

anism for continued ventilation/oxygenation using the catheter is beneficial in such patients.

The jet-stylet endotracheal catheter can be a valuable tool in intubation or reintubation of patients with severely compromised airways while maintaining a pathway for positive pressure or jet ventilation.

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## Effects of Fluid Therapy on Serum Glucose Levels in Fasted Outpatients

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Conventional preoperative management of outpatients involves fasting for 8-16 h prior to their scheduled operation. Whether these patients should be given glucose-containing fluids intravenously during surgery is controversial.<sup>1</sup> Although studies have determined serum glucose concentrations in fasted volunteers, diabetics, and inpatients undergoing major operations,<sup>1-5</sup> the incidence of hypoglycemia in a healthy adult outpatient surgery population after a prolonged fast is unknown. Furthermore, serum glucose concentrations have not been determined when fasted outpatients are not given glucose perioperatively. While glucose-containing fluids are often given during the perioperative period, the stress of surgery and anesthesia may produce a state of glucose "intolerance" (secondary to decreased glucose uptake and utilization).<sup>1,2,6</sup> Thus, the administration of an exogenous glucose load perioperatively may predispose the patient to developing hyperglycemia and glucosuria, enhancing fluid loss secondary to the osmotic diuresis.<sup>7,8</sup>

This study was designed to: (1) determine preoperative serum glucose levels in fasted young women undergoing elective outpatient surgery; (2) assess the effect of administering glucose-containing fluids intraoperatively (*vs* withholding glucose-containing fluid) on the postoperative serum glucose concentration; and (3) evaluate the effect

of orally administered glucose-containing solutions on the serum glucose level at the time of discharge.

#### MATERIALS AND METHODS

Fifty healthy, ASA physical status I or II, young women presenting for minor gynecological procedures were randomly assigned to one of two fluid treatment groups. All patients entered into this study had fasted for a period of at least 12 h (table 1). The control group ( $n = 25$ ) received lactated Ringer's solution (LR) and the study group ( $n = 25$ ) received dextrose 5% in lactated Ringer's solution ( $D_5LR$ ) intravenously during and immediately following outpatient surgery. The study was approved by the Committee on Human Research at Stanford University, and informed consent was obtained from each patient. Demographic data included age, weight, type of surgical procedure, duration of fasting (*i.e.*, the time from their last oral intake until their arrival in the operating room), and volume of intravenous (*iv*) fluid administered perioperatively. Patients with a history of glucose intolerance (*e.g.*, diabetes) or reactive hypoglycemia were excluded. Other exclusionary criteria included: pregnant women (where the surgery was not intended to terminate the pregnancy), morbid obesity ( $>30\%$  of ideal body weight), and evidence of hepatic, renal, or metabolic disease.

The day prior to the operation, each patient underwent a routine physical examination and urinalysis. Patients were instructed to abstain from eating or drinking after midnight. On the day of surgery, the patients were taken to the operating room where an 18-g *iv* cannula was inserted into an arm vein. At that time, a fasting blood sample was obtained and an infusion of either LR or  $D_5LR$  was started at a rate of 5-10 ml/min. All patients received meperidine, 1 mg/kg, *iv*, 3-5 min prior to induction of

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TABLE 1. Demographic Data for Patients Receiving either Lactated Ringer's Solution (LR) or Dextrose 5% in Lactated Ringer's Solution (D<sub>5</sub>LR) during the Perioperative Period\*

Variable	LR	D <sub>5</sub> LR
Number (N)	25	25
Age (yr)	25 ± 8	25 ± 7
Weight (kg)	58 ± 10	62 ± 14
Duration of fasting (h)	17 ± 1	16 ± 1
Duration of surgery (min)	23 ± 9	21 ± 6
Fluid volume (l)†	0.9 ± 0.2	1.0 ± 0.2

\* Mean values ± standard deviation.

† Total volume of fluid infused during and after surgery.

anesthesia with methohexital, 1.5 mg/kg, iv. Anesthesia was maintained with a methohexital infusion, 2–10 mg/min, iv, in combination with nitrous oxide 60–70% in oxygen. The methohexital infusion rate was varied according to the patient's clinical response to the surgical stimuli. An attempt was made to maintain a similar depth of anesthesia (*i.e.*, absence of purposeful movements) in both treatment groups.

At the end of surgery, the methohexital infusion and nitrous oxide were discontinued. Blood samples were obtained approximately 60 min after the operation for glucose determination. The iv fluid therapy was continued in the postanesthesia care unit until the patient was able to ambulate alone without symptoms of hypovolemia (*e.g.*, dizziness). At the time of ambulation, a urine sample was obtained and the urine glucose level determined using Ames N-Multistix reagent strips. The iv cannula was removed, and the type of fluid and total volume infused were recorded. A final blood sample was drawn approximately 30 min after the patient consumed 6 fl oz of a carbonated soft drink (*e.g.*, 7-Up™ or Coca Cola™) containing 30–40 g of sucrose.\* All blood samples were placed in red stoppered collection tubes and analyzed for determination of serum glucose concentration using the Technicon-bound hexokinase method.<sup>9</sup>

\* Sucrose is a disaccharide which is hydrolyzed to glucose and fructose by the intestinal mucosal enzyme sucrase (also called invertase).

In a subsequent study, 25 healthy young women undergoing similar operations were administered 1 l of lactated Ringer's solution to which 25 g of glucose had been added. The duration of fasting as well as the volume of iv fluid administered during the perioperative period were recorded as in the previous study. Blood glucose levels were measured preoperatively (fasting) and postoperatively (at the time of ambulation). Urine samples were obtained at the time of ambulation for glucose determination.

Data from the various fluid treatment groups were compared using the paired and unpaired Student's *t*-test as well as a Chi-square test, with *P* < 0.05 considered statistically significant. Data are presented as mean values ± standard deviation (S.D.).

## RESULTS

The original two fluid treatment groups were comparable with respect to demographic data (table 1). The preoperative fasting glucose concentrations (mean ± S.D.) were 53 ± 8 mg/dl and 55 ± 10 mg/dl for the LR and D<sub>5</sub>LR groups, respectively (table 2). Overall, 14% of our (fasted) outpatients had a serum glucose concentration of 45 mg/dl or less when they arrived in the operating room. Postoperatively, the patients in the LR group had a serum glucose level (57 ± 14 mg/dl) which was not significantly changed from their preoperative value. Of the patients who received LR alone during surgery, 36% had either no change or a further decrease in their serum glucose concentration (23% of the patients had postoperative serum glucose levels ≤ 50 mg/dl and 68% had glucose levels ≤ 60 mg/dl, with a range from 33–91 mg/dl). However, those patients who received D<sub>5</sub>LR (equivalent to 50 g of glucose) during and immediately after surgery showed a significant increase in their serum glucose level (208 ± 61 mg/dl).

The oral administration of glucose-containing fluids during the early postoperative period did not significantly increase the serum glucose concentration in either treatment group. The mean discharge serum glucose levels were 61 ± 12 mg/dl and 185 ± 45 mg/dl for the LR and D<sub>5</sub>LR treatment groups, respectively. No clinical

TABLE 2. Serum Glucose Concentrations Before and After Surgery in Patients Receiving either Lactated Ringer's Solution (LR) or Dextrose 5% in Lactated Ringer's Solution (D<sub>5</sub>LR)

	Glucose Level (mg/dl)					
	LR			D <sub>5</sub> LR		
	N	Mean ± S.D.	Range	N	Mean ± S.D.	Range
Preoperative	25	53 ± 8	36–69	25	55 ± 10	40–75
Postoperative	25	57 ± 14*	33–91	25	208 ± 61†	104–443
Discharge	25	61 ± 12*	40–94	25	185 ± 45†	144–258

\* Significantly different from D<sub>5</sub>LR group, *P* < 0.05.† Significantly different from preoperative (fasting) level, *P* < 0.05.

symptoms (*e.g.*, excessive autonomic activity) related to either hypoglycemia or hyperglycemia were observed during the perioperative period.

The preoperative urine glucose levels were comparable in the original two treatment groups (table 3), with 96% of the patients having no detectable glucose in their urine. However, in contrast to those patients who received LR alone, glucosuria was detected in 88% of the patients who received D<sub>5</sub>LR during the perioperative period (24% with 1+ to 2+ urine glucose and 64% with 3+ to 4+ urine glucose levels). In spite of the high incidence of glucosuria in the D<sub>5</sub>LR group, there was no significant difference between the two fluid treatment groups with respect to the incidence of postoperative dizziness or "lightheadedness" with ambulation (28% and 20% for the LR and D<sub>5</sub>LR groups, respectively).

In the third group of patients, the mean preoperative blood glucose was 63 ± 23 mg/dl (range: 51–77 mg/dl) following a fasting period of 14 ± 2 h (range: 9–16 h). After receiving 25 g of glucose during the perioperative period, the postoperative glucose level was 108 ± 24 mg/dl (range: 61–187 mg/dl). The postoperative glucose values were significantly increased (compared to the fasting levels), though they were not as high as those patients receiving D<sub>5</sub>LR. In addition, none of the patients in this group had glucosuria following surgery.

#### DISCUSSION

Healthy, asymptomatic adult outpatients can present for elective surgery with hypoglycemia secondary to prolonged fasting. Published glucose levels in fasted adults range from 65 ± 3 to 85 ± 17 mg/dl, depending on the population studied and the duration of the fast.<sup>1–5</sup> A study of female volunteers fasted for 12 h found a serum glucose level of 65 ± 3 mg/dl, which decreased to 56 ± 2 mg/dl after an additional 12 h of fasting.<sup>3</sup> Our data correlate with this latter study, with mean serum glucose concentrations of 53–63 mg/dl after a 14–17 h fast. Although we did not observe clinical signs of hypoglycemia in the preoperative period, symptoms relating to sympathetic nervous system hyperactivity may have been erroneously ascribed to excessive anxiety in these young, unpremedicated outpatients. Healthy subjects usually experience hypoglycemic symptoms at serum glucose levels below 45 mg/dl; however, there is a notable sex difference in glucose regulation.<sup>3</sup> In fact, young women may remain asymptomatic with plasma glucose concentrations as low as 30 mg/dl.<sup>4,5</sup>

Of greater concern may be the insidious development of hypoglycemia during anesthesia, where the usual clinical signs may be obscured by general anesthesia. It is possible that hypoglycemia might elude diagnosis in this situation with the attendant risk of damage to the central

TABLE 3. Urine Glucose Levels Before and After Surgery in Patients Receiving Either Lactated Ringer's Solution (LR) or Dextrose 5% in Lactated Ringer's Solution (D<sub>5</sub>LR)

	Urine Glucose Level*		
	0	1+ to 2+	3+ to 4+
Preoperative period			
LR (N = 25)	96	4	0
D <sub>5</sub> LR (N = 25)	96	0	4
Postoperative period			
LR (N = 25)	100	0	0
D <sub>5</sub> LR (N = 25)	12†	24†	64†

\* Percentage of patients in each of categories.

† Significantly different from LR group, *P* < 0.05.

nervous system. Unfortunately, we do not have data regarding the changes in serum glucose levels during these brief outpatient procedures. However, 36% of the patients receiving LR manifested either no change or a decrease in their postoperative serum glucose level, and nearly one-third of these patients had serum glucose concentrations below 50 mg/dl during the early postoperative period. Furthermore, the oral administration of glucose-containing fluids did not significantly increase the serum glucose concentration at the time of discharge. Possible explanations for the latter finding include inadequate time for absorption of the orally administered fluid and a slow rate of sucrose breakdown to glucose and fructose.

In the fasting patient, the serum glucose level is maintained as a result of both glycogenolysis and gluconeogenesis in liver and muscle tissue.<sup>10,11</sup> Several investigators have observed an increase in blood glucose during the perioperative period.<sup>7,8,12,13</sup> The emotional stress of being brought to the operating room and the subsequent stress of the operative procedure are more important than the type of anesthesia in determining the glucose response.<sup>2,12,14</sup> The increase in serum glucose which has been reported during an operation is usually attributed to activation of the autonomic nervous system (*i.e.*, excessive sympathetic activity) and catecholamine release in response to surgical stimulation.<sup>13,15</sup> The magnitude of the rise in the glucose level appears to be proportional to the degree of surgical stress (*e.g.*, maximal during traction on abdominal viscera).<sup>6,12</sup> Thus, outpatients with limited glycogen stores (following a prolonged fast) undergoing brief, minimally stressful procedures would be at increased "risk" to developing intraoperative hypoglycemia if only non-glucose-containing fluids (*e.g.*, normal saline) are administered during surgery.

On the other hand, the intraoperative administration of excessive glucose-containing solutions can cause hyperglycemia and associated glucosuria. Even non-glucose-containing solutions such as lactated Ringer's may contribute to an increase in plasma glucose because lactate is

metabolized to glucose.<sup>16</sup> In certain clinical situations (*e.g.*, during a cerebral ischemic episode), an elevated blood glucose may be harmful to the patient.<sup>17</sup> Furthermore, hyperglycemia resulting from excessive glucose administration during the operation may be associated with rebound hypoglycemia following discharge from the outpatient facility.

The degree of preoperative hypoglycemia appears to be related to the duration of the fasting period.<sup>3,18</sup> Outpatient pediatric patients fasted up to 8 h and operated on the following morning appeared to be at minimal risk of developing hypoglycemia.<sup>19,20</sup> Similarly, we found that those adult outpatients undergoing operative procedures in the morning had significantly higher blood glucose levels than outpatients scheduled as afternoon cases (unreported data). Since many of the patients in our study were undergoing midtrimester abortion procedures, the hormonal changes associated with pregnancy may have contributed to the low fasting glucose levels.<sup>21,22</sup> In addition, these patients might also be expected to have a higher incidence of glucosuria after a glucose load because pregnancy decreases the renal tubular reabsorption of glucose.<sup>23,24</sup>

In an effort to minimize the incidence of both hypoglycemia and hyperglycemia during and after short outpatient procedures, we administered 1 l of dextrose 2.5% in lactated Ringer's solution (equivalent to 500 ml of D<sub>5</sub>LR). One could argue that the glucose level is irrelevant during the perioperative period; however, it would seem prudent to protect against hypoglycemia by administering glucose-containing fluids after a prolonged fast. Clearly, a balance between the extremes of hypoglycemia and hyperglycemia is desirable during the perioperative period. Although we have no evidence that any patient suffered an adverse outcome as a result of the changes in their serum glucose concentration, we would still recommend that fasted (> 12 h) outpatients receive a glucose-containing solution during brief surgical procedures. Recently, some investigators have even questioned the advisability of an overnight fast when an elective operation is scheduled for the following afternoon.<sup>25,26</sup>

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