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CORRESPONDENCE

Lactate-buffered solutions in patients with citrin deficiency

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To the Editor,

Citrin deficiency is an autosomal recessive disorder caused by mutations in the *SLC25A13* gene and was first reported in Asia.[1] Citrin deficiency has two different phenotypes: neonatal intrahepatic cholestasis (NICCD) and adult-onset citrullinemia type 2 (CTLN2). In most patients with NICCD, symptoms resolve within the first year of life, and 10% of these patients then progress to CTLN2 within decades.[2] During the transition period, in addition to show a preference for low-carbohydrate foods to compensate for citrin deficiency, these patients can be clinically asymptomatic.[3] We report here the perioperative management of a patient with citrin deficiency during this compensation period.

A 14-yr-old adolescent girl (height, 160 cm; weight, 50 kg) was scheduled for partial hepatectomy for a tumor in liver segment VIII (hepatocellular carcinoma, 3 cm × 2.5 cm). She was diagnosed with NICCD by gene sequencing at birth and since then, her symptoms had naturally dissipated. She usually maintained a low-carbohydrate, high-fat, and high-protein diet. Her preoperative laboratory data were as follows: hemoglobin 96 $g \cdot L^{-1}$, total protein 59.6 $g \cdot L^{-1}$, plasma-free fatty acid 0.87 $mmol \cdot L^{-1}$, urine ketone body (+), plasma alpha-fetoprotein 703 $\mu g \cdot L^{-1}$, plasma lactate dehydrogenase level 110 $U \cdot L^{-1}$, fasting blood glucose level 4.3 $mmol \cdot L^{-1}$, plasma-glycated albumin level 10.6%, and serum ammonia 22 $\mu mol \cdot L^{-1}$.

A FreeStyle Libre Flash glucose monitoring sensor (Abbott Diabetes Care, Alameda, CA, USA) was placed one day before surgery for perioperative glucose monitoring. After fasting for eight hours, the patient entered the operating room and Ringer's lactate solution was used for liquid supplementation. Details of the anesthetic management is reported in the Electronic Supplementary Material (eAppendix) file. One hour after induction, arterial blood gas analysis showed that the lacate level had increased to 4.3 $mmol \cdot L^{-1}$ (Table). Because there was no intraoperative hypotension, we speculated that the infusion of Ringer's lactate solution had caused hyperlactatemia. Therefore, we immediately stopped this infusion and changed to 0.9% normal saline. The surgery proceeded for two hours and blood loss was 220 mL. A total of 600 mL of sodium Ringer's lactate solution and 500 mL of 0.9% normal saline were infused during the operation.

After being transferred to the postanesthesia care unit, the infusion fluids were changed to dextrose 5% half normal saline and 20% (w/w) lipid emulsions (Lipofundin® MCT/LCT, B. Braun Melsungen AG, Melsungen, Germany) to provide energy. Six hours after stopping Ringer's lactate solution infusion, the blood lactate level returned to 1.9 $mmol \cdot L^{-1}$. In the following

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Table Intraoperative and postoperative arterial blood gas analysis results in an asymptomatic patient with citrin deficiency

Parameter	After introduction	Immediately after LRS infusion	1 hr after stopping LRS infusion	6 hr after stopping LRS infusion
pH	7.33	7.29	7.32	7.31
$PaCO_2$ (mm Hg)	42	41	42	48
PaO_2 (mm Hg)	482 (F_IO_2 = 1.0)	534 (F_IO_2 = 1.0)	232 (F_IO_2 = 0.5)	177 (F_IO_2 = 0.3)
Na^+ (mm Hg)	137	136	137	135
K^+ (mmol·L^{-1})	3.8	3.7	3.9	4.2
Ca^{2+} (mmol·L^{-1})	1.23	1.23	1.26	1.24
Glucose (mmol·L^{-1})	6.3	6.8	5.2	6.0
Lactate (mmol·L^{-1})	1.7	4.3	3.4	1.9
Hematocrit (%)	32%	29%	30%	32%
HCO_3^- (mmol·L^{-1})	22.1	19.7	21.6	23.1
BE (mmol·L^{-1})	−3.8	−6.9	−4.5	−3.5

BE = base excess; F_IO_2 = fraction of inspired oxygen; LRS = lactated Ringer's solution; $PaCO_2$ = arterial partial pressure of carbon dioxide; PaO_2 = arterial partial pressure of oxygen

liquid therapy, we avoided using lactate-buffered solutions, and serum lactate levels remained within the normal range.

Citrin is an aspartate/glutamate transporter that is mainly expressed in hepatic mitochondria. It can interfere with the urea cycle, glycolysis, and gluconegenesis.[1] During the quiescent phase in patients with citrin deficiency, a low-carbohydrate diet helps prevent the onset of CTLN2, while a high-carbohydrate burden often leads to hyperammonemia.[4] Previous reports on perioperative management of these patients have mainly focused on monitoring intraoperative blood glucose and ammonia levels, but little attention has been paid to serum lactate levels.[5] Theoretically, lactic acidosis can occur in patients with rare inherited lactate metabolism disorders in the context of normal tissue perfusion. In hepatocytes, lactate is converted to pyruvate by lactate dehydrogenase and enters the tricarboxylic acid cycle.[1] Because the tricarboxylic acid cycle is disturbed, lactate metabolism is often impaired in patients with citrin deficiency.[1] The low plasma lactate dehydrogenase level in our case may have further exacerbated this imbalance. Hence, we suggest that in patients with citrin deficiency, perioperative serum lactate levels should be monitored, and the use of lactate-buffered solutions should be avoided, especially during liver surgery.

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