

Plasma Glucose Level in Elective Surgical Patients Administered with 5% Dextrose in 0.45% NaCl in Comparison with Those Receiving Lactated Ringer's Solution

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Objective: To determine the effect of dextrose containing solution (5% dextrose in 0.45% NaCl) compared to non-dextrose containing solution (lactated Ringer's solution) on plasma glucose level in elective surgical patients.

Material and Method: A prospective randomized double-blind control trial was conducted on 60 patients aged 18-60, with ASA physical status I to II, who were scheduled for elective surgery at Maharaj Nakorn Chiang Mai Hospital, Thailand between October, 2007 and September, 2008. The patients received either lactated Ringer's solution (Group L), or 5% dextrose in 0.45% NaCl (Group D) in the morning of the operation day. Blood glucose levels were determined before intravenous fluid administration (T_0), at the beginning (T_1), after the 1st hr (T_2), and at the end of surgery (T_3).

Results: Mean duration of preoperative fast was almost 11 hrs in both groups; however, none of the patients had preoperative hypoglycemia. The blood sugar levels were significantly higher in the patients receiving 5% dextrose solution compared to the patients receiving lactated Ringer's solution at the beginning, after the 1st hr and at the end of surgery (p -value = 0.06, 0.018 and 0.036 respectively). There were some patients having hyperglycemia after receiving 5% dextrose in 0.45% NaCl during surgery. However, none of the average plasma glucose values in either group was considered as hyperglycemia.

Conclusion: Though they fasted many hours before surgery, no patients were found to have hypoglycemia. The large volume of lactate Ringer's solution had minimal effect on the blood sugar levels compared to the levels in 5% dextrose in 0.45% NaCl group. Therefore, lactate Ringer's solution is probably the alternative choice of intravenous fluid for perioperative maintenance and can be used as replacement in healthy patients undergoing elective surgery.

Keywords: Dextrose, NaCl, Lactate Ringer's solution, Plasma glucose level

J Med Assoc Thai 2009; 92 (9): 1178-83

Full text. e-Journal: <http://www.mat.or.th/journal>

Glucose is a crucial fuel source, and insulin facilitates glucose movement into cells in a process that also requires potassium and phosphate. RBCs, healing wounds, the brain, and the adrenal medulla require glucose for fuel, totaling approximately 2 mg/kg/min. Requirements of maintenance fluid are 1.5-2 ml/kg/h, and these are independent of the type of

surgical procedure⁽¹⁾. Previous studies have mentioned the effect of fasting on preoperative glycemic levels and the influence of different intravenous solutions on perioperative glucose levels⁽²⁻⁵⁾. The surgical stress response increases endogenous glucose production (from glycogenolysis and gluconeogenesis) while decreasing clearance⁽⁵⁾. Hyperglycemia can be detrimental to the well-being of the patient^(6,7).

There are several kinds of crystalloid solution available for intravenous fluid administration. Two kinds of solution, which surgeons usually prescribe in

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the authors' hospital for intravenous fluid replacement during fast, are 5% dextrose in 0.45% sodium chloride and lactate Ringer's solution. Half-normal saline (0.45% NaCl), often with "D5" (5% dextrose), contains 77 mEq/L of Na and Cl and 50 g/L glucose. Whereas, one liter of lactated Ringer's Solution contains 130 mEq of sodium ion, 109 mEq of chloride ion, 28 mEq of lactate, 4 mEq of potassium ion and 3 mEq of calcium ion. The pH of the solution is 6.6 (6.0-7.5)⁽⁸⁾. Both 5% dextrose in 0.45% NaCl and lactate's Ringer solution should be used carefully in patients who tend to have high plasma glucose level. The administration of lactate ions should be done with great care in patients with metabolic or respiratory alkalosis and where there is an increased level or an impaired utilization of lactate ions, as in severe hepatic insufficiency⁽⁹⁾.

In the present study, the authors compared the plasma glucose levels in elective non-diabetic adult patients who received 5% dextrose in 0.45% NaCl perioperatively to those who received lactated Ringer's solution. The results of the present study should serve as a guideline for fluid management in fasted patients for elective surgery at Maharaj Nakorn Chiang Mai Hospital.

Material and Method

After approval by the institutional ethics committee and written informed consent was obtained, the authors enrolled 60 patients aged 18-60 with ASA physical status I to II, who were scheduled for elective surgery at Maharaj Nakorn Chiang Mai Hospital, Thailand between October 2007 and September 2008. The patients were given either lactate Ringer's solution (Group L) or 5% dextrose in 0.45% NaCl (Group D).

The exclusion criteria comprised patients who planned to have regional anesthesia; had preoperative diagnosis of diabetes mellitus, renal or hepatic dysfunctions; were receiving perioperative corticosteroid therapy; were undergoing cardiovascular thoracic or neurosurgery; or were undergoing surgery with an expected intraoperative blood loss more than 10% of total blood volume (about 400-500 ml) or large fluid shift. Patients were randomly allocated into two groups using a computer generated random number chart and sealed envelopes. Group L received 2 ml/kg/hr of lactate Ringer's solution, whereas Group D received the same amount of 5% dextrose in 0.45% sodium chloride. Infusion was started in the morning of the operation day once an intravenous catheter had been inserted. Blood was drawn from the other venous

catheter in the antecubital fossa of the opposite arm. Samples were taken before starting the infusion (T_0), before the operation started (T_1), one hour after the operation started (T_2) and just before the operation finished (T_3). All blood samples were analyzed at the hospital's central laboratory.

Anesthetic management depended on the judgment of the attending anesthesiologist and was not influenced or intentionally altered as a result of participation in the present study. For replacement of operative blood loss in both groups, 0.9% sodium chloride solution was administered in the other intravenous line. Demographic and anesthetic data were recorded.

Since there was no previous research conducted, the authors decided to do the present study as a pilot study; 30 patients in each group were chosen for the sample size. Discrete categorical data were presented as frequency (percent); and continuous data were presented as mean \pm SD. Plasma glucose levels between groups were compared using independent t test or Mann-Whitney U test. Statistical analysis for increasing plasma glucose from the baseline level in each group was carried out using the repeated measure of ANOVA with Bonferroni test and $p < 0.05$ was considered to be significant. ANCOVA was also used to find out the covariate factor. The plasma glucose level higher than 180 mg% was defined as hyperglycemia while the level lower than 60 mg% was hypoglycemia.

Results

Sixty patients were enrolled in the present study, 30 per group. Fifty-six patients completed the study protocol. Two patients in each group were excluded because of intraoperative blood loss more than 500 ml (about 10% of blood volume). There were no significant differences between groups in demographic characteristics including age, sex, preoperative fast time, duration and type of surgery (Table 1). Total amount of fluid at different times and blood loss are shown in Table 2.

There were no significant differences of administered fluid volume between groups at any time, except that the total receiving fluid volume at the end of surgery was significantly higher in lactate Ringer's solution group. This could be explained by the increased rate of fluid administration due to the clinical requirements of the patient, such as compensation for third space loss. Although the volume might be the covariate factor, the analysis with ANCOVA did not

Table 1. Demographic data

	Lactate Ringer's solution (n = 28)	5% dextrose in 0.45 NaCl (n = 28)
Age(years, mean \pm SD)	41.73 \pm 11.54	42.20 \pm 12.79
Weight(kg, mean \pm SD)	57.00 \pm 9.89	59.13 \pm 12.90
Sex ratio (M/F)	13/15	14/14
ASA (I/II)	17/11	18/10
Type of surgery(Gen surgery/ other)	15/13	18/10
Preoperative fast before receiving i.v. fluid (min, mean \pm SD)	608.83 \pm 153.19	618.33 \pm 119.08
Duration of receiving fluid before operation started (T ₀ -T ₁) (min, mean \pm SD)	283.50 \pm 143.98	248.33 \pm 121.95
Duration of surgery (min, mean \pm SD)	140.86 \pm 59.43	138.50 \pm 48.53

Table 2. Average amount of administered fluid and blood loss

	Lactate Ringer's solution (n = 28)	5% dextrose in 0.45% NaCl (n = 28)	p-value ^a
Maintenance volume/hour (ml, mean \pm SD)	96.83 \pm 10.24	100.17 \pm 19.68	0.419
Amount of administered fluid before operation started (ml, mean \pm SD)	448.67 \pm 208.70	414.27 \pm 210.22	0.559
Amount of administered fluid after the 1 st operative hour (ml, mean \pm SD)	578.87 \pm 233.51	512.76 \pm 211.83	0.260 ⁺
Total amount of fluid (ml, mean \pm SD)	841.38 \pm 317.18	634.30 \pm 252.02	0.007 ⁺⁺
Total amount of 0.9% NaCl solution in the other i.v. line (ml, mean \pm SD)	448.33 \pm 374.28	437.00 \pm 313.37	0.693
Blood loss (ml, mean \pm SD)	196.00 \pm 269.67	201.00 \pm 304.10	0.659

^a p-value obtained from the Mann Whitney U test

⁺ p-value was obtained from the independent t-test

* Statistically significant

find any influence of volume on the plasma glucose level.

The mean plasma glucose levels in both groups at different fluid administration times are shown in Table 3. None of the patients in either group had preoperative hypoglycemia despite average fasting times of almost 11 hrs. The average fasting blood sugar levels (T₁) were 93.90 \pm 13.56 in Group L and 92.10 \pm 19.15 mg/dl in Group D, which was not statistically significant. At the beginning of surgery, the average blood sugar level(T₁) rose to 112.21 \pm 33.76 mg/dl in Group D which was significantly higher than 93.93 \pm 10.52 mg/dl in Group L (p = 0.010); afterward the patients in each group received fluid of 448.67 \pm 208.70 ml and 414.27 \pm 210.22 ml, respectively, which were not statistically different. One patient in Group D had the plasma glucose of 250 mg% after receiving 5% dextrose in 0.45% NaCl 165 ml in 135 minutes.

One hour after the operation started (T₂), the plasma glucose level in Group D increased to 120.62 \pm 36.19 mg/dl and was significantly higher than the 103.03 \pm 15.90 mg/dl in Group L (p = 0.018). At the end of the operation (T₃), the plasma glucose levels in both groups were still increasing; 126.62 \pm 36.10 mg/dl in Group D was significantly higher than 110.48 \pm 18.20 mg/dl in Group L (p = 0.036). Though 5% dextrose in 0.45% NaCl solutions were infused at the usual maintenance rate, the plasma glucose levels at T₂ in 4 patients were considered as hyperglycemia (195, 199, 202, and 190 mg%). Three of them were still having high blood sugar at T₃ (190, 206, and 190 mg%). Whereas no patients in Group L were found having plasma glucose levels higher than 180 mg% at any time during surgery.

In summary, none of the average plasma glucose values was considered as hyperglycemia. In Group D there was a progressive increase in the plasma

Table 3. Plasma concentration of glucose at different times

	Lactate Ringer's solution (n = 28)	5% dextrose in 0.45% NaCl (n = 28)	p-value ^a
Plasma glucose control (T ₀) (mg%, mean ± SD)	93.90 ± 13.56	92.10 ± 19.15	0.457
Plasma glucose at the beginning of the operation (T ₁) (mg%, mean ± SD)	93.93 ± 10.52	112.21 ± 33.76	0.010*
Plasma glucose after the 1 st operative hour (T ₂) (mg%, mean ± SD)	103.03 ± 15.90	120.62 ± 36.19	0.018*
Plasma glucose at the end of the operation (T ₃) (mg%, mean ± SD)	110.48 ± 18.20	126.62 ± 36.10	0.036*

^a p-value obtained from the Mann Whitney U test

* Statistically significant

glucose values throughout the study period, and all plasma glucose levels at T₁, T₂, and T₃ were significantly higher than the baseline level (T₀) (p = 0.011, 0.001, and 0.000, respectively). In Group L, at T₂ and T₃, the levels of plasma glucose were also rising significantly from the baseline level (T₀) (p = 0.000 and 0.000).

Discussion

Surgery leads to increased stress and high counterregulatory hormones activity that promote glycogenolysis, gluconeogenesis, proteolysis, and lipolysis. Infusing pediatric patients with 10% dextrose with Ringer's solution or 5% Dextrose with normal saline maintains or significantly corrects the plasma glucose level, electrolytes, or acidosis⁽¹⁰⁾.

In adult elective patients, Chin KJ et al⁽¹¹⁾ concluded that initiation of intravenous fluid replacement with dextrose-containing solutions is not required to prevent hypoglycemia in elective surgery. On the contrary, a relatively small volume of 500 ml causes significant, albeit transient, hyperglycemia, even in non-diabetic patients. Coupled with the metabolic response to surgical stress, intravenous dextrose infusion may in fact cause significant hyperglycemia. Schwartz SS et al⁽¹²⁾ demonstrated a positive correlation between the rate of glucose infusion and intraoperative blood glucose levels in adults and children. The present study found that there was a progressive increase in the blood glucose values in patients receiving 5% dextrose throughout the study, but no average blood sugar levels at any time were considered as hyperglycemia.

Mean duration of preoperative fast was almost 11 hrs in both groups; however, none of the patients had preoperative hypoglycemia. Therefore, it

is not necessary to start dextrose containing solution to prevent hypoglycemia in normal elective patients. The effect of fasting on preoperative glycemc levels and the influence of different intravenous solutions on postoperative sugar levels has been studied. Bisono-Bido JD et al⁽³⁾ recommended that the fasting period be no longer than 12 hours in children and to immediately start intravenous restitution if this period is extended further. In addition, only Ringer's lactate solution or a 2 to 1 mixture is recommended to be used during surgery in order to avoid preoperative hypoglycemia and postoperative hyperglycemia.

Thomas JG et al⁽⁴⁾ concluded that the metabolism of lactate might contribute to an increase in plasma glucose due to conversion of lactate to glucose via the Cori's cycle⁽¹³⁾. However, this may be pertinent only in the diabetic population, which does not hold true in non-diabetics⁽⁴⁾. The results of the present study supported that lactate causes blood glucose levels to rise but to a lesser extent than dextrose. As in the study of Chin KJ et al⁽¹¹⁾, the authors found that patients receiving lactate Ringer's solution remained normoglycemic throughout the study period. When 5% dextrose in 0.45% NaCl was used as the perioperative maintenance fluid, there was a progressive increase in blood glucose values throughout the study period, and the increase was statistically significant. Kaye AD and Kucera IJ⁽¹⁴⁾ mentioned that if dextrose-containing solutions are infused at the usual 5% concentration at the rates often required during surgery, severe hyperglycemia will result. However, 28 patients who received 5% dextrose in 0.45% NaCl solution, there were only four patients having hyperglycemia. To confirm the results, further study should be developed in a larger series.

In conclusion, the present study was carried out to develop a practical approach to perioperative glucose administration during elective surgery. The large volume of lactate Ringer's solution had minimal effect on the blood sugar levels compared to the levels in 5% dextrose in 0.45% NaCl group. Therefore, lactate Ringer's solution is probably the alternative choice of intravenous fluid for perioperative maintenance and can be used as replacement in healthy patients undergoing elective surgery.

Acknowledgements

The authors wish to thank the Faculty of Medicine, Chiang Mai University for its financial support for this research and are grateful to Dr. Yodying Punjasawadwong and Mrs. Rochana Phuackchantuck for their statistical advice and data analysis.

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ระดับน้ำตาลในเลือดผู้ป่วยที่เข้ารับการผ่าตัดที่ได้รับสารน้ำ 5% dextrose in 0.45% NaCl เทียบกับ
ผู้ป่วยที่ได้รับ lactated Ringer's solution

อานันท์ชนก ศฤงคารินกุล, เกรียงศักดิ์ โคตระวีระ

วัตถุประสงค์: เพื่อศึกษาผลความแตกต่างของระดับน้ำตาลในเลือดของผู้ป่วยที่ได้รับสารน้ำทางหลอดเลือดดำ ชนิดที่มีน้ำตาล (5% dextrose in 0.45% NaCl) และไม่มีน้ำตาลเป็นส่วนประกอบ (lactated Ringer's solution) ในช่วงระหว่างการผ่าตัด

วัสดุและวิธีการ: เป็นการศึกษาไปข้างหน้าแบบ randomized double blind control ในผู้ป่วย 60 คน อายุ 18-60 ปี ASA physical status 1 ถึง 2 ที่นัดเข้ารับการผ่าตัดในโรงพยาบาลมหาวิทยาลัยเชียงใหม่ในเดือนตุลาคม พ.ศ. 2550 และเดือนกันยายน พ.ศ. 2551 ผู้ป่วยได้รับสารน้ำ lactate Ringer's solution (กลุ่ม L) หรือสารน้ำ 5% dextrose in 0.45% NaCl (กลุ่ม D) ในเช้าวันผ่าตัด ระดับน้ำตาลในเลือดจะถูกตรวจก่อนการให้สารน้ำ (T_0), ก่อนเริ่มผ่าตัด (T_1), หลังการผ่าตัด 1 ชั่วโมงแรก (T_2) และเมื่อการผ่าตัดสิ้นสุด (T_3)

ผลการศึกษา: ระยะเวลาเฉลี่ยการงดอาหารและน้ำเกือบ 11 ชั่วโมงในทั้งสองกลุ่ม อย่างไรก็ตามไม่มีผู้ป่วยคนใดที่เกิดภาวะน้ำตาลในเลือดต่ำ ระดับน้ำตาลในเลือดมีค่าสูงอย่างมีนัยสำคัญในกลุ่มผู้ป่วยที่ได้รับสารน้ำ 5% dextrose เมื่อเทียบกับผู้ป่วยที่ได้รับสารน้ำ lactated Ringer's solution ในช่วงก่อนเริ่มการผ่าตัด หลังการผ่าตัด 1 ชั่วโมงแรก และเมื่อการผ่าตัดสิ้นสุด (ค่า p-value เท่ากับ 0.06, 0.018 และ 0.036 ตามลำดับ) มีผู้ป่วยบางรายที่ระดับน้ำตาลในเลือดสูงหลังได้รับสารน้ำ 5% dextrose in 0.45% NaCl ในระหว่างการผ่าตัด อย่างไรก็ตามไม่พบว่ามีค่าเฉลี่ยระดับน้ำตาลในผู้ป่วยกลุ่มใดที่ถูกจัดว่าเป็นระดับน้ำตาลในเลือดสูง

สรุป: แม้ว่าจะถูกงดอาหารเป็นเวลาหลายชั่วโมง ก็ไม่พบว่ามีผู้ป่วยคนใดมีภาวะระดับน้ำตาลในเลือดต่ำ สารน้ำ lactate Ringer's solution ปริมาณค่อนข้างมากมีผลต่อระดับน้ำตาลในเลือดค่อนข้างน้อยเมื่อเทียบกับระดับน้ำตาลในกลุ่มผู้ป่วยที่ได้รับ 5% dextrose in 0.45% NaCl ดังนั้น lactate Ringer's solution อาจเป็นทางเลือกของการให้สารน้ำรักษาสมดุลในระหว่างการผ่าตัดและเป็นสารน้ำทดแทนในผู้ป่วยสุขภาพดีที่เข้ารับการผ่าตัดตามตารางนัดหมาย
