An analysis of perioperative hidden blood loss in femoral intertrochanteric fractures: Bone density is an important influence factor

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Research article

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Abstract

[Background] To explore the influencing factors of perioperative hidden blood loss of intertrochanteric fractures. [Method] We undertook a retrospective analysis from January 2016 to October 2019. Clinical data of 118 patients with intertrochanteric fractures was included in. Hidden blood loss was calculated from the hematocrit changes before and after surgery, using the Gross equation, based on height, weight, and hematocrit (HCT) changes before and after surgery. Patients’ gender, age, presence of underlying diseases (hypertension and diabetes), fracture types, anesthesia methods, time from injury to surgery, whether to take antiplatelet drugs within 6 months before surgery, use of anticoagulant drugs after surgery, bone density were statistically analyzed. The factors with statistical significance were screened out. And then the hidden blood loss was used as the dependent variable and each influencing factor was the independent variable. Multivariate linear regression analysis was used to analyze the related risk factors that affect the hidden blood loss during the perioperative period of intertrochanteric fractures.

[Result] The apparent blood loss during operation was (203.81 ±105. 51) ml, and the hidden blood loss was (517.55±191.47) ml. There were significant differences in the hidden blood loss of patients with different fracture types, anesthesia methods, antiplatelet or postoperative anticoagulant drugs, and different bone density(P<0.05). Multiple linear regression analysis showed that internal fixation, age, fracture type, anesthesia method, anticoagulant application, and bone density were related risk factors that affected hidden blood loss during surgical treatment of intertrochanteric fracture.

[Conclusion] Hidden blood loss is the main cause of perioperative blood loss in intertrochanteric fractures, and the risk factors for hidden blood loss include internal fixation, fracture type, anesthesia, use of anticoagulant drugs. Specially, we found bone density was a risk factor for hidden blood loss. It is not reliable to use the apparent blood loss as the basis for fluid replacement and transfusion. We must fully consider the existence of hidden blood loss and intervene as soon as possible to prevent complications.

Background

As aging of population, the average life expectancy increases, and the opportunities to participate in outdoor activities increase, the incidence of femoral intertrochanteric fracture is also increasing. Intertrochanteric fracture has becomes an universal hip fracture among the elderly[1]. In recent years, operation is the mostly treatment for femoral intertrochanteric fracture[2]. During the surgery, loss of blood is inevitable. In the past, the dominant blood loss during operation has been paid great attention to in clinical practice. While the existence of hidden blood loss perioperative has been neglected. However, the hemoglobin level of patients after operation has a great relationship with the hidden blood loss[3]. At present, there are increasing reports about the influencing factors of occult blood loss perioperative, but most of these reports are not comprehensive, especially the relationship between bone density and hidden blood loss. Therefore, we carried out this retrospectively study. From January 2016 to October 2019, 118 patients with intertrochanteric fractures were included. Gross equation was used to calculate
the hidden blood loss under different factors. By this study, we explore the influence factors of hidden blood loss perioperative. Thought to provide the reference of clinical treatment.

**Methods**

1) General information

From January 2016 to October 2019, 118 patients with intertrochanteric fractures treated in Hai’an People’s Hospital were included. Inclusion criteria was: (1) fresh intertrochanteric fractures without multiple fractures or pathological fractures; (2) no previous blood disease history, and normal coagulation function of preoperative test; (3) blood routine examination was done preoperatively and on day 2 and day 3 postoperatively. A total of 118 patients, 57 males and 61 females, met the inclusion criteria. The age distribution of patients: 31 cases < 60 years old, 87 cases ≥60 years old. There were 58 stable fractures and 60 unstable fractures. Anesthesia method: 47 cases got general anesthesia and 71 cases got intraspinal anesthesia. Sixty-four patients were treated with anticoagulant drugs. There were 57 patients with hypertension and 60 patients with diabetes. During bone density subgroup analysis, the included patients were divided into three groups according to the criteria recommended by WHO for the diagnosis of osteoporosis: the group with normal bone density (T-value > -1.0), the osteopenia group (-2.5< T-value < -1.0), and the osteoporosis group (T-value < -2.5).

2) Detection index

Hidden blood loss = total blood loss - apparent blood loss + transfusion. Patient blood volume (PBV) =K1× height (h) +K2× weight (Kg) +K3. For men, K1, k2 and k3 were 0.3669, 0.03219 and 0.6041 respectively. For women K1, k2 and k3 were 0.3561, 0.03308, and 0.1833[4]. Total RBC loss = preoperative blood volume (PBV) × (preoperative HCT- postoperative HCT). Total theoretical blood loss = total red blood cell loss / preoperative HCT. Actual perioperative blood loss = hidden blood loss + apparent blood loss. For patients requiring blood transfusions, 1 microliter of concentrated red blood cell suspension is equivalent to 200 ml of standard red blood cell volume.

3) Statistical analysis methods

SPSS 13.0 software was used for analysis. Statistical analysis was carried out on the variables of patients’ gender, age, weight, bone density, underlying diseases (hypertension, diabetes), fracture type, internal fixation method, anesthesia method, use of anticoagulant medication, etc. The risk factors were analyzed by multiple linear regression analysis with the hidden blood loss as the dependent variable and the influencing factors as the independent variables. P < 0.05 was statistically significant.

Results
1) Blood loss

The intraoperative apparent blood loss was (203.81 ± 105.51) ml, while the hidden blood loss was (517.55 ± 191.47) ml.

2) Comparison of hidden blood loss under different factors

The perioperative hidden blood loss of patients with femoral intertrochanteric unstable fractures was significantly higher than that of patients with stable fractures (P < 0.05). The hidden blood loss of patients using general anesthesia was significantly higher than patients with spinal canal anesthesia (P < 0.05). Hidden blood loss of patients using anticoagulant drugs was also significantly higher than the no users (P < 0.05). Hidden blood loss of patients no younger than 60 years old was significantly higher than patients younger than 60 years (P < 0.05). Specially, patients with osteoporosis had significantly higher hidden blood loss than patients of normal bone density and osteopenia patients (P < 0.05). (Table 1)

Table 1 Comparison of hidden blood loss under different factors (X±s)
| variable                | The number of cases | Hidden blood loss   | T/F   | P     |
|------------------------|--------------------|---------------------|-------|-------|
| gender                 |                    |                     |       |       |
| male                   | 57                 | 529.28±193.17       |       |       |
| female                 | 61                 | 506.48±190.79       | 0.648 | 0.518 |
| age                    |                    |                     |       |       |
| ≥60                    | 87                 | 531.49±188.37       |       |       |
| <60                    | 31                 | 413.98±188.98       | 2.190 | 0.030 |
| Time of operation      |                    |                     |       |       |
| ≥3h                    | 78                 | 511.37±188.37       |       |       |
| <3h                    | 40                 | 529.58±200.87       | -0.487| 0.627 |
| The fracture types     |                    |                     |       |       |
| stable                 | 58                 | 437.97±164.04       |       |       |
| unstable               | 60                 | 536.84±163.26       | -3.059| 0.003 |
| anesthesia             |                    |                     |       |       |
| General anesthesia     | 47                 | 596.20±177.26       |       |       |
| Intraspinal anesthesia | 71                 | 465.48±183.64       | -3.838| 0.000 |
| hypertension           |                    |                     |       |       |
| yes                    | 60                 | 530.90±194.70       |       |       |
| no                     | 58                 | 503.74±188.75       | 0.769 | 0.443 |
| diabetes               |                    |                     |       |       |
| yes                    | 57                 | 527.35±202.12       |       |       |
| no                     | 61                 | 508.39±182.16       | 0.536 | 0.593 |
| Bone mineral density   |                    |                     |       |       |
| normal                 | 23                 | 391.43±145.44       |       |       |
| osteopenia             | 46                 | 497.42±181.97       |       |       |
| osteoporosis           | 49                 | 595.63±185.44       | 10.895| 0.000 |
| Use of anticoagulants  |                    |                     |       |       |
| yes                    | 64                 | 559.17±190.16       |       |       |
| no                     | 54                 | 468.22±182.68       | -2.635| 0.010 |
BMI

|       |       |       |
|-------|-------|-------|
| ≥28   | 46    | 500.39±178.38 |
| <28   | 72    | 528.51±199.83  | -0.777   | 0.439 |

3) Analysis of risk factors affecting hidden blood loss

Multiple linear regression analysis was conducted with the hidden blood loss as the dependent variable and the influencing factors as the independent variables. The results showed that fracture type, anesthesia mode, use of anticoagulant drugs, age and bone mineral density were the risk factors affecting the perioperative hidden blood loss of patients with intertrochanteric fractures (P < 0.05). (Table 2)

Table 2 Analysis of the risk factors affecting the hidden blood loss

| Affecting Factors       | Unstandardized Coefficients | Standard error | Standardized Coefficients | t    | P     |
|-------------------------|-----------------------------|----------------|---------------------------|------|-------|
| gender                  | 0.029                       | 0.021          | 0.027                     | 1.380| 0.170 |
| age                     | 0.044                       | 0.015          | 0.058                     | 1.958| 0.034 |
| Time of operation       | -0.476                      | 0.501          | -0.059                    | -0.951| 0.344 |
| The fracture types      | 1.794                       | 0.194          | 0.427                     | 9.242| 0.000 |
| anesthesia              | 0.633                       | 0.024          | 0.493                     | 25.938| 0.000 |
| hypertension            | 0.002                       | 0.220          | 0.000                     | 0.010| 0.992 |
| diabetes                | 0.023                       | 0.055          | 0.014                     | 0.427| 0.670 |
| Bone mineral density    | -0.622                      | 0.032          | -0.482                    | -19.537| 0.000 |
| Use of anticoagulants   | -0.014                      | 0.004          | -0.059                    | -3.212| 0.002 |
| BMI                     | 0.001                       | 0.010          | 0.002                     | 0.099| 0.922 |

Discussion

Femur intertrochanteric fractures have a high incidence in the elderly population, and most of them are comminuted fractures. Operation is the preferred clinical treatment, which can not only effectively treat,
but also significantly reduce the complications caused by long-term bed rest. There are mainly two kinds of surgical treatment: extramedullary fixation and intramedullary fixation. And intramedullary fixation seems better. It is mainly reflected in the following aspects: (1) the arm of force is short, torque is small, and it's biomechanically stable; (2) minimally invasive operation, small incision and less intraoperative blood loss; (3) the fracture end does not need to be exposed, causing less damage to the periosteum and soft tissues, which can make the fracture heal better. Therefore, intramedullary fixation is becoming the preferred method in the surgical treatment of intertrochanteric fractures.

Perioperative blood loss may lead to many complications and poor prognosis. It also increases the incidence of infection and deep vein thrombosis. The patient's mortality rate also increases. Therefore, in the treatment of intertrochanteric fractures, it is important to find the causes of perioperative blood loss. Hidden blood loss accounts for a high percentage of total perioperative blood loss in patients with intertrochanteric fractures. If the presence of hidden blood loss is not paid attention to, it will often lead to anemia or low blood volume in patients, which will affect the postoperative recovery and even cause serious consequences. At present, the biological mechanism of hidden blood loss has not been clearly studied. And the existing researches believe that the causes of hidden blood loss mainly include the following aspects: 1) when the blood enters the tissue or the joint cavity, it no longer participates in the humoral circulation⁵, 2) red blood cell hemolysis caused by injury. Some stress during the operation, such as trauma and anesthesia, may lead to changes of the blood internal environment, red blood cell peroxidation damage, red blood cell damage in the process of autologous blood transfusion and other factors may cause hemolysis, thus making the hidden blood loss more serious. 3) gastrointestinal stress ulcer caused by trauma and surgery will also cause the occurrence of hidden blood loss.

In this study, factors affecting perioperative hidden blood loss in patients with intertrochanteric fractures were analyzed. And it was found that unstable fractures, advanced age, osteoporosis and general anesthesia were independent risk factors for increasing hidden blood loss. The form and mechanism of fracture injury determine the degree of comminution and the degree of damage to the surrounding soft tissue. That is to say, it determines the type of fracture. Patients with different degrees of injury also have some differences in blood loss, which indicates that there is a certain correlation between the amount of hidden blood loss and the type of fracture. Some investigators found significant differences in mean hemoglobin decrease between patients with intra and extracapsular fractures. Kumar et al. also observed significant differences in the amount of hidden blood loss in patients with different fracture types⁶. Some researchers found hidden blood loss of patients with Evans Ⅰ, Ⅱ type of fractures was significantly lower than Ⅰ, Ⅱ type. The results of this study showed that the hidden blood loss of patients with unstable fractures was significantly higher than patients with stable fractures. All the above studies have shown that there is a certain correlation between fracture type and hidden blood loss. So we should pay attention to the review of patients' blood routine and take timely blood transfusion during treatment.

The selection of anesthesia, the use of anticoagulant drugs and the age are also key factors affecting the perioperative hidden blood loss. It has been reported that the amount of hidden blood loss is significantly higher in patients under general anesthesia than those under epidural anesthesia. This may
be related to the fact that the antifibrinolysis ability of patients under general anesthesia is lower than that of patients under epidural anesthesia\(^7\). During the treatment of lower limb surgery patients, a certain amount of anticoagulant drugs will be used in order to prevent the formation of venous thrombosis. So the amount of hidden blood loss will also increase. In patients with total hip replacement, researchers found that the amount of hidden blood loss in patients older than 70 was significantly higher than patients younger than 70\(^8\). In this study, the amount of hidden blood loss was significantly higher in patients over 60 years old than in patients under 60 years. The reason may be that the older has a significant reduction in the function of cardiovascular system, blood vessels occur hyaline degeneration, and muscle atrophy. All of these factors can cause the decline in body's regulation ability. This makes the organization clearance fluid fail to supplement of blood circulation quickly. Finally, it increases the hidden loss of blood. The effect of gender on the amount of hidden blood loss is still controversial. Most researchers believe that there is no significant difference between male and female patients with intertrochanteric femur fracture\(^9\). However, still some researchers believe that there are significant differences in the amount of hidden blood loss between different genders\(^10\). The results of our study indicate that gender is not a risk factor for hidden blood loss, which is consistent with most reports.

At present, there are few reports on the effect of bone density on perioperative blood loss in patients with intertrochanteric fractures. In our study, there were significant differences in the amount of hidden blood loss between groups with different bone mineral density. This may because that for patients with low bone density, bone trabeculae become thin, and some even fracture. Osteoporosis may cause the enlargement of bone marrow space, the appearance of micropores and cancellation of bone cortex, and the enlargement of periosteal pores, cortical pores, and endosteum pores. As a result of the above changes, when the blood vessels are damaged after bone fracture, the blood entering the medullary cavity is more likely to flow into the surrounding tissues, resulting in local hematoma around the bone. Finally, it increases the amount of blood loss during the perioperative period. In addition, osteoporosis patients are generally older, the body's self-regulation ability is weakened, vascular elasticity is poor, which also increases the risk of hidden blood loss. In order to explore whether osteoporosis can lead to changes in hematopoietic function in the body, some researchers made a mouse model of osteoporosis and conducted a study. The results showed that with the decrease of bone density in the body, hematopoietic function gradually decreased. And the results showed that osteoporosis can cause the weakening of hematopoietic function in the body\(^11\). Therefore, it was speculated that the hematopoietic function of patients with osteoporosis was also weak, and the compensatory ability of the body was also relatively poor after the operation. This resulted in the low value of Hb and HCT in the patients after the operation. So we might measure more hidden blood loss during the perioperative period for osteoporosis patients. For this reason, we should assess the bone density of the patient before surgery according to the imaging examination and the patient's medical history. Once the diagnosis of osteoporosis is made, anti-osteoporosis treatment should be initiated. Strengthen the monitoring and management of the hidden blood loss in the perioperative period of osteoporosis patients, and making reasonable intervention to osteoporosis, can together accelerate the postoperative recovery of patients.
Conclusions

In summary, in clinical intertrochanteric fracture surgery, the index of hidden blood loss should be taken seriously. And the risk factors affecting the hidden blood loss should be positively evaluated before the surgery, so as to adopt appropriate prevention and treatment plans. The blood routine should be dynamically monitored during the perioperative period. However, there are also shortcomings in this study: the time span of each patient existed differences, and the standards of some influencing factors might be different. Other potential factors such as ASA grade and other complications were not included in the study. The cases were from multiple doctors and there might be differences during surgery.

Declarations

Ethics approval and consent to participate

This is a retrospective study. We declare that it does not need Ethics approval and consent to participate. For randomized controlled study, we need ethics approval to treat patients. But for retrospective study, we just collect and analyze the past clinical data. So we do not need ethics approval.

Consent for publication

All authors agree to published.

Availability of data and material

We can provide data if needed.

Competing interests

We have no financial and personal relationships with other people or organizations that can inappropriately influence our work. There are no competing interests. We declare that no other IRB approval was required in this study.

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Authors' contributions

HC and SL: operations, imaging assessment.

CY and KC: follow-up, data analysis, manuscripts writing.

We declare that all authors have read and approved the manuscript.
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