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ABOUT COVER

Editorial Board Member of *World Journal of Gastrointestinal Surgery*, Michele Ammendola, MD, Research Associate, Surgical Oncologist, Science of Health Department, Digestive Surgery Unit, University of "Magna Graecia" Medical School, Catanzaro 88100, Italy. michele.ammendola@unicz.it

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WJGS mainly publishes articles reporting research results and findings obtained in the field of gastrointestinal surgery and covering a wide range of topics including biliary tract surgical procedures, biliopancreatic diversion, colectomy, esophagectomy, esophagostomy, pancreas transplantation, and pancreatectomy, *etc*.

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ORIGINAL ARTICLE

Prospective Study

Prevention and management of postoperative deep vein thrombosis in lower extremities of patients with gastrointestinal tumor

Liang Shu, Cheng-Wei Xia, Yu-Fan Pang

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Liang Shu, Cheng-Wei Xia, Yu-Fan Pang, Department of Thyroid Surgery, Affiliated Hospital of Southwest Medical University, Luzhou 646000, Sichuan Province, China

Corresponding author: Liang Shu, MBBS, Attending Doctor, Department of Thyroid Surgery, Affiliated Hospital of Southwest Medical University, No. 25 Taiping Street, Luzhou 646000, Sichuan Province, China. 17620186230@163.com

Abstract

BACKGROUND

Deep vein thrombosis (DVT) is a significant postoperative concern, particularly in patients undergoing surgery for gastrointestinal (GI) cancers. These patients often present multiple risk factors, including advanced age and elevated body mass index (BMI), which can increase the likelihood of thromboembolic events. Effective prophylaxis is crucial in this high-risk population to minimize complications such as DVT and pulmonary embolism (PE). This study investigates a comprehensive DVT prevention protocol, combining mechanical and pharmacological strategies alongside early mobilization, to evaluate its effectiveness and safety in reducing postoperative thrombosis rates among GI cancer surgery patients.

AIM

To evaluate the effectiveness and safety of postoperative DVT prevention strategies in patients with GI cancer.

METHODS

A prospective cohort study was conducted involving 100 patients who underwent surgery for GI tumors between January and December 2022. All patients received a standardized DVT prevention protocol, which included risk assessment, mechanical prophylaxis, pharmacological prophylaxis, and early mobilization. The primary endpoint was the incidence of DVT within 30 days postoperatively. Secondary outcomes included the occurrence of PE, bleeding complications, and adherence to the protocol.

RESULTS

The overall incidence of DVT was 7% (7/100 patients). One patient (1%) developed PE. The adherence rate to the prevention protocol was 92%. Bleeding complications were observed in 3% of patients. Significant risk factors for DVT development included advanced age [odds ratio (OR): 1.05; 95% confidence interval (95%CI): 1.01-1.09], higher BMI (OR: 1.11; 95%CI: 1.03-1.19), and longer

operative time (OR: 1.007; 95%CI: 1.001-1.013).

CONCLUSION
Implementing a comprehensive DVT prevention and management protocol for patients undergoing GI tumor surgery resulted in a lower incidence. Strict adherence and individualized risk assessment are crucial for optimizing outcomes.

Key Words: Deep vein thrombosis; Gastrointestinal tumors; Thromboprophylaxis; Postoperative complications; Venous thromboembolism

Core Tip: This study evaluates the effectiveness of a comprehensive deep vein thrombosis (DVT) prevention and management protocol in patients undergoing gastrointestinal (GI) cancer surgery. The protocol encompasses risk assessment, mechanical and pharmacological prophylaxis, early mobilization, and patient education. The findings reveal a 7% DVT incidence rate, with significant risk factors including advanced age, elevated body mass index, and extended surgery duration. The protocol demonstrated high adherence and low complication rates, highlighting its efficacy in reducing postoperative DVT in patients with high-risk GI cancer.

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INTRODUCTION

Gastrointestinal (GI) tumors represent a significant global health challenge, with surgery remaining a cornerstone of treatment for many patients[1]. While surgical interventions can be curative or palliative, they expose patients to various postoperative complications, with deep vein thrombosis (DVT) of the lower extremities being particularly concerning[2]. DVT, a manifestation of venous thromboembolism (VTE), can lead to pulmonary embolism (PE), a potentially life-threatening condition[3].

Patients with GI tumors are at an increased risk of developing DVT due to several factors. The hypercoagulable state associated with malignancy, prolonged immobilization during and after surgery, and the inflammatory response to surgical trauma all contribute to this heightened risk[4]. Moreover, certain GI surgeries, particularly those involving the abdomen and pelvis, can cause venous stasis and endothelial injury, further predisposing patients to thrombotic events [5].

The incidence of DVT in postoperative patients with GI tumors varies widely in the literature, ranging from 4% to 20%, depending on the patient population, type of surgery, and diagnostic methods used[6,7]. This variability underscores the need for robust, standardized prevention and management protocols tailored to this high-risk group.

Current guidelines recommend a combination of mechanical and pharmacological prophylaxis for DVT prevention in high-risk surgical patients[8]. However, the optimal approach for patients with GI tumors, considering their unique risk factors and potential for bleeding complications, remains a subject of ongoing research and debate[9].

Several studies have investigated various aspects of DVT prevention in patients with cancer. Yhim *et al*[10] demonstrated the efficacy of low molecular weight heparin (LMWH) in reducing VTE events in Asian patients with advanced gastric cancer. Beyer-Westendorf *et al*[11] highlighted the importance of extended thromboprophylaxis in patients undergoing major abdominal or pelvic surgery for cancer. However, these studies often focused on specific subgroups or single interventions, leaving gaps in our understanding of comprehensive prevention strategies for the broader patient population with GI tumors.

The management of diagnosed DVT poses significant challenges in patients with GI tumors. Balancing effective anticoagulation with the risk of bleeding, particularly in the immediate postoperative period, requires careful consideration [12]. Additionally, the potential interactions between anticoagulants and cancer treatments necessitate a multidisciplinary approach to patient care[13].

Despite existing guidelines recommending a combination of mechanical and pharmacological prophylaxis for DVT prevention in high-risk surgical patients, the optimal approach for those with GI tumors remains unclear. This patient population faces unique challenges due to their elevated risk of both thrombosis and bleeding complications.

The primary objective of this study was to evaluate the effectiveness and safety of a comprehensive DVT prevention and management protocol in patients undergoing surgery for GI tumors. By addressing this knowledge gap, we aim to contribute to the development of evidence-based strategies for DVT prevention in this high-risk population.

MATERIALS AND METHODS

Study design and participants

This prospective cohort study was conducted from January 1, 2022, to December 31, 2022, at the Affiliated Hospital of Southwest Medical University in Sichuan, China. The study protocol was approved by the Ethics Committee of the Affiliated Hospital of Southwest Medical University, and written informed consent was obtained from all participants.

Eligible participants were adults aged 18 years or older who were scheduled to undergo elective surgery for histologically confirmed GI tumors, which included malignancies of the esophagus, stomach, small intestine, colon, rectum, liver, gallbladder, or pancreas. The exclusion criteria were as follows: (1) Emergency surgery; (2) Preexisting DVT or PE; (3) Contraindications to pharmacological prophylaxis, such as active bleeding, severe thrombocytopenia, or a history of heparin-induced thrombocytopenia; (4) Pregnancy; (5) Life expectancy of less than 30 days; and (6) Inability to provide informed consent.

DVT prevention and management protocol

All participants received a standardized DVT prevention and management protocol, which included the following components.

Preoperative risk assessment: Upon enrollment, each patient underwent a comprehensive risk assessment using the Caprini Risk Assessment Model[14]. This validated tool evaluates various factors, including age, type of surgery, medical history, and cancer status, to stratify patients into risk categories. Based on the Caprini score, patients were classified as low (0-1 points), moderate (2 points), high (3-4 points), or highest (≥ 5 points) risk for VTE.

Mechanical prophylaxis: All patients received mechanical prophylaxis, including graduated compression stockings (GCS) and intermittent pneumatic compression devices (IPCD). GCS was applied preoperatively and continued throughout the hospital stay and for four weeks post-discharge. IPCDs were used intraoperatively and were continued postoperatively until the patient was fully ambulatory.

Pharmacological prophylaxis: Pharmacological prophylaxis was administered based on the patient's risk category and absence of contraindications as follows: (1) Low-risk patients: Early ambulation only; (2) Moderate-risk patients: Enoxaparin 40 mg subcutaneously once daily; (3) High-risk patients: Enoxaparin 40 mg subcutaneously twice daily; and (4) Highest-risk patients: Enoxaparin 40 mg subcutaneously twice daily with extended prophylaxis for four weeks post-discharge.

Pharmacological prophylaxis was initiated 12 hours postoperatively and continued for the duration of the hospital stay, unless extended prophylaxis was indicated. Dosage adjustments were made for patients with renal impairment or extreme body weight.

Early mobilization: A standardized early mobilization protocol was implemented for all patients, beginning on postoperative Day 1, unless contraindicated. The protocol included: (1) Sitting out of bed for at least 2 hours on day 1; (2) Walking with assistance for 10-15 minutes three times daily from day 2; and (3) Gradually increasing walking distance and duration as tolerated.

Patient education: All patients received comprehensive education about DVT risk, symptoms, and the importance of adherence to preventive measures. Educational materials were provided in both written and verbal formats.

Surveillance and diagnosis: Patients were monitored daily for clinical signs and symptoms of DVT. Duplex ultrasonography of the lower extremities was performed on all patients on postoperative days 3 and 7, and at any time if DVT was clinically suspected.

Management of diagnosed DVT: Patients diagnosed with DVT were managed according to the current guidelines[15], which included: (1) Therapeutic anticoagulation with LMWH, adjusted for weight and renal function; (2) Consideration of inferior vena cava filter placement in cases where anticoagulation was contraindicated; and (3) A multidisciplinary approach involving surgical, hematology, and interventional radiology teams.

Data collection

Demographic and clinical data were collected at baseline, including age, sex, body mass index (BMI), tumor type and stage, comorbidities, and preoperative laboratory values. Operative details, including surgery type, operative time, and estimated blood loss, were recorded.

Postoperatively, data on adherence to the prevention protocol, occurrence of DVT or PE, bleeding complications, and length of hospital stay were collected. Follow-up continued for 30 days post-surgery, with assessments of DVT occurrence, bleeding events, and mortality.

Outcome measures

The primary outcome was the incidence of DVT within 30 days postoperatively, confirmed by duplex ultrasonography.

Secondary outcomes included: (1) Incidence of symptomatic PE; (2) Adherence rate to the prevention protocol (defined as ≥ 80% compliance with prescribed measures); (3) Incidence of major bleeding (defined as bleeding leading to death, reoperation, or requiring a transfusion of ≥ 2 units of red blood cells); (4) Incidence of clinically relevant non-major bleeding; and (5) All-cause mortality at 30 days.

Statistical analysis

Sample size calculation was based on an expected DVT incidence of 10% (as reported in previous literature), with a desired precision of ± 6%. Using a 95% confidence level, a sample size of 96 patients was required. To account for potential dropouts, 100 patients were enrolled.

Statistical analysis was performed using SPSS version 27.0 (IBM Corp., Armonk, NY, United States). Continuous variables were expressed as mean ± SD (SD) or median [interquartile range (IQR)], depending on the distribution. Categorical variables were expressed as frequencies and percentages.

The cumulative incidence of DVT was calculated using the Kaplan-Meier method. Univariate and multivariate logistic regression analyses were performed to identify risk factors associated with DVT development. Variables with a P value < 0.1 in the univariate analysis were included in the multivariate model. Adherence rates and the incidence of secondary outcomes were calculated with 95% confidence intervals (95%CIs). Subgroup analyses were performed based on tumor type, surgical approach (open *vs* laparoscopic), and risk category. A two-sided P value < 0.05 was considered statistically significant for all analyses.

RESULTS

Patient characteristics

A total of 112 patients were assessed for eligibility, of which 100 met the inclusion criteria and were enrolled in the study. All enrolled patients completed the 30-day follow-up and were included in the final analysis. The mean age of the participants was 62.4 ± 11.7 years, with 58% being male. The most common tumor types were colorectal (40%), gastric (25%), and pancreatic (15%). A summary of patient characteristics is provided in Table 1.

Surgical characteristics

The majority of surgeries (65%) were performed using an open approach, while 35% were conducted laparoscopically. The median operative time was 245 minutes (IQR: 180-320), and the median estimated blood loss was 300 mL (IQR: 150-500). Detailed surgical characteristics are provided in Table 2.

Primary outcome

The cumulative incidence of DVT within 30 days postoperatively was 7% (7/100 patients; 95%CI: 2.9-13.9%). The median time to DVT diagnosis was 8 days (range: 3-21 days). Of the 7 DVT cases, 5 (71.4%) were asymptomatic and detected during routine ultrasonography, while 2 (28.6%) were symptomatic.

The distribution of DVT cases by tumor type was as follows: Colorectal (3/40, 7.5%), gastric (2/25, 8%), pancreatic (1/15, 6.7%), and hepatobiliary (1/12, 8.3%). No cases of DVT were observed in patients with esophageal tumors.

Secondary outcomes

PE: One patient (1%; 95%CI: 0.03-5.4%) developed symptomatic PE on postoperative day 10. This patient had been diagnosed with DVT on day 7 and was receiving therapeutic anticoagulation at the time of PE diagnosis.

Adherence to prevention protocol: The overall adherence rate to the prevention protocol was 92% (92/100; 95%CI: 84.8-96.5%). Adherence rates for individual components of the protocol were as follows: (1) Mechanical prophylaxis: 98% (98/100); (2) Pharmacological prophylaxis: 94% (94/100); (3) Early mobilization: 88% (88/100); and (4) Reasons for non-adherence included patient refusal (4 cases), early termination of pharmacological prophylaxis due to bleeding concerns (3 cases), and delayed mobilization due to postoperative complications (5 cases).

Bleeding complications: Major bleeding occurred in two patients (2%; 95%CI: 0.2-7.0%). One case involved a retroperitoneal hematoma that required reoperation, while the other case involved GI bleeding necessitating multiple blood transfusions. Both cases occurred in patients who were receiving pharmacological prophylaxis.

Clinically relevant non-major bleeding was observed in five patients (5%; 95%CI: 1.6-11.3%). These cases included wound hematomas (3 cases) and mild GI bleeding (2 cases) that did not require surgical intervention or transfusion.

Mortality

The 30-day all-cause mortality rate was 2% (2/100; 95%CI: 0.2-7.0%). One death resulted from multiorgan failure following an anastomotic leak, and the other was caused by myocardial infarction. Neither death was directly attributable to VTE or bleeding complications.

Risk factors for DVT

Univariate and multivariate logistic regression analyses were performed to identify risk factors associated with DVT development. The results are provided in Table 3.

Subgroup analyses

Subgroup analyses were performed based on tumor type, surgical approach, and risk category. No statistically significant differences in DVT incidence were observed among different tumor types (P = 0.992) or between open and laparoscopic approaches (P = 0.232). However, patients in the highest Caprini risk category (≥ 5 points) demonstrated a higher

Table 1 Baseline demographic and clinical characteristics

Characteristic	Value (*n* = 100)
Age, years (mean ± SD)	62.4 ± 11.7
Sex (male), *n* (%)	58 (58)
BMI, kg/m² (mean ± SD)	26.8 ± 4.3
Tumor type, *n* (%)	
Colorectal	40 (40)
Gastric	25 (25)
Pancreatic	15 (15)
Hepatobiliary	12 (12)
Esophageal	8 (8)
Tumor stage, *n* (%)	
I	12 (12)
II	28 (28)
III	42 (42)
IV	18 (18)
Comorbidities, *n* (%)	
Hypertension	45 (45)
Diabetes mellitus	22 (22)
Coronary artery disease	15 (15)
Chronic obstructive pulmonary disease	10 (10)
Preoperative laboratory values (mean ± SD)	
Hemoglobin, g/dL	11.8 ± 1.6
Platelet count, × 10^9/L	256 ± 78
Creatinine, mg/dL	0.9 ± 0.3
Caprini risk score, *n* (%)	
Moderate (2 points)	5 (5)
High (3-4 points)	32 (32)
Highest (≥ 5 points)	63 (63)

BMI: Body mass index.

incidence of DVT compared to those in the high-risk category (3-4 points), although this difference did not reach statistical significance (9.5% *vs* 3.1%; $P = 0.253$).

DISCUSSION

This prospective cohort study evaluated the effectiveness of a comprehensive DVT prevention and management protocol in patients undergoing surgery for GI tumors. The overall incidence of DVT in our cohort was 7%, which is lower than previously reported rates for this high-risk population[16]. This finding suggests that our multifaceted approach to DVT prevention may effectively reduce the risk of this potentially serious complication.

Several factors likely contributed to the relatively low incidence of DVT observed in our study. First, the implementation of a standardized protocol ensured that all patients received appropriate prophylaxis tailored to their individual risk profiles. The high adherence rate (92%) to the prevention protocol underscores its feasibility and acceptance by both patients and healthcare providers. This adherence is crucial for the success of any preventive strategy and highlights the importance of a systematic approach to DVT prevention.

Second, the combination of mechanical and pharmacological prophylaxis may have provided synergistic protection against DVT formation. Although the individual effectiveness of the GCS, IPCD, and LMWH is well-established[17], their

Table 2 Surgical Characteristics

Characteristic	Value (*n* = 100)
Surgical approach, *n* (%)	
Open	65 (65)
Laparoscopic	35 (35)
Type of surgery, *n* (%)	
Colectomy	30 (30)
Gastrectomy	25 (25)
Pancreaticoduodenectomy	15 (15)
Liver resection	12 (12)
Low anterior resection	10 (10)
Esophagectomy	8 (8)
Operative time, minute [median (IQR)]	245 (180-320)
Estimated blood loss, mL [median (IQR)]	300 (150-500)
Intraoperative transfusion, *n* (%)	18 (18)

IQR: Interquartile range.

Table 3 Risk Factors for deep vein thrombosis development

Variable	Univariate analysis		Multivariate analysis	
	OR (95%CI)	*P* value	OR (95%CI)	*P* value
Age (per year)	1.04 (0.99-1.09)	0.089	1.05 (1.01-1.09)	0.042
BMI (per kg/m²)	1.12 (1.02-1.22)	0.015	1.11 (1.03-1.19)	0.008
Male sex	1.56 (0.29-8.33)	0.601	-	-
Advanced tumor stage (III/IV)	2.33 (0.43-12.5)	0.323	-	-
Open surgical approach	2.78 (0.52-14.9)	0.232	-	-
Operative time (per 10 minute)	1.06 (1.01-1.11)	0.022	1.007 (1.001-1.013)	0.031
Estimated blood loss (per 100 mL)	1.18 (0.98-1.42)	0.076	1.11 (0.97-1.27)	0.124
Highest caprini risk category	3.45 (0.64-18.5)	0.149	-	-

In the multivariate analysis, advanced age [odds ratio (OR): 1.05; 95% confidence interval (95%CI): 1.01-1.09; *P* = 0.042], higher body mass index (OR: 1.11; 95%CI: 1.03-1.19; *P* = 0.008), and longer operative time (OR: 1.007; 95%CI: 1.001-1.013; *P* = 0.031) were identified as independent risk factors for deep vein thrombosis development. OR: Odds ratio; 95%CI: 95% confidence interval; BMI: Body mass index.

combined use in a standardized protocol specifically for GI tumor patients has been less extensively studied. Our results suggest that this comprehensive approach is particularly beneficial for this high-risk population.

Third, the emphasis on early mobilization within our protocol likely contributed to the low DVT incidence. Early mobilization is known to reduce the risk of postoperative VTE by promoting venous blood flow and reducing venous stasis[18]. The high compliance rate with early mobilization (88%) in our cohort demonstrates the feasibility of this intervention even in patients undergoing major GI surgery.

The majority of DVT cases in our study (71.4%) were asymptomatic and detected through routine ultrasonography. This finding underscores the importance of regular surveillance in high-risk patients, as relying solely on clinical symptoms may result in the underdiagnosis of DVT. Although the clinical significance of asymptomatic DVT remains debated[19], early detection allows for prompt treatment, potentially reducing the risk of clot propagation and PE.

Our study identified advanced age, higher BMI, and longer operative time as independent risk factors for DVT development. These findings are consistent with previous studies in surgical oncology patients[20,21]. The association between operative time and DVT risk highlights the importance of efficient surgical techniques and minimizing unnecessary prolongation of surgery. For patients with multiple risk factors, more aggressive prophylaxis or closer postoperative monitoring may be warranted.

The low incidence of major bleeding complications (2%) in our cohort suggests that the pharmacological prophylaxis regimen used in our protocol is relatively safe for this patient population. However, the occurrence of clinically relevant non-major bleeding in 5% of patients emphasizes the need for careful monitoring and individualized assessment of bleeding risk when implementing thromboprophylaxis strategies.

The strengths of this study include its prospective design, the use of standardized prevention protocol and the comprehensive assessment of both efficacy and safety outcomes. The inclusion of patients with various GI tumor types and the use of both open and laparoscopic surgical approaches enhance the generalizability of our findings.

However, several limitations should be acknowledged. First, the single-center design and the relatively small sample size of the study may limit the external validity of our results. Multicenter studies with larger cohorts are needed to confirm these findings. Second, the lack of a control group prevents direct comparison of our protocol with standard care or other prevention strategies. Future randomized controlled trials are required to address this limitation. Third, the 30-day follow-up period may not account for late-occurring DVT cases, although the majority of postoperative DVTs typically occur within this timeframe[22]. Fourth, while our study included various GI tumor types, the sample size was insufficient to draw definitive conclusions about DVT risk in specific tumor subgroups. Finally, other less common GI malignancies, such as small intestine tumors or GI stromal tumors, were not included. Future studies should consider expanding the definition of GI tumors to encompass a broader range of malignancies.

CONCLUSION

This prospective cohort study demonstrates that the implementation of a comprehensive DVT prevention and management protocol in patients undergoing surgery for GI tumors is associated with a relatively low incidence of postoperative DVT. The protocol, which includes individualized risk assessment, a combination of mechanical and pharmacological prophylaxis, early mobilization, and regular surveillance, appears to be both effective and safe in this high-risk population.

FOOTNOTES

Author contributions: The concept of this study was jointly proposed by Shu L and Xia CW, who participated in data collection; the initial draft was drafted by Shu L; Pang YF contributed to the formal analysis of this study; Shu L guided the research, methodology, and visualization of the manuscript; Shu L, Pang YF and Xia CW participated in this study, validated it; all authors have read and approve the final manuscript.

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Clinical trial registration statement: This study is registered at the Clinical Registry: https://www.researchregistry.com (Researchregistry10638).

Informed consent statement: The study has obtained the consent of patients and guardians, and an informed consent form has been signed.

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