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Study on the Evaluation of Coagulation Characteristics in Patients with Gastrointestinal Malignancies by Thrombotic Molecular Markers

Ya'nan Meng, Chengbi Tong, Yankui Shi, Ji Qi*

Clinical Laboratory, Affiliated Hospital of Hebei University, Hebei, Baoding, 071000, China
**Corresponding author*

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Abstract: This study examines the coagulation function characteristics of patients with gastrointestinal malignancies. By comparing the levels of coagulation molecular markers in 215 patients with gastrointestinal malignancies (the case group) and 1 16 healthy controls, it was found that the levels of thrombin-antithrombin complex (TAT) and plasmin-α2-fibrin inhibitor complex (PIC) were significantly elevated in the case group ($P<0.001$). The t-PAIC level in gastric cancer patients differed from that in colorectal cancer patients ($P<0.05$), with higher levels in colorectal cancer patients compared to gastric cancer patients. There was no significant difference in thrombotic molecular markers across different tumor stages. The risk score for venous thromboembolism (VTE) increased, and the TM showed a gradient increase. This suggests that coagulation abnormalities may occur early in gastrointestinal malignancies, and as the risk of VTE increases, there is significant endothelial damage, with coagulation molecular marker levels being associated with tumor type and VTE risk.

1. Introduction

Patients with malignant tumors often experience coagulation disorders, and a hypercoagulable state is significantly associated with tumor progression, metastasis, and the risk of venous thromboembolism (VTE). Due to their anatomical location and biological characteristics, gastrointestinal cancers are more likely to activate the coagulation system. Studies show that approximately 15-20% of cancer patients develop VTE, with the risk being particularly high among those with gastrointestinal tumors[1]Coagulation molecular markers (such as TAT, PIC, TM, t-PAIC) can sensitively reflect the state of coagulation activation, hyperfibrinolysis and endothelial injury[2]The purpose of this study was to analyze the changes of these markers in patients with gastrointestinal malignancies and explore their relationship with tumor type, stage and VTE risk.

2. Data and methods

2.1 Research Object

A total of 215 patients with gastrointestinal malignancies, diagnosed through pathology and admitted to the Affiliated Hospital of Hebei University from January 2024 to April 2025, were collected as the case group. Among these patients, 6 7 had gastric cancer, 7 8 had colon cancer, and 7 0 had rectal cancer; 129 were male and 86 were female; their ages ranged from 30 to 83 years, with an average age of 6 3 ± 10.06 years. According to the 8th edition of the AJCC staging criteria, 14 were in stage I, 6 3 in stage II, 87 in stage III, and 51 in stage IV. The Caprini scoring system was used to assess the risk of VTE, with 7 8 cases classified as medium to high-risk (≤ 4 points) and 137 cases as very high-risk (≥ 5 points). Additionally, 116 healthy individuals from the same period were selected as the control group, including 61 males and 55 females, aged 30 to 7 8 years, with an average age of 6 1.82 ± 11.34 years. There was no statistically significant difference in age or gender ratio between the two groups (P> 0.05).

2.2 Research methods

Collect fasting venous blood and test after centrifugation:

TAT (thrombin-antithrombin complex), PIC (plasmin-α 2 plasmin inhibitor complex), TM (thrombomodulin), t-PAIC (tissue plasminogen activator-inhibitor complex)

The detection instrument is Wondfo Shine I 2900 fully automatic chemiluminescent immunoassay analyzer, and the reagent is the original kit.

2.3 Statistical treatment

SPSS 25.0 software was used. The measurement data were expressed as (x±s) or median (quartile), and the Mann-Whitney U test was used for inter-group comparison; the Kruskal-Wallis H test was used for multiple group comparison. P<0.05 indicated statistically significant difference.

3. Results

3.1 Comparison of coagulation markers between case group and control group

The levels of TAT and PIC in the case group were significantly higher than those in the control group (P<0.001), as shown in Table 1.

Table 1 Comparison of coagulation molecular markers between the two groups (x±s)

group	case load	TAT (μg/L)	PIC (μg/L)	TM (TU/mL)	t-PAIC (μg/L)
Case group	215	4.32 (2.65,6.86)	0 .73(0.54,1.11)	8 .78(7.19,10.48)	8 .54(5.74,13.81)
control group	116	1 .19(0.85,1.78)	0 .41 (0.33,0.55)	8.69 (7.28,10.47)	8 .62 (5.26,11.08)
Z		- 12.736	- 10.319	- 2.93 0	- 1.846
P		<0.001	<0.001	0.769	0.065

3.2 Comparison of coagulation markers in different tumor types

There were differences in t-PAIC levels among patients with gastric cancer, colorectal cancer and rectal cancer (P<0.05), with colorectal cancer higher than gastric cancer, and no significant differences in other markers, as shown in Table 2.

Table 2 Comparison of coagulation markers in gastric and colorectal cancer patients

metric	Gastric cancer (n = 67)	Colorectal cancer (n = 78)	Rectal cancer (n = 70)	H/F	*P*
TAT (μg/L)	4.13(2.53,8.02)	4.27(2.81,6.22)	4.43(2.50,6.23)	0.119	0.942
PIC (μg/L)	0.83(0.61,1.37)	0.72(0.52 ,1.06)	0.71(0.53,1.01)	4.658	0.097
t-PAIC (μg/L)	5.74(4.25,10.58)*	9.97(6.10,15.87)	10.33(7.59,13.71)	14.414	0.001
TM (TU/mL)	9.66±2.75	8.95±2.70	8 .79±2.88	1.891	0.153

Note: * indicates that P <0.05 compared with colorectal cancer and rectal cancer

3.3 Comparison of coagulation markers in different tumor stages

There was no difference in thrombotic molecular markers among patients with different tumor stages (P<0.05), as shown in Table 3.

Table 3 Comparison of coagulation markers at different stages

by stages	n	TAT (μg/L)	PIC (μg/L)	TM (TU/mL)	t-PAIC (μg/L)
I designated time	1 4	5.10(2.70,7.95)	0.53(0.47,1 .02)	8.78(7.48,10.38)	9.35(7.30,14.40)
II designated time	6 3	4.07(2.54,6.18)	0.79(0.59,1.15)	8.40(7.19,10.18)	9.94(5.74,15.74)
III designated time	8 7	4.34(2.53,7.47)	0.73(0.54,1.10)	8.66(7.00,10.18)	7.43(5.08,13.00)
IV designated time	5 1	4.35(2.53,7.20)	0.73(0.53,1.09)	9.36(7.33,11.25)	9.71(6.07,14.34)
H		3.884	2.977	3.433	2.49
P		0.274	0.395	0.330	0.477

3.4 Comparison of coagulation markers in different VTE risk levels

The levels of TAT, PIC and t-PAIC in the high-risk group (Caprini≥5 points) were significantly higher than those in the low-risk group (P<0.05), as shown in Table 4.

Table 4 Comparison of coagulation markers in different VTE risk levels

metric	Medium-high risk group (n = 78)	Very high-risk group (n = 137)	Z price	P price
TAT (μg/L)	4.24(2.70,7.27)	4.35(2.64,6.30)	-0.694	0.488
PIC (μg/L)	0.74(0.51,1.07)	0.73(0.56,1.13)	-0.597	0.550
TM (TU/mL)	7.98(6.57,9.87)	9.15(7.78 ,10.86)	-2.907	0.004
t-PAIC (μg/L)	8.45(5.71,13.76)	8.83(5.72,14.17)	-0.123	0.902

4. Discussion

This study confirms that patients with gastrointestinal malignancies exhibit significant coagulation disorders. The TAT and PIC levels in the case group were significantly higher than those in the healthy control group, indicating activation of the coagulation system (elevated TAT) and the fibrinolytic system (elevated PIC). This is associated with the release of procoagulant substances (such as tissue factor) by tumor cells and the activation of the coagulation cascade reaction by inflammatory factors[3].

Regarding tumor types, there are differences in t-PAIC levels between patients with gastric cancer and those with colorectal or rectal cancer (P<0.05). The levels of t-PAIC are higher in colorectal and rectal cancer patients compared to gastric cancer patients, while other markers show no significant differences. Elevated t-PAIC levels indicate an inhibition of the fibrinolytic system, which may lead to microthrombosis and promote immune suppression in the tumor microenvironment. Colorectal cancer is more likely to metastasize to the liver, and the enhanced ability of the liver to synthesize plasminogen activator inhibitor-1 (PAI-1) may be a key mechanism[4]. Although there was no statistical difference between different types of tumors, the level of TAT was higher than the reference range, indicating that patients with gastrointestinal

malignancies had a hypercoagulation state.

The tumor staging analysis showed no difference in thrombotic molecular markers among patients with different tumor stages. This result suggests that coagulation abnormalities may occur early in the tumor, rather than as they progress.

The VTE risk assessment found that the TM level was significantly increased in the very high-risk group (Caprini≥ 5 points). The Caprini score included high-risk factors such as age, tumor, surgical trauma, cardiovascular, inflammatory status, and VTE history. TM is actively secreted by endothelial cells, and its serum level can reflect the degree of endothelial cell damage[5]. In patients with an extremely high VTE score, endothelial injury is often caused by multiple factors.

Patients with gastrointestinal malignancies exhibit significant coagulation abnormalities, characterized by elevated levels of TAT and PIC. These changes are closely linked to the type of tumor (higher t-PAIC in colorectal cancer) and the risk level of VTE (higher TM levels in patients at extremely high risk). Dynamic monitoring of coagulation markers helps assess disease progression and thrombotic risk, providing a basis for personalized anticoagulation therapy.

Acknowledgments

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