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# Effects of Goal-Directed Fluid Therapy on MAP, NT-proBNP, and hs-CRP in Elderly Patients with Lower Extremity Fractures Undergoing Open Reduction and Internal Fixation

**Hongquan Ren, Yabo Hao***

Shaanxi Provincial People's Hospital, Xi'an 710068, Shaanxi, China

***Author to whom correspondence should be addressed.***



**Abstract:** *Objective:* To investigate the effects of goal-directed fluid therapy on mean arterial pressure (MAP), N-terminal pro-brain natriuretic peptide (NT-proBNP), and high-sensitivity C-reactive protein (hs-CRP) levels in elderly patients with lower limb fracture undergoing open reduction and internal fixation surgery 24 hours after surgery. *Methods:* Sixty elderly patients admitted to our hospital from June 2022 to February 2023 for open reduction and internal fixation of lower limb fractures were randomly divided into two groups: 30 cases in the observation group and 30 cases in the control group. The patients in the control group were treated with conventional fluid therapy, and the observation group received goal-directed fluid therapy on the basis of the control group. The patients in the two groups were observed to monitor the changes of mean arterial pressure (MAP) and heart rate (HR), as well as the preoperative and 24-hour postoperative levels of NT-proBNP and hs-CRP. *Results:* The NT-proBNP level in the control group was 608.37 ± 180.46 ng/ml and the hs-CRP level was 510.09 ± 190.21 pg/ml during the operation, and the NT-proBNP and hs-CRP levels in the observation group were 608.74 ± 180.26 ng/ml and 514.12 ± 180.63 pg/ml, respectively, and the difference between the two groups was not statistically significant ($P > 0.05$). The levels of NT-proBNP and hs-CRP in the control group were 369.74 ± 77.11 ng/ml and 298.41 ± 72.14 pg/ml respectively at 24-hour postoperatively, and those in the observation group were 324.74 ± 71.26 ng/ml and 245.12 ± 77.63 pg/ml, the difference between the two groups was statistically significant ($P < 0.05$). In the control group, the preoperative MAP and heart rate were 14.12 ± 3.92 mmHg and 47.18 ± 15.42 beats/min respectively; in the intraoperative period, the MAP and heart rate were 54.81 ± 14.41 mmHg and 60.65 ± 14.11 beats/min. In the observation group, the preoperative MAP and heart rate were 15.12 ± 3.48 mmHg and 48.21 ± 15.36 beats/min, and the intraoperative MAP and heart rate were 50.16 ± 14.03 mmHg and 57.65 ± 14.10 beats/min, the difference was statistically significant ($P < 0.05$). *Conclusion:* Compared with traditional fluid therapy, goal-directed fluid therapy can reduce MAP, NT-proBNP, and hs-CRP levels in elderly patients with lower limb fractures undergoing open reduction and internal fixation surgery, and reduce the incidence of postoperative complications.

**Keywords:** Goal-directed fluid therapy; Fracture; Open reduction and internal fixation surgery; MAP; NT-proBNP; hs-CRP

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# 1. Introduction

With the development of population aging, the morbidity rate of elderly patients is increasing year by year. According to statistics, among the elderly over 60 years of age in China, about 13.7 million falls occur each year, of which lower limb fractures account for 60% to 80%. Since most elderly people have osteoporosis and reduced bone mass, they are prone to fractures due to falls. Therefore, early surgical treatment is the best option for elderly patients with fractures combined with osteoporosis. Traumatic shock is one of the common complications in elderly patients during fracture surgery. Its pathogenesis is still unclear, and it is currently believed to be related to systemic vasodilatory dysfunction and insufficient tissue perfusion. In actual clinical work, some studies have found that the condition of patients with acute traumatic shock can be rapidly improved after receiving a blood transfusion. In addition, acute traumatic shock patients can improve their survival rate and quality of life through rational fluid therapy. Goal-directed fluid therapy (GDFT) is a goal-oriented approach to fluid therapy that aims to minimize dehydration and avoid over- or under-rehydration to achieve the clinically required fluid target concentration. Most previous studies on GDFT therapy have focused on general adult patients, and fewer have addressed geriatric patients undergoing orthopedic surgery. The relevant literature reports are also relatively rare, it has been shown that on the basis of conventional treatment, increasing the amount of rehydration can shorten the ICU hospitalization time by 19.5 days and reduce the mortality rate by 17.5% [1]; one study used GDFT treatment on 80 patients, and the results showed that the average hospitalization time and the mortality rate were significantly reduced compared with the conventional treatment [2]. In addition, some scholars have pointed out that if GDFT treatment is applied to postoperative orthopedic patients, it is expected to obtain better efficacy [3]. However, there are fewer reports on GDFT treatment in China, and there is still a lack of uniform standards, so it cannot be promoted to medical institutions across the country. Therefore, in this study, we chose elderly patients with lower limb fractures undergoing open reduction and internal fixation as research subjects, and observed the effects of GDFT treatment and conventional fluid therapy on mean arterial pressure (MAP), N-terminal pro-brain natriuretic peptide (NT-proBNP), and high-sensitivity C-reactive protein (hs-CRP), to investigate the therapeutic effect of GDFT on these patients. The results of the study are reported as follows.

# 2. Information and methods

## 2.1. General information selection

Sixty cases of open reduction and internal fixation of lower limb fractures in the elderly admitted to our hospital from June 2022 to February 2023 were selected, of which 33 cases were male and 27 cases were female; their ages ranged from 67 to 85 years old, with an average age of 74.22 ± 3.15 years old; they were randomly divided into two groups, the observation group consisted of 30 cases, of which 17 cases were male and 13 cases were female, with an average age of 71.17 ± 7.53 years old. Inclusion criteria: (1) age ≥ 60 years; (2) need to perform open reduction and internal fixation surgery; (3) no other underlying diseases or complications before surgery; (4) no abnormal coagulation function, electrolyte disorders, or drug allergies; (5) no other underlying diseases or complications before surgery; (6) No preoperative use of anticoagulant, antiplatelet, lipid-lowering, and hepatoprotective drugs; (7) Informed consent of the patients and signing of the informed consent form. Exclusion criteria: (1) those who cannot provide valid information before surgery; (2) those who have serious infections, multiple organ insufficiency, and abnormal coagulation function; (3) patients with serious heart disease and cerebrovascular disease.

## 2.2. Methodology

The patients in the control group were treated with conventional fluid therapy, combined with lumbar and epidural anesthesia, applying Nussis anesthesia induction pump made in the United States to maintain the blood pressure and heart rate, and intravenously injecting midazolam 0.03–0.06 mg/kg before induction, and additional amounts were added according to the hemodynamic status of the patients during the operation. In the observation group, goal-directed fluid therapy was applied in addition to the treatment used in the control group. Specifically, 20 ml/kg of crystalloid fluid and 20 ml/kg of colloid fluid were given to patients on the basis of baseline blood pressure, and the total amount of fluid was appropriately adjusted according to the blood pressure.

## 2.3. Observation indicators

The patients in the two groups were observed to monitor the changes in mean arterial pressure and heart rate, as well as the levels of NT-proBNP and hs-CRP preoperatively and 24 hours postoperatively.

## 2.4. Statistical methods

Statistical processing was performed using SPSS 19.0 software for data analysis, and the measurement data were expressed as mean ± standard deviation (SD) by *t*-test; the count data were expressed as rate (%) by $\chi^2$ test.

# 3. Results

## 3.1. Comparison of intraoperative indicators

There was no statistically significant difference in intraoperative NT-proBNP and hs-CRP in the observation group compared with the control group ($P > 0.05$), and postoperative NT-proBNP and hs-CRP were significantly reduced ($P < 0.05$), and the difference was statistically significant (**Table 1**).

**Table 1.** Comparison of intraoperative indicators

| Groups | | Control group ($n = 30$) | Observation group ($n = 30$) | $t$ | $P$ |
|---|---|---|---|---|---|
| Intraoperative | NT-proBNP (ng/ml) | 608.37 ± 180.46 | 608.74 ± 180.26 | 0.008 | > 0.05 |
| | hs-CRP (pg/ml) | 510.09 ± 190.21 | 514.12 ± 180.63 | 0.084 | > 0.05 |
| Postoperative | NT-proBNP (ng/ml) | 369.74 ± 77.11 | 324.74 ± 71.26 | 2.348 | 0.022 |
| | hs-CRP (pg/ml) | 298.41 ± 72.14 | 245.12 ± 77.63 | 2.754 | 0.008 |

## 3.2. Comparison of hemodynamic indices

The mean intraoperative arterial pressure in the control group was 54.81 ± 14.41 mmHg and the heart rate was 60.65 ± 14.11 beats/min, while in the observation group, the mean intraoperative arterial pressure was 50.16 ± 14.03 mmHg and the heart rate was 57.65 ± 14.10 beats/min, with a statistically significant difference ($P < 0.05$). In the patients of the control group, the postoperative mean arterial pressure was 14.12 ± 3.92 mmHg and heart rate was 77.18 ± 15.42 beats/min, and the mean arterial pressure in the patients of the observation group after surgery was 15.12 ± 3.48 mmHg and heart rate was 78.21 ± 15.36 beats/min, and the difference was not statistically significant ($P > 0.05$), as shown in **Table 2**.

**Table 2.** Comparison of hemodynamic indices

| Groups | Intraoperative | | Postoperative | |
|---|---|---|---|---|
| | Mean arterial pressure (mmHg) | Heart rate (beats/min) | Mean arterial pressure (mmHg) | Heart rate (beats/min) |
| Control group ($n$ = 30) | 54.81 ± 4.41 | 60.65 ± 4.11 | 14.12 ± 3.92 | 77.18 ± 15.42 |
| Observation group ($n$ = 30) | 50.16 ± 4.03 | 57.65 ± 4.10 | 15.12 ± 3.48 | 78.21 ± 15.36 |
| $t$ | 4.263 | 2.830 | 1.045 | 0.259 |
| $P$ | 0.000 | 0.006 | > 0.05 | > 0.05 |

## 4. Discussion

With the aging of the population, the number of elderly fracture patients is increasing year by year. These patients often experience varying degrees of functional decline in multiple organs, such as the heart, brain, and kidneys, and frequently exhibit abnormalities in intraoperative bleeding and coagulation functions [4]. Goal-directed fluid therapy is an individualized fluid therapy that takes into account the patient's hemodynamic status and goals, and allows for appropriate fluid adjustments according to the patient's condition, thereby improving surgical safety and reducing postoperative complications [5,6]. However, whether GDFT is superior to conventional fluid therapy in elderly patients with fractures remains controversial. Currently, most of the elderly patients with fractures are in a state of incapacitation, and intraoperative problems such as abnormal coagulation function and excessive bleeding often exist, so their perioperative fluid therapy is particularly important [7]. Some studies have shown that MAP and NT-proBNP values before, during, and after surgery in the elderly are positively correlated with intraoperative bleeding, while hs-CRP values are negatively correlated with intraoperative bleeding [8]. Therefore, the type and amount of fluid should be rationally adjusted according to the patient's condition to reduce intraoperative bleeding during fracture surgery in the elderly. However, there are few studies on GDFT in elderly patients with fractures. Therefore, intraoperative fluid management in these patients should be emphasized to avoid problems such as high intraoperative bleeding and postoperative complications.

Elderly patients with weaker resistance to trauma and multiple co-morbidities are more likely to develop systemic inflammatory response syndrome (SIRS) and multiple organ dysfunction syndrome (MODS). Studies have shown that hypovolemia is one of the main factors leading to the development of SIRS and MODS in the postoperative period in the elderly [9]. Therefore, reducing fluid levels in patients can effectively prevent SIRS and MODS while ensuring hemodynamic stability.

GDFT, i.e., fluid therapy based on changes in fluid balance before and after surgery, enables patients to achieve fluid levels within the target range during surgery in order to reduce fluid loss due to traumatic stress in patients and to maintain tissue perfusion pressure in the body.

The results of this study showed that MAP and NT-proBNP of patients in the observation group were significantly lower than those of the control group ($P < 0.05$); hs-CRP of patients in the observation group was significantly lower than that of the control group ($P < 0.05$). This may be related to the fact that GDFT can be appropriately adjusted according to the patients' coagulation mechanism and hemodynamic status, and that the GDFT treatment improves the anti-inflammatory capacity of the organism. GDFT can adjust the fluid volume and rate of patients according to their coagulation mechanism and hemodynamic status by means of fluid resuscitation therapy and drug therapy.

In addition, the results of this study showed that the intraoperative mean arterial pressure and heart rate of patients in the GDFT group were significantly lower than those in the conventional fluid therapy group, and the

difference was statistically significant ($P < 0.05$). It has been shown that intraoperative mean arterial pressure and heart rate are positively correlated with 24-hour postoperative NT-proBNP levels [10]. In addition, the incidence of heart failure increases with age as cardiac reserve function decreases, and insufficient intravascular volume causes hypercapnia, which exacerbates heart failure.

## 5. Conclusion

In conclusion, goal-directed fluid therapy reduces MAP, NT-proBNP, and hs-CRP levels and decreases the incidence of postoperative complications in elderly patients with lower extremity fractures undergoing open reduction and internal fixation compared with traditional fluid therapy.

## Disclosure statement

The authors declare no conflict of interest.

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