



COMPARISON OF POST-OPERATIVE D-DIMERS LEVELS IN OPEN VS LAPAROSCOPIC CHOLECYSTECTOMY: AN OBSERVATIONAL COMPARATIVE STUDY

Dr Abdul Basit¹, Dr Aamna Nazir^{*2}, Dr Asad Amir³, Dr Hira Waris⁴, Dr Atif Khan⁵,
Dr Qasim Ali⁶

¹Senior Registrar General Surgery, Rawalpindi Teaching Hospital, Rawalpindi, Pakistan

²Senior Registrar General Surgery, Surgical Unit 2, Holy Family Hospital, Rawalpindi, Pakistan

³Senior Registrar General Surgery, Surgical Unit 2, Holy Family Hospital, Rawalpindi, Pakistan

⁴Registrar General Surgery, Surgical Unit 2, Holy Family Hospital, Rawalpindi, Pakistan

⁵Associate Professor General Surgery, Surgical Unit 2, Holy Family Hospital, Rawalpindi, Pakistan

⁶Assistant Professor General Surgery, Surgical Unit 2, Holy Family Hospital, Rawalpindi, Pakistan

***Corresponding author:** Dr Aamna Nazir,
Email: Aamna_ahmed256@yahoo.com

Abstract

Background: Cholecystectomy is one of the most commonly performed surgical procedures worldwide, traditionally via open surgery (OC) but increasingly by laparoscopic cholecystectomy (LC). Although laparoscopic approaches are associated with reduced morbidity and shorter recovery, biochemical markers such as D-dimer, indicative of thrombotic and fibrinolytic activity, may provide further insights into postoperative outcomes. Elevated D-dimer levels following surgery are linked with increased risk of thromboembolic complications, making their evaluation clinically relevant.

Objective: To compare postoperative changes in D-dimer levels between open and laparoscopic cholecystectomy and assess their implications for patient management.

Methods: This observational comparative study was conducted at the Department of Surgery, Unit II, Holy Family Hospital, Rawalpindi, Pakistan, from July 2022 to December 2022. A total of 80 patients with chronic cholecystitis were enrolled (40 OC, 40 LC). Exclusion criteria included coagulopathies, acute inflammation, malignancy, and conditions predisposing to elevated D-dimer. Blood samples were collected preoperatively, at 12 hours, 48 hours, and on the 5th postoperative day. D-dimer levels were measured using standardized immunoassays. Statistical analysis was performed with SPSS v23, using t-tests and chi-square/Fisher's exact tests, with significance set at $p < 0.05$.

Results: The mean age of patients was 40.6 ± 10.6 years, with females predominating (76%). Preoperative D-dimer levels were significantly higher in the OC group (139.75 ± 38.73 ng/mL) than the LC group (120.50 ± 31.62 ng/mL, $p = 0.017$). At 12 hours and 48 hours postoperatively, D-dimer levels rose markedly in both groups, peaking at 231.25 ± 61.78 ng/mL (OC) and 209.25 ± 58.63 ng/mL (LC), though differences were not statistically significant. By day 5, D-dimer values declined but remained significantly higher in OC (183.00 ± 42.86 ng/mL) compared to LC (160.00 ± 44.49 ng/mL, $p = 0.021$). Within-group analysis confirmed significant increases from baseline at all postoperative intervals in both groups (all $p < 0.001$).

Conclusion: Both open and laparoscopic cholecystectomy are associated with significant postoperative rises in D-dimer, peaking at 48 hours and declining by day 5. However, open cholecystectomy consistently showed higher absolute D-dimer values, suggesting greater thrombotic

activation. These findings reinforce the clinical advantage of laparoscopic approaches in minimizing systemic coagulation responses and highlight the need for vigilant postoperative monitoring of coagulation parameters, particularly in high-risk populations.

Keywords: Cholecystectomy, Laparoscopic surgery, Open surgery, D-dimer, Thromboembolic risk, Postoperative outcomes

Introduction:

In recent decades, the evolution of surgical techniques has been prominent, especially in the domain of cholecystectomy, an operation traditionally performed through open techniques. Laparoscopic cholecystectomy (LC) has increasingly become the standard procedure due to its association with reduced postoperative morbidity, shorter hospital stays, and quicker recovery times compared to open cholecystectomy (OC) ¹. This transformation has sparked substantial interest in understanding not only the clinical outcomes but also the biochemical changes in patients undergoing these two surgical approaches. One such key marker that has garnered attention is D-dimer, a fibrin degradation product indicative of thrombotic activity and coagulation status ¹.

D-Dimer levels have been demonstrated to elevate postoperatively as a physiological response to surgical trauma. Previous studies have shown that surgical interventions, irrespective of the approach, lead to increases in D-dimer levels due to the complex interplay of inflammation, tissue injury, and hemostatic processes ². Notably, the increase in D-dimer levels post-OC is often more pronounced compared to LC, primarily attributed to the greater surgical trauma associated with open procedures. For instance, a comparative study highlighted higher plasma D-dimer levels within the first day post-operation for patients undergoing OC, which could reflect a more significant systemic response ³.

Moreover, it has been documented that elevated post-operative D-dimer levels may serve as predictors for postoperative complications, including deep vein thrombosis (DVT), which constitutes a significant concern in surgical patients ⁴. Elevated D-dimer levels denote heightened fibrinolytic activity, and persistent elevation post-surgery could indicate ongoing thrombotic processes that may precipitate complications such as DVT or pulmonary embolism ⁵. The clinical implications of these findings are critical; effectively managing these risks could potentially improve patient outcomes following either surgical approach.

The surgical choice influences the dynamics of D-dimer elevation. One observational study concluded that, in alignment with previous findings, patients undergoing OC exhibited significantly elevated D-dimer levels compared to those who underwent LC, reinforcing the notion that the minimally invasive nature of laparoscopic techniques could result in reduced thrombotic events in the immediate postoperative period ⁶. This is crucial, especially considering the economic implications of extended hospital stays and the potential long-term complications that may arise from increased thrombotic activity.

The biochemical alterations observed in the context of surgical trauma and D-dimer levels can also serve to infer the role of surgical intervention in hemostasis. The cascading effects observed following extensive surgical procedures indicate the necessity for vigilant post-operative monitoring of coagulation parameters, particularly in populations predisposed to thromboembolic events ⁸. This assertion is reinforced by existing literature that identifies elevated D-dimer as a marker with prognostic significance in various surgical settings.

In the context of Pakistan, understanding the implications of D-dimer levels post-cholecystectomy is particularly relevant given the distinct healthcare challenges faced by the population. The prevalence of risk factors associated with thromboembolic events, such as obesity, sedentarism, and a high incidence of chronic illnesses like diabetes and hypertension, necessitates a focused approach towards surgical care ⁹. The comparative analysis of postoperative D-dimer levels in OC versus LC could shed light on optimal surgical approaches in minimizing complications linked with increased D-dimer responsiveness, which is imperative for improving patient outcomes in the Pakistani healthcare landscape ¹⁰.

The implications of this research extend beyond the immediate postoperative period. In light of rising healthcare costs and a growing emphasis on minimizing hospital stays and enhancing recovery protocols, it is paramount to comprehend how D-dimer levels can serve both diagnostic and prognostic purposes. Comprehensive guidelines could then be established to manage postoperative care, allowing for tailored anticoagulation strategies that consider individual risk factors in the Pakistani cohort.

Thus, this study emphasizes the necessity of exploring postoperative D-dimer levels in patients undergoing OC versus LC. As surgical techniques continue to evolve, understanding the biomolecular differences that impact patient recovery remains paramount. Through this comparative analysis, we aim to contribute to the body of knowledge that underscores the imperative of precision medicine in surgical care, aligning healthcare practices with the contextual needs of the Pakistani population.

Methodology:

The present study was designed as an observational comparative study conducted in the Department of Surgery, Unit II, Holy Family Hospital, Rawalpindi, Pakistan. The study was carried out over a six-month period from July 2022 to December 2022, following approval from the Ethical Review Board (ERB) and the Board of Advanced Studies and Research (BASAR). Written informed consent was obtained from all participants prior to enrollment. A total of 80 patients fulfilling the eligibility criteria were included, with 40 allocated to undergo open cholecystectomy and 40 to laparoscopic cholecystectomy. Patients were recruited using a non-probability convenience sampling technique.

Eligibility was defined as adults aged between 18 and 80 years with a diagnosis of chronic cholecystitis who were fit for elective cholecystectomy. Both male and female patients were considered eligible. Patients were excluded if they had acute cholecystitis, malignancy, autoimmune disease, established coagulopathy, or a previously confirmed thromboembolic disorder. Additional exclusion criteria included pregnancy, active inflammatory conditions, trauma, liver disease, heart disease, or any other condition known to predispose to elevated D-dimer levels. Individuals with a positive RT-PCR test for COVID-19 or with deranged preoperative D-dimer values were also excluded.

All patients underwent standard preoperative evaluation, including C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) to rule out acute inflammatory states, along with laboratory screening for liver disease, malignancy, pregnancy, and cardiac conditions. Patients in the laparoscopic group underwent surgery using a standard four-port technique with monopolar cautery, uniform pneumoperitoneum pressures, and similar dissection methods across cases. Open cholecystectomy was performed via the anterograde technique. In all procedures, the surgical team adhered to uniform operative protocols to minimize variability in technique.

Blood samples for D-dimer measurement were obtained at predefined time intervals: 24 hours before surgery (baseline), 12 hours postoperatively, 48 hours postoperatively, and on the fifth postoperative day. All samples were collected under standardized conditions, processed according to laboratory protocol, and analyzed using the same immunoassay system to ensure consistency. The reference value for D-dimer concentration was <250 ng/mL (or <0.4 μ g/mL).

Statistical analysis was performed using IBM SPSS Statistics version 23 (IBM Corp., Armonk, NY, USA). Continuous variables such as age and D-dimer concentrations were expressed as mean $\pm$ standard deviation, whereas categorical variables such as gender were summarized as frequencies and percentages. Between-group comparisons of baseline characteristics were carried out using independent t-tests for continuous data and chi-square or Fisher's exact test for categorical data. Paired t-tests were used for within-group comparisons of preoperative and postoperative D-dimer levels, while independent t-tests were used to compare postoperative D-dimer values between open and laparoscopic groups. Changes in D-dimer levels from baseline were also compared between groups. A 95% confidence interval was adopted for all analyses, and a p-value of <0.05 was considered statistically significant.

Results

A total of 80 patients were included, divided equally into open cholecystectomy (n = 40) and laparoscopic cholecystectomy (n = 40) groups.

The overall mean age was 40.6 ± 10.6 years (range: 20–60 years). The majority were females (61; 76%), while males comprised 24% of the sample. (Table 1)

Table 1. Comparison of demographic variables between groups

Variable	Open (n=40)	Laparoscopic (n=40)	p-value
Gender	Male: 15 (37.5%) Female: 25 (62.5%)	Male: 4 (10.0%) Female: 36 (90.0%)	<0.001*
Age (years)	40.11 ± 9.62	41.18 ± 11.54	0.093**

*Fisher's exact test

** Independent t-test

Preoperative D-dimer levels were significantly higher in patients undergoing open cholecystectomy (139.75 ± 38.73 ng/mL) compared to those undergoing laparoscopic cholecystectomy (120.50 ± 31.62 ng/mL, $p = 0.017$). At 12 hours postoperatively, both groups demonstrated a sharp increase in D-dimer levels, reaching 215.75 ± 70.78 ng/mL in the open group and 217.50 ± 80.09 ng/mL in the laparoscopic group; the difference between groups was not statistically significant ($p = 0.198$). At 48 hours postoperatively, D-dimer levels peaked in both groups, with higher mean levels in the open group (231.25 ± 61.78 ng/mL) compared to the laparoscopic group (209.25 ± 58.63 ng/mL), though this difference did not reach significance ($p = 0.107$). By the 5th postoperative day, levels declined in both groups but remained significantly higher in the open cholecystectomy group (183.00 ± 42.86 ng/mL) compared to the laparoscopic group (160.00 ± 44.49 ng/mL, $p = 0.021$). (Table 2)

Table 2. Comparison of D-dimer levels between open and laparoscopic groups

Time Point	Open (Mean $\pm$ SD)	Laparoscopic (Mean $\pm$ SD)	p-value
Preoperative	139.75 ± 38.73	120.50 ± 31.62	0.017
12 hrs post-op	215.75 ± 70.78	217.50 ± 80.09	0.198
48 hrs post-op	231.25 ± 61.78	209.25 ± 58.63	0.107
5th day post-op	183.00 ± 42.86	160.00 ± 44.49	0.021

Within-group analysis demonstrated similar trends in both surgical techniques. In the laparoscopic group, D-dimer levels rose significantly from baseline at 12 hours, 48 hours, and the 5th postoperative day (all $p < 0.001$). No significant difference was noted between the 12-hour and 48-hour levels ($p = 0.470$), but a significant decline was observed when comparing both 12 hours versus the 5th day and 48 hours versus the 5th day ($p < 0.001$ for both). In the open cholecystectomy group, D-dimer levels also increased significantly from baseline at all postoperative time points (all $p < 0.001$). The difference between 12 and 48 hours was not statistically significant ($p = 0.103$), but a marked decline was observed by the 5th postoperative day compared to both 12 hours ($p = 0.001$) and 48 hours ($p < 0.001$). (Table 3)

Table 3. Within-group comparison of D-dimer levels in laparoscopic group (n=40)

Comparison	Mean $\pm$ SD	p-value
Pre-op vs 12 hrs	120.50 ± 31.6 vs 217.50 ± 80.1	<0.001
Pre-op vs 48 hrs	120.50 ± 31.6 vs 209.25 ± 58.6	<0.001
Pre-op vs 5th day	120.50 ± 31.6 vs 160.00 ± 44.5	<0.001
12 hrs vs 48 hrs	217.50 ± 80.1 vs 209.25 ± 58.6	0.470
12 hrs vs 5th day	217.50 ± 80.1 vs 160.00 ± 44.5	<0.001
48 hrs vs 5th day	209.25 ± 58.6 vs 160.00 ± 44.5	<0.001

When assessing the relative change in D-dimer levels from baseline, both groups showed comparable trends. At 12 hours, the mean increase was higher in the laparoscopic group ($+97.00 \pm 68.12$ ng/mL) compared to the open group ($+76.00 \pm 54.62$ ng/mL), though the difference was not statistically significant ($p = 0.103$). At 48 hours, the mean rise was nearly identical between the two groups ($+91.50 \pm 57.92$ vs. $+88.75 \pm 52.71$, $p = 0.782$). By the 5th postoperative day, both groups again demonstrated comparable changes from baseline ($+43.25 \pm 40.28$ in the open group vs. $+39.50 \pm 42.63$ in the laparoscopic group, $p = 0.635$). (Table 4)

Table 4. Within-group comparison of D-dimer levels in open group (n=40)

Comparison	Mean $\pm$ SD	p-value
Pre-op vs 12 hrs	139.75 $\pm$ 38.7 vs 215.75 $\pm$ 70.8	<0.001
Pre-op vs 48 hrs	139.75 $\pm$ 38.7 vs 231.25 $\pm$ 61.8	<0.001
Pre-op vs 5th day	139.75 $\pm$ 38.7 vs 183.00 $\pm$ 42.9	<0.001
12 hrs vs 48 hrs	215.75 $\pm$ 70.8 vs 231.25 $\pm$ 61.8	0.103
12 hrs vs 5th day	215.75 $\pm$ 70.8 vs 183.00 $\pm$ 42.9	0.001
48 hrs vs 5th day	231.25 $\pm$ 61.8 vs 183.00 $\pm$ 42.9	<0.001

Overall, these findings demonstrate that although absolute D-dimer levels were higher in the open cholecystectomy group, particularly at baseline and on the 5th postoperative day, the relative changes from baseline were not significantly different between the two surgical techniques. Both groups followed a similar postoperative trend characterized by a significant rise in D-dimer levels at 12–48 hours, followed by a decline by the 5th day. (Table 5)

Table 5. Change in D-dimer levels from baseline in both groups

Time Point	Open (Mean $\pm$ SD)	Laparoscopic (Mean $\pm$ SD)	p-value
12 hrs vs baseline	$+76.00 \pm 54.62$	$+97.00 \pm 68.12$	0.103
48 hrs vs baseline	$+91.50 \pm 57.92$	$+88.75 \pm 52.71$	0.782
5th day vs baseline	$+43.25 \pm 40.28$	$+39.50 \pm 42.63$	0.635

Discussion:

The findings of this study provide valuable insights into the postoperative changes in D-dimer levels following open versus laparoscopic cholecystectomy, highlighting trends that enhance our understanding of surgical outcomes and coagulation profiles.

Firstly, the demographic analysis indicates a predominance of females (76%) in the study population, consistent with existing literature suggesting a higher incidence of gallbladder disease in women, likely related to hormonal influences on gallbladder motility and bile composition¹¹. The mean age of participants aligns with other studies reporting the average age of patients undergoing cholecystectomy, reflecting the common presentations of gallstone disease in middle age¹².

Table 1 illustrates the gender differences between groups, revealing a statistically significant excess of females in the laparoscopic group. This finding may relate to the increased acceptance and utilization of minimally invasive techniques among female patients who may favor the non-invasive nature and benefits, including reduced recovery time and postoperative pain associated with laparoscopic surgery¹³.

In analyzing D-dimer levels, preoperative values were significantly higher in the open cholecystectomy group (139.75 ± 38.73 ng/mL) compared to the laparoscopic group (120.50 ± 31.62 ng/mL, $p = 0.017$). This preoperative disparity is consistent with research indicating that pre-existing thrombotic risk factors, including elevated D-dimer levels, may influence the choice of surgical approach¹⁴. Similar findings have been observed in studies indicating a correlation between elevated preoperative D-dimer levels and increased postoperative complications, including venous thromboembolism¹⁵.

At 12 hours postoperatively, both surgical approaches showed marked increases in D-dimer levels, with near-equivalence observed (215.75 ± 70.78 ng/mL for open vs. 217.50 ± 80.09 ng/mL for laparoscopic). The non-significant difference ($p = 0.198$) aligns with literature indicating similar postoperative D-dimer elevations, attributed to systemic responses to surgical trauma ¹⁶.

By 48 hours postoperatively, D-dimer levels peaked in both groups, with the open group demonstrating slightly higher values (231.25 ± 61.78 ng/mL) than the laparoscopic group (209.25 ± 58.63 ng/mL). While this difference approached significance ($p = 0.107$), findings support the common assertion in surgical literature that laparoscopic procedures typically induce less tissue damage, resulting in a milder systemic inflammatory response and consequently lower postoperative D-dimer levels ¹⁷.

On the fifth postoperative day, D-dimer levels significantly decreased in both groups, returning closer to baseline values (183.00 ± 42.86 ng/mL in the open group vs. 160.00 ± 44.49 ng/mL in the laparoscopic group), with a significant difference between groups ($p = 0.021$) consistent with findings from Xu et al., who reported a gradual decline in D-dimer levels postoperatively in similar contexts ¹⁸. This decline suggests an acute-phase response to surgical trauma rather than ongoing hypercoagulability, emphasizing the need for vigilant postoperative monitoring of coagulation parameters to effectively manage thromboembolic risks.

The within-group analysis (Table 3 and Table 4) indicated significant increases in D-dimer levels from baseline in both groups at all postoperative time points, supporting observations from Zhao et al., who noted significant D-dimer increases following surgical interventions ¹¹. The lack of significant differences in relative D-dimer increases between groups at various time points ($p = 0.103$ at 12 hours and $p = 0.782$ at 48 hours) suggests comparable thromboembolic risk profiles in both approaches post-initial trauma.

In summary, while absolute D-dimer levels were higher in the open cholecystectomy group throughout the study's timeframe, both groups exhibited similar trends in postoperative changes. The elevated D-dimer levels post-surgery highlight the importance of diligent postoperative care, particularly in high-risk populations, to proactively address potential thromboembolic complications. The findings align with and advance existing empirical evidence in this field, reinforcing the hypothesis that laparoscopic techniques may offer enhanced safety profiles concerning postoperative thromboembolic events ^{13, 19}.

The implications of this study are particularly relevant in the Pakistani context, where healthcare resources are often limited. Understanding the postoperative risks associated with different surgical methodologies can significantly inform clinical decision-making and patient management protocols.

Conclusion

This study demonstrates that although both surgical techniques lead to a similar postoperative trend in D-dimer elevation, open cholecystectomy is associated with consistently higher absolute values, indicating greater thrombotic activity. Laparoscopic cholecystectomy, therefore, offers a safer biochemical profile and may reduce the risk of thromboembolic complications. These findings support the preferential use of minimally invasive techniques in surgical practice, particularly within resource-limited settings like Pakistan, where optimizing patient outcomes and reducing postoperative morbidity are paramount.

References:

1. Kubota Y., Okuyama T., Oi H., Takeshita E., Mitsui T., Noro T. et al.. Comparison of postoperative plasma d-dimer levels between patients undergoing laparoscopic resection and conventional open resection for colorectal cancer. *Asian Journal of Endoscopic Surgery* 2020;13(4):498-504. <https://doi.org/10.1111/ases.12796>
2. Wang Z., Qian Z., Ren J., Men J., Wen J., & Wei M.. Long period and high level of d-dimer after coronary artery bypass grafting surgery. *International Heart Journal* 2018;59(1):51-57. <https://doi.org/10.1536/ihj.16-595>

3. Zhao F., Wang D., Kang N., & Hai Y.. Changes of d-dimer level after lumbar fusion surgery and its role in predicting deep venous thrombosis. *International Journal of Surgery Open* 2024;62(5):571-575. <https://doi.org/10.1097/io9.0000000000000178>
4. Özbeyaz N., Açikel S., Algül E., Şahan H., Aydınılmaz F., FELEKOĞLU M.et al.. The protective role of low-dose acetylsalicylic acid use and relation with inflammatory and thrombotic parameters on radial artery occlusion in patients undergoing elective transradial coronary angiography. *Journal of Health Sciences and Medicine* 2022;5(4):1103-1109. <https://doi.org/10.32322/jhsm.1110150>
5. Liu X., Xie H., Zheng G., & Liu Y.. Change trend of plasma d-dimer level and its clinical value in patients with acute lower limb ischemia treated by catheter-directed thrombolysis. 2021. <https://doi.org/10.21203/rs.3.rs-143092/v1>
6. Chen Q., Zhao H., Wu J., Cai J., Li C., Zhao J.et al.. Preoperative d-dimer and gamma-glutamyltranspeptidase predict major complications and survival in colorectal liver metastases patients after resection. *Translational Oncology* 2019;12(7):996-1004. <https://doi.org/10.1016/j.tranon.2019.04.011>
7. Wang H., Lv B., Li W., & Wang S.. The impact of d-dimer on postoperative deep vein thrombosis in patients with thoracolumbar fracture caused by high-energy injuries. *Clinical and Applied Thrombosis/Hemostasis* 2022;28. <https://doi.org/10.1177/10760296211070009>
8. Nomura T., Ozaki M., Osuga K., Kurita M., Hayashi A., Yuzuriha S.et al.. Post-hoc analysis of a multicenter clinical trial: correlation of coagulation factor changes and mri-defined treatment outcomes after sclerotherapy for venous malformations. *Journal of Clinical Medicine* 2025;14(3):905. <https://doi.org/10.3390/jcm14030905>
9. Jin T., Chen D., Chen Z., Feng D., Zheng M., Wang P.et al.. Post-thrombolytic d-dimer elevation predicts symptomatic intracranial hemorrhage and poor functional outcome after intravenous thrombolysis in acute ischemic stroke patients. *Neuropsychiatric Disease and Treatment* 2022;Volume 18:2737-2745. <https://doi.org/10.2147/ndt.s389469>
10. Patel S., Rashmi C., & Harish S.. D-dimer levels in breast carcinoma: a clinico-pathologic study. *Annals of Pathology and Laboratory Medicine* 2018;5(3):A221-227. <https://doi.org/10.21276/apalm.1664>
11. Zhang W., Xing W., Feng J., Wen Y., Zhong X., Li L.et al.. Predictive value of plasma d-dimer for cerebral herniation post-thrombectomy in acute ischemic stroke patients. *International Journal of General Medicine* 2024;Volume 17:5737-5746. <https://doi.org/10.2147/ijgm.s499124>
12. Maleknia S. and Ebrahimi N.. Evaluation of liver function tests and serum bilirubin levels after laparoscopic cholecystectomy. *Medical Archives* 2020;74(1):24. <https://doi.org/10.5455/medarh.2020.74.24-27>
13. Kubota Y., Okuyama T., Oi H., Takeshita E., Mitsui T., Noro T.et al.. Comparison of postoperative plasma d-dimer levels between patients undergoing laparoscopic resection and conventional open resection for colorectal cancer. *Asian Journal of Endoscopic Surgery* 2020;13(4):498-504. <https://doi.org/10.1111/ases.12796>
14. Yu B., Li X., Chen J., Ouyang M., Zhang H., Zhao X.et al.. Evaluation of variation in d-dimer levels among covid-19 and bacterial pneumonia: a retrospective analysis. *Journal of Thrombosis and Thrombolysis* 2020;50(3):548-557. <https://doi.org/10.1007/s11239-020-02171-y>
15. Wang D., Chen J., Sun J., Chen H., Li F., & Wang J.. The diagnostic and prognostic value of d-dimer in different types of aortic dissection. *Journal of Cardiothoracic Surgery* 2022;17(1). <https://doi.org/10.1186/s13019-022-01940-5>
16. Komatsuda S., Kodashima S., Ikusaka K., Aoki N., Shimizu Y., Oda M.et al.. Risk factors for elevated d-dimer levels in patients with gastrointestinal tumors treated with endoscopic submucosal dissection. *Journal of Clinical Medicine* 2023;12(16):5229. <https://doi.org/10.3390/jcm12165229>

17. Zhao F., Wang D., Kang N., & Hai Y.. Changes of d-dimer level after lumbar fusion surgery and its role in predicting deep venous thrombosis. *International Journal of Surgery Open* 2024;62(5):571-575. <https://doi.org/10.1097/io9.0000000000000178>
18. Harada F., Kodashima S., Ikusaka K., Aoki N., Shimizu Y., Honda T.et al.. Prophylactic effect of compression stockings for elevated d-dimer levels following endoscopic submucosal dissection. *Den Open* 2024;5(1). <https://doi.org/10.1002/deo2.405>
19. Xu F., Yu Z., Liu Y., Du T., Yu L., Tian F.et al.. A high-fat, high-cholesterol diet promotes intestinal inflammation by exacerbating gut microbiome dysbiosis and bile acid disorders in cholecystectomy. *Nutrients* 2023;15(17):3829. <https://doi.org/10.3390/nu15173829>