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CLINICAL CHARACTERISTICS AND SOCIO-DEMOGRAPHIC DIFFERENCES OF TOTAL PARENTERAL NUTRITION (TPN) PRACTICES IN A NEONATAL INTENSIVE CARE UNIT (NICU)

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Abstract

Purpose: The objective of this study is to evaluate the clinical characteristics of the neonatal patients receiving total parenteral nutrition (TPN) and also to determine the socio-demographic differences in parenteral nutrition practices. *Design/methodology/approach:* A two-year retrospective cross-sectional observational study design was selected to conduct this study. Subjects of this research were neonatal patients receiving TPN in the Neonatal Intensive Care Unit (NICU) of Hospital Penang, Malaysia. A self-developed data collection form was used in this study, using a single data collector to avoid data collection bias. Data analysis was done via the Statistical Package for Social Science 15.0 (SPSS 15.0).

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Findings: All of the 234 (100%) patients admitted to NICU Hospital Pulau Pinang were included in this study. Among them, the majority (123, 52.6%) were females and the rest (111, 47.4) were males. Ethnic distribution showed a predominance of Malay with 158 (67.5%), followed by Chinese 41 (17.5%), Indian 23 (9.8%) and 12 (5.1%) other races. Most patients (98, 41.8%) were born at 28-31 weeks of gestation and 156 (66.67%) were in the range of 1001-2000 grams. The majority of patients (91, 38.89%) were administered with TPN through the longline route, 173 (73.93%) were started in the range of Day 1 to Day 3 of life, 217 (92.7%) could not tolerate feeding and 51 (21.8%) had an infection. In conclusion, generally, the study found a lack of TPN screening and assessment practices in the study hospital. Appropriate practices are required to reduce the medical complications among neonates.

Keywords: TPN, Pediatrics, Clinical care, Parenteral nutrition

All the authors contributed equally in this manuscript

INTRODUCTION

Malnutrition is a state in which a deficiency of nutrients such as energy, protein, vitamins and minerals causes measurable adverse effects on body composition, function or clinical outcome (NICE, 2006). Malnutrition is both a cause and a consequence of ill health. It is common and increases a patient's vulnerability to disease. Methods to improve or maintain nutritional intake are known as nutrition support (Wilmore and Dudrick, 1968). These include: oral nutrition support – for example, fortified food, additional snacks and/or sip feeds, enteral tube feeding – the delivery of a nutritionally complete feed directly into the gut via a tube and parenteral nutrition: the delivery of nutrition intravenously (NICE, 2006). These methods can improve outcomes, but decisions on the most effective and safe methods are complex (NICE, 2006; Wilmore and Dudrick, 1968)

Ever since the late 1960s, when Wilmore and Dudrick first published their research on central venous alimentation, which promoted growth in an infant (Wilmore and Dudrick, 1968), parenteral nutrition has been an important adjunctive therapy for many patients with catabolic medical conditions, including the elderly. Whether these patients are receiving this therapy in an acute-care setting, a long-term care setting,

or at home, pharmacists should be knowledgeable about the therapy, and be able to assess its effectiveness as well as prevent complications associated with total parenteral nutrition (TPN) (ASCP, 1999).

Over the past four decades, parenteral nutrition (PN) has become an important primary (e.g., intestinal failure) and adjunctive therapy of disease states (ASCP, 1999). PN is commonly used in such conditions as severe pancreatitis, short bowel syndrome, inflammatory bowel disease exacerbations, and gastrointestinal (GI) fistulae, as well as in critically ill patients, infants with very low birth weight, and patients with cancer receiving hematopoietic cell transplantation (Wilmore and Dudrick, 1968; ESPGHAN, 2005).

Tube feeding can be used for a short time, after which the tube is removed and the patient can begin to eat normally again. Tube feeding can be given through different types of tubes (NICE, 2006; ASCP, 1999). One type of tube can be placed through the nose into the stomach or small bowel. This is called a nasogastric or nasoenteral feeding tube. Sometimes the tube is placed directly through the skin into the stomach or small bowel. This is called a gastrostomy or jejunostomy (Wilmore and Dudrick, 1968; ASPEN, 2002; Bankhead *et al.*, 2009).

If the patient is unable (e.g. nausea, frailty) to drink nutritional sip feeds, enteral tube feeding should be considered (NICE, 2006; ASCP, 1999; ASPEN, 2002). The benefits of enteral tube feeding include the following: nutrients are effectively mobilized and utilized compared to parenteral feeding; the function of the gut barrier is preserved, preventing "bacterial translocation" and hence reducing the chance of sepsis; complications are generally less serious than those of parenteral nutrition; it is easier to manage than parenteral nutrition and cheaper than parenteral nutrition (ASCP, 1999; Bankhead *et al.*, 2009). The choice of enteral tube feed depends on: the route of nutritional support, nutritional requirements, impairment of the gastrointestinal tract, and associated clinical conditions (e.g. renal or liver failure) (ASCP, 1999; ESPGHAN 2005; Planas and Camilo, 2002).

Parenteral nutrition (PN) is the intravenous administration of nutrition, which may include protein, carbohydrate, fat, minerals and electrolytes, vitamins and other trace elements for patients who cannot eat or absorb enough food through a tube feeding formula to maintain good nutrition status (Planas and Camilo, 2002; Canada *et al.*, 2009).

Achieving the right nutritional intake in a timely manner can help combat complications and is an important part of a patient's recovery (Canada *et al.*, 2009).

Parenteral nutrition is used for a short time, after which it is reduced or discontinued when the person begins to eat normally again (NICE, 2006). Parenteral nutrition bypasses the normal digestion in the gastrointestinal (GI) tract (ESPGHAN, 2005). It is a sterile liquid chemical formula given directly into the bloodstream through an intravenous (IV) catheter (needle in the vein) (ASCP, 1999; ASPEN, 2002; Planas and Camilo, 2002; Canada *et al.*, 2009). Patients may need PN for a variety of diseases or conditions that impair food intake, nutrient digestion or absorption (Wilmore and Dudrik, 1968). Some diseases and conditions where PN is indicated include, but are not limited to, short bowel syndrome, GI fistulas, bowel obstruction, critically ill patients, and severe acute pancreatitis (NICE, 2006; ASPEN, 2002; Bankhead *et al.*, 2009). Some patients may require this therapy for a short time, but others receive PN at home for a lifetime (Wilmore and Dudrik, 1968; ASCP, 1999; Canada *et al.*, 2009). PN is a life-saving but complex therapy, which is not without risk of complications (NICE, 2006; Wilmore and Dudrik, 1968). Some of these complications include infection, metabolic, and fluid issues. Management by an interdisciplinary Nutrition Support Team can optimize patient outcomes associated with this therapy (Canada *et al.*, 2009; Mirtallo *et al.*, 2004).

Failure of enteral feeding is the main indication for parenteral nutrition (NICE, 2006; Canada *et al.*, 2009; Mirtallo *et al.*, 2004). Enteral tube feeding is inappropriate in proximal intestinal fistulas, intestinal obstruction or post-chemotherapy mucositis (Durfee *et al.*, 2006). Long-term parenteral nutrition is well established and can be delivered at home safely and with an excellent quality of life (Mirtallo *et al.*, 2004).

The objective of this study is to evaluate the clinical characteristics of the neonatal patients receiving TPN and also to determine the socio-demographic differences in parenteral nutrition practices.

METHODOLOGY

Study design

This study is a cross-sectional observational study with retrospective analysis. The subjects of this research were neonate patients receiving

TPN in the Neonatal Intensive Care Unit (NICU), General Hospital Penang, Malaysia. This study aimed to determine drug-drug interaction and drug-TPN interaction among neonatal patients who had received TPN during their hospitalization.

STUDY TIME AND LOCATION

This study was conducted in the Neonatal Intensive Care Unit (NICU), General Hospital Penang, Malaysia. Data were collected by collating all medical records of the patients admitted from January 2008 to December 2009.

POPULATION AND SAMPLING PROCEDURE

The study population were all patients admitted to the NICU from January 2008 to December 2009. The sampling procedure for this study was universal sampling by collecting all available patients' medical record that met our inclusion and exclusion criteria. After inclusion and exclusion criteria, 234 patients were included in this study.

SAMPLING TECHNIQUE

The universal sampling technique was used in this study, using all the patients' medical records available in the medical records office. No information was gathered directly from patients in the ward.

INCLUSION CRITERIA

Inclusion criteria for this study are listed below:

1. Neonatal patients admitted to the NICU between the duration dates of the study.
2. Patients receiving TPN.
3. Patients receiving intravenous drug administration.

EXCLUSION CRITERIA

Exclusion criteria for this study are listed below:

1. Neonatal patients admitted to the NICU outside the dates of the study.

2. Patients admitted to wards other than the NICU.
3. Patients who did not receive TPN.
4. Patients who did not receive intravenous drug administration.
5. Records not available in the record office.

PATIENTS DATA COLLECTION FORM

A self-developed data collection form was used for data collection in this study. A single data collector was employed for data collection to avoid data collection bias. The data collection form comprised the following:

DEMOGRAPHIC DATA

Patients demographic data consisted of gender, race/ethnicity, gestational age, birth weight, gravida parity, multiplicity and mode of delivery.

DISEASE AND TREATMENT

The second part of the data collection form collected information on diagnosis and disease management, including: diagnosis of the current illness and current medication provided (name, dose, frequency, duration, combination and route of administration).

INTRAVENOUS ADMINISTRATION DATA

The third section of the data collection form classified the data for both TPN and intravenous admixture drugs, including: TPN start date, TPN cessation date, duration, route of administration, type of TPN admixture, dose of TPN contents, complications of TPN, reason for TPN administration and reason for discontinuation. IV drugs classification included: dose, frequency, duration, compatibility and drug-drug interaction.

ETHICAL CLEARANCE

Ethical clearance was obtained from both the local institution (Clinical Research Committee CRC) where the study was conducted, and the Ministry of Health Research Ethics Committee (MREC). This study was also registered with the National Medical Research Register (NMRR-09-964-4880) in compliance with current NIH guidelines.

DATA COLLECTION PROCEDURE

The first step of data collection was to determine the subjects by collecting the medical records of all NICU patients admitted between January 2008 and December 2009. They were matched with the inclusion and exclusion criteria. The research subjects were all patients admitted to the NICU receiving TPN at the General Hospital Pulau Pinang, Malaysia. Step two was to record all the information from patients' medical records, such as demographic data, disease and management, intravenous administration data and laboratory test values. All information was recorded on the data collection form. In step three, the data were keyed into Excel and SPSS worksheets for analysis and data interpretation (as seen in the study flow chart).

DATA ANALYSIS

Data analysis was carried out via the Statistical Package for Social Science 15.0 (SPSS 15.0). Data obtained was transferred to tables, histograms and charts to describe patient distribution. Categorical variable such as patients' gender, race, multiplicity, type of diagnosis, treatment regimen and other variables were expressed in frequencies and percentage. Appropriate statistical tests were applied to perform analyses according to the normality of the data.

RESULTS

All 234 (100%) patients admitted to the NICU Hospital Pulau Pinang were included in this study. Among them the majority (123, 52.6%) was females and the rest (111, 47.4) were males. Ethnic distribution showed a predominance of Malay with 158 (67.5%) followed by Chinese (41, 17.5%), Indian (23, 9.8%) and 12 (5.1%) other races. Most of the patients (98, 41.8%) were born at 28–31 weeks of gestation and 156 (66.67%) were in the range of 1001–2000 grams. The majority of patients (91, 38.89%) were administrated with TPN through the longline route, 173 (73.93%) began from Day 1 to Day 3 of life, 217 (92.7%) could not tolerate feeding and 51(21.8%) had an infection. Table 1 shows socio-demographic characteristics of the study population.

The majority of patients were born as singletons (208, 88.9%), preterm (203, 86.75%) and their modes of delivery were: caesarian section 143 (61.11%). Table 2 shows clinical characteristics of pregnancy in the patients.

Characteristic	N (%)
TOTAL	234 (100.0)
Gender	
Male	111 (47.4)
Female	123 (52.6)
Race	
Malay	158 (67.5)
Chinese	41 (17.5)
Indian	23 (9.8)
Other	12 (5.1)
Gestation age	
22 – 24 weeks	1 (0.4)
25 – 27 weeks	25 (10.7)
28 – 31 weeks	98 (41.8)
32 – 36 weeks	79 (33.7)
≥ 37 weeks	31 (13.2)
Birth weight	
< 1000 grams	40 (17.09)
1001 – 1500 grams	99 (42.3)
1501 – 2000 grams	57 (24.36)
2001 – 2500 grams	11 (4.7)
>2500 grams	27 (11.5)
Gravida parity	
G1P0	95 (40.6)
G2P1	59 (25.21)
G3P2	42 (17.95)
Multipara	38 (16.24)

Table 1. Socio-demographic characteristics of the study population

Characteristic	N (%)
TOTAL	234 (100.0)
Multiplicity	
Singleton	208 (88.9)
Twins	14 (6.0)
Triplet	12 (5.1)
Term	
Full term	31 (13.25)
Preterm	203 (86.75)
Mode of Delivery	
SVD	74 (31.62)
Breech	15 (6.41)
Forceps	1 (0.43)
Ventouse	1 (0.43)
Caesarian section	143 (61.11)

Table 2. Clinical characteristics of pregnancy in patients

Cross-comparisons of gender findings showed that both male (76, 48.1%) and female (82, 51.9%) were predominantly Malay. Significant differences (P=0.013) have been showed in term classes of patients: among both male (96, 47.29%) and female, 107 (52.71%) were preterm. Findings also suggested that the majority of both male (67, 46.85%) and females (76, 53.15%) were born via caesarian section. Table 3 shows a comparison of gender differences among various variables.

Ethnic distribution suggested that the preterm majority were Malay (142, 69.95%) followed by Chinese (32, 15.76%), Indian (19, 9.36%)

Table 3. Comparison of gender differences among various variables

Characteristic		Gender		*P* Value*
		Male N (%)	Female N (%)	
Race	Malay	76 (48.1)	82 (51.9)	.621
	Chinese	21 (51.22)	20 (48.78)	
	Indian	8 (34.78)	15 (65.22)	
	Others	6 (50.0)	6 (50.0)	
Multiplicity	Singleton	103 (49.52)	105 (50.48)	.021
	Twin	7 (50.0)	7 (50.0)	
	Triplet	1 (8.33)	11 (91.67)	
Term	Full term	15 (48.39)	16 (51.61)	.013
	Preterm	96 (47.29)	107 (52.71)	
Mode of Delivery	SVD	33 (44.59)	41 (55.41)	.314
	Breech	10 (66.67)	5 (33.33)	
	Forceps	-	1 (100.0)	
	Ventouse	1 (100.0)	-	
	Caesarian section	67 (46.85)	76 (53.15)	
Gestation age	22 – 24 weeks	-	1 (100.0)	.645
	25 – 27 weeks	9 (37.5)	15 (62.5)	
	28 – 31 weeks	49 (49.49)	50 (50.51)	
	32 – 36 weeks	38 (48.10)	41 (51.9)	
	≥ 37 weeks	15 (48.39)	16 (51.61)	
Birth weight	< 1000 grams	17 (42.5)	23 (57.5)	.509
	1001 – 1500 grams	44 (44.44)	55 (55.56)	
	1501 – 2000 grams	30 (52.63)	27 (47.37)	
	2001 – 2500 grams	4 (36.36)	7 (63.64)	
	>2500 grams	16 (59.26)	11 (40.74)	
Gravida parity	G1P0	46 (48.42)	49 (51.58)	.855
	G2P1	30 (50.85)	29 (49.15)	
	G3P2	18 (42.86)	24 (57.14)	
	Multipara	17 (44.74)	21 (55.26)	

and others (10, 4.93%). Malays had significant association (P=0.017) with birth weights of the range 1001–1500 grams followed by 1501–200 grams. Most of them (68, 71.58%) were delivered as a first child, but no significant association was found (Table 4).

Mode of delivery had a significant association (P=0.000) with gestational age. Similarly birth weight (P=0.012) and gravid parity (P=0.000) were also significantly associated with gestational age. Multiplicity showed no significant relation to gestational age (Table 5).

Characteristic		Race				P value
		Malay N (%)	Chinese N (%)	Indian N (%)	Others N (%)	
Multiplicity	Singleton	137 (65.87)	38 (18.27)	21 (10.10)	12 (5.76)	.975
	Twin	11 (78.57)	2 (14.29)	1 (7.14)	-	
	Triplet	10 (83.34)	1 (8.33)	1 (8.33)	-	
Term	Full term	16 (51.61)	9 (29.03)	4 (12.9)	2 (6.46)	.150
	Preterm	142 (69.95)	32 (15.76)	19 (9.36)	10 (4.93)	
Mode of Delivery	SVD	54 (72.97)	7 (9.46)	7 (9.46)	6 (8.11)	.081
	Breech	10 (66.67)	4 (26.67)	-	1 (6.66)	
	Forceps	-	1 (100.0)	-	-	
	Ventouse	-	1 (100.0)	-	-	
	Caesarian section	94 (65.73)	28 (19.58)	16 (11.19)	5 (3.5)	
Gestation age						
	22 – 24 weeks	1 (100.0)	-	-	-	
	25 – 27 weeks	20 (80.0)	3 (12.0)	2 (8.0)	-	.853
	28 – 31 weeks	66 (67.35)	16 (16.33)	9 (9.18)	7 (7.14)	
	32 – 36 weeks	54 (68.35)	14 (17.72)	8 (10.13)	3 (3.8)	
	≥ 37 weeks	17 (54.84)	8 (25.80)	4 (12.9)	2 (6.46)	
Birth weight						
	< 1000 grams	28 (70.0)	6 (15.0)	4 (10.0)	2 (5.0)	
	1001 – 1500 grams	69 (69.7)	12 (12.12)	12 (12.12)	6 (6.06)	0.017
	1501 – 2000 grams	40 (70.18)	12 (21.05)	3 (5.26)	2 (3.51)	
	2001 – 2500 grams	4 (36.36)	5 (45.45)	1 (9.09)	1 (9.09)	
	>2500 grams	17 (62.96)	6 (22.22)	3 (11.11)	1 (3.71)	
Gravida parity						
	G1P0	68 (71.58)	9 (9.47)	12 (12.63)	6 (6.32)	
	G2P1	37 (62.71)	17 (28.81)	3 (5.08)	2 (3.4)	.162
	G3P2	26 (61.9)	10 (23.81)	4 (9.52)	2 (4.77)	
	Multipara	27 (71.05)	5 (13.16)	4 (10.53)	2 (5.26)	

Table 4. Comparison of race with various variables

Table 5.
Comparison of gestational age with various variables

Characteristic	Gestational age					*P* value
	22-24 weeks N (%)	25-27 weeks N (%)	28-31 weeks N (%)	32-36 weeks N (%)	>37 weeks N (%)	
Multiplicity						
Singleton	1 (0.48)	23 (11.06)	90 (43.27)	63 (30.29)	31 (14.9)	.095
Twin	-	2 (14.29)	4 (28.57)	8 (57.14)	-	
Triplet	-	-	4 (33.33)	8 (66.67)	-	
Mode of Delivery						
SVD	1 (1.35)	15 (20.27)	28 (37.84)	15 (20.27)	15 (20.27)	.000
Breech	-	4 (26.67)	8 (53.33)	3 (20.0)	-	
Forceps	-	-	1 (100.0)	-	-	
Ventouse	-	-	-	-	1 (100.0)	
Caesarian section	-	6 (4.20)	61 (42.66)	61 (42.66)	15 (10.48)	
Birth weight						
< 1000 grams	1 (2.5)	16 (40.0)	18 (45.0)	5 (12.5)	-	
1001 – 1500 grams	-	9 (9.1)	54 (54.54)	33 (33.33)	3 (3.03)	0.012
1501 – 2000 grams	-	-	25 (43.86)	31 (54.39)	1 (1.75)	
2001 – 2500 grams	-	-	1 (9.09)	8 (72.73)	2 (18.18)	
>2500 grams	-	-	-	2 (7.41)	25 (92.59)	
Gravida parity						
G1P0	-	17 (17.89)	37 (38.95)	29 (30.53)	12 (12.63)	0.000
G2P1	1 (1.7)	1 (1.7)	25 (42.37)	21 (35.59)	11 (18.64)	
G3P2	-	4 (9.52)	15 (35.71)	17 (40.48)	6 (14.29)	
Multipara	-	3 (7.9)	21 (55.26)	12 (31.58)	2 (5.26)	

Singleton (P=0.015) and preterm (P=0.027) categories had significant association with birth weight of the study population. However, mode of delivery and gravida parity showed no significant association with birth weight. Table 6 provides brief details.

DISCUSSION

The goal of nutrition assessment is to identify any specific nutrition risk(s) or clear existence of malnutrition (ASPEN, 2010). Nutrition assessments may lead to recommendations for improving nutrition status (eg, some intervention such as change in diet, enteral or parenteral nutrition, or further medical assessment) or a recommendation for rescreening (Ukleja *et al.*, 2010; Durfee *et al.*, 2006; Kovacevich *et al.*, 2005). Nutrition assessment has been defined by the American Society of Parenteral and Enteral Nutrition (ASPEN) as "a comprehensive approach to diagnosing nutrition problems that uses a combination of the following: medical, nutrition, and medication histories; physical examination; anthropometric measurements; and laboratory data" ASPEN 1998). A nutrition assessment provides the basis for a nutrition intervention. Our study finding suggested a lack of assessment and screening practices on TPN in the hospital setting (Ukleja *et al.*, 2010; Durfee *et al.*, 2006).

Nutrition assessment performed by a nutrition support clinician is a rigorous process that includes obtaining diet and medical history, current clinical status, anthropometric data, laboratory data, physical assessment information, and often functional and economic information; estimating nutrient requirements; and, usually, selecting a treatment plan. Clinical skill, resource availability, and the setting determine the specific methods used to perform a clinical nutrition assessment (Pesce-Hammond and Wessel, 2005; Russel and Mueller, 2007).

Some techniques and tools used for nutritional assessment (Kaushal *et al.*, 2007) include:

Weight: Weight loss is a useful means of nutritional assessment in the absence of fluid shifts, which often account for sudden changes (ASPEN, 1998).

Body mass index (BMI) (Russel and Mueller, 2007; Kaushal *et al.*, 2007).

Table 6.
Comparison of birth weight with various variables

Characteristic	Birth weight					*P* value
	<1000 grams N (%)	1001-1500 grams N (%)	1501-2000 grams N (%)	2001-2500 grams N (%)	>2500 grams N (%)	
Multiplicity						
Singleton	33 (15.87)	86 (41.35)	51 (24.52)	11 (5.28)	27 (12.98)	0.015
Twin	6 (42.86)	5 (35.71)	3 (21.43)	-	-	
Triplet	1 (8.33)	8 (66.67)	3 (25.0)	-	-	
Mode of Delivery						
SVD	14 (18.92)	26 (35.13)	17 (22.97)	3 (4.05)	14 (18.92)	0.951
Breech	4 (26.67)	6 (40.0)	5 (33.33)	-	-	
Forceps	-	-	1 (100.0)	-	-	
Ventouse	-	-	-	-	1 (100.0)	
Caesarian section	22 (15.38)	67 (46.85)	34 (23.78)	8 (5.6)	12 (8.39)	
Term						
Full term	-	4 (12.9)	2 (6.45)	2 (6.45)	23 (74.19)	0.027
Preterm	40 (19.7)	95 (46.8)	55 (27.09)	9 (4.43)	4 (1.98)	
Gravida parity						
G1P0	23 (24.21)	44 (46.32)	14 (14.74)	4 (4.2)	10 (10.53)	
G2P1	5 (8.47)	24 (40.68)	16 (27.12)	5 (8.47)	9 (15.25)	0.794
G3P2	8 (19.05)	14 (33.33)	14 (33.33)	-	6 (14.29)	
Multipara	4 (10.53)	17 (44.74)	13 (34.21)	2 (5.26)	2 (5.26)	

BMI = weight in kg (height in m)2
Normal BMI = 20–25.

Anthropometry (Pesce-Hammond and Wessel, 2005).
Used for long-term nutritional support.

Measures lean body mass and body fat stores
Mid-arm circumference (MAC): simple estimate of muscle mass
Triceps skinfold thickness (TSF): measure of fat stores
Mid-arm muscle circumference (MAMC): indication of skeletal muscle mass.

Dietary history (Kovacevich *et al.*, 2005; Kaushal *et al.*, 2007).

Allows detailed assessment of oral intake.

Biochemical markers (Russel and Mueller, 2007; Kaushal *et al.*, 2007).

Serum transport proteins (pre-albumin and transferrin) are rarely used for assessment of nutritional status, and albumin can provide useful or confusing information.

A low level of serum albumin with raised level of C-reactive protein is suggestive of sepsis (Russel and Mueller, 2007).

A low level of serum albumin and normal level of C- reactive protein is suggestive of dilution, increased losses or reduced synthesis (Kaushal *et al.*, 2007).

A rising level of albumin after critical surgical illness confirms that the patient is free of sepsis and being adequately nourished (ASPEN, 1998).

PN is commonly indicated in neonates experiencing congenital malformation of the gastrointestinal tract, gastroschisis, meconium and paralytic ileus, short bowel syndrome, necrotizing enterocolitis (NEC), respiratory distress syndrome, extreme prematurity, sepsis and malabsorption. The ability to provide PN and TPN over the past four decades has significantly improved the overall survival of newborns when other options of adequate nutritional support were not possible (Brine and Ernst, 2004).

The goal of TPN is to initially provide sufficient nutrients to prevent negative energy and nitrogen balance and essential fatty acid deficiency and support normal rates of intrauterine growth of appropriate composition without increased significant morbidity (Ukleja A *et al.*, 2010; Durfee *et al.*, 2006; Russel and Mueller, 2007; Brine and Ernst, 2004). Fear of toxicity and metabolic imbalance has alerted clinicians to use TPN with caution, especially in the sickest and most premature infants (Kaushal *et al.*, 2007). An increasing number of practitioners appreciate that this cautionary management has resulted in the suboptimal nutrition intake of these infants (Lemons *et al.*, 2001). Practitioners have speculated that this cautionary practice contributed in part to national growth failure outcome statistics published for infants extremely low in birth weight (ELBW; less than 1,000 grams) and appropriate for gestational age (AGA; weight $\geq 10^{th}$ percentile norm) born from 1995 to 1996. When assessed at discharge ($\approx$ 36 weeks' corrected age), 99% of these infants had significant growth failure with weights less than the 10th percentile compared with intrauterine growth standards (Brine and Ernst, 2004; Lemons *et al.*, 2001). Longer-term statistics indicate that a significant percentage of infants born very low in birth weight (VLBW; less than 1,500 grams) may suffer substantial neurodevelopmental deficits in part attributable to inadequate nutritional support in the neonatal period (Hack and Fanaroff, 1999). In more recent years, the earlier introduction and more aggressive advancement of TPN was shown to be safe and effective, even in the smallest and most immature infants (Thureen, 1999; Thureen and Hay, 2000, Thureen *et al.*, 2003; Heird, 1999; Poindexter and Denne, 2003).

Timely intervention with TPN begins with the provision of glucose as soon as possible after birth with amino acids within the first 12 hours, intravenous fat within the first 24 to 48 hours, and trophic feeding within the first 24 hours (Wilson *et al.*, 1997). Optimal use of routine TPN for nutritional support of ELBW and VLBW infants may influence short-term outcomes such as lower propensity to infection and shortened hospital stay, as well as longer-term outcomes such as decreased growth deficits, improved neurodevelopment, and overall morbidity (Hay, Lucas and Heird, 1999; Dusick *et al.*, 1998; Vohr, Wright and Dusick, 2000).

Incompatibilities include physico-chemical reactions occurring *in vitro*. Pharmacological interactions take place *in vivo* and affect drug action (synergy or antagonism, adverse drug reactions) (Vohr, Wright and Dusick, 2000). All-in-One mixtures constitute the standard for

parenteral nutrition; in the ready-to-use form they show restricted stability and shelf life (Lemon *et al.*, 2001; Vohr, Wright and Dusick, 2000). The high number of chemically reactive components and the oil/water (o/w) emulsion character of lipid-containing AIO admixtures represent a most complex vehicle for drug admixing (Hardy, Ball and McElroy, 1998). Incompatibilities may result from direct reactions between soluble components, but also from reactions with the container material or with the gas (oxygen) present in the container. These physico-chemical reactions depend on concentration, temperature, and other co-factors like light exposure, catalysts (trace elements), etc., (King, Catania, 2002; Mühlebach, 2009; August *et al.*, 2002). When drugs are added via a Y-site infusion or injection, or by a three-way stopcock, except for the exposure time (time-dependent reactions), there is no general difference regarding incompatibility reactions in this situation (August *et al.*, 2002).

CONCLUSION

Generally, the study concluded that there is a lack of TPN screening and assessment practices in the study hospital. Study findings concluded that both gestational age and birth weight are significant factors for parenteral use among neonates. The Malay race is predominant in TPN use compared to other races. A high rate of infections associated with TPN use has also been found.

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