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

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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 the population ages, the incidence of femoral intertrochanteric fracture is increasing. Indeed, intertrochanteric fracture has become the most prevalent type of hip fracture among elderly individuals[1]. At present, surgery is the most common treatment for femoral intertrochanteric fracture[2]. During surgery, loss of blood is inevitable. In the past, dominant blood loss during operations has received great attention in clinical practice. However, the existence of perioperative hidden blood loss has been neglected frequently. However, the haemoglobin level of patients after surgery has a great influence on hidden blood loss[3]. At present, an increasing number of studies have focused on the influencing factors of hidden blood loss perioperatively. However, most of these reports are not comprehensive, especially with respect to the relationship between bone density and hidden blood loss. Therefore, we carried out this retrospective study to explore the influencing factors of hidden blood loss perioperatively

and thereby provide a reference for clinical treatment. From January 2016 to October 2019, 118 patients with intertrochanteric fractures were included. The gross equation was used to calculate the hidden blood loss under different factors. In this study, we widely explored the influencing factors of hidden blood loss perioperatively to provide a reference for clinical treatment.

Methods

1) General information

From January 2016 to October 2019, 118 patients with intertrochanteric fractures treated at Hai'an People's Hospital were included. The inclusion criteria were as follows: (1) fresh intertrochanteric fractures without multiple fractures or pathological fractures; (2) no previous blood disease history and normal coagulative function on the preoperative test; and (3) routine blood examination performed preoperatively and on days 2 and 3 postoperatively. A total of 118 patients, 57 males and 61 females, met the inclusion criteria. The age distribution of patients was as follows: 31 patients < 60 years old and 87 patients ≥60 years old. There were 58 stable fractures (Evans type I, II) and 60 unstable fractures (Evans type III, IV)[4]. Anaesthesia method: Forty-seven patients received general anaesthesia, and 71 patients received intraspinal anaesthesia. Sixty-four patients were treated with anticoagulant drugs. There were 57 patients with hypertension and 60 patients with diabetes. All patients underwent dual energy X-ray absorptiometry to test their bone density before surgery. During the bone density subgroup analysis, the included patients were divided into three groups according to the criteria recommended by the 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, respectively[5]. Total red blood cell (RBC) loss = preoperative blood volume (PBV) × (preoperative HCT- postoperative HCT). Total theoretical blood loss = total RBC loss/preoperative HCT. Actual perioperative blood loss = hidden blood loss + apparent blood loss. Apparent blood loss = intraoperative blood loss + volume of drainage. For patients requiring blood transfusions, 1 microlitre of concentrated RBC suspension is equivalent to 200 ml of standard RBC volume.

3) Statistical analysis methods

SPSS 13.0 software was used for analysis. A statistical analysis was carried out on the variables of patient gender, age, weight, bone density, underlying diseases (hypertension, diabetes), fracture type, internal fixation method, anaesthesia method, use of anticoagulant medication, etc. The risk factors were analysed by multiple linear regression analysis, with hidden blood loss as the dependent variable and influencing factors as the independent variables. $P < 0.05$ was considered 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 greater than that of patients with stable fractures (P < 0.05). The hidden blood loss of patients using general anaesthesia was significantly greater than that of patients with spinal canal anaesthesia (P < 0.05). The hidden blood loss of patients using anticoagulant drugs was also significantly greater than that of the non-users (P < 0. 05). The hidden blood loss of patients equal to or older than 60 years old was significantly greater than that of patients younger than 60 years (P < 0.05). Specifically, patients with osteoporosis had significantly greater hidden blood loss than patients with normal bone density and osteopenia (P < 0.05). (Table 1)

Table 1 Comparison of hidden blood loss under different factors (X±s)

Variable	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 (years)				
≥60	87	531.49±188.37		
60	31	413.98±188.98	2.190	0.030
Time of the operation				
3 h	78	511.37±188.37		
	40	529.58±200.87	-0.487	0.627
Fracture type				
stable	58	437.97±164.04		
unstable	60	536.84±163.26	-3.059	0.003
Anaesthesia				
general anaesthesia	47	596.20±177.26		
intraspinal anaesthesia	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 hidden blood loss as the dependent variable and influencing factors as the independent variables. The results showed that fracture type, anaesthesia mode, use of anticoagulant drugs, age and bone mineral density affected the perioperative hidden blood loss of patients with intertrochanteric fractures (P < 0.05). (Table 2)

Table 2 Analysis of the risk factors affecting 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 the operation	-0.476	0.501	- 0.059	-0.951	0.344
Fracture type	1.794	0.194	0. 427	9.242	0.000
Anaesthesia	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 these fractures are comminuted. Displacement is a factor negatively affecting the outcome of intertrochanteric fractures[6]. Currently, surgery is the preferred clinical treatment method for intertrochanteric fractures, with satisfactory curative effects and low complication rates[6]. There are mainly two kinds of surgical approaches: extramedullary fixation and intramedullary fixation. Intramedullary fixation is becoming the preferred method for the surgical treatment of intertrochanteric fractures. Regarding the outcomes and complications of femoral intertrochanteric fractures, the fracture type, blood loss, operation, level of irisin hormone and presence of a pseudoaneurysm are important influencing factors[7,8].

Perioperative blood loss may lead to many complications and a poor prognosis[9]. Such loss also increases the incidence of infection and deep vein thrombosis. Moreover, the patient's mortality rate rises[9]. Therefore, to improve the efficacy of treatment, it is important to identify the causes of perioperative blood loss. Hidden blood loss accounts for a high percentage of the total perioperative blood loss in patients with intertrochanteric fractures. If the presence of hidden blood loss is not considered, it will often lead to anaemia or low blood volume in patients. This will affect postoperative recovery and even cause serious consequences. At present, the biological mechanism of hidden blood loss has not been clearly studied. The existing studies report that the causes of hidden blood loss include the following aspects: 1) blood that enters the tissue or the joint cavity and thus no longer participates in the humoral circulation[10] and 2) RBC haemolysis caused by injury. Some stressful events that occur during the operation, such as trauma and anaesthesia, may lead to changes in the internal blood environment and subsequent RBC peroxidation damage. On the other hand, RBC damage during the

process of autologous blood transfusion and other factors may cause haemolysis, thus making hidden blood loss more serious. 3) Gastrointestinal stress ulcers caused by trauma and surgery will also cause hidden blood loss.

In this study, factors affecting perioperative hidden blood loss in patients with intertrochanteric fractures were analysed. We found that unstable fractures, advanced age, osteoporosis and general anaesthesia 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, it determines the type of fracture. Patients with different degrees of injury also exhibit 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 have found significant differences in the mean haemoglobin decrease between patients with intra- versus extracapsular fractures. Kumar et al. observed significant differences in the amount of hidden blood loss in patients with different fracture types[11]. Some researchers found that the hidden blood loss in patients with Evans □ and □ type fractures was significantly lower than that in patients with □ and □ type fractures. They also found that there was a relationship between mean platelet volume and reoperation occurrence[4]. The results of our study showed that the hidden blood loss in patients with unstable fractures was significantly higher than that in patients with stable fractures, which confirms present research. It seems that there is a certain correlation between fracture type and hidden blood loss[12-15]. Therefore, we should pay attention to reviewing patients' routine blood tests and take timely blood transfusions during treatment for complicated fracture types.

In our study, we found that the selection of anaesthesia, the use of anticoagulant drugs and age are also key factors affecting perioperative hidden blood loss. It has been reported that the amount of hidden blood loss is significantly higher in patients under general anaesthesia than in those under epidural anaesthesia. This may be related to the fact that the antifibrinolytic ability of patients under general anaesthesia is lower than that of patients under epidural anaesthesia[16]. During the treatment of lower limb surgery patients, a certain amount of anticoagulant medication will be used to prevent the formation of venous thrombosis. Thus, the amount of hidden blood loss will also increase. In terms of age, in patients with total hip replacement, researchers found that the amount of hidden blood loss in patients older than 70 years was significantly higher than that in patients younger than 70 years[17]. In our study, the amount of hidden blood loss was significantly higher in patients over 60 years old than in patients under 60 years old. The reasons may be that older adults have a significantly reduced function of the cardiovascular system, their blood vessels undergo hyaline degeneration, and muscle atrophy is present. All of these factors can cause a decline in the body's regulatory ability. This makes the organized clearance of fluid fail to supplement the blood circulation quickly, and finally, 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[18]. The results of our study indicate that gender is not a risk factor for hidden blood loss, which is consistent with most reports. In addition, some researchers believe that there are significant differences in the amount of hidden blood loss between different internal fixators, such as proximal

femoral nail antirotation and the dynamic hip screw[19,20]. Some investigators also undertook studies regarding the time of occurrence of hidden blood loss. They found that hidden blood loss occurred just after injury and ended on postoperative day 2[21, 22].

At present, there are few reports on the effect of bone density on perioperative blood loss in patients with intertrochanteric fractures. In our study, we found significant differences in the amount of hidden blood loss between groups with different bone mineral densities. This may be because, in patients with low bone density, the bone trabeculae become thin, and some even fracture. Osteoporosis may cause enlargement of the bone marrow space; the appearance of micropores and cancellation of the 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, blood entering the medullary cavity is more likely to flow into the surrounding tissues, resulting in a local haematoma around the bone and, finally, increasing the amount of blood loss during the perioperative period. In addition, patients with osteoporosis are generally older, their body's self-regulation ability is weakened, and their vascular elasticity is poor, which can also increase the risk of hidden blood loss. We should assess the bone density of each patient before surgery according to the imaging examination and the patient's medical history. Once the diagnosis of osteoporosis is made, anti-osteoporosis treatment is suggested to be initiated. Strengthening the monitoring and management of hidden blood loss in the perioperative period of osteoporosis patients and performing reasonable interventions for osteoporosis can together accelerate the postoperative recovery of patients.

The advantages of this study are that bone density is an important influencing factor. This might affect the clinical strategy for intertrochanteric bone fracture. For example, for osteoporosis patients, we should improve their bone density to avoid more hidden blood loss. The limitations of this study are as follows: the time span of each patient was different, and the standards for some influencing factors might be different. Other potential factors, such as American Society of Anesthesiologists (ASA) grade and other complications, were not included in the study. The cases were obtained from multiple doctors, and there might have been differences during surgery.

Conclusion

Hidden blood loss is the main cause of perioperative blood loss in intertrochanteric fractures. The risk factors for hidden blood loss include internal fixation, fracture type, anaesthesia, and use of anticoagulant drugs. Specifically, we found that bone density was a risk factor for hidden blood loss. It is not reliable to use 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.

Declarations

Ethics approval and consent to participate: Not applicable

Consent to publish: Yes

Availability of data and materials: Author Haidong Cui can provide original data upon reasonable request. His email is 2036126481@qq.com.

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