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Original Research Article

Recommendation of an ideal mixed fluid preparation to be used as partial parenteral nutrition in surgical Neonatal Intensive Care Unit

Arindam Ghosh, Aniruddha Basak, Dibyarup Datta Pramanik, Prafulla Kumar Mishra*

Department of Pediatrics, Surgery, N R S Medical College and Hospital, Kolkata, West Bengal, India

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***Correspondence:**
Dr. Prafulla Kumar Mishra,
E-mail: mishraprafulla54@gmail.com

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ABSTRACT

Background: This study was conducted to assess the role of Partial Parenteral Nutrition (PPN) and a specially prepared "mixed fluid formula" used as PPN in sick surgical neonates.
Methods: This single institution based Randomised Control Trial was performed in Surgical NICU of a tertiary care Centre. Surgical neonates who required bowel rest for >3 days like Esophageal Atresia (22), Duodenal Atresia (38), Jejuno-Ileal Atresia (50), Necrotising Enterocolitis (29) and others (11), were chosen. As a CONTROL population half (75) neonates were allowed maintenance fluid only (Isolyte P) and rest (75) were given a combination of maintenance fluid (Isolyte P) and PPN (specially prepared mixed fluid). This mixed fluid each 100 ml was prepared with 65ml Isolyte P, 15 ml 25% Dextrose, 10 ml Normal Saline, 7 ml Astymin 3, 2 ml Multivitamin and 1 ml Injection KCl. Fluid was continued till enteral feeding was established.
Results: Neonates according to their body weight were divided in three groups <1 kg (50), 1-2.5 kg (71) and >2.5 kg (29) and their post-operative outcome was assessed as Clinical Positive/Negative and Laboratory Positive/Negative. Results were separately assessed in 3 body weight groups under "Control" and "Study" which showed both Clinical and Biochemical improvement in "Study group".
Conclusions: The composition of mixed fluid, its nutritional value, calorie supplementation, compatible osmolarity for peripheral venous administration and most importantly its easy and cost-effective preparation were assessed thoroughly and we recommend this "mixed fluid" preparation as a very useful PPN for sick surgical neonates.

Keywords: Calorie requirement, Osmolarity, Partial parenteral nutrition, Post-operative IV fluid, Surgical neonate

INTRODUCTION

Sick surgical neonates and neonates with medical co-morbidities and Low Birth weight are very delicate and require intensive care and observation. Surgical outcome in Neonates and infants depend on various factors - preoperative (hydration, nutrition); operative (skill, suture materials etc.) and post-operative (fluid and electrolyte balance, antibiotics and infection control and nutrition).

Among these, it has been observed since last decade, importance is given on Nutrition and fluid electrolyte balance.[1-4] Early initiation of Enteral feeding (EN) begets better result but in some Gastro Intestinal surgeries prolong intestinal rest is needed thus requires Parenteral Nutritional (PN) support.

Normal neonatal physiology is different from adults. All babies are born with an excess of Total Body Water (TBW), mainly Extra Cellular Fluid (ECF). Adults have 60% water (20% ECF, 40% ICF) whereas Term neonates have 75% water (40% ECF, 35% ICF) and Preterm neonates have more water (23 weeks: 90% ;60% ECF, 30% ICF).[4-7] High water content provides a large volume

of distribution for water soluble medications which has great anaesthetic and post-operative implication.[8]

After birth, there is efflux of fluid from ICF to ECF - these floods the neonatal kidneys eventually resulting in a salt and water diuresis by 48-72 hours which is commonly known as Physiological weight loss in new born. But the neuroendocrine stress response due to surgery or medical illness results in substantially increased secretion of anti-diuretic hormone (ADH) that will result in retention of free water. A physiologically more appropriate approach during these circumstances is to use a solution with a 'close to physiological' concentration of sodium (120- 140 mmol/litter) combined with the administration of a reduced infusion volume compared with the normal situation (50-70% of normal infusion rate).[9,10]

Sick newborns premature and under-weights (LBW, VLBW) usually have increased caloric and protein requirements. Along with-it sick neonates after surgery lack glycogen stores. So, hyporglycemia is more commonly encountered. It causes brain damage. Again, hyperglycemia causes Osmotic diuresis resulting in dehydration and electrolyte imbalance. So, the optimum concentration of Dextrose in mantainance fluid is very important.[11-13]

The common and prime composition of an ideal PN includes Protein, Carbohydrate, Fat, Vitamin, Minerals and Electrolytes which should fulfil caloric requirement and osmolarity for peripheral administration.[11-18] Keeping all these in mind and for the nutritional supplementation of Sick neonates we are using a mixed preparation of "fluid formula" for this sick newborn and sick surgical neonates, LBW, VLBW who need a long term (>3 days) parenteral therapy in the Neonatal surgery unit.

Authors commonly use this preparation for patients where oro -enteral nutrition is contraindicated for >3 days and where intestine needs rest for prolonged period thus require long term parenteral nutrition. They are

- Esophageal Atresia (and/or Tracheo Esophageal Fistula),
- Duodenal Atresia,
- Jejuno Ileal atresia,
- Necrotising Enterocolitis (and/or perforation)
- Meconeum ileus with jejunostomy or ileostomy,
- Short bowel syndrome due to resection of long length of bowel (Volvulus, Gangrene),
- Other upper gastro intestinal surgeries requiring long term parenteral therapy.

METHODS

Study population was conducted in the Surgical NICU (Neonatal Intensive Care Unit) of Paediatric Surgery Department in a Tertiary Care Hospital during January 2018 to February 2020.

Total 150 sick neonates were included in the study. 75 were under "STUDY" group and 75 under "CONTROL" group. A Randomised Control Study was conducted with randomisation of patient selection among all Surgical Sick Neonate. Out of that 150 patients 29 weighted >2.5 kg, 50 patients <1kg and rest (79) 1-2.5kg.

Administered fluid amount

Administered fluid amount varies according to body weight (Table 1).

Table 1: Fluid requirements for sick neonates[13]

Days	<1 kg	1-2.5 kg	>2.5 kg
1	100*	80	60
2	120	100	80
3	140	120	100
4 and onward	150	140	120-150

*fluid requirement in ml/kg/day

Administered type of fluid

In this Randomised control study we randomly selected patients for two groups (Table 2).

Table 2: Administered type of fluid.

Study group	Control group
50% Maintenance fluid (Isolyte P) + 50% PPN (Mixed Fluid)	Maintenance fluid only (Isolyte P)

Maintenance fluid was used Isolyte-P and PPN was mixed fluid preparation

PPN composition and preparation

This PPN preparation contains 6 components in 100 ml fluid

Isolyte P	65 ml
Normal Saline	10 ml
25% Dextrose	15 ml
Astymin 3	7 ml
Multivitamine	2 ml
Injectin KCl	1 ml
……..	
	100 ml

This PPN "mixed fluid" is prepared in NICU with maintaining complete asepsis. Authors have taken all precaution to avoid bacterial contamination during preparation of mixed fluid.

Inclusion criteria

Authors used this preparation for patients who require long term (>3days) Parenteral Nutrition (PN) for intestinal rest. For the purpose of study, they were broadly divided in 5 groups

- Esophageal Atresia and TEF (EA)
- Duodenal Atresia (DA)
- Jejuno Ileal atresia (JIA)
- Necrotising Enterocolitis (NEC)and/or perforation
- Others

Meconeum ileus with jejunostomy or ileostomy,
Short bowel syndrome due to resection of long length of bowel (Volvulus, Gangrene),
Other upper gastro intestinal surgeries requiring long term parenteral therapy.

Exclusion criteria

- Other congenital abdominal wall defects like Gastroschisis etc were not included in the study.
- Few neonates required Total Parenteral Nutrition (TPN) where enteral feeding was not possible due to very high output Stoma.
- Neonate whose parents were not willing to undergo study were also excluded.

Duration of fluid therapy

After starting PPN monitoring was done on Clinical, Biochemical, Hematological and sepsis screening criteria till initiation and establishment of full enteral feeding. The amount of fluid was decreased gradually with increase of oral/enteral feeding.

Outcome assessment

For the purpose of Study and its outcome we focused both on Subjective and Objective responses. Assessment for "POSITIVE" and "NEGATIVE" response was calculated based on few criteria. They were

Clinical (5)

- SEPSIS
- General Condition (Cry/Reflex/Activity)
- Weight Gain
- Bowel movement (IPS/NG tube suction/Stool)
- Wound status (dehiscence/anastomosis)

Laboratory (5)

- Sepsis screen
- Hemoglobin
- Electrolytes
- Blood glucose
- LFT (Albumin, Total protein) and pre-albumin

Assessment of outcome was graded as

- "Clinical positive" (CP) if No Sepsis with any other 2 clinical improvement
- "Clinical negative" (CN) if Sepsis with any other 2 clinical deterioration
- "laboratory positive" (LP) if Sepsis screen negative with any 2 normal laboratory value
- "laboratory negative" (LN) if Sepsis screen positive with any 2 abnormal laboratory value

RESULTS

In this Study authors used Intravenous Fluid as postoperative parental nutrition in total 150 patients. 75 of them were in Control Group who received maintenance fluid only and other 75 were in Study group who received additional "Mixed Fluid" as Parental Nutrition. Patients of both the groups were chosen randomly.

Among these 150 patients, babies with body weight of <1, 1-2.5 and > 2.5 kg are 24, 36 and 15 in Study group and 26,35 and 14 in Control group respectively.

Average duration of fluid therapy in Control group is 5.6 days (minimum 4 days and maximum 10 days) where as in Study group 4.9 days (minimum 4 days and maximum 9 days).

Clinical response

Authors monitored the clinical response in all 150 patients and for statistical calculation we categorised them into "Clinical Positive" and "Clinical Negative" according to 5 criteria.

Sepsis

In postoperative period during fluid therapy total 37 patients had features of Septicaemia which were treated conservatively according to blood culture sensitivity report. 23 were under "Control group" and 14 under "Study group". Despite common belief of increased chance of infection in "Mixed fluid" our study shows a marked difference in outcome probably due to over cautious preparation of fluid in NICU under strict asepsis control. Authors also emphasised our outcome assessment of both clinical and laboratory parameters based in "Sepsis" and "Sepsis screening" negativity.

General condition

General condition of neonate in terms of Cry, Reflex and Activity there were no difference in both groups. In Study and Control Group it is 36 and 32 respectively.

Weight gain

Weight gain during fluid therapy in "Study group" is significantly high (37) compared to "Control group" (19).

Though in majority of cases actual weight gain could not be assessed, in measurable cases average weight gain was noted 15-20 gm/day.

It is also a well-known fact that in postoperative period weight gain depends on different factors like Birth weight, prematurity, other co-morbidities, loss of fluid in Stoma and other third space loss etc.

Bowel movement

Bowel movement was established in almost all post-operative patients except 4 who had post-operative paralytic ileus and was treated conservatively (correction of electrolytes) and most importantly all were under "Control group". Study group had no electrolyte abnormality causing paralytic ileus.

Anaestomotic leak

Anaestomotic leak was seen in 6 patients - 5 in "Control group" and 1 in "Study group". All were treated conservatively. Wound dehiscence was seen in 14 patients among them study group had only 3.

According to above 5 criteria and for the purpose of statistical analysis we marked "Clinical Positive" to a neonate without Sepsis with any 2 positive clinical criteria and "Clinical Negative" to a baby with Sepsis with any 2 negative clinical criteria.

In this study we found "Clinical Positive" 61 and 37 in "Study" and "Control" group respectively.

Laboratory response

Laboratory values were again assessed and divided into "Laboratory Positive" and "Laboratory Negative" based on 5 criteria. In our study "Laboratory Positive" and "Laboratory Negative" outcome seen in Study group 61 and 14 respectively.

Sepsis

Sepsis screen was positive in 27 patients in "Control group" and 14 in "Study group".

Haemoglobin

Haemoglobin level was normal in most of the patients. Only 8 had anaemia- 4 in each "Study" and "Control group".

Electrolyte and serum calcium

Electrolyte and Serum Calcium abnormality was found in 20 patients of "Control group" and much less in "Study group" (only 4).

Hypoglycemia

Hypoglycemia was seen in 21 neonates with Maintenance fluid and only 6 in neonates having "Mixed Fluid".

Liver function test (LFT) and albumin

Liver Function Test (LFT) and Albumin was normal in most of "Study Group" neonates. Only 3 had abnormality compared to 10 in "Control group".

In 75 "Control Group" neonates Esophageal Atresia (EA) was 10, Duodenal Atresia (DA) 20, Jejuno Ileal Atresia (JIA) 25, Necrotising Enterocolitis (NEC) 15 and Other 5 (Table 3).

Table 3: Control group.

Disease	Response	Clinical			Biochemical		
		<1kg	1-2.5kg	>2.5kg	<1kg	1-2.5kg	>2.5kg
DA (20)	Positive	2	5	3	2	5	3
	Negative	3	5	2	3	5	2
	Total	5	10	5	5	10	5
EA (10)	Positive	1	2	1	1	2	1
	Negative	3	2	1	3	2	1
	Total	4	4	2	4	4	2
JIA (25)	Positive	4	6	3	3	6	3
	Negative	6	5	1	7	5	1
	Total	10	11	4	10	11	4
NEC (15)	Positive	2	4	1	2	5	1
	Negative	3	4	1	3	3	1
	Total	5	8	2	5	8	2
Others (5)	Positive	1	1	1	1	1	1
	Negative	1	1	0	1	1	0
	Total	2	2	1	2	2	1

Table 4: Study group.

Disease	Response	Clinical			Biochemical		
		<1kg	1-2.5kg	>2.5kg	<1kg	1-2.5kg	>2.5kg
DA (18)	Positive	3	8	5	3	8	5
	Negative	1	1	0	1	1	0
	Total	4	9	5	4	9	5
EA (12)	Positive	2	5	2	2	5	2
	Negative	2	1	0	2	1	0
	Total	4	6	2	4	6	2
JIA (25)	Positive	6	10	4	6	10	4
	Negative	2	2	1	2	2	1
	Total	8	12	5	8	12	5
NEC (14)	Positive	4	6	2	4	6	2
	Negative	2	0	0	2	0	0
	Total	6	6	2	6	6	2
Others (6)	Positive	1	2	1	1	2	1
	Negative	1	1	0	1	1	0
	Total	2	3	1	2	3	1

In 75 "Study Group" neonates Esophageal Atresia (EA) was 12, Duodenal Atresia (DA) 18, Jejuno Ileal Atresia (JIA) 25, Necrotising Enterocolitis (NEC) 14 and Other 6 (Table 4).

Among all EA patients "Clinical positivity" increased in increasing body weight- 50%, 83.3% and 100% in neonates with body weight <1,1-2.5 and >2.5 kg respectively. In "Control group" the ratio is much lower 25%, 50% and 50% respectively.

For neonates with DA, JIA and NEC the results are again better in "Study Group" and improved with increased body weight as depicted in Table 2 and 3. Even the laboratory outcome is corroborating with the clinical values.

Another important observation is that in Extremely Low Birth Weight (ELBW) babies (BW <1 kg) the outcome improves with the use of "Mixed Fluid". For LBW babies with EA, DA, JIA and NEC "Clinical Positivity" was 25, 40, 40 and 40% respectively in "Control Group" which found to be 50, 75, 75 and 66.67% in "Study Group".

DISCUSSION

Parenteral nutrition (TPN or PPN) is the intravenous infusion of all nutrients necessary for metabolic requirements and growth.[11]

In this Study we used "Mixed Fluid preparation" as PPN in Sick Surgical Neonates who required bowel rest for >3days like neonates with EA, DA, JIA, NEC and other condition with short bowel syndrome.

Earlier introduction and more aggressive advancement of TPN is safe and effective, even in the smallest and most immature infants. Premature infants tolerate PN from day 1 of post-natal life.

Thus, it is important to start PN within the first 24 hours of life in the smaller preterm infants <1000 grams birth weight.[12,14-18]

In this Study authors categorically monitored the outcome of babies with different body weight groups and noted an improved outcome even in Extremely Low Birth Weight Babies. The results support effectiveness of our PN preparation.

Table 5: Isolyte P composition.

Isolyte P Composition [20]		
Components (100 ml contains)	**Individual amounts**	
Dextrose anhydrous 5gm	Na^+	23meq/l
Potassium Chloride 0.13gm	K^+	20meq/l
Sodium Acetate 0.32gm	Mg^{+2}	3meq/l
Di basic potassium phosphate 0.026gm	Cl^-	22meq/l
	Acetate	24meq/l
Magnesium chloride 0.031gm	Phosphate	3 meq/l
	Total cations	46
	Total anions	43
	Calorie	170 Kcal/l
	Osmolarity...366mOsm /l	
	pH	5.0(4.0-6.0)

Table 6: Astymin 3 composition.

Composition of astymin 3[21]	
Essential amino acid	13.84 gm
Total nitrogen content	2.62gm
Protein content (high biologic value)	16.38 gm
Total amino acid	18.24 gm
Energy content	105 Calorie.
Osmolarity	1000 mOsmol/ L

The goal of TPN is to provide sufficient nutrients to prevent negative energy and nitrogen balance and to support normal growth rates without increased significant morbidity.[12,14-18]

Good clinical outcome as measured by "Clinical positivity" is a reliable indicator of effectiveness of a good Parenteral Nutrition formula (TPN or PPN) and in "Study group" it is higher.

Table 7: Multivitamine injection (paediatric) composition.

Multivitamine injection (paediatric) composition[22]	
Fat soluble vitamines*:	**Water soluble vitamins**:**
Vitamin A 2300 USP units	Riboflavin 1.4 mg
Vitamin D 400 USP units	Thiamine 1.2 mg
Vitamin E 7 mg equals 7 USP units	Vitamin B6 1.0 mg
*with 30% Propylene glycol and 2% Gentisic acid ethanolamide as stabilizers and preservatives Sodium hydroxide for pH adjustment; 1.6% Polysorbate 80; 0.028% polysorbate 20; 0.002% butylated hydroxyl toluene; 0.0005% butylated hydroxyanisone	Vitamin C 80 mg
	Vitamin B12 1 mcg
	Folic acid 140 mcg
	Dexpanthenol 5.0 mg
	Niacin 17 mg
	Biotin 20 mcg
	**Fat soluble vitamins are water stabilised with Polysorbate 80.

Vitamin K - 200 mcg (Not included in the solution, separately given through injection).

Table 8: 25% Dextrose solution composition.

25% Dextrose solution composition[23]	
1 ml solution contain	250 mg Dextrose
Each ml solution gives energy	0.85 Kcal (@3.4 Kcal/gm)
Osmolarity	1390 mOsmol/L
pH	4.5 (3.2 - 6.5)

The essential components of parental nutrition are - Fluid, Carbohydrate, Amino Acid, Lipids, Electrolytes, Vitamins and Trace minerals and the Goal is to provide adequate energy (calorie).[14-18]

This preparation 100 ml TPN contain:

Isolyte-P	65ml
25%dextrose	15ml
Normal saline (0.9%)	10ml
Astymine-3	7ml
MVI	2ml
KCL	1ml

Individual composition of available components like Isolyte P (Table 5), Astymin 3 (Table 6), Multivitamine Injection (Paediatric) (Table 7), 25% Dextrose Solution (Table 8), Normal saline (0.9%) (Table 9), Injection KCl (Table 10) are discussed and total calorie value of the Mixed fluid is calculated (Table 11).

Table 9: Normal saline (0.9%) composition.

Normal saline (0.9%) composition[24]	
Sodium	154 meq/L
Chloride	154 meq/L
Osmolarity	308 mOsmol/L

Table 10: Injection KCL composition.

Injection KCL composition[25]	
10% KCL contain in10 ml	
Potassium	13.4 meq
Chloride	13.4 meq
Osmolarity	4000 mOsmol /L

Osmolarity of individual components and total osmolarity of the fluid preparation is also calculated (Table 12). To decrease the likelihood of phlebitis, the osmolarity of Partial Parenteral Nutrition (PPN) should be 600-900 mOsmol/L.[26] However, some paediatric data suggest the PPN osmolarity limit should be 500-700 mOsmol/ L yet A.S.P.E.N. (American Society for Parenteral and Enteral Nutrition) recommends a limit of 900mOsmol/L.[27]

This fluid composition (PPN) yields 30 Kcal energy per 100 ml mixed fluid which is lower than the recommended TPN calorie value of 90-110 Kcal/kg/day. Low calorie yielded from this PPN formula is as par with requirement for short Pre- and post-operative period till oral feed is resumed to tide over the crisis period.[14-18]

To avoid Re-feeding syndrome which is fatal in sick babies, we prefer to offer them low Calorie and Low Amino acid Formula.[15,17]

Though Lipids prevent essential fatty acid deficiency, provide energy substrates and improve delivery of fat-soluble vitamins, it is noted that LBW infants may have immature mechanisms for fat metabolism. Also, some conditions inhibit lipid clearance e.g. infection, stress, malnutrition. Moreover, Lipid component increases fluid osmolarity which is unfavourable for a peripheral intravenous line. Lastly this lipid emulsion is a good

culture medium for bacterial overgrowth causing septicaemia.

Lastly, neonatal requirement of essential fatty acid is low (0.5-1mg/kg/day) so lipid component is excluded in this study.[14-18] The recommended values of Carbohydrate, Amino acid, Electrolytes, Minerals and Vitamin are close to the composition's individual values as well as a complete fluid with adequate adjustment of osmolarity.

Authors can compare daily requirement of nutrients for Surgical Neonate and amount supplied by the "Mixed fluid" preparation as Partial Parenteral Nutrition (PPN) from Table 13.

Table 11: Calorie calculation of mixed fluid.[20-25]

	Ml	Glucose (g)	Amino acid (gm)	Electolytes			Trace elements			Vitamine (ml)	Calorie value (kcal)
				Sodium (meq)	Potassium (meq)	Chloride (meq)	Mg^{+2} (meq)	$HPO4^{-2}$(meq)	Acetate (meq)		
Isolyte P*	65	3.25	-	1.49	1.24	1.43	0.195	0.195	1.56	-	12.675
(0.9%) NS	10	-	-	1.54	-	1.54	-	-	-	-	-
25% D	15	3.75	-	-	-	-	-	-	-	-	14.625
Astymin 3**	7	-	0.9	-	-	-	-	-	-	-	3.6
10%KCL	1	-	-	-	1.34	1.34	-	-	-	-	-
MVI	2	-	-	-	-	-	-	-	-	2	-
Total=	100	7.0	0.9	3.03	2.58	4.31	0.195	0.195	1.56	2	30.9

Table 12: Osmolarity calculation.[20-25]

Component	Amount (ml)	Osmolarity (mOsmol/L)
Isolyte P	65	340
Normal saline (0.9%)	10	308
25% Dextrose	15	1390
Astymin 3	7	1000
Multivitamine injection	2	500
Injection KCL	1	4000
Total	100	587

The major benefit of this fluid is that the preparation is very easy and cost-effective in comparison to commercially available TPN.

In Indian scenario this preparation may be useful keeping in mind its cost benefit ratio. Though the preparation of mixed fluid within the Ward atmosphere without laminar flow carries the risk of infection we have taken all precaution to avoid bacterial contamination during preparation of mixed fluid.

Authors have formulated the composition in 100 ml solution so that it can be easily calculated by multiplication or fraction of fluid requirement (60-100ml/kg/day). This study clearly showed the difference in outcome (clinical and laboratory) in sick surgical neonate which is better in Study group compared to Control group as explained earlier. Authors deviate in the amount of the different composition of mixture in specific situations like very low birth weight baby and other abdominal wall defects like Gastroschisis (excluded in this study). Further study with this "mixed fluid" preparation is required for comparison of outcome with commercially available TPN and also its role in other congenital anterior abdominal wall defects like Gastroschisis etc. Again, emphasising on its best part that it can be easily prepared in the NICU, we recommend this fluid for the sick surgical neonat.

Table 13: Daily requirement of components and comparison with our PPN.[14-18]

Component	Normal Daily Requirement	Amount present in PPN	Remarks
Carbohydrate	1.5-20 gm (Rate of infusion 1-2 mg/kg/min to 15 mg/kg/min)	7 gm (energy 3.4 Kcal/gm)	Adequate
Amino acid	0.5-1 gm/kg	0.9 gm	Adequate
Lipid	0.5-1 gm/kg	Nil	Osmolarity is maintained for peripheral vein administration
Sodium	2-3 meq	3.03 meq	Adequate

Component	Normal Daily Requirement	Amount present in PPN	Remarks
Potassium	1-3 meq	2.58 meq	Adequate
Magnesium	0.25-0.5 meq	0.2 meq	Near normal
Multivitamine	1-2 ml	2 ml	Adequate
Calorie	90-100 Kcal (30-40 Kcal/day energy is required for normal body catabolism)	30.7 Kcal	Low Calorie yield for short period and to prevent re-feeding syndrome and to avoid Central Venous Line

CONCLUSION

Surgical outcome in recent times, especially in sick surgical neonates and very low birth weight babies, depends upon Nutrition both enteral and parenteral. As a part of parenteral nutrition our "mixed fluid" preparation is scientific, easy to prepare, components comprise of recommended daily requirements, supply adequate calorie requirement, osmolarity is compatible for peripheral veins and lastly cost effective. So, authors recommend use of this "mixed fluid" preparation for sick surgical neonates where parenteral nutrition is required.

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