EFFECTS OF TOTAL PARENTERAL NUTRITION ON ANTHROPOMETRIC VALUES AND METABOLISM IN NEWBORNS

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ABSTRACT

Objective: *To compare one-year-results of short- and long-term total parenteral nutrition on anthropometric measurements and metabolism in newborns after surgery.*

Material and Method: *This study includes 20 newborns who were treated between June 2003 and October 2006. Total parenteral nutrition was given to the newborns for less than 15 days in the short-term total parenteral nutrition group and for more than 15 days in the long-term total parenteral nutrition group. Anthropometric measurements, biochemical and elemental parameters were evaluated once a week and hormonal parameters twice a week during total parenteral nutrition period. These parameters were measured at 1st, 2nd, 3rd, 6th, and 12th months after stopping total parenteral nutrition.*

Results: *There was a parallel increase in anthropometric measurement values in both groups. One-month cholesterol values in both groups, and high density lipoprotein and low density lipoprotein in the short-term total parenteral nutrition group were significantly high. Lactate dehydrogenase values at 3rd month and alanine aminotransferase and aspartate aminotransferase values at 6th month were significantly low in both groups. One-month phosphorus (P) and 6-month calcium (Ca) values in the long-term total parenteral nutrition group were significantly decreased.*

Conclusion: *There was no statistically significant difference regarding anthropometric measurements and biochemical parameters between short-term total parenteral nutrition and long-term total parenteral nutrition groups. However, there were significant changes in cholesterol, HDL, LDL, LDH, AST, ALT, Ca, and P values at 1st, 3rd, and 6th months. Long-term follow-up can help in understanding of negative effects of total parenteral nutrition on newborn metabolism.*

Key Words: *Total parenteral nutrition, metabolism, newborn, anthropometric measurement.* ***Nobel Med 2011; 7(3): 100-107***

TOTAL PARENTERAL BESLENMENİN YENİDOĞANLARDA ANTROPOMETRİK ÖLÇÜMLER VE METABOLİZMA ÜZERİNDEKİ ETKİLERİ

ÖZET

Amaç: Bu çalışmada cerrahi hastalığı olan yenidoğanlarda kısa ve uzun dönem total parenteral beslenmenin, antropometrik ölçümler ve metabolizma üzerindeki bir yıllık sonuçlarının karşılaştırılması amaçlandı.

Materyal ve Metod: Haziran 2003 - Ekim 2006 tarihleri arasında, 20 yenidoğan üzerinde çalışıldı. Total parenteral beslenme, kısa dönem grubuna 15 günden az ve uzun dönem grubuna 15 günden fazla verildi. Parenteral beslenme süresi içerisinde, antropometrik ölçümleri, biyokimyasal ve elementel parametreleri haftalık ve hormonal değerleri iki haftalık aralarla bakıldı. Bu parametreler total parenteral beslenme sonlandırıldıktan sonra da 1. , 2., 3., 6. ve 12. aylarda ölçüldü.

Bulgular: Antropometrik ölçümler her iki grupta birbirine paralel arttı ve 1. yaşlarında iki grubun değerleri birbirine yakındı. Her iki grubun 1. ay kolesterol değerlerinde ve kısa dönem total parenteral beslenme grubunun 1. ay HDL ve LDL değerlerinde anlamlı yükselme tespit edildi. Yine her iki grubun 3. ay LDH ve 6. ay AST- ALT değerlerinde anlamlı bir düşme görüldü. Uzun dönem total parenteral beslenme grubunun 6. ay kalsiyum (Ca) ve 1. ay fosfor (P) değerlerinde anlamlı derecede düşme görüldü.

Sonuç: Kısa ve uzun dönem total parenteral beslenme grupları arasında antropometrik ölçümler ve biyokimyasal parametreler açısından anlamlı bir farklılık yoktu. Ancak 1., 3. ve 6. aylarında kolesterol, HDL, LDL, LDH, AST, ALT, Ca ve P değerlerinde anlamlı değişiklikler oldu. Uzun dönem takip, total parenteral beslenmenin yenidoğan metabolizması üzerindeki negatif etkilerinin anlaşılmasında katkı sağlayabilir.

Anahtar Kelimeler: Total parenteral beslenme, metabolizma, yenidoğan, antropometrik ölçüm. **Nobel Med 2011; 7(3): 100-107**

INTRODUCTION

The major problem in newborns (NBs) with low birth weight (LBW) is that their ability to consume sufficient calories is limited. Therefore, the essential part of the treatment protocol consists of total parenteral nutrition (TPN) in many newborn intensive care units (NICUs).[1] Complication rates are considered low during TPN and TPN does not affect the rate of mortality during major surgical procedures in patients with nutritional disorders.[2,3] However, some problems may occur in patients receiving TPN with regard to the duration of application.[3] While positive developments such as increases in weight and blood protein have been identified, the values of aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma-glutamyl transpeptidase (GGT), and bilirubin were high in NBs given TPN.[1,4] Elemental deficiency may also occur.[1,5] Some changes may continue over subsequent months. Although metabolic changes in patients receiving short-term TPN have been studied, there is no information regarding the long-term results of short- and long-term TPN in the literature.[4]

Our knowledge on risk factors and our interest on NB metabolism after stopping TPN have led us to develop new hypothesis regarding the anthropometric measurements (AMs) and metabolic results of TPN during one-year of follow-up. In this study, the effects of TPN on growth and development of NB and risk factors on metabolism were investigated. These risk factors in the patients to whom TPN were given for less than 15 days and for more than 15 days are:

(a) the effects of TPN on AMs, an easy and sure parameter in identifying growth and development retardation and in evaluating feeding situation.[6]

(b) the fact that triglyceride and total cholesterol measurements were high in the literature in which the cause of fatty liver was investigated.[7] The effects of TPN on lipid profile consisting of high density lipoprotein (HDL), low density lipoprotein (LDL), and lactate dehydrogenase (LDH) can also be added to these parameters.

(c) the effects of TPN on liver profile consisting of AST, ALT, GGT, total bilirubin, conjugated bilirubin, albumin, total protein, and prealbumin, for liver enzymes were high in many literatures regarding hepatic dysfunction.[1,7-12]

(d) the effects of TPN on elemental values [calcium (Ca), phosphorus (P), magnesium (Mg), zinc (Zn), and copper (Cu)], for trace element deficiencies were reported during TPN[1,5] and the effects of trace elements on liver dysfunction were discussed.[8]

(e) the effects of TPN on hormonal values. Thyroid hormone performing growth in postnatal period, growth hormone regulating growth, transferrin which is one →

Table 1: Demographic data in patients in STTPN group

Patient number	TPN beginning age	Gestation age	Diagnosis	Surgical procedure	TPN duration (day)
1	7th day	Mature	CDH	Primary repair	7
2	22th day	Premature	IEA	Primary anastomosis	7
3	7th day	Mature	IO	Primary anastomosis	8
4	7th day	Mature	Exomphalos	Primary repair	7
5	12th day	Mature	Exomphalos	Primary repair	10
6	5th day	Premature	Ladd's band	Excision	12
7	3rd day	Mature	Gasroschisis	Primary repair	11
8	10th day	Mature	Exomphalos	Primary repair	13
9	4th day	Premature	Gasroschisis	Primary repair	10
10	5th day	Mature	Esophagus atresia	Primary anastomosis	13

CDH: Congenital diaphragmatic hernia, IEA: Isolated esophagus atresia, IO: Intestinal obstruction, STTPN: Short-term total parenteral nutrition

Table 2: Demographic data in patients in LTTPN group

Patient number	TPN beginning age	Gestation age	Diagnosis	Surgical procedure	TPN duration (day)
1	2nd day	Premature	Gasroschisis	Primary repair	30
2	2nd day	Mature	CDH	Primary repair	16
3	4th day	Mature	Jejunal atresia	Primary anastomosis	23
4	14th day	Mature	EA	Primary anastomosis	16
5	5th day	Mature	Gasroschisis	Primary repair	23
6	3rd day	Mature	CDH	Primary repair	16
7	22nd day	Mature	Volvulus	R+ PA	38
8	8th day	Mature	CDH	Primary repair	17
9	12th day	Mature	Jejunal atresia	Primary anastomosis	30
10	7th day	Premature	EA	Primary anastomosis	26

CDH: Congenital diaphragmatic hernia, EA: Esophagus atresia, R+PA: Resecion+ Primary anastomosis, LTTPN: Long-term total parenteral nutrition

of the indicators of malnutrition and vitamin B_{12} were investigated.

We think that long-term follow-up with great number of parameters will help us understand negative effects of TPN on NB metabolism.

MATERIAL and METHOD

This clinical study included 20 NBs, 8 (40%) female and 12 (60%) male, who were not fed orally and to whom TPN was given because of surgical procedures they underwent between June 2003 and October 2006 in our department. Two groups were studied: TPN was given for less than 15 days in the short-term total parenteral nutrition (STTPN) group (n=10) and for more than 15 days in the long-term total parenteral nutrition (LTTPN) group (n=10). Demographic data of the patients were shown in Table 1 and 2. Anthropometric measurements and blood samples were obtained by a NB nurse with 12 years of experience at Meram Medical School. Material (blood) was obtained from NBs at the appropriate intervals in accordance with the TPN follow-up protocol of our department.

AMs [weight, height, circumference of the head (COTH), and periphery of proximal-middle extremity (POPME)] were evaluated once a week during TPN period. These parameters were measured at 1, 2, 3, 6, and 12th months after stopping TPN until the NBs become one year old. Zero month values show birth weights (Table 3).

Biochemical values were evaluated once a week during TPN period. Zero month values show the measurements in the beginning of TPN when the months are considered. Cholesterol, trigliserid, HDL, LDL, and LDH in the follow-up of lipid profiles (Table 4); ALT, AST, ALP, GGT, total bilirubin, conjugated bilirubin, albumin, total protein, and prealbumin in the follow-up of liver profiles (Table 5); Ca, P, Mg, and Cu in the follow-up of elemental data (Table 6) were measured once a week during TPN. TSH, FSH, vitamin B_{12}, transferrin, and GH in the follow-up of hormonal values (Table 7) were measured every 2 weeks during TPN. Biochemical, elemental, and hormonal parameters were measured at 1, 2, 3, 6, and 12th months after stopping TPN.

The daily energy needs of the patients were calculated as 100 calorie/kg/day (3 g/kg/day protein, 3 g/kg/day lipid, 15 g/kg/day dextrose). One-third of the liquid and energy protocol was given on the 1st day, 2/3 on the 2nd day, and a full dose on the 3rd day. 6% amino acid solution, 10-20% lipid as lipid solution, and 10-20% dextrose as carbohydrate was given. As vitamin support, 1.2 mg/kg/day B and 80 mg/day C vitamins were given to mature NBs together with TPN (0.35 mg/kg/day B and 25 mg/day C vitamins for premature NBs). Multivitamins were given 1 ml/day to the patients 0 to 6 months old (1.5 ml/day for the patients 6 to 12 months old), when they were fed orally. Moreover, 2 to 4 ml/kg 10% Ca gluconate was given to the NBs who had hypocalcemia. Meanwhile, 5 mg/kg/day zinc was given orally to the patients who had zinc insufficiency.

Mature babies were fed with formula containing prebiotic (72 calorie energy, 1.5 gr protein, 3.6 gr lipid, 8.4 gr carbohydrate, 0.4 gr prebiotic fiber, mineral, and vitamins in 100 ml formula) in addition to breast feeding, while premature babies were fed with formula (80 calorie energy, 2.4 gr protein, 4.4 gr lipid, 7.7 gr carbohydrate, mineral, and vitamins in 100 ml formula), which is suitable for their gastrointestinal system and metabolic functions, when the babies were →

fed orally. One baby, who was operated on because of volvulus and had short bowel syndrome, was fed with formula (67 calorie energy, 1.8 gr protein, 3.6 gr lipid, 6.8 gr carbohydrate, mineral, and vitamins in 100 ml formula), which contains middle chain fatty acid. Additional food was added to their feeding protocol after they reached the age of four months.

All values in the tables are expressed as mean ± SD. The values found according to the months were determined to be independent from each other. The different parameters in the groups were compared in different times. Differences in parameters between the groups were assessed using an unpaired Student's t test. The statistical analyses were performed using the Statistical Package for the Social Sciences version 13 software (SPSS, Chicago). $p<0.05$ was considered statistically significant.

RESULTS

The duration of STTPN was 9.8±2.44 days while that of LTTPN was 23.4±7.66 days. The average age of STTPN group was 8.2±5.55 days, and the average age of LTTPN group was 7.9±6.42 days.

There was no significant increase regarding the age in AMs in both groups. There was no statistically significant difference between the groups regarding the application periods (Table 3).

One-month cholesterol levels in both groups were increased compared with the 0 month (p=0.030) (Table 4). Triglyceride measurements did not differ between the groups. One-month HDL levels in the STTPN group were significantly higher than those in the LTTPN group (p=0.036) (Table 4). One-month LDL levels in the STTPN group were significantly higher than those in the LTTPN group (p=0.028) (Table 4). LDH levels in both groups were significantly decreased at 3rd month compared with those at 0th, 1st, and 2nd months (p=0.024) (Table 4).

AST values in the STTPN and LTTPN groups at 6 months were significantly lower than those in the previous months (p=0.005), as were ALT values (p=0.025) (Table 5). The highest ALP value was identified at 2nd month in the STTPN group and at 1st month in the LTTPN group. However, ALP levels in both groups were decreased at 12th month compared to the previous months (Table 5). There was no significant difference in terms of GGT or bilirubin results between the STTPN and LTTPN groups (p>0.05) (Table 5). There was no significant difference in the STTPN and LTTPN groups regarding serum proteins (albumin, prealbumin, or total protein values) (p>0.05) (Table 5). In the LTTPN group 6-month Ca levels were significantly lower than those in the STTPN group (p=0.020) (Table 6). In the LTTPN group 1-month p levels were significantly lower than those in the STTPN group (p=0.000) (Table 6). However, there was no significant difference between the groups regarding Mg, Zn or Cu values (p>0.05) (Table 6).

Table 3: Anthropometric measurements in patients

	Zeroth day	1st month	2nd month	3rd month	6th month	12th month
Weight (kg)						
Group 1	2390+697.64	2661+679.27	3496+775.93	4296+885.13	5943+1186.92	7822+1330.81
Group 2	2473+704.32	2620+556.85	3194+875.40	3952+1212.47	5525+1418.02	7979+1156.28
Height (cm)						
Group 1	47.6+3.56	49.45+4.08	53+3.26	56.75+4.09	66.15+6.88	74.30+5.37
Group 2	48.20+3.79	49.75+3.44	52.4+4	56.60+4.78	63.15+5.19	73.45+4.29
COTH (cm)						
Group 1	32.67+2.19	33.75+2.57	36.15 +2.74	37.95+2.43	41.25+3.03	44.25+2.87
Group 2	33.30+2.21	34.40+1.91	36.00+2.32	37.80+3.09	41.52+2.33	45.65+1.93
POPME (cm)						
Group 1	8.20+1.27	8.3.0+1.18	9.55+1.57	10.80+1.39	12.30+1.31	13.60+1.17
Group 2	8.35+1.15	8.38+0.84	8.90+1.55	9.80+2.07	11.35 +1.79	13.40 +1.26

NOTE. Values are expressed as mean ± SD., COTH: Circumference of the head, POPME: Periphery of proximal-middle extremity

Vitamin B_{12} levels were highest at 0 months and 1 month and returned to normal at the age of 1. There was no significant difference between the groups (p>0.05) (Table 7).

Transferrin levels increased gradually from 0-month to 12th months. But the difference between the STTPN and LTTPN groups was not significant at the age of 1 (p>0.05) (Table 7).

There was no significant difference in both groups regarding TSH and FSH values (p>0.05) (Table 7). GH levels were highest at 0 months, but decreased gradually at 1st, 2nd, 3rd, and 6th months, and were lowest at 12th month. There was no significant difference between the groups (p>0.05) (Table 7).

CONCLUSION

The application of TPN in children is different from than that in adults due to the age factor and growth, which continues.[13] Age is especially important in terms of protein and other nutrients during the neonatal period and early childhood. Children must be fed with consideration given to both their normal activities and growth.[13] Insufficient feeding affects growth and development negatively; causes infection diseases by decreasing immunity, and increases metabolic problems. AMs are easy and quick procedures compared to biochemical and biophysical procedures in identifying feeding situation of the →

Table 4: Lipid profile data in patients

	Zeroth day	1st month	2nd month	3rd month	6th month	12th month
Cholesterol (mg/dl)						
Group 1	100.4+31.42	139.0+38.37[a]	110.7+48.60	139.5+49.47	133.3+39.28	139.9+31.50
Group 2	102.5+40.88	105.6+22.98[b]	123.9+26.61	138.6+43.54	135.4+16.95	134.5+31.68
Trigliserid (mg/dl)						
Group 1	117.4+47.90	172.8+87.19	161.5+46.46	173.9+102.60	119+70.15	11.5+38.32
Group 2	112.3+72.30	142.6+46.55	184.0+74.20	200.0+93.06	163.8+29.38	127.8+64.11
HDL (mg/dl)						
Group 1	36.0+10.61	42.4+12.43[c]	32.4+12.99	34.6+7.15	42.9+13.53	43.4+17
Group 2	32.6+10.06	29.3+13.43[d]	31.4+5.62	32.0+10.93	37.0+4.64	38.9+6.55
LDL (u/L)						
Group 1	49.6+16.97	62.3+25.63[e]	55.9+29.70	63.2+41.95	64.0+35.23	72.5+30.42
Group 2	41.4+23.25	39.0+17.09[f]	55.6+21.25	65.2+38.12	62.9+17.93	67.3+37.40
LDH (u/L)						
Group 1	948.0+640.91	489.3+156.46	438.7+152.82	424.4+107.18[g]	401+147.16	303.7+73.37
Group 2	664.5+364.36	413.7+191.02	352.4+117.63	320.2+80.12[h]	322.2+104.38	289.2+92.64

NOTE. Values are expressed as mean ± SD, a: p=.030 when compared with other months, b p=.030 when compared with other months, c: p=.036 when compared with other months, d: p=.036 when compared with other months, e: p=.028 when compared with other months, f: p=.028 when compared with other months, g: p=.024 when compared with 0, 1, and 2nd months, h: p=.024 when compared with 0, 1, and 2nd. months, HDL: High density lipoprotein, LDL: Low density lipoprotein, LDH: Lactate dehydrogenase

patient.[6] AMs are sensitive procedures for identifying protein-energy malnutrition, degree of obesity, and insufficient growth and development. POPME, body weight, and height measurements are frequently used.[6]

In the present study, the effects of TPN were investigated in NBs, who represent a major population of children fed parenterally. Mean values of weight and POPME in the STTPN group were higher than those in the LTTPN group at 2nd, 3rd, and 6th months, but these values were nearly the same at 12th month. According to our findings, NBs who were fed orally after TPN, showed better growth due to gastrointestinal motility. But it was observed that NBs who were given TPN for long period caught same growth at the age of 1 too. However, the measurements of height and COTH increased at the same rate in both groups.

Lipids produce more energy with small volumes because of their concentrated energy storage. Lipids are very important in TPN, because of their essential fatty acids and vitamins, which dissolve in fat.[14,15] Increased serum triglyceride level demonstrates fat intolerance in the best form.[7] Triglyceride levels were reported to be increased in patients fed with hypertonic glucose and amino acids before fat emulsions were discovered.[16] Serum triglyceride and cholesterol levels are within normal values in the majority of patients fed fatty acid emulsion.[17]

In our study, the trigliserid values did not increase regardless of TPN duration. The trigliserid values were nearly the same from zeroth month to 12th month in both groups. One-month cholesterol values in both groups increased significantly compared to zero month in each group. There was no significant difference between the cholesterol values in both groups in long-term follow-up. The researchers who investigate the effects of lipids in liver dysfunction reported that the infusion of excessive glucose leads to abnormally high trigliserid synthesis and the accumulation of glycogen in the liver. It was proved that lipid addition to TPN infusions was important because of the convertion of excessive glucose to trigliserid in the liver.[7] Cholesterol and trigliserid follow-up are important in lipid intolerance in TPN infusion. We investigated the changes of HDL, LDL, and LDH in lipid profil and the long-term results of these values. HDL and LDL values in the STTPN group were significantly higher than those in the LTTPN group at the end of 1 month. However, LDH levels in both groups were similar at 0th, 2nd, 3rd, 6th, and 12th months. LDH values in both groups were significantly decreased at 3rd month but were nearly the same at 12th month.

Parenteral nutrition-associated cholestasis (PNAC) is a pathology characterized by deterioration of the biliary process or flow.[8,18] Decreased biliary process and flow occur depending on the increase in biliary salt and conjugated bilirubin in the blood.[8] PNAC is frequently identified in prematures, infants and NBs depending on temporary immaturity of liver function.[8] PNAC was observed in 19 (56%) of 34 small for gestational age infants to whom TPN were fed for more than 7 days and in 19 (27%) of 69 mature who were very low birth weight infants. It was reported that PNAC risk occurred in higher rate and more early in very low birth weight and small for gestational age infants. Liver function turned to normal values after TPN was stopped.[9] The cholestasis rate was 50% in the babies who weigh less than 1000 gr and were fed with TPN for 2 weeks, 18% in the babies who weigh between 1000 to 1499 gr, and 7% in the babies who weigh between 1500 to 2000 gr.[1] TPN appears to be a risk factor for developing liver dysfunction.[19] All PNAC cases are diagnosed nearly in 2 to 10 weeks of TPN usage, and are sometimes identified several years after TPN usage. PNAC is usually defined as a serum level of conjugated bilirubin greater than or equal to 2 mg/dL, and usually occurs after less than 2 weeks of TPN use.[8] In our study, PNAC was diagnosed in 1 (10%) premature baby in STTPN, and in 3 (30%) mature babies in LTTPN group. Liver function turned to normal conditions after TPN was stopped in accordance with the literature. We did not observe an important complication regarding PNAC at the end of one-year of follow-up.

In our study, the patient population was small because of difficulty of long-term follow-up and the exclusion→

of the babies who died before one year old. But, in this study, PNAC risk was high in the prematures fed with TPN for less than 15 days in accordance with the literature. In addition, we think that PNAC risk was high in the mature infants who were small for gestational age (SGA), and fed with TPN for long-term. Liver function turned to normal conditions in the days following TPN stopping at one-year of follow-up. In our study, turning of liver function to normal conditions in the baby who was SGA and mature was the longest. Long-term follow-up of liver function tests of premature and SGA mature babies may be useful. However, we think that the studies including more infants for long-terms are necessary.

Increases in cholestasis parameters such as serum conjugated bilirubin, AST, ALT, ALP and GGT levels during TPN use have been discussed by many researchers.[1,9-12] 6th month AST and ALT values in the STTPN and LTTPN groups were lower compared to those at 3rd month during TPN. The highest ALP value was identified at 2 months in the STTPN group and at 1 month in the LTTPN group. There was no significant difference between both groups at one-year of follow-up but it can be thought that long-term TPN may cause high ALP values. We may think that ALP values should be followed at 1 and 2 months after TPN was stopped. The histologic changes in the liver in PNAC occur before clinical findings. The increasing of GGT in addition to conjugated hyperbilirubinemia is an indicator of early cholestatic changes. However, the increasing of hepatic transaminases is a late finding.[1] In our study, GGT and conjugated bilirubin levels of 4 patients in both groups were above normal values. While high bilirubin levels returned to normal values in the short term, GGT returned to normal values after 3 months of follow-up. However, 0, 1, 2, and 3 months GGT values in the LTTPN group were obviously higher than those in the STTPN group. 12th month GGT values in both groups were similar and in normal limits. High GGT levels together with conjugated bilirubin showed that follow-up of GGT was important regarding PNAC. GGT levels in LTTPN group were higher than those in STTPN group. We think that GGT follow-up is important in the patients to whom long-term TPN were given because GGT values turn back to normal levels at long duration.

Plasma albumin level, which included an important amount of serum total protein, decreases in long-term nutritional insufficiency. The follow-up of the prealbumin level is a more reliable criterion for demonstrating malnutrition.[20] Prealbumin levels decrease in 3 to 4 days due to a lack of calories. Total protein and albumin levels increase while TPN is received. The nonsignificant increases in the levels of total protein, albumin and prealbumin in both groups in our study were consistent with the literature.[21]

Table 5: Liver profile data in patients

	Zeroth day	1st month	2nd month	3rd month	6th month	12th month
ALT (u/L)						
Group 1	25.5+22.07	20.9+17.66	28.4+28.41	32.2+32.53	24.9+16.14[a]	34.0+40.92
Group 2	18.3+17.18	26.5+33.66	50.6+72.04	61.2+66.39	51.1+28.71[b]	22.6+8.23
AST (u/L)						
Group 1	62.7+52.10	45.2+29.86	37.1+16.64	41.5+15.96	35.9+8.08[c]	47.8+31.49
Group 2	32.4+17.08	46.4+37.12	64.6+67.38	72.2+55.23	53.9+15.63[d]	39.1+7.17
ALP (u/L)						
Group 1	236.9+80.39	427.7+229.15	675.6+321.04	582.5+314.82	499.8+334.16	248.4+94.61
Group 2	204.6+91.21	675.8+377.44	598.7+346.37	499.9+215.18	398.5+256.7	231.1+59.99
GGT (u/L)						
Group 1	90.0+96.30	194.6+136.67	195.8+208.07	84.3+118.94	23.6+11.83	15.5+6.96
Group 2	112.2+102.24	260.6+182.6	280.4+282.34	199.6+207.67	50.2+60.24	18.4+11.03
Total bilirubin (mg/dl)						
Group 1	7.1+6.13	1.5+1.62	2.0+4.05	0.5+0.50	0.3+0.15	0.3+0.18
Group 2	7.1+5.20	2.9+2.50	2.5+3.00	0.5+0.34	0.3+0.28	0.3+0.34
Conjugated bilirubin (mg/dl)						
Group 1	0.6+29	0.6+0.76	1.1+2.67	0.2+0.31	0.1+0.07	0.1+0.06
Group 2	1.0+0.85	1.3+1.06	1.2+1.25	0.2+0.18	0.1+0.04	0.1+0.06
Albumin (gr/dl)						
Group 1	3.3+0.37	3.8+0.56	3.7+0.39	4.1+0.35	4.4+0.34	4.5+0.29
Group 2	3.1+0.68	3.6+0.62	3.9+0.56	4.1+0.54	4.3+0.51	4.2+0.70
Total protein (gr/dl)						
Group 1	5+0.42	5.7+0.67	5.5+0.67	5.8+0.52	6.6+0.45	6.5+0.28
Group 2	4.6+0.93	5.4+0.91	5.8+0.96	6.4+0.92	6.7+0.61	6.6+0.57
Prealbumin (mg/dl)						
Group 1	12.1+4.64	11.4+3.58	11.7+6.47	14.5+11.59	14.1+4.58	15.4+6
Group 2	10.7+4.04	12.0+5.72	13.7+6.12	14.8+5.20	15.3+9.03	13.2+3.79

NOTE. Values are expressed as mean ± SD, a: p=0.025 when compared with other months, b : p=0.025 when compared with other months, c: p=0.005 when compared with other months, d: p=0.005 when compared with other months

It is reported that trace element deficiency may be seen during TPN.[1,5] Some researchers think that the addition of Ca and P is ideal for patients who have had TPN, while others claim that the addition of Ca is not necessary for TPN lasting less than 10 days.[22] In our study, Ca was added to intravenose solutions according to biochemical values of NBs. In our study 6th month Ca and 1st month p values in the LTTPN group were lower than those in the STTPN group. This result shows that long-term follow-up of 1st month P and 6th month Ca values is important in NBs given TPN for a long period.

The effect of magnesium (Mg) deficiency could not completely be identified in humans, while findings such as anorexia, growth insufficiency, diarrhea, edema, and hypotony in copper (Cu) deficiency are reported. [8,23] It was reported that overinfusion of magnesium caused cholestasis[8] and abnormalities→

Table 6: Elemental parameters in patients

	Zeroth day	1st month	2nd month	3rd month	6th month	12th month
Calcium (mg/dl)						
Group 1	8.26+2.07	9.7+0.76	10+0.78	10.3+0.53	10.5+0.38[a]	10+0.70
Group 2	8+0.64	9.8+0. 51	9.5+0.82	10.1+0.89	9.9+0.50[b]	9.8+0.74
Phosphor (mg/dl)						
Group 1	4.5+1.03	5.7+0.79c	5.6+1.11	5.6+0.53	5.8+0.42	5.3+1.23
Group 2	4.4+1.78	3. 6+0.79d	5.1+1.74	5.1+1.20	6.2+0.81	5.8+0.71
Magnesium (mg/dl)						
Group 1	1.9+0.58	1.9+0.38	2.1+0.25	2.3+0.18	2.4+0.24	2.3+ 0.26
Group 2	1.8+0.39	1.8 +0.23	2+0.24	2.0+0.58	2.4+0.17	2.4+0.34
Zinc (mmol/l)						
Group 1	101.2+40.81	110.6+53.80	80.6+22.42	78.2+16.73	80.9+16.29	81.5+26.56
Group 2	98.5+37.92	93.4+24.34	85.3+21.17	78.9+19.54	76.3+14.56	74.4+25.40
Copper (mg/dl)						
Group 1	78.4+34.55	138.6+71.51	124.8+39.89	162.4+84.43	139.6+70.76	182.2+74.92
Group 2	117.6+54.03	112.8+54.51	169.7+104.06	153.1+63.48	161.3+33.98	142.5+55.09

NOTE. Values are expressed as mean ± SD, a: p=0.020 when compared with other months., b: p=0.020 when compared with other months, c: p=0.000 when compared with other months, d: p=0.000 when compared with other months.

Table 7: Hormonal values in patients

	Zeroth day	1st month	2nd month	3rd month	6th month	12th month
Vitamin B_{12} (pg/mll)						
Group 1	657+364.80	758+390.54	489.7+286.30	440.7+240.39	311+166.58	291.6+164.51
Group 2	859.5+608.94	1048+611.89	746.2+535.89	545.4+264.59	516.7+259.11	410.7+188.82
Transferrin (mg/dl)						
Group 1	121.7+73.96	173+77.73	177.6+44.89	231.7+76.92	304.7+40.78	303.7+31.85
Group 2	128.1+43.54	143.7+27.03	204.6+63.01	249.4+73.24	299.4+92.15	361+92.97
TSH (mIU/mL)						
Group 1	6.5+6.80	4.5+2.65	10.8+24.13	6. 8+9.43	4.7+6.04	2.0+1.13
Group 2	12+13.21	3.4+2.80	3.6+2.83	3.0+1.82	3.9+2.21	2.5+1.79
FSH (mIU/mL)						
Group 1	1.1+0.98	3.7+3.94	2.4+1.27	2.7+1.37	3.4+4.25	3+2.98
Group 2	1.1+0.82	3.9+5.58	2.1+2.34	1.8+1.20	1.6+1.51	2+2.66
GH (ng/mL)						
Group 1	26.8+12.63	13.9+9.92	8.4+9.45	6.5+2.34	5.4+6.96	3.4+3.35
Group 2	28.1+14.62	19.7+8.99	10.4+7.20	8.0+7.07	4.8+3.70	3.8+2.65

NOTE. Values are expressed as mean ± SD, TSH: Tiroid stimulan hormon, FSH: Follicule stimulan hormon, GH: Growth hormon

in the Cu metabolism in patients with PNAC.[24] Both the 1993 Consensus and 1988 American Society for Clinical Nutrition (ASCN) suggested that trace elements are not necessary in the first 2 weeks after birth, and Cu and Mg are not to be given to patients with cholestasis.[1] Cu and Mg were not added to TPN in our study and there was no difference between the STTPN and LTTPN groups.

Zinc (Zn) deficiency is frequently seen in patients who receive long-term TPN.[25] The 1993 Consensus and 1988 ASCN suggested that Zn must be added to TPN after the first day of birth.[1] Deficiency of Zn, which is a trace element, was reported to occur early and at least after 2 months' TPN application according to other trace elements. Therefore, Zn is suggested to be given to the patients fed parenterally 1 to 2 weeks after the beginning of TPN.[1] In our study, there were nonsignificant decreases in Zn values after 1 month in both groups. In our study, Zn was given to the NBs with low Zn values and were fed orally due to its importance in the growth and development. Zn values were low in especially at 3 and 4 months. Therefore, Zn follow-up is important in the NBs to whom long-term TPN was given. We think that Zn support is important in NB growth.

Vitamin deficiency syndrome was rarely reported in patients who have had TPN,[24] but vitamins are recommended during TPN application, because of their positive effects on wound healing and immune functions.[1,24] We observed that vitamin B_{12} levels did not differ between the groups at the end of one-year of follow-up. Transferrin is the protein investigated most in malnutrition.[26] There was no difference in terms of this protein between the groups at the subsequent months in our study.

Thyroid hormone is an essential hormone that provides growth in all of the postnatal periods. TSH, T3, and T4 levels decrease slowly during infancy and childhood after sudden changes seen in the neonatal period and arrive at the adult level in 6 months.[27] We did not determine a difference between TSH and FSH values in both groups regarding TPN duration.

The most important hormone that regulates growth after birth is GH, although various hormones affect growth. GH is increased in NBs compared with other age groups.[28] GH values in our patients were the highest at 0 months, which was consistent with the literature, but it was in normal limits with decreased values at one year age. There was no difference between GH levels of the groups when 12th month values in both groups were compared regarding TPN duration.

There was no significant difference regarding AMs, biochemical and hormonal parameters between STTPN and LTTPN groups at one-year of follow-up of each patient. However, we suggest that cholesterol, HDL, LDL, LDH, AST, ALT, Ca, and P values may be followed in NBs at 1st, 3rd, and 6th months even if TPN was stopped, for there were significant changes in these parameters in NBs at 1st, 3rd, and 6th months. TPN is quite important in the NBs who had to be fed parenterally because of surgical manipulations. Hypothesis related the negative effects of TPN on NB metabolism has been keeping its actuality. Short- and long-term follow-up of NBs fed with TPN can help→

diagnose complications related with TPN earlier and treat them. Further controlled studies are needed with larger groups in order to demonstrate the metabolic and AM effects of short and long-term TPN in NBs. It is hoped that this study may help in understanding the effects of TPN on the NB metabolism.

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