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Nutritional Assessment in Children with Chronic Liver Diseases

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ABSTRACT

Background: Malnutrition is a frequent complication in pediatric cases with chronic liver disease (CLD), exerting detrimental effects on overall growth and especially on neurocognitive outcomes. **Objective:** To assess the nutritional status of pediatric cases with CLD attending Mansoura University Children's Hospital.

Patients and methods: This case-control investigation enrolled 100 CLD pediatric cases attending the hepatology outpatient clinic at Mansoura University Children's Hospital, along with 100 sex- and age-matched healthy children as controls. Eligible participants were 4–18 years and were stratified into three groups based on the Child-Pugh classification of disease severity. All subjects underwent detailed history taking, thorough clinical examination, anthropometric assessment, and bioelectrical impedance analysis.

Results: All anthropometric measurements were affected with statistically significant lower Z-score values for weight, height, BMI, MUAC, and triceps SFT scores among children with CLD compared to control. Children with liver disease exhibited a substantially lower mean total body fat percentage relative to controls. In addition, both trunk fat mass (kg) and fat mass (kg) were reduced in cases relative to controls.

Conclusion: Malnutrition in pediatric chronic liver disease is evident from lower anthropometric measures, reduced BMD, and altered body composition compared with controls.

Key words: CLD, BIA, Malnutrition.

INTRODUCTION

Various factors underlie CLD in pediatric cohorts. Biliary atresia is the chief cause in early infancy, succeeded by inherited metabolic conditions. In older age groups, autoimmune hepatitis, chronic viral infections, nonalcoholic fatty liver disease, and genetic metabolic abnormalities predominate [1,2]. Malnutrition represents a major concern in pediatric CLD, contributing to growth failure and compromised neurocognitive development [3]. Monitoring nutritional status in children enables early identification of those requiring additional support and provides a means of evaluating outcomes after treatment [4].

Nutritional assessment in CLD is often complicated by ascites and peripheral edema, which can falsely elevate conventional anthropometric indices such as body weight and BMI. Measures such as skinfold thickness (biceps, subscapular, triceps) and MUAC are considered more reliable for detecting malnutrition in this population, despite potential inter-observer variability [4]. Osteoporosis is a common complication in children with biliary atresia and Alagille syndrome, and its severity tends to increase with disease progression [5]. CLD is associated with a decline in bone metabolism, primarily driven by nutritional deficiencies, physical inactivity, and hormonal dysregulation [6]. Determination of BMD remains the most reliable technique for establishing the diagnosis and severity of bone involvement [7].

Dual-energy X-ray absorptiometry (DXA), a noninvasive and highly sensitive technique, is the most widely used method for assessing bone mineral content in CLD cases [8].

BIA represents a practical alternative for evaluating body composition and hydration status. Similar to anthropometric methods, it is safe, economical, and user-friendly. By applying regression analysis, this technique generates predictive models for calculating FFM and TBW [9].

Accordingly, this study aims to assess the nutritional status of children with CLD attending Mansoura University Children's Hospital.

PATIENTS AND METHODS

A hundred children diagnosed with CLD who attended the Hepatology Outpatient Clinic at Mansoura University Children's Hospital and a hundred seemingly healthy kids of the same age and gender were the subjects of this case control study.

Inclusion criteria: Children cases aged 4–18 years with CLD were included in the study. According to the Child-Pugh classification system, disease severity was categorized as mild (Class A; score 5–6), moderate (Class B; score 7–9), or severe (Class C; score 10–15).

Exclusion criteria: a) Children younger than 4-year, b) Coexisting diseases that could potentially cause malnutrition, c) Severe decompensated liver disease either severe edema, tense ascites and/or encephalopathy.

METHODS

All cases underwent the following:

A thorough medical history was obtained for all cases, recording demographic variables (name, age, sex, gender, residence) along with the diagnosis and duration of the primary disease.

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Complete physical examination including a) General, abdominal, chest, cardiovascular examination. b) Anthropometric measurements including BMI, height, weight, MUAC, TSFT. Age and SDS for BMI, MUAC, weight, height, and TSFT were calculated using the Egyptian growth charts [10].

BIA of body fat was carried out using the Tanita BC-418 MA analyzer (Tanita Corporation, Tokyo, Japan). DXA examinations were obtained with a single scanner (GE-Lunar Prodigy Primo, GE Healthcare, Madison, WI, USA) and processed using pediatric GE enCORE software (version 113). This system determines BMD for the lumbar spine (L1–L4), whole body, and TBLH, reporting values in g/cm² by dividing BMC (g) by the area of bone scanned (cm²). Pediatric BMD Z-scores were interpreted in accordance with ISCD standards: values ≥ -1.0 were considered normal, -1.0 to -2.0 indicated risk of low BMD, and ≤ -2.0 defined low BMD associated with elevated fracture risk [11].

Ethical consideration:

Informed consent was secured from the parents of all participating children prior to enrollment. The study protocol was reviewed and approved by the Institutional Review Board of the Faculty of Medicine, Mansoura University. All data were handled with strict confidentiality, and the investigation adhered to the principles of the Declaration of Helsinki.

Statistical analysis

SPSS 16 for Windows processed and analyzed the data. Numbers and percentages are qualitative data, which were compared using Chi square test. Quantitative data included mean, SD, median, interquartile range, minimum, and maximum. The independent t-test was employed to determine significance among cases and controls if quantitative data were normally distributed after Kolmogorov-Smirnov testing. Data not regularly distributed were tested with Mann Whitney test. A two-tailed P-value less than 0.05 was considered statistically significant. Pearson correlation (r) measured the strength of connection between two continuous variables.

RESULTS

Table (1) showed no substantial variation among the CLD and control groups concerning sex and age (p >0.05).

Table (1): Data on demographics among studied groups

Demographic data	CLD group (n=100)	Control group (n=100)	Test of significance	P value
Age (Years)			t=1.61	0.110
Mean ± SD	11.54± 3.42	10.82± 2.89		
Min-Max	4.5-18	4.50-15		
Sex			χ^2 =3.57	0.06
Male	55 (55%)	68 (68%)		
Female	45(45%)	32 (32%)		

Quantitative data are expressed as mean ± SD and qualitative data expressed as no (%).
Abbreviations: t: Independent t test, $\chi^{2:}$ Chi square test.

Table (2) shows that all anthropometric measurements were affected with statistically significant lower Z-score values for weight, height, BMI, MUAC, triceps SFT scores among children with CLD compared to control.

Table (2): Anthropometric measurements between children with CLD and control groups.

Anthropometric measurements	CLD group (n=100)	Control group (n=100)	Test of significance	P value
Weight- Z score	-0.85 (-2.30-1.10)	-0.58 (-1.70-2.20)	Z=4.127	≤0.001*
Height- Z score	-1.20 (-4.20-2.00)	-0.55 (-3.00-2.40)	Z=3.897	≤0.001*
BMI-Z score	-0.75 (-1.93-1.40)	-0.36 (-1.60-2.10)	Z=3.243	0.001*
MUAC-Z score	-1.87 (-4.42-0.28)	-1.29 (-3.67-1.40)	Z=3.030	0.002*
Triceps SFT- Z score	-0.81 (-2.89-1.49)	-0.01 (-3.05-1.48)	Z=3.362	0.001*

n: number, Z: Mann Whitney test statistic, BMI: Body mass index, MUAC: Mid upper arm circumference, SFT: Skin fold thickness, *: Significant P-value.

Table (3) showed that children had a statistically significant lower mean total body fat (%) than controls. Differences in lower trunk FM (Kg) and fat mass (Kg) were also detected between children with liver disease relative to controls.

Table (3): Results of body composition parameters using BIA technique among study groups.

BIA SCAN	CLD group (n=100)	Control group (n=100)	Test of significance	P value
Total body Fat (%), Mean ± SD	20.81±7.54	30.29±11.61	t=6.85	≤0.001*
Total body Fat Mass (Kg) Median (Min-Max)	6.40 (1.40-83)	13.30 (1.90-51)	Z=5.08	≤0.001*
Total body muscle mass (Kg) Mean ± SD	28.51±11.75	30.71±9.97	t=1.43	0.155
Trunk FM (Kg) Median (Min-Max)	2.75 (0.50-9.00)	4.80 (0.3-21.3)	Z=5.23	≤0.001*
Appendicular FM (Kg) Mean ± SD	25.08±10.89	23.92±6.76	t=0.902	0.368

SD: Standard deviation, BIA: Bioelectrical impedance analysis, FM: Fat mass, t: Independent t test, Z: Mann Whitney test, *: Significant P-value.

Compared with Child-Pugh A cases, those in Child-Pugh B had significantly higher alkaline phosphatase, Ph, total serum bilirubin (TSB), and liver enzyme levels, along with lower platelet counts and serum albumin. Anthropometric indices did not differ substantially between groups, but BMD Z-scores were markedly more reduced in Child-Pugh B. Furthermore, mean total body muscle mass, appendicular fat mass, and appendicular muscle mass were all significantly decreased in Child-Pugh B cases relative to Child-Pugh A.

Table (4): Association between Child score and laboratory investigations.

Laboratory investigations	Child score A (n=86)	Child score B (n=14)	Test of significance	P value
Anthropometric measurements				
WT- Z score	-0.85 (-2.10-1.10)	-0.80 (-2.30-0.17)	Z=0.229	0.819
HT- Z score	-1.20 (-4.20-2.00)	-0.78 (-3.20-0.78)	Z=0.219	0.827
BMI-Z score	-0.70 (-1.93-1.40)	-0.90 (-1.50- -0.10)	Z=0.325	0.745
MUAC-Z score	-1.83 (-4.42-0.28)	-2.23 (-3.73--0.63)	Z=0.676	0.499
Triceps SFT- Z score	-0.84 (-2.89-1.49)	-0.73(-1.85-1.23)	Z=0.159	0.874
BIA SCAN				
Total body Fat (%)	21.19±7.91	18.41±4.08	t=1.283	0.202
Total body Fat Mass (Kg)	5.0 (1.4-83)	8.0 (2.7-11.4)	Z=0.815	0.415
Total body muscle mass (Kg)	35.44±14.59	27.38±10.91	t=2.44	0.016*
Trunk FM (Kg)	2.4 (0.5-9.0)	3.2 (1.0-5.1)	Z=0.656	0.512
Appendicular FM (Kg)	32.15±13.75	23.93±9.98	t=2.70	0.008*
Appendicular MM (Kg)	15.81±7.30	11.74±6.66	t=2.09	0.039*
BMD Z score	-1.6 (-3.52-0.3)	-2.1 (-3.6- -0.6)	Z=2.46	0.014*
Laboratory investigations				
Alk P (IU/l)	229 (103-1787)	342 (183-815)	Z=2.09	0.037*
Ph (mg/dl)	5.29±0.94	5.86±1.03	t=2.035	0.045*
Ca (mg/dl)	9.35±0.69	8.97±0.76	t=1.874	0.064
PLT (k/uL)	274.16±22.21	149.43±33.22	t=3.781	<0.001*
TLC (k/uL)	7.71±1.13	7.86±1.68	t=0.167	0.868
HB (g/dl)	11.36±1.50	10.71±1.43	t=1.501	0.137
TSB (mg/dl)	0.8 (0.3-2.2)	2.0 (1-7.1)	Z=5.63	<0.001*
Albumin (mg/dl)	4.57±0.36	3.46±0.61	t=9.644	<0.001*
SGPT (U/ml)	50 (14-263)	95 (59-226)	Z=2.624	0.009*
SGOT (U/ml)	52 (16-336)	180 (85-245)	Z=4.115	<0.001*

n: number, WT: Weight, HT: Height, BMI: Body mass index, MUAC: Mid upper arm circumference, SFT: Skin fold thickness, BIA: Bioelectrical impedance analysis, FM: Fat mass, MM: Muscle mass, BMD: Bone mineral density, Alk P: Alkaline phosphatase, Ph:

Phosphorus, Ca: Calcium, PLT: Platelets, TLC: Total leukocyte count, HB: Hemoglobin, TSB: Total serum bilirubin, SGPT: Serum glutamic pyruvic transaminase, SGOT: Serum glutamic oxaloacetic transaminase, SD: Standard deviation, t: Independent t test, Z: Mann Whitney test, *: Significant P-value.

Table 5 demonstrated significant negative correlations between lumbar spine (L2–L4) BMD Z-scores and disease duration, activity score, Modified Knodell score, Child-Pugh score, liver enzymes (SGPT and SGOT), and trunk fat mass. In contrast, positive correlations were noted with hemoglobin, weight-for-age Z-score, height-for-age Z-score, and MUAC Z-score.

Table (5): Correlation between bone mineral density Z- score of lumbar spines (L2-L4) and both anthropometric and biochemical parameters among children with CLD.

laboratory and anthropometric measurements	Bone mineral density Z- score of lumbar spines (L2-L4)	
	r	P value
Duration of disease	-0.308	0.002*
WT- Z score	0.457	≤0.001*
HT- Z score	0.569	≤0.001*
BMI-Z score	0.194	0.055
MUAC-Z score	0.290	0.003*
Triceps Skin fold thickness- Z score	0.027	0.793
Total body Fat (%)	-0.177	0.078
Total body Fat Mass (Kg)	-0.167	0.098
Total body muscle mass (Kg)	-0.019	0.854
Trunk FM (Kg)	-0.232	0.02*
Appendicular FM (Kg)	0.039	0.699
Appendicular MM (Kg)	-0.001	0.991
Child score	-0.247	0.013*
Alk P (IU/l)	0.103	0.310
Ph (mg/dl)	0.035	0.733
Ca (mg/dl)	0.031	0.759
PLT (k/uL)	0.128	0.205
TLC (k/uL)	-0.057	0.573
HB (g/dl)	0.214	0.033*
TSB (mg/dl)	-0.107	0.289
Albumin (mg/dl)	0.124	0.218
SGPT (U/ml)	-0.283	0.004*
SGOT (U/ml)	-0.343	≤0.001*
Activity score	-0.398	0.005*
Fibrosis grade	-0.220	0.128
Modified Knodell score	-0.526	≤0.001*

WT: Weight, HT: Height, BMI: Body mass index, MUAC: Mid upper arm circumference, FM: Fat mass, MM: Muscle mass, BMD: Bone mineral density, Alk P: Alkaline phosphatase, Ph: Phosphorus, Ca: Calcium, PLT: Platelets, TLC: Total leukocyte count, HB: Hemoglobin, TSB: Total serum bilirubin, SGPT: Serum glutamic pyruvic transaminase, SGOT: Serum glutamic oxaloacetic transaminase, *: Significant P-value.

As presented in **Table 6**, total body fat percentage exhibited significant positive associations with weight-for-age, BMI, MUAC, and triceps skinfold thickness Z-scores. Total fat mass (kg) correlated positively with disease duration, pubertal stage, and the same anthropometric Z-scores, but inversely with fibrosis stage and Modified Knodell score. Total muscle mass (kg) demonstrated an identical correlation pattern, showing positive associations with disease duration, puberty assessment, and anthropometric indices, and negative associations with fibrosis grade and Modified Knodell score. Trunk fat mass (kg) correlated positively with disease duration, puberty, and anthropometric Z-scores, but negatively with fibrosis grade. Appendicular fat mass was positively associated with weight-for-age and MUAC Z-scores but inversely related to fibrosis. Appendicular muscle mass showed positive correlations with disease duration and all anthropometric indices, whereas it was negatively correlated with fibrosis grade.

Table (6): Relationship among Body composition parameters using BIA technique and clinical, laboratory and pathological parameters among children with CLD.

Patients' characteristics	Body composition parameters using BIA technique						
		Total body Fat (%)	Total BFM	Total BMM	Trunk FM	AFM	AMM
Duration of disease	**r**	0.103	0.251	.247	.328	.196	.250
	p	.309	.012*	.013*	.001*	.051	.012*
WT- Z score	**r**	.349	.412	.358	.353	.302	.367
	p	≤0.001*	≤0.001*	≤0.001*	≤0.001*	.002*	≤0.001*
HT- Z score	**r**	-.276	-.150	.189	-.247	.286	.179
	p	.005*	.135	.060	.013*	.004*	.075
BMI-Z score	**r**	.527	.522	.281	.528	.150	.313
	p	≤0.001*	≤0.001*	.005*	≤0.001*	.141	.002*
MUAC-Z score	**r**	.474	.555	.351	.509	.267	.352
	p	≤0.001*	≤0.001*	≤0.001*	≤0.001*	.007*	≤0.001*
Triceps SFT Z score	**r**	.279	.445	.334	.364	.272	.341
	p	.005*	≤0.001*	.001*	≤0.001*	.006*	.001*
Activity	**r**	.018	-.034	.070	.054	.074	.009
	p	.901	.818	.632	.714	.612	.951
Fibrosis	**r**	-.125	-.425	-.446	-.469	-.409	-.484
	p	.393	.002*	.001*	.001*	.004*	≤0.001*
Modified Knodell score	**r**	.010	-.207	-.231	-.102	.148	.061
	p	.923	.038*	.021*	.315	.309	.677
Child score	**r**	-.104	.082	.188	.066	.212	.200
	p	.304	.418	.061	.514	.034*	.046*

BIA: Bioelectrical impedance analysis, BFM: Body fat mass, BMM: Body muscle mass, FM: Fat mass, AFM: Appendicular fat mass, AMM: Appendicular muscle mass, WT: Weight, HT: Height, BMI: Body mass index, MUAC: Mid upper arm circumference, SFT: Skin fold thickness, *: Significant P-value.

Weight-for-age Z-score was positively associated with hemoglobin levels. Height-for-age Z-score showed negative associations with disease duration and liver enzymes (SGPT and SGOT), but a positive correlation with alkaline phosphatase. BMI Z-score was inversely related to activity score and fibrosis grade, while positively correlated with albumin. MUAC Z-score demonstrated positive associations with calcium, hemoglobin, and albumin. Triceps skinfold thickness Z-score correlated negatively with platelet count but positively with total serum bilirubin.

Table (7): Comparison of anthropometric measures with diseases features and lab tests.

	Anthropometric measurements					
		WT-Z score	**HT-Z score**	**BMI-Z score**	**MUAC-Z score**	**Triceps Skin fold thickness-Z score**
Duration of disease	**r**	-0.169	-.341	.162	-.059	.166
	p	0.093	.001*	.112	.560	.099
Activity	**r**	-.235	-.119	-.298	.176	.120
	p	.104	.417	.037*	.227	.411
Fibrosis	**r**	-.162	.142	-.396	-.206	-.212
	p	.267	.332	.005*	.156	.143
Modified Knodell score	**r**	-.083	-.092	.080	-.160	-.141
	p	.411	.362	.435	.111	.163
Child score	**r**	-.023	-.022	-.033	-.068	.016
	p	.820	.828	.747	.502	.875
Alk P (IU/l)	**r**	.154	.204	.147	.101	.101
	p	.125	.041*	.149	.318	.316
Ph (mg/dl)	**r**	.123	.126	.104	-.012	-.047
	p	.223	.213	.310	.904	.644
Ca (mg/dl)	**r**	.090	.004	.076	.256	.100
	p	.373	.968	.455	.01*	.321
PLT (k/uL)	**r**	-.015	-.025	.119	-.182	-.259
	p	.886	.806	.244	.070	.009*
TLC (k/uL)	**r**	-.115	-.123	.127	-.098	-.103
	p	.256	.222	.213	.334	.308
HB (g/dl)	**r**	.246	.015	.195	.232	.075
	p	.014*	.886	.055	.02*	.461
TSB (mg/dl)	**r**	-.051	-.131	.025	.112	.234
	p	.617	.195	.807	.268	.019*
Albumin (mg/dl)	**r**	.190	.00	.230	.223	.101
	p	.058	1.00	.022*	.026*	.318
SGPT (U/ml)	**r**	-.094	-.218	.097	.146	.168
	p	.355	.029*	.341	.147	.095
SGOT (U/ml)	**r**	-.156	-.205	.030	.055	.130
	p	.121	.041*	.770	.584	.196

WT: Weight, HT: Height, BMI: Body mass index, MUAC: Mid upper arm circumference, SFT: Skin fold thickness, Alk P: Alkaline phosphatase, Ph: Phosphorus, Ca: Calcium, PLT: Platelets, TLC: Total leukocyte count, HB: Hemoglobin, TSB: Total serum bilirubin, SGPT: Serum glutamic pyruvic transaminase, SGOT: Serum glutamic oxaloacetic transaminase, *: Significant P-value.

DISCUSSION

This investigation assessed the nutritional status of children with CLD. Findings revealed that all anthropometric indicators were adversely affected, with substantially lower Z-scores for BMI, height, weight, MUAC, and triceps skinfold thickness compared with controls ($p \leq 0.05$). Consistent with our findings, **El Koofy *et al.*** [12] found that median Z-score for weight, height, MUAC, triceps SFT were significantly decreased in cases group matched to controls.

This study demonstrated that lumbar spine BMD Z-scores were significantly lower in cases with Child-Pugh B compared to those with Child-Pugh A. Lumbar spine BMD Z-scores demonstrated substantial negative associations with disease duration, activity score, Modified Knodell score, Child-Pugh score,

pubertal stage, SGPT, SGOT, and trunk fat mass (kg). In contrast, significant positive associations were observed with hemoglobin, weight-for-age Z-score, height-for-age Z-score, and MUAC Z-score.

In agreement with our study, DXA analysis was done by **Loomes *et al.*** [13] Matched to the control group, the in-patient group had noticeably reduced BMD and BMC Z scores in children suffering from intrahepatic cholestatic disorders.

In this study, no substantial variations were observed between Child-Pugh A and B groups with respect to anthropometric parameters. However, laboratory findings differed significantly: cases with Child-Pugh B exhibited elevated levels of alkaline phosphatase, TSB, Ph, and liver enzymes, but lower platelet counts and albumin compared with Child-Pugh A. Moreover, mean total body muscle mass (kg), appendicular fat mass (kg), and appendicular muscle mass (kg) were significantly greater in Child-Pugh A cases.

In their study of cases with liver cirrhosis, **Yovita *et al.*** [14] used the Child-Pugh classification to assess nutritional status by anthropometrics and biochemical testing. None of the cases with liver cirrhosis had a healthy nutritional condition according to MAMC testing. Mild to severe malnutrition affects the majority of them. The Child-Pugh score was not significantly related to anthropometric measurements. Additionally, anthropometric measurements did not correlate significantly with albumin, prealbumin, or serum transferrin levels; however, there was a substantial association between the levels of prealbumin and transferrin and the Child-Pugh score.

In this study, the WT-Z score correlated positively with hemoglobin, while the HT-Z score showed a negative correlation with disease duration. Both SGPT and SGOT were positively associated with alkaline phosphatase. BMI-Z score was inversely correlated with activity score and fibrosis grade, but positively correlated with albumin. MUAC-Z score demonstrated positive correlations with calcium, hemoglobin, and albumin. Triceps skinfold thickness Z-score was negatively correlated with platelet count and positively associated with TSB.

El Koofy *et al.* [12] analyzed the relationship between anthropometric indicator z-scores and biochemical and hemodynamic parameters in individual cases. The study found no significant link between the z-scores for head circumference (HCZ), triceps SFT (Z score), and arm fat area (AFAZ) and any of the LFTs tested. With the exception of GGT, none of the derived arm indicators—UAAZ, AMAZ and AFAZ—correlate significantly with AST, ALT, or ALP when it comes to liver enzymes. Except for the Height for Age Z score (HAZ), there was a significant correlation among conjugated bilirubin and INR mean values of z scores for other anthropometric measures. There was a positive and statistically significant connection between albumin and all anthropometric parameters except for W/HZ. Similarly, except for WAZ, HAZ, and HCZ, there was a statistically significant association among hemoglobin and anthropometric variables.

Yodoshi *et al.* [15] evaluated a pediatric NAFLD cohort to examine the association between BIA-derived body composition parameters and histological severity of liver disease. A multifrequency octopolar BIA equipment was employed to gather data on body composition. After adjusting for possible factors, multivariate regression analyses revealed a -ve relationship among skeletal muscle mass index and hepatic steatosis. The degree of hepatic steatosis was negatively correlated with the appendicular muscle mass index. Hepatic steatosis was not correlated with percentage body fat. Similarly, no substantial relationships were found between body composition parameters and lobular inflammation, NAFLD Activity Score, ballooning, or fibrosis stage.

LIMITATIONS

This investigation was constrained by a very small sample size and specific selection limitations dictated by eligibility criteria that permitted cases enrollment irrespective of the progression of their hepatic illness.

CONCLUSION

Malnutrition in pediatric CLD is evident from lower anthropometric measures, reduced BMD, and altered body composition compared with controls.

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