

Perioperative Effects of Dextrose and Non-Dextrose Containing Intravenous Fluids on Blood Glucose Level in Paediatric Patients

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ABSTRACT

Background: Perioperative fluid therapy is essential for maintaining blood glucose homeostasis in paediatric patients, but the optimal choice between dextrose-containing and non-dextrose-containing fluids remains controversial due to the risks of both hypoglycaemia and hyperglycaemia. **Objective:** The aim of the study was to compare the perioperative effects of dextrose-containing versus non-dextrose intravenous fluids on blood glucose levels in paediatric patients. **Methods & Materials & Materials:** This randomized controlled trial was conducted in the Department of Anaesthesia, Pain, Palliative & Intensive Care in collaboration with the Department of Paediatric Surgery, Dhaka Medical College Hospital (DMCH), Dhaka, Bangladesh (July 2023–June 2024), involving 60 paediatric patients (1–5 years) undergoing elective surgery under general anaesthesia. Patients were randomized to Group A (5% dextrose in 0.225% saline) or Group B (Ringer's lactate) with standardized anaesthesia and fluid management. Capillary blood glucose (T1–T5), haemodynamics, and adverse events were recorded and analyzed using SPSS ($p < 0.05$). **Results:** In 60 paediatric patients ($n=30/\text{group}$), baseline characteristics, perioperative haemodynamics, blood loss, and fluid volumes were similar between groups ($p > 0.05$). Blood glucose was significantly higher in the dextrose group from 30 min post-induction to 2 h postoperatively ($p = 0.001$). Delayed recovery (26.7% vs 6.7%) and hyperglycaemia (36.7% vs 13.3%) were higher in the dextrose group, while severe hyperglycaemia occurred only in this group (10%); hypoglycaemia was comparable (6.7% vs 10%). **Conclusion:** Non-dextrose-containing intravenous fluids (Ringer's lactate) provide better

perioperative glycaemic stability with fewer adverse effects than dextrose-containing fluids in paediatric patients undergoing elective surgery under general anaesthesia.

Keywords: Paediatric Patients, Perioperative Fluid Therapy, Blood Glucose, Ringer's Lactate, Dextrose-Containing Fluids.

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INTRODUCTION

Starvation, surgery and anaesthesia cause stress and alter physiology. Intravenous fluids are administered peri-operatively to maintain homeostasis during this period. Water and electrolytes are required to correct fluid deficits and ensure adequate intravascular volume, cardiac output and tissue oxygen delivery, while dextrose may be required to prevent hypoglycaemia [1].

General anaesthesia and surgery trigger a stress response leading to increased cortisol and catecholamine release, resulting in enhanced glycogenolysis and gluconeogenesis, reduced peripheral glucose utilization, and subsequent hyperglycaemia [2,3]. Perioperative hyperglycaemia is associated with poor outcomes such as surgical site infections, acute kidney injury, and prolonged hospital stay [4-6]. Conversely, inadequate glucose

administration may result in hypoglycaemia, particularly in paediatric patients. Thus, perioperative blood glucose control is a key consideration in children undergoing surgery [5,6].

Fluid therapy in children is fundamental for safe anaesthesia, as inappropriate management can lead to serious complications including brain injury and mortality. Major concerns in paediatric perioperative fluid management include hypoglycaemia, hyperglycaemia, hyponatraemia and volume overload [7]. Hypotonic fluids such as 5% dextrose solutions have been associated with hyperglycaemia and hyponatraemia and are therefore discouraged in the perioperative setting [8].

International guidelines recommend that paediatric intraoperative fluids should have physiological osmolality and sodium

concentration. The 2011 European Consensus Statement recommends balanced isotonic solutions with 1%–2.5% glucose to maintain normoglycaemia and avoid hypoglycaemia, hyperchloraemia and lipolysis [9]. Similarly, current recommendations suggest balanced salt solutions such as Ringer's lactate for fluid deficits and maintenance, while dextrose-containing solutions may be reserved for longer procedures or high-risk patients [10]. Isotonic solutions such as Ringer's lactate or normal saline are widely used in children. However, normal saline carries a risk of hyperchloraemic acidosis due to its high chloride content [11], whereas balanced crystalloids such as Ringer's lactate are preferred due to their more physiological composition and metabolic advantages [12,13]. Some guidelines still recommend hypotonic solutions with glucose based on

the traditional Holliday–Segar formula, although these may contribute to hyponatraemia after anaesthesia induction [14,15].

While isotonic, non-dextrose fluids are generally recommended for children over one month of age, certain groups remain at risk of hypoglycaemia, including low body weight children, those receiving parenteral nutrition or dextrose preoperatively, prolonged surgeries, and cases involving extensive regional anaesthesia [16]. In such patients, dextrose-containing fluids or close glucose monitoring is advised. However, studies show variable effects of dextrose-free fluids, with some reporting stable glycaemia and others noting occasional hypoglycaemia or rising glucose levels [17,18].

Although adult studies have evaluated the effects of dextrose-containing fluids during anaesthesia, limited evidence exists in paediatric populations, particularly regarding comparative effects of dextrose versus non-dextrose fluids on perioperative glycaemic control [19,20]. Therefore, this study aimed to evaluate and compare the effects of Ringer's lactate and 5% dextrose in 0.225% sodium chloride saline on perioperative blood glucose levels in paediatric patients undergoing elective surgery under general anaesthesia.

OBJECTIVE

To compare the perioperative effects of dextrose-containing versus non-dextrose intravenous fluids on blood glucose levels in paediatric patients.

METHODS & MATERIALS

This randomized controlled trial was conducted in the Department of Anaesthesia, Pain, Palliative & Intensive Care in collaboration with the Department of Paediatric Surgery, Dhaka Medical College Hospital (DMCH), Dhaka, Bangladesh, over a period of 12 months from July 2023 to June 2024. A total of 60 paediatric patients aged 1–5 years, scheduled for elective surgeries under general anaesthesia, were included in the study based on predefined inclusion and exclusion criteria. Patients were selected using purposive sampling and randomly allocated into two groups, with 30 patients in each group. Group A received 5% dextrose in 0.225% sodium chloride saline, while Group B received Ringer's lactate solution for perioperative fluid management.

Inclusion Criteria

- Age 1–5 years
- ASA physical status I and II
- Scheduled for elective surgery
- Expected duration of surgery 60–120 minutes
- Informed written consent from parents/guardians

Exclusion Criteria

- Diabetes mellitus or other endocrine/metabolic disorders
- Steroid or catecholamine therapy
- Preoperative hypo- or hyperglycaemia
- Hepatic, renal, or neurological disease

Preoperative Preparation and Anaesthetic Technique

Standard fasting guidelines were followed, including 8 hours for heavy meals, 6 hours for light meals or non-human milk, 4 hours for breast milk, and 2 hours for clear fluids. Intravenous access (22G or 24G cannula) was secured in an upper limb after application of EMLA cream. Standard monitoring, including ECG, non-invasive blood pressure (NIBP), and pulse oximetry (SpO₂), was applied. Anaesthesia was induced with glycopyrrolate (0.004 mg/kg IV) and propofol (3 mg/kg IV) with 100% oxygen. Succinylcholine (2 mg/kg IV) was used to facilitate tracheal intubation. Anaesthesia was maintained with isoflurane (1.2–1.5 vol%) in 50% nitrous oxide and oxygen. Atracurium was administered for muscle relaxation, and neuromuscular blockade was reversed with neostigmine (0.04 mg/kg) and atropine (0.02 mg/kg IV) at the end of surgery.

Fluid Management and Blood Glucose Monitoring

Maintenance and replacement fluids were calculated using the Holliday–Segar formula: $4 \times (\text{first } 10 \text{ kg body weight}) + 2 \times (\text{next } 10 \text{ kg}) + 1 \times (\text{remaining weight})$. Half of the calculated fluid deficit was administered during the first hour, and the remaining half over the next two hours. Group A received 5% dextrose in 0.225% sodium chloride saline, while Group B received Ringer's lactate solution. No blood products or colloids were administered during the study period. Capillary blood glucose was measured from the fingertip of the non-cannulated hand using a glucometer (Accu-Chek®, Roche, Germany) at predefined time points: before induction (T1), 30 minutes (T2), 60 minutes (T3) after induction, and 1 hour (T4) and 2 hours (T5) postoperatively. Hypoglycaemia was defined as $<4 \text{ mmol/L}$, hyperglycaemia as $>10 \text{ mmol/L}$, and severe hyperglycaemia as

$>13.9 \text{ mmol/L}$. Hypoglycaemia was managed with 25% dextrose (1 mL/kg IV bolus), while hyperglycaemia was managed by stopping dextrose-containing fluids and administering 0.9% saline (20 mL/kg), with insulin used if severe hyperglycaemia persisted.

Data Collection and Analysis

Data were collected using a structured case record form. Baseline demographic and clinical information was obtained from hospital records. Perioperative blood glucose levels, haemodynamic parameters (heart rate, systolic and diastolic blood pressure), and adverse events (delayed recovery, hypo-/hyperglycaemia, severe hyperglycaemia) were recorded at predefined time points under supervision. Data were analyzed using SPSS software. Quantitative variables were expressed as mean $\pm$ standard deviation, and categorical variables as frequency and percentage. Independent t-test and chi-square test were used for comparisons, with $p < 0.05$ considered statistically significant.

Ethical Considerations and Quality Assurance

Ethical approval was obtained from the Institutional Review Board of Dhaka Medical College Hospital. Written informed consent was obtained from parents or guardians. Confidentiality and patient safety were strictly maintained. A standardized and pretested data collection sheet was used, and all procedures were closely supervised to ensure data accuracy and consistency.

RESULTS

Table 1 presents the baseline and operative characteristics of the study patients in both groups. The mean age was 3.5 ± 1.24 years in Group A and 4.6 ± 1.43 years in Group B. Mean weight was $13.62 \pm 2.76 \text{ kg}$ in Group A and $15.82 \pm 3.24 \text{ kg}$ in Group B. In Group A, 16 (53.33%) were male and 14 (46.67%) were female, while in Group B, 18 (60.0%) were male and 12 (40.0%) were female. Most patients belonged to ASA class I (Group A: 25, 83.33%; Group B: 23, 76.67%), followed by ASA class II (Group A: 5, 16.67%; Group B: 7, 23.33%). The mean duration of surgery was 109.9 ± 6.4 minutes in Group A and 114.9 ± 4.2 minutes in Group B, while mean duration of anaesthesia was 116.3 ± 6.9 minutes and 124.7 ± 7.3 minutes, respectively. Total fasting duration was 14.7 ± 1.14 hours in Group A and 16.4 ± 1.27 hours in Group B. No statistically significant differences were observed between the groups ($p > 0.05$).

Table I
Baseline and Operative Characteristics of the Study Patients (n = 60).

Variables	Group A (n=30)	Group B (n=30)	P value
Age (years)	3.5 ± 1.24	4.6 ± 1.43	0.465
Weight (kg)	13.62 ± 2.76	15.82 ± 3.24	0.381
Gender			
Male	16 (53.33%)	18 (60.0%)	0.428
Female	14 (46.67%)	12 (40.0%)	0.421
ASA Status			
I	25 (83.33%)	23 (76.67%)	0.354
II	5 (16.67%)	7 (23.33%)	0.316
Duration of surgery (min)	109.9 ± 6.4	114.9 ± 4.2	0.249
Duration of anaesthesia (min)	116.3 ± 6.9	124.7 ± 7.3	0.186
Total duration of fasting (hours)	14.7 ± 1.14	16.4 ± 1.27	0.831

Table II presents perioperative blood loss and fluid administration in both groups. Mean blood loss was 27.6 ± 2.37 ml in Group A and 23.4 ± 2.17 ml in Group B. Mean maintenance fluid was 44.8 ± 7.3 ml and 46.7 ± 7.5 ml, respectively. Replacement fluid volume was 265.2 ± 33.3 ml in Group A and 276.5 ± 37.8 ml in Group B. Total fluid administered was 523.8 ± 47.6 ml in Group A and 556.6 ± 53.5 ml in Group B. No statistically significant differences were observed between the groups (p > 0.05).

Table II
Perioperative Blood Loss and Fluid Administration in the Study Groups (n = 60).

Variables	Group A (n=30)	Group B (n=30)	P value
Blood loss (ml)	27.6 ± 2.37	23.4 ± 2.17	0.572
Maintenance fluid (ml)	44.8 ± 7.3	46.7 ± 7.5	0.758
Replacement fluid (ml)	265.2 ± 33.3	276.5 ± 37.8	0.683
Total fluid volume (ml)	523.8 ± 47.6	556.6 ± 53.5	0.615

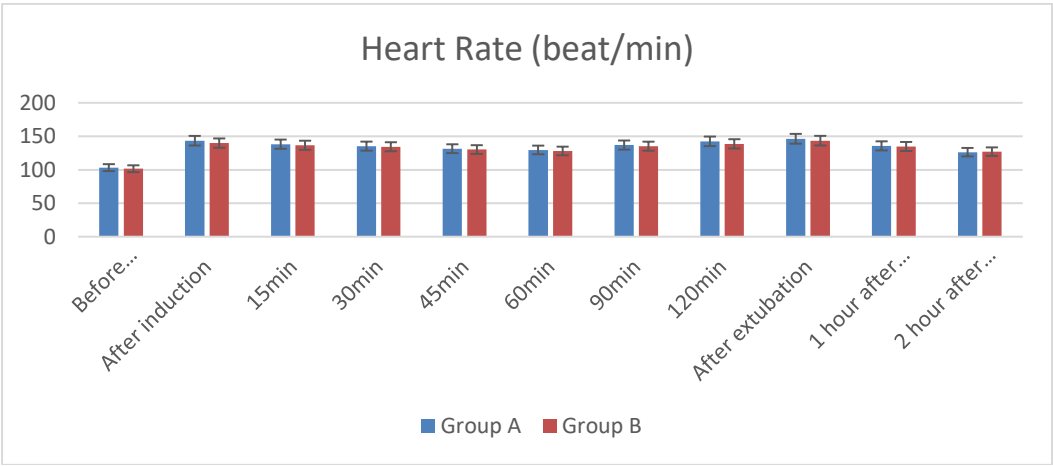


Figure 1 Perioperative Heart Rate of the Patients in Both Study Groups (n = 60).

Figure 1 demonstrates perioperative heart rate trends in both groups. No statistically significant differences were observed in mean heart rate between Group A and Group B at any time point during the perioperative period (p > 0.05).

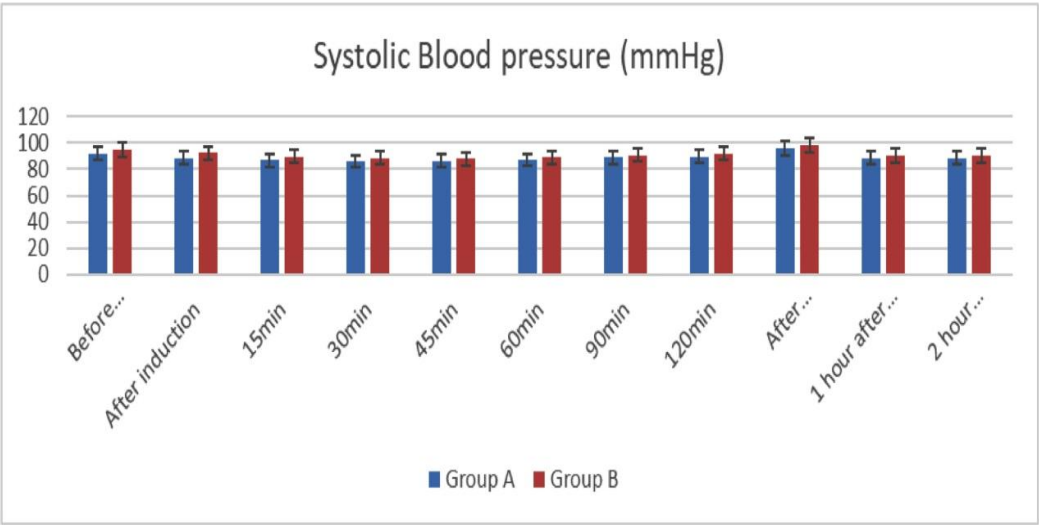


Figure 2 Perioperative Systolic Blood Pressure (mmHg) of the Patients in Both Study Groups (n = 60).

Figure 2 shows perioperative systolic blood pressure trends in both groups. comparable between Group A and Group B no statistically significant differences observed (p > 0.05).
Systolic blood pressure remained

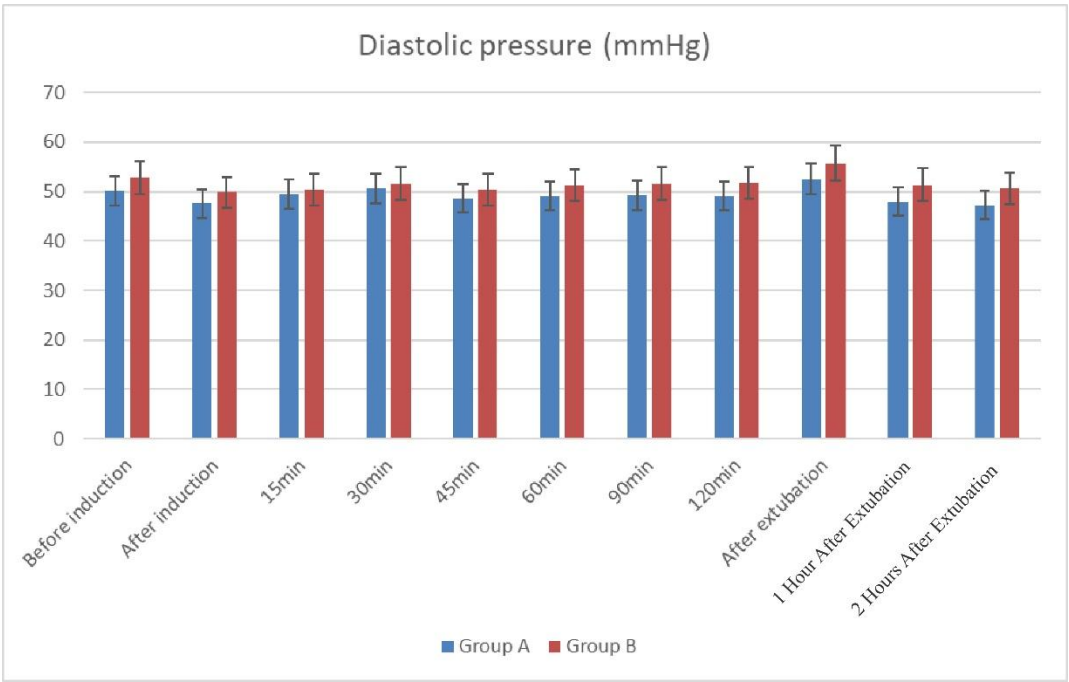


Figure 3 Perioperative Diastolic Blood Pressure (mmHg) of the Patients in Both Study Groups (n = 60).

Figure 3 presents perioperative diastolic blood pressure trends in both groups. No statistically significant differences were observed between Group A and Group B at any measured time point (p > 0.05).
Table III presents perioperative blood glucose levels at different time intervals. Baseline blood glucose levels (T1) were comparable between Group A (4.55 ± 0.34 mmol/L) and Group B (4.50 ± 0.27 mmol/L). From 30 minutes after induction (T2) onwards, Group A showed significantly higher blood glucose levels compared to Group B, persisting at 60 minutes (T3), 1 hour postoperatively (T4), and 2 hours postoperatively (T5) (p = 0.001 at all time points).

Table III
Perioperative Blood Glucose Levels at Different Time Points in the Study Groups (n = 60).

Interval	Group A (n=30)	Group B (n=30)	P value
Before induction (T1)	4.55±0.34	4.50±0.27	0.415
30 min after induction (T2)	6.20±0.63	4.90±0.26	0.001
60 min after induction (T3)	7.28±1.02	5.57±0.74	0.001
1 hr after surgery (T4)	8.50±2.21	6.0±1.9	0.001
2 hrs after surgery (T5)	8.4±2.25	5.90±1.14	0.001

Table IV presents perioperative adverse events in both groups. Delayed recovery occurred in 8 (26.7%) patients in Group A and 2 (6.7%) in Group B. Hypoglycaemia

was observed in 2 (6.7%) and 3 (10%) patients, respectively. Hyperglycaemia occurred in 11 (36.7%) patients in Group A and 4 (13.3%) in Group B, while severe

hyperglycaemia was observed only in Group A (3, 10%).

Table IV
Perioperative Adverse Events in the Study Groups (n = 60).

Adverse Event	Group A (n=30)	Group B (n=30)	P value
Delayed recovery	8 (26.7%)	2 (6.7%)	0.037
Hypoglycemia	2 (6.7%)	3 (10%)	0.437
Hyperglycemia	11 (36.7%)	4 (13.3%)	0.032
Severe Hyperglycemia	3 (10%)	0	--

DISCUSSION

This study was carried out in the Department of Anaesthesia, Pain, Palliative & Intensive Care in collaboration with the Department of Paediatric Surgery. Administration of dextrose-containing fluids has been advocated to prevent hypoglycaemia and provide sufficient energy during the fasting period in the perioperative setting. However, its use in paediatric patients remains controversial. Infants and children undergoing preoperative fasting are at risk of perioperative hypoglycaemia, which may remain unrecognised, particularly in those receiving non-dextrose-containing fluids during surgery. On the other hand, administration of large quantities of dextrose-containing solutions during surgery may predispose patients to perioperative hyperglycaemia [21]. This study analysed perioperative blood glucose levels after administering either Ringer's lactate solution or 5% dextrose in 0.225% sodium chloride saline as maintenance and replacement fluid in paediatric patients. In this study, after analysing demographic variables (age, weight, gender, ASA status), no statistically significant differences were found between the two groups (p > 0.05). Similar findings have been reported in other studies comparing different types of fluid therapy in children, where no significant differences in age, gender, weight, or type of operation were observed [22]. Another study also reported comparable demographic and clinical characteristics between groups receiving lactated Ringer's solution and isotonic glucose solution [22]. These findings support the present study. After analysing the indication of surgery between the groups, no statistically

significant difference was observed (p > 0.05). Similar findings were reported in studies comparing different fluid regimens in paediatric surgical patients, where no significant difference in surgical procedures between groups was noted [23,24]. These findings are consistent with the present study. Maintenance fluid plus replacement fluid represented the total intraoperative fluid administered after induction of anaesthesia. In this study, Group A received 44.8 ± 7.3 ml of maintenance fluid and Group B received 46.7 ± 7.5 ml. Replacement fluid was 265.2 ± 33.3 ml in Group A and 276.5 ± 37.8 ml in Group B. Total fluid volume was 523.8 ± 47.6 ml in Group A and 556.6 ± 53.5 ml in Group B. No statistically significant differences were observed between the groups (p > 0.05). Similarly, previous studies reported comparable maintenance and replacement fluid administration between groups [25]. Another study also found no significant difference in total perioperative fluid volume or blood loss between groups [26,27], supporting the present findings. Current preoperative fasting guidelines recommend 6 hours for solids or non-human milk, 4 hours for breast milk, and 2 hours for clear fluids. Prolonged fasting is associated with discomfort, dehydration, biochemical imbalance, and hypoglycaemia, especially in children, and is therefore discouraged in anaesthetic practice. However, prolonged fasting remains common in many settings worldwide [28]. In this study, total fasting duration was 14.7 ± 1.14 hours in Group A and 16.4 ± 1.27 hours in Group B. Blood loss was 27.6 ± 2.37 ml in Group A and 23.4 ± 2.17 ml in Group B. These findings are

consistent with previous studies reporting prolonged fasting durations in paediatric patients, often exceeding recommended guidelines [29-31]. In the present study, perioperative heart rate showed no statistically significant difference between the groups at all time intervals. Similarly, systolic and diastolic blood pressure showed no statistically significant differences between the groups (p > 0.05 throughout). Some studies have reported increases in haemodynamic parameters with dextrose-containing fluids; however, other studies have also demonstrated no significant changes in heart rate or blood pressure following administration of either dextrose-containing or non-dextrose-containing fluids [32,33]. These findings are consistent with the present study. In the present study, baseline blood glucose levels were comparable between the groups (p > 0.05). However, at 30 minutes after induction (6.20 ± 0.63 mmol/L vs 4.90 ± 0.26 mmol/L), 60 minutes after induction (7.28 ± 1.02 mmol/L vs 5.57 ± 0.74 mmol/L), 1 hour after surgery (8.50 ± 2.21 mmol/L vs 6.0 ± 1.9 mmol/L), and 2 hours after surgery (8.4 ± 2.25 mmol/L vs 5.90 ± 1.14 mmol/L), Group A showed significantly higher blood glucose levels compared to Group B (p = 0.001 at all time points). Thus, patients receiving dextrose-containing intravenous fluids had significantly higher perioperative blood glucose levels. Similar findings were reported in previous studies, where dextrose-containing fluids resulted in significantly higher perioperative blood glucose levels compared to non-dextrose fluids [23,26]. Another study also demonstrated a greater rise in blood glucose in the dextrose group

compared to the Ringer's lactate group [32]. However, some studies reported no significant changes in blood glucose levels between groups [25], which differs from the present study findings.

In the present study, patients receiving dextrose-containing intravenous fluids had a higher incidence of delayed recovery (26.7% vs 6.7%), hyperglycaemia (36.7% vs 13.3%), and severe hyperglycaemia (10% vs 0%). Hypoglycaemia was slightly more frequent in the non-dextrose group (10% vs 6.7%), although this difference was not statistically significant. Delayed recovery and hyperglycaemia were statistically significant ($p < 0.05$) [23].

Similar findings have been reported in other studies, where dextrose administration was associated with higher rates of hyperglycaemia in paediatric patients [26]. Some studies also reported no hypoglycaemic episodes in non-dextrose groups [32], while others observed higher hyperglycaemia incidence in dextrose groups compared to non-dextrose groups [23].

Overall, the findings of this study suggest that glucose-free maintenance fluids such as Ringer's lactate are safer in paediatric patients undergoing surgery compared to 5% dextrose in 0.225% sodium chloride saline. Although dextrose-containing fluids may prevent hypoglycaemia, they are associated with a higher risk of perioperative hyperglycaemia and delayed recovery from anaesthesia [27]. Hyperglycaemia has been associated with adverse physiological effects including impaired immune function, increased inflammation, polyneuropathy, and poor wound healing, which may negatively affect surgical outcomes [34]. These outcomes were not evaluated in the present study.

Therefore, Ringer's lactate provides better perioperative glycaemic stability and is associated with lower rates of hyperglycaemia and delayed recovery compared to dextrose-containing intravenous fluids in paediatric surgical patients.

LIMITATIONS

The study had a few limitations:

- Paediatric surgeries were completed within 120 minutes, and the assessed parameters were analyzed only within this limited intraoperative period.
- Blood glucose estimation was performed using capillary blood with a glucometer and test strips; the use of arterial blood gas analyzers could have provided more accurate measurements.
- The study evaluated fluid therapy effects over a short-term period (up to 2 hours postoperatively);

therefore, long-term outcomes such as delayed postoperative hyperglycaemia were not assessed.

CONCLUSION

Non-dextrose-containing fluid (Ringer's lactate solution) maintains preoperative blood glucose levels better than dextrose-containing fluid (5% dextrose in 0.225% sodium chloride saline) in paediatric patients undergoing elective surgery under general anaesthesia. The incidence of adverse effects, such as delayed recovery and hypoglycaemia, is lower in patients receiving non-dextrose-containing intravenous fluids.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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