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EVALUATION OF PRE- AND POST-OPERATIVE COAGULATION PARAMETERS IN PATIENTS UNDERGOING MAJOR SURGERIES

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Abstract

The issue of coagulation abnormality is a critical problem among patients who undergo major surgical operations since this may aggravate the chances of perioperative bleeding and thrombotic events. Hemostatic mechanisms can change due to surgical trauma, anesthesia, and related physiological stress, with an observable change in coagulation parameters. It will be critical to track such changes to timely identify and treat any possible complications. Prothrombin time (PT), activated partial thromboplastin time (APTT), and international normalized ratio (INR) are common laboratory indicators that are widely used to evaluate the coagulation and inform clinical decision-making in patients undergoing surgery.

Study Rationales: *The current research was carried out to compare and contrast the pre- and post-operative coagulation parameters (PT, APTT and INR) in patients who undergo major surgeries. It also sought to establish the level of alterations in coagulation profile post-surgical and evaluate the possibility of the occurrence of abnormal coagulation during the perioperative phase.*

Methodology: *This cross-sectional but comparative study was conducted on 30 patients aged over 18 years having undergone major surgical operations. Aseptic conditions were observed in the collection of blood samples prior to surgery and in a specified post-operative period. Standard laboratory techniques were used to analyze the samples in order to ascertain PT, APTT and INR values. Appropriate demographic and clinical information were also taken. The mean values of the preoperative and postoperative coagulation parameters were compared to conduct a statistical analysis and assess significant differences.*

Results: *The results of the study revealed that the values of the PT, APTT, and INR in the post-operative period were altered with respect to their previous values, which indicated the change of the coagulation status after a major surgical intervention. There was a tendency to longer coagulation times in some of the*

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patients, which indicated a higher risk of bleeding during the period right after the operation.

Conclusion: *The findings emphasized the need to regularly check the coagulation parameters in patients with major surgery. Timely intervention and prevention of complications can be achieved by early detection of coagulation abnormalities by simple and reliable laboratory tests, thus enhancing patient outcomes. This research highlighted the importance of appropriate perioperative laboratory evaluation in the provision of safe surgical management and efficient care of patients.*

INTRODUCTION

Hemostasis is a highly complex and tightly regulated physiological process that helps to maintain vascular integrity by avoiding excessive blood loss after vascular damage and sustains normal blood flow in the circulation. It is a fluctuation between the procoagulant and anticoagulant systems. Any disturbance in this balance may lead to some pathological states like hemorrhage or thrombosis [1, 2, 3, 4, 5].

Hemostatic process is triggered right after vascular injury and consists of a complex interplay between vascular endothelium, platelets in circulation, coagulation factors and fibrinolytic systems [1, 2, 6, 7]. First, the injury of the vessels causes vasoconstriction, and it causes the short-term decrease in blood supply to the injured area. Primary hemostasis is then followed wherein platelets stick to the exposed subendothelial collagen through von Willebrand factor, are activated and form a temporary platelet plug [3, 4, 18, 19].

Secondary hemostasis happens subsequently by activation of coagulation cascade, a cascade of enzyme reactions involving clotting factors. The results of these reactions are the production of thrombin, which is a major enzyme that transforms soluble fibrinogen into insoluble fibrin strands. The initial platelet plug is stabilized by the fibrin network to create a hard and tough clot that, in effect, stops bleeding [6, 7, 9, 19].

The coagulation cascade has been traditionally broken down into intrinsic and extrinsic pathways, which both become convergent into a shared pathway that results in the formation of fibrin. Endothelial damage and exposure of subendothelial components is the intrinsic pathway, and tissue injury and release of tissue factor is the extrinsic pathway. Although this classical separation, however, the current knowledge indicates that these pathways act in an overlapping and interactive fashion in vivo [6, 7, 19, 22, 23].

After the formation of the clot, fibrinolysis is triggered to break up the clot after vascular repair is achieved. This is necessary to ensure normal circulation of blood and avoid the unnecessary clot formation. Natural anticoagulants and regulation processes tightly regulate the whole hemostatic process, so that the formation of clots does not develop into systemic thrombosis [1, 19, 25, 26, 27].

Altogether, hemostasis and blood coagulation represent a carefully balanced physiological process comprising of cellular and molecular parts that work together to preserve the stability in circulatory processes [1, 19, 40]. This is a process of great concern in clinical environments, especially in the surgical population, where coagulation condition changes can play a large role in determining perioperative outcomes [28, 29, 30, 42, 49].

1. Physiology of coagulation cascade

1.1 Overview on the Coagulation Cascade

The coagulation cascade is a complicated physiological system of events that is at the center stage in the process of hemostasis as it creates a stable clot of fibrin at the location of vascular damage. It is a cascade of sequential enzymatic reactions that involve converting inactive plasma proteins, called clotting factors, to active forms. The majority of these clotting factors are produced in the liver and circulate in the blood in the form of inactive zymogens until triggered. The cascade is set to enhance a quick amplification of the

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clotting response and avoids excessive loss of blood [6, 7, 9, 19, 40].

The coagulation cascade consists of a number of clotting factors, conventionally called I to XIII. They are fibrinogen (factor I), prothrombin (factor II), tissue factor (factor III), calcium ions (factor IV) and other protein cofactors. Most of these are vitamin K-dependent such as factors II, VII, IX, and X that are critical to normal coagulation. These factors are highly regulated to interact with each other and one factor activated catalyzes the activation of the next leading to a cascade effect [6, 7, 9, 15, 19].

Intrinsic Pathway

Contact activation pathway or intrinsic pathway is activated when blood is in contact with negatively charged surfaces like exposed subendothelial collagen after vascular injury. This cascade causes the consecutive activation of factor XII, factor XI and factor IX which, in combination with factor VIII as a cofactor, cause factor X to become activated. Intrinsic pathway is slower in nature and contributes considerably to enhancing the coagulation process. It is clinically measured using the activated partial thromboplastin time (APTT) [6, 7, 9, 11, 54, 55].

Extrinsic Pathway

The extrinsic pathway is triggered by external injury leading to the release of tissue factor (factor III) by broken endothelial cells. Tissue factor and factor VII interact to produce a complex that quickly activates factor X. It is a quicker pathway compared to the intrinsic pathway and the major initiator of coagulation in the body. Prothrombin time (PT) is a clinically determined test [6, 7, 9, 11, 54, 56].

Common Pathway

Both intrinsic and extrinsic pathways lead to the common pathway, the initial step of which is activation of factor X to factor Xa. Through a combination of factor Xa, factor V, calcium ions and phospholipids, prothrombin (factor II) is processed into thrombin (factor IIa). Thrombin is a major enzyme which transforms fibrinogen (factor I) to fibrin, and which forms the structural framework of the clot [6, 7, 9, 19].

1.2 Regulation of the Coagulation Cascade

There is a regulated cascade of coagulation to ensure that clots do not form excessively. Antithrombin, protein C and protein S are natural anticoagulants that prevent different clotting factors to achieve the balance. These self-governing processes make sure that the formation of clots is confined to the damage location [1, 19, 21, 27].

Recent developments have changed the perception of coagulation to a cell-based model, rather than the traditional cascade model. This model focuses on the role of cellular surfaces that are especially platelets and endothelial cells in the onset, amplification, and continuation of coagulation. It brings out the fact that the intrinsic and extrinsic pathways are not distinct processes but work in an integrated and overlapping fashion [19 ,22, 23, 40].

It is important to know the physiology of the coagulation cascade in clinical practice particularly among surgical patients. Coagulation abnormalities may result in excessive bleeding or thrombotic complications. The common laboratory tests include PT, APTT, and INR that help to monitor various elements of the cascade and make informed decisions about the perioperative management [11, 17, 44, 50, 53].

2. Coagulation Pathways

2.1 Intrinsic Pathway (Contact Activation Pathway)

Activation of the intrinsic pathway occurs when blood is in contact with negatively charged or damaged surfaces including exposed subendothelial collagen after vascular injury. This route is called intrinsic since all the factors required to form clots are in the blood itself [6, 7, 19].

Characteristics of intrinsic pathways are Less rapid than the extrinsic pathway. Enhances the coagulation mechanism. Needs cofactors like calcium ions, phospholipids. Activated partial thromboplastin time (APTT) clinically tested [11, 54, 55, 87].

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2.2 Extrinsic Pathway (Tissue Factor Pathway)

The extrinsic pathway is initiated by external injury that results in injury to tissues beyond the blood vessel. It is termed extrinsic since it entails the involvement of tissue factor, which does not exist in the circulation of blood [6, 7, 9, 19].

Characteristics of extrinsic pathways are Quick activation (first stage of coagulation in vivo). Does not involve many steps as the intrinsic pathway. Relies on the tissue factor that is leaked out of injured cells. Clinically assessed using prothrombin time (PT) and standardized as INR [11, 54, 56, 87]. The extrinsic route is especially susceptible to factor VII deficiencies and it is prevalent in liver disease and vitamin K deficiency. PT/INR is commonly employed in managing the management of patients taking oral anticoagulants like warfarin [53 ,55, 61, 88, 89].

2.3 Common Pathway

The common pathway is through activation of factor X by both intrinsic and extrinsic pathways [6, 7, 19].

The end result is a stable fibrin clot which strengthens the platelet plug created during primary hemostasis [1, 9, 19].

Knowledge of intrinsic and extrinsic pathways plays an important role in perioperative care. The process of surgery may disrupt the normal coagulation causing a bleeding or thrombotic complication. The laboratory tests (PT, APTT and INR) are regularly performed to assess these pathways both pre- and post-operative, contributing to risk assessment and management [44, 50, 54, 55, 56, 71].

Table 01: Comparison of Intrinsic and Extrinsic Pathways

Feature	Intrinsic Pathway	Extrinsic Pathway
Trigger	Internal vessel damage	External tissue injury
Speed	Slower	Faster
Key Factors	XII, XI, IX, VIII	VII, Tissue Factor (III)
Laboratory Test	APTT	PT/INR
Function	Amplification	Initiation

3. Role of Platelets in Hemostasis

Platelets or thrombocytes are tiny and anucleated fragments of cells that originate in megakaryocytes in the bone marrow and are very important in sustaining hemostasis. They play a vital role in arresting blood loss in case of vascular damage by quickly developing a platelet plug at the point of damage. Platelets also help in secondary hemostasis in addition to primary hemostasis as they provide a place of coagulation reactions and promote the fibrin clotting process. Their role is thus crucial towards keeping the balance of bleeding and clotting in the circulatory system [3, 4, 18, 19].

3.1 Platelet Hemostatic Mechanism

Platelet hemostasis starts as soon as vascular damage happens, and platelets attach, activate, and form clots. Subendothelial collagen and von Willebrand factor (vWF) are revealed when the endothelial lining of blood vessels is damaged. Platelets stick to these structures via certain surface receptors, especially glycoprotein Ib, attaching to vWF. After the adhesion, platelets are activated and change dramatically in morphology, becoming spiny and pseudopodia-like cells, and thus expanding their surface area [18, 19].

Platelets emit the granulometry of their granules such as adenosine diphosphate (ADP), thromboxane A 2 (TXA 2), serotonin and calcium ions, on activation. Those substances are vital in the process of recruiting and activating more platelets, enhancing the hemostatic reaction. Platelet aggregation then takes place by binding fibrinogen to glycoprotein IIb/IIIa receptors on neighboring platelets to create a temporary platelet plug [18, 19, 83].

In addition to primary hemostasis, platelets are also involved in secondary hemostasis through the provision of phospholipid surface facilitating the activation of clotting factors in the coagulation cascade. This enhances the production of

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thrombin, and fibrinogen to fibrin, which results in a stable clot. Platelets also play an additional role in stabilizing the clot by means of clot retraction, facilitated by their contractile proteins, which aids in decreasing the clot size and dragging the sides of the damaged vessel towards each other [19, 22, 40].

The activity of platelets is closely controlled in the regular physiological state to avoid the unjustified formation of clots. In normal vessels, platelet activation is inhibited by the release of inhibitory substances by endothelial cells including prostacyclin and nitric oxide. But when there is a vascular trauma, then this inhibition is eliminated and platelets become effective at the localized injury [19, 40, 43].

Abnormal platelet count or platelet dysfunction can cause severe hemostatic dysfunction. A decrease in the number or defective functioning of platelets can lead to excessive bleeding and an increase in platelet activity can lead to thrombotic complications. Maintaining hemostatic balance in surgical patients depends on the correct functioning of the platelets and any malfunction can have a considerable impact on the final results of the surgery [1, 9, 71, 83].

4. Impact of Surgical Trauma on Coagulation System

Surgical trauma has a significant impact on the coagulation system because of tissue damage, disruption of blood vessels, and the body stress and inflammatory response. During and after surgery, the hemostatic system gets highly activated in the attempt to avoid excessive blood loss. Nonetheless, such activation can result in a precarious balance between bleeding and thrombosis, especially when operating on a large scale. The entire impact of surgical trauma on coagulation is dynamic and varies according to the level of injury, length of surgery, blood loss, and other factors associated with the patient [28, 29, 30, 34, 42, 43].

Intraoperative tissue injury exposes subendothelial collagen and liberates tissue factor (TF) leading to extrinsic coagulation pathway activation. This causes factor VII to be activated rapidly and factor X to be activated, which causes the generation of thrombin. Thrombin is at the center of the process as it changes fibrinogen into fibrin, creating a stable clot where the injury occurs. Moreover, platelet activation and aggregation are improved by surgical trauma, which further reinforces primary hemostasis. The combination of platelets and coagulation factor activity gives rise to a short-term hypercoagulable state, a phenomenon that can be regarded as a protective physiological reaction to restrict intraoperative bleeding [6,7,19,34,42].

Surgical injury leads to a great rise in procoagulant activity, such as fibrinogen, thrombin, and activated clotting factor presentations. Simultaneously, natural anticoagulant systems like antithrombin and protein C can be comparatively inhibited. This is shifted toward clot formation and predisposes venous thromboembolism (VTE) especially in orthopedic, abdominal, and oncological surgeries [19, 28, 29, 71, 89].

Also, immobilization during and after surgery is another contributing factor to venous stasis that is part of the triad of Virchow that predisposes the patient to deep vein thrombosis [28, 28, 30, 71]. The coagulation system can be depleted during extensive surgical trauma or when there is a considerable amount of blood loss. This causes platelet and clotting factor consumption resulting in the condition called consumptive coagulopathy [71, 80, 91]. This condition can be further aggravated by dilutional effects of intravenous fluid infusion or blood transfusion [71, 81].

This can manifest in clinically as a long prothrombin time (PT), activated partial thromboplastin time (APTT), and elevated INR levels [54,55, 56, 64]. The severe cases can lead to disseminated intravascular coagulation (DIC), which is a life-threatening complication with extensive clotting and hemorrhage [70, 71]. Trauma surgery triggers a systemic inflammatory event whereby cytokines of interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF- 6), and other inflammatory mediators are released [30, 42, 43]. These cytokines have a direct effect on the coagulation system, specifically, they increase tissue factor expression, and stimulate the formation of thrombin [19, 42, 43].

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Meanwhile, inflammation inhibits natural anticoagulants and fibrinolysis, which promotes an even more prothrombotic condition. This strong association between inflammation and coagulation is the reason why postoperative patients are more susceptible to thrombotic complications [19, 43, 47]. Fibrinolytic activity can be inhibited immediately after surgical trauma because of a higher secretion of the plasminogen activator inhibitor -1 (PAI-1). This inhibition of fibrinolysis not only encourages the stability of clots but also leads to a hypercoagulable state [26, 28, 29]. Increased fibrinolytic activity can occur later in the postoperative period and results in possible bleeding complications unless well managed [26, 71].

5. Importance of Pre-operative and Post-operative Coagulation Assessment

Perioperative evaluation of coagulation pre- and post-surgery is a key element of care. Surgery, particularly big surgeries, may dramatically change the hemostatic equilibrium, and predispose to bleeding or thrombotic complications. Regular checks on the coagulation parameters like Prothrombin Time (PT), Activated Partial Thromboplastin Time (APTT) and International Normalized Ratio (INR) are used to detect abnormalities early and provide suitable clinical care to protect the patients [11, 54, 55, 56, 64, 77].

8.1 Pre-operative Coagulation Assessment

Coagulation testing should also be done pre-operative to identify any underlying hemostatic abnormalities that can predispose patients to excessive bleeding in the operating room. This assessment involves an overview of the patient history, medications (including anticoagulants or antiplatelet agents), and laboratory tests and analysis such as PT, APTT, and INR [44, 53, 55, 71]

Coagulation disorders like deficiency of clotting factors, liver dysfunction, or vitamin K deficiency can be corrected in time by proper interventions that may include administration of vitamin K, plasma transfusion, or changes in anticoagulant therapy. This minimizes chances of hemorrhage during surgeries and enhances better surgical results [71, 88, 89].

Besides, pre-operative examination assists in risk stratification and surgical planning especially in high-risk patients who are undergoing major surgeries [28, 30, 82, 90].

8.2 Post-operative Coagulation Assessment

Monitoring of coagulation after an operation is also very critical since surgical trauma, blood loss, fluid administration, and inflammatory processes can dramatically change the coagulation status. Patients can either get hypocoagulable or hypercoagulable conditions that cause bleeding or thrombosis respectively [28, 29, 30, 42, 71].

Routine monitoring of PT, APTT, and INR during the postoperative phase can be used to identify complications, including dilutional coagulopathy, disseminated intravascular coagulation (DIC), or loss of clotting factors [54, 55, 56, 64, 70, 71]. It is also helpful in assessing the efficacy of therapy like blood transfusions or anticoagulant therapy [11, 17, 44, 53].

Rationale of study

Significant physiological stress and tissue damage are related to major surgical procedures, potentially causing changes in the hemostatic system. Depending on the alterations, they can cause either hypercoagulable, which predisposes to thromboembolic complications, or hypocoagulable, which causes excessive bleeding. Proper evaluation of the coagulation status during the perioperative period is thus crucial in-patient safety and enhancing surgical outcomes.

Common lab values, including Prothrombin Time (PT), Activated Partial Thromboplastin Time (APTT), and International normalized ratio (INR), are a popular way of assessing the various coagulation cascade pathways. Although these parameters have clinical significance, the changes in the parameters prior to and following surgery are not always consistently monitored and interpreted especially in healthcare settings where resources are limited. This can contribute to the late diagnosis of coagulation disorders and greater chances of complications.

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Moreover, surgical trauma, blood loss, and fluid administration, as well as anesthesia, may have a considerable amount of impact on the parameters of coagulation, which is why it is essential to analyze the alterations in a systematic manner. The pattern of pre-operative and post-operative changes in PT, APTT, and INR are likely to be understood to aid in the early diagnosis of coagulopathies and inform the administration of subsequent measures like blood transfusion or anticoagulant treatment.

Hence, this research was undertaken to compare and contrast pre-operative and post-operative coagulation measurements of patients undergoing major surgeries. The results of this research are likely to be very helpful in understanding the changes in the hemostatic during perioperative care and underline the significance of periodic coagulation testing to prevent complications and enhance patient care.

METHODOLOGY

Study Design

This study was conducted as a hospital-based cross-sectional analytical study to evaluate and compare preoperative and postoperative coagulation parameters in patients undergoing major surgical procedures.

Study Area and Duration

The study was carried out in the surgical wards and medical laboratory department of Ashraf Medical Center, Sargodha, Pakistan. Data collection was conducted over a period of 03 months.

Sample Size and Selection

A total of 30 patients were recruited using a convenience or consecutive sampling technique, depending on patient availability during the study period.

Table 02: Calculation of Sample Size

Confidence level	95%
Margin of error	5%
Population proportion	1.4%
Population size	2500000

Selection Criteria

Inclusion Criteria

- Patients aged 18 years and above undergoing major surgery.
- Patients who provide informed consent to participate in the study.
- Patients with available preoperative and postoperative blood samples.

Exclusion Criteria

- Patients with known bleeding disorders.
- Patients on anticoagulant or antiplatelet therapy.
- Patients with chronic liver disease, renal failure, or malignancy.
- Patients who receive massive transfusion prior to postoperative sampling.

Specimen Collection

- After obtaining ethical approval and informed consent, demographic and clinical data such as age, sex, and type of surgery collected using a structured data collection form.
- Venous blood samples were collected preoperatively (within 24 hours before surgery) and postoperatively (48 hours after surgery). Approximately 3 mL of blood was drawn into trisodium citrate tubes (3.2%) for coagulation studies.
- Samples were centrifuged at 3000 rpm for 10–15 minutes to obtain platelet-poor plasma. Prothrombin time (PT) and activated partial thromboplastin time (APTT) were analyzed using an automated coagulation analyzer following manufacturer's instructions.

Quality Control:

All laboratory analyses were performed using calibrated equipment. Internal quality control

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materials were run daily, and standard operating procedures were strictly followed to ensure accuracy and reliability of results.

Chemical Analysis
Weiner Lab kits were used to perform PT, APTT tests in lab both pre and post operatively using automated analyzer Sysmex CA500.

Prothrombin Time (PT)
Principle:
The method is based on the measurement of fibrin clot formation time, by adding calcium thromboplastin to a citrated plasma.

PROVIDED REAGENTS
A. Reagent A
Non-Provided Reagents
Saline solution
Coagulation Calibrator from Wiener lab.

Sample:
Citrated plasma.
Collection:
Collect blood carefully (avoiding stasis or trauma) and place in a tube with anticoagulant in an exact 9 + 1 ratio (example: 4.5 ml blood + 0.5 ml anticoagulant).
Mix gently. Centrifuge for 15 minutes at 2500 g and separate plasma before 30 minutes. It is advisable to perform collection with plastic syringes.

Procedure:
1. Preheat Reagent A at 37°C (no more than 20 minutes)
2. In a tube preheated at 37°C, place 100 ul sample. Incubate for 1 minute in a water bath at 37°C.
3. Trigger timer with the addition of 200 ul pre-heated re- agent A. Prior to the estimated coagulation time, remove the tube from bath, gently sliding the liquid content from the bottom to the middle of the tube and stop the stopwatch at the time of clot appearance.
4. Record clot formation time.
5. Repeat the determination and average the result for each sample. If the difference between the replicates is greater than 5%, it is advisable to repeat the procedure.

Interpretation of results:
- Prothrombin time (PT) was recorded in seconds.

Quality Control Method
Plasma Control normal from Wiener lab. **Coagulation Control N - Coagulation Control P** from Wiener lab.
Controls are processed in the same way as samples.

Reference range:
10 to 14 seconds

Activated Partial Thromboplastin Time (APTT)
Principle:
The assay is based on measuring the coagulation time of a decalcified plasma placed on a water bath at 37 degrees centigrade and in the presence of excess of cephalin, activator and calcium.

Provided Reagents:
Reagent A: Vial containing cephalin with a diatomaceous earth as a particulate activator.
Reagent B: 0.025mol/l calcium chloride solution
Non-Provided Reagents:
Bidistilled or deionized water
Sample:
Plasma

Required Material:
- Hemolysis tube
- Pipettes and micropipettes for measuring the stated volume
- Water bath at 37 degrees centigrade
- Stopwatch
- Light source (for clot observation)

Procedure:
- Incubate the reagent B in water bath at 37 degrees centigrade before performing the test.
- In a hemolysis tube place:
- Sample 100 ul
- Reagent 100 ul
- Mix and incubate for 3 mins at 37 degrees centigrade then add,
- Reagent B 100 ul at 37 degrees centigrade

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- Start the stopwatch at same time. Shake briefly to homogenize content. Keep in water bath for about 25 seconds. Then move tube from water bath. Tilt gently and stop the stopwatch where clot is formed. Record the coagulation time.

Interpretation of results:
Results are expressed as:

- APTT in seconds.
- The ratio obtained between the time obtained with the unknown and the time obtained with the controlled plasma.

Reference range:
33 to 48 seconds
Quality Control Method:
Wiener Labs plasma control normal

Data Analysis

- Data was entered and analyzed using statistical software such as SPSS version 26.0.
- Descriptive statistics has been used to summarize demographic characteristics and laboratory parameters.
- Continuous variables have been expressed as mean ± standard deviation.
- Paired t-test has been used to compare preoperative and postoperative coagulation parameters. A p-value of <0.05 was obtained considering the data statistically significant.

Ethical Considerations

- Ethical approval was obtained from the Institutional Review Board of Ashraf Medical Center.
- Written informed consent was obtained from all participants.
- Confidentiality was maintained by using coded identifiers, and all data will be used strictly for research purposes.

RESULTS

The analysis of the study data using the statistical approach was done both descriptive and inferential. The variables were summarized using descriptive statistics which included the calculation of mean, median, mode and standard deviation of all preoperative and postoperative coagulation parameters. These actions gave an impression of central tendency and variability in the data. Findings were streamlined and displayed in tables and graphical figures that would allow one to easily compare the preoperative and postoperative values. To conduct the inferential analysis, paired t-test was employed to determine the significance of the difference in the preoperative and postoperative measurements in the same group of patients. The reason why this test was chosen was that it is suitable in the event of comparing two related samples and finding out whether the difference in the means is significant or not. This method was used to analyze all the parameters to determine any significant changes in coagulation profiles in the perioperative period. The p-value of 0.05 was deemed to be significant. These analysis results are provided in the next section.

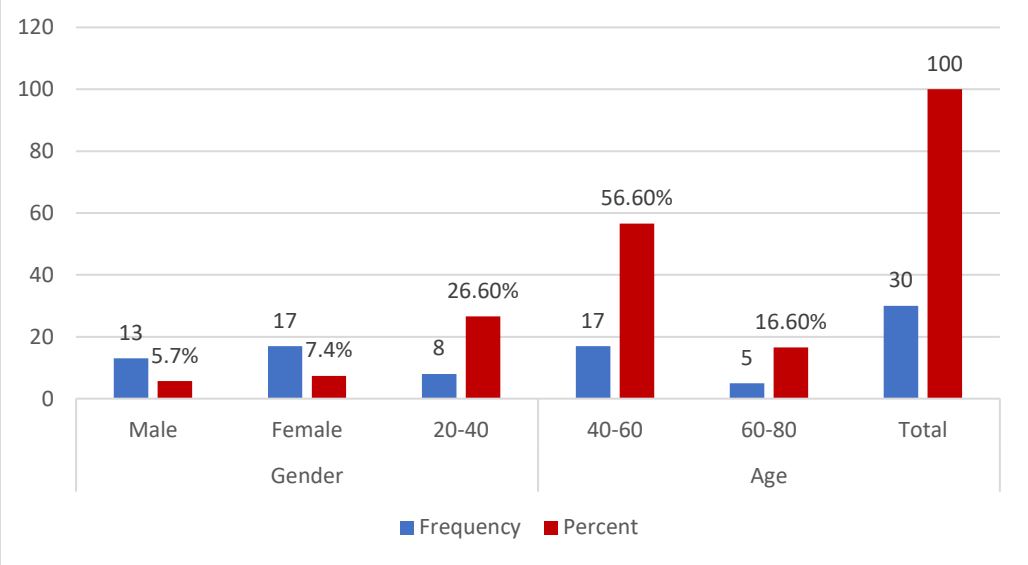
Table 2: Distribution of Patients by Gender and Age

Variable		Frequency	%
Gender	Male	13	5.7
	Female	17	7.4
Age	20-40	8	26.6
	40-60	17	56.6
	60-80	5	16.6
	Total	30	100

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The sample size used in the study consisted of 30 patients, with the majority of them being females (56.7%), with 43.3 percent being males. The age distribution revealed that the majority of patients were between 40 and 60 years (56.7%), 20-40 years (26.7) and 60-80 years (16.7). This shows that patients that were middle aged had the highest percentage of major surgical procedures carried out in the study population.



Graph 1: Demographic characteristics of patients undergoing major surgeries

Table 3: Descriptive Statistics of Pre-operative and Post-operative Parameters

	N	Minimum	Maximum	Mean	Std. Deviation
Pre Operative	30	14	121	23.73	23.857
Pre Operative	30	33	138	45.83	25.590
Pre Operative	30	1.2	9.2	1.940	1.8995
Post-Operative	30	15	124	26.57	25.206
Post-Operative	30	34	142	49.03	25.598
P	30	1.2	10.6	2.553	2.4558

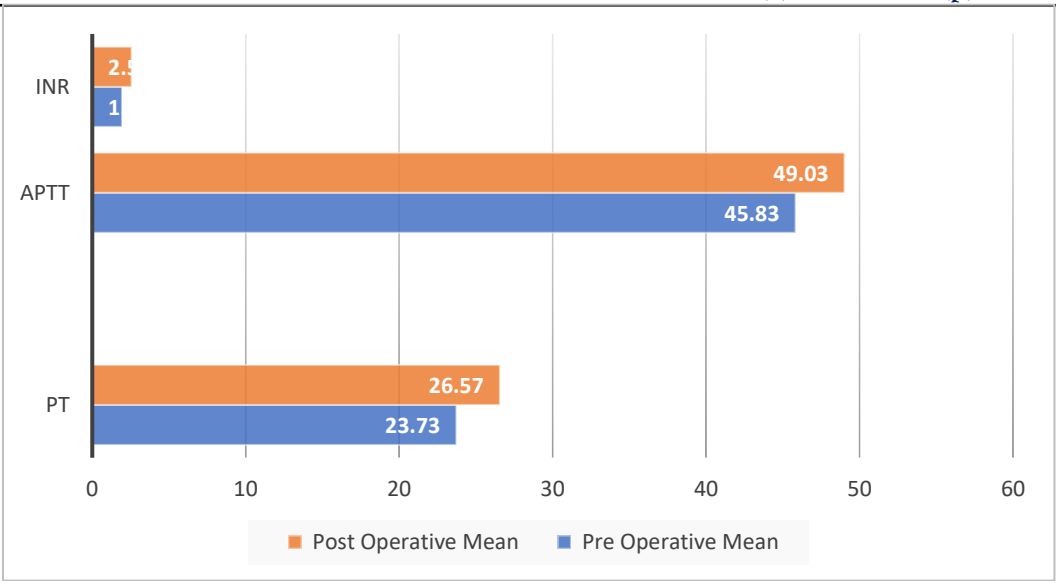
Coagulation parameters (preoperative and postoperative) underwent descriptive statistical analysis. The mean preoperative PT was 23.73 ± 23.85, which increased to 26.57 ± 25.20 postoperatively. On the same note, the average APTT was 45.83 +25.59 before surgery and 49.03 +25.59 after surgery. The mean INR also showed an increase from 1.94 ± 1.89 to 2.55 ± 2.45 following surgery.

In general, all coagulation parameters showed a rising tendency in postoperative values in comparison with preoperative values. The large standard deviations of both preoperative and postoperative measurements reveal the variability of patients. These results indicate a propensity to change in coagulation profile after major surgical operations.

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Graph 2: Pre operative and post operative comparison of coagulation parameters

Table 4: Comparison of Pre-operative and Post-operative Coagulation Parameters Using Paired t-test

		Mean	Std. Deviation	df	Sign(2-tailed)
PT	Pre Operative	23.73	23.857	29	.022
	Post-Operative	26.57	25.206		
APTT	Pre Operative	45.83	25.590	29	.0001
	Post-Operative	49.03	25.598		
INR	Pre Operative	1.940	1.8995	29	.001
	Post-Operative	2.553	2.4558		

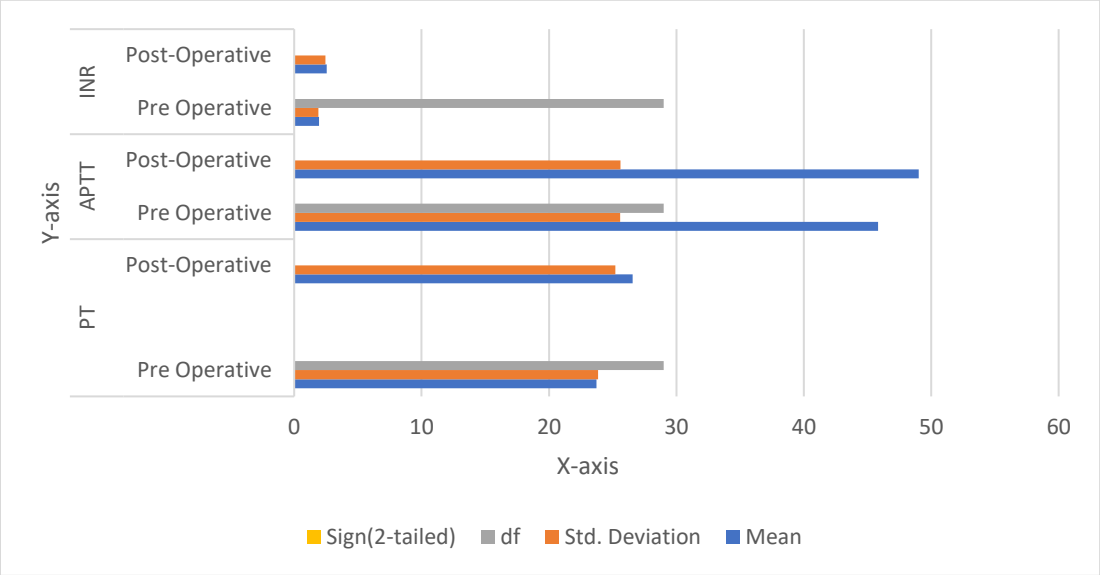
A paired t -test was used to compare preoperative and postoperative coagulation parameters. The results showed a statistically significant difference between the prothrombin time (PT) of 23.73 +23.85 before the operation and 26.57 +25.21 after the operation (p = 0.022). On the same note, the activation partial thromboplastin time (APTT) increased significantly, 45.83 ± 25.59 to 49.03 ± 25.60 (p = 0.0001). The international normalized ratio (INR) too showed statistically significant increase of 1.94 + 1.90 preoperative to 2.55 + 2.46 postoperative (p = 0.001).

On the whole, these data suggest that the coagulation parameters change considerably after major surgery, and all the measured variables increase after it. This indicates that surgical intervention has a quantifiable effect on the coagulation profile of patients.

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Graph: 3 Pre- and Postoperative Variation in PT, APTT, and INR

DISCUSSION

The current research was carried out to determine the variation in parameters of coagulation, namely prothrombin time (PT), activated partial thromboplastin time (APTT), and international normalized ratio (INR) in patients who undergo major surgical procedures through comparison of the preoperative and postoperative values. The results indicated statistically significant improvement of all three parameters after surgery, which implies the presence of definite changes in the coagulation profile after surgery.

In this study, the mean PT increased from 23.73 ± 23.85 preoperatively to 26.57 ± 25.21 postoperatively ($p = 0.022$), while APTT increased from 45.83 ± 25.59 to 49.03 ± 25.60 ($p = 0.0001$). Similarly, INR showed a significant rise from 1.94 ± 1.90 to 2.55 ± 2.46 ($p = 0.001$). These results imply that surgical stress is related to considerable changes in both intrinsic and extrinsic coagulation pathways. The described postoperative PT and APTT prolongation could be due to consumption of clotting factors, hemodilution, inflammatory processes, or perioperative physiological stress.

The rise in INR also promotes the existence of abnormal coagulation condition during the postoperative period. Even though the changes in INR were statistically significant, clinical significance might not be the same across all situations with varying levels of deviation outside the normal ranges and the context of the individual patient. The standard deviations were relatively large and this is indicative of inter-individual variability, possibly due to factors like type of surgery, time of procedure, intra-operative blood loss and comorbidity of patients.

These results are in agreement with other studies that have been carried on perioperative changes in coagulation parameters. Research done on laparoscopic and major abdominal surgeries has shown post operative induction of coagulation processes and signs of fibrinolysis, usually indicated by elevated D-dimer levels and a change in PT/APTT values. Equally, studies on liver surgery have also emphasized that traditional coagulation assays can indicate hypocoagulability, whereas the overall haemostatic situation can be complicated and dynamic. This lends credence to the idea that the changes in perioperative coagulation are multifactorial and not necessarily well represented by the single laboratory values.

The findings of the current research are also consistent with the literature that reveals that a balance between procoagulant and anticoagulant mechanisms determines perioperative

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coagulation. Coagulation cascades, endothelial damage, and the release of inflammatory mediators are activated as a result of surgical trauma, which cause haemostatic changes. This can predispose patients to a hypercoagulable state in some instances and in others the consumption of clotting factors can result in a relative hypo coagulable state, depending on the clinical situation.

Although statistically significant changes in coagulation parameters were found, it is noteworthy that laboratory changes are not necessarily directly associated with clinical outcomes like bleeding or thromboembolic events. This points out the weakness of the use of conventional coagulation tests as the only means of risk assessment of perioperative. According to the recent literature, active monitoring and integration of clinical variables can be used to give a more detailed assessment of the haemostatic status.

The demographic of the current research revealed that the majority of patients were aged 40-60 years, and there was an insignificant female dominance. This could affect the coagulation responses because of age-related physiological changes and hormonal effects, but in this study, these associations were not explicitly examined.

Such strengths of this study as the paired analysis that provides the possibility to directly compare the preoperative and postoperative values in the same patient eliminate the inter-individual variability. Nevertheless, there are some limitations that should be considered. The sample size was also quite small (n = 30) and this could be a limitation to the external validity of the results. Also, the results were not stratified according to type or duration of surgery, intraoperative factors, or comorbid conditions, which might affect the outcome of coagulation. Another limitation is the lack of the more sophisticated coagulation test technology like thromboelastography (TEG) because it can give a more in-depth evaluation of haemostatic activity.

Overall, the current paper shows that significant alterations in the parameters of coagulation are related to major surgical procedures, as PT, APTT, and INR values increase during the postoperative period. The results highlight the significance of perioperative evaluation of coagulation profiles to detect possible abnormalities and inform clinical practice. It is desirable that further research should be conducted on a larger scale and incorporation of advanced coagulation assessment methods should be incorporated to gain a better insight into the clinical implications of such changes.

CONCLUSION

The current research has been conducted to assess the changes in perioperative coagulation parameters, prothrombin time (PT), activated partial thromboplastin time (APTT), and international normalized ratio (INR) of patients undergoing major surgical operations. The study was able to show a statistically significant difference in all parameters measured before and after surgery by comparing preoperative and postoperative values within the same cohort. The results of the study reveal that significant surgical procedures are linked with changes in the coagulation profile that can be measured.

The noticed extension of PT and APTT indicates that both the extrinsic and intrinsic pathways of coagulation were involved, with the increase in INR additionally indicating the alterations in the overall haemostatic state. The cause of these changes may be related to various perioperative issues such as surgical trauma, inflammatory response, hemodilution, and intake of clotting factors. The findings confirm the idea that surgery is a dynamic and complicated haemostatic reaction instead of a straightforward shift towards hypercoagulability or hypocoagulability.

Though the differences in the parameters of coagulation were significant, their clinical concerns should be viewed cautiously. Abnormalities in the laboratory are not necessarily directly related to clinical outcomes, which are bleeding or thromboembolism. This creates the weakness of the traditional coagulation tests as a means of assessing perioperative risk. The large variation in patients also highlights the impact of individualization of several factors including type of surgery, duration, intraoperative blood loss, and underlying patient factors.

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The research highlights the need to observe coagulation parameters of patients undergoing major surgery on a regular basis. The timely detection of abnormalities can contribute to their early intervention and help to diminish possible complications. Nonetheless, concerning the shortcomings of conventional laboratory tests, more holistic methods are required such as incorporation of clinical examination and, where possible, more complex methods of coagulation monitoring.

Although the study has strengths such as the paired analysis design, the lack of stratification by the surgical or patient variable, and the relatively small sample size limit the study. Thus, it is possible that the results will not be completely applicable to all surgical groups.

Finally, substantial alterations in coagulation parameters in response to surgical stress occur with major surgical procedures and are manifested by alterations in coagulation parameters. The results support the importance of close control and patient-specific evaluation of his or her coagulation condition to facilitate the provision of high-quality perioperative care and better patient outcomes. Additional large-scale investigations with the use of more sophisticated haemostatic measurement methods are suggested to clarify the clinical relevance of these changes better.

Limitations of study

- Postoperative coagulation changes (secondary hypercoagulability or late bleeding tendencies) may not be discerned within the short follow-up period (several days after surgery).
- Since it is a single-center study, it is possible that the results are affected by the local clinical practice, patient population, and perioperative management guidelines and thus cannot be applied to other hospitals or the entire healthcare environment.
- The inability to monitor dynamic coagulation parameters over time by using only one post-operative measurement limits the possibility of tracing the progress, changes in the peak, or pattern of recovery in the coagulation parameters following surgery.
- The small number of parameters of coagulation measured could be insufficient to evaluate the hemostatic system in full detail since more elaborate or sensitive measures (like thromboelastography or fibrinolytic markers) were not provided.

Recommendations

- To increase statistical power and increase the generalizability of findings, future research needs to have a bigger sample size and multi-center design to enhance the study.
- To gain a clearer insight of the changes in coagulation parameters over time and dynamically, serial postoperative measurements at various time points should be utilized instead of a single post-operative value.
- More coagulation tests including more sophisticated tests like thromboelastography and fibrinolytic parameters should be introduced to provide a more elaborate evaluation of hemostatic alterations.
- The possible confounding variables that include comorbidities, medications, transfusions and perioperative management of fluids should be better regulated or put into consideration to enhance the validity and accuracy of the results.

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