Lipids

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Polish Society for Enteral, Parenteral Nutrition and Metabolism
Conflict of interest

Speaker's honoraria: Baxter, B Braun, Fresenius Kabi, Nestle, Nutricia, Shire, Vipharm

Consultant’s honoraria: Baxter, B Braun, Fresenius Kabi, Nestle, Therachon

Main/ co-author: ESPEN guidelines in Surgery, ESPEN guidelines in Gastroenterology, ESPEN definition of malnutrition, Acute Intestinal Failure Position Paper, ESPEN Recommendations on intestinal failure
Stanley Dudrick’s Memorial Hospital in Skawina, Poland
Intestinal Failure Center at Stanley Dudrick’s Memorial Hospital in Skawina

1999-2018
Number of Home Artificial Nutrition Patients
HPN Center in Krakow/ Skawina
(est. 1999)

January 2019

142 pts/ day
Why should we talk about lipid emulsions?

They can change the outcome of our treatment!
What Is a Fatty Acid?

Fatty acids are hydrocarbon chains with a methyl group at one end of the chain and a reactive carboxyl group at the other end.

\[ \text{Methyl terminus} \quad \text{Variable length hydrocarbon chain (n=2 to 28)} \quad \text{Reactive carboxylic acid} \]

\[ \text{H}_3\text{C}-\text{CH}_2(n)-\text{COOH} \]

Fatty acids may be classified according to 3 characteristics

- **Chain length**: the number of carbon atoms
- **Degree of saturation**: presence and number of double bonds
- **Omega (ω) classification**: position of the first double bond relative to the non-carboxylic (i.e. methyl) end of the carbon chain

**Example:**

Oleic acid 18:1 n-9

Fatty Acid Classification: Chain Length

Long-chain fatty acids (LCT)
• Fatty acids ≥14 carbons long

Medium-chain fatty acids (MCT)
• Fatty acids 6 to 12 carbons long

Short-chain fatty acids
• Fatty acids 2 to 4 carbons long
• Not used in PN

Fatty Acid Classification: Saturation

**Saturated Fatty Acids (SFA):**
- No double bonds in carbon chain
- Example: Stearic Acid

**Monounsaturated Fatty Acids (MUFA):**
- 1 double bond in carbon chain
- Example: Oleic Acid

**Polyunsaturated Fatty Acids (PUFA):**
- ≥2 double bonds in carbon chain
- Example: Linoleic Acid

The \( \omega \) nomenclature refers to the distance, in carbons, of the first double bond from the \( \omega \) (non-carboxylic acid) end of the carbon chain.

**\( \omega-3 \):** first double bond is 3 carbons from the \( \omega \) end

\[
\text{H}_3\text{C} \quad \text{COOH}
\]

\( \omega \)-end

\( \alpha \)-Linolenic Acid (18:3 n-3)

**\( \omega-6 \):** first double bond is 6 carbons from the \( \omega \) end

\[
\text{H}_3\text{C} \quad \text{COOH}
\]

\( \omega \)-end

Linoleic Acid (18:2 n-6)

**\( \omega-9 \):** first double bond is 9 carbons from the \( \omega \) end

\[
\text{H}_3\text{C} \quad \text{COOH}
\]

\( \omega \)-end

Oleic acid (18:1 n-9)

Types of IVLEs

Intralipid® - Long - chain triglycerides (LCT)

Lipofundin® - Medium chain triglycerides (MCT/LCT, 50:50%)

Clinoleic® - Olive oil (OO/LCT, 80:20%)

Lipoplus/Lipidem® - MCT/LCT/FO

SMOFLipid® - LCT/MCT/OO/FO

Omegaven® - Fish oil (FO, 100%)
Nutrition: always complete

Water
Carbohydrates
Lipids
Proteins
Vitamins
Minerals
Trace elements
Modern PN – ALL-in-One Admixtures

COMPONENTS

- Glucose 10-40%
  - Na, K, Ca, P
- Amino acids
  - Na, K, Mg
- Lipid emulsions
- Trace elements
- Vitamins

Limit: stability
- Glucose
- Amino acids
- Lipid emulsions MCT/ LCT
- Na⁺
- K⁺
- Ca++
- Mg++
- Fe, Zn, Mn, Cu, Cr, Mo, Se, F, J
- (Vit. A, B, C, D, E, K...)
**Modern PN – ALL-in-One Admixtures**

**COMPONENTS**

- Glucose 10-40%
  - Na, K, Ca, P
- Amino acids
  - Na, K, Mg
- Lipid emulsions
- Trace elements
- Vitamins

**Limit: stability**

- Glucose
- Amino acids
- Lipid emulsions MCT/ LCT
- Na⁺
- K⁺
- Ca++
- Mg++
- P²⁺
- Fe, Zn, Mn, Cu, Cr, Mo, Se, F, J
- (Vit. A, B, C, D, E, K...)
Lipids should be an essential component of parenteral admixture in patients on long-term HPN.

Lipid emulsions serve as a source of EFA and non-protein energy. Moreover, they can be used as an immunomodulating component of PN.

Considering intravenous fat emulsion recommendations, the need to cover EFA requirements must be balanced against prevention of intestinal failure associated liver disease (IFALD), which can be achieved by limiting the lipid dose.
Lipid in PN solutions:

- provides a concentrated form of energy reducing the need for infusion of large amounts of glucose,
- preventing essential fatty acid deficiency
- minimize respiratory and metabolic stress
- allows peripheral infusion of nutrients
The commonly used formula of 25 kcal/kg ideal body weight furnishes an approximate estimate of daily energy expenditure and requirements. Under conditions of severe stress requirements may approach 30 kcal/kg ideal body weight. In illness/stressed conditions a daily nitrogen delivery equivalent to a protein intake of 1.5 g/kg ideal body weight (or approximately 20% of total energy requirements) is generally effective to limit nitrogen losses. The Protein:Fat:Glucose caloric ratio should approximate to 20:30:50%. At present, there is a tendency to increase the glucose:fat calorie ratio from 50:50 to 60:40 or even 70:30 of the non-protein calories, due to the problems encountered regarding hyperlipidemia and fatty liver, which is sometimes accompanied by cholestasis and in some patients may progress to non-alcoholic steatohepatitis. Optimal nitrogen sparing has been shown to be achieved when all components of the parenteral nutrition mix are administered simultaneously over 24 hours.
ESPEN Guidelines on Parenteral Nutrition: Home Parenteral Nutrition (HPN) in adult patients

The electrolyte composition of the HPN regimen should reflect fluid losses.
The total calories should normally be 20–35 kcal/kg per day.
The non-protein energy provision should be 100–150 kcal for every gram of nitrogen in the HPN.
The unstressed adult HPN patient will require 0.8–1.0 g amino acids/kg per day.

For long-term HPN treatment (>6 months) the provision of intravenous lipid should not exceed 1 g/kg per day. Essential fatty acids should be supplied.
The daily requirement for essential fatty acids is 7–10 g, which corresponds to 14–20 g LCT fat from soya oil and 30–40 g LCT fat from olive/soya oil.

MCT/LCT and fish oil emulsions also appear safe and effective.

What Are Essential Fatty Acids?

- EFAs are fatty acids that cannot be manufactured in the body and must, therefore, come from our diet\(^1\)
- Linoleic acid and \(\alpha\)-linolenic acid are considered indispensable EFAs in humans\(^1,2\)

To prevent EFA deficiency, guidelines\(^2\) for total daily energy intake recommend at least:

- 2.5% of total energy intake as linoleic acid
- 0.5% of total energy intake as \(\alpha\)-linolenic acid

---

Essential fatty acids deficiency

Courtesy of Stanley Dudrick, MD
Table 3  Qualitative study. Multiple logistic regression to determine clinical factors associated with PN hypertriglyceridemia

<table>
<thead>
<tr>
<th>Variables</th>
<th>Hypertriglyceridemia</th>
<th>Odds ratio</th>
<th>Confidence interval 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Infection</td>
<td>24</td>
<td>133</td>
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<tr>
<td>No</td>
<td>12</td>
<td>24</td>
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<tr>
<td>Local</td>
<td>32</td>
<td>35</td>
<td>4.48</td>
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<tr>
<td>Renal failure</td>
<td>52</td>
<td>185</td>
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</tr>
<tr>
<td>No</td>
<td>16</td>
<td>7</td>
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<tr>
<td>Yes</td>
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<td></td>
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</tr>
<tr>
<td>Pancreatitis</td>
<td>56</td>
<td>171</td>
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</tr>
<tr>
<td>No</td>
<td>12</td>
<td>21</td>
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<tr>
<td>Infused lipids</td>
<td>62</td>
<td>187</td>
<td>1</td>
</tr>
<tr>
<td>&lt; 1.5 g/kg/day</td>
<td>6</td>
<td>5</td>
<td>3.03</td>
</tr>
<tr>
<td>&gt; 1.5 g/kg/day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corticoids</td>
<td>50</td>
<td>178</td>
<td>1</td>
</tr>
<tr>
<td>&lt; 0.5 mg/kg</td>
<td>18</td>
<td>14</td>
<td>7.98</td>
</tr>
<tr>
<td>&gt; 0.5 mg/kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heparin</td>
<td>67</td>
<td>186</td>
<td>1</td>
</tr>
<tr>
<td>&lt; 3 mg/kg</td>
<td>1</td>
<td>6</td>
<td>0.11</td>
</tr>
<tr>
<td>&gt; 3 mg/kg</td>
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<tr>
<td>Serum glucose</td>
<td>44</td>
<td>165</td>
<td>1</td>
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<tr>
<td>&lt; 10 mmol/l</td>
<td>24</td>
<td>27</td>
<td>1.263</td>
</tr>
<tr>
<td>&gt; 10 mmol/l</td>
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<td></td>
</tr>
</tbody>
</table>

Llop et al, Clin Nutr 2003 22:577-83
The optimal amount of lipids for patients on HPN is not precisely established. At least 1 g/kg/per week should be supplemented to avoid EFAD in patients totally dependent on IVS. Probably most of the patients who maintain some oral intake of fat can be safely treated with provision of 0.3-0.9 g of intravenous lipid per kg of body weight per day.

For long-term HPN treatment (>6 months), the amount of intravenous soybean oil lipid emulsion should not exceed 1 g/kg per day. Administration of soybean oil lipid emulsion in higher doses was associated with significantly increased risk of development of IFALD. Infusion of parenteral lipid emulsions at rates of 0.8-1.5 g/kg body weight per day is safe, but should not exceed 2.6 g/kg per day (0.11 g/kg/h) because side effects have been reported for cases in which that threshold was exceeded.
Most experts recommend avoiding a triglyceride level greater than 5 mmol/dL, although hard data supporting this are lacking.

When this level is reached it is recommended by many experts in the field to diminish the fat content (especially n-6 poly-unsaturated fatty acids (PUFAs)) of the parenteral nutrition or temporarily to withdraw fat.

In this event the energy deficit should not be replaced by adding more glucose because this may exceed the patient’s oxidative capacity.
Hipertriglyceridemia during HPN

Reference values: 0.45-1.71 mmol/L (40-150 mg/dL)

>400 mg/dl – IVLE dose reduction (ie. 50%)

>400 mg/dl – withholding
Lipids should be an essential component of parenteral admixture in patients on long-term HPN.

Lipid emulsions serve as a source of EFA and non-protein energy. Moreover, they can be used as an immunomodulating component of PN.

Considering intravenous fat emulsion recommendations, the need to cover EFA requirements must be balanced against prevention of intestinal failure associated liver disease (IFALD), which can be achieved by limiting the lipid dose.

Intestinal failure associated liver disease (IFALD)
# Hepatobiliary complications of HPN

<table>
<thead>
<tr>
<th>Common disorders</th>
<th>Rare disorders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steatosis</td>
<td>Fibrosis</td>
</tr>
<tr>
<td>Steatohepatitis</td>
<td>Micronodular cirrhosis</td>
</tr>
<tr>
<td>Biliary sludge</td>
<td>Acalculous cholecystitis</td>
</tr>
<tr>
<td>Cholelithiasis</td>
<td>Cirrhosis</td>
</tr>
<tr>
<td>Cholestasis</td>
<td>Hepatocellular carcinoma</td>
</tr>
</tbody>
</table>
## IFALD  Natural history

<table>
<thead>
<tr>
<th></th>
<th>Main feature</th>
<th>Evolution to cirrhosis</th>
<th>Non-progressive cirrhosis (after cholestasis resolution)</th>
<th>Related death (% of death on HPN)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infants &lt; 6-12 mo.</strong></td>
<td>Cholestasis related to septis</td>
<td>Rapid</td>
<td>Frequent</td>
<td>16-60% (16 studies)</td>
</tr>
<tr>
<td><strong>Children &amp; adults</strong></td>
<td>Steatosis for years Evolution to NASH in some pts.</td>
<td>Slow</td>
<td>Rare</td>
<td>4-5% (22 studies)</td>
</tr>
</tbody>
</table>

Liver injury due to factors related to intestinal failure and/or to parenteral nutrition, and no other evident cause

**Abnormal Liver Function Tests in patients on HPN**

- **Incidence**: 0-50%
- **Prevalence**: 5-85%

Children > Adults


ESPEN GLs on CIF in adults, Clin Nutr, 2016
Liver disease on HPN

Chronic cholestasis
- a value at least 1.5 fold the upper limit of normal on two of $\gamma$-GT, Alk. Phosph. or bilirubin for at least 6 months

Hepatic Complications
- jaundice for at least 1 month
- portal hypertension
- ascites
- liver encephalopathy
- liver failure
- portal fibrosis (grade 2) or cirrhosis

IFALD Risk factors

Parenteral Nutrition
- Energy overfeeding
- Glucose overload >7 mg/kg/min
- Lipid emulsion (LCT) overload
- Soybean LE > 1 g/Kg/day
- Continuous infusion (24/24h)
- Contaminants (phytosterols)
- Antioxidant deficiency
- Nutrient deficiency (choline, carnitine, methionine, taurine, EFAD, ...)

Intestinal Failure
- Lack of oral feeding
- SBS (SB remnant < 50 cm)

Inflammation/infection
- Sepsis (CVC-related, ...)
- Small bowel bacterial overgrowth (SIBO)
- Gut inflammation

IFALD - Protective factors

Cyclic PN infusion $\rightarrow$ ↓ insulin secretion
  $\downarrow$ lipid deposition
  $\uparrow$ lipid oxidation

IV Lipid “strategy”
  $\downarrow$ total amount
  Soybean LE < 1 g/Kg/d
  Replace Soybean LE
  $\downarrow$ Phytosterols
  $\uparrow$ a-tocopherol
  $\uparrow$ n-3 FAs

Lacaille F et al, JPGN, 2015; Lee WS & Sokol RJ, JPEDS, 2015;
IVLE available in Europe for HPN

Intralipid® - Long - chain triglycerides (LCT)

Lipofundin® - Medium chain triglycerides (MCT)/LCT

Clinoleic® - Olive oil (OO)/LCT

Lipoplus/Lipidem® - MCT/LCT/FO

SMOFLipid® - LCT/MCT/OO/FO

Omegaven® - Fish oil (FO)
LCT emulsions

Soya oil based lipid emulsions:
- too high content of unsaturated fatty acids,
- too small content of alpha-tocoferol,
- cell membrane destabilisation,
- increase in the synthesis of proinflammatory LT and PG,
- immunosupression
Prevention of IFALD

- To encourage oral food intake
- To prefer cyclical regimen
- To limit intestinal bacterial overgrowth
- To avoid environmental toxic factors (alcohol, virus, drugs)
- To treat - rapidly and adequately - any septic episode
- To provide less than 1 g lipid/kg/day and prevent overfeeding
- To provide urso-deoxycholic acid in case of cholestasis
We suggest that most patients on long-term HPN for CIF without ongoing metabolic complications be safely treated with provision of no more than 1 g/kg/day of intravenous soybean-based lipid emulsion.
SIRS

CARS

eicosanoids

HLA-DR

TNF, IL-1, 6 etc.

CD4/CD8 ratio

physiologic range

of inflammation

overwhelming
inflammation

immune paralysis

shock

self destruction
tissue injury

breakdown of host defense

Modified from Axel Heller
Too much n-6 fatty acid?
MCT/LCT
MCT/LCT 50:50

Metabolic pathways of MCTs and LCTs
Critically ill and MCT/LCT

Elwyn DH et al., ESPEN Congress in Leipzig (1988)
FISH OIL
Liver histology. Left column H&E, middle column PAS, and right column Oil Red O staining as described in methods section. All sections are at 400× magnification (Bar = 100 μm). Control mice show normal hepatic architecture (A) and glycogen storage patterns (B) without evidence of hepatic steatosis (A, C). Livers from HCD-only mice had diffuse macro- and micro-vesicular steatosis (black, red arrow, D–F) with minimal glycogen storage (green arrow, E). HCD+O3FA-oral livers had well-preserved hepatic architecture with only rare microvacuoles in the cytoplasm of midzone hepatocytes (G, I). HCD+O3FA-iv livers had minimal microvesicular steatosis in midzone hepatocytes (J, L), and appeared to have less glycogen than HCD+O3FA-oral livers (K). HCD+LIP-iv livers had severe macro- and micro-vesicular steatosis (M, O) with minimal glycogen storage (N).
Fish oil: dose-dependency

- N=661 (82 hospitals)
- well-nourished patients

Fish oil had the most favorable effects on survival, infection rates, and length of stay **when administered in doses between 0.1 and 0.2 g.kg\(^{-1}\).day\(^{-1}\)**. Lower antibiotic demand by 26\% was observed when doses of 0.15-0.2 g.kg\(^{-1}\).day\(^{-1}\) were infused as compared with doses of <0.05 g.kg\(^{-1}\).day\(^{-1}\). After peritonitis and abdominal sepsis, multiple quasi-linear regression models revealed a fish oil dose for minimizing intensive care unit stay of 0.23 g.kg\(^{-1}\).day\(^{-1}\) and an inverse linear relationship between dosage and intensive care unit stay in major abdominal surgery.

Heller et al. Crit Care 2006
Parenteral Soybean Oil Induces Hepatosteatosis Despite Addition of Fish Oil in a Mouse Model of Intestinal Failure–Associated Liver Disease

Results: The PN + saline group was the only group with EFAD, with a serum and hepatic triene/tetraene ratio of 0.53. NSCRN scores were highest in the PN + SO group (5.5; 95% confidence interval [CI], 4.9–6.1), followed by the PN + FO/SO (4.5; 95% CI, 3.5–5.5) group, with the lowest score in the PN + FO (2.0; 95% CI, 1.1–2.9) group. Acetyl CoA carboxylase α and acetyl CoA carboxylase β expression was lower in the PN + FO group than in the PN + FO/SO or PN + SO groups. Conclusions: Our data demonstrate that a mixed fat emulsion of 50% SO and 50% FO is inferior to 100% FO in reducing hepatosteatosis in this model. These data suggest that use of parenteral SO with parenteral FO, in a 1:1 ratio, may still contribute to liver injury, although it is less hepatotoxic than pure SO.

A combination of 50% SO and 50% FO emulsions. The purpose of this study was to determine if mixing 50% SO and 50% FO emulsions would prevent hepatosteatosis in a murine model of
## Composition of intravenous lipid emulsions

<table>
<thead>
<tr>
<th></th>
<th>Ingredient composition ¹</th>
<th>Concentrations of selected fatty acids, % by weight ⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soybean Oil %</td>
<td>MCT %</td>
</tr>
<tr>
<td><strong>Single oil lipids</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intralipid</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Omegaven</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td><strong>Lipid blends</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinoleic</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>Lipofundin MCT/LCT</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Lipidem</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>SMOFlipid</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

² Ratios calculated from data presented in reference 4

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Differences in Ω-3 concentration

- **Ph Eur monograph nr 1352**
  - EPA + DHA ≥ 45%
  - Total n3-FAs ≥ 60%

- **Ph Eur monograph nr 1912**
  - EPA + DHA ≥ 22%
  - Total n3-FAs ≥ 28%

Triglicerydy kwasów omega-3

Olej z ryb, bogaty w omega-3 kwasy
Immunoregulation by Parenteral Lipids: Impact of the n-3 to n-6 Fatty Acid Ratio

HELMUT GRIMM, MD*†; ANNIKA TIBELL, MD†; BIRN NORRLIND‡; CHRISTOPH BLECHER‡; SIGRID WILKER‡; AND KONRAD SCHWEMMLE, MD, Ph.D*

From the *Department of General and Thoracic Surgery, University of Giessen, Germany; the †Department of Transplantation Surgery, Karolinska Institute, Huddinge Hospital, Stockholm, and the ‡Department of Nutrition Research Institute G4, Rabi Pharmacia, Stockholm

ABSTRACT. Background: The immune system is reported to be influenced by polyunsaturated fatty acids. Therefore, immunoregulation caused by intravenous fat emulsions with different n-3 to n-6 fatty acid ratios was studied in an in vivo model. Methods: Experimental rat heart allotransplantation served as a defined immunologic challenge. Twenty percent emulsions of safflower oil (n-3 to n-6 = 1:370), fish oil (n-3 to n-6 = 7.6:1), and soybean oil (n-3 to n-6 = 1.6:5) and a 1:1 mixture of safflower oil and fish oil (n-3 to n-6 = 1:2:1) were continuously infused (9 g of fat per kg of body weight per day) after transplantation until complete rejection. The prolongation of graft survival, an accepted parameter of immunosuppression, was assessed. Beyond that, cytokine release by mitogen-stimulated peripheral-blood mononuclear cells (PBMCs) from animals exsanguinated on day 4 after transplantation was evaluated. Results: The mean rejection time was 7.8 days in the sham-infused saline control group and 6.7 days in the safflower- and fish-oil-mixture group (oil control group). Continuous infusion of soybean oil prolonged the graft survival time to 10.4 days, fish oil to 12.3 days, and safflower oil to 13.3 days. PBMC α-tumor necrosis factor release was significantly reduced in the fish-oil group (51.9 ± 13.0 pg/10^6 PBMCs vs 70.8 ± 10.9 pg/10^6 PBMCs [controls], p < .004). Interleukin-6 release was diminished in both the fish-oil group (22.2 ± 13.6 pg/10^6 PBMCs vs 40.7 ± 8.3 pg/10^6 PBMCs [controls], p < .002) and the safflower-oil group (28.4 ± 6.9 pg/10^6 PBMCs, p < .002). Conclusions: The n-3 to n-6 fatty acid ratio determined the immunoregulatory potential of intravenous fat emulsions in vivo. Both n-3 and n-6 fatty acids were immunosuppressive when applied as the main polyunsaturated fatty acid sources. PBMC cytokine release was significantly reduced in these groups. The more balanced the n-3 to n-6 ratios, the less immunosuppressive the fat emulsion. There was no immunosuppressive effect at an n-3 to n-6 ratio of 1:2:1. (Journal of Parenteral and Enteral Nutrition 18:417–421, 1994)
Parenteral lipids: the mixture doesn’t work?

Figure was created using data from the publication

Grimm H et al, JPEN 1994
OLIVE OIL
PUFA Content of Parenteral Lipid Emulsions

PUFA, polyunsaturated fatty acid; MCT, medium-chain triglyceride; LCT, long-chain triglyceride.


In all cases, percentages were calculated using data from cited sources and then plotted graphically.
Lipid Peroxidation and Stability

- Lipids with high concentrations of PUFAs are more susceptible to coalescence and peroxidation than those with high concentrations of MUFAs\(^1\)\(^-\)\(^3\)

- In total nutrition admixture, ClinOleic\(^R\) has demonstrated superior physical stability and reduced coalescence compared with soybean oil and MCT/LCT emulsions\(^1\),\(^4\)

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**Storage of admixtures at 5° C for 7 days**

<table>
<thead>
<tr>
<th>ClinOleic(^R)</th>
<th>Soybean</th>
<th>MCT/LCT</th>
</tr>
</thead>
</table>

Significant decrease in alkaline phosphatases and gamma-glutamyl transferase (A) & aspartate aminotransferase & alanine aminotransferase (B) activities after ClinOleic® introduction in the treatment.

GT, glutamyl transferase; ALT, alanine aminotransferase; AST, aspartate aminotransferase.
Preserved Hepatobiliary Function in Burn Patients

A lower percentage of burn patients who received ClinOleic had biochemical evidence of cholestasis after 6 days of PN compared with those who received an MCT/LCT emulsion.

*P = 0.04.

*a Conjugated bilirubin, alkaline phosphatases, and γ-glutamyl transpeptidase.

Impact of Clinical Use of Parenteral Lipid Emulsions on Bile Acid Metabolism and Composition in Neonatal Piglets.

Lavallee CM1,2, Lim DW1, Wizzard PR1, Mazurak VC2, McL S2,3, Curtis JM2, Willing BP2, Yap JY1, Wales PW1,4, Turner JM1.

Abstract

BACKGROUND: Neonates with intestinal failure dependent on parenteral nutrition (PN) are at risk of intestinal failure-associated liver disease (IFALD). PN lipid composition relates to the risk of IFALD, but the mechanisms are poorly understood. We investigated the effects of soybean oil (SO), a mixed-lipid (ML) emulsion containing fish oil (FO), and a pure FO. We hypothesized FO-containing PN lipids would result in increased gene expression of canalicular bile acid transporters and a larger, more hydrophilic bile acid pool, predictive of increased bile flow.

METHODS: Neonatal piglets were allocated to receive 1 of SO, ML, or FO throughout 14 days of PN feeding. Relative expression of genes involved in bile acid synthesis and transport were determined through quantitative polymerase chain reaction. Bile secreted from the liver was collected and measured. Bile acid composition was determined using tandem mass spectrometry. Regression analysis was used to determine predictors of bile flow.

RESULTS: PN reduced bile acid secretion (P < .001). FO-containing PN lipids were associated with greater expression of bile acid and organic solute transport genes (P < .05) and greater secretion of hydrophobic bile acids (P < .001). Farnesoid X receptor (P = .01), bile salt export pump (P < .01), multidrug resistant protein 2 (P < .01), and unconjugated hyocholic acid (P < .001) independently predicted bile flow.

CONCLUSIONS: PN lipid modulation altered bile acid metabolism and composition. These alterations may explain the hepatoprotective effects of FO-containing PN lipids and support their use in the prevention and treatment of IFALD.
Olive oil: Improved Resistance to Oxidative Stress *(in-vitro)*

- The incubation of different lipid emulsions with phenylhydrazine, a reducing agent capable of inducing oxidative stress, produce thiobarbituric acid–reactive substances (TBARS).
- ClinOleic® was the emulsion with less TBARS produced, compared with 2 soybean & an MCT/LCT emulsion.

![Graph showing TBARS levels for different emulsions](image)

- TBARS are formed during decomposition of lipid peroxidation
- They are markers of lipid peroxidation & oxidative stress


MCT, medium-chain triglyceride; LCT, long-chain triglyceride.

*a* Represents the average TBARS production for 2 soybean oil emulsions.
## Comparing Effects of Fatty Acids

<table>
<thead>
<tr>
<th></th>
<th>EFFECT ON INFLAMMATION</th>
<th>RISK OF IMMUNOSUPPRESSION</th>
<th>RISK OF OXIDATIVE STRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omega-3 (Fish)</td>
<td>Anti-inflammatory</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Omega-6 (Soy)</td>
<td>Pro-inflammatory</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Omega-9 (Olive)</td>
<td>Neutral</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Which IVLE to use?
Type of lipid emulsions in the parenteral nutrition admixture, at time of starting the home parenteral nutrition program (BS) and at time of inclusion in the study (CS).

<table>
<thead>
<tr>
<th>Lipid emulsion</th>
<th>BS Patients n. (%)</th>
<th>CS Patients n. (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean</td>
<td>18 (15.9)</td>
<td>1 (0.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Soybean/MCT</td>
<td>13 [5, 11]</td>
<td>5 (4.4)</td>
<td></td>
</tr>
<tr>
<td>Olive oil/soybean</td>
<td>43 (38.1)</td>
<td>62 (54.8)</td>
<td></td>
</tr>
<tr>
<td>Soybean/MCT/olive/fish</td>
<td>7 (6.2)</td>
<td>20 (17.8)</td>
<td></td>
</tr>
<tr>
<td>Fish oil</td>
<td>2 (1.8)</td>
<td>4 (3.5)</td>
<td></td>
</tr>
<tr>
<td>Olive oil/soybean + fish</td>
<td>0</td>
<td>1 (0.9)</td>
<td></td>
</tr>
<tr>
<td>Soybean/MCT/olive/fish + fish</td>
<td>0</td>
<td>2 (1.8)</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>10 (8.9%)</td>
<td>18 (15.9%)</td>
<td></td>
</tr>
<tr>
<td>Not available</td>
<td>20 (17.6)</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Chi square test.
Polish Experiences
32 adults receiving long-term HPN with Intralipid as the LE were transferred to receive either SMOFLipid (n = 13) or ClinOleic (n = 19) for 60 days.

### Table 2

Blood markers of liver function and blood lipids in the two treatment groups before (t\textsubscript{START}) and after (t\textsubscript{END}) 60 days of a new lipid emulsion as part of HPN.

<table>
<thead>
<tr>
<th></th>
<th>SMOFLipid (n = 12)</th>
<th>ClinOleic (n = 16)</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal range</td>
<td>t\textsubscript{START}</td>
<td>t\textsubscript{END}</td>
</tr>
<tr>
<td>Total bilirubin (mg/dL)</td>
<td>0–1.2</td>
<td>0.50 (0.40, 1.00)</td>
<td>0.50 (0.40, 1.20)</td>
</tr>
<tr>
<td>ALT (U/L)</td>
<td>0–33</td>
<td>47.0 (31.0, 76.0)</td>
<td>47.0 (29.0, 105.0)</td>
</tr>
<tr>
<td>AST (U/L)</td>
<td>0–33</td>
<td>27.0 (20.0, 37.0)</td>
<td>25.0 (20.0, 49.0)</td>
</tr>
<tr>
<td>GGT (U/L)</td>
<td>6–42</td>
<td>43.0 (16.0, 158.0)</td>
<td>42.0 (27.0, 108.0)</td>
</tr>
<tr>
<td>Total cholesterol (mg/dL)</td>
<td>&lt;190</td>
<td>127.0 (112.0, 174.0)</td>
<td>131.0 (110.0, 163.0)</td>
</tr>
<tr>
<td>Triglycerides (mg/dL)</td>
<td>&lt;150</td>
<td>122.0 (85.0, 127.0)</td>
<td>100.0 (95.0, 134.0)</td>
</tr>
</tbody>
</table>

Data are median (25th percentile, 75th percentile).

*P value for comparison t\textsubscript{END} vs t\textsubscript{START} within a treatment group (Wilcoxon signed ranks test).

P value for comparison between treatment groups at t\textsubscript{END} (Mann Whitney U-test).
32 adults receiving long-term HPN with Intralipid as the LE were transferred to receive either SMOFLipid (n = 13) or ClinOleic (n = 19) for 60 days.

Table 4
Plasma concentrations of cytokines (pg/ml) in the two treatment groups before (tSTART) and after (tEND) 60 days of a new lipid emulsion as part of HPN.

<table>
<thead>
<tr>
<th>Cytokine</th>
<th>SMOFLipid (n = 12)</th>
<th>ClinOleic (n = 16)</th>
<th>P*</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tSTART</td>
<td>tEND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IL-6</td>
<td>14.0 (11.0, 22.0)</td>
<td>17.0 (10.0, 20.0)</td>
<td>0.502</td>
<td></td>
</tr>
<tr>
<td>IL-8</td>
<td>856.5 (392.0, 1438.5)</td>
<td>646.8 (446.5, 978.0)</td>
<td>0.530</td>
<td></td>
</tr>
<tr>
<td>IL-10</td>
<td>19.5 (14.2, 22.2)</td>
<td>17.7 (15.5, 21.0)</td>
<td>0.387</td>
<td></td>
</tr>
<tr>
<td>TNF-α</td>
<td>43.5 (36.5, 61.0)</td>
<td>47.5 (35.2, 53.5)</td>
<td>0.814</td>
<td></td>
</tr>
<tr>
<td>TNF-α/IL-10</td>
<td>2.44 (2.10, 3.06)</td>
<td>2.43 (2.03, 2.95)</td>
<td>0.646</td>
<td></td>
</tr>
<tr>
<td>IL-6</td>
<td>22.25 (10.75, 62.50)</td>
<td>17.0 (9.5, 33.5)</td>
<td>0.289</td>
<td>0.587</td>
</tr>
<tr>
<td>IL-8</td>
<td>611.25 (464.25, 839.00)</td>
<td>526.2 (406.2, 645.0)</td>
<td>0.030</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>IL-10</td>
<td>17.50 (13.75, 33.50)</td>
<td>23.0 (14.7, 31.0)</td>
<td>0.756</td>
<td>0.377</td>
</tr>
<tr>
<td>TNF-α</td>
<td>51.75 (36.25, 70.50)</td>
<td>44.0 (34.2, 58.2)</td>
<td>0.108</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TNF-α/IL-10</td>
<td>2.25 (1.34, 3.47)</td>
<td>1.95 (1.51, 2.65)</td>
<td>0.252</td>
<td>0.320</td>
</tr>
</tbody>
</table>

Data are median (25th percentile, 75th percentile).
P value for comparison tEND vs tSTART within a treatment group (Wilcoxon signed ranks test).
P value for comparison between treatment groups at tEND (Mann Whitney U-test).
Intravenous lipid emulsions and liver function in adult chronic intestinal failure patients: results from a randomized clinical trial.

Stanislaw Klek, Kinga Szczepanek, Lucyna Scislo, Elzbieta Walewska, Magdalena Pietka, Magdalena Pisarska, Michal Pieszat

Open Access
DOI: https://doi.org/10.1016/j.nut.2018.03.008
Study design

• Double blind, randomized study: 4 arms
• HPN patients (treatment > 12 months)
• n=68
• Patients randomised to receive:
  • Intralipid
  • Lipofundin MCT/LCT
  • SMOFlipid
  • Clinoleic
<table>
<thead>
<tr>
<th></th>
<th>Lipofundin MCT/LCT</th>
<th>ClinOleic</th>
<th>Smoflipid</th>
<th>Intralipid 20</th>
<th>p</th>
</tr>
</thead>
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<tr>
<td><strong>General description</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of patients, n</td>
<td>18</td>
<td>17</td>
<td>16</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td>Females, n (%)</td>
<td>10 (55.5%)</td>
<td>10 (58.8%)</td>
<td>8 (50%)</td>
<td>9 (56.25%)</td>
<td>0.0923</td>
</tr>
<tr>
<td>Males, n (%)</td>
<td>8 (44.5%)</td>
<td>7 (41.2%)</td>
<td>8 (50%)</td>
<td>5 (43.75%)</td>
<td></td>
</tr>
<tr>
<td>Mean age, years ± SD (median)</td>
<td>56.3±15.4 (58)</td>
<td>54.8±12.9 (54.5)</td>
<td>47.8±12.5 (52)</td>
<td>59.6±17.6 (61)</td>
<td>0.1190</td>
</tr>
<tr>
<td>BMI, kg/m² ± SD (median)</td>
<td>19.5±4.2 (18.7)</td>
<td>18.9±2.9 (19.0)</td>
<td>18.5±4.3 (17.8)</td>
<td>22.2±6.5 (21.0)</td>
<td>0.1865</td>
</tr>
<tr>
<td>BMI, kg/m² ± SD (median)</td>
<td>21.5±3.9 (21.0)</td>
<td>19.9±2.8 (19.8)</td>
<td>20.5±4.1 (20.5)</td>
<td>22.0±4.5 (21.4)</td>
<td>0.4913</td>
</tr>
<tr>
<td>BMI, kg/m² ± SD (median)</td>
<td>21.4±3.3 (21.4)</td>
<td>22.3±2.1 (22.4)</td>
<td>20.2±4.5 (20.1)</td>
<td>24.0±3.9 (23.5)</td>
<td>0.0264</td>
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<tr>
<td><strong>Nutrition</strong></td>
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<td></td>
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<tr>
<td>Lipids (g)/ week</td>
<td>4.6±1.5 (4.5)</td>
<td>4.5±3.0 (4.1)</td>
<td>5.2±1.3 (4.7)</td>
<td>5.0±1.3 (4.9)</td>
<td>0.3412</td>
</tr>
<tr>
<td>Energy intake (g/kg/d)</td>
<td>20.0±4.4 (19)</td>
<td>20.8±5.8 (20.7)</td>
<td>23.1±6.1 (21.7)</td>
<td>18.2±5.4 (17.7)</td>
<td>0.0627</td>
</tr>
<tr>
<td>Volume (ml)</td>
<td>1332.5±390.9 (1250)</td>
<td>1428.1±233.1 (1500)</td>
<td>1448.2±896.7 (1250)</td>
<td>1446.8±203.2 (1540)</td>
<td>0.36</td>
</tr>
<tr>
<td>Number of PN bags per week</td>
<td>6.1±1.1 (7)</td>
<td>6.1±0.9 (6)</td>
<td>6.2±1.0 (7)</td>
<td>5.6±0.7 (6)</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>Lipofundin MCT/LCT</td>
<td>ClinOleic 20%</td>
<td>Smoflipid 20%</td>
<td>Intralipid 20%</td>
<td>( p )</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------------</td>
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<td>---------------</td>
<td>---------------</td>
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</tr>
<tr>
<td><strong>Before HPN</strong></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Mean SGPT±SD (median)</td>
<td>32.6±25.7 (26)</td>
<td>62.1±48.1 (38.5)</td>
<td>37.4±22.4 (33.5)</td>
<td>49.6±39.6 (34)</td>
<td>0.0144</td>
</tr>
<tr>
<td>Mean SGOT±SD (median)</td>
<td>27.3±21.3 (23.3)</td>
<td>45.4±28.6 (35)</td>
<td>25.2±11.4 (22)</td>
<td>35.1±22.9 (28)</td>
<td>0.0109</td>
</tr>
<tr>
<td>Mean GGTP±SD (median)</td>
<td>87.3±82.9 (68)</td>
<td>222.5±205.8 (165)</td>
<td>84.8±78.6 (66)</td>
<td>105.4±109.5 (60)</td>
<td>0.0220</td>
</tr>
<tr>
<td>Mean FA±SD (median)</td>
<td>185.1±132.3 (148.5)</td>
<td>234.4±183.5 (175.5)</td>
<td>217.7±153.4 (163)</td>
<td>178.8±136.7 (134.5)</td>
<td>0.5380</td>
</tr>
<tr>
<td>Mean bilirubin ±SD (median)</td>
<td>15.6±37.8 (9.4)</td>
<td>28.1±25.3 (18)</td>
<td>10.8±5.3 (9.4)</td>
<td>18.4±20.4 (9.4)</td>
<td>0.0045</td>
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<tr>
<td><strong>After six months of HPN</strong></td>
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<td></td>
</tr>
<tr>
<td>Mean SGPT±SD (median)</td>
<td>36.8±35.9 (25)</td>
<td>43.9±23.6 (40)</td>
<td>40.6±21.6 (37.6)</td>
<td>35.2±26.6 (28)</td>
<td>0.1679</td>
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<tr>
<td>Mean SGOT±SD (median)</td>
<td>28.1±17.4 (24.3)</td>
<td>33.0±13.6 (25.5)</td>
<td>31.7±15.5 (27)</td>
<td>30.0±14.7 (27)</td>
<td>0.1709</td>
</tr>
<tr>
<td>Mean GGTP±SD (median)</td>
<td>86.8±119.8 (44.3)</td>
<td>144.0±146.3 (83.8)</td>
<td>88.9±81.9 (74)</td>
<td>57.1±36.2 (47)</td>
<td>0.3416</td>
</tr>
<tr>
<td>Mean FA±SD (median)</td>
<td>194.0±159.8 (154.4)</td>
<td>231.8±192.0 (159.5)</td>
<td>203.1±128.4 (193)</td>
<td>192.2±100.5 (170)</td>
<td>0.7817</td>
</tr>
<tr>
<td>Mean bilirubin ±SD (median)</td>
<td>12.3±9.8 (9.9)</td>
<td>13.1±6.8 (11.7)</td>
<td>18.4±16.7 (12.8)</td>
<td>20.0±34.6 (13.7)</td>
<td>0.0857</td>
</tr>
<tr>
<td><strong>After 12 months of HPN</strong></td>
<td></td>
<td></td>
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<tr>
<td>Mean SGPT±SD (median)</td>
<td>36.1±29.2 (25.5)</td>
<td>53.8±54.7 (21.5)</td>
<td>47.3±48.7 (32)</td>
<td>38.0±29.5 (32)</td>
<td>0.8779</td>
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<tr>
<td>Mean SGOT±SD (median)</td>
<td>29.6±23.3 (23.6)</td>
<td>50.1±56.0 (27)</td>
<td>42.7±45.7 (22.5)</td>
<td>31.1±23.0 (27)</td>
<td>0.5749</td>
</tr>
<tr>
<td>Mean GGTP±SD (median)</td>
<td>78.4±90.5 (45.5)</td>
<td>146.6±197.7 (29)</td>
<td>144.6±149.5 (78)</td>
<td>85.8±92.4 (65)</td>
<td>0.3616</td>
</tr>
<tr>
<td>Mean FA±SD (median)</td>
<td>214.3±213.7 (175)</td>
<td>188.5±124.5 (145.4)</td>
<td>280.2±427.5 (135)</td>
<td>233.4±318.6 (171.5)</td>
<td>0.9565</td>
</tr>
<tr>
<td>Mean bilirubin ±SD (median)</td>
<td>14.0±10.2 (10.5)</td>
<td>11.1±4.5 (10.3)</td>
<td>14.0±10.9 (9.2)</td>
<td>16.8±13.5 (13.0)</td>
<td>0.8466</td>
</tr>
<tr>
<td>Time of intervention</td>
<td>0</td>
<td>6 m</td>
<td>12 m</td>
<td>p</td>
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<td>--------------</td>
<td>--------------</td>
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</tr>
<tr>
<td><strong>Lipofundin MCT/LCT</strong></td>
<td></td>
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</tr>
<tr>
<td>Mean SGPT±SD (median)</td>
<td>32.6±25.7 (26)</td>
<td>36.8±35.9 (25)</td>
<td>36.1±29.2 (25.5)</td>
<td>0.4328</td>
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</tr>
<tr>
<td>Mean SGOT±SD (median)</td>
<td>27.3±21.3 (23.3)</td>
<td>28.1±17.4 (24.3)</td>
<td>29.6±23.3 (23.6)</td>
<td>0.5138</td>
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</tr>
<tr>
<td>Mean GGTP±SD (median)</td>
<td>87.3±82.9 (68)</td>
<td>86.8±119.8 (44.3)</td>
<td>78.4±90.5 (45.5)</td>
<td>0.2638</td>
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<tr>
<td>Mean FA±SD (median)</td>
<td>185.1±132.3 (148.5)</td>
<td>194.0±159.8 (154.4)</td>
<td>214.3±213.7 (175)</td>
<td>0.2375</td>
<td></td>
</tr>
<tr>
<td>Mean bilirubin ±SD (median)</td>
<td>15.6±37.8 (9.4)</td>
<td>12.3±9.8 (9.9)</td>
<td>14.0±10.2 (10.5)</td>
<td>0.0501</td>
<td></td>
</tr>
<tr>
<td><strong>ClinOleic</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mean SGPT±SD (median)</td>
<td>62.1±48.1 (38.5)</td>
<td>43.9±23.6 (40)</td>
<td>53.8±54.7 (21.5)</td>
<td>0.8007</td>
<td></td>
</tr>
<tr>
<td>Mean SGOT±SD (median)</td>
<td>45.4±28.6 (35)</td>
<td>33.0±13.6 (25.5)</td>
<td>50.1±56.0 (27)</td>
<td>0.1485</td>
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<tr>
<td>Mean GGTP±SD (median)</td>
<td>222.5±205.8 (165)</td>
<td>144.0±146.3 (83.8)</td>
<td>146.6±197.7 (29)</td>
<td>0.0079</td>
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<tr>
<td>Mean FA±SD (median)</td>
<td>234.4±183.5 (175.5)</td>
<td>231.8±192.0 (159.5)</td>
<td>188.5±124.5 (145.4)</td>
<td>0.6065</td>
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</tr>
<tr>
<td>Mean bilirubin ±SD (median)</td>
<td>28.1±25.3 (18)</td>
<td>13.1±6.8 (11.7)</td>
<td>11.1±4.5 (10.3)</td>
<td>0.0023</td>
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<tr>
<td><strong>Smoflipid</strong></td>
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<tr>
<td>Mean SGPT±SD (median)</td>
<td>37.4±22.4 (33.5)</td>
<td>40.6±21.6 (37.6)</td>
<td>47.3±48.7 (32)</td>
<td>0.6457</td>
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</tr>
<tr>
<td>Mean SGOT±SD (median)</td>
<td>25.2±11.4 (22)</td>
<td>31.7±15.5 (27)</td>
<td>42.7±45.7 (22.5)</td>
<td>0.2466</td>
<td></td>
</tr>
<tr>
<td>Mean GGTP±SD (median)</td>
<td>84.8±78.6 (66)</td>
<td>88.9±81.9 (74)</td>
<td>144.6±149.5 (78)</td>
<td>0.6271</td>
<td></td>
</tr>
<tr>
<td>Mean FA±SD (median)</td>
<td>217.7±153.4 (163)</td>
<td>203.1±128.4 (193)</td>
<td>280.2±427.5 (135)</td>
<td>0.7659</td>
<td></td>
</tr>
<tr>
<td>Mean bilirubin ±SD (median)</td>
<td>10.8±5.3 (9.4)</td>
<td>18.4±16.7 (12.8)</td>
<td>14.0±10.9 (9.2)</td>
<td>0.3806</td>
<td></td>
</tr>
<tr>
<td><strong>Intralipid</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean SGPT±SD (median)</td>
<td>49.6±39.6 (34)</td>
<td>35.2±26.6 (28)</td>
<td>38.0±29.5 (32)</td>
<td>0.2270</td>
<td></td>
</tr>
<tr>
<td>Mean SGOT±SD (median)</td>
<td>35.1±22.9 (28)</td>
<td>30.0±14.7 (27)</td>
<td>31.1±23.0 (27)</td>
<td>0.8965</td>
<td></td>
</tr>
<tr>
<td>Mean GGTP±SD (median)</td>
<td>105.4±109.5 (60)</td>
<td>57.1±36.2 (47)</td>
<td>85.8±92.4 (65)</td>
<td>0.3017</td>
<td></td>
</tr>
<tr>
<td>Mean FA±SD (median)</td>
<td>178.8±136.7 (134.5)</td>
<td>192.2±100.5 (170)</td>
<td>233.4±318.6 (171.5)</td>
<td>0.5760</td>
<td></td>
</tr>
<tr>
<td>Mean bilirubin ±SD (median)</td>
<td>18.4±20.4 (9.4)</td>
<td>20.0±34.6 (13.7)</td>
<td>16.8±13.5 (13.0)</td>
<td>0.6744</td>
<td></td>
</tr>
</tbody>
</table>
Key findings

No significant difference between IVLEs for most outcomes measured

Demonstrated that liver tests may normalize with time regardless of IVLE type

Clinoleic was the only lipid emulsion demonstrated to significantly reduce both bilirubin ($p=0.0023$) and GGTP ($p=0.0079$).
Key messages

- IVLE is an inevitable component of PN
- PN should be tailored to improve the outcome
- Selection of proper IVLE is essential to create high quality PN
- HPN patients may benefit from 2nd and 3rd generation of IVLE
SAVE THE DATE
31 Aug - 3 Sep 2019
KRAKOW, POLAND

For more information
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