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ORIGINAL RESEARCH ARTICLE

Effect of Crystalloids on Intraoperative Plasma Glucose Levels in Elective Non-Diabetic Patients under General Anaesthesia

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ABSTRACT

Background: In this study, non-diabetic patients undergoing elective major non-cardiac surgery under general anaesthesia were monitored to examine the different crystalloids frequently used in daily practice and to evaluate as to how maintenance fluid regimens affected intraoperative blood glucose levels.

Methods: This was a hospital-based randomized prospective study conducted among 90 non-diabetic patients of ASA physical status I or II of age group 18-50 years of either sex undergoing major non-cardiac surgery under general anaesthesia in the Department of Anaesthesiology and Critical Care, SCB Medical College and Hospital, Cuttack, Odisha, from March 2021 to February 2023, after obtaining clearance from the institutional ethics committee and written informed consent from the study participants.

Results: The CBG just after intubation was significantly higher than baseline in group D but was lower than baseline and comparable between groups R and N. The CBG in the 1st and 2nd intra-operative hours was significantly higher in group D than in groups R and N, but the CBG in the 3rd intra-operative hour was comparable among all the groups. 27% of patients in group R and 20% of patients in group N, in contrast to 100% of patients in group D, had at least one episode of hyperglycaemia and required rescue insulin. The incidence of hyperglycaemic episodes (CBG ≥ 150 mg/dL) was highest in group D, i.e., 82%, whereas in group R it was 9% and in group N it was only 7%. In comparison to groups R and N, group D had a considerably greater mean insulin consumption. The incidence of hyperglycaemia despite rescue insulin was much higher (59%) in groups D in comparison to groups R and N.

Conclusion: As far as intra-operative hyperglycaemia due to stress is concerned, RL and NS are preferable maintenance fluids over DNS for elective major surgeries.

Keywords: Crystalloids, Intraoperative Plasma Glucose Levels, Elective, Non-Diabetic Patients, Anaesthesia

INTRODUCTION

Replacement of large blood and plasma losses with crystalloids is only transiently effective in maintaining intravascular volume, as crystalloids lack colloidal oncotic pressure.[1-2] Traditionally, any balanced salt solution that contains both potassium chloride and sodium chloride works just as well as a maintenance fluid. Dextrose-containing fluids, however, are the only ones that can satisfy the mandatory glucose needs of the brain and RBC. If additional sources of carbohydrate are not available to a patient who is fasting, glycogenolysis and gluconeogenesis from pools of amino acids supply the required glucose while accelerating protein catabolism. Protein catabolism is avoided by dextrose.[3] The stress

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 08, 2023

response to surgery, anaesthesia and other injuries has been considered a homeostatic defence mechanism important for the body's adaptation and for withstanding noxious insults. But such exaggerated physiological changes in patients with coexisting diseases are always life-threatening. This can be prevented by using appropriate fluids, electrolytes, and glucose to reduce nitrogen loss. Appropriate reduction of the stress response improves surgical outcomes.[4] Glucagon, growth hormone, cortisol, and catecholamine levels rise during surgery, which leads to insulin resistance, which can be indirectly seen by the frequency of hyperglycaemia.[5-7] In the intraoperative period, certain crystalloid fluids may also change blood glucose levels.[8]

AIMS AND OBJECTIVES

- The purpose of this study was to determine how various crystalloids routinely used in daily practise affected the intra-operative blood glucose levels of non-diabetic patients undergoing elective major non-cardiac surgery under general anaesthesia.
- To know the blood glucose levels immediately before initiation of intravenous fluid, just after intubation and intra-operatively, in three groups of patients.
- To determine and compare the prevalence of intra-operative hyperglycaemia in patients receiving Ringer's lactate solution (RL), or 5% dextrose in 0.9% sodium chloride (DNS) or 0.9% NaCl solution (NS), as a maintenance fluid (capillary blood glucose ≥150 mg/dL).

MATERIALS & METHODS

This was a hospital-based randomized prospective study conducted among 90 non-diabetic patients of ASA physical status I or II of age group 18-50 years of either sex undergoing major non-cardiac surgery under general anaesthesia at the Department of Anaesthesiology and Critical Care, SCB Medical College and Hospital, Cuttack, Odisha, from March 2021 to February 2023, after obtaining clearance from the institutional ethics committee and written informed consent from the study participants.

Inclusion Criteria

- Non-diabetic patients of ASA physical status I or II of age group 18-50 years of either sex undergoing major non-cardiac surgery under general anaesthesia.

Exclusion Criteria

- Unwilling patients
- Patients with diabetes mellitus, impaired postprandial glucose tolerance (2 hour postprandial blood glucose ≥ 140mg/dL) and impaired fasting glucose (fasting blood glucose ≥ 110mg/dL).
- Patients with severe respiratory, cardiovascular, neurological, or renal disease.
- ASA physical status III and IV
- Haemodynamically unstable patients
- Pregnancy
- Body weight <35 kg
- Body weight >75 kg
- Patients requiring colloid and/or blood products intra-operatively.

Parameters Studied

- Capillary blood glucose (CBG) level immediately before initiation of intravenous fluid (Baseline) in each group.

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 08, 2023

- Changes of CBG from baseline: just after intubation, then at hourly intervals till the end of surgery.
- Incidences of hyperglycaemia (CBG ≥ 150 mg/dL) in each group of patients.
- Total requirement of rescue insulin therapy to maintain normoglycemia (CBG < 150 mg/dL) in each group of patients.

Study Procedure

After approval of institutional ethics committee and obtaining written informed consent from the patients, 30 patients in each of the 3 groups were taken for the study. All the patients underwent thorough pre-operative evaluation and checked against the exclusion criteria of this study. In the operating room, venous cannulation was done in a large peripheral vein of hand using an 18G polyurethane intravenous cannula and a three-way stop cock was attached. Intravenous maintenance fluid was started according to the following table:

Group	Maintenance Fluid
R	Ringer's Lactate (RL)
D	5% Dextrose in 0.9% NaCl (DNS)
N	0.9% NaCl (NS)
Table 1	

Rate of hourly maintenance fluid infusion for each patient was calculated from ''4-2-1 rule'' as per the following table.[9]

Body weight (kg)	Fluid Rate (mL/kg/hr)
For first 10kg (0-10)	4
For next 10 kg (11-20)	+2
For each kg above 20kg	+1
Table 2	

Example: For a patient of 50kg body weight, rate of maintenance fluid per hour is = (4X10) + (2X10) + (1X30) = 90 mL/hr.

The patients were temporarily randomized into the 3 study groups; R, D and N. Randomization list was generated by a random number function using Microsoft Excel (2007) spreadsheet resulting a list of 90. Group R patients received Ringer's lactate solution (RL), Group D patients received 5% dextrose in 0.9% NaCl solution (DNS) and Group N patients received 0.9% NaCl solution (NS) as maintenance fluid as per calculated hourly infusion rate according to their body weight.

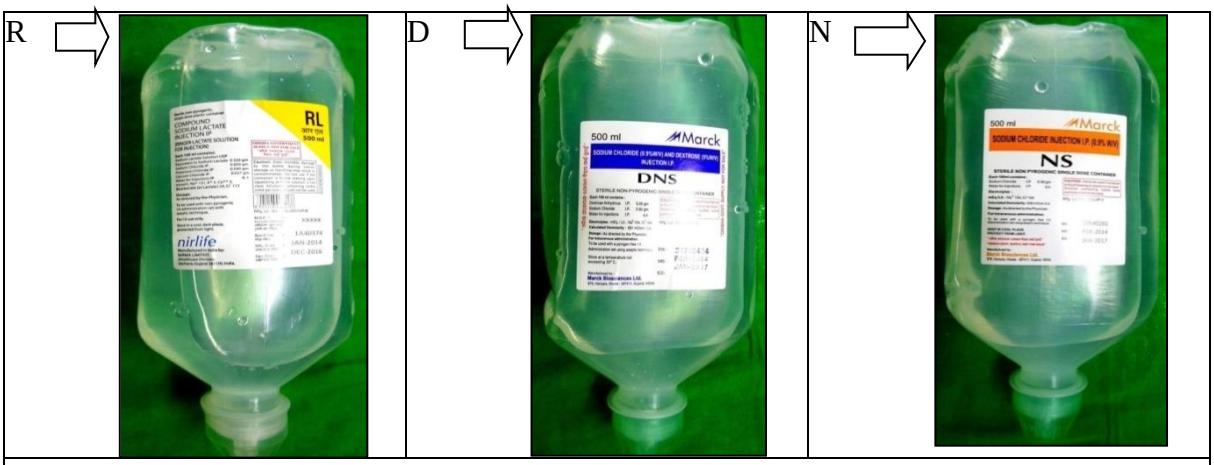

Figure 1.

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 08, 2023

After the monitors were attached, all the patients were premedicated with Inj. Glycopyrrolate 0.2mg, Inj. Midazolam 1mg, Inj. Butorphanol 1mg, Inj. Ranitidine 50mg and Inj. Ondansetron 4mg; intravenously five minutes prior to induction of anaesthesia as per our OT protocol. Preoxygenation was done for 3 min. Induction was done with inj. Thiopentone 4mg/kg i.v. & tracheal intubation was facilitated with inj. Succinylcholine 1.5mg/kg i.v. Anaesthesia was maintained with O_2 33%+ N_2O 66% + Isoflurane 0.5-1% by IPPV. Muscle relaxation was maintained with initial dose of Vecuronium 0.08mg/kg followed by 0.02mg/kg i.v. subsequently as per requirement. Fluid deficit arising from overnight fasting was corrected by the maintenance fluid. Fifty percent of total deficit was corrected in the first hour and the remaining fifty percent was corrected in next 2 hours. Redistribution & evaporative surgical fluid loss compensation[10] was done according to the following table:

Degree of Tissue Trauma	Additional Fluid Requirement
Minimal	0–2 mL/kg
Moderate	2–4 mL/kg
Severe	4–8 mL/kg

Table 3

Blood loss calculated from mops & suction drain bottle, was replaced up to the transfusion threshold (10-20% of total blood volume depending upon the clinical condition)[10] with crystalloids in 1:3 ratio. Intra-operative vitals were maintained within normal limit & urine output was targeted @1ml/kg/hr. Inj. Mephenteramine 5mg I.V. was given if required to maintain blood pressure. Patients who required colloid / blood or both to maintain hemodynamical stability were excluded from the study.

All patients had baseline capillary blood glucose (CBG) measured immediately prior to the start of intravenous infusion of any fluid. Thereafter CBG levels were measured just after intubation and then at hourly intervals till the end of surgery. Glucose concentration was determined in fresh capillary blood by reflectance photometry using SD-CHECK-Gold blood glucose meter, SD Biosensor, INC. Human soluble insulin was given as iv bolus, any time CBG ≥ 150mg/dL, at a calculated dose CBG/100 IU.[11] We considered CBG values of 150 mg/dL as the treatment initiation point because a recent analysis of the cohort found a positive correlation between the average postoperative glucose level and mortality, with the lowest mortality in patients with average post-operative blood glucose of 150 mg/dL (8.3 mmol/L).[12]

RESULTS

	R	D	N	P-Value
Mean	82.2	196.23	82.53	ANOVA
SD	10.82	32.65	7.88	
Sample Size –N	30	30	30	
Standard Error of Mean (SEM)	1.975	5.962	1.439	< 0.0001(extremely significant)
Lower 95% Confidence Limit	78.16	184.04	79.59	TUKEY-KRAMER MULTIPLE COMPARISONS TEST
Upper 95% Confidence Limit	86.24	208.42	85.476	
Minimum	65.0	141.0	68.0	
Median	80.5	188.5	82.0	
Maximum	113.0	273.0	101.0	
Normality Test KS	0.1372	0.1516	0.0936	

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 08, 2023

Normality Test P Value	>0.10	0.0766	>0.10	R vs. D	R vs. N	D vs. N
Passed Normality Test	YES	YES	YES	<0.001	>0.05	<0.001
Table 4: Comparison of CBG-INT (just after intubation) among the Study Groups						

There was no statistically significant difference in CBG-INT (just after intubation) between groups R and N (P>0.05), but a significant difference was present between groups R and D (P<0.001), and D and N (P<0.001).

	R	**D**	**N**	**P-Value**		
Mean	126.73	184.07	120.5	ANOVA		
SD	23.92	24.16	22.06			
Sample Size –N	30	30	30			
Standard Error of Mean (SEM)	4.37	4.41	4.03	< 0.0001 (extremely significant)		
Lower 95% Confidence Limit	117.8	175.05	112.26	TUKEY-KRAMER MULTIPLE COMPARISONS TEST		
Upper 95%. Confidence Limit	135.67	193.09	128.74			
Minimum	89.0	142.0	84.0			
Median	121.0	180.50	119.0			
Maximum	201.0	246.00	178.0			
Normality Test KS	0.1462	0.1011	0.1396			
Normality Test P Value	>0.10	>0.10	>0.10	R vs D	R vs N	D vs N
Passed Normality Test	YES	YES	YES	<0.001	>0.05	<0.001
Comparison of CBG-1 Hour among the Study Groups						
	R	**D**	**N**	**P Value**		
Mean	135.6	157.6	130.12	ANOVA		
SD	15.54	16.68	16.31			
Sample Size –N	25	25	24			
Standard Error of Mean (SEM)	3.108	3.337	3.33	< 0.0001 (extremely significant)		
Lower 95% Confidence Limit	129.18	150.71	123.24	TUKEY-KRAMER MULTIPLE COMPARISONS TEST		
Upper 95% Confidence Limit	142.02	164.49	137.01			
Minimum	92.00	133.00	104.00			
Median	138.0	152.0	130.5			
Maximum	164.0	192.0	156.0			
Normality Test KS	0.1503	0.1686	0.1642			
Normality Test P Value	>0.10	0.0648	0.0933	R vs D	R vs N	D vs N
Passed Normality Test	YES	YES	YES	<0.001	>0.05	<0.001
Comparison of CBG-2 Hour among the Study Groups						
Table 5						

There was no statistically significant difference present between group R and N (P>0.05) regarding CBG-1 hour, but there was a significant difference between group R and D (P<0.001), and group D and N (P<0.001).

There was no statistically significant difference found between group R and N (P>0.05) regarding CBG-2hr, but a significant difference was present between group R and D (P<0.001), group D and N (P<0.001).

	R	**D**	**N**	**P Value**
Mean	0.44	4.51	0.32	Kruskal-Wallis Test (Nonparametric ANOVA)
SD	0.75	1.47	0.66	
Sample Size –N	30	30	30	
Standard Error of Mean (SEM)	0.138	0.27	0.12	< 0.0001 (extremely significant)
Lower 95% Confidence Limit	0.16	3.96	0.078	DUNN'S MULTIPLE

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 08, 2023

Upper 95% Confidence Limit	0.72	5.06	0.57	COMPARISONS TEST		
Minimum	0.0	1.6	0.0			
Median	0.0	4.1	0.0			
Maximum	2.1	8.0	1.7			
Normality Test KS	0.455	0.135	0.4882			
Normality Test P Value	<0.0001	>0.10	<0.0001	R vs D	R vs N	D vs N
Passed Normality Test	NO	YES	NO	<0.001	>0.05	<0.001

Table 6: Comparison of Insulin Consumption among the Study Groups

It was clear that group D's mean insulin consumption was higher than that of groups R and N ($P < 0.001$) by a significant margin, but no significant difference was found regarding mean insulin consumption between groups R and N ($P > 0.05$) [Dunn's multiple comparisons test].

DISCUSSION

Several studies concluded that hyperglycaemia leads to metabolic alterations, impaired wound healing, exacerbation of ischemic brain injury, increased risk of infection, increased risk of renal failure, and increased surgical morbidity and mortality.[13,14,15,16] Traditionally, any sodium chloride or potassium chloride-based balanced salt solution works well as a maintenance fluid. However, only solutions containing dextrose are able to satisfy the mandatory glucose needs of the brain, RBC, and adrenal medulla. If an external source of carbohydrates is not available to a patient who is fasting, glycogenolysis and gluconeogenesis from pools of amino acids provide the required glucose while accelerating protein catabolism. Protein-sparing metabolic effects of dextrose.[3]

Blood glucose levels may be impacted by various crystalloid fluids during the intraoperative phase.[8] The increased risk of post-operative problems, particularly following cardiovascular surgery in diabetic patients, has repeatedly been reported to be associated with persistent hyperglycaemia in blood glucose levels during the intraoperative phase. Neonatal and paediatric populations have been researched to determine the effects of various hydration regimens.[8,17] Although peri-operative hyperglycaemia is highly common in non-diabetic patients having cardiac surgery, it is not yet known how often it occurs in non-diabetic individuals having elective major non-cardiac surgery. In the current study, non-diabetic patients undergoing elective major non-cardiac surgery under general anaesthesia were evaluated to determine the effects of various maintenance fluid regimens on intra-operative blood glucose levels.

For this randomised prospective trial, 90 non-diabetic patients (30 in each group) with ASA physical status I and II and either sex, between the ages of 18 and 50, were enrolled after receiving approval from the institutional ethical committee. Group R patients received Ringer's lactate solution (RL), group D patients received 5% dextrose in 0.9% NaCl solution (DNS) and group N patients received 0.9% NaCl solution (NS) as maintenance fluid. The rate of intravenous fluid infusion was calculated according to the body weight of the patients as per the *''4-2-1'' rule.*[18] Redistribution and evaporative surgical fluid loss compensation[19] were done according to the degree of tissue trauma (minimal: 0-2 ml/kg, moderate: 2-4 ml/kg, severe: 4-8 ml/kg). Blood loss from mops and suction drain bottles was replaced with crystalloids in a 1:3 ratio up to the transfusion threshold (10–20% of total blood volume, depending on the clinical situation). None of the patients in the three groups required additional colloid or blood to maintain hemodynamic stability. Capillary blood glucose (CBG) was measured just before the initiation of maintenance fluid (baseline), just after intubation and thereafter at an hourly interval till the end of the surgery. Premedication, induction and maintenance of anaesthesia were carried out as per the existing protocol for general anaesthesia for major surgery in our institute. Rescue doses of human soluble insulin were given in a calculated dose of CBG/100 IU, whenever CBG was found to be more than

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 08, 2023

or equal to 150 mg/dL intra-operatively. Changes in CBG from baseline, incidences of hyperglycaemia (CBG ≥150 mg/dL) and the total dose of rescue insulin to maintain normoglycaemia (CBG < 150 mg/dL) were noted.

Regarding the distribution of the patients' demographic parameters, such as age, sex, height, and weight, it was discovered that there was no statistically significant difference between the three groups. The ASA physical status distribution among the groups was comparable, with no statistically significant difference. The duration of surgery also had no statistically significant difference and was comparable among the three groups.

When the three groups were compared, there was statistically no significant difference between FBS, PPBS, and CBG-0 (baseline).

CBG-INT (just after intubation) was lower in comparison to CBG-0 (baseline) and the difference was statistically non-significant when compared between groups R and N, but CBG-INT was much higher than CBG-0 in the case of group D and the difference was statistically significant when compared with groups R as well as group N. 28 out of 30 patients in group R and all the patients in group N showed a fall in CBG just after intubation, whereas 2 patients in group R and all the patients in group D showed a rise in CBG just after intubation. Thus, a fall in CBG just after intubation was found in almost all patients receiving non-dextrose containing solutions as maintenance fluids, except for the 2 patients in group R. whereas all the patients receiving dextrose-containing solutions as maintenance fluids had a significant rise in CBG just after intubation.

The CBG in the 1st and 2nd hours was significantly higher in group D than in groups R and N but was comparable between groups R and N. However, there was no statistically significant difference in CBG in the 3rd intra-operative hour among the three groups.

The incidence of hyperglycaemic episodes (CBG ≥ 150 mg/dL) was highest in group D, i.e., 82%, whereas in group R it was 9% and in group N it was only 7%. In group R, 8 out of 30 patients (27%) and in group N, 6 out of 30 patients (20%) had at least one hyperglycaemic episode and required rescue insulin, whereas in group D, all 30 patients (100%) had at least one hyperglycaemic episode and required rescue insulin.

Mean insulin consumption was significantly higher in group D when compared with groups R and N, but no significant difference was present between groups R and N. In group D, there were 44 hyperglycaemic episodes (59% of total hyperglycaemic episodes) despite rescue insulin. No such incidents were found in groups R and N.

In this study, we tried to analyze the trend of change in intra-operative CBG from baseline. Our study found that CBG just after intubation was lower than baseline in patients receiving Ringer's lactate solution (RL) and 0.9% NaCl solution (NS) as maintenance fluid. However, in the case of patients receiving 5% dextrose in 0.9% NaCl solution (DNS), the CBG just after intubation was significantly higher than the baseline level. We tried to find out the cause of this trend in CBG change just after intubation. Our study found that benzodiazepines decrease the release of ACTH and hence cortisol production.[20] They also decrease sympathetic stimulation but paradoxically increase growth hormone secretion and bring down the glycaemic response to stress.[21] Similarly, the use of opioids in anaesthesia has also been found to decrease sympathetic stimulation and inhibit the hypothalamic-pituitary axis, probably through a direct effect on the hypothalamus and higher centers.[22] The abolition of the catabolic hormonal response to stress will therefore abolish the hyperglycaemia seen in normal patients.[23] In our study, we used midazolam (benzodiazepine) and butorphanol (opioid) as premedication. We hypothesize that, due to overnight fasting, the stress hormones were already in action and were maintaining the baseline CBG. When we gave premedication in the form of midazolam and butorphanol, they inhibited the stress hormones as described above, which may be the cause of the fall in the CBG just after intubation. Also, the timing of taking the sample for CBG-INT is such that the stress response due to fasting is decreased in

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 08, 2023

intensity by the premedicant drugs as described above but the major stress response i.e., surgical incision has not yet started. We also presume that the stress hormone inhibitory effect of midazolam and butorphanol was also present in patients receiving DNS as maintenance fluid, but such an effect was probably masked due to the external dextrose supplied through DNS and resulted in a higher CBG just after intubation. However, measurement of CBG before intubation and after giving premedication could have further clarified our hypothesis, but we could not do it as it was beyond our study design. Hence, we suggest that further study in this regard be carried out to conclude our hypothesis.

Our analysis regarding the trend of change in intra-operative CBG from baseline also shows that CBG level increases with progression of surgery, and the mean CBG in the 1st and 2nd intra-operative hours was significantly higher in patients who received 5% dextrose in 0.9% NaCl solution (DNS) as maintenance fluid in contrast to those who received Ringer's lactate (RL) or 0.9% NaCl solution (NS) as maintenance fluid. However, CBG in the 3rd intra-operative hour was comparable among the three groups of patients.

Our study also found that, exogenous insulin requirement to maintain normoglycaemia (CBG < 150 mg/dL) is significantly higher in patients receiving dextrose containing solutions (DNS) than in patients receiving non-dextrose containing solutions (RL, NS). The incidence of hyperglycaemic episodes was also much higher in patients who received dextrose containing solutions than in those who received non-dextrose containing solutions.

Our results were similar to the findings of Chin KJ et al.[24] Saringcarinkul A and Kotrawera K.[25] They also found an increased incidence of hyperglycaemia in those patients receiving dextrose containing fluid in the intra-operative period.

In accordance with our study, Chin KJ et al. found that initiating intravenous fluid replacement with dextrose-containing solutions is not necessary to prevent hypoglycaemia in elective surgery, since we did not find a single incidence of hypoglycaemia in patients receiving non-dextrose containing fluids though the CBG was lower just after intubation in comparison to baseline. On the contrary, a relatively small volume of 500 ml of dextrose containing solution causes significant, albeit transient, hyperglycaemia even in non-diabetic patients. Coupled with the metabolic response to surgical stress, intravenous dextrose infusion may in fact cause significant hyperglycaemia, as was found in our study.

In 2008, Rasoul Azarfarin and Azin Alizahed Asl came to the conclusion that there was a high prevalence of severe hyperglycaemia during CABG operations. In that study, the prevalence of severe hyperglycaemia (blood glucose > 180 mg/dL) was 54.6% higher than the prevalence of at least one episode of hyperglycaemia (blood glucose > 126 mg/dL). On the other hand, they did not mention their intraoperative fluid protocol. In our study, in non-cardiac major elective surgery, we found that 100% of patients who received dextrose containing fluids (DNS) had at least one episode of hyperglycaemia (capillary blood glucose ≥ 150 mg/dL), which was much lower in patients who received non-dextrose containing fluids, i.e., 27% in patients who received RL and 20% in those who received NS.

Patients receiving 5% dextrose during surgery showed a progressive rise in blood glucose levels, according to Saringcarinkul A. and Kotrawera K. In our study, we also found the same progressive pattern of increase in intra-operative blood glucose not only in patients receiving dextrose containing fluids but also in patients receiving non-dextrose containing fluids. They eliminated major surgical patients and defined hyperglycaemia as blood glucose levels greater than 180 mg/dL; however, no patient ever had blood glucose levels that were higher than 180 mg/dL at any time. On the contrary, in our analysis, we only included major surgical patients, and hyperglycaemia was taken into account whenever blood sugar levels were greater than or equivalent to 150 mg/dL.

According to Smith et al.'s research,[26] 73% of non-diabetic patients experience hyperglycaemia (blood glucose > 144 mg/dL) after a kidney transplant. 70% of non-diabetic

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 08, 2023

patients undergoing CABG surgery had blood glucose levels ≥ 200 mg/dL at least once during the peri-operative period, according to Prasad et al.[27] Our observations were also corroborated by these studies, even though we considered non-diabetic patients undergoing non-cardiac major surgery.

In our study, 27% of patients getting RL and 20% of patients receiving NS as maintenance fluids, compared to 100% of patients receiving 5% dextrose in 0.9% NaCl solution (DNS), experienced at least one episode of hyperglycaemia (CBG ≥150 mg/dL). We also found that the requirement for insulin to maintain normoglycaemia and the incidence of hyperglycaemia despite rescue insulin were much higher in patients receiving dextrose containing maintenance fluid (DNS) than in those patients who received non-dextrose containing solutions (RL, NS) as maintenance fluid.

The higher incidence of hyperglycaemia despite rescue insulin in patients receiving DNS as maintenance fluid was obvious due to the continuous supply of external dextrose in addition to the increasing stress effect with the duration of surgery and our inability to increase the rescue insulin dose beyond our study design. Further studies are required to assess the adequate dose of rescue insulin to maintain normoglycaemia according to the specific maintenance fluid used intra-operatively in addition to the hyperglycaemia due to the stress effect.

CONCLUSION

Our study concludes that non-diabetics frequently experience stress-induced hyperglycaemia in patients undergoing significant non-cardiac surgery. Intra-operative blood glucose levels remained higher than baseline, which was more significant in DNS than RL and NS. However, blood glucose falls from baseline just after intubation in patients receiving RL and NS, which is masked in patients receiving DNS as maintenance fluid. Incidences of intra-operative hyperglycaemia, total dose of rescue insulin requirement and hyperglycaemia despite rescue insulin are much higher in patients receiving DNS as maintenance fluid. Hence, so far as intra-operative hyperglycaemia due to stress is concerned, RL and NS are preferable maintenance fluids over DNS for elective major surgeries.

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