time and leading to improved patient care. Moreover, as opposed to laboratory testing, POCTs are more accessible and can be performed by non-laboratory personnel (Yenice, 2021). Although testing can yield less precise results when compared with automated laboratory-based assays, they are more advantageous in particular circumstances that require quick and targeted therapy, such as for intraoperative patients, critically ill patients, and patients with chronic illnesses or medications that can be managed at home (Wool, 2019).

POCT for hemostasis can measure PT, INR, APTT, modifications of TT, Activated Clotting Time (ACT), Platelet function, and D-dimer. Viscoelastic coagulation tests and coagulometers are some of the most widely available and commonly used tests to assess clot formation, stability, and lysis in real-time and monitor anticoagulant therapy (Sahli *et al.*, 2020). The thromboelastographic system and the rotational thromboelastic system under viscoelastic testing allow the detection of delayed coagulation initiation, measure fibrinogen level, evaluate fibrinolytic activity, and indicate the presence of anticoagulants. These automated devices most often require citrated whole blood and have ready-to-use cartridges for simultaneous testing. In addition, platelet function can be quantitatively assessed using light transmission aggregometry, wherein the increase in light transmission through platelet-rich plasma is measured as platelets aggregate upon adding procoagulants (e.g., ADP, collagen, arachidonic acid). The Platelet Function Analyzer, which is based on platelet adhesion under shear stress, and the VerifyNow Assay, a fully automated test based on optical detection, are also available for platelet function POCT.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Figure 2: Platelet function analyzers which may be used for rapid point of care testing, the VerifyNow Assay [1] and the Platelet Function Analyzer [2] on the left and right respectively.

[1] Note: from the Werfen Company Site https://www.werfen.com/na/en/point-of-care-testing-devices/platelet-testing-verifynow
[2] Note: from Melrose Biotechnologies https://www.exportersindia.com/product-detail/platelet-function-analyzer-5483666.htm

A paper by Aria et al. (2019) discussed some of the advancements in monitoring blood coagulation using POCT devices by employing microfluidics, fluorescent microscopy, electrochemical sensing, photoacoustic detection, and micro/nano electrochemical systems to evaluate the electrochemical, optical, and mechanical properties of clotting blood. In the paper, the authors highlighted how recent breakthroughs in microfluidic technology have proven to be helpful in the evaluation of anticoagulant therapies and the diagnosis of blood coagulation abnormalities as they have allowed researchers to simulate the process of blood coagulation in physiological conditions, as well as examine these processes at the molecular level. Another innovative approach that allows micromechanical blood clot testing for the measurement of PT and INR is by making use of smartphones, as described by Chan et al. (2022). In order to monitor and detect the formation of clots, a coagulation reaction is initiated by utilizing the smartphone's camera and vibrator to mix the blood sample with the test reagents. These recent breakthroughs are significant advancements that signify a shift towards more convenient and efficient coagulation testing methods at the point of care.

Advantages and Disadvantages of Point-of-Care Blood Coagulation Testing

Despite the history of traditional laboratory blood coagulation testing, rising demand for POC devices has begun manifesting in recent years. The primary advantage of POC devices for blood coagulation monitoring lies in their short measurement durations (Aria et al., 2019). Typically, POC coagulation testing ranges from 25 to 45 minutes; this is much shorter than the longer time required for conventional coagulation tests, which usually take 40 to 60 minutes. This advantage proves especially beneficial for individuals in specific situations, including intraoperative patients, individuals facing immediate life-threatening conditions, and outpatients dealing with chronic illnesses or medications that can be effectively monitored at home or in nearby settings through POC testing (Wool, 2019).

POC devices offer fresh possibilities for evaluating hemostasis, including viscoelastic coagulation tests, platelet function tests, blood gas analysis, and other coagulometers. Viscoelastic methods, one of the most commonly used coagulation tests, enable the real-time assessment of both the clot formation and clot stability rate. These methods prove beneficial in promptly diagnosing trauma-induced coagulopathy, managing transfusions, and implementing targeted hemostatic therapy within a brief timeframe. Incorporating these methods in POC-guided treatment algorithms enhances survival rates, lowers the need for blood component transfusions, and demonstrates cost-effectiveness in transfusion and coagulation support, as proved in several meta-analyses (Sahli et al., 2020).

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

POC coagulation devices exhibit distinct properties, and these systems are not interchangeable. Given the intricate nature of POC hemostasis testing, it is crucial to recognize the significance of accuracy in anticoagulation monitoring. The potential repercussions of overlooking a high or low international normalized ratio (INR) are severe and irreversible (Wool, 2019).

However, POCT is often prone to preanalytic, analytic, and post-analytic errors since it is performed by less-trained non-laboratory personnel most of the time. Factors such as insufficient calibration, quality control assessment, maintenance, and documentation affect the test. For instance, decreases in vitamin K-dependent coagulation and anticoagulation factors have proven to cause significant discrepancies in high INR measurements between POCT instruments such as the CoaguChek XS Plus and conventional laboratory devices (Kim et al., 2023). A study by Palaparti et al. (2020) further backs these findings, wherein INR values greater than 3.5 were found to present poor correlations between the two types of tests. They attributed the cause to the electrochemical sensor or mechanical methods in POC INR measurement, which only estimate the INR. Palaparti points out that POC devices using electrochemical sensors are supposedly more accurate than mechanical methods. This type of test is also more expensive than laboratory-based assays and, unfortunately, is generally less precise. To ensure proper testing techniques and reliable quality processes, such as sufficient personnel training, oversight, and management guidelines must be established (Wool, 2019).

Point-of Care Blood Coagulation Testing Applications

Upon an initial review of 17,200 articles to investigate the current trend of Blood Coagulation POCT usage, most articles detailed extensive use in the operational field. As cited from a study conducted by Azvolinsky (2022), "the use of POC coagulation testing, such as Thromboelastography, decreased blood product transfusions and surgical re-exploration due to postoperative bleeding." This explains the frequent appearance of studies concerning surgical-related blood coagulation POCT. Surgery can lead to massive bleeding and thromboembolic events, which necessitates perioperative monitoring of hemostasis. Conversely, a study provided by Ondondo (2018) exposed extreme variability and a lack of correlation among the various point-of-care platelet function testing assays. The study attributed this to differing parameters, agonists, and cut-off values between the different assays. This result is concerning because, in a surgical setting, the limitation of variability is essential, particularly in coagulation testing, to prevent postoperative complications due to internal hemorrhage or intravascular coagulation.

Blood Coagulation Monitoring using Point-of-Care Testing in the Operating Room

In exploring point-of-care coagulation in the operating room, it is noted that point-of-care tests in a neonatal setting are less widely used in comparison to the adult population, given that neonates and infants are considerably more delicate. Management of bleeding and coagulopathy are central features in the treatment of neonates and children undergoing cardiac surgery, which is made more complex due to several underlying factors (Bianchi et al., 2020). Heparin impact monitoring is used to monitor pediatric patients, and there are no discernible changes between the monitoring of pediatric patients and adult patients. Activated clotting time, however, is not a dependable enough measure in children, particularly after cardiopulmonary bypass. The hemodilution experienced, along with temperature fluctuations, leads to a substantially poorer reliability of activated clotting time than previously thought (Harnish et al., 2022).

Several advantages associated with point-of-care (POC) coagulation testing in cardiovascular surgery have been evident in prior trials, particularly those involving cardiac surgical patients. Consistent findings across these studies indicate a potential reduction in transfusion requirements when employing POC diagnostics. Noteworthy benefits were observed in trials specifically focusing on coagulopathic patients, where POC techniques demonstrated a substantial decrease in postoperative blood loss, leading to favorable outcomes in clinically relevant endpoints. A pivotal study by Nuttall et al. showcased the efficacy of POC-guided transfusion practices, integrating coagulation tests such as prothrombin time, aPTT, platelet counts, thromboelastogram maximum amplitude, and fibrinogen concentration. The POC-guided group exhibited lower transfusion rates for erythrocytes, frozen plasma, and platelets, along with reduced postoperative mechanical ventilation duration, a shorter length of ICU stay, a lower composite adverse events rate, decreased costs of hemostatic therapy, and a lower 6-month mortality rate compared to the control group following conventional tests. These findings underscore the positive impact of POC coagulation testing in cardiovascular surgery,

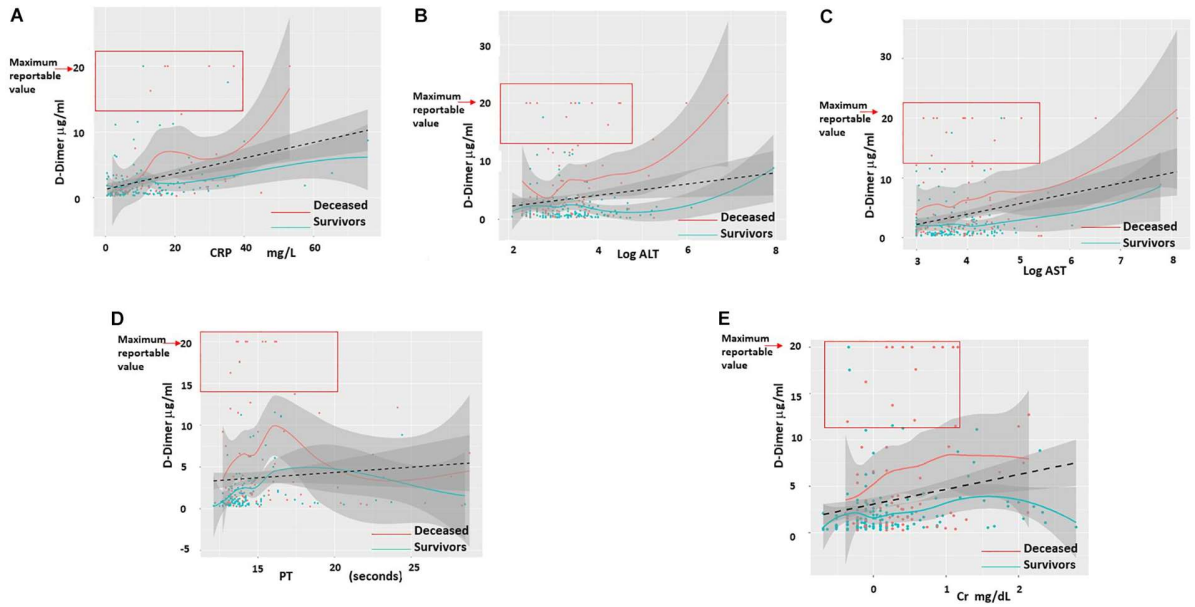
ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

contributing to more efficient blood management, improved patient outcomes, and cost-effectiveness (Meybohm et al., 2013).

Additionally, in a pragmatic stepped-wedge cluster randomized controlled trial encompassing 7402 patients across 12 hospitals, the integration of point-of-care (POC) hemostatic testing within a comprehensive transfusion algorithm yielded significant reductions in red blood cell transfusions, platelet transfusions, and instances of major bleeding. The study revealed that, for every 20 to 30 enrolled patients, the intervention effectively prevented one major bleeding episode, offering a cost-effective alternative (approximately $60 per patient) compared to traditional methods like cell salvage. Cell salvage, costing around $200 per patient, only marginally outperformed in reducing red blood cell transfusions (23% relative risk reduction), with no impact on major bleeding and potential increases in platelet and plasma transfusions. This POC strategy, achieved through simple, rapid laboratory assays with no risk of harm, notably reduced platelet transfusions by 23%. Given the challenges in platelet inventory management and the observed benefits, our results recommend adopting near-patient, POC-based testing strategies in centers conducting cardiac procedures. (Keyvan Karkouti et al., 2016).

Applications of Point-of-Care Blood Coagulation Testing beyond the Operating Room

Beyond surgical applications, POC blood coagulation testing has been seen with recent interest due to the COVID-19 pandemic and the numerous global conflicts. Recent and rapid airborne evacuations from emergent belligerent nations have catalyzed research to prevent the most common battlefield cause of medical death: hemorrhagic shock. When evaluated under high altitude conditions, viscoelastic POC systems such as the "TEG 6s" have proven reliable and resistant to high altitude conditions (Boye et al., 2020). On the other side of the medical field, the COVID-19 pandemic raised an urgent need for Coagulation POC treatment as timely and adequate hemostasis and inflammation monitoring has been proven vital to prevent and treat potentially the lethal consequences of the infection (Lazarević et al., 2023). Research helping to advance towards an integrated optofluidic device combining microfluidics and photonic sensor technology has seen traction as thromboelastography, the clinical standard, suffers from limited portability and low sensitivity when miniaturized (Singh et al., 2020). This is made even more pertinent as there is evidence to indicate that COVID-19 is closely correlated to hypercoagulation among severely ill patients, with Singh's study explicitly pointing to point-of-care testing as a means to help with treatment by enabling the administration of controlled doses of medication to patients and to understand the disease's underlying pathophysiology promptly.



ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingtheculturefresearch@etcor.org
Mobile Number : 0939-202-9035

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Figure 3. The results of a study conducted by Gil et al. (2021) depicting the correlation between various Coagulation parameters within 48 hours of admission and the mortality of patients. The significant differences in admission PT, absolute neutrophil count (ANC) and first D-Dimer present the need to conduct near rapid measurement of these parameters among patients admitted due to COVID - 19.

Of the first applications of blood coagulation POCT, POC blood coagulation testing has always been evident in monitoring therapeutic regimens. Predominantly, the Internalized Normal Ratio (INR) is often used in monitoring Oral Anticoagulation Therapy (OAT) and other regimens requiring anticoagulant management. POC INR has been compared extensively with laboratory PT/INR results and proved to be within the acceptable analytical precision and accuracy range. It offers significant logistical advantages over laboratory hemostasis (Wool, 2018). However, Wool's study advises against using POCT to detect congenital or acquired coagulopathies. In addition to the limitations of POC INR testing, EQA programs of these parameters remain relatively few despite the accepted reliability of these tests (Maule, 2021).

Conclusions

The investigation into the various journals proved the dynamic landscape of POC coagulation testing, with a wide variety of methods for measuring these vital parameters. Whether it is through the detection of mechanical elasticity properties or electrochemical sensory methods, POCT's convenience and its capability for rapid assessment and targeted treatment cannot be denied. This paper sought to provide a comprehensive and unbiased look into these procedures, where common consensus tends to emphasize the benefits in accessibility and capability to reduce turnaround time.

POC coagulation testing has thus far proven essential in many intraoperative cases due to the speed of measurement of blood coagulation parameters using these devices. It has also served as a boon for personal monitoring, as is the case with anticoagulant therapy regimens. Advancement into POCT development in these parameters have taken the attention of many members of the medical community, as emphasized by various studies, into the effects of prompt testing on the prognosis of many intra and postoperative scenarios, as well as some diseases such as COVID - 19.

The systematic and comprehensive review of these journals on Blood Coagulation Point-of-Care testing uncovers the ongoing investigation and advancement of methods to increase reliability and ensure the best patient care. These findings provide a current-day picture of the various uses, indications, and contraindications in using these point-of-care devices. Catalyzed by recent events, ongoing research into the improvement, development, and creation of these specialized devices should continue to be a subject of interest within the healthcare community for the years to come.

Recommendations

With the advantages POCT holds, it also comes with certain limitations. Although the speed of procedures brought about by these methods is commendable, its accuracy may lag behind laboratory-based tests due to the latter's highly automated nature. While most articles testify to the general screening efficacy of these procedures, a general finding among the screened articles emphasized poor diagnostic reliability in some parameters, such as high INR presenting poor correlations with non-POC testing. Emphasis must be placed on superb quality control measures through personnel training and standardized protocols in order to mitigate errors and ensure reliability in POCT. Most studies cite possible improvement once sufficient technology has been developed for these machines, such as the currently in-development microfluidic POC device meant for high-altitude use.

The application of POCT in various medical procedures—blood coagulation testing and monitoring, in this case—has become a beacon for rapid assessment of health problems and targeted therapy. However, it still requires a meticulous approach, as the benefit of the speedy test procedures comes with potential errors and accuracy issues. As technology advances, protocols strengthen, and more research regarding this matter is done, POCT is poised to revolutionize coagulation monitoring and create a more efficient and effective landscape for patient care.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

REFERENCES

Azvolinsky, A. (2022). Thromboelastography: Measuring Blood Coagulation in Real Time. *American Society of Hematology*. https://ashpublications.org/ashclinicalnews/News/6430/Thromboelastography-Measuring-Blood-Coagulation-in

Bianchi, P., Beccaris, C., Norbert, M., Dunlop, B., & Ranucci, M. (2020). Use of coagulation point-of-care tests in the management of anticoagulation and bleeding in pediatric cardiac surgery: a systematic review. *Anesthesia & Analgesia*, *130*(6), 1594-1604. https://doi.org/10.1213/ANE.0000000000004563.

Boyé, M., Boissin, J., Poyat, C., Pasquier, P., & Martinaud, C. (2022). Evaluation of the altitude impact on a point-of-care thromboelastography analyzer measurement: Prerequisites for use in airborne medical evacuation courses. *European Journal of Trauma and Emergency Surgery*, *48*(1), 489-495. https://doi.org/10.1007/s00068-020-01420-2

Chan, J., Michaelsen, K., Estergreen, J. K., Sabath, D. E., & Gollakota, S. (2022). Micro-mechanical blood clot testing using smartphones. *Nature communications*, *13*(1), 831. https://doi.org/10.1038/s41467-022-28499-y.

Cohen, T., Haas, T., & Cushing, M. M. (2020). The strengths and weaknesses of viscoelastic testing compared to traditional coagulation testing. *Transfusion*, *60*, S21-S28. https://doi.org/10.1111/trf.16073

Comparison of prothrombin time and international normalized ratio values using point-of-care system with a standardized laboratory method in patients on long-term oral anticoagulation – A prospective study. *Journal of Clinical and Preventive Cardiology.* https://doi.org/10.4103/jcpc.jcpc_55_19.

Comparison of prothrombin time and international normalized ratio values using point-of-care system with a standardized laboratory method in patients on long-term oral anticoagulation – A prospective study. *Journal of Clinical and Preventive Cardiology.* https://doi.org/10.4103/jcpc.jcpc_55_19.

Demailly, Z., Wurtz, V., Barbay, V., Surlemont, E., Scherrer, V., Compère, V., Billoir, P., Clavier, T., & Besnier, E. (2023). Point-of-Care Viscoelastic Hemostatic Assays in Cardiac Surgery Patients: Comparison of Thromboelastography 6S, Thromboelastometry Sigma, and Quantra. *Journal of Cardiothoracic and Vascular Anesthesia, 37*(6), 948–955. https://doi.org/10.1053/j.jvca.2023.02.015

Favaloro, E. J., Pasalic, L., & Lippi, G. (2022). Getting smart with coagulation. *Journal of Thrombosis and Haemostasis*, *20*(7), 1519-1522. https://doi.org/10.1111/jth.15691.

Han, J. H., Jang, S., Choi, M. O., Yoon, M. J., Lim, S. B., Kook, J. R., Kang, D. W., Kwon, S. U., Kim, J. S., & Jeon, S. B. (2019). Point-of-care coagulation testing for reducing in-hospital delay in thrombolysis. *Hong Kong Journal of Emergency Medicine, 26*(4), 218-224. https://doi.org/10.1177/1024907918799938.

Harnish, J., Beyer, K., & Collins, J. (2022). Anticoagulation Strategies in Pediatric Cardiopulmonary Bypass, Weight-Based vs. Concentration-Based Approaches. *The Journal of ExtraCorporeal Technology*, *54*(2), 153. https://doi.org/10.1182/ject-153-160.

Keyvan Karkouti, Callum, J., Wijeysundera, D. N., Rao, V., Crowther, M., Grocott, H. P., Pinto, R., Scales, D. C., & Tacs Investigators. (2016). Point-of-Care Hemostatic Testing in Cardiac Surgery. *Circulation*, *134*(16), 1152–1162. https://doi.org/10.1161/circulationaha.116.023956.

Kim, Y., Choi, J.-W., Song, S., Ho Young Hwang, Suk Ho Sohn, Ji Seong Kim, Kang, Y., Gu, J., Kyung Hwan Kim, & Hyun Kyung Kim. (2023). Comparison of the International Normalized Ratio Between a Point-of-Care Test and a

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Conventional Laboratory Test: the Latter Performs Better in Assessing Warfarin-induced Changes in Coagulation Factors. *Annals of Laboratory Medicine, 43*(4), 337–344. https://doi.org/10.3343/alm.2023.43.4.337

Leon-Justel, A., & Macmillan, J. (2021). Point of Care Viscoelastic Haemostasis Monitoring During Liver Transplant Surgery. *Anesthesia for Hepatico-Pancreatic-Biliary Surgery and Transplantation*, 209-223.. https://doi.org/10.1007/978-3-030-51331-3_11

Maule, W. M. (2020). Point-of-care testing: is it a paradox in international normalised ratio measurements?. *The Journal of Medical Laboratory Science and Technology of South Africa*, *2*(2), 109-113. https://hdl.handle.net/10520/ejc-medtech1-v2-n2-a11.

Meybohm, P., Zacharowski, K., & Weber, C. F. (2013). Point-of-care coagulation management in intensive care medicine. *Critical care*, *17*(2), 1-9. https://doi.org/10.1186/cc12527.

Milić, D., Lazarević, M., Vuković, N., Kamenov, A., Perić, V., Golubović, M., Stošić, M., Spasić, D., Stojiljković, V., & Stokanović, D. (2023). Monitoring the Coagulation Profile of COVID-19 Patients Using Standard and ClotPro® Hemostasis Tests. *Medicina, 59*(7), 1202. https://doi.org/10.3390/medicina59071202

Mohammadi Aria, M., Erten, A., & Yalcin, O. (2019). Technology advancements in blood coagulation measurements for point-of-care diagnostic testing. *Frontiers in Bioengineering and Biotechnology*, *7*, 395. https://doi.org/10.3389/fbioe.2019.00395

Moore, R. (2020). *International Normalised Ratio Monitoring in Children: Comparing the accuracy of portable point-of-care monitors to standard of care laboratory monitoring at Red Cross War Memorial Children's Hospital* (Master's thesis, Faculty of Health Sciences). http://hdl.handle.net/11427/32880.

Ondondo, B. O. (2018). Platelet function testing for cardiac surgery patients on antiplatelet therapy: the extreme variability of point-of-care tests. *Biomedical and Pharmacology Journal*, *11*(2), 593-607. https://dx.doi.org/10.13005/bpj/1412

Palta, S., Saroa, R., & Palta, A. (2014). Overview of the coagulation system. *Indian journal of anaesthesia*, *58*(5), 515. https://doi.org/10.4103/0019-5049.144643

Rali, A. S. (2021, February 19). *Viscoelastic Haemostatic Assays in Cardiovascular Critical Care*. Radcliffe Cardiology; Radcliffe Cardiology. https://www.cfrjournal.com/articles/viscoelastic-haemostatic-assays-cardiovascular-critical-care

Reyes Gil, M., Gonzalez-Lugo, J. D., Rahman, S., Barouqa, M., Szymanski, J., Ikemura, K., Lo, Y., & Billett, H. H. (2021). Correlation of coagulation parameters with clinical outcomes during the Coronavirus-19 surge in New York: observational cohort. *Frontiers in Physiology*, *12*, 618929. https://doi.org/10.3389/fphys.2021.618929

Sahli, S. D., Rössler, J., Tscholl, D. W., Studt, J. D., Spahn, D. R., & Kaserer, A. (2020). Point-of-care diagnostics in coagulation management. *Sensors*, *20*(15), 4254. https://doi.org/10.3390/s20154254.

Singh, R., Frydman, A. B. G., Kimerling, L., Agarwal, A., & Anthony, B. W. (2020). Integrated optofluidic sensor for coagulation risk monitoring in COVID-19 patients at point-of-care. *ArXiv (Cornell University).* https://doi.org/10.48550/arXiv.2010.02081.

Winter, W. E., Flax, S. D., & Harris, N. S. (2017). Coagulation testing in the core laboratory. *Laboratory medicine*, *48*(4), 295-313. https://doi.org/10.1093/labmed/lmx050

Wool, G. D. (2019). Benefits and pitfalls of point-of-care coagulation testing for anticoagulation management: an ACLPS critical review. *American journal of clinical pathology*, *151*(1), 1-17. https://doi.org/10.1093/ajcp/aqy087.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Yenice, S. (2021). Training and competency strategies for point-of-care testing. *EJIFCC*, *32*(2), 167. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8343045/.