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Original Article

Application of LiDCO-Rapid in peri-operative fluid therapy for aged patients undergoing total hip replacement

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Abstract: Objective: To explore a good strategy for fluid therapy, we observed the effect of application of LiDCO-Rapid on peri-operative hypotension and complications in aged patients undergoing total hip replacement, performed under combined spinal-epidural anesthesia (CSEA). Methods: Forty patients were randomly divided into normal fluid therapy group (group N) and LiDCO-Rapid guiding fluid therapy group (group L). For group N, anytime mean arterial pressure (MAP) was less than 65 mmHg, a rapid intravenous infusion of 150 ml hydroxyethyl starch solution (HES, 130/0.4, 6%) was given. For group L, whenever stroke volume variation (SVV) was more than 10%, HES (130/0.4, 6%) was also given to patients until SVV returned to normal limits. After administration of HES, MAP still less than 65 mmHg called for 25-50 μg of phenylephrine to be given to maintain normal MAP in both groups. Heart rate (HR), MAP and lactate level of arterial blood (LAC) was compared between the two groups as prior to anesthesia (T0); instantly (T1), 15 min (T2), 30 min (T3), 60 min (T4), 90 min (T5) after spinal anesthesia; and at the end of surgery (T6). Results: MAP and HR were significantly higher in group L than in group N at T4 to T6 (all $P<0.05$). LAC was significantly lower in group L than in group N at T5 and T6 (all $P<0.05$). Phenylephrine requirements and incidences of peri-operative complications were also significantly lower in group L than in group N (all $P<0.05$). Conclusion: LiDCO-Rapid may be used in fluid therapy for aged patients undergoing total hip replacement.

Keywords: Fluid therapy, aged patients, total hip replacement, LiDCO-Rapid

Introduction

With population aging in China, total hip replacement has become common in the aged patients [1]. Both general anesthesia and combined spinal-epidural anesthesia (CSEA) may be used for total hip replacement, but some aged patients cannot tolerate general anesthesia due to poor cardiopulmonary function. Therefore, CSEA is relatively safe for all aged patients [2]. However, hemodynamic changes are relatively severe in aged patients undergoing total hip replacement during CSEA, and usually include hypotension, organ ischemia, secondary ischemia reperfusion injury and cerebral thrombosis [3]. The hypotension readily occurs if pharmacological prophylaxis is not adopted during CSEA [4]. Peri-operative complications are directly associated with the hypotension. Though drug therapies are important to decrease the incidence of hypotension, optimal fluid management is crucial for patients undergoing total hip replacement, performed under CSEA [5]. As we know, peri-operative complications are related to the persistent hypovolemia, but on the other hand, fluid overload is also harmful [6]. It is reported that therapeutic effects vary according to different kinds of fluid [7, 8]. Most aged patients are weaker, poorer adaptable and have other lesions [9]. Water electrolyte disorder is one important reason which leads to death [10]. Appropriate peri-operative fluid therapy can maintain electrolyte balance and stable internal environment. The peri-operative fluid therapy is one of the important topics in surgery, anesthesia and ICU. In this study, we explored the optimal fluid therapy for aged patients undergoing total hip replacement, performed under CSEA.

Materials and methods

All study methods were approved by Institutional Review Board and Ethics Committee of

Table 1. General data in both groups before total hip replacement (n=20, mean ± SD)

	Group N	Group L	*t*	*P*
Age (years)	73.9±61	74.0±5.9	0.0527	0.9582
Male/female (n)	13/7	13/7	0	1
Body weight (kg)	71.2±18.7	71.3±18.5	0.017	0.9865
Height (cm)	167.9±11.8	167.8±11.5	0.0271	0.9785
ASA status I/II (n)	2/18	2/18	Fisher	1
Puncture point L2, 3/L3,4 (n)	6/14	6/14	0	1
Level of sensory block	T11.8±2.3	T11.5±2.4	0.4036	0.6888
Mean duration of operation (min)	115.8±15.9	11.72±16.7	0.2715	0.7875

Notes: group N: normal fluid therapy; group L: LiDCO-Rapid guiding fluid therapy; ASA: American Society of Anesthesiologists.

Shengjing Hospital of China Medical University. All the subjects enrolled into the study gave written formal consent to participate.

Preanesthetic preparation

A total of 40 patients who underwent elective total hip replacement between April and September 2014 were enrolled in this study. Among the 40 patients, the levels of blood glucose had been controlled within normal limits before total hip replacement for those who had diabetes mellitus. Patients in this study might have slight chronic bronchitis or other complications. Inclusion criteria were; (1) age 65 to 80 years; (2) unilateral hip replacement; (3) American Society of Anesthesiologists (ASA) physical status I-II; and (4) no contraindications for spinal anesthesia. Exclusion criteria were; (1) cardiovascular diseases such as; hypotension, heart valve disease, arrhythmia, heart failure or a history of heart infarction; (2) severe complications including renal failure or severe hypovolemia; and (3) contraindications for central neural blockade such as; elevated intracranial pressure or coagulopathy. The 40 patients were randomly divided into normal fluid therapy group (group N) and LiDCO-Rapid guiding fluid therapy group (group L), each group with 20 patients. There was no significant difference in age, body weight, sex, ASA status, puncture point, sensory block level and operative duration between the two groups (all $P>0.05$, **Table 1**).

Preoperative general data

Patients were fasted 8 h prior to operation. The patients did not receive intravenous fluid prior to entering operating rooms. After arrival at operating rooms, multi-parameters of patients including blood pressure (BP), heart rate (HR) and pulse oxygen saturation (SpO2) were monitored and recorded. Intravenous access was established with an 18 gauge cannula. A pressure kit was directly connected to the radial arterial in the patients of group N; but in the patients of group L, LiDCO-Rapid with fingerstalls on the left index and middle fingers for monitoring, was used instead of the pressure kit. HR and mean arterial pressure (MAP) were continuously observed and recorded in both groups.

Anesthesia

All patients were fasted 8 h prior to operation. After cannulating the vein, ECG, SpO2, BP and body temperature were monitored. A direct radial arterial pressure kit or LiDCO-Rapid system was used to monitor related parameters in group N and group L, respectively. A standard intravenous infusion of lactated Ringer's solution was given at a rate of 10 ml/kg/h during operation in both groups. Patients were in the right lateral decubitus position, as spinal anesthesia was performed under aseptic condition at L2/L3 or L3/L4 interspaces. All patients received 10 mg of 0.5% bupivacaine by subarachnoid injection with a 25 G needle within 18 s, and then returned in the supine position. The anesthesiologists who carried out anesthesia for the patients in this study did not know this study design. For group N, whenever MAP came less than 65 mmHg, a rapid intravenous infusion of 150 ml hydroxyethyl starch solution (HES, 130/0.4, 6%) was given to patients within 15 min. For group L, anytime stroke volume variation (SVV) was more than 10%, HES (130/0.4, 6%) was also given to patients under the guidance of LiDCO-Rapid until SVV returned to normal limits. In both groups, anytime MAP was still less than 65 mmHg after fluid bolus test, 25-50 μg of phenylephrine was given to maintain normal MAP. If HR was less than 50 beats/min, 0.3 mg of atropine was given. If

Table 2. HR and MAP between two groups at different time points

	T0	T1	T2	T3	T4	T5	T6
HR (beat/min)	N: 73.3±19.1	69.4±15.3	65.7±13.7	63.7±13.3	64.2±14.3	64.1±13.8	67.0±13.3
	L: 72.9±18.9	69.8±16.6	65.6±13.6	64.1±13.2	68.0±17.2*	68.7±16.1*	70.7±15.1*
MAP (mmhg)	N: 81.5±15.2	70.3±18.5	73.5±16.3	78.0±13.2	77.5±16.5	78.8±15.3	80.8±16.4
	L: 81.4±15.3	70.5±18.4	73.6±16.1	78.3±13.0	80.4±17.3*	80.9±16.2*	83.2±16.9*
LAC level (mmol/L)	N: 1.32±0.32	---	---	1.33±0.42	1.39±0.43	1.63±0.47	1.96±0.82
	L: 1.33±0.31	---	---	1.33±0.43	1.36±0.41	1.49±0.40*	1.63±0.64*

Notes: HR: heart rate; MAP: mean arterial pressure; LAC: lactate level; T0: prior to anesthesia; T1: instantly after spinal anesthesia; T2: 15 min after spinal anesthesia; T3: 30 min after spinal anesthesia; T4: 60 min after spinal anesthesia; T5: 90 min after spinal anesthesia and T6: at the end of surgery; N: normal fluid therapy group and L: LiDCO-Rapid guiding fluid therapy group. *Indicates $P<0.05$ as compared to group N.

Table 3. Intra-operative fluid volume and blood consumption between the two groups (n=20, mean ± SD)

	Group N	Group L	*t*	*P*
Phenylephrine (μg)	67.8±32.3	35.9±12.2*	4.1318	0.0002
Total input (ml)	545±387	1959±217*	4.173	0.0002
Crystalloids (ml)	1089±265	1178±276	1.04	0.3048
Colloids (ml)	485±283	791±249*	3.630	0.0008
Blood loss (ml)	472±213	480±218	0.1174	0.9072
Urine output (ml)	345±130	624±268*	4.189	0.0002
Total blood transfusion (ml)	368±173	208±119*	3.408	0.0016

Notes: *Indicates $P<0.05$ as compared to group N. Group N: normal fluid therapy and Group L: LiDCO-Rapid guiding fluid therapy.

hemoglobin (Hb) was less than 100 g/L, blood transfusion was performed.

Monitoring parameters for patients

Hemodynamic parameters such as HR and MAP were continuously monitored and recorded as prior to anesthesia (T0); instantly (T1), 15 min (T2), 30 min (T3), 60 min (T4), 90 min (T5) after spinal anesthesia; and at the end of surgery (T6). The levels of LAC were determined at T0, T3, T4, T5 and T6. Parameters such as blood loss, urine output, phenylephrine requirements, and peri-operative complications were monitored.

Statistical analysis

Statistical treatment was performed with Stata SE (Version 10, College Station, TX, USA). Continuous data were expressed as means ± SD and were compared using paired *t*-test. Categorical data were expressed as numbers or percentages, and were compared using a chi-squared test. Statistical significance was established at $P<0.05$.

Results

General data

There was no statistical difference in age, sex, body weight, height, ASA status, operation duration, level of sensory block and puncture point between the two groups (all P>0.05, **Table 1**). No one was excluded from this study due to failure of puncture or other reasons.

Hemodynamic changes

After anesthesia, MAP decreased in both groups to varying degrees, but MAP and HR were significantly higher in group L than in group N at T4 to T6 (all P<0.05) (**Table 2**). There were no significant differences in MAP and HR between the two groups at T0 to T3 (all $P>0.05$). The levels of LAC were significantly lower in group L than in group N at T5 and T6 (all $P<0.05$) (**Table 2**). Phenylephrine requirement was also significantly lower in group L than in group N ($P<0.05$). Total administrative fluid volume, colloid volume (HES) and urine output were higher in group L than in group N (all $P<0.05$). The total blood transfusion was significantly higher in group N than in group L ($P<0.05$). There was no significant difference in crystalloid volume (Ringer's solution) and blood loss between the two groups ($P>0.05$) (**Table 3**).

Postoperative data and complications

No one had severe complications during the peri-operative period. There were 12 patients whose hypotension returned to normal limits after administration of 25-50 μg of intravenous phenylephrine. Incidences of hypotension after

Table 4. Peri-operative complications between the two groups [n=20, n (%)]

	Group N	Group L	X^2	*P*
Hypotension	9 (45)	3 (15)*	4.286	0.038
Arrhythmias	3 (15)	1 (5)	Fisher	0.605
Acute coronary syndrome	1 (5)	1 (5)	Fisher	1
Pneumonia	0	0 (0)		
Pulmonary embolism	0	0 (0)		
Urinary infection	4 (20)	1 (5)	Fisher	0.342
Acute renal failure	0	0 (0)		
Headache, nausea or vomiting	8 (40)	2 (10)*	4.8	0.028

Notes: *Indicates *P*<0.05 as compared to group N. Group N: normal fluid therapy and Group L: LiDCO-Rapid guiding fluid therapy.

spinal anesthesia were higher in group N than in group L (all *P*<0.05). There were no peri-operative respiratory complications in both groups. Headache, nausea and vomiting were more frequent in Group N than in Group L (all *P*<0.05, **Table 4**).

Discussion

During spinal anesthesia, vasodilator effect of anesthetic drugs can allow large amount of fluid to enter peripheral vessels, leading to hypovolemia [11]. Though cardiopulmonary changes are not obvious in normal people, severe hemodynamic changes such as; high blood volume, pulmonary edema and respiratory failure may occur in aged patients during spinal anesthesia [12]. Hypotension is also a prominent side effect of spinal anesthesia. Prophylactic methods against hypotension include fluid bolus, intravenous vasopressor and change of body position [13, 14]. To effectively prevent hypotension, fluid bolus must be sufficient and appropriate in order to increase cardiac output. Therefore, we explored a more effective and safe fluid therapy method in this study.

Much more clinical studies begin to pay close attention to the reactivity of fluid infusion. It has been confirmed that rapid infusion of crystalloid can not decrease the incidence of hypotension during spinal anesthesia [15]. Compared with pure Ringer's lactate, HES can increase CO, preventing hypotension effectively [16]. Therefore, we used HES to improve hypotension in this study. In general, the hemodynamic variations during spinal anesthesia are observed only based on monitoring BP and HR, and fluid therapy also depend on BP, HR and urine output. The application of LiDCO-Rapid can let us easily achieve more accurate parameters such as; MAP, HR and SVV [17, 18]. From our results we could see that hemodynamics was more stable, and the frequency of using phenylephrine was also lower in group L than in group N.

SVV is a known functional hemodynamic parameter. We can easily achieve SVV with LiDCO-Rapid [19]. Though some factors such as; application of vascular drugs and changes in vascular tension can change the accuracy of SVV, it is still a good reference for fluid therapy [20, 21]. In this study, SVV was used as a main parameter to guide fluid therapy in aged people undergoing total hip replacement for the first time. Our results indicated that there was no significant difference in sensory block level between two groups, demonstrating no significant difference in anesthetic effects between two groups during operation. However, MAP was significantly lower in group N than in group L. This may be that intra-operative colloid infusion volume and total input were more in group L than in group N under the guidance of SVV. The patients with a SVV >10% required fluid therapy which both increased cardiac output and maintained stable hemodynamics.

Serum LAC level is an anaerobic biochemical parameter. It can be used as an early indicator for prognosis of patients [22]. Some researches show that LAC is directly related to postoperative complications [23]. Artery serum LAC level can better reflect organ perfusion and predict patients' prognosis [24]. In this study, the serum LAC level in patients was significantly higher in group N than in group L. This suggests that patients have a better prognosis in group L than in group N.

In this study, more fluids were administered and there were fewer complications in group L as compared to group N. This may be that the timing of fluid administration is important, and LiDCO system can indicate to us the right timing. Goal-directed fluid therapy can administrate adequate fluid to ensure stable hemodynamics without blood pressure reduction and tachycardia. Complications such as nausea and vomiting occurred more frequently in group

N due to a higher incidence of hypotension. This suggests that goal-direct fluid therapy assisted by LiDCO-Rapid have a preventive effect on spinal anesthesia-induced hypotension in aged patients undergoing total hip replacement. The optimal timing of fluid therapy remains to be further explored in our proceeding studies.

Fluid therapy is an important treatment during peri-operative period because it can decrease the incidence of hypotension, and reduce adverse reactions and complications.

In summary, goal-directed fluid therapy can administer adequate fluid at appropriate timing to ensure effective cardiac output and stable hemodynamics.

Disclosure of conflict of interest

None.

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