原 著

Effects of 1% Glucose-Containing Ringer's Solution on Intraoperative Plasma Glucose Concentration in Elderly and Young Patients

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Abstract

The purpose of this study was to evaluate the effects of 1% glucose-containing solution on plasma glucose concentration in elderly and young patients. Twenty-two elderly (>65yr) and 24 young (20–59yr), ASA physical status I or II patients scheduled for elective surgery under general anesthesia were studied. Patients received acetated Ringer's solution containing 1% glucose at a rate of $10ml \cdot kg^{-1} \cdot hr^{-1}$. Plasma glucose, sodium and potassium concentrations, and urine volume were measured at just before the incision (baseline), and at 1, 2, and 3 hours (h) after the incision. Plasma glucose concentration in the elderly and the young groups did not change significantly from the baseline values during the 1–3h periods. Plasma glucose at 2h in the young group was significantly lower than that in the elderly group ($p < 0.05$). Incidence of hypoglycemia in the elderly group was significantly lower than that in the young group ($p < 0.05$). Hypoglycemia occurred only in young female patients. 1% glucose-containing solution produced stable intraoperative plasma glucose concentration in the elderly group and the young group except female patients.

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Key words; fluid management, 1% glucose, elderly, young

Introduction

Oral intakes of water and foods are prohibited before operation. Therefore, fluid and glucose are necessary to administer intraoperatively to prevent dehydration and hypoglycemia. The fluid requirement is composed of compensatory intravascular volume expansion, deficit replacement, maintenance fluids, restoration of losses and substitution for fluid redistribution. We usually use Ringer's solution during scheduled surgery with infusion rates at 5–$14ml \cdot kg^{-1} \cdot hr^{-1}$, and majority of Ringer's solutions contain 0% or 5% glucose. Glucose free solution can produce hypoglycemia, and 5% glucose-containing solution may produce severe hyperglycemia[1]. Therefore, low concentration of glucose and Ringer's solution would be useful especially in elderly patients, because glucose tolerance is low in elderly[2]. Recently, 1% glucose-containing acetated Ringer's solution is available for clinical use. Nevertheless, intraoperative plasma glucose levels using 1% glucose-containing solution in elderly and young patients have not been investigated.

The objective of the study was therefore to elucidate the effects of 1% glucose-containing acetated Ringer's solution on plasma glucose concentration in elderly and young patients.

Materials and methods

The study was approved by our ethical committee (University of Yamanashi, Japan), and written informed consent was obtained from all patients. We enrolled 22 elderly patients aged over 65 years (elderly group), and 24 young patients aged 20–59 years (young group) who were scheduled to undergo head and neck, breast, or abdominal surgery under general anesthesia. They were ASA physical status I or II. Exclusion criteria included diabetes mellitus, neuropsychiatric disorders, daily use of corticosteroids, hypothyroidism, hypermagnesemia, and impaired kidney function.

Oral intakes for solid foods and clear liquids were prohibited 12 hours preceding the induction of anesthesia. Patients were premedicated with intramuscular 0.04mg·kg^{-1} midazolam 30min before entering the operating room. An 18- or 20-gauge venous catheter was inserted into a vein in the wrist, and acetated Ringer's solution containing 1% glucose (Physio 140®: Na^+; 140, K^+; 4, Ma^{2+}; 2, Ca^{2+}; 3, Cl^-; 115, Acetate$^-$; 25, Gluconate$^-$; 3, Citrate^{3-}; 6mEq/l, Otsuka, Tokyo, Japan) was infused at a rate of 10ml·kg^{-1}·hr^{-1} during this investigation. Anesthesia was induced with 2mg·kg^{-1} propofol. Vecuronium 0.1mg·kg^{-1} was given to facilitate tracheal intubation. Anesthesia was maintained with 1–2% sevoflurane and 67% nitrous oxide in oxygen (GOS). Fentanyl was allowed during surgery in the case of persistent tachycardia and/or hypertension (defined as values 30% more than preanesthetic values) that did not respond to increases of the inspired sevoflurane concentration. Ventilation was adjusted to maintain end-tidal carbon dioxide between 32–38mmHg by mechanical ventilation. A 22-gauge catheter was inserted into a radial artery. Systemic arterial pressure, heart rate, rectal temperature, and pulse oximetry were monitored continuously and maintained within a normal range. Hypotension (defined as values 30% less than preanesthetic values) was treated with ephedrine 0.1mg·kg^{-1}.

Blood samples were obtained from the radial arterial catheter. Plasma glucose, sodium and potassium concentrations were measured just before the incision (baseline), and at 1, 2, and 3h after the incision by using blood gas analyzer (Stat Profile plus 9, Nova Biomedical, Tokyo, Japan). Urine volume was also evaluated. Hypoglycemia was defined as plasma glucose concentration lower than 90mg·dl^{-1}. Severe hypotension, which was defined as plasma glucose concentration lower than 60mg·dl^{-1}, was treated with intravenous injection of 50% glucose 20ml.

Data are presented as means±SD. Sample size of 18 patients per group was required to achieve a power of 0.8 and an α of 0.05 to detect a difference of 15mg·dl^{-1} in plasma glucose between groups, with a SD of 15mg·dl^{-1}. Patients' age, height, weight, and blood loss volume were compared using unpaired *t* test. Within-group comparisons in plasma glucose, sodium and potassium concentrations were performed using one-way analysis of variance for repeated measurements, followed by the Dunnett *post hoc* test. Inter-group differences in plasma glucose, sodium and potassium concentrations were analyzed by factorial analysis of variance with Scheffé multiple comparison tests. The incidence of hypoglycemia was compared using chi-square test. *P* values less than 0.05 were considered statistically significant.

Results

The two groups were similar with regard to gender, height, weight, sites of operation, anesthetic methods, and blood loss volume (**Table 1**). Urine output did not differ between the two groups. Ephedrine was used in 3 elderly and 1 young patients during the study period. The difference was not statistically significant.

Plasma glucose concentrations in the elderly and the young groups did not change significantly from the baseline values during the study period (**Table 2**). However, plasma glucose at 2h in the young group was significantly lower than that in the elderly group ($p < 0.05$; **Table 2**). Hypoglycemia occurred in 4 young female patients, and one patient showed marked hypoglycemia (59mg·dl^{-1}), whereas no elderly or young male patients developed hypoglycemia.

Table 1 Patient characteristics, sites of operation, anesthetic methods, and blood loss

Parameter	Elderly group	Young group
n	22	24
Age (years)	72±5*	46±11
Gender (female/male)	8/14	14/10
Height (cm)	158±8	160±8
Weight (kg)	58±9	63±12
Sites of operation (HN/B/UA/LA)	6/1/5/10	10/5/3/6
Anesthetic methods (GOS/GOSF/GOS+Epi)	3/5/14	6/10/8
Blood loss volume/3h (g)	212±204	130±182

Note: Values are means±SD or absolute numbers. HN: head and neck, B: breast, UA: upper abdomen, LA: lower abdomen, G: nitrous oxide, O: oxygen, S: sevoflurane, F: fentanyl, Epi: epidural anesthesia.
*$p<0.0001$ versus the young group.

Table 2 Plasma glucose concentrations

	Elderly group	Young group
n	22	24
Baseline ($mg \cdot dl^{-1}$)	113±15	113±13
1h ($mg \cdot dl^{-1}$)	120±16	110±17
2h ($mg \cdot dl^{-1}$)	121±18*	109±17
3h ($mg \cdot dl^{-1}$)	118±17	113±17

Note: Values are means±SD or absolute numbers. Baseline: just before incision, 1h: 1 hour after the incision, 2h: 2 hour after the incision, 3h: 3 hour after the incision. *$p<0.05$ vs. young group.

The difference in the incidence of hypoglycemia was statistically significant between the elderly and the young groups ($p<0.05$). Plasma sodium and potassium were not different between the two groups during all the experimental period.

Discussion

Our study demonstrates that infusion of 1% glucose-containing acetated Ringer's solution induced stable plasma glucose concentration in elderly patients and in most of young patients. Nevertheless, hypoglycemia was observed in several young female patients.

Intraoperative glucose administration is necessary to prevent hypoglycemia, to provide energy, to conserve protein and to prevent ketosis. Terajima and Ogawa[3] reported that optimal intraoperative glucose dose for young patients (mean age; approximately 40yr) was $0.1\text{-}0.2 g \cdot kg^{-1} \cdot hr^{-1}$. However, glucose tolerance decreases with age, because elderly patients have been shown to be more insulin resistant than younger individuals[2]. Furthermore, surgical stress provokes hyperglycemia with the discharge of anti-insulin hormones. Therefore, hyperglycemia is anticipated in elderly patients during the operation even though optimal dose of glucose is infused. In the present study, glucose was infused at rates of $0.1 g \cdot kg^{-1} \cdot hr^{-1}$, and this dose produced stable plasma glucose concentration in elderly patients.

Contrary to Terajima and Ogawa's report[3], infusion rates of glucose at $0.1 g \cdot kg^{-1} \cdot hr^{-1}$ may not be optimal for young patients, because hypoglycemia developed in 4 young female patients and severe hypoglycemia occurred in one female patient in the present study. Our results concur with Doze's report demonstrating that young women fasted for a period at least 12h showed severe hypoglycemia ($53 \pm 8 mg \cdot dl^{-1}$; mean±SD)[4]. Fasting women would be likely to generate hypoglycemia. These findings suggest that intraoperative doses of glucose more than $0.1 g \cdot kg^{-1} \cdot hr^{-1}$ may be necessary to young female patients.

Because oral intake of water is prohibited before

surgeries, rapid fluid administration is necessary to prevent dehydration. In addition, glucose should be administered intraoperatively. We usually obtain one venous route unless the massive bleeding would be expected during the surgery. Thus volume maintenance and glucose administration are provided in one route. Ringer's solution is widely used intraoperatively, and the majority of Ringer's solutions contain 5% or 0% glucose. A rapid infusion of 5% glucose-containing solution may cause severe hyperglycemia[1]. Hyperglycemia could induce osmotic diuresis[5], deterioration of ischemia-induced brain damage[6], and wound healing delay[7]. On the other hand, infusion with glucose free solution may lead to hypoglycemia and protein catabolism. Hypoglycemia is dangerous since glucose is the sole fuel source for the brain. To prevent hyperglycemia and hypoglycemia, 2.5% glucose-containing fluids are recommended to use intraoperatively[8]. However, plasma glucose concentration just after infusion of 12.5ml·kg^{-1} of 2.5% glucose for 45min was approximately 200mg·dl^{-1} [9]. Glucose concentrations that are lower than 2.5% and Ringer's solution would be preferable as an intraoperative fluid regimen. We confirmed in the present study that 1% glucose-containing Ringer's solution is favorable for intraoperative use.

In the present study, there was significant statistical difference in plasma glucose concentration between the groups at 2h, but the difference did not expanded at 3h. One possible cause was that blood glucose at 3h was restored by 50% glucose injection in a woman in whom the blood glucose declined to 59mg·dl^{-1}. In addition, absolute values of mean plasma glucose concentrations at any time points between the groups were comparable clinically.

Several factors such as anesthetic methods[10], operative procedures[11], ephedrine[12], etc, may have influenced plasma glucose concentration. In the present study, anesthetic methods, sites of operation, and ephedrine use were not different between the groups. Therefore, those factors potentially affected our results, however, the effects could have been small.

Conclusion

1% glucose-containing acetated Ringer's solution produces stable intraoperative plasma glucose concentration in elderly and young patients except some young female patients.

References

1) Kuze S, Naruse T, Ito Y, et al: Comparative study of intravenous administration of Ringer's lactate, Ringer's acetate and 5% glucose containing these Ringer's solutions in human being. J Anesth 1990; 4: 155-61.
2) Basu R, Breda E, Oberg AL, et al: Mechanisms of the age-associated deterioration in glucose tolerance: contribution of alterations in insulin secretion, action, and clearance. Diabetes 2003; 52: 1738-48.
3) Terajima K, Ogawa R: What is the optimal dose of glucose administration during minor surgery under sevoflurane anesthesia? J Anesth 2000; 14: 14-8.
4) Doze VA, White PF: Effects of fluid therapy on serum glucose levels in fasted outpatients. Anesthesiology 1987; 66: 223-6.
5) Chiasson JL, Aris-Jilwan N, Belanger R, et al: Diagnosis and treatment of diabetic ketoacidosis and the hyperglycemic hyperosmolar state. CMAJ 2003; 168: 859-66.
6) Kurihara J, Katsura K, Siesjo BK, et al: Hyperglycemia and hypercapnia differently affect post-ischemic changes in protein kinases and protein phosphorylation in the rat cingulate cortex. Brain Res 2004; 995: 218-25.
7) Spravchikov N, Sizyakov G, Gartsbein M, et al: Glucose effects on skin keratinocytes: implications for diabetes skin complications. Diabetes 2001; 50: 1627-35.
8) Kaye AD, Kucera IJ: Intravascular Fluid and Electrolyte Physiology. In: Miller RD, editor. Miller's Anesthesia. 6th ed. Philadelphia: Churchill Livingstone; 2005. p.1763-98.
9) Strandberg P, Hahn RG: Volume kinetics of glucose 2.5% solution and insulin resistance after abdominal hysterectomy. Br J Anaesth 2005; 94: 30-8.
10) Lattermann R, Carli F, Wykes L, et al: Perioperative glucose infusion and the catabolic response to surgery: the effect of epidural block. Anesth Analg 2003; 96: 555-62.
11) Sieber FE, Smith DS, Traystman RJ, et al: Glucose: a reevaluation of its intraoperative use. Anesthesiology 1987; 67: 72-81.
12) Persky AM, Ng C, Song MH, et al: Comparison of the acute pharmacodynamic responses after single doses of ephedrine or sibutramine in healthy, overweight volunteers. Int J Clin Pharmacol Ther 2004; 42: 442-8.