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# Effects of Goal-Directed Fluid Therapy on Postoperative Delirium in Elderly Hip Fracture Patients

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**Abstract:** *Objective:* To analyze the effects of goal-directed fluid therapy on postoperative cerebral oxygen metabolism level ($rScO_2$), blood pressure (MAP), heart rate (HR), and incidence of intraoperative hypotension and delirium in elderly hip fracture patients. *Methods:* Sixty-six elderly patients who underwent hip fracture surgery under intrathecal anesthesia in a hospital between October 2023 and September 2024 were selected and divided into a control group and an observation group using the mean score method, each with 33 cases. Both groups were given dexmedetomidine 10 min before surgery, and the control group was treated with conventional intraoperative fluid replacement, while the observation group was treated with goal-directed fluid therapy. The $rScO_2$, MAP, HR, the incidence of intraoperative hypotension, and the index of delirium MMSE score at preoperative ($T_0$), subarachnoid block for 5 min ($T_1$), and surgical 30 min ($T_2$) were observed and compared between the two groups. *Results:* The difference between the left $rScO_2$ and right $rScO_2$ levels at $T_0$ between the two groups was not significant ($P > 0.05$), but the left $rScO_2$ and right $rScO_2$ levels were significantly higher in the observation group than in the control group at $T_1$ and $T_2$ ($P < 0.05$); compared with the group at $T_0$, the patients in the control group at $T_1$, left $rScO_2$ and right $rScO_2$ levels were significantly lower at $T_2$ ($P < 0.05$); the left $rScO_2$ and right $rScO_2$ levels at $T_1$ and $T_2$ of patients in the observation group were higher than those at $T_0$, and the difference was not statistically significant ($P > 0.05$). There was no statistically significant difference in the levels of MAP and HR at $T_0$ between the two groups ($P > 0.05$), and the levels of MAP and HR at $T_1$ and $T_2$ were significantly higher in the observation group than those of the control group ($P < 0.05$); compared with the group's levels at $T_0$, there was a significant decrease in the levels of MAP and HR in the control group at $T_1$ and $T_2$, with the difference being statistically significant ($P < 0.05$); HR at $T_1$ was significantly lower than that at $T_0$ in patients in the observation group ($P < 0.05$); however, the difference between MAP at $T_1$ and $T_2$ and HR at $T_2$ compared with that at $T_0$ was not statistically significant ($P > 0.05$); the incidence of intraoperative hypotension in the observation group (3.03%) was significantly lower than that of the control group (24.24%) ($P < 0.05$). There was no statistically significant difference in MMSE scale scores between the two groups of patients in the preoperative 1d ($P > 0.05$); compared with the preoperative 1d in the group, there was a significant decrease in MMSE scale scores in the postoperative 1d and 3d in the two groups, with the observation group being significantly higher than the control group ($P > 0.05$); the difference between MMSE scale scores in the postoperative 1d and 3d in the control group and those of the preoperative 1d in the control group had statistical significance ($P < 0.05$); the difference between the postoperative 1d and 3d MMSE scale scores of the observation group and the preoperative 1d was not statistically significant ($P > 0.05$). *Conclusion:* During the implementation of intrathecal anesthesia for hip fracture surgery in the elderly, the application of goal-directed fluid therapy can improve the oxygen metabolism of cerebral tissues, reduce the fluctuation of intraoperative blood pressure and heart rate, lower the incidence of postoperative hypotension, and help to promote the recovery of patients' postoperative cognitive functions.

**Keywords:** Goal-directed fluid therapy; Elderly hip fracture; Intrathecal anesthesia; Postoperative delirium

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## 1. Introduction

Hip fracture is a common traumatic disease in the elderly population, and its high incidence and poor prognosis have become an important challenge for global public health. With the aging of the population, the demand for surgical treatment of hip fractures in the elderly is increasing year by year, but the incidence of postoperative complications remains high, which significantly affects patients' functional recovery and long-term quality of survival [1]. Postoperative delirium (POD) is an acute, fluctuating cognitive dysfunction manifested by inattention, altered level of consciousness, and disorganized thinking, which occurs through a complex mechanism involving multiple factors such as neuroinflammation, oxidative stress, and abnormal cerebral perfusion [2]. In elderly hip fracture patients, the incidence of POD can be as high as 20–40% and is strongly associated with long-term cognitive decline and increased mortality. Therefore, it is clinically important to explore modifiable risk factors for POD and develop targeted intervention strategies [3]. Intraoperative hemodynamic instability, especially hypotension (mean arterial pressure, MAP < 65 mmHg) and imbalance of cerebral oxygen metabolism, are important triggers of POD. Elderly patients are often combined with decreased vascular elasticity, autonomic dysfunction, and insufficient cardiac reserve, and are more prone to intraoperative blood pressure fluctuations and hypoperfusion [4]. Regional cerebral oxygen saturation ($rScO_2$) is a non-invasive indicator of the balance between cerebral oxygen supply and demand, and a decrease in intraoperative $rScO_2$ levels may directly impair neuronal function by inducing cerebral ischemia and energy metabolism disorders, which in turn increases the risk of delirium [5]. In addition, abnormal fluctuations in heart rate (HR) (e.g., tachycardia or severe bradycardia) may also be indirectly involved in the development of POD by affecting cardiac output and cerebral perfusion. Goal-directed fluid therapy (GDFT) is an individualized fluid management strategy based on hemodynamic monitoring aimed at maintaining intraoperative hemodynamic stability by optimizing cardiac output and tissue perfusion [6]. In recent years, the role of GDFT in reducing postoperative complications has attracted much attention, but its effect on POD in elderly hip fracture patients is controversial. The aim of this study was to investigate the effect of GDFT on postoperative delirium in elderly hip fracture patients, and to focus on its association with intraoperative $rScO_2$, MAP, HR, and hypotensive events, with a view to achieving the goal of improving the quality of postoperative rehabilitation in elderly hip fracture patients.

## 2. Information and methodology

### 2.1. General information

Sixty-six cases of elderly patients who underwent hip fracture surgery under intralesional anesthesia in a hospital between October 2023 and September 2024 were selected and divided into a control group and an observation group using the mean score method, each with 33 cases. In the control group, there were 15 males and 18 females, with an age range of 65–89 years, a mean of 76.21 ± 6.82 years; body mass index (BMI): 23.50 ± 3.22 kg/$m^2$; and operation time: 55.4 ± 12.6 min. In the observation group, there were 16 males and 17 females, with an age range of 64–88 years, a mean of 75.80 ± 7.15 years; BMI: 23.8 ± 3.0 kg/$m^2$; operation time: 56.9 ± 11.9 min. The differences in general information between the two groups were not statistically significant ($P > 0.05$) and were comparable.

Inclusion criteria: (1) age ≥ 64 years; (2) diagnosis of unilateral hip fracture (femoral neck or intertrochanteric fracture); (3) American Society of Anesthesiologists (ASA) classification grade II to III; (4) absence of severe cardiac, pulmonary, hepatic, and renal dysfunction; and (5) preoperative Mini-Mental State Examination (MMSE) score ≥ 24 to exclude baseline cognitive dysfunction.

Exclusion criteria: (1) presence of severe cerebrovascular disease or history of dementia; (2) long-term use of psychotropic drugs; (3) intraoperative conversion to general anesthesia; (4) incomplete clinical data or loss of visits.

## 2.2. Methodology

All patients were fasted for 6 h and water-fasted for 2 h. After admission to the room, intravenous access was established, and real-time blood pressure was monitored by radial artery puncture catheterization. Electrocardiogram (ECG), heart rate (HR), mean arterial pressure (MAP), and pulse oximetry ($SpO_2$) were continuously monitored, and 2 L/min oxygen was administered by mask. Thirty minutes before position placement, 0.375% ropivacaine (Jiangxi Hengrui Medicine Co., Ltd., State Pharmaceutical Certificate: H20060137) was used to perform an iliac fascia block on the affected side to reduce operation-related pain. Anesthesia was performed by subarachnoid block with isogravimetric ropivacaine (10 mg), and dexmedetomidine (0.5 μg/kg, 15-min infusion) was injected intravenously 10 min before skin incision, and the intraoperative dose of 0.5 μg/kg/h was maintained, and the drug was discontinued 10 min before the end of the operation. Intraoperative electric blankets were applied to maintain body temperature, and postoperative intravenous self-controlled analgesia (PCA) was used in all cases to optimize pain management.

The control group was treated with conventional intraoperative fluid replacement. The total amount of intraoperative fluid infusion was supplemented with crystalloid fluid (e.g. lactated Ringer’s solution or saline) based on the patient’s body weight, fasting time, intraoperative blood loss, and urine output. The rate of fluid replenishment was maintained at 6–8 mL/kg/h and dynamically adjusted according to hemodynamic parameters (e.g. MAP, urine output). If intraoperative bleeding was large (> 500 mL), colloidal fluids (e.g., hydroxyethyl starch) were supplemented as appropriate to maintain effective circulating blood volume. If the patient’s MAP decreased by > 20% from the preoperative baseline value for more than 1 min, norepinephrine 4 μg (Harvest Pharmaceuticals) was pushed intravenously, and the dose was repeated if necessary. Deleterious, suspended red blood cells were infused when the red blood cell pressure (HCT) was < 25%. The goal of routine rehydration is to maintain hemodynamic stability while avoiding abnormal tissue perfusion due to volume overload or underload.

The observation group was treated with goal-directed fluid therapy. The basal fluid requirement was first maintained with sodium lactate Ringer’s solution 1–2 ml/kg/h, while volume responsiveness was assessed by dynamic monitoring of stroke volume per beat (stroke volume, SV). When the monitoring showed SV > 10%, 200 ml of hydroxyethyl starch 130/0.4 solution was rapidly infused (done within 5 minutes), and the trend of SV was observed. If the decrease in SV after infusion exceeded 10% of the baseline value, it was judged to be positive for volume responsiveness, and an additional 200 ml of colloidal solution of the same specification was infused until the SV parameter was stabilized below the 10% threshold, so as to realize individualized and precise rehydration therapy.

## 2.3. Observation indicators

(1) The cerebral oxygen metabolism level ($rScO_2$), blood pressure (MAP), heart rate (HR), and the occurrence of intraoperative hypotension were observed and recorded at preoperative ($T_0$), subarachnoid block for 5 min ($T_1$), and surgical 30 min ($T_2$) in both groups.

(2) The patients' memory, attentional calculation, orientation, and language ability were assessed using the Mini-Mental State of Intelligence Scale (MMSE), with 30 questions and a total score range of 0–30, and an MMSE score of < 27 was classified as cognitive dysfunction.

## 2.4. Statistical treatment

SPSS 21.0 statistical software was used to process the data, and the measurement information was expressed as mean ± standard deviation (SD) with *t*-test, and the count information was expressed as percentage (%) with $\chi^2$ test, and the difference was considered statistically significant with $P < 0.05$.

# 3. Results

## 3.1. Comparison of postoperative cerebral oxygen metabolism levels between the two groups of patients

The differences in the levels of left $rScO_2$ and right $rScO_2$ at $T_0$ between the two groups were not significant ($P > 0.05$), but the levels of left $rScO_2$ and right $rScO_2$ at $T_1$ and $T_2$ in the patients of the observation group were higher than those of the control group, and the differences were statistically significant ($P < 0.05$); compared with that of the group at $T_0$, the levels of left $rScO_2$ and right $rScO_2$ in the patients of the control group were significantly lower at $T_1$ and $T_2$, the levels of left $rScO_2$ and right $rScO_2$ were significantly lower than those in the control group at $T_2$, and the difference was statistically significant ($P < 0.05$); the levels of left $rScO_2$ and right $rScO_2$ in patients of the observation group at $T_1$ and $T_2$ compared with those at $T_0$, and the difference was not statistically significant ($P > 0.05$). See **Table 1**.

**Table 1.** Comparison of postoperative cerebral oxygen metabolism levels ($rScO_2$) between the two groups (mean ± SD, %)

| Groups | Left $rScO_2$ | | | Right $rScO_2$ | | |
|---|---|---|---|---|---|---|
| | $T_0$ | $T_1$ | $T_2$ | $T_0$ | $T_1$ | $T_2$ |
| Control group (*n* = 33) | 72.79 ± 4.87 | 65.39 ± 5.06$^{\#}$ | 62.16 ± 4.12$^{\#}$ | 71.25 ± 4.52 | 64.41 ± 4.12$^{\#}$ | 61.13 ± 3.98$^{\#}$ |
| Observation group (*n* = 33) | 73.14 ± 4.98 | 70.83 ± 4.89 | 69.97 ± 7.72 | 70.88 ± 4.36 | 68.78 ± 5.74 | 67.94 ± 7.24 |
| *t* | 0.2887 | 4.4410 | 5.1271 | 0.3384 | 1.6736 | 1.9984 |
| *P* | 0.7738 | < 0.001 | < 0.001 | 0.7361 | 0.0991 | 0.0499 |

Note: $^{\#}P < 0.05$ when compared to within-group $T_0$.

## 3.2. Comparison of blood pressure, heart rate, and the occurrence of intraoperative hypotension between the two groups of patients

There was no statistically significant difference in the levels of MAP and HR at $T_0$ between the two groups ($P > 0.05$), and the levels of MAP and HR at $T_1$ and $T_2$ were higher than those of the control group in the observation group, and the difference was statistically significant ($P < 0.05$); compared with that of the group at $T_0$, the levels of MAP and HR were significantly lower at $T_1$ and $T_2$ in the control group, and the difference was statistically significant ($P < 0.05$); HR at $T_1$ was lower than that at $T_0$ in patients in the observation group, and the difference was statistically significant ($P < 0.05$); however, the differences between MAP at $T_1$, $T_2$ and HR at $T_2$ compared with that at $T_0$ were not statistically significant ($P > 0.05$); the incidence of intraoperative hypotension in patients in the observation group (3.03%) was lower than that of the control group (24.24%), and the difference was statistically significant ($P < 0.05$). See **Table 2**.

**Table 2.** Comparison of blood pressure, heart rate, and the occurrence of intraoperative hypotension between the two groups of patients

| Groups | MAP (mmHg) | | | HR (beats/min) | | | Incidence of hypotension [*n* (%)] |
|---|---|---|---|---|---|---|---|
| | $T_0$ | $T_1$ | $T_2$ | $T_0$ | $T_1$ | $T_2$ | |
| Control group (*n* = 33) | 97.26 ± 5.19 | 94.62 ± 5.47* | 92.32 ± 3.11* | 86.39 ± 5.34 | 79.93 ± 4.75* | 82.14 ± 4.08* | 8 (24.24) |
| Observation group (*n* = 33) | 98.18 ± 6.13 | 97.87 ± 6.16 | 95.43 ± 4.31 | 86.57 ± 5.82 | 82.98 ± 4.43* | 84.41 ± 4.73 | 1 (3.03) |
| *t* | 0.6580 | 2.2663 | 3.3614 | 0.1309 | 2.6975 | 2.0876 | 4.6316 |
| *P* | 0.5129 | 0.0268 | 0.0013 | 0.8963 | 0.0089 | 0.0408 | 0.0314 |

Note: *$P < 0.05$ when compared to within-group $T_0$.

## 3.3. Comparison of preoperative and postoperative delirium MMSE scores between the two groups of patients

There was no statistically significant difference in the preoperative 1d MMSE scale scores between the two groups ($P > 0.05$); compared with the preoperative 1d in the group, there was a significant decrease in the postoperative 1d and 3d MMSE scale scores in both groups, and the observation group was higher than the control group, and the difference was not statistically significant ($P > 0.05$); compared with the preoperative 1d in the control group, the difference between the postoperative 1d and 3d MMSE scale scores in the control group was statistically significance ($P < 0.05$), and the difference between the 1d and 3d postoperative MMSE scale scores of the observation group compared with the preoperative 1d was not statistically significant ($P > 0.05$). See **Table 3**.

**Table 3.** Comparison of preoperative and postoperative delirium MMSE scores between the two groups (mean ± SD, points)

| Groups | 1d preoperative | 1d postoperative | 3d postoperative |
|---|---|---|---|
| Control group (*n* = 33) | 28.16 ± 1.22 | 25.72 ± 2.06[a] | 26.24 ± 1.67[a] |
| Observation group (*n* = 33) | 28.17 ± 1.14 | 27.86 ± 1.74 | 27.39 ± 2.12 |
| *t* | 0.0344 | 4.5590 | 2.4479 |
| *P* | 0.9727 | < 0.001 | 0.0171 |

Note: [a]$P < 0.05$ when compared with 1d preoperatively in the group.

## 4. Discussion

Elderly hip fracture patients often have a variety of underlying diseases, with decreased physiological reserve function, poor tolerance to anesthesia and surgery, and intraoperative cerebral hypoxia easily triggered by hemodynamic fluctuations, inadequate tissue perfusion, and other factors, which in turn increase the risk of postoperative delirium. In addition, the vascular elasticity of elderly patients is reduced and sensitive to volume changes, and traditional rehydration strategies are prone to lead to hypotension or cardiac failure, further aggravating cerebral tissue hypoxia [7]. Therefore, exploring a fluid therapy strategy that optimizes hemodynamic stability and improves cerebral oxygen metabolism is important for reducing the incidence of postoperative delirium and improving patient prognosis. Conventional fluid replacement therapy mostly relies on empirical infusion or static parameters (e.g., blood pressure, urine output), lacks individualized regulation, is difficult to accurately reflect the patient's volume status, and fails to identify and correct such problems in a timely manner, which can easily lead to an imbalance between cerebral oxygen supply and demand and increase the risk of postoperative delirium [8]. Goal-directed fluid therapy is an individualized rehydration strategy based on dynamic hemodynamic indices (e.g., volume per beat variability, cardiac output, etc.), aiming to maintain tissue perfusion and oxygen supply by optimizing cardiac preload. It centers on monitoring patient volume responsiveness in real time to avoid blind rehydration or volume insufficiency [9]. In elderly patients, GDFT may improve cerebral oxygen metabolism by maintaining a stable hemodynamic state and reducing hypotensive events.

The results of this study showed that the observation group had significantly higher $rScO_2$ levels than the control group at $T_1$ and $T_2$ time points, and had more stable MAP and HR, and a lower incidence of intraoperative hypotension (3.03% vs. 24.24%), suggesting that GDFT can effectively maintain stable cerebral oxygen metabolism and hemodynamics. The postoperative MMSE scores of the control group decreased significantly, whereas there was no statistically significant difference in the change of the scores of the observation group, suggesting that GDFT may alleviate postoperative cognitive impairment by improving the balance of cerebral oxygen supply and demand. Specifically, GDFT reduces the risk of delirium by optimizing cardiac output and tissue perfusion, avoiding cerebral hypoxia and hypotension caused by conventional rehydration [10].

## 5. Conclusion

In conclusion, the application of goal-directed fluid therapy in geriatric hip fracture surgery reduces cerebral hypoxic events and maintains neurological stability, and the long-term effects of GDFT on delirium and the specific pathophysiological pathways need to be further explored in the future.

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## Disclosure statement

The authors declare no conflict of interest.

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