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■ Case Report

Fasting is not always good: perioperative fasting leads to pronounced ketone body production in patients treated with SGLT2 inhibitors: a case report

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ABSTRACT

Ketone bodies produced by sodium-glucose cotransporter 2 (SGLT2) inhibitors can be advantageous, providing an efficient and stable energy source for the brain and muscles. However, in patients with diabetes, ketogenesis induced by SGLT2 inhibitors may be harmful, potentially resulting in severe diabetic ketoacidosis (DKA). During fasting, ketone body production serves as an alternative and efficient energy source for the brain by utilizing stored fat, promoting mental clarity, and reducing dependence on glucose. The concurrent use of SGLT2 inhibitors during perioperative fasting may further elevate the risk of euglycemic DKA. We describe a case of DKA that occurred during perioperative fasting in a patient receiving empagliflozin, an SGLT2 inhibitor. This case underscores the importance of recognizing the potential risk of DKA in patients with diabetes using SGLT2 inhibitors during perioperative fasting.

Keywords: Sodium-Glucose Transporter 2 Inhibitors; Diabetic Ketoacidosis; Fasting; Preoperative Care; Case Reports

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Introduction

Sodium-glucose cotransporter 2 inhibitors and ketogenesis

Sodium-glucose cotransporter 2 (SGLT2) inhibitors are increasingly used for managing type 2 diabetes mellitus due to their glucose-lowering effects and cardiovascular and renal benefits. These inhibitors reduce blood glucose levels by decreasing glucose reabsorption in the S1 segment of the proximal kidney tubules through an insulin-independent mechanism. However, studies indicate that SGLT2 inhibitors may also induce ketogenesis, leading to elevated ketone body production. This occurs due to increased glucagon release from alpha cells and enhanced beta-oxidation of fatty acids (FFAs), resulting in higher plasma ketone body concentrations [1,2]. Ketone bodies, such as β-hydroxybutyrate and acetoacetate, function as alternative metabolic fuel sources, playing a crucial role in energy homeostasis. In the postprandial state, glucose serves as the primary energy source, and intestinal glucose absorption stimulates insulin secretion while suppressing FFA production and fat oxidation. Conversely, during fasting, glucose levels decline, insulin secretion decreases, and lipolysis increases, releasing FFAs from adipose tissue and promoting fat oxidation. This physiological "starvation response" enables the liver, muscles, heart, and other organs to utilize FFAs as their main energy source, conserving glucose for glucose-dependent tissues, including the brain, erythrocytes, and renal medulla.

Benefits of ketogenesis with SGLT2 inhibitors

Ketogenesis induced by SGLT2 inhibitors offers several benefits. First, ketone bodies serve as an alternative energy source for various tissues, including the brain, which is particularly beneficial for individuals with diabetes struggling to control blood sugar levels. Second, it enhances fat metabolism, contributing to weight loss. Third, increased ketone body production improves insulin sensitivity, aiding in long-term blood sugar regulation. Finally, ketone bodies suppress appetite, potentially reducing overeating and supporting weight management.

Side effects of ketogenesis caused by SGLT2 inhibitors

Ketogenesis caused by SGLT2 inhibitors can also lead to several side effects. First, there is an elevated risk of diabetic ketoacidosis (DKA), including "euglycemic ketoacidosis," where abnormal ketogenesis occurs even with normal or slightly elevated blood glucose levels. Second, the excretion of excess glucose through urine can cause dehydration and place strain on the kidneys, which may be particularly concerning for individuals with chronic kidney disease. Third, increased glucose levels in urine heighten the risk of urinary tract and genital infections. Finally, combining a ketogenic diet with SGLT2 inhibitors may lead to nutritional deficiencies due to restricted carbohydrate intake.

Fasting and ketogenesis

The complex regulatory processes governing nutrient and energy metabolism during fasting enable organisms to endure extended periods of food deprivation. During fasting, fuel utilization shifts from a combination of carbohydrates and fat to primarily fat. The liver engages in metabolic processes such as gluconeogenesis and ketogenesis, which enhance the production of glucose and ketone bodies, respectively. In the fasting state, ketone bodies serve as a significant fuel source for the brain, heart, and skeletal muscles.

The beneficial effects of increased ketone bodies include: (1) energy efficiency and (2) weight loss. Reduced carbohydrate intake during fasting decreases body glucose storage. Ketone bodies produced in the liver provide an alternative energy source for many tissues, particularly the brain, resulting in more efficient energy use and improved cognitive function. Also, fasting reduces total calorie intake, while ketone body production promotes fat breakdown, potentially contributing to weight loss and reduced body fat [3].

What is the effect of combining SGLT2 inhibitors and fasting?

SGLT2 inhibitors may enhance ketogenesis. Perioperative fasting also stimulates ketone body production. When SGLT2 inhibitors are used in conjunction with fasting, the increase in ketone body production becomes more pronounced. SGLT2 inhibitors reduce glucose reabsorption in the kidneys, leading to increased urinary glucose excretion and decreased blood glucose levels. During fasting, blood glucose levels decrease due to reduced intake. To compensate, the body breaks down FFAs in the liver to produce ketone bodies for energy. The combined effects of SGLT2 inhibition and fasting accelerate the shift from glucose to fat as the primary energy source, thereby increasing ketogenesis and elevating ketone body levels in the bloodstream. As a result, the use of SGLT2 inhibitors during perioperative fasting may heighten the risk of DKA.

Ketogenesis has both beneficial and harmful effects. Ketone bodies can lead to ketosis or ketoacidosis when accumulated excessively, posing significant risks to individuals with diabetes. However, emerging evidence suggests that mild elevation of ketones may provide benefits, such as organ protection and potential extension of healthy lifespan through fasting or calorie restriction-induced ketosis [4].

The severity of DKA as a potentially life-threatening complication cannot be overstated. Since the approval of canagliflozin in 2013, the first case of SGLT2 inhibitor-related DKA was reported in 2015, and numerous subsequent reports have documented similar cases [5]. Ketogenesis, the process by which FFAs are converted into ketone bodies in the liver, typically occurs during periods of carbohydrate scarcity, such as during fasting or with low carbohydrate intake.

We report a case of DKA that occurred during perioperative fasting in a patient receiving empagliflozin, an SGLT2 inhibitor. This case underscores the importance of increased awareness regarding the risk of SGLT2 inhibitor-associated "euglycemic" DKA during perioperative fasting.

Case Report

A 65-year-old male patient was admitted for total laparoscopic distal

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gastrectomy following a diagnosis of stomach cancer (adenocarcinoma) located at the greater curvature of the gastric body and the posterior wall of the antrum during a routine medical check-up. The patient was 167 cm tall, weighed 60 kg, and had undergone cholecystectomy 10 years prior. He had a history of diabetes and was prescribed Jardiance Duo (empagliflozin/metformin 12.5/1,000 mg) once daily, gliclazide 60 mg once in the morning and 30 mg once in the evening, and rosuvastatin 5 mg once daily at a local internal medicine clinic. Although the exact timing of the discontinuation of the SGLT2 inhibitor empagliflozin before surgery was not confirmed, it is believed that the patient took the medication the morning prior to admission for surgery. No substitute medication for the SGLT2 inhibitor empagliflozin was administered at this hospital on the day before surgery, the day of surgery, or postoperatively.

In the pre-anesthesia evaluation, vital signs, electrocardiogram (ECG), chest radiography, pulmonary function tests, and chest computed tomography were normal. His diabetes mellitus was poorly controlled, with a serum glucose level of 252 mg/dL, a hemoglobin A1c level of 7.8%, and a urine glucose level of 3+. Renal function was normal, with serum creatinine at 0.95 mg/dL and a calculated creatinine clearance of 79.7 mL/min. After fasting from midnight, his capillary blood glucose level was 112 mg/dL immediately before surgery, and he was transferred to the operating room.

Non-invasive monitors for blood pressure (BP), ECG leads, pulse oximetry, and SedLine (Masimo) were attached. The preliminary vital signs were as follows: BP 162/89 mm Hg; heart rate, 83 beats per minute (bpm); oxygen saturation 98%; and ECG, normal. Preoxygenation with 100% oxygen through a facemask was performed, and 90 mg of propofol was administered intravenously. After confirming the patient's loss of consciousness and a decreased SedLine patient state index, 50 mg of rocuronium was administered intravenously, and intubation was performed. Balanced anesthesia with sevoflurane and remifentanil was administered. An arterial line was inserted into the right radial artery, and an intravenous line with a 16G catheter was inserted into the right external jugular vein. During surgery, the depth of anesthesia, cardiac output, cardiac index, stroke volume variation, and pulse pressure variation were monitored. Two routine arterial blood gas tests were performed at 2-hour intervals, showing no abnormalities. During the 4-hour and 25-minute anesthesia period, fluid intake was 1,650 mL of plasma solution, and urine output was 430 mL. Vital signs remained stable throughout the operation, and vasopressors or inotropes were not required. Immediately before the end of anesthesia, 50 mcg of fentanyl, 0.3 mg of ramosetron, and 200 mg of sugammadex were administered intravenously. In the post-anesthesia care unit, 0.5 mg of nicardipine was administered intravenously twice because of a high systolic BP of 188 mm Hg. Within 30 minutes of recovery, the patient had stable vital signs and was transferred to a general ward.

Two hours postoperatively, acute uncompensated metabolic acidosis was observed with the following values: pH 7.348, partial pressure of carbon dioxide in arterial blood ($PaCO_2$) 36.1 mm Hg, and bicarbonate (HCO_3^-) 19.4 mmol/L (Table 1). Blood tests revealed no electrolyte abnormalities or decreased renal function, aside from elevated aspartate aminotransferase (AST)/alanine aminotransferase (ALT) levels (613/339 U/L). Four hours postoperatively, the patient exhibited tachycardia, with a heart rate exceeding 100 bpm and a high systolic BP of 175–180 mm Hg. Nicardipine was administered intravenously 3 times, 1 mg each. Capillary blood glucose levels were 143 mg/dL and 206 mg/dL at 1 hour and 6 hours after surgery, respectively. No additional medications were administered for glucose control.

On postoperative day (POD) 1, the patient was alert, but oxygen saturation deteriorated, necessitating oxygen administration via a mask with a reservoir bag. Intravenous (IV) insulin lispro was administered twice (4 IU each time) due to uncontrolled capillary blood glucose levels consistently exceeding 200 mg/dL. Tachycardia persisted, and 1 mg of nicardipine was administered due to elevated BP. A morning blood test revealed partially compensated metabolic acidosis with the following results: pH 7.203, $PaCO_2$ 26.5 mm Hg, HCO_3^- 10.2 mmol/L, serum glucose 210 mg/dL, and anion gap (AG) 33.0 mmol/L (normal range, 10–20 mmol/L). The CO_2 level (normal range, 21–32 mmol/L) had decreased to <10. This decrease in CO_2 is a compensatory mechanism in response to metabolic acidosis, involving increased breathing.

To correct metabolic acidosis, a mixture of 80 mL of 8.4% sodium bicarbonate in 1,000 mL of plasma solution was continuously infused at a rate of 80 mL/h. Due to insufficient control of acidosis, a bolus of 40

Table 1. Changes in laboratory test results over time

Variable	Preop	Intraop		Postop	POD #1				POD #2			POD #3			POD #4
		12:45[a]	14:38	18:14	8:23	11:20	14:20	18:06	6:26	16:23	22:00	10:44	14:28	20:25	6:04
pH		7.47	7.41	7.348	7.203	7.202	7.264	7.329	7.288	7.274	7.321	7.262			
$PaCO_2$ (mm Hg)		34	39	36.1	26.5	27.8	30.4	30.6	31	28	28.7	27.5			
HCO_3- (mmol/L)		24.7	24.7	19.4	10.2	10.7	13.5	15.7	14.5	12.7	14.5	12.1			
AG (mmol/L)		5.3	6.3	20.6	33				28.6			31.4	27.4	19.2	17.7
Glucose (mg/dl)	252	112	104	142	210				138			186	174	107	92
CO_2 (mmol/L)					<10.0							<10.0	12.1	21.5	24.7
UA ketone											3+			3+	
UA glucose	3+										3+			3+	

Preop, preoperative; Intraop, intraoperative; Postop, postoperative; POD, postoperative day; $PaCO_2$, partial pressure of carbon dioxide in arterial blood (normal range, 32–45 mmol/L); HCO_3-, bicarbonate (normal range, 21–28 mmol/L); AG, anion gap (normal range, 10–20 mmol/L); CO_2, blood carbon dioxide (normal range, 21–32 mmol/L); UA, urinalysis.
[a]Time (h:min).

mL of 8.4% sodium bicarbonate was administered intravenously, and additional bicarbonate fluid was administered by mixing 140 mL of 8.4% sodium bicarbonate in 1,000 mL of 5% dextrose at a rate of 40 mL/h, while the rate of the existing bicarbonate fluid infusion was reduced to 40 mL/h. Follow-up tests showed: pH 7.329, $PaCO_2$ 30.6 mm Hg, and HCO_3^- 15.7 mmol/L.

On POD 2, tachycardia persisted, and the capillary blood glucose level was 209 mg/dL. An additional 4 IU of IV insulin lispro was administered to manage glucose levels. Hypertension persisted; accordingly, 0.2 mg/mL nicardipine was infused at a rate of 5 mL/h, targeting a systolic BP of <160 mm Hg. Laboratory test results still indicated metabolic acidosis: pH 7.288, $PaCO_2$ 31.0 mm Hg, HCO_3^- 14.5 mmol/L, serum glucose 138 mg/dL, AG 28.6 mmol/L, urine glucose 3+, and urine ketone 3+. To address metabolic acidosis, the same bicarbonate fluid treatment as the previous day was administered, along with an additional bolus of 40 mL of 8.4% sodium bicarbonate.

On POD 3, metabolic acidosis had not improved compared to POD 2, with the following values: pH 7.262, $PaCO_2$ 27.5 mm Hg, HCO_3^- 12.1 mmol/L, serum glucose 186 mg/dL, and AG 31.4 mmol/L. The patient was transferred to the Department of Integrative Medicine for the treatment of euglycemic DKA. A mixture of 100 IU of insulin lispro in 100 mL of normal saline was infused at a rate of 2 mL/h, and the existing bicarbonate fluid was discontinued. Plasma solution infusion was maintained at 40 mL/h. A peripherally inserted central catheter was placed through the right basilic vein for electrolyte correction, and the patient was transferred to the surgical intensive care unit (ICU). Tachycardia subsided, but a heart rate greater than 20 bpm persisted. After insulin administration, the capillary blood glucose dropped to 94 mg/dL, leading to a reduction in the insulin infusion rate and the administration of 30 mL of 50% dextrose. Follow-up at 3 hours revealed a blood glucose level of 109 mg/dL. Serum glucose, $PaCO_2$, and AG levels normalized. Potassium levels showed a decreasing trend; therefore, 20 mEq of potassium in 100 mL of normal saline was administered. After consuming Nucare No-NPO (200 mL/100 kcal, a carbohydrate supplement drink) and Nucare roasted rice (200 mL/200 kcal, a nutritional drink meal) on POD 3, CO_2 levels returned to normal, and the AG decreased to normal levels by 20:25 on POD 3.

On POD 4, vital signs were stable with tachypnea, and serum glucose levels were well-controlled with an insulin infusion rate of 1 mL/h. No significant electrolyte imbalances were detected, and serum glucose, CO_2, and AG levels normalized. The patient was transferred to the general ward and surgery department.

On POD 6, AST/ALT levels normalized to 14/36 U/L. The patient was discharged from the hospital on POD 8 after improvement in general condition. Table 1 summarizes the changes in laboratory tests over time.

The patient provided written informed consent for the publication of the research details and clinical images.

Discussion

Historically, preoperative fasting involved abstaining from oral intake starting at midnight before surgery or any procedure requiring general anesthesia. Postoperatively, the practice typically required complete avoidance of oral nutrition until postoperative ileus resolved or bowel function recovered, often resulting in several days of fasting. However, numerous studies over the past few decades have consistently refuted the need for prolonged perioperative fasting [6].

Benefits of perioperative fasting

Preoperative nocturnal fasting originated when anesthetic techniques were still developing and chloroform was the most commonly used anesthetic. The rationale for this practice was to prevent respiratory complications arising from vomiting and aspiration of gastric contents. These recommendations were based on the symptoms described in Mendelson's syndrome, named after the American obstetrician who, in 1946, reviewed cases of death in pregnant women due to aspiration of solid gastric contents during surgery under general anesthesia [7]. Since then, perioperative fasting has been recommended for various reasons, each contributing to patient safety and recovery. The key benefits of perioperative fasting are as follows:

Reduction in pulmonary aspiration risk

The primary benefit of preoperative fasting is the significant reduction in the risk of pulmonary aspiration. Aspiration of gastric contents during anesthesia can lead to severe complications, including pneumonia and acute respiratory distress syndrome. Studies and guidelines from the American Society of Anesthesiologists emphasize that fasting from both solids and liquids is essential for minimizing this risk, particularly in patients with certain risk factors, such as obesity, diabetes, and gastroesophageal reflux disease [8].

Consistency in gastric volume and pH levels

A complete NPO (NO) regimen maintains more consistent and safer levels of gastric volume and pH. Meta-analyses have indicated that patients who adhere to a strict NPO regimen tend to have lower gastric volumes and higher pH levels, which reduces the risk of aspiration and its associated complications during surgery [8].

Avoidance of unpredictable complications

Some observational studies suggest that even small amounts of liquid intake before surgery may unpredictably increase gastric content, potentially compromising patient safety during anesthesia. Therefore, a complete NPO approach is crucial to ensure that no variable factors compromise perioperative patient safety [9].

Postoperative outcomes

Complete NPO was associated with more predictable and controlled postoperative outcomes compared to flexible fasting protocols. A study of oncologic patients undergoing elective surgery indicated that strict postoperative fasting protocols were associated with lower complication rates, such as infections, although ICU stay duration varied depending on other factors [10].

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Disadvantages of perioperative fasting

While perioperative fasting was traditionally implemented to reduce the risk of pulmonary aspiration during anesthesia, several disadvantages can affect patient outcomes and comfort. Some key issues associated with prolonged fasting before surgery include:

Increased patient discomfort

Prolonged fasting is associated with a range of adverse effects, including increased thirst, hunger, anxiety, and general malaise. These effects can negatively impact the overall patient experience and may increase preoperative anxiety levels [11].

Catabolic

Extended fasting, combined with the trauma imposed by surgery, can lead to elevated state and insulin resistance levels of catabolic hormones, such as cortisol and glucagon, along with an inflammatory response and catecholamine secretion. This hormonal increase results in insulin resistance, similar to that observed in type 2 diabetes, where glucose uptake by cells is diminished due to impaired glucose transporter type 4 (GLUT-4) function. The main consequence is a catabolic state characterized by high glycogen consumption and reduced glycogen synthesis, proteolysis, and lipolysis [12,13]. These metabolic changes can negatively impact postoperative recovery, increasing the risk of complications and impairing wound healing.

Delayed gastric emptying and increased aspiration risk

Prolonged fasting may occasionally result in delayed gastric emptying, particularly in patients experiencing stress or anxiety. This paradoxical effect can increase the risk of aspiration, contrary to the primary goal of fasting protocols [14].

Impact on postoperative recovery

Long fasting periods have been shown to negatively impact postoperative recovery. Allowing patients to drink clear fluids closer to the time of surgery has been shown to improve hydration, reduce postoperative nausea and vomiting, accelerate gastrointestinal function recovery, and shorten hospital stays. Research indicates that shorter fasting times for clear fluids do not compromise safety or improve overall recovery outcomes [15].

Dehydration and hemodynamic instability

Prolonged fasting, particularly from clear fluids, can lead to dehydration and electrolyte imbalances, which may cause hemodynamic instability during surgery. Maintaining adequate hydration by allowing clear fluids until a few hours before surgery helps ensure hemodynamic stability and reduces dehydration-related complications.

In diabetic patients taking SGLT2 inhibitors and fasting after surgery, ketone body production may increase the risk of DKA

Fasting after surgery poses a significant risk for patients with diabetes, particularly those taking SGLT2 inhibitors. These drugs, commonly prescribed for type 2 diabetes to lower blood glucose levels by facilitating renal glucose excretion, can inadvertently enhance ketone body production. This process is particularly concerning during fasting periods, such as after surgery, when the body's usual energy sources are depleted. Under normal conditions, when glucose is insufficient for energy due to fasting, the body begins to break down fat stores, leading to ketone body production. Although ketones can serve as alternative fuel sources, their excessive accumulation, especially with SGLT2 inhibitor use, can be harmful. These inhibitors further lower insulin levels and glucose availability, promoting fat breakdown and, consequently, ketone production. In the context of SGLT2 inhibitors and surgery-related fasting, the risk of DKA is increased. Fasting reduces carbohydrate intake, which lowers insulin requirements and glucose levels. For patients on SGLT2 inhibitors, this reduced glucose availability, combined with the drug's mechanism, causes the body to rely more on fat for energy, leading to excessive ketone body production. Without adequate insulin to regulate this process, high ketone levels can acidify the blood and trigger DKA. A population-based study indicated that surgery is a significant precipitating factor of DKA in patients taking SGLT2 inhibitors. The mechanism by which these inhibitors promote glucose excretion through the urine can heighten reliance on fat metabolism, increasing ketone body production, particularly during fasting or reduced carbohydrate intake post-surgery.

Preventing DKA during perioperative fasting in diabetic patients taking SGLT2 inhibitors

Preventing DKA during perioperative fasting in diabetic patients taking SGLT2 inhibitors is as follows: First, considering the nature of the surgery and the patient's health status, the medical team may recommend temporarily discontinuing SGLT2 inhibitors or switching to an alternative blood glucose-lowering medication. Second, blood glucose and ketone body levels should be monitored frequently before and after surgery to detect early changes. Managing blood glucose levels and monitoring ketone body levels are crucial, particularly if fasting is required after surgery. Third, dehydration can elevate ketone body levels and increase the risk of DKA. It is essential to keep patients well-hydrated and maintain electrolyte balance post-surgery. Fourth, resuming safe nutrition as soon as possible, as directed by healthcare providers, is important. Providing a stable diet shortly after surgery helps stabilize blood glucose levels and suppress ketone body production. Finally, patients and their caregivers should be informed about the side effects of SGLT2 inhibitors and the signs of DKA. They should notify medical staff immediately if any symptoms occur, as early diagnosis and treatment are critical.

Factors explaining the normalization of CO_2, AG, and blood glucose levels on POD 3 are as follows: First, taking oral nutritional supplements on POD 3 likely improved the patient's condition by alleviating fasting-related side effects and providing nutrients to a depleted body. Second, on POD 3, normalization of CO_2, AG, and blood glucose levels may also be due to the reduced effects of the SGLT2 inhibitor. If the pa-

tient had been using the SGLT2 inhibitor until the day before surgery, POD 3 would have been the fourth day after discontinuation of the medication, allowing its effects to subside. This aligns with literature recommending discontinuation of SGLT2 inhibitors at least 3 days before major surgery to prevent euglycemic DKA. Finally, the combined effects of taking Nucare No-NPO and Nucare Roasted Rice on the third day after surgery, along with discontinuation of the SGLT2 inhibitor for 4 days, may have had a synergistic impact on the patient's recovery.

In summary, although ketone bodies can serve as an alternative energy source during fasting, their excessive production, triggered by SGLT2 inhibitors during surgical fasting, can lead to dangerous acidosis and the onset of DKA. Between 2013 and 2015, the Food and Drug Administration (FDA) identified 73 cases of ketoacidosis in patients with type 1 and type 2 diabetes who used SGLT2 inhibitors. Following this review, the FDA approved modifications to the prescribing information for these medications. Health care professionals should consider discontinuing canagliflozin, dapagliflozin, and empagliflozin at least 3 days prior to surgery, and ertugliflozin at least 4 days before, to reduce the risk of ketoacidosis post-surgery.

Managing this risk requires meticulous planning, continuous monitoring, and adjustment of diabetes medications during the perioperative period. If surgery is planned for a patient with diabetes on an SGLT2 inhibitor, the surgeon and anesthesiologist should be informed and collaborate on the postoperative care plan.

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References

1. Hou YC, Zheng CM, Yen TH, Lu KC. Molecular mechanisms of SGLT2 inhibitor on cardiorenal protection. Int J Mol Sci 2020;21:7833.
2. Zhu X, Lin C, Li L, Hu S, Cai X, Ji L. SGLT2i increased the plasma fasting glucagon level in patients with diabetes: a meta-analysis. Eur J Pharmacol 2021;903:174145.
3. de Cabo R, Mattson MP. Effects of intermittent fasting on health, aging, and disease. N Engl J Med 2019;381:2541-51.
4. Arima Y. The impact of ketone body metabolism on mitochondrial function and cardiovascular diseases. J Atheroscler Thromb 2023;30:1751-8.
5. Chow E, Clement S, Garg R. Euglycemic diabetic ketoacidosis in the era of SGLT-2 inhibitors. BMJ Open Diabetes Res Care 2023;11:e003666.
6. Lambert E, Carey S. Practice guideline recommendations on perioperative fasting: a systematic review. JPEN J Parenter Enteral Nutr 2016;40:1158-65.
7. Campos SB, Barros-Neto JA, Guedes GD, Moura FA. Pre-operative fasting: why abbreviate? Arq Bras Cir Dig 2018;31:e1377.
8. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures: an updated report by the American Society of Anesthesiologists Task Force on preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration. Anesthesiology 2017;126:376-93.
9. American Society of Anesthesiologists Committee. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures: an updated report by the American Society of Anesthesiologists Committee on Standards and Practice Parameters. Anesthesiology 2011;114:495-511.
10. Fachini C, Alan CZ, Viana LV. Postoperative fasting is associated with longer ICU stay in oncologic patients undergoing elective surgery. Perioper Med (Lond) 2022;11:29.
11. Chon T, Ma A, Mun-Price C. Perioperative fasting and the patient experience. Cureus 2017;9:e1272.
12. Dock-Nascimento DB, de Aguilar-Nascimento JE, Magalhaes Faria MS, Caporossi C, Slhessarenko N, Waitzberg DL. Evaluation of the effects of a preoperative 2-hour fast with maltodextrine and glutamine on insulin resistance, acute-phase response, nitrogen balance, and serum glutathione after laparoscopic cholecystectomy: a controlled randomized trial. JPEN J Parenter Enteral Nutr 2012;36:43-52.
13. Ljungqvist O, Nygren J, Thorell A. Modulation of post-operative insulin resistance by pre-operative carbohydrate loading. Proc Nutr Soc 2002;61:329-36.
14. Ljungqvist O, Soreide E. Preoperative fasting. Br J Surg 2003;90:400-6.
15. Witt L, Lehmann B, Sumpelmann R, Dennhardt N, Beck CE. Quality-improvement project to reduce actual fasting times for fluids and solids before induction of anaesthesia. BMC Anesthesiol 2021;21:254.