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ORIGINAL ARTICLE

Occurrence of Thrombosis and Thrombocytopenia in Females During Perimenopause Post-COVID-19 Vaccination

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ABSTRACT
The COVID-19 vaccine has saved many lives from the SARS-COV-2 virus around the world but it has also shown some side effects. Some short-term side effects include inflammation, fever, muscle pain, headache, etc. and long-term side effects include thrombosis and thrombocytopenia. Perimenopause is the age when a female is in a transition phase and about to reach the end of her reproductive years which is called menopause. During perimenopause females undergo several hormonal changes and a decrease in the levels of protective hormones like Estrogen makes them prone to diseases. In this article, we have tried to find out the possibility of thrombosis and thrombocytopenia occurring in females during perimenopause as side effects of the COVID-19 vaccine. Platelet count and Haemoglobin were measured using auto-analyser. Prothrombin time was estimated using a tilt-tube technique. The levels of Fibrinogen, D-dimer, and Platelet factor-4 were estimated using respective ELISA kits. Out of 60 samples, mean age of the total sample population was 51 years, mean platelet count was 1.8 x106/ml, mean hemoglobin level was 13.4 g/dl, mean fibrinogen level was 3.6 g/dl, mean prothrombin time was 12.1 sec., mean D-dimer level was 465.7 ng/ml, and mean PF-4 was found to be 18.5 ng/ml. After administration of the COVID-19 vaccine, an autoimmune reaction was triggered in some individuals resulting in the release of anti-PF4 antibodies. Anti-PF4 antibodies bind with PF4 resulting in thrombosis of platelets and thrombocytopenia in such individuals.
Keywords: COVID-19 vaccine, Perimenopause, D-dimer, Thrombosis, Thrombocytopenia

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INTRODUCTION

COVID-19 vaccine is an m-RNA vaccine. All of our body's cells produce and use mRNA in the process of making proteins. Because of this, cells have systems in place to make sure that no protein is produced more than what is required. The fact that mRNA has a "poly(A) tail" is one way this occurs. This tail ensures that mRNA decays in the cytoplasm. The length of the poly(A) tail shortens as the mRNA is utilized by the cell to produce proteins until it is no longer long enough for the mRNA to be used as a template for proteins (1). Following this, the mRNA degrades and is eliminated as cell waste. The amount of protein that is made is constrained by this process, which also affects how long mRNA stays in the cytoplasm. Therefore, poly(A) tails guarantee that the vaccine mRNA is broken down by the cell promptly. With this knowledge, vaccine-delivered mRNA can be designed to guarantee that it does not remain in the cell for longer than necessary to produce protection (2).

Covishield (ChAdOx1-nCOV or AZD1222) is a recombinant, replication-deficient chimpanzee adenovirus vector encoding a SARS-CoV-2S glycoprotein vaccine developed by the Serum Institute of India (SII). This includes non-replicating strains of SARS-CoV-2 (adenoviruses) that have been genetically modified and weakened. One vaccine dose contains several recombinant virus particles. In addition to ChAdOx1-S

(recombinant), this vaccine also contains magnesium chloride hexahydrate, L-histidine, L-histidine hydrochloride monohydrate, sodium chloride, ethanol, sucrose, polysorbate 80, and water for injections. This vaccine is stored and transported at 2-8°C. The Covishield immunization schedule consists of two doses of intramuscular injection (0.5 ml in each dose) and must be administered between 4 to 6 weeks (3,4).

Side effects of the COVID-19 vaccine have been observed in some females in their perimenopausal age. To list such side effects, fever, muscle pain, headache, and inflammation are considered to be some of the short-term side effects (effects that appear after a few days of vaccination) and Thrombosis and thrombocytopenia are a few of the long-term side effects (5). Thrombosis is a condition when there is coagulation of blood cells and thrombocytopenia is the condition when there is coagulation of platelets itself causing a decrease in its number. Irregularities in the menstrual cycle of females have been observed after receiving the COVID-19 vaccine. Loss of platelets in women may lead to severe anemia, thrombocytopenia, and related disorders. It may also significantly increase the risk of hemorrhage and blood clots (6,7).

The megakaryocyte constitutes the first source of the platelet, a tiny anucleated cell that comes from the hematopoietic lineage. Megakaryocytes undergo a controlled and organized process called platelet manufacturing, which is believed to take place primarily in the bone marrow (8,9). It has long been known that platelets are essential for preserving hemostasis and that deficiencies in either their quantity or quality cause bleeding (10–12). Activated platelets release a tiny chemokine protein called platelet factor 4 (PF4). While promoting blood coagulation is one of PF4's primary physiological roles, this cytokine also plays a role in innate and adaptive immunity when platelets are activated in response to infections (13,14).

One essential element of blood clots is fibrinogen. Fibrinogen is converted into insoluble fibrin during coagulation. Fibrinogen is a protein that is produced in large quantities in the liver and is crucial to numerous physiological functions (15). After vascular injury, the creation of a stable blood clot made of polymerized and cross-linked fibrin is essential for stopping blood loss and promoting wound healing. It is crucial to strike a balance between clotting (the conversion of fibrinogen to fibrin) and fibrinolysis (the proteolytic breakdown of the fibrin mesh) (16). Different diseases can be brought on by disturbances to this balance. Certain pathological disorders arise due to changes in fibrinogen levels, whereas other conditions are associated with the structural characteristics of the molecule. Clinical implications also originate from the location of fibrinogen protein and the source of fibrinogen expression (17).

In extra-hepatic tissues, such as carcinomas, low levels of fibrinogen expression have been found, which may be a contributing factor to the disease. Pathological fibrinogen deposits can also occur at aberrant locations, such as the kidney or central nervous system. Fibrinogen, the thrombin substrate that produces fibrin, is essential for regulating bleeding after vascular damage (18). It also plays a significant role in wound healing, tissue regeneration, and the modulation of inflammatory responses that aid the immune system in combating invasive invaders. Many evidences suggest that fibrinogen has a role in pathological conditions and these contributions could be the consequence of structural modifications, changes in plasma concentration, or the effect of polymorphisms on clot stiffness, permeability, and resistance to lysis. The existence of fibrinogen in specific areas could also be one of the factors assisting in the disease development (19).

Our bodies produce the protein fragment known as D-dimer when a blood clot breaks down. Our body produces fibrin, a protein, during the hemostasis process, and these threads connect to form a fibrin net (20,21). The net serves as an anchor for the growing blood clot until the wound heals. Our body produces an enzyme called plasmin to break down the blood clot into smaller pieces so that it may be removed once the injury has healed and our body no longer needs it. D-dimer is one of the pieces that are referred to as fibrin split-products or fibrin breakdown products (22,23). Blood clots can occur in a person with a blood clotting problem even in the absence of an injury and it could be life-threatening. Since the level of D-dimer can significantly increase during substantial blood clot formation and breakdown in the body, having a high D-dimer level in the blood may indicate the presence of a blood clotting issue (24,25).

Females in the age group from 40 to 65 years are considered to be in their perimenopausal age. Estrogen hormone in women protects organs like skin, heart, bones, breasts, brain, etc., and also acts as an immunity booster and plays a somewhat protective role against infections (26,27). Women in perimenopause have a decrease in Estrogen levels which could potentially cause vulnerability to severe symptoms during this period (28,29). In this study, we have tried to explore the possibility of the occurrence of thrombosis and thrombocytopenia in females during perimenopause (having low levels of Estrogen) after they have been vaccinated with both the doses of COVID-19 vaccine.

MATERIAL AND METHODS

Study design

This was a prospective study to assess the probability of thrombosis and thrombocytopenia in females during perimenopause after COVID-19 vaccination. To achieve this aim we assessed the levels of clotting factors (e.g., Platelet count, D-dimer, PF4, etc.) in females of perimenopausal age after COVID-19 vaccination and analyzed the data obtained for the probability of thrombosis and thrombocytopenia in such females. An informed consent was obtained from the participant of the study. Ethical approval for this study was obtained from university's institutional ethical committee (ethical approval number: PM/Ethical/COPS/2022/032).

Sample collection

The samples were collected from the individuals who were previously administered both the doses of COVID-19 vaccine (Covishield, Serum Institute of India) and came to TMU hospital for a booster dose of the same vaccine. Blood from such individuals was collected by the hospital staff before the booster dose to estimate the antibody titer. For our study, we chose healthy females around perimenopausal age (40-65 years) and individuals having any complications or diseases were excluded from this study. 2 ml blood was isolated from a total of 60 subjects, and Platelet count, Haemoglobin, Fibrinogen, Prothrombin time, D-dimer, and Platelet factor-4 were measured.

Estimation of Haemoglobin and Platelet count

Platelet count and Haemoglobin were estimated by CBC auto-analyzer (FA-120 Fully automatic Biochemistry Analyzer, Clindiag Systems Co. Ltd.).

Measurement of Prothrombin time

One of the many blood tests frequently used in clinical practice to assess a patient's coagulation status is the prothrombin time. More precisely, prothrombin time is used to assess the common and extrinsic pathways of coagulation, aiding in the identification of low fibrinogen concentrations and inadequacies of factors II, V, VII, and X. When thromboplastin, a combination of tissue factor, calcium, and phospholipid, is added to a patient's plasma sample, the prothrombin time indicates how long it takes for the plasma to clot in seconds. A tilt-tube technique that relied on visually recognizing clot development in plasma samples has been used to detect clot formation as an endpoint. The temperature was maintained at 37 °C using a water bath (30).

Estimation of Fibrinogen, D-dimer, and Platelet factor-4

Fibrinogen, D-dimer, and Platelet factor-4 were estimated using enzyme-linked immunosorbent assay (ELISA) kits (Krishgen Biosystems, USA), and the stepwise protocol was followed as provided by the manufacturer. Briefly, to extract serum, collected blood samples were centrifuged for 10 minutes at 4°C at a speed of 3000 revolutions per minute. Before the tests were conducted, serum samples were stored at -80°C. Serum samples were frozen on ice and diluted at a ratio of 1:400 before being used for the measurements. To each well, 50 µL of the standard, control, or sample was added. The calibrator diluent was used as the control. Absorbance was read at 450 nm optical density using a microplate reader (Oscar OR-500, Oscar Medicare, Pvt. Ltd., India).

Statistical Analysis

Statistical Analysis was performed using OriginPro software (version 10.1, USA). Mean, Standard deviation and Pearson's correlation were calculated in the measured samples to find the relationship among them.

RESULTS

Distribution of the age groups

The samples collected were from females in their perimenopausal age (40-65 years) and they were further divided into various sub-groups. The age distribution of the total sample population (Figure 1) shows that among the total sample population, a majority (51.7%) of the females belonged to the 45-50 years of age group. The second largest population (20%) belonged to the age groups of 51-55 years and 55-60 years. The least of the sample population (8.3%) belonged to females of more than 60 years of age.

Levels of different parameters measured

Different parameters were measured in the samples collected using various methods as described in the materials and methods section. In this study out of 60 samples, the mean age of the total sample population was 51 years, the mean platelet count was 1.8 x106/ml, mean hemoglobin level was 13.4 g/dl, mean fibrinogen level was 3.6 g/dl, mean prothrombin time was 12.1 sec., mean D-dimer level was 465.7 ng/ml, and mean PF-4 was found to be 18.5 ng/ml (Table 1).

The relationship of Platelet count, Hemoglobin, Fibrinogen, Prothrombin, D-dimer, and PF-4 with age

After analysing the relationship of different parameters measured with age, it was observed that platelet count (-0.13), Hemoglobin (-0.19), and Prothrombin time (-0.04), showed negative correlation while Fibrinogen (0.02), D-dimer (0.41) and PF-4 (0.38) showed positive correlation with age (Figure 2).

The individuals with high values of both D-Dimer and PF-4

Having higher levels of D-Dimer and PF-4 indicate higher tendency of blood clotting. Out of 60 samples, 6 individuals had high values of both D-Dimer and PF-4 (Table 2) indicating that these individuals are at high risk of clotting tendencies.

The individuals with high clotting factor

Among the total sample population, only 2 individuals had values of D-Dimer, PF-4, and Fibrinogen all higher than the normal range (Table 3). These parameters are involved in the processes of thrombosis and thrombocytopenia and the individuals having a high value of these factors might be at high risk of having thrombosis and thrombocytopenia after COVID-19 vaccination.

Table 1: Mean (± SD) of different parameters measured in the samples.

Parameter	Mean ± SD
Age (years)	50.6 ± 5.2
Platelet Count (x106/µl)	1.8 ± 0.6
Hb (g/dl)	13.3 ± 1.1
Fibrinogen (g/dl)	3.5 ± 0.8
Prothrombin Time (sec.)	12.0 ± 1.7
D-dimer (ng/ml)	465.7 ± 227.8
PF-4 (ng/ml)	18.5 ± 4.9

Table 1: Table 1 shows the levels of different parameters measured in the samples. The mean age was 51 years, mean platelet count was 1.8 x106/ml, mean hemoglobin level was 13.4 g/dl, mean fibrinogen level was 3.6 g/dl, mean prothrombin time was 12.1 sec., mean D-dimer level was 465.7 ng/ml, and mean PF-4 was found to be 18.5 ng/ml. Data represent mean (± SD) of 60 samples.

Table 2: Individuals showing high values of both D-dimer and PF-4.

S.N.	Age	D-dimer (ng/ml)	PF-4 (ng/ml)
1.	50	923	28
2.	63	1097	30.0
3.	52	1090	28.0
4.	56	1010	27.0
5.	58	884	26.0
6.	61	945	27.0

This table shows the details of the individuals showing high values of both D-dimer and PF-4. Out of 60 samples, 6 individuals had D-dimer levels of 923, 1097, 1090, 1010, 884, 945 and PF-4 levels of 28, 30.0, 28.0, 27.0, 26.0, 27.0 which were higher than the normal range.

Table 3: Individuals showing high values of D-dimer, PF-4, and Fibrinogen.

S.N.	Age	D-dimer (ng/ml)	PF-4 (ng/ml)	Fibrinogen (g/dl)
1.	63	1097	30.0	5.8
2.	56	1010	27.0	5.4

Table 3 lists the individuals having high values of D-dimer, PF-4, and Fibrinogen. Out of 60 samples, 2 individuals had D-dimer levels of 1097 and 1010, PF-4 levels of 30.0 and 27.0 and Fibrinogen levels of 5.8 and 5.4, respectively.

Figure 1: Distribution of age group among the subjects

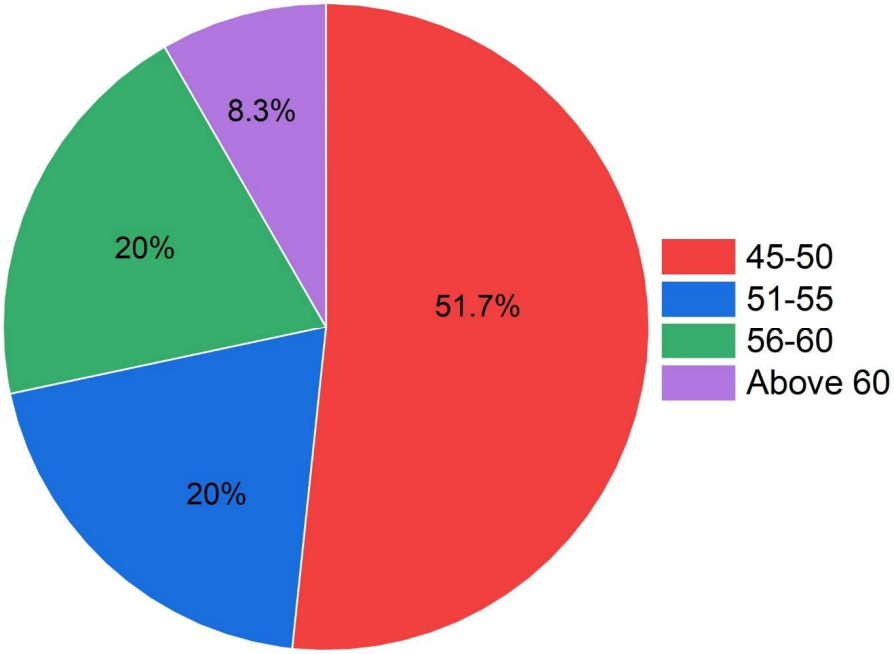

Figure 1 shows the distribution of age group among the samples. 51.7% samples belonged to the age group of 45-50 years, 20% samples belonged to the age groups of 51-55 years and 55-60 years and 8.3% samples belonged to 60 years of age group.

Figure 2: Correlation of different parameters with age

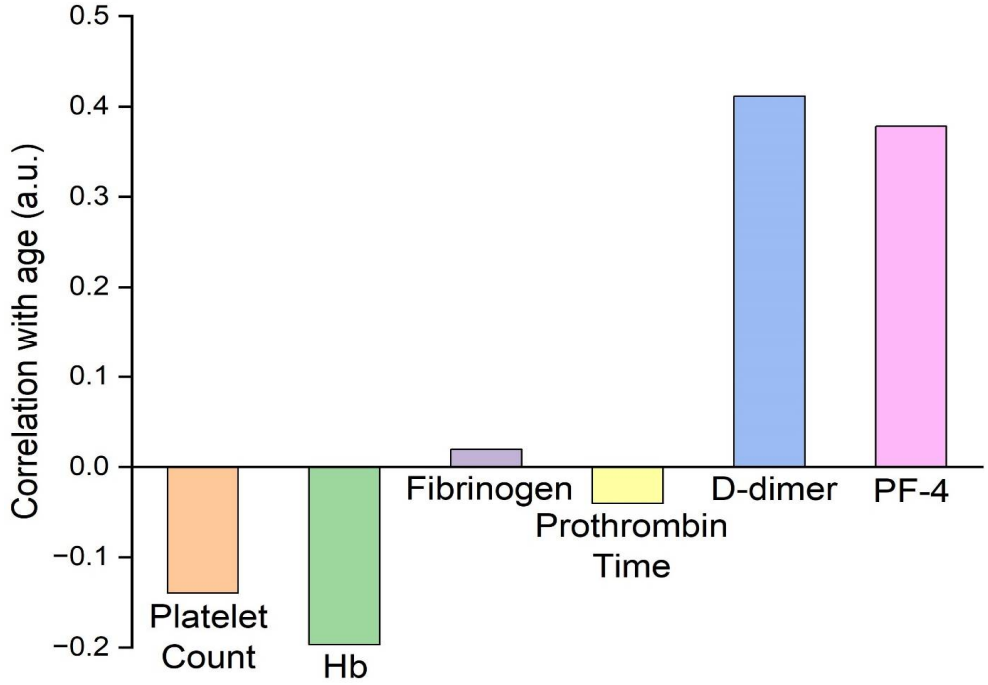

Figure 2 shows the correlation of different parameters with age. Platelet count, Hemoglobin, and Prothrombin time showed negative correlation with age having correlation coefficient values of -0.13, -0.19, and -0.04, respectively while Fibrinogen, D-dimer and PF-4 showed positive correlation with age having coefficient values of 0.02, 0.41 and 0.38, respectively.

DISCUSSION

With the growing age, some parameters (Platelet count, Hemoglobin, Fibrinogen, and Prothrombin) showed a negative correlation while others (D-dimer and PF-4) showed a positive correlation. There was a strong positive correlation (0.6) observed between D-dimer and PF-4. Out of a total of 60 samples, 6

(10%) showed both high D-dimer and high PF-4 values indicating such individuals being at higher risk of thrombocytopenia in comparison to those who did not have both values high. Out of those 6 samples, 2 showed high Fibrinogen value as well indicating them being at even higher risk of thrombocytopenia (31,32). Thus, from the results obtained it might be concluded that after administration of the COVID-19 vaccine, an autoimmune reaction was triggered in some individuals resulting in the release of anti-PF4 antibodies. Anti-PF4 antibodies bind with PF4 resulting in thrombosis of platelets and thrombocytopenia in such individuals (33–35).

CONCLUSION

This study attempts to explore the possibility of thrombosis and thrombocytopenia in females during perimenopause as a side effect of COVID-19 Vaccination. Out of a total of 60 samples, 2 showed high values of D-dimer, PF4, and fibrinogen indicating such individuals being at higher risk of thrombocytopenia. The results of this study point out that after administration of the COVID-19 vaccine, an autoimmune reaction might be triggered in some individuals resulting in the release of anti-PF4 antibodies. Anti-PF4 antibodies bind with PF4 resulting in thrombosis of platelets and thrombocytopenia in such individuals.

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REFERENCES

1. Hussain A, Yang H, Zhang M, Liu Q, Alotaibi G, Irfan M, et al. (2022). mRNA vaccines for COVID-19 and diverse diseases. J Controlled Release. ;345:314–33.
2. Dolgin E. (2021). The tangled history of mRNA vaccines. Nature. 14;597(7876):318–24.
3. Das S, Kar SS, Samanta S, Banerjee J, Giri B, Dash SK. (2022). Immunogenic and reactogenic efficacy of Covaxin and Covishield: a comparative review. Immunol Res. 70(3):289–315.
4. Pramod S, Govindan D, Ramasubramani P, Kar SS, Aggarwal R. (2022). Effectiveness of Covishield vaccine in preventing Covid-19 – A test-negative case-control study. Vaccine. 26;40(24):3294–7.
5. Hekmat AS, Javanmardi K. (2021). Possible Risk of Thrombotic Events following Oxford-AstraZeneca COVID-19 Vaccination in Women Receiving Estrogen. BioMed Res Int. 25;2021:7702863.
6. Matar SG, Nourelden AZ, Assar A, Bahbah EI, Alfryjat AM, Hasabo EA, et al. (2023). Effect of COVID-19 vaccine on menstrual experience among females in six Arab countries: A cross sectional study. Influenza Other Respir Viruses. 17(1):e13088.
7. Menni C, Klaser K, May A, Polidori L, Capdevila J, Louca P, et al. (2021). Vaccine side-effects and SARS-CoV-2 infection after vaccination in users of the COVID Symptom Study app in the UK: a prospective observational study. Lancet Infect Dis. 1;21(7):939–49.
8. Holinstat M. (2017). Normal platelet function. Cancer Metastasis Rev. 6(2):195–8.
9. Jurasz P, Ignjatovic V, Lordkipanidzé M. (2022). Editorial: Established and Novel Roles of Platelets in Health and Disease. Front Cardiovasc Med [Internet]. [cited 2024 Feb 13];9. Available from: https://www.frontiersin.org/articles/10.3389/fcvm.2022.835615
10. Portier I, Campbell RA. (2021). Role of Platelets in Detection and Regulation of Infection. Arterioscler Thromb Vasc Biol [Internet]. [cited 2024 Feb 15];41(1). Available from: https://pubmed.ncbi.nlm.nih.gov/33115274/
11. Scherlinger M, Richez C, Tsokos GC, Boilard E, Blanco P. (2023). The role of platelets in immune-mediated inflammatory diseases. Nat Rev Immunol. 23(8):495–510.
12. Schlesinger M. (2018). Role of platelets and platelet receptors in cancer metastasis. J Hematol OncolJ Hematol Oncol. 11;11(1):125.
13. Cai Z, Greene MI, Zhu Z, Zhang H. (2020). Structural Features and PF4 Functions that Occur in Heparin-Induced Thrombocytopenia (HIT) Complicated by COVID-19. Antibodies Basel Switz.10;9(4):52.
14. Ye L, Zhang YP, Yu N, Jia YX, Wan SJ, Wang FY. (2017). Serum platelet factor 4 is a reliable activity parameter in adult patients with inflammatory bowel disease: A pilot study. Medicine (Baltimore). 96(11):e6323.
15. Kaur J, Jain A. (2025). Fibrinogen. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; [cited 2025 Mar 10]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK537184/
16. Tenopoulou M. (2025). Fibrinogen post-translational modifications are biochemical determinants of fibrin clot properties and interactions. FEBS J. 292(1):11–27.
17. Kattula S, Byrnes JR, Wolberg AS. Fibrinogen and Fibrin in Hemostasis and Thrombosis. Arterioscler Thromb Vasc Biol. 2017 Mar;37(3):e13–21.
18. Pieters M, Wolberg AS. (2019). Fibrinogen and fibrin: An illustrated review. Res Pract Thromb Haemost. ;3(2):161–72.
19. Vilar R, Fish RJ, Casini A, Neerman-Arbez M. (2020). Fibrin(ogen) in human disease: both friend and foe. Haematologica. 1;105(2):284–96.

20. He X, Yao F, Chen J, Wang Y, Fang X, Lin X, et al. (2021). The poor prognosis and influencing factors of high D-dimer levels for COVID-19 patients. Sci Rep. 19;11(1):1830.
21. Lehmann A, Prosch H, Zehetmayer S, Gysan MR, Bernitzky D, Vonbank K, et al. Impact of persistent D-dimer elevation following recovery from COVID-19. PLoS ONE. 2021 Oct 28;16(10):e0258351.
22. Paliogiannis P, Mangoni AA, Dettori P, Nasrallah GK, Pintus G, Zinellu A. D-Dimer Concentrations and COVID-19 Severity: A Systematic Review and Meta-Analysis. Front Public Health. 2020 Aug 4;8:432.
23. Poudel A, Y P, A A, Bb A, D D, T B, et al. D-dimer as a biomarker for assessment of COVID-19 prognosis: D-dimer levels on admission and its role in predicting disease outcome in hospitalized patients with COVID-19. PloS One [Internet]. 2021 Aug 26 [cited 2024 Feb 15];16(8). Available from: https://pubmed.ncbi.nlm.nih.gov/34437642/
24. Yao Y, Cao J, Wang Q, Shi Q, Liu K, Luo Z, et al. D-dimer as a biomarker for disease severity and mortality in COVID-19 patients: a case control study. J Intensive Care. 2020 Jul 10;8(1):49.
25. Yu HH, Qin C, Chen M, Wang W, Tian DS. D-dimer level is associated with the severity of COVID-19. Thromb Res. 2020 Nov;195:219–25.
26. Nita AR, Knock GA, Heads RJ. Signalling mechanisms in the cardiovascular protective effects of estrogen: With a focus on rapid/membrane signalling. Curr Res Physiol. 2021 Jan 1;4:103–18.
27. Xue B, Hay M, Johnson AK. Chapter 3 - The Protective Role of Estrogen and Brain Estrogen Receptors in the Pathogenesis of Hypertension. In: LaMarca B, Alexander BT, editors. Sex Differences in Cardiovascular Physiology and Pathophysiology [Internet]. Academic Press; 2019 [cited 2024 Feb 16]. p. 23–39. Available from: https://www.sciencedirect.com/science/article/pii/B9780128131978000038
28. Xiang D, Liu Y, Zhou S, Zhou E, Wang Y. Protective Effects of Estrogen on Cardiovascular Disease Mediated by Oxidative Stress. Oxid Med Cell Longev. 2021 Jun 29;2021:e5523516.
29. Iorga A, Cunningham CM, Moazeni S, Ruffenach G, Umar S, Eghbali M. The protective role of estrogen and estrogen receptors in cardiovascular disease and the controversial use of estrogen therapy. Biol Sex Differ. 2017 Oct 24;8:33.
30. Yang R, Zubair M, Moosavi L. Prothrombin Time. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 [cited 2024 Feb 15]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK544269/
31. Ornelas-Aguirre JM, Gómez-Alcalá AV, Ramírez-Leyva DH. (2022). Increment of D-dimer Associated with Immune Thrombotic Thrombocytopenia in ChAdOx1 nCoV-19 Vaccinated Individuals. Arch Med Res.1;53(4):341–51.
32. Cines DB, Greinacher A. (2023). Vaccine-induced immune thrombotic thrombocytopenia. Blood. 6;141 (14):1659–65.
33. Ling VWT, Fan BE, Lau SL, Lee XH, Tan CW, Lee SY. (2022). Severe Thrombocytopenia, Thrombosis and Anti-PF4 Antibody after Pfizer-BioNTech COVID-19 mRNA Vaccine Booster—Is It Vaccine-Induced Immune Thrombotic Thrombocytopenia? Vaccines. 26;10(12):2023.
34. Uaprasert N, Watanaboonyongcharoen P, Vichitratchaneekorn R, Trithiphen S, Akkawat B, Sukperm A, et al. (2021). Prevalence of thrombocytopenia, anti–platelet factor 4 antibodies and D-dimer elevation in Thai people After ChAdOx1 nCoV-19 vaccination. Res Pract Thromb Haemost. 18;5(6):e12580.
35. Buoninfante A, Andeweg A, Baker AT, Borad M, Crawford N, Dogné JM, et al. (2022). Understanding thrombosis with thrombocytopenia syndrome after COVID-19 vaccination. Npj Vaccines. 9;7(1):1–6.

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