

Research progress on the risk factors and prevention strategies for venous thrombosis in patients with liver cancer undergoing perfusion chemotherapy

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Abstract

Hepatic arterial infusion chemotherapy (HAIC) is widely used in the clinical treatment of patients with advanced liver cancer. Because of the need for re-puncture and catheterization for each postoperative perfusion chemotherapy and long-term bed rest with a catheter for pump infusion of chemotherapeutic drugs in patients undergoing HAIC, the risk of venous thromboembolism (VTE) is significantly increased. This article reviews the incidence characteristics, risk factors, prevention strategies, and research progress of HAIC-related VTE in patients. The incidence of VTE in HAIC patients is as high as 5%–20%. The main risk factors for HAIC-related VTE include tumor-related hypercoagulable state, catheter indwelling, and vascular endothelial damage caused by chemotherapeutic drugs. Preventive measures for HAIC-related VTE include mechanical prevention, drug prevention, and comprehensive management strategies. This review provides a reference for preventing VTE in patients with liver cancer undergoing perfusion chemotherapy. More high-quality studies are needed to optimize VTE prevention strategies for patients undergoing HAIC.

Keywords: hepatic arterial infusion chemotherapy, venous thromboembolism, liver cancer, chemotherapy, nursing, review

Introduction

Primary liver cancer is the fourth most common malignant tumor and the second leading cause of cancer-related death in China, with an increasing incidence ^[1]. Because of its insidious onset and low early diagnosis

rate, only 15%–30% of patients with liver cancer are eligible for surgical resection. Hepatic arterial infusion chemotherapy (HAIC) has become one of the main treatment options for patients with advanced liver cancer and liver metastases ^[2]. HAIC delivers chemotherapeutic drugs directly into the tumor-feeding artery;

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this approach significantly increases local drug concentration while reducing systemic toxic reactions. However, the risk of venous thromboembolism (VTE) during treatment cannot be ignored ^[3]. The specific treatment mode of HAIC, while reducing systemic toxic reactions. However, the specific treatment mode of HAIC, including repeated puncture and catheterization, long-term bed rest with a catheter, and 24-h immobilization after catheter removal^[4], can cause venous endothelial damage, blood stasis, and blood hypercoagulability, thereby increasing the risk for venous thromboembolism (VTE) ^[5]. VTE not only disrupts the continuity of anti-tumor treatment but may also lead to fatal pulmonary embolism. Currently, there is no unified clinical consensus on the risk factors and prevention strategies for HAIC-related VTE.

This review systematically summarizes the high-risk factors and current preventive measures for HAIC-related VTE in patients, with the aim of providing a theoretical basis for the early identification of high-risk groups and optimization of thrombosis management.

HAIC and VTE

HAIC

During HAIC, a catheter is inserted through the femoral artery and placed in the tumor-feeding artery. High doses of chemotherapeutic drugs are injected through the catheter into the tumor-feeding blood vessel to achieve local chemotherapy and kill tumor cells ^[6-7]. Compared with systemic chemotherapy, HAIC enables increased drug concentrations in cancer cells and reduces the peripheral toxic and side effects of chemotherapeutic drugs, thereby reducing systemic adverse reactions ^[8]. HAIC treatment regimens involve the single or combined administration of drugs such as

5-fluorouracil, cisplatin, doxorubicin, oxaliplatin, epirubicin, mitomycin C, zinostatin stimalamer, mitoplatin, and FOLFOX.

VTE

VTE is a pathological state where blood coagulates abnormally in veins, accompanied by hemodynamic changes and abnormal activation of the coagulation system, resulting in complete or incomplete obstruction of venous blood vessels. VTE is a venous reflux disease that includes deep vein thrombosis and pulmonary embolism and represents the second leading cause of cancer death ^[9]. Slow venous blood flow, damaged venous walls, and a hypercoagulable state of blood are the main factors for thrombosis formation.

Factors related to VTE in patients with liver cancer undergoing perfusion chemotherapy

Studies have shown that the incidence of VTE is significantly higher in patients with liver cancer receiving HAIC compared with other patients with cancer, at approximately 5%–20% ^[3]. The high incidence of VTE is related to various factors. First, liver cancer leads to a hypercoagulable state through the release of procoagulant substances and activation of the coagulation system; second, the catheter indwelled during HAIC treatment may damage the vascular endothelium and change hemodynamics; and third, the chemotherapeutic drugs used in HAIC, such as oxaliplatin and 5-fluorouracil, can directly damage the vascular endothelium. VTE most commonly occurs within 1–3 months after HAIC treatment, and catheter-related thrombosis accounts for a considerable proportion of cases. The incidence of HAIC-related VTE in Asian populations may be higher than that in Western

populations, which may be related to genetic factors and differences in treatment regimens ^[10].

Tumor-related factors

Studies have shown that patients with cancer have a 4–7 times higher risk of developing VTE than non-cancer patients. Liver cancer itself has a high risk of thrombosis. One study reported that the incidence of VTE in hospitalized patients with liver cancer is 2.8% ^[11]. VTE in patients with liver cancer may be related to tumor cells releasing tissue factors, causing increased platelet activation and excessive secretion of cytokines, and producing cancer procoagulant substances, leading to a hypercoagulable state of blood in these patients ^[12]. Studies have shown that with the progression of tumor grade and stage, the risk of developing VTE increases. Patients with advanced metastatic cancer have a higher risk of developing VTE than those with localized cancer ^[13]. In China, most patients with liver cancer are diagnosed at an advanced stage, and HAIC is used as the main treatment method for advanced liver cancer ^{[2] [14]}. The incidence of VTE in patients with liver cancer undergoing perfusion chemotherapy is relatively increased, posing a great threat to patient health.

HAIC treatment-related factors

HAIC treatment generally involves re-puncture and catheterization after each perfusion. However, repeated vascular puncture can cause damage to the vascular endothelium, increasing the risk of VTE. Patients receiving HAIC generally need to stay in bed for approximately 31–55 h after surgery ^[15]. Studies have shown that a longer catheter indwelling time is associated with a higher risk of blood clot formation on the catheter surface and a higher risk of VTE ^[16]. After

perfusion chemotherapy, the catheter needs to be removed and compression bandaging is required for 24 h, which limits the movement of the operative limb and slows down the blood flow in the lower extremities, making patients extremely prone to VTE ^[17]. Studies have also shown that chemotherapeutic drugs can directly damage the vascular endothelium, increasing the risk of VTE in patients with cancer by 2–6 times ^[18]. Patients with liver cancer undergoing perfusion chemotherapy thus have a higher risk of postoperative venous thrombosis.

Patient-related factors

Research has shown that patients with advanced age, obesity, chronic constipation, diabetes mellitus, previous VTE history, and varicose veins have a higher risk of VTE ^[15]. Patients are important participants in VTE prevention. However, Haiyan et al. reported that the current level of patients' understanding of VTE is low, which may be related to patients' educational level and nurses' health education ^[19]. Patients' insufficient understanding of VTE is also a risk factor for VTE ^[20].

Preventive measures for VTE in patients with liver cancer undergoing perfusion chemotherapy

A nursing assessment for VTE

Comprehensively investigate and assess patients' conditions, such as advanced age, obesity, diabetes mellitus, frequency of HAIC treatment, and previous VTE history, and actively identify the influencing factors of VTE ^[21]. The Caprini risk assessment model widely used in clinical practice has been proven to have certain operability and effectiveness in evaluating VTE in

hospitalized patients (such as those in orthopedics, cancer, and trauma treatment) ^[22]. Inform patients and their families of the venous thrombosis risk level and corresponding preventive measures to be taken according to the score and encourage patients and their families to actively cooperate and participate in the prevention of VTE. However, this scoring scale for the assessment of postoperative HAIC patients lacks specificity and the included factors are incomplete.

Drug prevention

The guidelines of the Chinese Society of Clinical Oncology propose that all hospitalized patients with cancer should be given anticoagulant therapy to prevent VTE as long as there are no bleeding symptoms or other anticoagulant contraindications ^[23]. Domestic expert consensus in China suggests that for patients with a score ≥ 5 points, physical prevention is recommended; if there are no contraindications to anticoagulant drugs, anticoagulant drugs are also recommended ^[24]. Anticoagulant therapy mainly includes vitamin K antagonists (such as warfarin), low molecular weight heparin, and new oral anticoagulants, such as rivaroxaban ^[25]. Jinpeng et al. combined conventional anticoagulant western medicines with 11 kinds of blood-activating traditional Chinese medicine injections, including Danshen Chuanxiongqin injection, Danshen injection, Danhong injection, Safflower Yellow Pigment injection, Safflower injection, Kudiezi injection, Shuxuetong injection, Xuesaitong injection, Xueshuantong injection, Salvianolate injection, Ginkgo leaf extract, and Dipyridamole injection for the prevention of deep vein thrombosis after orthopedic surgery ^[26]. The results showed that the combined application of traditional Chinese medicine injections on the basis of conventional anticoagulant western medicines improved the prevention of postoperative

deep vein thrombosis in orthopedic patients. However, these analyses have not yet been performed on patients with liver cancer undergoing perfusion chemotherapy; therefore, more clinical studies are required to verify these results. Lan Lan et al. examined the external application of modified Buyang Huanwu Decoction for the prevention of calf muscular venous thrombosis after total knee arthroplasty ^[27]. This decoction reduced the incidence of postoperative deep vein thrombosis by improving blood circulation. However, the sample size of the study was small, and thus larger sample trials are needed to verify the conclusions.

Bed rest time with HAIC

Patients need to maintain a specific body position during perfusion chemotherapy to prevent bleeding and catheter displacement. Patients rest in bed during HAIC treatment, and the operative limb cannot be bent until the end of perfusion, before getting out of bed. However, Xiaoyun et al. showed that getting out of bed with a catheter 6 h after liver cancer perfusion chemotherapy did not increase the incidence of complications such as bleeding, hematoma, catheter blockage, and catheter displacement ^[28]. After the end of perfusion chemotherapy and catheter removal, compression hemostasis is required for 15 min, and the punctured lower extremity needs to be immobilized for 24 h before the patient can get out of bed ^[29]. Interventional experts pointed out in the “Clinical Practice Guidelines for Transcatheter Arterial Chemoembolization (TACE) in Hepatocellular Carcinoma in China (2021 Edition)” that after removing the catheter and catheter sheath through the femoral artery approach, the punctured lower extremity can be immobilized for 6–12 h ^[30]. The study by Wei et al. reported that after femoral artery puncture interventional surgery, if there is no bleeding risk, bed rest and immobilization for

3–4 h are sufficient, and patients can get out of bed 6 h later without increasing the bleeding risk ^[31]. Clinically, it is recommended that the bed rest and immobilization time during perfusion can be appropriately shortened in accordance with the patient's individual situation.

Health education on disease-related knowledge

Studies have proposed that the prevention of VTE is more important than treatment ^[32]. Because patients are important participants in VTE prevention, it is crucial that they obtain knowledge on HAIC, VTE, and preventive measures. By introducing knowledge such as the concepts, risk factors, clinical manifestations, and preventive measures of HAIC and VTE to patients, the patients' awareness of VTE prevention can be effectively improved ^[20]. By developing appropriate health education content and methods, such as turning rigid abstract language text into vivid and intuitive videos, patients' comprehension and awareness of prevention can be effectively improved ^[33]. For example, videos on the risk factors, clinical manifestations, and preventive measures of HAIC and VTE can be played on the department's display screen or shared with patients through WeChat. Studies have shown that inviting patients with good postoperative recovery to share their experiences and the methods, advantages, and experiences of early exercise can effectively improve patients' awareness of VTE prevention ^[34].

Health education on physical exercise

Ankle pump exercise is currently the simplest, most economical, and effective exercise therapy for preventing VTE in clinical practice and has been verified as an effective postoperative strategy ^[35]. The study by Rui et al. examined HAIC patients that returned to the

ward and were guided to perform ankle pump exercises in the supine position by nurses ^[16]. The results showed that ankle pump exercises achieved a good effect in preventing VTE in these patients. However, if patients are only educated and guided once without supervision and reinforcement, their compliance may gradually decrease, reducing the preventive effect. In the study by Xiaoyan et al., standardized and easy-to-understand ankle pump exercise videos were played on TV at fixed times every day to guide patients to exercise ^[36]. The patients' compliance with ankle pump exercises was higher, and the effect of preventing VTE was also better. Studies have explored the use of elastic stockings, lower extremity massage, and ankle pump exercises in combination to prevent lower extremity deep vein thrombosis, and the results found that the combined application has a better effect ^[37,38]. One study used ultrasound pulse electrical conduction combined with auricular point pressing to improve the quality of life of patients with liver cancer undergoing perfusion chemotherapy. This approach showed a good curative effect on improving patients' lower extremity circulation and preventing liver function damage ^[39]. However, the sample size of this study was limited and this effect needs further verification.

Training for nursing staff

Nursing staff can be the best personnel to assess VTE and implement nursing measures for hospitalized patients. Studies have shown that improving nursing staff's understanding of VTE and changing their attitudes and behaviors play a positive role in preventing VTE in patients ^[40]. Xiaoyan et al. trained nursing staff in the entire hospital on VTE-related knowledge and the risk assessment process of VTE in hospitalized patients, focusing on assessments such as VTE prevention and treatment guidelines, specific measures, and ankle

pump exercises; this training played a positive role in VTE prevention and treatment ^[41]. Clinically, it is recommended that hospital managers encourage nursing staff to learn HAIC and VTE-related knowledge and preventive measures organized by the nursing department and the hospital, update HAIC and VTE-related practice guidelines or cutting-edge clinical knowledge in a timely manner, and improve the nursing level.

Discussion

This article reviewed the influencing factors and prevention strategies of VTE in patients undergoing HAIC. Tumor-related factors, HAIC treatment-related factors, and patient factors such as advanced age, obesity, chronic constipation, diabetes mellitus, previous VTE history, varicose veins, and educational level are all influencing factors of VTE. VTE can be better prevented by conducting VTE risk assessment, drug intervention, shortening bed rest time, improving patients' knowledge of VTE, and providing professional training for nurses in managing patients with liver cancer undergoing perfusion chemotherapy.

Several challenges in managing HAIC-related VTE remain, including the lack of a special VTE risk assessment tool for HAIC patients. Current evidence supports the adoption of preventive measures for high-risk patients, but specific strategies need to balance the risk-benefit ratio. Moreover, there is no consensus on the optimal timing of prevention, nursing strategies, and drug selection. Therefore, future research directions should focus on developing and verifying HAIC-specific VTE risk prediction models and conducting high-quality randomized controlled trials to compare the efficacy and safety of different prevention strategies. Additionally, multidisciplinary collaboration is the key to optimizing VTE manage-

ment in HAIC patients. Close cooperation among the interventional department, oncology department, hematology department, and nursing team and full-process management from patient assessment, prevention plan formulation, to treatment monitoring will help improve patient prognosis. With the continuous expansion of the application of HAIC in liver cancer treatment, research on the prevention of related VTE will increase, providing a more reliable evidence basis for clinical practice and ultimately improving the treatment safety and clinical outcomes of HAIC patients.

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Author contributions

Xuemin Jing and Kaijie Zou contributed equally to this work and share first authorship. Xuemin Jing, Kaijie Zou, and Huijuan Ge conceived and designed the study. Ruiying Ma collected and organized the data. Li Zhou, Yinghua Zhang, and Lili Zhang performed data analysis and interpretation. Xuemin Jing and Kaijie Zou drafted the manuscript. Huijuan Ge and Li Zhou critically revised the manuscript for important

intellectual content. All authors read and approved the final version of the manuscript.

Conflict of interest

All authors declare no conflicts of interest.

References

- [1] Zhou J, Sun H, Wang Z, Cong W, Zeng M, Zhou W, et al. Guidelines for the Diagnosis and Treatment of Primary Liver Cancer. *Liver cancer*. 2022 (12): 405-444.
- [2] Wang YF, Zeng J, Wu J, Chen M, He DF. Application and research progress of hepatic arterial infusion chemotherapy in malignant liver tumors. *Tumor*. 2022 (42):708-714. In Chinese.
- [3] Al-Taei AM, Mohammed KA, Khneizer GW, Neuschwander-Tetri BA. Correlates, trends, and short-term outcomes of venous thromboembolism in hospitalized patients with hepatocellular carcinoma. *Journal of Gastrointestinal Cancer*. 2019 (50):357-360.
- [4] Chinese Society of Liver Cancer, China Anti-Cancer Association, Chen MS. Liver Cancer Professional Committee of China Anti-Cancer Association. Chinese expert consensus on hepatic arterial infusion chemotherapy for hepatocellular carcinoma (2021 edition). *Chinese Journal of Digestive Surgery*. 2021 (20):754-759. In Chinese.
- [5] Huang L, Ou YQ, Zhong Z, Huang M, Huang X. Application research of whole-course intervention nursing in preventing lower-extremity deep vein thrombosis in patients undergoing transfemoral coronary interventional therapy. *Electronic Journal of Practical Clinical Nursing Science*. 2017 (2):76-78. In Chinese.
- [6] Zeng LH, Luo ZP, Lu YY, Hu ML, Zhong GT. Application effect of exercise rehabilitation nursing in the perioperative period of liver cancer TACE patients. *Family Nurse*. 2021 (19): 97-99. In Chinese.
- [7] Zhu YE, Yu JX, Yi XY, Lin SS, Wu XY, Fang SH et al. Implementation effect of continuous care after interventional therapy for liver cancer. *International Journal of Nursing*. 2021 (40): 549-553. In Chinese.
- [8] Zhao M, Wu JM, Lyu N. Evidence-based medicine proof and development trends of first-line treatment for advanced hepatocellular carcinoma. *Chinese Journal of Digestive Surgery*. 2021 (20): 191-196. In Chinese.
- [9] Shi ZY, Fu WG. Anticoagulation principles and management of complications in venous thromboembolism. *Chinese Journal of Practical Surgery*. 2021 (41):1345-1348. In Chinese.
- [10] Joraku A, Nittas T, Tanaka K, Ichioka D, Ikeda A, Yoshino Tet al. Screening of deep vein thrombosis prior to surgery using D-dimer testing and venous ultrasonography of lower extremities. *Hinyokika Kyo*. 2017 (63):229-233.
- [11] Committee of Tumor and Thrombosis, Chinese Society of Clinical Oncology. Guidelines for the prevention and treatment of tumor-related venous thromboembolism (2019 edition). *Chinese Journal of Clinical Oncology*. 2019 (46):653-660. In Chinese.
- [12] Serrano PE, Parpia S, Linkins LA, Elit L, Simunovic M, Ruo L, et al. Venous Thromboembolic Events Following Major Pelvic and Abdominal Surgeries for Cancer: A Prospective Cohort Study. *Annals of Surgical Oncology*. 2018 (25): 3214-3221.
- [13] Blom JW, Doggen CJ, Osanto S, Rosendaal FR. Malignancies, Prothrombotic Mutations, and the Risk of Venous Thrombosis. *JAMA*. 2018 (293):

715-722.

- [14] Wang J, Zhao L. Application value of perioperative quantitative ankle pump exercise in reducing postoperative lower-extremity deep vein thrombosis in gynecological cancer patients. *Journal of Thrombosis and Hemostasis*. 2020 (26): 1061-1062. In Chinese.
- [15] Yuan R, He FY. Effect of ankle pump exercise on lower-extremity deep vein thrombosis and self-efficacy in patients undergoing hepatic arterial infusion. *Evidence-Based Nursing*. 2022 (8): 2254-2256. In Chinese.
- [16] Sun Y, Huang YT, Xu LF, Sun YX, Cao J. Research progress on risk factors of venous thromboembolism in patients undergoing hepatic arterial infusion chemotherapy. *Family Nurse*. 2022 (20):3772-3775. In Chinese.
- [17] Zhang Z. Application of preventive intervention in patients with liver cancer interventional therapy complicated with high risk of deep vein thrombosis. *Capital Food and Medicine*. 2019 (26):124. In Chinese.
- [18] Blom JW, Vanderschoot JP, Oostindier MJ, Osanto S, van der Meer FJ, Rosendaal FR. Incidence of venous thrombosis in a large cohort of 66,329 cancer patients: results of a record linkage study. *J Thromb Haemost*. 2006 (4):529-535.
- [19] Pan HY, Dong MY, Fan LM, Lu LN, Fu YH, Lin Y, et al. Investigation and analysis of cognitive status and follow-up needs regarding venous thromboembolism in patients at high risk of thrombosis. *Journal of Electrocardiology and Circulation*. 2022 (41):254-257. In Chinese.
- [20] Li YL, Wang R, Tang GD, Hu XM, Long H, Wan YP. Cognitive status and influencing factors of venous thromboembolism in hospitalized cancer patients in internal medicine. *Qilu Journal of Nursing*. 2020 (26):37-40. In Chinese.
- [21] Zou WN, Song DD. Application of risk management in prevention of deep vein thrombosis in patients after liver cancer surgery. *Contemporary Nurse*. 2020 (09):55-56. In Chinese.
- [22] Chen L. A case-control study on the application and effect of the Caprini venous thrombosis risk assessment model in VTE prevention in perioperative hospitalized patients[D]. China Medical University. 2023. In Chinese.
- [23] Guidelines Committee of Chinese Society of Clinical Oncology. Guidelines for the prevention and treatment of venous thrombosis in tumor patients (2019 edition). *Chinese Journal of Clinical Oncology*. 2019 (46): 653-660. In Chinese.
- [24] He MK, Zou RH, Li QJ, Zhou ZG, Shen JX, Zhang YF, et al. Phase II Study of Sorafenib Combined with Concurrent Hepatic Arterial Infusion of Oxaliplatin, 5-Fluorouracil and Leucovorin for Unresectable Hepatocellular Carcinoma with Major Portal Vein Thrombosis. *Cardiovascular and Interventional Radiology*. 2018 (41):734-743.
- [25] Huang YX, Wang Y, Shen MY. Research progress on the safety of anticoagulant drugs for venous thrombosis. *Chinese Journal of Geriatric Care Medicine*. 2022 (02):98-101. In Chinese.
- [26] Jing JP, Zhang Y, Liu XM, Liu Yi. Network meta-analysis of blood-activating traditional Chinese medicine injections for preventing deep vein thrombosis after orthopedic surgery. *Chinese Journal of Tissue Engineering Research*. 2022 (26): 1467-1476. In Chinese.
- [27] Lan L, Zhu SL. Clinical observation of external application of modified Buyang Huanwu decoction in preventing calf muscular venous thrombosis after total knee arthroplasty. *Guiding Journal of Traditional Chinese Medicine and Pharmacy*. 2022 (28):81-84. In Chinese.
- [28] Zhao XY, Jin Y, Chen XF, Huang H, Zhou HM.

- Construction and application of a program to lift bed-rest restriction during hepatic arterial infusion chemotherapy. *Electronic Journal of Liver Cancer*. 2022 (02):35-40. In Chinese.
- [29] Liver Cancer Professional Committee of China Anti-Cancer Association. Chinese expert consensus on hepatic arterial infusion chemotherapy for hepatocellular carcinoma (2021 edition). *Chinese Journal of Digestive Surgery*. 2021 (20):754-759. In Chinese.
- [30] Clinical Guidelines Committee of Chinese College of Interventionalists. Chinese clinical practice guidelines for transcatheter arterial chemoembolization (TACE) in hepatocellular carcinoma (2021 edition). *Chinese Journal of Internal Medicine*. 2021 (7):599-614. In Chinese.
- [31] Mo W, Xiang H, Yang XC, Ding FX. Evidence-based research on immobilization time after femoral artery puncture interventional surgery. *Journal of Interventional Radiology*. 2019 (28):85-88. In Chinese.
- [32] Wang RJ, Zhu KN, Zhang YQ, Xie Q, Xie HH. Study on individualized whole-chain nursing management for lung cancer surgery patients. *Journal of Nursing Science*. 2024 (39):32-37. In Chinese.
- [33] Zeng Z, Zhao TX. Research status of health education for preventing venous thromboembolism during perioperative period. *Nursing of Integrated Traditional Chinese and Western Medicine*. 2020 (02):190-192. In Chinese.
- [34] Dai L. Nursing experience in preventing lower-extremity deep vein thrombosis in patients undergoing transfemoral artery puncture interventional surgery. *Electronic Journal of Practical Clinical Nursing Science*. 2020 (5):131-135. In Chinese.
- [35] Chen XY. Application of modified ankle pump exercise in deep vein thrombosis after lower-extremity varicose vein surgery. *Evidence-Based Nursing*. 2023 (9):3555-3557. In Chinese.
- [36] Wang XY, Chen JF, Ma K, Liu XM. Application of a standardized health education program for ankle pump exercise in patients with lower-extremity fractures. *Nursing Practice and Research*. 2019 (14):43-45. In Chinese.
- [37] Wang Y, Zhang Y. Application of medical elastic stockings combined with early rehabilitation training in preventing lower-extremity deep vein thrombosis after knee arthroplasty. *Nursing Practice and Research*. 2019 (16):81-83. In Chinese.
- [38] Chen YL. Effect of ankle pump exercise combined with bilateral lower-extremity massage on preventing lower-extremity deep vein thrombosis in pregnant women with placenta previa after bed rest. *Journal of Thrombosis and Hemostasis*. 2019 (25):1063-1064. In Chinese.
- [39] Fu LX, Yu HQ, Wang YY, He Y, Chen SB, Yao HX. Effect evaluation of ultrasound pulse electrical conduction combined with auricular point pressing on the life quality of patients with liver cancer undergoing arterial perfusion chemotherapy. *Chinese Journal of General Practice*. 2022 (20):1466-1468+1597. In Chinese.
- [40] Zhang ZH, Peng YT. Current status and strategies of hospital venous thromboembolism prevention and control. *Guangdong Medical Journal*. 2022 (43):271-275. In Chinese.
- [41] Xu XY, Guo HL, Liu HL, Yang HL, Zheng SD. Construction and application of a specialized nursing prevention and control management system for venous thromboembolism. *Journal of Thrombosis and Hemostasis*. 2020 (26):484-487. In Chinese.