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To compare perioperative hidden blood loss in the treatment of femoral intertrochanteric fractures with percutaneous compression plate (PCCP) and proximal femoral nail anti-rotation (PFNA) in elderly patients, and analyse its influencing factors in order to provide the necessary data support for clinical perioperative treatment, and choice of appropriate internal fixation method. Retrospective analyses was carried out on data obtained from 158 patients with intertrochanteric fracture treated with PCCP or PFNA from January 2010 to May 2017. Data were obtained from variables such as age, gender, height, weight, operative bleeding and postoperative drainage, operation time, etc. Upon blood routine examination before and after surgery (RBC, Hb and Hct), total and hidden blood losses were calculated using Gross equations. A comparative analysis was carried out on the differences in hidden blood loss, postoperative complications and prognosis between PCCP and PFNA. Visible blood loss was higher in PCCP than in PFNA, but total and hidden blood losses were significantly lower in PFNA ($P < 0.05$). Within the two groups, hidden blood loss in elderly patients was significantly higher ($P < 0.05$). Start time of weight-bearing of PCCP group was significantly longer than of PFNA group ($P < 0.05$), but incidences of complications of important organs and perioperative mortality in PCCP group were significantly lower than those of PFNA group ($P < 0.05$). There were no significant differences in operation time, infection of incision, failure of internal fixation, fracture healing time, or Harris function score of half year after operation between the two groups ($P < 0.05$). There is serious hidden blood loss before and after operation in elderly patients with femoral intertrochanteric fractures, of which intramedullary fixation is higher. Intramedullary fixation causes more severe complications of important organs than extramedullary fixation.

Key words: Percutaneous compression plate, proximal femoral anti-rotation nail, femoral intertrochanteric fractures, hidden blood loss.

INTRODUCTION

With an aging society, the incidence of femoral Intertrochanteric fractures (the most common type of hip fracture) is on the increase (Yu et al., 2015). In order to reduce the occurrence of complications caused by being bedridden and malunion after fracture, early surgical

treatment has become the consensus of orthopedic surgeons (Bao et al., 2016). Dynamic hip screw (DHS) and proximal femoral nails (PFN) are commonly used internal fixing instruments. However, they are often associated with complications and failure in elderly patients. In recent

years, percutaneous compression plate (PCCP) and proximal femoral anti-rotation nail (PFNA) have been developed to minimize the invasive surgery especially in elderly cases. PCCP is an extramedullary fixation system, while PFNA is an intramedullary fixation system. They are both minimally invasive to the soft tissue, however, severe anemia is associated with them. This not only leads to increased incidence of complications, but also extends patients' rehabilitation process. Sehlal et al. (2000) first proposed the concept of hidden blood loss, which reasonably explained this phenomenon.

This paper retrospectively analyzed clinical data of patients with intertrochanteric fracture treated with PCCP or PFNA by comparing characteristics of perioperative blood loss between the two types of internal fixation treatment in elderly patients and thus providing the basis for clinically perioperative treatment.

MATERIALS AND METHODS

The data of 158 patients with intertrochanteric fracture treated with PCCP or PFNA from January 2010 to May 2017 in Wuxi People's Hospital were analyzed. The inclusion criteria were as follows: (1) Older than 60 years; (2) No previous history of blood diseases, preoperative Hb>80g/L; (3) Non-multiple trauma; (4) Routine coagulation tests were within the normal range before treatment; (5) Existing blood test within three days preoperatively and postoperatively; (6) Prophylactic use of anticoagulants in perioperative period; (7) Infusion volume in the day of surgery <2000 ml; (8) Fracture can be adopted by closed reduction. Clinical data included age, gender, height, weight, fracture type, mechanism of injury, preoperative and postoperative blood routine examination (RBC, Hb, Hct), ASA (American Society of Anesthesiologists) classification, anesthesia method, operative bleeding and postoperative drainage, perioperative blood transfusion, surgical complications (upper gastrointestinal hemorrhage, lung infection, heart failure etc.), ambulation, fracture healing time and etc. The 158 patients (65 males and 93 females) with mean age 76.9±10.6 (range 60-92) years met all the inclusion criteria with 90 cases younger than 80 years and 68 cases older than 80 years. Causes of injury were: Slip injury in 89 cases and car accidents and fall injury in 69 cases. Based on the OTA (Orthopedic Trauma Association) classification, 45 cases were type 31A1, 77 cases were type 31A2 and 36 cases were type 31A3. There were 63 (26 male cases, 37 female cases) patients in the PCCP group and 95 (37 male cases, 58 female cases) in the PFNA group. The mean age of the PCCP group was 76.6±10.4 years and of the PFNA group 77.3±11.6 years. The two groups of patients were mostly with different degrees of medical conditions of which hypertension (26 cases in PCCP group; 43 cases in PFNA group), diabetes (22 cases in PCCP group, 36 cases in PFNA group), coronary heart disease (5 cases in PCCP group, 8 cases in PFNA group), chronic obstructive pulmonary

disease (10 cases in PCCP group, 14 cases in PFNA group). For Preoperative ASA Score the PCCP group showed the following: ASA score of I 6 cases, II 18 cases, III 31 cases, and IV 8 cases; while for the PFNA group, ASA score of I 6 cases, II 29 cases, III 50 cases, and IV 10 cases. There were no significant differences in age, gender, ASA score and fracture type between both groups ($P>0.05$).

In both groups (PCCP and PFNA groups) standard closed reduction operation procedures were used (Figures 1 and 2)

PCCP group

After anesthesia, the patient was placed supine on the traction table. When satisfied tractive reduction was confirmed by C-arm fluoroscopy, a length of about 20 mm skin incision was made down to the greater trochanter slopes, slid down and plate inserted. Another cut of about 30 mm in the lateral femoral thigh was made, from where the plate holding forceps was placed so as to fix on the femur. With the extracorporeal aiming frame, the inferior femoral neck main nail, three cortex femoral nail and the superior femoral neck main nail were implanted sequentially through the distal incision under C-arm fluoroscopy.

PFNA group

After anesthesia, the patient was placed supine on the traction table. When tractive reduction was satisfactory and confirmed by C-arm fluoroscopy, the greater trochanter landmark was touched. A longitudinal incision of about 40 mm proximally was made and the gluteus medius muscle was dissected bluntly. The apex of greater trochanter was clearly palpated and the guide pin inserted. After confirming the placement of the guide pin in the medullary cavity under fluoroscopy, a main nail of appropriate length was inserted after reaming the depth was confirmed by fluoroscopy. Then the guide pin was inserted along the femoral neck under the instruction of an extracorporeal guider, with anteroposterior at the middle to lower third of the femoral neck and lateral at the center. The spiral blade and distal interlocking nail were inserted.

Operation time and intraoperative blood loss from the beginning of skin incision to complete suture were recorded. Drainage tube is generally not placed after surgery, except in minor cases (PCCP group 5 cases, PFNA group 6 cases). Post-operative infusion volume was controlled at less than 2000 ml to reduce the blood-thinning effect. Daily drainage was recorded and the tube was clogged at <50 mL/d drainage. Intravenous antibiotics were applied within 48 h after surgery. Knee, ankle and toes training initiatively began 1 day after surgery and hip flexor, 3 days after surgery. Routine blood test was reviewed immediately and after the first day of surgery, blood transfusions was given to patients with Hb <80g/L. Routine blood test was reviewed on the third day after surgery and regarded as final Hb and Hct.



Figure 1: Male, 85Y, post-op with PFNA.

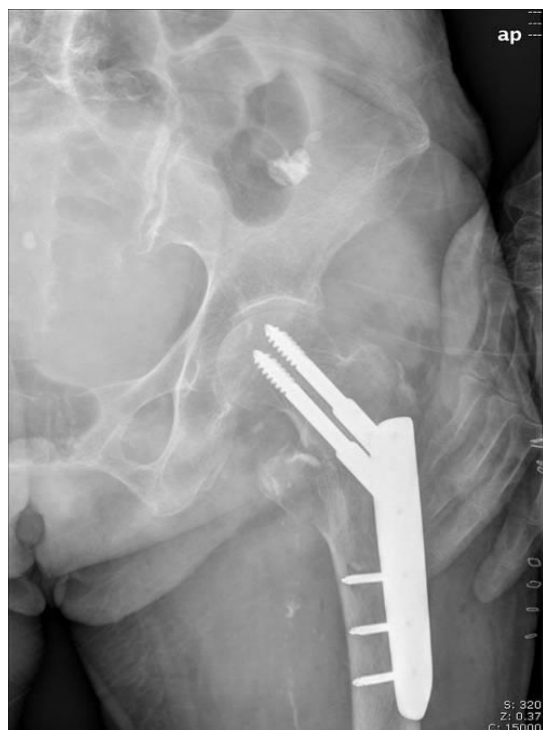


Figure 2: Female, 87Y, post-op with PCCP.

Method of calculating hidden blood loss

Total RBC loss was calculated using the Gross formula (Gross, 1983) (Formula 1). Preoperative patient blood volume (PBV)

was calculated using the Nadler (Nadler et al., 1962) method (where h = height, in m; w = weight, in kg; k is a constant, male $k_1 = 0.3669$, $k_2 = 0.0322$, $k_3 = 0.6041$, Female $k_1 = 0.3561$, $k_2 = 0.0331$, $k_3 = 0.1833$) (Formula 2).

Total RBC loss = preoperative PCV \times (preoperative Hct - postoperative Hct). (Formula 1)

$PBV = k_1 \times h^3 + k_2 \times w + k_3$. (Formula 2)

Theoretical total blood loss = total red blood cell loss / preoperative Hct.

Perioperative actual blood loss = hidden blood loss + overt blood loss = theoretical blood loss + transfusion.

Overt blood loss = Intraoperative blood loss + postoperative drainage.

Patients with intertrochanteric fracture exist blood concentration, using coefficient 0.9 to correct.

Because patients with fractures cannot be measured on account of lying in bed, height and weight were recorded as much as possible before surgery. The weight of some patients can be calculated based on their height: standard weight of men older than 60 years = height (cm) \times 0.65 - 48.7, standard weight of women older than 60 years = height (cm) \times 0.56 - 33.4 (Luo et al., 2011).

Statistical analyses

All statistical analyses were performed using SPSS Statistics version 13.0. All continuous data were expressed as mean \pm standard deviation (SD) and all enumeration data were expressed as percentages. Quantitative variables were analyzed using student's t-test and categorical variables were analyzed by the Fisher's exact test. The level of significance was set at $p < 0.05$.

RESULTS

Operative time and blood loss

In the PCCP Group, the mean operative time was 52.8 ± 4.8 min while the average intraoperative blood loss was 95.6 ± 4.3 mL. Significant decrease of Hb ($Hb < 80$ g/L) after surgery occurred in 46 cases followed by transfusion. The average amount of blood transfusion was 275.6 ± 15.4 mL. Preoperative and postoperative average Hb was 112.0 ± 10.5 and 97.55 ± 9.8 g/L. Drainage tubes were inserted in 5 cases after surgery. The average dominant blood loss PCCP group was 107.5 ± 2.5 mL. The average total blood loss was 610.0 ± 3.6 mL while average hidden blood loss was 502.5 ± 2.6 mL. Comparing 30 cases of elderly patients in the group (aged > 80 years) and 33 cases of non-elderly patients (aged < 80 years), the average dominant blood loss was 108.6 ± 3.1 and 105.4 ± 2.6 mL, average total blood loss was 612.2 ± 2.7 mL and 603.1 ± 3.8 mL, the average hidden blood loss was 503.6 ± 3.4 and 497.7 ± 2.7 mL.

In Group PFNA, the mean operative time was 52.1 ± 4.3 min while average intraoperative blood loss was 78.7 ± 3.2 mL. Significant decrease of Hb ($Hb < 80$ g/L) after surgery occurred in 86 cases followed by transfusion. The average

Table 1. Comparison of operation time and blood loss between Group PCCP and PFNA

Group	N	Operation time	Total blood loss	Dominant blood loss	Hidden blood loss
Group PCCP					
Elderly patients	30	53.1±2.6	612.2±2.7	108.6±3.1	503.6±3.4
Non-elderly patients	33	50.7±5.4	603.1±3.8*	105.4±2.6*	497.7±2.7*
Total	63	52.8±4.8	610.0±3.6	107.5±2.5	502.5±2.6
Group PFNA					
Elderly patients	38	53.5±4.5	681.2±3.5	102.3±2.9	578.9±5.8
Non-elderly patients	57	51.4±4.1	607.4±4.2*	86.1±3.8*	521.3±4.6*
Total	95	52.1±4.3	654.3±4.0#	94.2±3.6#	560.1±5.4#

* Compared with elderly patients in group, P<0.05.

Compared with Group PCCP, P<0.05.

Table 2. Comparison of perioperative complications between PCCP and PFNA groups

Group	N	Infection of incision	Hospital vital organ complications	Perioperative mortality	Failure of internal fixation
Group PCCP					
Elderly patients	30	1(3.3)	2(6.7)	1(3.3)	0
Non-elderly patients	33	0	1(3.0)	0	0
Total	63	1(1.6)	3(4.8)	1(1.6)	0
Group PFNA					
Elderly patients	38	1(2.6)	6(15.7)*	4(10.5)*	3(7.9)
Non-elderly patients	57	1(1.8)	2(3.5)	1(1.8)	0
Total	95	2(2.1)	8(8.4)	5(5.3)	3(3.2)

* Compared with elderly patients in Group PCCP, there are differences, but not significantly significant at P <0.05.

amount of blood transfusion was 300.6±16.6 mL. Preoperative and postoperative average Hb were 111.7±11.2 and 93.6±10.8 g/L. Drainage tubes were inserted in 6 cases after surgery. The average dominant blood loss was 94.2±3.6 mL. The average total and hidden blood losses were 654.3±4.0 and 560.1±5.4 mL, respectively. Comparatively, there were 38 cases of elderly patients (aged >80 years) and 57 cases of non-elderly patients (aged <80 years) in the group. Between the elderly and non-elderly patients, the average dominant blood loss was 102.3±2.9 and 86.1±3.8 mL, average total blood loss was 681.2±3.5 and 607.4±4.2 mL and average hidden blood loss was 578.9±4.2 mL and 521.3±5.4 mL, respectively.

There were no significant differences in operation time between the two groups (P>0.05). Dominant blood loss with PCCP was higher than with PFNA, however total and hidden blood losses were significantly lower than with PFNA (P<0.05). Compared with non-elderly patients within the two groups, hidden blood loss in elderly patients was significantly higher (P<0.05) (Table 1).

Comparison of perioperative complications happening

Considering the special body condition of elderly patients, it is difficult to obtain a high rate of postoperative follow-up, and statistical complication rate is also very difficult to ensure accuracy. Complications in important organs

included 4 cases of upper gastrointestinal hemorrhage, 8 cases of lung infection, 3 cases of heart failure, 2 cases of infarction and 5 cases of deep vein thrombosis.

There were no significant differences in infection of incision and failure of internal fixation after operation between the two groups (P>0.05). Vital organ complications and perioperative mortality occurred less in elderly patients in the PCCP group than in PFNA group. However, on account of low absolute numbers of incidence, there were no significant differences between the two groups (P>0.05). Comparing non-elderly patients in the two groups, there were no significant differences in vital organ complications and perioperative mortality (P>0.05) (Table 2).

Prognosis and Harris function score

Start time of weight-bearing in Group PCCP was significantly longer than in Group PFNA (P<0.05). There were no significant differences in fracture healing time and Harris function score half year post-operation between the two groups (P>0.05) (Table 3).

DISCUSSION

Elderly patients with femoral intertrochanteric fractures are often associated with varying degrees of diseases. Because

Table 3. Comparison of prognosis and Harris function score in PCCP and PFNA groups

Group	N	Start time of weight-bearing(d)	fracture healing time(d)	Harris function score(分)
Group PCCP				
Elderly patients	30	24.1±2.1	69.2±6.3	83.3±8.6
Non-elderly patients	33	22.3±1.5	65.1±5.1	80.2±7.9
Total	63	23.2±1.7	67.3±5.5	82.1±8.3
Group PFNA				
Elderly patients	38	15.1±1.5*	68.7±5.9	84.1±8.2
Non-elderly patients	57	13.8±1.1	66.3±5.2	81.7±7.7
Total	95	14.5±1.3#	67.5±5.3	83.2±7.9

* Compared with elderly patients in Group PCCP, $P < 0.05$.

Compared with Group PCCP, $P < 0.05$.

of the bad basic body condition, complications such as hemorrhagic anemia occurs frequently leading to hypoxia which in turn affects fracture healing. At the same time, incidences of infection and deep vein thrombosis increased in elderly patients.

Early surgery has become the preferred treatment option for intertrochanteric fractures. Percutaneous compression plate (PCCP) is a common extramedullary fixation system while proximal femoral nail anti-rotation (PFNA) is commonly used in intramedullary fixation system. Both are minimally invasive, shorter operation time and less blood loss. However, perioperative hidden blood loss is often neglected in clinical course, leading to delayed management in patients in critical condition and other complications.

At present, many scholars agree that intramedullary fixation has obvious advantages in biomechanics for elderly patients with femoral intertrochanteric fractures (Ul Haq et al., 2014). Because the fixture is located close to the centerline, the arm is shortest when bearing axial stress, thus reducing the incidence of fracture fixation. Thus, patients can walk with load earlier, and complications caused by factors such as lying in bed and muscle atrophy can be reduced. However, intramedullary fixation has its inherent flaws, of which the most important is hidden bleeding. Especially in elderly patients with severe osteoporosis, once reamed (medullary space expansion) there must be a large amount of bleeding and longer duration.

For extramedullary fixation, because they do not directly open fracture and the bone marrow cavity is not disturbed, the volume of delayed bleeding or hidden bleeding will be relatively lower and the surgical injury is not large (Zhang et al., 2014). Therefore, extramedullary fixation becomes an alternative for elderly patients. As a dynamic compression device, PCCP requires fracture to withstand pressure. PCCP cannot be applied in patients with severe osteoporosis, comminuted fracture and an incomplete outer wall.

According to the study results, factors that influence increase in hidden blood loss in patients with intertrochanteric fractures are as follows:

1. Fracture bleeding: Intertrochanteric fractures are

cancellous bone fracture. This portion has rich blood circulation, and the cavities surrounding soft tissue are large. It is hard to stop bleeding. Continuous bleeding of closed fracture penetrates surrounding soft tissue thus forming hematoma and causing swelling of the limbs.

2. Closed reduction of fracture, reamed and other operations: Closed reduction of fracture, reamed and other operations in surgery increases local bleeding. When implanting the intramedullary needle, large area of trauma increases bleeding in the marrow cavity. At the same time, small incision operations do not allow direct and complete hemostasis at soft tissue hemorrhage, resulting in local blood penetrating the tissue space and an increase in hidden blood loss (Zhuang et al., 2013).

3. The age factor: Because of poor body condition, the volume of hidden blood loss in elderly patients with intertrochanteric fracture is greater. The capacity of storing red blood cell in vivo and bone marrow decreases. The reduction of coagulation factors and fibrinogen causes abnormal coagulation and extension of coagulation time (P and Rao, 2013).

4. Other factors: According to the literature (Morris et al., 2017), hidden blood loss in intertrochanteric fracture is associated with other factors such as gender, weight, underlying disease, drug factors; mechanism of injury, damage energy, and fracture type etc. These factors are statistically significant and still controversial currently thus further studies are necessary.

Conclusion

In summary, elderly patients with femoral intertrochanteric fracture often experience postoperative anemia after PCCP or PFNA treatment due to hidden blood loss. Application of intramedullary fixation easily causes perioperative hidden blood loss especially in elderly patients. In order to prevent the occurrence of postoperative hemorrhagic anemia, clinicians should pay attention to preoperative Hb concentration, assess perioperative blood loss individually and select appropriate internal fixation method. Blood

transfusion should be on time according to monitoring of hemoglobin after surgery, to reduce the occurrence of symptoms of postoperative anemia. Meanwhile diet should be reasonably planned based on the recovery of gastrointestinal tract (Wilson, 2013).

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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