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Research Article

Comparative Study between Dextrose 1%, 2.5% and 5% in Isotonic Solutions as Fluid Therapy during Paediatric Anaesthesia

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Abstract

Introduction: When paediatric patients undergo anaesthesia and surgery, their needs must be recognised and managed separately and looked after by staff with appropriate experience and training. **Aim of the work:** This study aims to evaluate three fluid regimens of isotonic solutions, including glucose 1%, 2.5% and 5%, during paediatric anaesthesia, focusing on changes in blood glucose concentrations, electrolytes, and acid-base status. **Patients:** The study was conducted in Alexandria's main university hospital after obtaining approval from the medical ethics and patient safety committee and informed written consent from all patients' guardians. Thirty paediatric patients who fasted for 6 hours after allowing 2 hours for free fluids aged 2-4 years were scheduled for minor non-haemorrhagic elective surgery under general anaesthesia. **Method:** Pre-operative assessment: all patients included in this study were assessed thoroughly by detailed medical and surgical history taken from guardians, complete clinical examination, and routine laboratory investigations, including Hb%, Hct%, blood glucose level, urea, serum creatinine, Na, and K. **Discussion:** During paediatric anaesthesia, many factors can induce changes in blood glucose; both hypoglycaemia and hyperglycaemia could be harmful to the body, so it is paramount to maintain paediatric blood glucose in the normal range; there is still some controversy about whether glucose fluid should be adopted or not and how to use it rationally. **Conclusion:** Glucose 1% containing solutions have better glycaemic control than higher glucose concentration solutions; paediatric patients can regulate blood glucose levels within normal limits with or without intra-operative glucose and if the intra-operative glucose supply is interrupted. The patient's acid-base status was not affected by hyperglycaemia with glucose 1%. **Recommendations:** Less glucose concentration is better than higher concentrations in fluid therapy in paediatric patients. If glucose and salt are to be given, it is better to be glucose 1% in isotonic solutions. Isotonic solutions are better than hypotonic solutions to avoid hyponatremia.

Keywords: Fluid therapy; Glucose 1%; Intraoperative management; Paediatric anaesthesia

Introduction

Paediatrics comprise a significant percentage of the population. Many will require anaesthesia to treat various surgical conditions, including (Ear, Nose and Throat) ENT, orthopaedic, dental, plastic, trauma, cardiothoracic, ophthalmic, and general paediatric surgery [1]. The particular needs must be recognised whenever paediatric patients undergo anaesthesia and surgery. They should be managed in special facilities and looked after by staff with appropriate experience and training [2].

Paediatric patients are not small adults: they differ physiologically, emotionally, and socially. Doses of drugs and fluids need to be precisely calculated, and anaesthesia equipment for more minor paediatric patients differs from that used in older paediatric patients and adults [3].

The cardiovascular system in Paediatrics shows a higher cardiac output and oxygen consumption per kilogram than in adults, they support this by a higher baseline heart rate [4], as shown in Table 1. The tidal volume and dead space are equally unchanged in the respiratory system, where the minute volume is high due to increased respiratory rate [5].

Age	Heart rate (beats/min)	Systolic BP (mm Hg)	Respiratory rate (breaths/ min)	Blood volume (ml/kg body weight)
Neonate	100-160	60-90	30-60	90
Infant	90-120	80-100	30-40	80
2-5 years	95-140	80-120	20-30	80
5-12 years	80-120	90-110	15-20	80
> 12 years	60-100	100-120	12-15	70

Table 1: Cardiovascular vital signs in paediatrics [6].

Temperature regulation, hypothermia can result in delayed recovery, cardiac irritability and respiratory depression due to cold intravenous fluids, dry anaesthesia gases, and wound exposure; paediatrics lose heat to the environment more readily than adults due to increased body surface area per kilogram. Therefore, it is essential to prevent heat loss in a warm operating room environment [7].

Pharmacologic Differences in Paediatric include that drugs are generally dosed on a per kilogram basis. Additionally, neonates are more sensitive to opiate analgesics during the first four weeks of life, leading to an increased risk of hypoventilation. The volume of distribution for most of the drugs, including muscle relaxants, is increased in paediatric patients so that a regular dose can lead to a lower plasma level than in adults. However, paediatric patients are sensitive to the effects of muscle relaxants, so a lower plasma level leads to the same effective dose [8].

Fluid Management Divisions are deficit therapy, maintenance therapy, and replacement therapy [9].

Fluid deficit therapy refers to managing fluid and electrolyte losses that occur before presentation for surgery, and they are three components; estimation of dehydration severity, determination of fluid deficit type, and deficit repair [10].

Dehydration severity is usually estimated from history and clinical evaluation. Investigations that may confirm the dehydration include serum osmolality, serum sodium, acid-base status, serum pH, base deficits, and serum potassium compared with the pH and urine output (rule out acute tubular necrosis) [11].

The biochemical investigation will reveal whether the type of dehydration is hyponatraemia (serum osmolarity < 270 mOsm/L, serum Na < 130 mEq/L), isonatraemic (serum osmolarity 270-300 mOsm/L, serum Na 130-150 mEq/L) or hypernatremic (serum osmolarity > 310 mOsm/L, serum Na > 150 mEq/L) [12].

Weight, kg	Fluid Needs
1-10	100 ml/kg
11-20	1000 ml+40 ml/kg for each kg > 10 kg
> 20	1500 ml+20 ml/kg for each kg > 20 kg

Table 2: Holliday and Segar's and modified by Oh Replacement therapy (Measured Losses) [13].

Maintenance fluid requirements have been calculated in several ways, including caloric expenditure and body surface area [14]. The most straightforward and commonly used formula was advised by Holliday and Segar and modified by Oh, as seen in Table 2 [13]; it relates to energy (caloric) expenditure and, therefore, the fluid volume required to weigh in kilograms [13].

Fluid loss replacement should be with an isotonic fluid, e.g., normal saline, a colloid, or blood, to replace haemorrhage without resulting in low haemoglobin levels [15]. Fluid evaporation from an open wound or third space loss varies depending on the operation and may range from 5 to 20 ml/kg/ hour. Loss of fluid via the lungs due to humidification of inspired gas may be reduced using a circle system or heat and moisture exchange filters in the breathing circuit [16].

The allowable blood loss = Estimated blood volume x Hb (current) - Hb (acceptable)/Hb (mean) [17].

Neonates (up to 44 weeks post-conceptual age) have a different fluid requirement; they are physiologically "waterlogged" but lose up to a tenth of their body weight in the first week of life. Premature or low birth new-borns have a greater surface area to weight ratio, lose more fluid by evaporation, and, as a result, require more replacement fluid (Table 3) [18].

Weight/age	< 1.0 kg	1.0 - 1.5 kg	1.5 - 2.0 kg	> 2.0 kg
Fluid requirement in ml/kg/day				
Day 1	100-120	80-100	460-80	40-60
Day 2	120-150	110-130	90-110	60-90
Day 3	150-170	140-160	120-140	80-100
Day 4	180-200	160-180	140-160	100-120
Day 5	180-200	170-200	150-180	120-150

Table 3: The fluid requirement in paediatric surgical unit guidelines, Sheffield Paediatric Patients' Hospital [19].

Glucose may be required to prevent hypoglycaemia while the child is starved, although this appears to be less problematic than what was previously thought [19].

Body physiology about glucose showed that diurnal variation in cortisol levels affects blood glucose levels. These are higher in the morning than in the afternoon. Paediatric patients who starved overnight have more elevated blood glucose than those who starved during the day. The surgery's stress and starvation increase the blood glucose level in paediatric patients as young as two weeks; this occurs even if no glucose-containing fluids are given. Administration of glucose will exacerbate this even further [20].

Glucose requirement in paediatrics may be calculated on an mg/kg/hour basis; glucose 120 mg/kg/hour maintains blood glucose level within a normal range and prevents lipid mobilisation. If solutions containing less than 5% glucose are unavailable, glucose may be given as an individual infusion or added to normal saline or combined saline and lactated ringer's [21].

Patients at risk of hypoglycaemia or hyperglycaemia should monitor their blood glucose regularly.

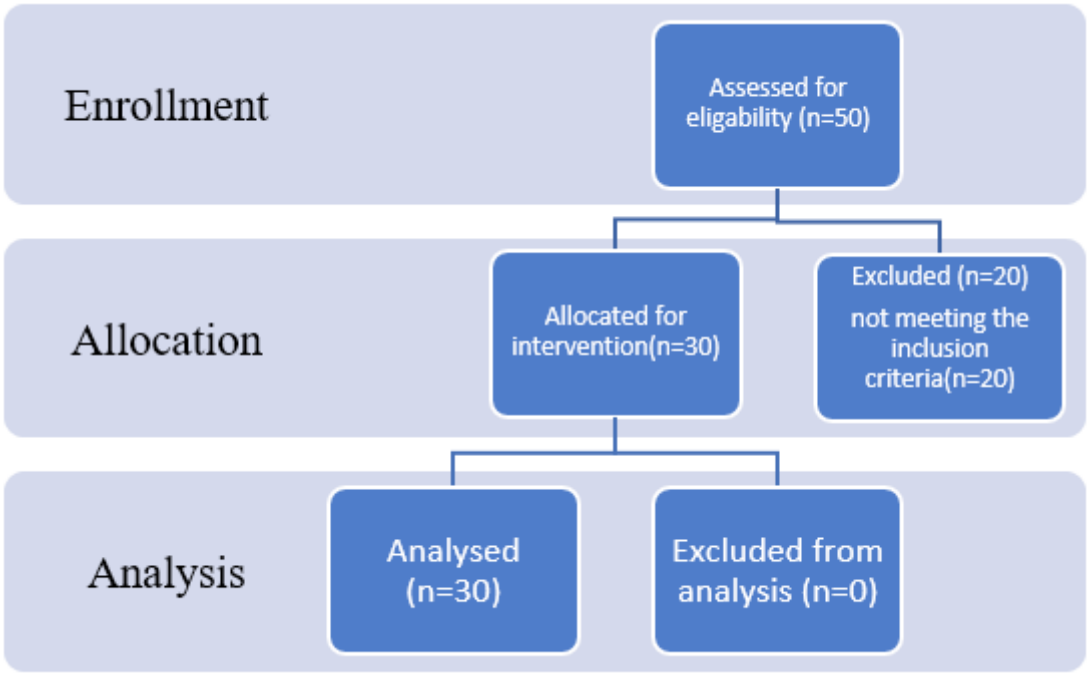
Anaesthesia and surgery can induce significant life-threatening hypoglycaemia. However, intra-operative hypoglycaemia is extremely rare in paediatric patients. On the other hand, hyperglycaemia is more commonly encountered during anaesthesia and surgery because intraoperative glucose uptake by the muscle is reduced [22]. The response to anaesthesia, surgery, anxiety and pain further increases blood sugar levels. The impaired effectiveness of insulin may further aggravate hyperglycaemia during anaesthesia. A glucose administration rate of more than 10 mg/kg/min may overwhelm the renal threshold and result in glucosuria and osmotic diuresis. With decreased tolerance to exogenous glucose and increased endogenous glucose production, a solution containing low glucose concentrations in a balanced salt solution may be required as a maintenance fluid. The replacement fluid should either be free of glucose or should not have more than 1% glucose. The present recommendations include using low glucose-containing solutions for maintenance fluid therapy to ensure adequate blood sugar levels without inducing hyperglycaemia [23].

Aim of the Work

This study evaluates the use of three fluid regimens of isotonic solutions, including glucose 1%, 2.5% and 5%, during paediatric anaesthesia to focus on changes in blood glucose concentrations, electrolytes, and acid-base status.

Patients

The study was carried out in Alexandria University Hospital after obtaining approval from the medical ethics and patient safety committee of the faculty of medicine and informed written consent from all patient's guardians. The study was done on 30 paediatric patients who fasted for 6 hours after allowing 2 hours for free fluids, aged 2-4 years (the medical statistic department calculated the sample size, medical research institute by using NCSS2004 and PASS2000 Program), scheduled for minor non-haemorrhagic elective surgery under general anaesthesia as shown in the following flow diagram.



Study flow diagram.

Exclusion Criteria

1. Diabetic patients.
2. Patients who have a nutritional disorder.
3. Patients who are having major cardiac surgery.
4. Patients who are having a haemorrhagic operation.
5. Patients who are on total parenteral nutrition.
6. Patients who have an operative duration of less than one hour.

Methods

Pre-Operative Assessment

After obtaining informed written consent from guardians of all patients included in this study, they were assessed thoroughly by a detailed medical and surgical history taken from guardians, followed by a complete clinical examination in conjunction with checking the routine laboratory investigations including Hb%, Hct%, blood glucose level, urea, serum creatinine, Na, and K.

Method of solution preparation (one litre): The Infection Control Department has instructed to prepare any given solutions under a completely closed system to prevent any infection risk.

1. Glucose 1% isotonic solution: [G1% + NaCl 0.7%]= (200 cc G5% + 800 cc Normal saline0.9%), Osmolarity around 289.77 mOsm/L.
2. Glucose 2.5% isotonic solution: [G2.5% +NaCl 0.45%]=(500 cc G5% + 500 cc Normal saline0.9%), Osmolarity is around 280 mOsm/L.
3. Glucose 5% isotonic solution: [G5% + NaCl 0.15%]=(700 cc G5%+150 cc G10% + 150 cc Normal saline0.9%), osmolarity around 303.2 mOsm/L. [24].

Premedication

All patients were pre-medicated with midazolam (0.3-0.5 mg/kg) intra- nasal 15 minutes before arrival at the operation room. Monitoring: On arrival at the theatre, the patient was connected to the standard monitoring, including lead π electrocardiograph, non-invasive arterial blood pressure, pulse oximetry and axillary or rectal probe for temperature monitoring using the Hewlett Packard (HP) viridian 24 multi-channel monitors. Induction: Before induction of anaesthesia, patients were pre-oxygenated with FiO^2 1 for at least 3 minutes; then sevoflurane mask in 100% oxygen was used to insert IV access, then Induction of anaesthesia was established by the fentanyl 1ug/kg followed by (0.1-0.15mg/kg) cis-atracurium to allow proper placement of suitable size LMA and to allow pressure controlled mechanical ventilation.

Given solutions

Group (I) received glucose 1% isotonic solution, group (II) received glucose 2.5% isotonic solution, and group (III) received glucose 5% isotonic solution. The fluid requirement and replacement in the three groups were managed according to fasting time, maintenance and losses based on the (4:2:1 rule) [25].

Measurement Parameters

a) Haemodynamics: have been recorded as average heart rates recorded throughout the operation, and the mean arterial blood pressures are tabulated to be discussed later.

b) Laboratory investigations: blood glucose level, blood gases, Na, K before and after infusion.

Sampling Time

The blood glucose levels, Na, K, and blood gases were sampled just before starting infusion and beginning to awaken the patient; another sample during operation for blood glucose level was taken to stop glucose infusion if hyperglycemia occurred. Recovery: By the end of the procedure, the patient started to recover by stopping Sevoflurane inhalation, reversing the muscle relaxant with neostigmine (30-50 ug/kg) preceded by atropine (0.01 - 0.02 mg/kg) and regaining spontaneous breathing oral suction and removal of the inflated LMA, then face mask with FiO^2 1 is allowed until the patient starts to cry clearly with 100% oxygen saturation on the monitor to be discharged from the operating room safely.

Statistical Analysis

Data were fed to the processor using the Predictive Analytics Software (PASW Statistics 18).

Measures such as median, minimum, and maximum values were used to describe the quantitative data, along with the mean and standard deviation.

The normality of the distributions of the quantitative variables was assessed by applying the Kolmogorov-Smirnov and Shapiro-Wilk tests. The D'Agstino test was used if there was a doubt between the two previous tests. If it shows normal data distribution, parametric tests were applied. If the data were abnormally distributed, non-parametric tests were used.

The Mann-Whitney test was used to analyse two independent populations for abnormally distributed data. The Mann-Whitney Suppose more than two populations were analysed Kruskal Wallis test to be used. Wilcoxon Signed Rank test was assessed for two periods. The same case test was used to analyse two independent populations for an abnormally distributed data massive group.

Massive test results are quoted as two-tailed probabilities. The obtained results were evaluated at a significance level of 5% [26].

Results

This study was conducted on 30 ASA I physical status paediatric patients aged 2 to 4 years and scheduled for surgical correction of congenital hypospadias. Intravenous solutions of different glucose concentrations and the patient's data in each group were recorded, analysed, and tabulated.

As regards the loss volumes from the patient, there were no significant differences as all patient losses were around 30 to 50ml of blood, which was of no significant difference as the P

value was 0.167. As regards the total infusion volume of the given fluid, which was around 300 to 350 ml statistically, no significant differences were reported between each group and the other group as the P value was 0.944 (Figure 1,2).

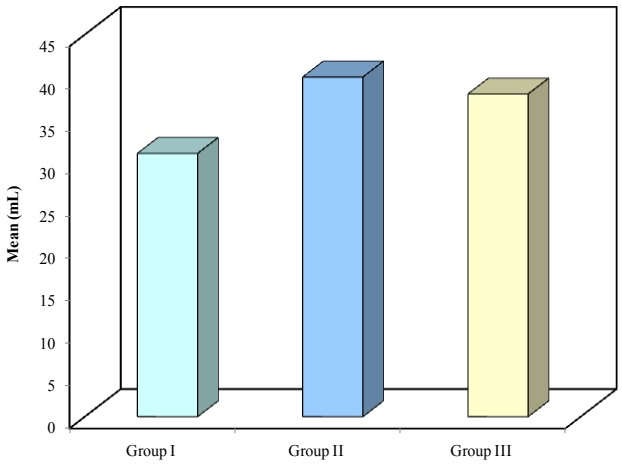


Figure 1: Comparison between the studied groups according to losses.

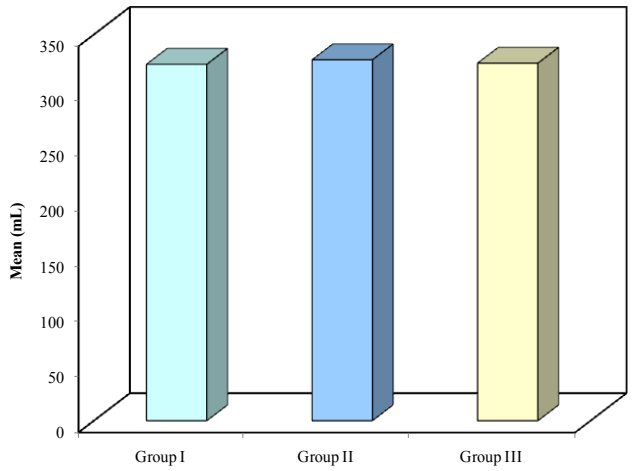


Figure 2: Comparison between the studied groups according to Infusion volume.

The following tables show the distribution of the studied cases according to investigations immediately pre-operative in 3 groups, as seen in the following (Tables 4-6).

	RBG (mg/dl)	Na (mEq/L)	K (mEq/L)	pH	PaO_2 (mmHg)	$PaCO_2$ (mmHg)	HCO_3 (MEq/L)
Min.	100.0	135.0	3.64	7.35	324.0	33.0	22.0
Max.	130.0	138.0	4.24	7.38	394.0	37.0	25.0
Mean	113.0	136.10	3.87	7.36	368.0	35.40	23.20
SD	8.56	0.99	0.16	0.01	23.67	1.17	1.03
Median	110.0	136.0	3.84	7.36	374.0	36.0	23.0

Table 4: The studied cases according to investigations immediately pre-operative in group I.

	RBG (mg/dl)	Na (mEq/L)	K (mEq/L)	pH	PaO_2 (mmHg)	$PaCO_2$ (mmHg)	HCO_3 (MEq/L)
Min.	98	133.0	3.50	7.35	310.0	35.0	22.0
Max.	120.0	140.0	4.20	7.38	416.0	37.0	25.0
Mean	107.90	136.30	3.82	7.37	365.90	35.70	23.70
SD	7.06	2.21	0.29	0.01	33.74	0.67	1.16
Median	107.0	136.0	3.80	7.37	368.0	36.0	24.0

Table 5: Studied cases according to investigations immediately pre-operative in group II.

	RBG (mg/dl)	Na (MEq/L)	K (MEq/L)	pH	PaO_2 (mmHg)	$PaCO_2$ (mmHg)	HCO_3 (MEq/L)
Min.	100.0	133.0	3.50	7.34	358.0	35.0	22.0
Max.	116.0	140.0	4.20	7.41	406.0	39.0	26.0
Mean	107.80	136.70	3.82	7.37	386.70	36.60	24.10
SD	5.83	2.21	0.24	0.02	15.91	1.43	1.52
Median	108.0	137.0	3.85	7.38	389.0	36.50	24.50

Table 6: According to investigations, the studied cases were immediately pre-operative in group III.

The following tables show the distribution of the studied cases according to investigations immediately post-operative in 3 groups, as seen in the following (Tables 7-9).

	RBG (mg/dl)	Na (mEq/L)	K (mEq/L)	pH	PaO_2 (mmHg)	$PaCO_2$ (mmHg)	HCO_3 (MEq/L)
Min.	135.0	136.0	3.80	7.36	320.0	35.0	22.0
Max.	160.0	139.0	4.20	7.37	390.0	37.0	26.0
Mean	144.10	137.40	3.95	7.36	372.50	36.30	24.20
SD	7.77	0.79	0.14	0.01	25.95	0.67	1.32
Median	142.50	137.50	3.90	7.36	382.50	36.0	24.0

Table 7: The studied cases according to investigations immediately post-operative in group I.

	RBG (mg/dl)	Na (mEq/L)	K (mEq/L)	pH	PaO_2 (mmHg)	$PaCO_2$ (mmHg)	HCO_3 (MEq/L)
Min.	230.0	136.0	3.60	7.35	344.0	33.0	22.0
Max.	319.0	142.0	4.10	7.38	415.0	40.0	26.0
Mean	278.30	138.0	3.90	7.36	380.10	36.10	23.80
SD	28.99	2.0	0.15	0.01	24.04	2.02	1.32
Median	282.50	137.50	3.90	7.36	382.50	36.0	24.0

Table 8: According to investigations, the studied cases were immediately post-operative in group II.

	RBG (mg/dl)	Na (mEq/L)	K (mEq/L)	pH	PaO_2 (mmHg)	$PaCO_2$ (mmHg)	HCO_3 (MEq/L)
Min.	319.0	134.0	3.60	7.35	355.0	35.0	22.0
Max.	426.0	139.0	4.10	7.37	403.0	40.0	25.0
Mean	381.90	136.60	3.87	7.36	387.20	37.20	24.0
SD	30.49	1.71	0.18	0.01	15.21	1.75	1.05
Median	380.50	136.50	3.85	7.36	390.0	37.0	24.0

Table 9: According to investigations, the studied cases were immediately post-operative in group III.

As regards the comparison between the studied groups according to separate investigation immediately post-operative, there were no significant differences between them except for RBG results which resulted in substantial differences as the P value was <0.001, as seen in (Table 9).

By comparing the results of the three groups pre and post-operatively, there was statistically no significant differences between them except for the RBG results, which revealed significant differences between the three group as the P value was <0.05, as seen in Table 10 and Figure 3-8. In group II, the RBG level increased 1.5-fold the preoperative value, and in group III RBG level increased by 2.5-fold the preoperative value

	Group I		Group II		Group III	
	Pre	Post	Pre	Post	Pre	Post
RBG (mg/dl)	113.0±8.56	144.10±7.77	107.90±7.06	278.30±28.99	107.80±5.83	382.90±30.49
P*	0.005*		0.005*		0.005*	

Table 10: Comparison between the studied groups according to RBG (mg/dl) pre- and post-operatively.

P*: p-value for Wilcoxon signed ranks test between pre- and post-operative.

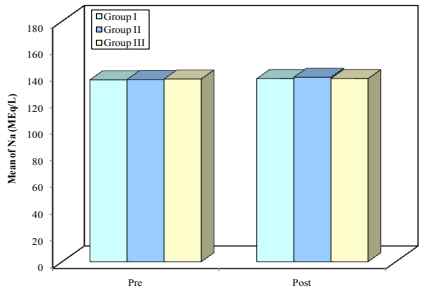


Figure 3: Comparison between the studied groups according to Na results.

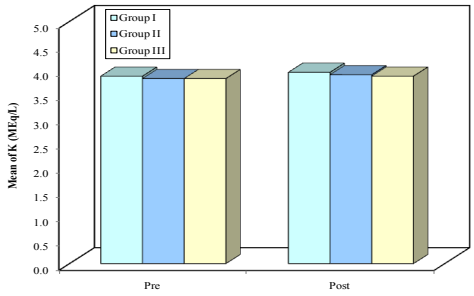


Figure 4: Comparison between the studied groups according to K results.

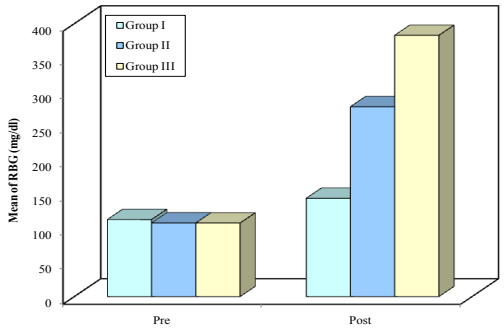


Figure 5: Comparison between the studied groups according to RBG results.

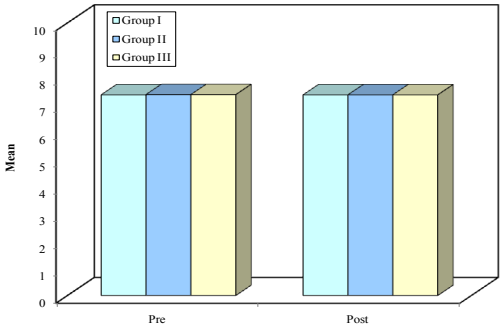


Figure 6: Comparison between the studied groups according to pH results.

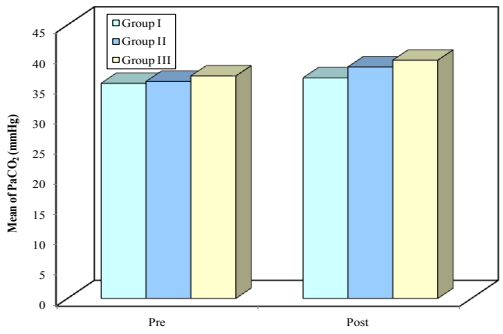


Figure 7: Comparison between the studied groups according to $PaCO_2$ results.

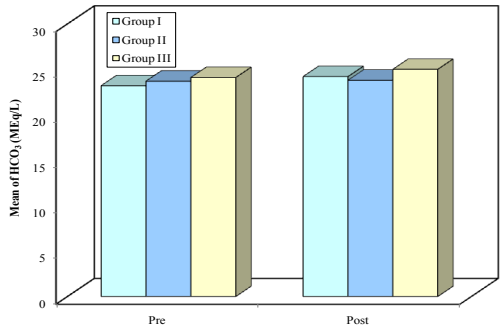


Figure 8: Comparison between the studied groups according to HCO_3 results.

Discussion

During paediatric anaesthesia, many factors can induce changes in blood glucose. There is still some controversy about whether glucose-containing fluid should be adopted and how to use it rationally [2]. The previous studies showed that free glucose fluid could be used in paediatric patients with stable general conditions who were fasting for a short time. On the contrary, a low glucose concentration could be adopted in newborns and premature patients with long pre-operative fast duration [2].

Recent developments in perioperative fluid management in the paediatric patient have highlighted the volume of fluids, the amount of electrolytes and glucose needed to be replaced, and the anticipated physiological losses from breath, sweat, and urine to prevent hypoglycemia [3]. Many authors generally consider hyperglycemia as a whole blood glucose concentration greater than 120 to 125mg/dl; hyperglycemia (glucose >200 mg/dl) has also been noted in older infants and paediatric patients given 5% glucose in lactated Ringer's as an intraoperative maintenance fluid [4]. When intra-operative hypoglycemia is extremely rare in paediatric patients, on the other hand, hyperglycemia is more commonly encountered during anaesthesia and surgery because intraoperative glucose uptake by the muscle is reduced [22]. The current study compared fluid regimens of isotonic solutions, including glucose 1%, 2.5% and 5%, during paediatric anaesthesia, focusing on changes in the blood glucose concentrations, electrolytes, and acid-base status.

In the glucose, 1% group, RBG post-operatively increased but still was not at a significant level as the mean ±SD was 144.1 ±7.7 mg/dl. About 3 cases reported RBG post-operatively were more than 150 mg/dl, and seven cases reported RBG post-operatively as less than 150 mg/dl; this result comes as Dubois et al., [27] found in the group that received lactated ringer with glucose 1% in same paediatric age group report mean ±SD 117 ± 37.8mg/dl. Berleur et al., [28] said that lower glucose concentrations could be used as the glucose concentration here was 0.9% glucose in a lactated ringer. This study was carried out on 142 cases from one month to 12 years, and the RBG post-operatively reported mean ±SD as 140 ±27 mg/dl. Welborn et al. [29] also studied the effect of glucose 1% in paediatric patients of age group 2.5-2.9 years for minor surgery; results showed that RBG post-operatively increased by 39.6mg/dl more than the pre-operative level, which means ± SD was 82.8 ±10.8 mg/dl.

Geib et al., [30] studied 41 paediatric patients aged six months to 11 years, giving glucose 1% in lactated ringers where the mean ±SD was 81 ± 84.6 mg/dl. Dagli et al., [31] studied 1-12year paediatric patients receiving glucose 1% in ringer lactate; the result was mean ±SD140.4 ±27mg/dl. Sümpelmann et al., [23] said that glucose levels increased in patients receiving glucose 1%; this occurred in 54 cases, where RBG pre-operatively were (84±32.4mg/dl), and RBG post-operatively was (162±28.8mg/dl). The previous results reflect the role of glucose 1% in glycemic control and prevention of hyperglycemia in the paediatric patient.

As regards the glucose 2.5% group, the increase in the RBG post-operatively was 1.5-fold of the pre-operative value, where 2 cases reported hyperglycemia of more than 300mg/dl, 6 cases reported hyperglycemia of more than 250mg/dl, and 2 cases were less than 250 mg/dl as mean ±SD was 278±28.9mg/dl. Welborn et al., [29] reported that on giving glucose 2.5% in a Lactated ringer, hyperglycemia occurred, and mean± SD was 207±40.5 mg/dl, the same as the current study.

Also, Dubois et al., [27] said that when glucose 2.5% concentration was used, hyperglycemia occurred as the mean ±SD was 145±28.8mg/dl in this study. The minor change in RBG post-operatively may be due to age group, which was up to 11 years and also the type of surgery which was superficial plastic surgery and removal of various orthopaedic materials and orchidopexy.

Regarding the usage of glucose, 5% concentration, 3rd group RBG post-operatively increased 2.5-fold of the pre-operative value (Figure 5), as the mean±SD was 382±30mg/dl, where 3 cases

reported more than 400mg/dl RBG post-operatively and seven patients reported more than 300mg/dl RBG post-operatively.

Mikawa et al., [32] found that with glucose 5% concentrations in paediatric patients aged 1.5-9 years, a group of about 45 cases was divided into three groups of 15 patients each. 1st group received only lactated ringer, and 2nd group received glucose 2% in the lactated ringer's. The 3rd group received glucose of 5% in a lactated ringer's, which reported RBG post-operatively up to 271mg/dl, which was more significant than the rise in RBG post-operatively in the 1st and 2nd groups. Furthermore, the difference was correlated to glucose concentration in the three solutions. Sandstorm et al., [33] said that the paediatric patients appeared capable of regulating blood glucose levels within normal ranges with or without intra-operative glucose. The study was carried out in four groups; each received fluids intra-operatively and post-operatively. Still, differences were in the glucose content of these fluids pre and post-operatively; they found that even the paediatric patient did not receive glucose as in the 4th group, the RBG level post-operatively was not lower than usual.

The previous opinion highlighted that the glucose content of the given fluid could affect RBG levels but still with a particular paediatric age group only.

Regarding total infusion volume, the three groups in the current study received nearly up to 350 ml of the specific solution for each group to maintain hydration and replace losses.

Paut et al., [21] said that the postoperative period is at risk for non-osmotic secretion of antidiuretic hormone, which decreases the ability of the kidneys to excrete free water. In the context of antidiuretic hormone release, the associated low urine output reduces the maintenance volume requirement to 50% of the calculated hourly rate. Nevertheless, the restriction of fluids based on this opinion only applies to short-term operations without fluid shifts.

According to Leelanukorum et al., [34], Infusion of large volumes or higher maintenance rates of hypotonic solutions should not be the case. Minor surgery in fit paediatric patients who will re-establish oral intake in the early postoperative phase and will not need routine intravenous fluids. Hypovolemia should be corrected with a rapid infusion of isotonic saline. In contrast, dehydration is corrected slowly over 14-72 hours as appropriate; ongoing losses should be measured and replaced.

Another study reflects that paediatric fluid therapy departmental protocols are not established at many centres as Way et al., [35] a survey of current prescribing practice done on 289 anaesthesia, said that about 50% of they were giving 4% glucose in 0.18% saline, and 15.7% of them were giving 2.5% glucose in half normal saline, and 24.2% used normal saline. As regards the tonicity of the fluid given in the current study, the tonicity of fluid in the glucose 1% group was 280 mOsm/L, and the tonicity of fluid in the glucose 2.5% group was 289mOsm/L. The tonicity of fluid in the glucose 5% group was 308 mOsm/L.

In the current study, sodium chloride is added to solutions to adjust the tonicity of the fluid given, not considering the sodium content itself, as the study was on patients with average sodium profiles.

Paut et al., [21] said that giving isotonic fluids is better than hypotonic ones; this was to guard against hyponatremia that can occur but still, the sodium content of the infusion fluid is under debate.

Halberthal et al., [36] reviewed the occurrence of in-hospital hyponatremia; they found that the leading cause was the infusion of hypotonic solutions, where they found that all cases received a hypotonic solution, while the majority of cases (about 13 case from 23 case) developed hyponatraemia post-operatively.

As regards potassium results, there were no significant differences between pre and post-operative values as the mean ±SD was 3.95±1.4 mEq/L in the glucose 1% group,3.9±0.15 mEq/L in the glucose 2.5% group and 3.87±0.18 mEq/L, the p-value was 0.546 of no significant differences.

Sümpelmann et al., [23] found that potassium post-infusion value was 4.5±0.8 mEq/L while pre-infusion was 4.3±0.8mEq/L, so usage of glucose 1% isotonic solution kept potassium level within normal limits. As regards sodium results in the current study, it was found that sodium levels post-operatively in the glucose 1% group were (137±1.7 mEq/L), in the glucose 2.5%group was (138±2mEq/L), and in the glucose 5% group was (137±1.76mEq/L), Sümpelmann et al., [23] found that post infusion value of sodium levels was 137±3 mEq/L. At the same time, pre-infusion was 137±4mEq/L, so usage of glucose 1% isotonic solution keeps sodium level within normal limits.

Berleur et al., [28] said that paediatric patients were given a solution containing 65 or 43mmol/L of sodium (not mentioning the tonicity of the fluid). They also said that it had about half of the plasma sodium levels. After infusion, the patients reported significant hyponatremia pre-operatively (138.15±4.85mEq/L) and post-operative (133.3±4.5mEq/L); this means that the tonicity of the fluid affects sodium level post-infusion rather than sodium content itself; this needs further evaluation and further studies. Dubois et al., [27] said that there was no change in sodium levels in the group which received ringer lactate and glucose 1% in ringer lactate; this confirms the current study results in the glucose 1% group.

Regarding a change in acid-base status, the current study revealed no difference in PH, blood gases or HCO3. Mikawa et al., [32] did a study on 45 paediatric patients, 1.5-9 years, lasting

6-hour operations received glucose 5% in lactated ringer and glucose 2% in lactated ringer, focusing on insulin, glucose, ketone bodies and triglyceride. There was no change in any previous variables, so acid-base status also did not change. This study differs in age group range and operation duration from the current study; this may explain why hyperglycemia did not occur as in recent research with these glucose concentrations.

Sümpelmann et al., [23] study showed that the intraoperative use of an isotonic balanced electrolyte solution with 1% glucose helped to avoid acid-based balance, hyponatraemia, hypoglycemia, ketoacidosis, and hyperglycemia in surgical neonates.

As regards the usage of glucose 1% in long-term operation in paediatrics, Torii et al., [37] said to explore changes in glucose and insulin concentrations. Administering 1% glucose in acetated Ringer solution in paediatric surgical patients on seven patients between a month and two years of age with biliary atresia undergoing hepatic Porto-enterostomy, during anaesthesia, fluid containing 1% glucose in acetated Ringer solution was infused. Blood glucose (mg/dL), insulin (U/mL), base excess (mmol/L) and lactic acid (mmol/L) were measured at anaesthesia induction as a baseline, 30min later, two hours later, and four hours later, respectively; the results were Blood glucose, and insulin concentrations maintained at normal ranges.

Conclusion

Healthy paediatric patients can regulate blood glucose levels within normal limits with or without intra-operative glucose. A fasting period of 6 hours does not impact blood glucose levels in the event of an interruption in the supply of intraoperative glucose. If no significant volume losses or fluid shifts exist, electrolytes such as Na and K are unaffected with isotonic glucose 1% infusion. In addition, the patient's acid-base status was not affected by hyperglycemia with glucose 1%. This study's limitations emphasise the need for further research with larger sample sizes, randomised controlled trials, longer follow-up periods, and consideration of potential confounding factors to enhance our understanding of fluid therapy in paediatric anaesthesia.

Conflict of Interest

No areas of conflict

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