

Clinical Research Progress of Perioperative Hidden Blood Loss in Elderly Patients with Femoral Intertrochanteric Fractures

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Abstract: Intertrochanteric fracture of femur is a common type of fracture in elderly patients with osteoporosis. At present, this fracture is mainly treated by surgery. With the advancement of medical technology, trochanteric fracture can be completed by minimally invasive intramedullary nailing in a short time and with low blood loss. With the popularization of this technique, many clinicians found that the decrease of hemoglobin after intertrochanteric fracture in elderly patients was not proportional to the amount of intraoperative bleeding, suggesting that there was a large amount of hidden blood loss in addition to intraoperative bleeding during perioperative period. Excessive blood loss affects the prognosis and even leads to patient death. It is also found that the patient's own health status, operation timing, preoperative use of anticoagulant drugs, fracture site, fracture type, anesthesia method, operation time, surgical internal fixation method and other factors are closely related to hidden blood loss, and blood transfusion, tranexamic acid, erythropoietin, iron, traditional Chinese medicine, pressure dressing, ice compress treatment, etc. are often used to treat hidden blood loss. Therefore, this article reviews the related research progress of hidden blood loss in elderly intertrochanteric fracture.

Keywords: Elderly; Intertrochanteric Fracture; Hidden Blood Loss; Influencing Factors; Treatment Measures; Review.

1. Introduction

With the aggravation of population aging speed and the huge population base of our country, the incidence of hip fracture in the elderly in our country shows a significant upward trend [1]. Intertrochanteric fracture of femur, as a common hip fracture disease in the elderly, accounts for about 40%~60% of hip fracture in the elderly [2]. At present, surgical internal fixation is the first choice for intertrochanteric fracture of femur in the elderly. However, perioperative complications seriously affect the prognosis of patients. Studies have shown that elderly patients with femoral intertrochanteric fracture have severe limitation of limb movement and many complications. The mortality rate at 12 months after operation is as high as 30%, and the mortality rate is higher in patients with underlying diseases [3]. Among many complications, hip fracture often leads to massive blood loss at the fracture site, which, combined with perioperative blood loss, increases the risk of perioperative anemia [4]. In 1973, Pattison [5] found that hemoglobin and hematocrit in postoperative reexamination decreased significantly compared with that before operation, and the actual bleeding volume during perioperative period was much higher than that observed during and after operation. Until 2000, this phenomenon of significant decrease in hemoglobin and hematocrit after operation, the degree of decrease was not consistent with the apparent blood loss, which was called "hidden blood loss" [6]. In 2006, Foss [7] found that the total blood loss after hip fracture surgery was six times that observed during surgery, significantly exceeding the blood observed and collected during and after surgery. hidden blood loss during perioperative period of intertrochanteric fracture is often hidden and difficult to detect, which brings many

serious complications and seriously jeopardizes patient prognosis [8]. This article reviews the history and present situation, mechanism, influencing factors and related treatment of hidden blood loss by reading a large number of literatures, and provides reference for the treatment of hidden blood loss in perioperative period of elderly femoral intertrochanteric fracture.

2. Mechanism of Hidden Blood Loss During Perioperative Period

After fracture, the fracture ends are exposed, the tightness of bone marrow cavity is destroyed, blood oozes from medullary cavity, and trochanteric fracture belongs to extracapsular fracture, lacking the blocking and protection of joint capsule. The oozed blood accumulates in tissue space and cannot participate in the effective circulation of the body and then be sent to the whole body. In a study, Erskine [9] found that blood enters tissue space and joint cavity to form ineffective circulation is the main cause of hidden blood loss. Sehat [6] found that extra-tissue blood accumulation accounted for about 60% of the total hidden blood loss during perioperative period. Because a large amount of blood accumulated in tissue space, patients with intertrochanteric fracture often suffered from limb swelling after operation. Some studies showed that [10] the swelling degree of affected limb was parallel to the hidden blood loss. The greater the hidden blood loss, the more swollen the affected limb. This also proved that blood infiltration into tissue space was one of the main mechanisms of hidden blood loss.

The studies of YUAN [11, 12] and BAO [13] showed that the mechanism of recessive blood loss may be related to erythrocyte damage caused by oxidative stress mediated by high serum concentration of free fatty acids. Through

simulation experiments on rats, they found that high concentration of arachidonic acid would cause erythrocyte damage through oxidative stress reaction, thus causing recessive blood loss. At the same time, surgical trauma, anesthesia and so on will lead to changes in the internal environment of the body, so that the body secretes a large number of oxygen free radicals, resulting in increased cell membrane permeability and cell swelling rupture, damage and change the structure of red blood cells, and finally cause hemolysis, resulting in hidden blood loss during perioperative period.

3. Calculation Method of Hidden Blood Loss

According to Nadler formula [14] (estimated blood volume EBV) = $K_1 \times \text{height}^3 \text{ (m)} + K_2 \times \text{weight (kg)} + K_3$, male patients $K_1=0.3669$, $K_2=0.03219$, $K_3=0.6041$, female patients $K_1=0.3561$, $K_2=0.03308$, $K_3=0.1833$. Note: Height (m), weight (kg). Total blood loss was calculated according to Gross equation [15] (total blood loss, TBL): $\text{TBL} = \text{EBV} \times (\text{preoperative HCT} - \text{postoperative HCT}) / \text{HCT mean}$, The mean $\text{HCT} = 1/2 \times (\text{preoperative HCT} + \text{postoperative HCT})$, hidden blood loss = $\text{TBL} + \text{transfusion volume} - \text{overt blood loss (intraoperative blood loss + postoperative drainage volume)}$. When the hemoglobin level of the body drops below 80g/L, the risk of hypoxia injury to various tissues and organs will increase. In this case, it is necessary to appropriately transfuse red blood cells for the patient. Clinically, 1U leukocyte-depleted red blood cells are transfused according to the standard of 200mL blood. Intraoperative blood loss is defined as the total amount of blood in the aspiration bottle during surgery minus the net weight added by the use of irrigation fluid and gauze dressings.

4. Influencing Factors of Perioperative Hidden Blood Loss

4.1. Preoperative Factors

The patient's predisposing factors With age increasing, muscle content of elderly patients decreases, soft tissues such as muscle fascia relax and atrophy, interstitial fluid decreases, vascular elasticity is poor, coagulation function is poor, so that the compensatory ability of elderly patients is worse than that of young people, blood loss can not be effectively adjusted, and often combined with multiple underlying diseases, hidden blood loss risk is greater. Wang [16] found that among the elderly patients who received intramedullary nail treatment, the postoperative hemoglobin of patients older than 75 years old was significantly lower than that of patients younger than 75 years old. Cui [17] found that age and bone mineral density were independent risk factors for occult blood loss in elderly patients with osteoporosis. The elderly often had osteoporosis and bone mineral loss in vivo. As a result, bone trabecula becomes sparse and cortical bone pores increase. When small blood vessels rupture during surgery, blood easily flows to surrounding loose soft tissues along tissue gaps, and these bleeds cannot be absorbed because they cannot enter the blood circulation in the body. Therefore, after fracture occurs in elderly patients with osteoporosis, bleeding is more likely to gather in femoral marrow cavity or surrounding tissues, resulting in hidden blood loss. Meanwhile, fracture healing in

elderly patients is slower after fracture occurs. This leads to continuous blood loss at the fracture end and intensifies hidden blood loss after surgery. Hypertension, diabetes and other internal diseases also affect postoperative blood loss. The patient's high blood pressure is difficult to control during surgery, resulting in large intraoperative blood loss and poor hemostatic effect. The wound also continues to ooze blood after surgery. Ge Hongqing [18] found that patients with hypertension have increased total blood loss and hidden blood loss. Diabetes patients, fracture and injury capillary healing time is relatively long, these are aggravated perioperative blood loss, therefore, hypertension, diabetes and other medical diseases are important factors of blood loss [19].

Timing of surgery After a trochanteric fracture, the fracture end continues to ooze blood, shortening the fracture to surgery time, delaying surgery will significantly reduce preoperative hemoglobin and increase bleeding volume. In one study [20], for unstable elderly trochanteric fractures, preoperative blood loss accounted for half of the total perioperative blood loss, and patients who performed surgery more than 5 days after fracture had lower HB and greater blood loss than patients who performed surgery within 5 days. Previous studies [21] have shown that emergency surgery (within 24 hours of injury) can shorten hospital stay, reduce complications and mortality. Therefore, early surgical treatment after elderly trochanteric fractures can reduce blood loss and improve prognosis.

Anticoagulant and antiplatelet drugs Elderly patients are prone to thromboembolism after long-term bed rest after fracture. Anticoagulant therapy is required before operation and even during the whole perioperative period, which increases the risk of bleeding. In the case-control study of Chechik [22] et al., the experimental group used aspirin, clopidogrel and other anticoagulant or antiplatelet aggregation drugs before operation, while the control group did not use them. The total blood loss of the former group was significantly higher than that of the latter group after operation.

The effect of fracture site on hidden blood loss When fracture occurs, the difference of tissue structure around fracture site is also an important factor leading to hidden blood loss Intra-articular fracture, such as femoral neck fracture, soft tissue such as joint capsule and ligament around femoral neck will have certain protective effect on oozing blood, so that blood loss is limited to joint capsule and further blood loss is avoided. Harper [23] found that preoperative blood loss and preoperative transfusion volume were significantly reduced in intracapsular hip fractures compared with extracapsular fractures. For fractures located in the trochanteric region, although muscle coverage and tendon attachment exist, the muscle and tendon are not completely attached to the bone surface, and there are muscle spaces, so oozing blood can still enter these spaces, resulting in the failure to form an effective barrier to protect blood loss at the fracture site. In addition, the muscle content of the elderly is reduced, and the protective effect on blood loss is further weakened. Studies [24] show that elderly patients with intertrochanteric fractures have more blood loss than femoral neck patients.

Fracture type Intertrochanteric fracture perioperative hidden blood loss is closely related to fracture type, unstable fracture than stable fracture blood loss significantly increased [25]. In the study of SMITH [26], the average blood loss and hidden blood loss can reach 253.35mL and 440.97mL for

simple fracture types, while the blood loss of irreducible intertrochanteric fracture and type A3 fracture is larger. In the study of Zhu Xiaozhong [27], hidden blood loss can reach 937mL and 706mL, but no matter how much hidden blood loss is, the proportion of hidden blood loss to total blood loss is similar [28]. About 80%.

4.2. Intraoperative Factors

Anesthesia In the study of Shi Shaohua [29] it was found that general anesthesia would lead to an increase in hidden blood loss, which was related to large area injury of vascular endothelial cells caused by general anesthesia, resulting in endothelial dysfunction. The long recovery time of general anesthesia would increase the risk of cardiovascular and cerebrovascular diseases, while spinal anesthesia could reduce the blood flow of local small blood vessels, increase the flow rate, reduce blood infiltration into tissue space, and thus reduce hidden blood loss. Therefore, appropriate and individualized anesthesia should be selected according to the actual condition of the patient in elderly trochanteric fracture surgery.

Internal fixation methods Internal fixation methods for intertrochanteric fractures mainly include extramedullary fixation and intramedullary fixation. Extramedullary fixation mainly includes dynamic hip screw (DHS), dynamic condylar screw (DCS) and percutaneous compression plate (PCCP) [30]. At present, intramedullary fixation methods such as interTan and PFNA are the mainstream methods for treating trochanteric fractures. Intramedullary nailing is a minimally invasive procedure that does not require a large surgical incision and does not require complete exposure of the fracture end compared to traditional extramedullary fixation. However, intramedullary nailing usually requires the establishment of a needle entry point at the apex of the greater trochanter, and then reaming is required to facilitate the insertion of the main nail. During reaming, bone marrow is damaged, resulting in blood loss. The resulting blood loss leaks from the gap between the intramedullary nail and the enlarged medullary cavity. Therefore, the hidden blood loss of intramedullary fixation is often greater than that of extramedullary fixation [31]. Some studies [32] show that although intramedullary nail surgery can effectively reduce the intraoperative overt blood loss, it still significantly increases the total perioperative blood loss, with an average of 937ml, of which 81.96% is hidden blood loss. Meanwhile, the length of intramedullary nail, the amount of reaming, the matching degree of medullary cavity and intramedullary nail diameter are all related to hidden blood loss.

Time of operation The longer the operation time, the greater the damage to medullary cavity, fracture end and soft tissue, and the greater the hidden blood loss. In the study of Lei Pengcheng [33], it was found that the extension of operation time would lead to the expansion of surgical trauma, which aggravated the soft tissue damage of patients. Meanwhile, the prolonged operation time consumed coagulation factors in patients' blood, which promoted coagulation mechanism disorder, thus affecting blood coagulation ability and increasing the risk of local hidden blood loss. Additionally, prolonged operative time is often associated with increased postoperative recovery time, which may result in patients requiring more supportive care postoperatively, thereby increasing the overall medical burden and risk of complications. Therefore, controlling intraoperative time and reducing secondary trauma can help

reduce perioperative blood loss.

5. Treatment of Hidden Blood Loss in Perioperative Period

Transfusion therapy The peak period of hidden blood loss after blood transfusion for treatment of femoral intertrochanteric fracture is often about 1-3 days after operation [34]. At this stage, the indicators such as red blood cells and hemoglobin of patients decrease greatly, and severe anemia symptoms are often seen, even life-threatening. Blood transfusion is the most direct and effective treatment measure. Transfusion of appropriate amount of isotype red blood cells can rapidly replenish blood volume and improve anemia symptoms. Therefore, Kearns [35] believes that blood transfusion should be performed when the postoperative hemoglobin is lower than 90g/L or when there are other cardiovascular diseases before operation and the hemoglobin is lower than 100g/L. Blood routine tests should also be reviewed regularly after surgery, and blood indicators should be closely monitored. Dynamic changes and timely formulation of corresponding plans.

Hemostatic drug therapy Tranexamic acid, a synthetic derivative of lysine, competitively inhibits plasminogen activation of serine protease by binding to the Kringle domain, resulting in inhibition of plasminogen activation and fibrin binding to plasminogen by blocking the lysine binding site of plasminogen, thereby reducing fibrinolysis and achieving hemostasis [36]. In a large randomized controlled study [37], tranexamic acid has a good hemostatic effect on patients, can reduce perioperative blood loss, and significantly reduce the risk of death in patients with hemorrhagic trauma. Based on this property of tranexamic acid, and the use of fewer complications, tranexamic acid is widely used in the treatment of perioperative blood loss in various operations [38]. In addition, another study [39] showed that intravenous TXA combined with intramedullary nailing in elderly patients with intertrochanteric fractures significantly reduced total blood loss and hidden blood loss, while also reducing transfusion rates and volumes without increasing the risk of thrombotic events or mortality. Early repeated intravenous injections of TXA, especially in patients injured within 24 hours, are effective and safe in reducing perioperative hidden blood loss in elderly patients with intertrochanteric fractures [40].

Treatment by chinese herbs At present, tranexamic acid is commonly used in clinical treatment to prevent and treat postoperative hidden blood loss. In recent years, traditional Chinese medicine has made progress in the treatment of perioperative hidden blood loss. Liu Hongchen [41] believe that Danggui Buxue Decoction can significantly reduce inflammatory indicators, relieve pain and promote postoperative healing when used to treat inflammation after knee and hip replacement, and has good clinical application value. Xie Qing [42] believed that Danggui Buxue Decoction combined with intramedullary nail had a definite effect on the treatment of occult blood loss of intertrochanteric fracture in the elderly, which could alleviate anemia symptoms, promote hip joint recovery and reduce complications. In a study [43], conventional treatment combined with Yiqi Buxue Decoction, Yangxue Rougan Decoction, Sanqi Powder and other traditional Chinese medicines had obvious effect on the improvement of postoperative hemoglobin (Hb); conventional treatment plus Siwu Decoction could effectively

reduce the amount of hidden blood loss after surgery.

Erythrogen, iron Hidden blood loss after surgery is often accompanied by loss of iron, resulting in a lack of an important element for synthesizing hemoglobin. In the study of Liang Dingtian [44], oral administration of ferrous lactate to patients with intertrochanteric fracture can effectively reduce postoperative hidden blood loss and contribute to early postoperative rehabilitation of patients. Zhu Yun [45] used erythropoietin combined with iron to treat intertrochanteric fractures, and found that the combination of the two could reduce postoperative blood loss and blood transfusion rate without increasing the incidence of infection and venous thrombosis of lower limbs.

Physiotherapeutics Pressure bandaging and cold compress are widely used to reduce soft tissue oozing. Pressure bandage can help vasoconstriction and reduce blood outflow by applying a certain pressure, thus effectively reducing the oozing volume of soft tissue. Research shows that [46], appropriate pressure can improve local blood circulation and help absorb hematoma. Meanwhile, pressure bandage can make surrounding tissues fit well according to anatomical structure and fill the defect position, forming external fixation effect, eliminating potential lacunae and effectively reducing blood accumulation. Reduce hidden blood loss. Cold compress therapy is to apply physical factors lower than human body temperature to stimulate the body to achieve cooling, pain, hemostasis and reduce inflammatory edema and exudation. Zhan Xuehua [47] believes that local cold compress can cause the temperature drop of skin, subcutaneous and muscle tissue, and can also stimulate the skin cold receptor, cause vasoconstriction, reduce peripheral blood flow and change vascular permeability, which helps to reduce blood exudation and exudation, and indirectly achieve the purpose of reducing blood loss; In addition, cold compress treatment can reduce the oxygen consumption in tissue metabolism, inhibit the generation of tissue fluid and lymph, and promote congestion and edema regression.

6. Summary

Hidden blood loss often occurs in elderly patients with femoral intertrochanteric fracture after operation. hidden blood loss is harmful and must be paid attention to. At the same time, hidden blood loss is related to many factors, such as age, hypertension, diabetes, preoperative anemia, fracture site, fracture type, operation mode, anesthesia mode, operation time, etc. During hospitalization, hidden blood loss should be discovered in time, and blood transfusion, tranexamic acid infusion for hemostasis or erythropoietin, iron and other drugs to promote erythropoiesis should be given in time. Therefore, the health status of elderly patients with fracture should be comprehensively evaluated after admission and before operation. Minimize the trauma and operation time during operation, closely monitor the changes of blood volume after operation and treat in time.

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