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ORIGINAL ARTICLE

Early aggressive total parenteral nutrition to premature infants in neonatal intensive care unit (NICU)

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Abstract:

Introduction: *Iatrogenic intrauterine growth restriction in NICU has been a prevailing problem in these days when smaller babies are being salvaged. Early aggressive TPN is defined when total of 4g/kg/day of amino acid is administrated via standardized TPN to neonates over first week of life. Our main objective of the study is to evaluate the efficacy, safety and tolerability of early aggressive standardized TPN to infants. We also explore the impact of early and high dose of amino acid with hypophosphatemia in extreme low birth weight (ELBW) infants, growth velocity in infants with TPN therapy and TPN cost when the hang time is extended from 24 hours to 48 hours.*

Methods: *This is a prospective study on premature infants in NICU, Sarawak General Hospital for 6 months. Demographics and anthropometric data of eligible infants were collected. Biochemical test, growth velocity and cost of TPN therapy were analysed.*

Results: *There are 69 eligible infants recruited. Serum electrolytes of all infants were found to be within normal range throughout TPN therapy except serum phosphate concentration. We found that incidence of hypophosphatemia is high with high amino acid supply in ELBW infants. There is a negative correlation (-0.26) between serum urea concentration and birth weight. Targeted growth velocity is achieved with standardized TPN and ELBW premature infants were found to have highest weight growth velocity. By extending TPN hang time to 48 hours, TPN related cost is associated with minimizing and resulted in yearly savings of RM 62556.60, exclusive of labour cost and nursing cost.*

Conclusion: *Early aggressive PN therapy is safe and it achieved goal of postnatal growth velocity and body composition in premature infants. This study also demonstrated that the current practice of extending hang time is financially beneficial to hospital.*

Keywords: *Preterm infants, low birth weight infants, aggressive PN therapy, electrolytes, serum phosphate concentration, urea, growth velocity, hang time, TPN related cost*

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Introduction

First week of life is a molding period in neonates, especially premature babies. Iatrogenic intrauterine growth restriction (IUGR) in neonatal intensive care unit (NICU) has been a prevailing problem in these days when smaller and smaller babies are being salvaged. Early aggressive total parenteral nutrition (PN) is defined when total of 4g/kg/day of amino acid is administrated via standardized PN to neonates over first week of life. Aggressive nutrition and optimal energy intake has a positive impact on growth [1, 2], pulmonary morbidity, reduces risk of necrotizing enterocolitis and decreases hospital stay [3]. PN should therefore be started as soon as possible to achieve glucose level and enhance positive protein

accretion. Increased protein intake at first week of life is also associated with improved neurodevelopmental outcome.[4] However, nutritional regimens to achieve these goal have not been fully understood, thus the varying parental nutrition formularies. Intrauterine protein accretion rate occur at 2 g/kg/day until 32 weeks of life and followed by 1.8 g/kg/day thereafter. However, if preterm infants were only given glucose, they will lose more than 1% of total protein stores each day. In a premature infant, optimal growth is achieved by a protein intake of 3.5 g/kg/day (0.56 g/kg/day of nitrogen). Studies have shown that protein intake as high as 4 g/kg/day are safe.[3]

Table 1: Compositions of standardized PN formulations

Components	Starter PN	Standard Preterm PN	High sodium Preterm PN	7.5% Dextrose Preterm PN	Term PN
	Conc/Litre				
Amino acid, g	33	30	30	30	23
Glucose, g	100	100	100	75	120
Na, mmol	20	33	60	33	25
K, mmol	0	22	22	22	20
Cl, mmol	0	22	22	22	20
Ca, mmol	6	6	6	6	6
Mg, mmol	2.5	2.5	2.5	2.5	2.5
P, mmol	7.4	7.4	7.4	7.4	7.4
Acetate, mmol	5.2	18.2	45.2	18.2	10.2
Osmolarity, mosm/L	849.08	895.98	949.98	758.87	933.19
		At 60mL/kg/day		**At 135ml/kg/day**	
Amino acids, g	2	4	4	4	3
Glucose, g	6	13.5	13.5	10	16.2
Na, mmol	1.2	4.5	8.1	4.5	3.4
K, mmol	0	3	3	3	2.7
Cl, mmol	0	3	3	3	2.7
Ca, mmol	0.36	0.8	0.8	0.8	0.8
Mg, mmol	0.15	0.3	0.3	0.3	0.3
P, mmol	0.44	1.5	1.5	1.5	1.5
Acetate, mmol	0.3	2.5	6.1	2.5	1.4

**Na: Sodium, K Potassium, Cl: Chloride, Ca: Calcium, Mg: Magnesium, P: Phosphorus*

Generally, PN is gradually advanced within 1 to 2 weeks of life due to fear of intolerance attributed by immature metabolic pathways and ill state of premature newborns. There were concerns of uremia and metabolic acidosis if amino acid load were increased too aggressive in these infants.

The objective of our study is to promote growth without causing metabolic derangement in extremely preterm and extremely low birth weight infants via PN. There are 5 different PN regimens to fulfill nutritional requirement of infants. Started PN regimen provides amino acids of 2 g/kg/day at 60 ml/kg/day at 24 hours of life. It contains minimum amount of sodium and no potassium.

Standard preterm PN regimen provides 13.5 g/kg/day of glucose and 4 g/kg/day of amino acid when it runs at maximum of 135 mL/kg/day. Electrolytes and essential trace elements are formulated as per recommendation of European Society of Paediatric Gastroenterology, Hepatology and Nutrition (ESPHAN) and American Academy of Paediatrics (AAP). [5, 6]

Term PN regimen is designed for term infants with amino acid of 3 g/kg/day. 7.5% of dextrose PN regimen and high sodium PN regimen are designed to cater for hyperglycemia and hyponatremia in infants respectively.

PN regimens are designed at 135 ml/kg/day and lipid emulsion at 3 g/kg/day (15 ml/kg/day) meets the parenteral nutrient and energy requirement, both protein and non protein energy, of the infant.

Table 2: Parenteral and enteral feeding regimen in our unit's policy

	Parenteral intake (mL/kg/day)	Lipid intake (mL/kg/day)	Protein intake from PN (g/kg/day)	Lipid intake (g/kg/day)	Mean enteral intake (mL/day)	Mean Protein intake from enteral feeding (g/kg/day)
Day 1	60	5	2	1	-	-
Day 2	90	10	2.7	2	-	-
Day 3	120	15	3.6	3	-	-
Day 4	135	15	4	3	-	-
Day 7	105	15	3.1	3	30	0.4
Day 10	63	15	1.9	3	72	0.8

** When lipid is given at 3 g/kg/day, the volume of 15 mL/kg/day will be included in total fluid intake per day.*

Fluid intake of 60 ml/kg/day was started on day 1 of life and increase by 30 ml/kg/day every 24 hours to a maximum fluid intake of 150 ml/kg/day. The volume contributed by SMOF® Lipid emulsion 20% is included when it reaches 3 g/kg/day. Amino acid content in expressed breast milk (EBM) is 1.1 g/100mL. Enteral feeding was initiated at day 1 of life but due to inconsistent EBM supply and minimal volume from enteral feeding, it was not included in total fluid requirement per day until averagely day 7 of life. SMOF® Lipid emulsion 20% was initiated at 1 g/kg/day at day 1 of life and titrate it according to serum triglycerides level.

OBJECTIVES

1) To evaluate the efficacy, safety and tolerability of early aggressive of standardized TPN to neonates in NICU
2) To relate the impact of early and high dose of amino acid in PN with hypophosphatemia in extreme low birth weight infants
3) To study the velocity of growth in neonates after PN therapy
4) Cost evaluation of PN therapy

METHODS

Study design

We performed a prospective study in NICU, in Sarawak General Hospital (SGH), from April 2013 to September 2013. Consent was taken from parents for insertion of umbilical venous catheter (UVC) for administration of PN.

Subjects

All newborns who admitted to NICU, SGH, with a gestation age of ≤ 32 weeks and/ or ≤ 1500g, or preterm infants with gestation age of > 32 weeks or > 1500g, or term infants, who is anticipated that enteral feeding of at least 120 ml/kg/day is unable to be established by day 5 and day 7 of life respectively, with PN, are eligible for participation in the study. Exclusion criteria were the duration of PN therapy is less than 5 days.

All newborns received PN when keep nothing by mouth. Enteral nutrition, expressed breast milk (EBM), was slowly introduced to stable newborns according to unit's feeding protocol guideline, concurrent with PN therapy. PN are taken off once they achieved near full feeding of at least 120 ml/kg/day of enteral feeding.

Protocol

Eligible infants were commenced with PN within 24 hours of life, unless specified. UVC is inserted after consent by parents. Once UVC is inserted, PN will be connected straight by the medical personnel who had inserted the UVC, to ensure the sterility. Peripheral indwelling central catheter (PICC) will be inserted if UVC dislodged or not suitable for use. During the first 24 hours of life, all infants were commenced with starter PN regimen which does not contain any potassium in the bag. After 24 hours of life, either standard term regimen or standard preterm regimen was given according to their gestation age. All PN regimens had been formulated according to the recommendations of AAP and ESPGHAN and were prepared by qualified pharmacy team in aseptic compound.

Each PN bag lasts for 48 hours and glucose concentration of the standard PN can be varies, either 7.5% or 10%. However, generally 10% glucose PN was given, unless specified.

All recruited infants are subjected to blood taking on the first 3 days after initiation of PN then every alternate day, which corresponds to PN ordering day. Blood investigations that were monitored include full blood count, renal profile, liver profile, biochemical test, blood gas and sugar profile. Occipitofrontal head circumference (OFC) and body length of infants were taken twice per week. Daily weighing was done but only weekly weights were collected.

In the event of any signs of line sepsis, UVC will be removed and PN halted. Blood cultures were then taken both from UVC or PICC and peripherally to confirm site of sepsis.

The Statistical Package for Social Sciences (SPSS, Version 16) software was used for statistical analysis. Correlation between two categorical variables was assessed by correlation coefficient.

RESULT

This is a prospective study which involving of 69 eligible infants. Demographic characteristic are displayed in Table 3.

In our sample population, 97% were premature and among the premature infants, 38% were extremely low birth weight infants, 46% were very low birth weight infants and 13% were low birth weight infants. 5.8% of infants who started PN after 24 hours were not able to tolerate feeding as targeted.

Starter PN bag is introduced to newborn infants at day 1 of PN therapy. Starter PN, with total fluid volume of 60 mL/kg/day is administrated to infants, which composes of 2 g/kg/day of amino acid; electrolytes are initiated at the minimum requirement of a newborn baby and potassium only initiated to infants at day 2 of life onwards, in view of their not well established renal function.

Table 3: Demographics characteristic of recruited infants

	N (F:M)	Mean ± SD gestation age (weeks)	Mean ± SD birth weight (grams)	Mean ± SD OFC at birth (cm)	Mean ± SD length at birth (cm)	Mean ± SD duration of TPN days
ELBW (< 1000g)	26 (15:11)	26 ± 2	791 ± 130	22.6 ± 2.1	31.7 ± 3.5	13 ± 2
VLBW (1000g –1500g)	32 (15:17)	30 ± 2	1253 ± 150	26.5 ± 2.18	36.6 ± 2.75	10 ± 3
LBW (>1500g - ≤ 2500g)	9 (5:4)	33 ± 3	1822 ± 304	28.7 ± 1.1	42 ± 2.1	9 ± 1
Term (≥ 2500g)	2 (0:2)	39 ±1	3118 ± 187	32 ± 0	49.8 ± 1.1	12 ± 3
TOTAL	69 (35:34)	29 ± 3	1210 ± 500	25.5 ± 3.2	35.9 ± 5.1	11 ± 3

**SD: Standard deviation*

Mild hypokalemia was noticed at day 2 of therapy; however, it resolved when standard preterm PN bag was initiated. Hypophosphatemia was noticed as well even though it is adequately supplemented with the dose recommended by AAP and ESPGHAN.[5, 6] Other serum electrolytes were maintained within normal range throughout the PN therapy.

In our sample population, all the indicators for safety measure were fall within normal range. Serum BUN concentrations and serum triglyceride concentrations were in increasing trend on the first 3 and 5 day of PN therapy but stabilized after that. Serum bilirubin and serum alkaline phosphatase are the indicators for cholestasis and PN is the common cause of that. Figure displayed in Table 5 showed increasing trend of both indicators throughout PN days but were still maintained in normal range of pediatrics group.

Table 4: Serum electrolytes concentration to reflect the efficacy of TPN therapy (Outcome: Efficacy measure)

Electrolytes (mmol/L)	Normal range (mmol/L)	Day 1	Day 2	Day 3	Day 5	Day 7	Day 10
Sodium	132-147	137 ± 4.9	140 ± 4.4	142 ± 4.7	139 ± 4.0	138 ± 4.5	135 ± 4.5
Potassium	3.6-6	3.9 ± 0.7	3.5 ± 0.6	3.6 ± 0.6	4.1 ± 0.7	4.4 ± 0.8	4.4 ± 0.7
Calcium	2.1-2.7	2.1 ± 0.2	1.9 ± 0.3	2.1 ± 0.3	2.3 ± 0.4	2.3 ± 0.2	2.3 ± 0.2
Phosphate	1-2.58	2.1 ± 0.5	1.8 ± 0.5	1.5 ± 0.4	1.3 ± 0.4	1.3 ± 0.5	1.4 ± 0.4
Magnesium	0.8-0.95	0.9 ± 0.2	1.0 ± 0.4	1.1 ± 0.3	1.1 ± 0.4	1.1 ± 0.3	1.0 ± 0.1

Table 5:Indicators to reflect the tolerability to PN therapy (Outcome: Safety measure)

Indicators (mmol/L)	Day 1	Day 2	Day 3	Day 5	Day 7	Day 10
Triglyceride	0.53 ± 0.43	1.04 ± 0.63	1.34 ± 0.69	1.53 ± 0.68	1.50 ± 0.56	1.43 ± 0.60
Urea	4.0 ± 2.4	6.8 ± 2.7	7.5 ± 3.0	6.8 ± 2.9	6.5 ± 3.1	5.5 ± 2.9
Serum bilirubin	59.8 ± 34.3	91.8 ± 28.1	102 ± 365	122.2 ± 48.3	130 ± 50.6	127.3 ± 30.5
Alkaline Phosphatase	188 ± 73.9	179.2 ± 68.1	183.1 ± 63.4	213.3 ± 62.1	266.6 ± 133.4	379.1 ± 193.2

Correlation coefficient of -0.26 showed a negative correlation between serum urea concentration and birth weight (grams) with different gestation age groups, which displayed in Figure 1. In our sample population, same amount of amino acid were supplied to all preterm infants. Extremely premature infants with extremely low birth weight had highest mean urea concentration if compared to moderate to late preterm infants. As reported, extremely low birth weight infants have highest growth rate.[7] Therefore, rising BUN values are not just a reflection of extremely low birth weight infant's intolerance to amino acid infusion but it reflects appropriate amino acid utilization for both energy and lean mass production.[10]

Another unusual phenomenon is arising when various clinical trials are supporting aggressive amino acid to premature infants. During our study period, we noticed that with higher amount of amino acid supply, the lower is the serum phosphate level, in all infants recruited. Correlation coefficient of -0.92 showed a perfect negative correlation between amounts of amino acid administrated and serum phosphate concentration.

Figure 1: Correlation between serum urea concentration and birth weight (grams) with different gestation age groups

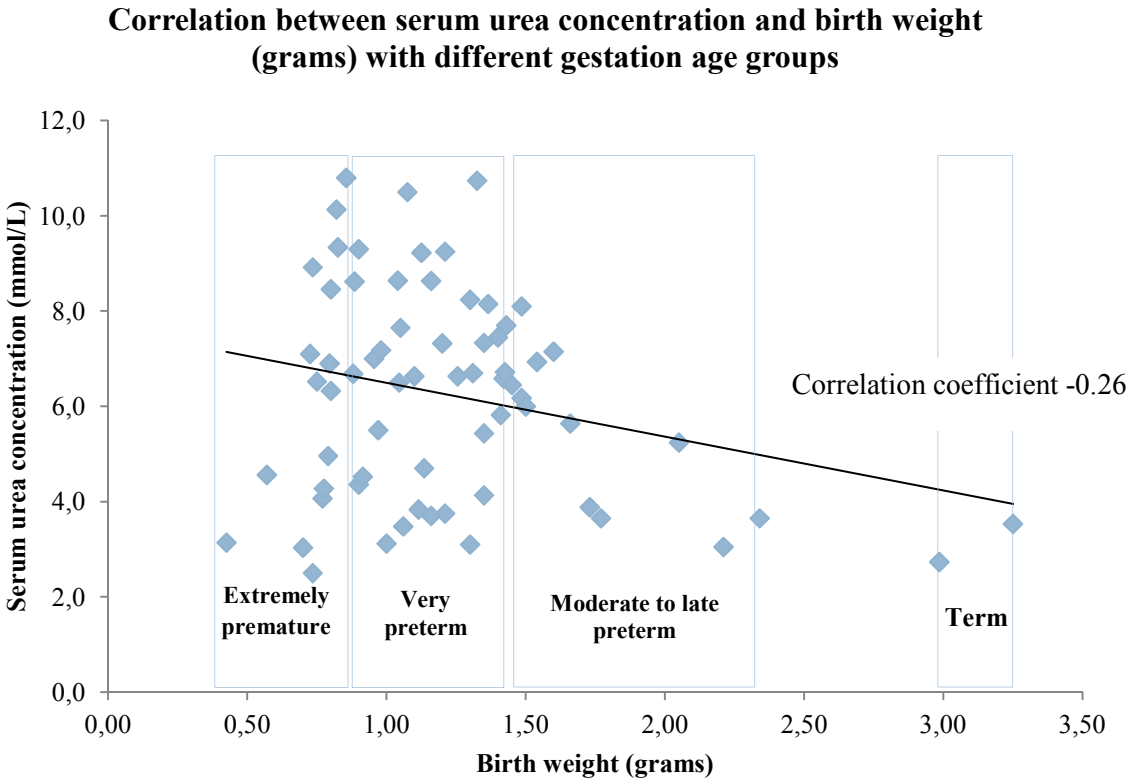
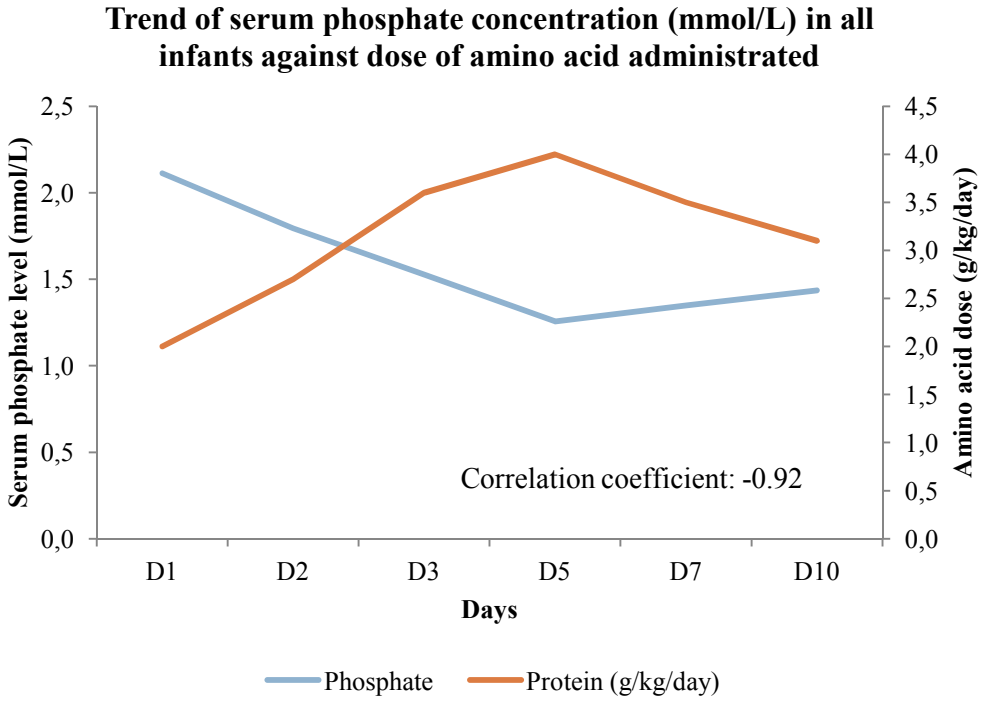
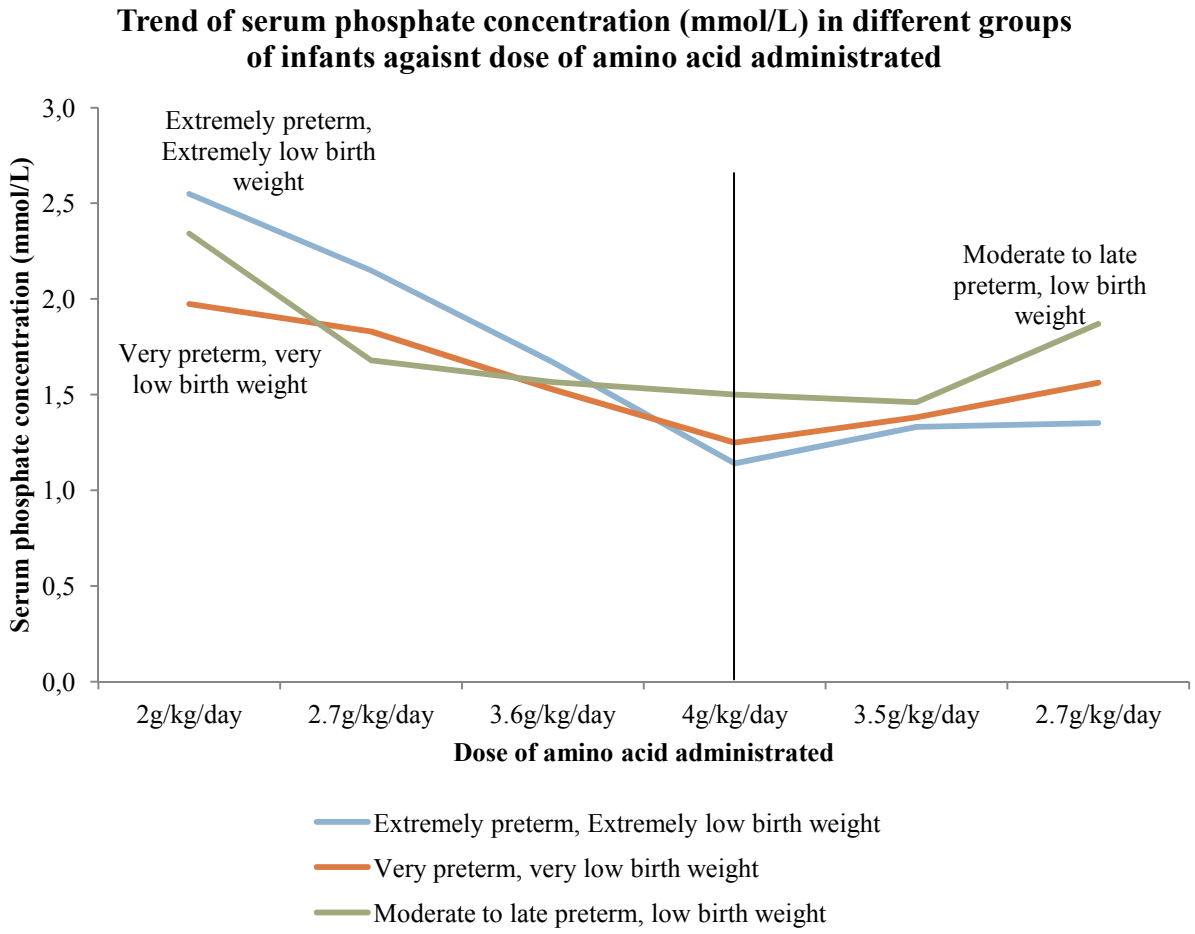


Figure 2: Serum phosphate concentrations change in all infants stratified by amount amino acid intake



In Figure 3, where all infants recruited are categorized under extremely preterm, with extremely low birth weight, very preterm with very low birth weight and moderate to late preterm with low birth weight, hypophosphatemia is found more prominent in extremely preterm infants with extremely low birth weight during highest amino acid supply than moderate to late preterm with low birth weight.In our PN regime, sodium acetate is added. Acetate content has been partially replacing the chloride in the PN bags to reduce hyperchloremic metabolic acidosis and improving serum bicarbonate. Metabolic acidosis is improved when acetate intake increases alongside with increasing total fluid intake.

Figure 3: Serum phosphate concentration change in different groups of infants stratified by amount amino acid intake



There are 12.9% of premature neonates did not regain birth weight after 7 days of PN therapy. As displayed in Table 8, ELBW premature neonates had highest weight growth velocity if compared to LBW premature neonates and term infants. However, they did not have high OFC growth velocity. To calculate weight gain velocity, exponential model (EM) is used. EM can accurately estimates postnatal growth velocity in infants. The equation to calculate EM is Growth velocity = [1000 x ln (W_n/W_1)] / (D_n - D_1), where W_1 is initial weight and W_n is weight at second time point, D is day of life. [8] As shown in Table 9, standard PN per unit bag is slightly more expensive than previous custom PN; however the standard PN is given over 48 hours instead of previous 24 hours making a cost savings of almost half. With current practice, SMOF® lipid emulsion 20% is added with soluble vitamins.

Table 6: Anthropometric characteristics before PN therapy (Outcome: Growth velocity)

Before PN				
	Mean ± SD duration (days)	**Mean ± SD birth weight (grams)**	**Mean ± SD OFC (cm)**	**Mean ± SD body length (cm)**
ELBW (< 1000g)	13 ± 2`	791 ± 130	22.6 ± 2.1	31.7 ± 3.5
VLBW (1000g – 1500g)	10 ± 3	1262 ± 165	25.1 ± 1.8	36.6 ± 2.75
LBW (>1500g - ≤ 2500g)	9 ± 1	1822 ± 304	28.7 ± 1.1	42 ± 2.1
Term (≥ 2500g)	12 ± 3	3118 ± 187	32 ± 0	49.8 ± 1.1
TOTAL	11 ± 3	1210 ± 500	25.5 ± 3.2	35.9 ± 5.1

**SD: Standard deviation*

Table 7: Anthropometric characteristics after PN therapy

After PN			
	Mean ± SD body weight (grams)	**Mean ± SD OFC (cm)**	**Mean ± SD body length (cm)**
ELBW (< 1000g)	1012 ± 142	24.2 ± 1.7	34.4 ± 2.4
VLBW (1000g – 1500g)	1440 ± 219	26.9 ± 1.6	38.4 ± 3.4
LBW (>1500g - ≤ 2500g)	2069 ± 454	29.6 ± 1.7	43.9 ± 2.2
Term (≥ 2500g)	3535 ± 21	33.8 ± 0.4	51 ± 1.4
TOTAL	1388 ± 552	26.2 ± 2.8	37.8 ± 4.7

**SD: Standard deviation*

Table 8: Measured velocity of growth after PN therapy

Velocity of growth			
	Weight gained (g/kg/day)	**OFC gained (cm/week)**	**Length gained (cm/week)**
ELBW (<1000g)	19	0.86	1.45
VLBW (1000g – 1500g)	13	1.26	1.26
LBW (>1500g - ≤ 2500g)	14	0.70	1.48
Term (≥ 2500g)	11	1.05	0.7
TOTAL	14.3	1	1.2

**ELBW: Extremely low birth weight, VLBW: Very low birth weight, LBW: Low birth weight,*

Table 9: Cost of PN bag per unit (inclusive of infusion tubing, filter, lipid tubing and syringes) (Evaluation: Cost analysis)

	200ml	**350ml**	**500ml**	**900ml**
Custom PN	RM 75.28	RM 97.59	RM 120.50	Not available
Standard PN starter	RM 83.64	Only 200mL available		
Standard PN preterm	RM 82.05	RM 109.41	RM 136.73	Not available
Standard PN term	RM 75.41	RM 97.95	RM 120.49	RM 179.88
Standard PN high sodium	RM 83.11	RM 111.24	RM 139.38	RM 210.10
Standard PN 7.5% dextrose	RM 81.86	RM 109.08	RM 136.26	RM 207.80

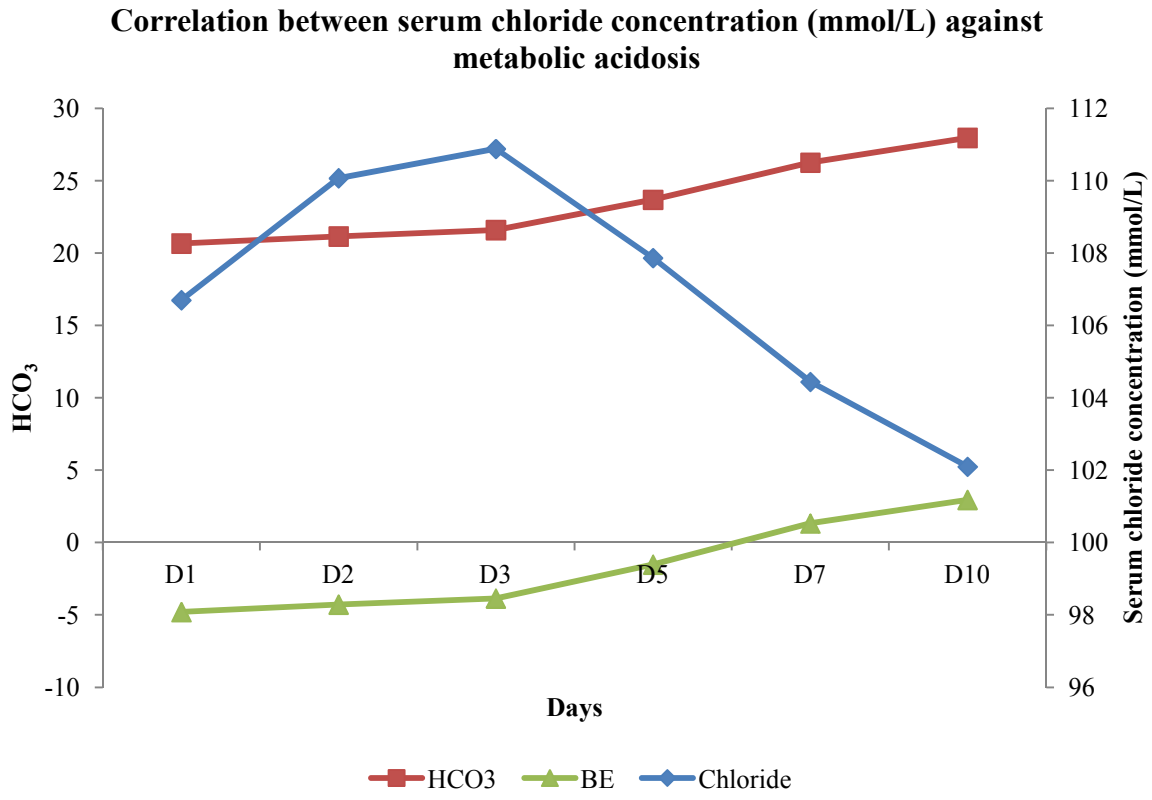
Table 10: Cost of lipid emulsion

		15mL	**30mL**	**45mL**	**60mL**
SMOF® Lipid emulsion 20%	Previous practice	RM 10.00	RM 19.40	RM 26.40	Not available
	Current practice	RM 13.20	RM 30.50	RM 41.20	RM 43.60

Table 11: Annual cost saving

	Annual expenses
Previous practice	RM 309517.20
Current practice	RM 246960.60
Annual cost saving	RM 62556.60

Figure 4: Correlation between serum chloride concentrations (mmol/L) against metabolic acidosis



DISCUSSION

Recent data has been supporting the importance of early aggressive amino acid administration via PN to newborns. The major concerns about early and aggressive delivery of amino acid especially to ELBW infants are the development of azotemia, hyperammonemia and metabolic acidosis.

Various studies also showed that there was no correlation between serum blood urea nitrogen (BUN) and amino acid intake. Restricting amino acid load solely based on serum BUN is not warrant because BUN also represents the complex interaction of hydration, renal function, energy quality and quantity and degree of illness. Rising BUN values are, therefore, not just a reflection of the ELBW infant's intolerance to amino acid infusion. In addition, PN therapy started within 24 hours of life shown to have better weight gains in all infants.

Restriction of amino acid load not only affects anabolic reactions and also it influences velocity of growth in premature infants. In addition, studies have shown that blood urea concentration up to 14 mmol/L in premature infants who receiving PN is acceptable.[2] Serum BUN is high when there is high amino acid oxidation. A study by Ridout *et.al* (2005) showed that there was no correlation between high amino acid intake and urea in preterm infants, especially extremely low birth weight infants, but due to their high rate of protein breakdown.[9] Studies of fetal amino acid oxidation also suggest that higher BUN reflects appropriate amino acid utilization for both energy and lean mass production.[9, 10, 11]

Hypertriglyceridemia is defined as triglyceride level above 2.8 mmol/L. With balanced lipid emulsion commenced at dose 1 g/kg/day at day 1 of PN therapy and increased in steps of 1 g/kg/day on day 2, maximum dose of 3 g/kg/day from day 3 onwards and infusion rate of 0.125 g/kg/hr is relatively safe. With this infusion rate, it also helps in enhancing lipoprotein lipase activity and thus plasma clearance.[12] Intravenous lipid emulsion is not only

helps in improving nitrogen balance, providing non-protein energy source, improved weight gain but also supplying essential fatty acid to premature infants.[13] Brans YW *et al.* also suggested no effects on serum bilirubin with dose of 3 g/kg/day of lipid emulsion.[14]

The mean weight gain of premature infants in our study population is 15.3 g/kg/day, at a rate similar to the intrauterine weight gain of 15 g/kg/day where as term infants had weight gain of 11 g/kg/day, at a rate higher than reported intrauterine growth of 10 g/kg/day at term.[15, 16] ELBW infants have highest growth rate if compared to VLBW infants and LBW infants.[17] In addition, our sample population had average weekly increment in length of 1.2 cm and OFC of 1 cm, which are corresponded to reported intrauterine and postnatal growth of 1 cm/week and 0.5-1 cm/week respectively.[19]

Growth velocity plays a major role in development outcomes and as an indicator of well being of infants. Slowest rate of weight gain in ELBW infants has highest morbidity.[19] A recent study by Ehrenkranz *et al*. also found that growth velocity influences growth and neurodevelopemental outcomes.[19] As the rate of weight gain and OFC increased, the better the neurodevelopment and the least of neurodevelopmental impairment.[19] Another concern of providing PN therapy to premature infants, especially to extremely premature newborns is the incidence of metabolic acidosis. In our PN formulation, sodium acetate is added in to partially replace the chloride to reduce the severity of acidosis and hyperchloraemia. Furthermore, a study by te Braake *et al*. showed that no significant differences in degree of acidosis in infants who received aggressive amino acid nutrition.[20]

Another issue is arising when practice of nurturing premature infants with high amino acid load to enhance anabolism and promote growth. Similar to our result, Francesco Bonsante and colleagues (2013) also found that incidence of hypophosphatemia is high with high amino acid supply via PN therapy.[21] During our study, all premature infants were instituted with same amount of amino acid, however, the severity of hypophosphatemia is less in moderate to late preterm infants with low birth weight, where severe hypophosphatemia is found in extremely preterm infants with extremely low birth weight, as shown in Figure 2. Phosphorus is a main component of Adenosine triphosphate (ATP), membrane phospholipids and nucleic acids. Furthermore, rapid cell growth can be achieved when sufficient amount of nitrogen, potassium and phosphorus is provided. Thus, with the aggressive amino acid supply to promote extrauterine growth to premature infants especially to extremely preterm infants whose growth rate is the highest among all premature infants, results in high metabolism of phosphorus and high uptake of phosphorus into cell, thus affects its plasma concentration.[21] In addition, Mizumoto defined this phenomenon as re-feeding syndrome as nutrition is commenced after intense nutritional deprivation in intrauterine.[22]

On the other hand, by extending PN hang time to 48 hours instead of 24 hours is associated with minimizing TPN related cost. The change of practice also resulted in yearly savings of RM 62556.60, exclusive of labor cost and nursing cost. Another concern about extending hang time is increase risk of line sepsis; however a study by Kiran Kumar Balegar V *et al*. had suggested that no increase in central line–associated blood stream infection (CLABSI) with longer hang time.[23]

CONCLUSION

This single center study has proven that PN therapy is relatively safe to infants. With the standardized PN, it achieved goal of postnatal growth velocity and body composition in premature infants. In addition, the serum concentration of phosphate needs to be closely monitored and the amount of phosphorus needs to be optimized as to reduce the severity of hypophosphatemia condition. This study also demonstrated that the current practice of extending hang time is financially beneficial to hospital and reduced TPN pharmacy and nursing workload.

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