

Advances in the Prevention and Nursing Care of Venous Thromboembolism After Bone Tumor Surgery

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Abstract: Venous thromboembolism (VTE) is a significant complication that poses a serious threat to the health of patients following bone tumor surgery. Although bone tumors are relatively rare, they are highly malignant, and the risk of VTE in postoperative patients is increased due to various factors. This article aims to review the latest advancements in the prevention and nursing care of VTE after bone tumor surgery, providing a comprehensive theoretical foundation for clinical practice. The findings aim to optimize preventive and nursing strategies for postoperative VTE and improve the quality of patient outcomes.

Keywords: Bone tumor surgery; Venous thromboembolism; Prevention; Nursing care

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1. Introduction

Venous thromboembolism (VTE) is an abnormal clotting of blood within a vein, causing vascular obstruction and impaired blood return. VTE primarily arises from venous wall damage, infection, or venous stasis and includes deep venous thrombosis (DVT) and pulmonary embolism (PE). It is the third most common cardiovascular condition, following acute coronary syndrome and stroke^[1].

Bone tumors, while relatively rare, are highly malignant, prone to recurrence, and metastasize easily. These characteristics place a significant emotional and financial burden on patients and their families. Current treatment for bone tumors primarily involves surgical intervention. Post-surgery, patients often experience reduced mobility and impaired venous blood return in the lower limbs, significantly increasing their risk of VTE.

Moreover, in patients undergoing bone tumor surgery, the combination of surgical trauma, prolonged immobilization of limbs, and hypercoagulable states further elevates the incidence of VTE. Once VTE

occurs, the consequences can range from prolonged hospitalization and delayed recovery to life-threatening complications such as pulmonary embolism or post-thrombotic syndrome, severely impacting the prognosis and quality of life of patients.

2. Mechanisms of venous thromboembolism after bone tumor surgery

2.1. Hypercoagulable state

The interaction between malignant tumor cells, their products, and the host leads to a hypercoagulable state in the blood. The causes of hypercoagulability in cancer patients include thrombocytosis, increased platelet viscosity, and congenital genetic defects ^[2-4]. During this process, tumor cells interact strongly with the host's endothelial cells, monocytes/macrophages, and platelets. On one hand, tumor cells synthesize and release inflammatory cytokines that reduce the antithrombotic ability of endothelial cells and enhance their procoagulant activity. On the other hand, tumor cells adhere to vascular endothelium or the endothelial matrix via membrane adhesion factors, inducing endothelial cells to express intercellular adhesion molecules, which play a critical role in cancer cell metastasis.

Moreover, once tumor cells adhere to the vascular wall, they release cytokines that promote the adhesion of leukocytes and platelets. The integrin $\alpha V\beta 3$ expressed by tumor cells bridges with glycoprotein IIb/IIIa on platelets, causing platelet aggregation. This process activates local coagulation and thrombus formation, increases the number of adhesion molecules in the blood, and ultimately leads to a hypercoagulable state.

2.2. Hemodynamic changes

Anesthetic agents, sedatives, and muscle relaxants used during surgery can cause peripheral venous dilation and affect muscle and venous function. Anesthetic drugs relax the smooth muscle of venous walls, exposing endothelial cell gel and impairing venous return. Muscle paralysis during anesthesia eliminates the “muscle pump” effect ^[5].

For instance, in elderly patients undergoing lower limb orthopedic surgery, general anesthesia can disrupt respiratory physiology, potentially leading to delayed extubation, atelectasis, or pulmonary infection. Spinal anesthesia blocks sympathetic nerves, reducing vascular resistance, venous return, and cardiac output. Subarachnoid block anesthesia combined with opioids results in more stable hemodynamics.

Postoperative factors such as reduced limb movement, vascular endothelial injury, and slow or stagnant blood flow due to extended immobilization, prolonged surgical trauma, and long operative times contribute to venous stasis ^[6]. Additionally, prolonged bed rest, reduced mobility, and poor venous blood return in the lower limbs increase the risk of VTE ^[7].

2.3. Vascular endothelial injury

Mechanical manipulations during surgery, improper use of hip retractors, and other factors can cause contusion to the femoral vein wall, leading to platelet adhesion, fibrin deposition, and eventually thrombosis. Surgical trauma directly damages the vascular intima, activating the intrinsic coagulation system and producing procoagulant factors such as factors VII, IX, and XI. These factors combine with calcium ions to form prothrombin activators, which convert prothrombin to thrombin. Thrombin then converts fibrinogen into fibrin, which forms a mesh structure trapping blood cells to form a thrombus.

For example, in orthopedic surgery, immobilization, supine positioning, and anesthesia can damage the vascular wall, activating the intrinsic coagulation system and increasing thrombus risk. Surgical trauma and soft tissue swelling can also damage the vascular wall^[6]. Injury to the vascular intima triggers intrinsic coagulation system activation, promoting platelet aggregation and adhesion, increasing plasma fibrinogen and thrombin levels, and leading to thrombosis^[8].

3. Risk assessment for venous thromboembolism after bone tumor surgery

The Caprini Risk Assessment Model^[9] is used to classify patients into VTE risk categories: low risk (score < 2), moderate risk (score 2–3), and high risk (score > 3). This tool is an effective, simple, and cost-efficient method for predicting VTE risk and is applicable to all hospitalized patients, including those recovering from bone tumor surgery. It encompasses general patient characteristics, body mass index, VTE history, and other relevant factors, effectively addressing nearly all risk factors for DVT in hospitalized patients.

For patients undergoing bone tumor surgery, specific focus is placed on factors such as age, surgical type, duration of bed rest, obesity, abnormal pregnancies, use of oral contraceptives or hormone replacement therapy, bedridden medical conditions, history of inflammatory bowel disease, lower limb edema, varicose veins, severe pulmonary disease, impaired pulmonary function, acute myocardial infarction, congestive heart failure, sepsis, history of major surgery, and other high-risk conditions.

While other risk assessment tools exist, the Caprini model has unique advantages for bone tumor patients, offering more precise risk evaluations. It provides a robust foundation for healthcare professionals to implement targeted VTE prevention measures effectively.

4. Preventive measures for venous thromboembolism after bone tumor surgery

4.1. Pharmacological prevention

Common pharmacological agents for VTE prevention include low-molecular-weight heparin (LMWH), low-dose heparin, standard heparin, warfarin, dextran, and aspirin. LMWH, as an anticoagulant, functions by inhibiting coagulation factor activity. In patients recovering from bone tumor surgery, it suppresses the activities of coagulation factor Xa and thrombin, thereby preventing blood clotting and reducing VTE risk.

Rivaroxaban, a selective factor Xa inhibitor, directly blocks the active site of factor Xa in a dose-dependent manner, affecting prothrombin time and partial thromboplastin time without requiring antithrombin III. It has been shown to reduce the risk of VTE in elderly patients undergoing knee joint surgery for bone tumors. When combined with LMWH-based anticoagulation, rivaroxaban effectively lowers the postoperative VTE incidence in these patients^[10]. This combined approach provides a more optimal pharmacological prevention strategy, allowing for tailored treatments based on individual patient conditions and improving the effectiveness of VTE prevention.

4.2. Mechanical prevention

Mechanical devices for VTE prevention primarily include limb compression devices (intermittent or continuous) and compression stockings. In clinical practice, VTE is a critical postoperative concern for patients undergoing gynecologic cancer surgery. Studies have demonstrated^[11] that combining LMWH with compression stockings

for VTE prevention in this patient group offers significant advantages over using LMWH alone.

This combined approach not only reduces the incidence of postoperative VTE but also yields better results in improving coagulation function. Such findings provide a more scientific and effective strategy for postoperative VTE prevention in patients undergoing gynecologic malignancy surgery, enhancing postoperative recovery and minimizing adverse effects associated with VTE.

5. Nursing interventions for venous thromboembolism after bone tumor surgery

5.1. Preoperative nursing

Bone tumor surgeries are often high-risk and invasive, leading to significant patient anxiety and fear. In such cases, psychological intervention plays a crucial role, as stable mental states contribute to faster recovery, reduced pain, and higher compliance with rehabilitation training. Psychological support can improve patient adherence, helping them better manage surgical stress and cooperate with treatment and nursing care, ultimately promoting recovery and reducing complications ^[12].

Nurses should tailor psychological interventions based on the patient's mental state, education level, and socioeconomic status. They should provide detailed explanations about the surgery, including potential complications and procedures, to address patients' concerns, alleviate anxiety, and create favorable conditions for rehabilitation training ^[13]. Educating patients about the surgery prepares them mentally, reduces fear of the unknown, builds confidence in treatment, and encourages better cooperation with post-surgical care, such as adhering to rehabilitation exercises and dietary or activity restrictions.

5.2. Intraoperative nursing

Bone tumor surgeries combine the complexities of both oncological and orthopedic procedures, often involving prolonged surgery, extended limb immobilization, surgical trauma, vascular wall damage, significant blood loss, transfusions ^[14], and intraoperative oxygen desaturation ^[15], all of which increase the risk of venous thromboembolism (VTE).

During surgery, healthcare providers must closely monitor vital signs such as heart rate, blood pressure, respiration, and oxygen saturation. Any abnormalities, such as decreased oxygen saturation, should be promptly addressed by adjusting oxygen concentration or improving ventilation. Coordination between surgeons and nurses is essential to ensure gentle handling during surgical procedures, avoiding excessive traction or compression of blood vessels to minimize vascular damage.

For lengthy surgeries, intermittent leg massage can promote venous blood flow. For instance, nurses can gently massage the patient's lower limbs periodically to stimulate muscle activity and encourage blood circulation. Managing intraoperative blood loss is also critical, with timely transfusions as needed while monitoring for potential transfusion reactions. Additionally, VTE prevention strategies, such as administering low-molecular-weight heparin and using intermittent pneumatic compression devices, can be employed during surgery to facilitate venous blood flow and prevent thrombosis.

5.3. Postoperative nursing

Close monitoring of the patient's condition is vital after surgery, with vigilance for signs of pulmonary embolism (PE). Nurses should frequently inquire about symptoms such as shortness of breath, chest pain, or

coughing, which may indicate early-stage PE. If such symptoms arise, immediate notification of the physician for further examination and diagnosis is required. Monitoring vital signs, including heart rate, respiratory rate, blood pressure, and oxygen saturation, is also critical. Symptoms such as tachycardia, rapid breathing, hypotension, or reduced oxygen saturation may suggest PE.

Attention should also be paid to the condition of the lower limbs, as swelling, pain, changes in skin temperature, and discoloration may indicate deep vein thrombosis (DVT), a major risk factor for PE. Prompt intervention for DVT symptoms is necessary to prevent PE. Nurses must remain vigilant, routinely assessing patients for discomfort and tracking changes in their condition to mitigate risks ^[16].

For patients experiencing pain, nursing plans should focus on alleviating discomfort ^[17,18]. Professional pain assessment tools should be used to evaluate pain levels comprehensively, enabling the creation of individualized nursing plans. Mild pain may be addressed with non-pharmacological methods such as cold compresses, heat therapy, massage, and relaxation training to ease muscle tension and discomfort. For moderate to severe pain, pain-relief medications should be administered as prescribed, with nurses monitoring for adverse reactions such as nausea, vomiting, or dizziness and notifying the physician if necessary.

Psychological support can also help alleviate pain. By engaging in open communication, nurses can understand the patient's pain causes and experiences, offering emotional reassurance and support. They can encourage patients to adopt a positive mindset and distract themselves from pain with activities such as listening to music, watching TV, or reading, which can help reduce perceived pain levels.

6. Conclusion and future perspectives

The prevention and nursing care of venous thromboembolism (VTE) after bone tumor surgery are both critical and complex. An in-depth exploration of the pathogenesis reveals that hypercoagulability, hemodynamic changes, and vascular endothelial damage play key roles. Risk assessment tools like the Caprini scale enable healthcare professionals to identify high-risk patients effectively. Both pharmacological and physical prevention measures offer unique advantages. Nursing interventions are particularly significant in reducing VTE incidence and improving patient outcomes.

Looking ahead, large-scale, multicenter studies are needed. On the one hand, optimizing risk assessment models could enhance the precision of patient identification. On the other hand, efforts should focus on developing safer and more effective preventive medications, along with designing personalized nursing plans. These advancements will better address the challenges of postoperative VTE in bone tumor patients, ultimately improving their quality of life and survival rates.

Disclosure statement

The authors declare no conflict of interest.

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