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• GASTRIC CANCER •

Effects of 7.5% hypertonic saline on fluid balance after radical surgery for gastrointestinal carcinoma

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Abstract

AIM: To investigate the effects of 7.5% hypertonic saline on positive fluid balance and negative fluid balance, after radical surgery for gastrointestinal carcinoma.

METHODS: Fifty-two patients with gastrointestinal carcinoma undergoing radical surgery were studied. The patients were assigned to receive either Ringer lactate solution following 4 mL/kg of 7.5% hypertonic saline (the experimental group, n = 26) or Ringer lactate solution (the control group, n = 26) during the early postoperative period in SICU. Fluid infusion volumes, urine outputs, fluid balance, body weight change, PaO_2/FiO_2 ratio, anal exhaust time as well as the incidence of complication and mortality were compared between the two groups.

RESULTS: Urine outputs on the operative day and the first postoperative day in experimental group were significantly more than in control group (P<0.000001, P = 0.000114). Fluid infusion volumes on the operative day and the first postoperative day were significantly less in experimental group than in control group (P = 0.000042, P = 0.000415). The volumes of the positive fluid balance on the operative day and during the first 48 h after surgery, in experimental group, were significantly less than in control group (P<0.000001). Body weight gain post-surgery was significantly lower in experimental group than in control group (P<0.000001). The body weight fall in experimental group occurred earlier than in control group (P<0.000001). PaO_2/FiO_2 ratio after surgery was higher in experimental group than in control group (P = 0.000111). The postoperative anal exhaust time in experimental group was earlier than in control group (P = 0.000006). The overall incidence of complications and the incidence of pulmonary infection were lower in experimental group than in control group (P = 0.0175, P = 0.0374).

CONCLUSION: 7.5% hypertonic saline has an intense diuretic effect and causes mobilization of the retained fluid, which could reduce fluid infusion volumes and positive fluid balance after radical surgery for gastrointestinal carcinoma, as well as, accelerate the early appearance of negative fluid balance after the surgery, improve the oxygen diffusing capacity of the patients' alveoli, and lower the overall incidence of complications and pulmonary infection after the surgery.

Key words: Hypertonic saline; Fluid balance; Positive fluid balance; Negative fluid balance; Abdominal surgery; Gastrointestinal carcinoma

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INTRODUCTION

The practice of perioperative fluid therapy is variable. In the perioperative fluid therapy of radical surgery for gastrointestinal carcinoma, the positive fluid balance significantly exists after which the negative fluid balance appears[1]. The volume of positive fluid balance is the important risk factor of the postoperative complications and in-patient mortality. In the nonsurvivors group a much more positive fluid balance was found, together with increasing the extent of the organ dysfunction. The stronger correlation between fluid intake and fluid balance in nonsurviving patients compared with survivors points to the need for careful fluid management in critically -ill patients[2,3]. Appearance of the negative fluid balance indicates surgical stress response subsiding and resuming of the internal environment stability, and portends a good prognosis. The delaying of the negative fluid balance indicates that the stability of the internal environment has not been restored and complications may occur[4].

In recent years, attention has been directed towards the problem of larger volume of positive fluid balance after abdominal aortic aneurysm resection and coronary artery bypass grafting surgery, which seriously impacts the resuming of the cardiopulmonary function. Hypertonic saline is being applied abroad to stimulate excretion of excess body fluid, accumulated during and after surgery, to decrease the volumes of positive fluid balance[5-10], and to accelerate the early appearance of negative fluid balance after surgery[6].

Hence, we applied 7.5% hypertonic saline to the patients with gastrointestinal carcinoma undergoing radical surgery to observe the effects on the positive and negative fluid balance after the surgery.

MATERIALS AND METHODS

Case selection

Fifty-two patients with gastrointestinal carcinoma undergoing radical surgery in our hospital from February 2003 to March 2004 were divided into the experimental group (n = 26) and the control group (n = 26) according to their diseases and surgery modes. Diseases and surgery modes of the two groups are shown in Table 1. General information of the two groups are shown in Table 2, of which POSSUM (Physiological and Operative Severity Score for the EnUmeration of Mortality and Morbidity) scoring is accounted by Copeland method[11].

Table 1 Diseases and surgery modes of experimental group and control group

	Experimental group	Control group
Gastric carcinoma		
Distal gastrectomy D_2	8	8
Proximal gastrectomy D_2	2	2
Total gastrectomy D_3	2	2
Carcinoma of the colon		
Sigmoid colon D_3 excision	4	4
Right-half colon D_3 excision	2	2
Left-half colon D_3 excision	1	1
Transverse colon D_3 excision	1	1
Rectal carcinoma		
Dixon procedure	4	4
Miles procedure	2	2

Table 2 Comparison of general data between experimental group and control group

	Experimental group	Control group	t or χ^2	P
Sex (male/female cases)	12/14	15/11	χ^2 = 0.69	0.4050
Age (yr)	57.19±9.58	55.19±13.48	t = 0.567821	0.575221
Body weight (kg) [1]	55.58±9.44	58.21±9.72	t = 1.074640	0.292797
Serum sodium (mmol/L)[1]	139.92±2.46	139.31±3.87	t = 0.813147	0.423811
HCT[1]	0.33±0.07	0.34±0.07	t = 0.773980	0.446200
Serum albumin (g/L) [1]	38.35±3.53	39.42±3.73	t = 1.001330	0.326262
PaO_2/FiO_2 ratio[1]	395.88±45.55	410.43±60.33	t = 1.021750	0.316684
MAP (mmHg) [2]	91.88±11.31	96.17±13.35	t = 1.145300	0.263864
Heart rate (times/min) [2]	89.38±12.85	88.54±11.49	t = 0.223948	0.824775
POSSUM score	34.54±4.83	33.46±4.12	t = 0.951963	0.350230
Operative period (min)	252.42±73.35	248.85±73.19	t = 0.208407	0.836599
Blood transfusion (cases)	8	5	χ^2 = 0.92	0.3367

[1]Examination results before surgery. [2]Result at time of entering SICU.

Fluid therapy after surgery

After surgery, the patients were immediately sent into SICU. Patients in the experimental group firstly received 4 mL/kg of 7.5% hypertonic saline and were continuously transfused with Ringer lactate solution. Non-visible dehydration was calculated according to 400 mL/(m^2·d), transfusing 12% more when the body temperature rose by 1 ℃ and supplied 5% glucose solution. Patients in the control group that did not receive 7.5% hypertonic saline and other fluid therapies were same as that of the experimental group. Transfusion of the whole process was measured with the transfusion pump and the transfusion speed was adjusted according to urine outputs of every hour, which referred to blood pressure, pulse and HCT value. The objective was to keep the hemodynamics stable and enough urine outputs. When urine outputs <0.5 mL/(kg·h) and/or pulse speed and HCT rose, the transfusion was accelerated; when urine outputs >1.0 mL/(kg·h), transfusion was slower.

The fluid volumes transfused and discharged and the urine outputs of every hour were recorded. Fluid balance of unit time was calculated. After surgery, body -weight of each hour was measured with the hydraulic weighing sickbed. Body weight increase value = postoperative maximum body weight-preoperative basic value of the body weight (kg). Bodyweight falling time refers to the hour difference between time of starting of body weight falling and time of entering SICU (h). Serum electrolyte and arterial blood gas analysis were checked every 6 h until negative fluid balance disappeared.

Data analysis

Curves of body weight and urine outputs of each hour after surgery were drawn. Fluid infusion volumes, urine outputs, volumes of positive fluid balance, body weight gain value, body weight falling time, PaO_2/FiO_2 ratio, anal exhaust time, complication incidence and mortality of two groups were compared. Data mean value was expressed with mean±SD. Comparison of statistics difference was inspected with χ^2 test and t test. Statistical analysis was performed with software SPSS10.0.

RESULTS

Statistic comparability

Difference of surgery modes (Table 1), patient conditions and POSSUM scores (Table 2), fluid infusion volumes (Table 3) and urine outputs (Table 4) during surgery between the two groups are not significant but are statistically comparable.

Fluid infusion volumes

Difference of fluid infusion volumes between the two groups are summarized in Table 3.

Urine outputs

Comparison of urine outputs of experimental group and control group are shown in Table 4.

Table 3 Fluid infusion volumes (mL) of experimental group and control group

	During surgery	Operative day	First postoperative day
Experimental	3 607.69±1 029.15	7 140.23±1 497.91	3 051.58±968.16
Control	3 657.69±1 086.34	8 888.04±1 389.93	4 458.85±1 415.86
t	0.192560	4.953730	4.068690
P	0.848859	0.000042	0.000415

Table 4 Comparison of urine outputs (mL) between experimental group and control group

	During surgery	Operation day	First postoperative day
Experimental	630.77±212.64	2 446.73±361.12	2 641.65±558.97
Control	723.08±316.93	1 735.31±381.04	1 998.65±482.76
t	1.081120	6.958838	4.569320
P	0.289961	<0.000001	0.000114

Fluid balance and body weight change

Differences of fluid balance and body-weight change between the two groups are summarized in Table 5. On the day of operation, patients of the two groups had significant positive fluid balance; on the first postoperative day, 19 patients of the experimental group showed negative fluid balance and only one in the control group showed negative fluid balance (χ^2 = 26.33, R67.8, 95% CI 58.3-77.2, P<0.0001; NNT1.44).

Table 5 Comparison of fluid balance and body weight between experimental group and control group

	VPFB on operative day (mL)	VPFB in 48 h after surgery (mL)	BW increase value (kg)	BW falling time (h)
Experimental	2 832.85±970.67	2 519.15±1 629.44	3.46±1.15	18.38±7.16
Control	4 944.46±1 289.67	6 887.31±2 115.84	6.96±2.41	29.58±7.80
t	7.475810	9.19234	7.096470	7.23379
P	<0.000001	<0.000001	<0.000001	<0.000001

Note: VPFF = volume of positive fluid balance; BW = body weight.

PaO_2/FiO_2 ratio

PaO_2/FiO_2 ratio of patients of two groups before surgery was not different (Table 2). Within 6 h after entering ICU, PaO_2/FiO_2 ratios of the experimental group and control group were respectively 463.03±136.23 and 339.79±54.42 (t = 4.578857, P = 0.000111).

Postoperative anal exhaust time

Postoperative anal exhaust time of the patients of the experimental group on an average was about 2.81±0.75 (1-4) d after surgery and that of the control group was about 4.27±1.04 (2-7) d after surgery (t = 5.718330, P = 0.000006).

Postoperative hypernatremia

After surgery, serum sodium concentration of five patients of the experimental group (within 6 h after entering SICU) was 145.2-153 mmol/L but had no clinical symptom; after 6 h (12 h after entering SICU) serum sodium concentration returned to the normal value. Patients of the control group had no hypernatremia.

Postoperative complications and mortality

Two patients of the experimental group had complications (7.69%) after surgery and nine patients of the control group had complications (34.62%) after surgery (χ^2 = 5.65, P = 0.0175). In the two groups, five patients had wound infection (9.62%) after surgery, who were cured through drainage therapy; four patients developed pulmonary infection (7.69%), who were cured through antibiotic therapy; one anastomotic leak case (1.92%), who was a patient for 18 d after right-half colon D_3 excision, clinically diagnosed as anastomotic leak because of the localized peritonitis accompanying high fever and cured through total parenteral nutritional support and antibiotic therapy; one ileus case (1.92%), who was cured through non-surgical therapy such as gastrointestinal decompression, spasmolysis and low pressure clysis. A patient of the control group died (0.04%), who was patient of right-half colon D_3 excision for carcinoma of cecum and died on the 21st postoperative day due to hepatic failure. Comparison results of the incidence of complication and mortality between the experimental group and the control group are shown in Table 6.

Table 6 Comparison of complications and mortality (cases) between the two groups

	Wound infection	Pulmonary infection	Ileus	Anastomotic leak	Death
Experimental	2	0	0	0	0
Control	3	4	1	1	1
χ^2	0.22	4.33	1.02	1.02	1.02
P	0.6381	0.0374	0.3126	0.3126	0.3126

DISCUSSION

The principles of perioperative fluid therapy were fostered in the late 1950s and early 1960s. Recommendations for restricted fluid regimen came primarily from Moore. In contrast, Shires postulated a decrease in extracellular volume after surgery, due to internal redistribution of fluids, the 'third space' losses, and advocated replacement of these losses by additional fluid infusion[12]. Clinical practice has largely been influenced by Shires' recommendations in elective surgical procedures. This is especially the case in major abdominal surgery[13].

Major surgical operation, similar to severe trauma, burn and sepsis, may cause systemic inflammatory response syndrome and systemic capillary leakage. In response to surgery, serum colloid osmotic pressure is decreased, which is primarily caused by increased capillary permeability, resulting in fluid shifts from the vascular bed to the interstitial fluid. In these cases, except local effusion and edema, increased systemic capillary permeability causes intravascular fluid loss into the extravascular compartment[14]. As a result, hypovolemia, hyposarca, less urine outputs and higher HCT value occur. Fluid resuscitation must cause positive fluid balance, worse hyposarca and body weight gain[1,8].

Administration of excess fluid may cause several problems after surgery. The resulting increased demands on cardiac function, due to an excessive shift to the right on the Starling myocardial performance curve, may potentially increase postoperative cardiac morbidity. Fluid accumulation in the lungs may predispose patients to pneumonia and respiratory failure. Gastrointestinal motility may be inhibited, prolonging postoperative ileus. Excess fluid may decrease tissue oxygenation with implications for wound and anastomotic healing[14]. Petrašovicová *et al*[2] found, through observing 117 surgical critical patients, that patients with large volume positive fluid balance indicate poor prognosis and have higher organ dysfunction incidence and mortality. Result of the logic regression analysis of Moller *et al*[3] shows that the large volume of positive fluid balance is the most important risk factor of the postoperative complications and mortality. Alsous *et al*[4] found through analysis that appearance of negative fluid balance indicates the disease is turned back with good prognosis and delaying of negative fluid balance indicates poor prognosis. Thus, how to decrease fluid intake and the volume of positive fluid balance and to make negative fluid balance appear early as possible is the key to the postoperative fluid therapy.

In this research, diseases and surgery modes of two groups of patients are shown in Table 1. Dereference of two groups of patients on sex ratio (male/female patients), age, basic body- weight, preoperative biochemical factors (serum sodium concentration, serum albumin concentration, HCT and PaO_2/FiO_2 ratio), hemodynamic conditions when entering SICU (mean arterial pressure and heart rate) and number of blood-transfusing patients is insignificant (Table 2).

The documents of our department prove that POSSUM score (physiology score and surgery severity score) can exactly predict the sizes of the surgery for gastrointestinal cancer and their postoperative complication incidence and mortality[15]. Difference between the two groups of patients on POSSUM and surgery hours is insignificant (Table 2). It is obvious that clinical data of the cases of the experimental group and control group are statistically comparable.

The research results prove that 7.5% hypertonic saline has an intense diuretic effect, which is manifested by the urine outputs increase of the patients in the experimental group on the operative day and the first postoperative day. Such diuresis effect is different from diuretic, which can increase the plasma volume within a short time, keep stability of hemodynamics and cause mobilization of the retained fluid excess. As a result, the postoperative fluid infusion volumes were significantly decreased, also the postoperative positive fluid balance of the patients in the experimental group was reduced. This effect was confirmed by the lesser increase in body-weight measured after surgery in the experimental group. This is consistent with application result of 7.5% hypertonic saline after abdominal aortic aneurysm resection and coronary artery bypass graft surgery[5-10].

The body weight gain is the objective exhibition of positive fluid balance (input fluid volume >excreted fluid volume). Increased extent of the body weight indicates volume of the positive fluid balance. Falling of the body weight indicates appearance of the negative fluid balance (input fluid volume <excreted fluid volume). Research shows that 7.5% hypertonic saline increasingly makes the extent of postoperative body weight, of the patients in the experimental group, smaller and falling of the body weight occurring earlier to prove that transfusion of hypertonic saline not only decreases volume of positive fluid balance after surgery but also makes negative fluid balance appear earlier. This has not been reported in foreign literature.

In 6 h after entering SICU, PaO_2/FiO_2 ratio of the patients in the experimental group was significantly higher than that of the control group (P = 0.000111), which shows that hypertonic saline can improve the patients' oxygenation conditions. Hypertonic saline may make intrapulmonary venous admixture less and improve alveolar gas exchange[6]. Someone also thinks it reduces systemic and pulmonary inflammatory responses as well as improves pulmonary perfusion and oxygenation[16].

The overall incidence of postoperative complication and the incidence of pulmonary infection of the experimental group were significantly lower than that of the control group (P = 0.0175, P = 0.0374; Table 6), which may relate to diuretic effect and improving effect of oxygen supply of hypertonic saline. The intestinal functional rehabilitation time (anus exsufflation) of the patients in the experimental group was significantly earlier than that in the control group (P = 0.000006), which may be the result of the fact that the hypertonic saline decreases fluid infusion volumes and volumes of the positive fluid balance to relieve postoperative intestinal edema.

After 6 h of transfusing hypertonic saline, five patients of the experimental group had hypernatremia, but serum sodium concentration was not above 153 mmol/L. After 6 h (after 12 h in ICU), serum sodium concentration returned to the normal value.

The foreign researchers concluded that the use of hypertonic saline might be of interest for use in surgical patients. The suggested explanations for the beneficial effects of hypertonic saline are (1) compartmental redistribution with a fluid shift to the vascular bed and consequent plasma expansion[17,18]; (2) a reduction in blood viscosity through hemodilution and reduced endothelial and red blood cell swelling improved microcirculation[19]; (3) an endothelial barrier mechanism decreased microvascular fluid loss during states of elevated microvascular leak[20,21]; (4) the effects of improving tissue oxygenation and perfusion, and reducing systemic and pulmonary inflammatory responses[22]; and (5) hormonal and immunologic effects[23] that are possible mechanisms of the long-lasting impact of hypertonic saline.

This study's findings through a prospective control study of 52 patients with gastrointestinal carcinoma undergoing radical surgery suggest that 7.5% hypertonic saline has an intense diuretic effect, which may decrease volumes of postoperative fluid infusion and positive fluid balance; and make negative fluid balance appear earlier. In addition, 7.5% hypertonic saline can also improve postoperative oxygenation conditions and reduce the incidence of overall postoperative complication and pulmonary infection.

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