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Multiorgan Failure in a Malnourished Infant

Inappropriate Use of Goat Milk, Dilution, or Both?

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Abstract: Goat milk is gaining popularity in the United States as an alternative to cow and soy milk. The milk is presented as a healthier and less allergenic alternative, with casein and more MCT oil. The interest in goat milk has increased significantly with the recent formula shortage. Goat milk is available in many forms in the United States, including liquid and powdered formulations. However, there are no approved infant formulas in the United States that are goat milk-based. This case describes an infant who became critically ill due to family confusion over goat milk feeds, highlighting the importance of understanding the nutritional components and safety of various goat milk formulations.

Key Words: Africa, goat milk formula, infant formula, powdered, safety

INTRODUCTION

Liquid and powdered goat milk-based formulations are now available both from farms and grocery stores. Goat milk-based formulas have been shown to adequately substitute for cow-milk-based formulas in toddlers and adults (1). However, these are not suitable for infants, as infants have unique nutritional needs, and goat milk is known to be naturally deficient in folate and other micronutrients, with higher levels of protein and specific electrolytes (2). In Europe, goat milk-based infant formulas are fortified and adjusted to provide appropriate nutrition and have been approved by regulatory bodies (3). However, there are no goat milk-based infant formulas approved in the United States. This case describes an infant with severe malnutrition and multiorgan failure from the use of a powdered goat milk-based formula designed for toddlers that was also inappropriately diluted due to parental confusion.

CASE DESCRIPTION

A full-term male was born via spontaneous vaginal delivery to an 18-year-old G1P1 female with limited prenatal care. His birth weight was 2.615 kg, there were no complications, and he was discharged on day 2 of life. His pediatrician first saw him at 3 months of age. At the time, he was feeding well on Gerber Gentlease, 4–5 oz every 4–5 hours, but weighed 3.18 kg (z-score −5.4), with a length of 55.9 cm (z-score −2.6), and a weight-for-length z-score of −5.2. No concerns were noted at the visit. At 4 months of age, the parents had concerns about poor weight gain, so they added a multivitamin and switched him to powdered Meyenberg goat milk, as the grandfather knew that goat milk was given to infants in his native Africa. The patient tolerated this well taking in 32–40 oz per day. At 5 months of age, he was seen for a scheduled follow-up and was noted to be very irritable with severe malnutrition, weighing 3.47 kg (z-score −6.4), with a length of 57.2 cm (z-score −3.9), and a weight-for-length z-score of −5.1. He was referred directly to the emergency department.

In the emergency department, the patient had altered mentation and agonal breathing. Vital signs were significant for a temperature of 29.7°C and a blood pressure of 85/39 mm Hg. Laboratory results showed a glucose of 10 mg/dL, sodium 112 mEq/L, and hemoglobin of 11.2 g/dL. He was intubated, given intravenous fluids, atropine, sodium, and broad-spectrum antibiotics, and transferred to the intensive care unit. Further laboratory work-up showed his hemoglobin drop to 7.8 g/dL, pancytopenia with platelets of 42 10^3/uL, international normalized ratio 2.8, albumin 2.2 g/dL, aspartate transaminase/alanine aminotransferase of 106/50 U/L, and ammonia 95 ug/dL. The ammonia was drawn correctly. Blood, urine, and cerebrospinal fluid cultures were negative. He required vasopressors, respiratory support, and blood products. He was empirically started on folate, and a multivitamin, and gastroenterology was consulted regarding nutritional deficiencies and abnormal liver tests.

Upon detailed review, the parents acknowledged they mixed the Gentlease formula with 1.5 scoops/8 oz of water (vs the recommended 4 scoops/8oz) as the patient seemed to tolerate it better, with fewer episodes of emesis. Upon switching to goat milk, they also inadvertently diluted it, mixing the powdered goat milk at 0.5 scoops/8oz of water (vs the recommended 2 scoops/8oz ratio) to improve tolerance further.

The patient was noted to have deficiencies in carnitine and vitamin C, with a suspected vitamin K deficiency. Vitamin C and carnitine supplementation were given. The INR partially corrected to 1.7 after 3 doses of intravenous vitamin K, and there were no further concerns for liver failure thereafter as the international normalized ratio eventually normalized. Genetics was consulted due to low levels of amino acids and carnitine, which ultimately were thought to be due to nutritional deficiencies. When transitioned to enteral feeds with a small amount of Gentlease, the patient developed medical necrotizing enterocolitis with abdominal distension and a confirmatory abdominal x-ray, treated with antibiotics and gut rest for 7 days. The patient also had hypoglycemia and required a high glucose infusion rate for a short period of time. Gradually, feeds were reintroduced, and the patient ultimately tolerated Alimentumm 27 kcal/oz ad lib by bottle without further issues. A social worker saw the patient and did not have concerns for neglect, as the parents sought care for poor weight gain and made formula adjustments due to intolerance. The patient was seen in the gastroenterology clinic 1 month after discharge with an improving weight of 5.92 kg (z-score −2.95). Four months after discharge from

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the gastroenterology clinic, his z-scores for weight, height, and head circumference were all at approximately the 10th percentile.

DISCUSSION

Two important components led to this patient's presentation: extreme formula dilution causing severe malnutrition and related sequelae, along with the inappropriate use of goat milk-based formula designed for toddlers. Per the Center for Disease Control and Prevention guidelines, infant formulas must be regulated by the Food and Drug Administration to ensure appropriate nutritional requirements. This includes ensuring appropriate protein, carbohydrate, and micronutrient contents to adequately simulate breast milk. There are no approved goat milk-based infant formulas in the United States as in other countries. Nonetheless, goat milk continues to gain popularity as an alternative to cow and soy-based formulas in the United States and is readily available on the shelves for toddlers and older children in a powder formulation. Historically, its packaging looked similar to regular infant formulas which confused the parents in this case. Since then, some packaging now specifically states that these toddler formulas are not suitable for infants. Goat milk-based formula is available in European countries and on websites that provide access to families in the United States, but there are concerns about its safety during handling the product for shipment (4).

Table 1 shows the composition of different goat milk-based formulas for toddlers and infants compared with formula for infants. While there are variations in deficiencies based on the specific goat milk-based formula, the formula our patient took had higher contents of protein, calcium, potassium, phosphorus, and sodium, with a deficiency of folate, iron, vitamin C, zinc, B_3, B_{12}, and fat-soluble vitamins A, D, E, and K. Clinically, because our patient received goat milk-based formula diluted to ¼ strength, we did not see any toxicities such as azotemia or elevated electrolytes. And because he was on a multivitamin, we did not see all the relative deficiencies listed above. Instead, we just saw deficiencies in vitamin K, vitamin C, vitamin D, and carnitine; along with sequelae from severe malnutrition that included suspected bone marrow failure (pancytopenia), hyponatremia, hypoglycemia, and liver dysfunction. Table 2 shows the different compositions of goat milk, cow milk, human milk, and ready-to-feed infant formula (2). Goat milk directly from the mammal is available in the United States, both on farms and in stores. The table notes how this is similar to cow milk, but when compared with infant formula, it has fewer carbohydrates, iron, vitamin C, folate, and vitamin K, with higher levels of protein, calcium, phosphorous, potassium, and sodium. As such, liquid goat milk is not recommended until 6–12 months of age, but the World Health Organization allows high-risk infants younger than 6 months of age to take goat milk if diluted with water and supplemented with sugar in emergency situations where infant formulas are not available (5). We suspect

TABLE 1. Comparison of powdered toddler goat milks vs infant goat formula vs infant cow formula

Nutrient	Kabrita, goat milk toddler formula powder (100 mL)*	Meyenberg, whole powdered goat milk (100 mL)*	Kendamil, first infant goat milk, powder (100 mL) UK†	Enfamil, Premium, infant formula, ready-to-feed (100 mL)*
Macronutrients				
Protein (g)	**2.5**	**2.9**	1.3	1.38
Fat (g)	3.3	3.3	3.5	3.48
Carbohydrate (g)	9.1	**4.1**	7.2	7.39
Calories	75	58	66	66
Minerals				
Calcium (mg)	**166**	**125**	44	51
Iron (mg)	**2.25**	0	**0.7**	1.18
Phosphorus (mg)	**100**	--	27	28
Potassium (mg)	**108**	**175**	84	71
Sodium (mg)	**29**	**35**	22	18
Zinc (mg)	**1.25**	0	0.5	0.66
Vitamins				
Vitamin C (mg)	13	0	12	7.9
Thiamin (mg)	**0.16**	0	0.06	0.053
Riboflavin (mg)	0.19	0	0.15	0.09
Niacin (mg)	1.6	0	0.65	0.66
Vitamin B_6 (mg)	0.1	0	0.05	0.04
Folate, total (μg)	0	**33**	17	11
Vitamin B_{12} (μg)	0.4	0	0.12	0.2
Vitamin A (μg)	**125**	0	59	60
Vitamin E (mg)	0	0	**2.2**	0.63
Vitamin D (IU)	43	0	56	49
Vitamin K (μg)	0	0	4.3	5.9

Bold denotes significantly higher vs infant formula.
Red denotes significantly lower vs infant formula.
Source:
*US Department of Agriculture, FoodData Central.
†https://kendamil.com/products/goat-first-infant-milk.

TABLE 2. Comparison of liquid mammalian milks vs traditional infant formula

Nutrient	Goat milk with added vitamin D, fluid (100 g)*	Cow milk with added vitamin D, fluid (100 g)*	Mature human milk (100 g)*	Infant formula RTF Enfamil w/iron (100 g)*
Macronutrients				
Protein (g)	**3.6**	**3.3**	1	1.4
Fat (g)	4.1	3.2	4.4	3.5
Carbohydrate (g)	**4.4**	**4.8**	6.9	7.4
Calories	69	60	70	66
Minerals				
Calcium (mg)	**134**	**123**	32	51
Iron (mg)	**0.05**	**0.03**	**0.03**	1.2
Phosphorus (mg)	**111**	**101**	14	28
Potassium (mg)	**204**	**150**	51	71
Sodium (mg)	**50**	**38**	17	18
Zinc (mg)	0.3	0.4	0.2	0.7
Vitamins				
Vitamin C (mg)	**1.3**	**0**	5	7.9
Thiamin (mg)	0.05	0.06	0.01	0.05
Riboflavin (mg)	0.14	0.14	0.04	0.1
Niacin (mg)	0.3	0.1	0.2	0.7
Vitamin B6 (mg)	0.05	0.06	0.01	0.04
Folate, total (µg)	**1**	**0**	5	11
Vitamin B12 (µg)	0.07	**0**	0.05	0.2
Vitamin A (µg)	57	32	61	60
Vitamin E (mg)	0.07	0.05	0.08	0.6
Vitamin D (IU)	51	44	3	49
Vitamin K (µg)	0.3	0.3	0.3	**5.9**

Bold denotes significantly higher vs infant formula.
Red denotes significantly lower vs infant formula.
Source:
*US Department of Agriculture, FoodData Central.

that this recommendation, along with the more routine consumption of liquid goat milk in older infants and toddlers in Africa, led the patient's grandfather to suggest the consideration of goat milk for this patient.

Given the current popularity of goat milk, it is important for both providers and patients to know the nutritional components of all formulations of goat milk. In addition, given the current environment of episodic formula shortages and the potential for families to dilute them, this case serves as an important reminder for providers to be aware of this possibility and the associated risks.

All attempts have been exhausted in trying to contact the parents or guardians for the purpose of attaining their consent to publish the submitted report.

REFERENCES

1. Clark S, Mora García MB. A 100-Year Review: Advances in goat milk research. *J Dairy Sci*. 2017;100:10026–10044.
2. Fooddata Central. *FoodData Central*. (n.d.). Retrieved March 14, 2022, from https://fdc.nal.usda.gov/
3. Martin CR, Ling PR, Blackburn GL. Review of Infant Feeding: Key Features of Breast Milk and Infant Formula. *Nutrients*. 2016;8:279.
4. DiMaggio DM, Du N, Porto AF. Nutritional and safety concerns of infant feeding trends. *J Pediatr Gastroenterol Nutr*. 2022;74:668–673.
5. Koniz-Booher P, Burkhalter B, de Wagt A, Iliff P, Willumsen J (eds). 2004. *HIV and Infant Feeding: A Compilation of Programmatic Evidence*. Bethesda, MD: Published for UNICEF and the U.S. Agency for International Development by the Quality Assurance Project, University Research Co., LLC.