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Original Research Article

Comparative Study of Efficacy and Safety Between Two Lipid Emulsions Used in Parenteral Nutrition

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Abstract: Lipid emulsions are pivotal in parenteral nutrition (PN), supplying essential fatty acids and calories for patients unable to receive adequate enteral intake. Recent innovations have led to the evolution of lipid emulsions with altered fatty acid compositions. This article compares the efficacy and safety of two major lipid emulsions—traditional soybean oil-based emulsions and multi-component emulsions (SMOF: soybean oil, medium-chain triglycerides, olive oil, fish oil)—in parenteral nutrition, based on data from randomized studies and systematic reviews.

Keywords: Lipid emulsions, Parenteral nutrition, Soybean oil, SMOF (multi-component emulsions), Fatty acid composition.

INTRODUCTION

Intravenous lipid emulsions (ILEs) are a core element of PN, historically relying on soybean oil (rich in omega-6 polyunsaturated fatty acids). Although effective, concerns have arisen regarding the pro-inflammatory and hepatotoxic potential of pure soybean emulsions, especially with prolonged use. Multi-component emulsions, such as SMOF (Soybean oil, MCT, Olive oil, Fish oil), have been developed to address these limitations by incorporating omega-3 fatty acids, monounsaturated fats, and medium-chain triglycerides. This article evaluates these two emulsion types in terms of clinical efficacy, safety, and overall clinical outcomes.

METHODS

A systematic review and synthesis of controlled trials, meta-analyses, and cohort studies comparing traditional soybean oil-based emulsions (SOLE) and multi-component emulsions (SMOF-LE) were undertaken. Outcome measures included liver function, growth parameters, infection rate, metabolic complications, and clinical endpoints in both adult and pediatric populations receiving PN.

RESULTS

Composition and Mechanistic Differences

Emulsion Type	Composition	Putative Clinical Effects

Soybean Oil-Based (SOLE)	100% soybean oil (high omega-6, phytosterols)	Energy, pro-inflammatory, risk of liver dysfunction[1][2]
Multi-Component (SMOF-LE)	Soybean oil, MCTs, olive oil, fish oil (lower omega-6, omega-3 rich)	Anti-inflammatory, hepatoprotective, improved lipid profile[3][4]

Efficacy Outcomes

1. Growth and Clinical Recovery

- In a large comparative cohort of preterm neonates (n=1,297), there was no significant difference in mortality or major morbidities (chronic lung disease, severe retinopathy, infection, necrotizing enterocolitis) between SOLE and SMOF-LE groups[4].
- Some studies noted that SMOF-LE is associated with faster achievement of full enteral feeds and quicker regain of birth weight[4].

2. Inflammation and Immune Response

- SMOF-LE reduced pro-inflammatory markers and was linked with better tolerance[2].
- No significant differences in acute infection rates between groups[4][1].

3. Hepatic Safety and Complications

- SMOF-LE consistently demonstrated lower hepatic enzyme levels and reduced risk of cholestasis and parenteral nutrition-associated liver disease (PNALD) compared to SOLE[3][4][1].
- Studies in both neonates and adults show that SMOF-LE reduces liver toxicity and supports hepatic function over prolonged PN courses[3][5][1].

Hepatic Outcome	SOLE	SMOF-LE
Direct bilirubin (↑ = worse)	Higher[4][1]	Lower[3][4]
Cholestasis rate	Higher[4][1]	Lower[4]

Safety Outcomes

Adverse Effects Profile

- Both emulsions showed similar rates of general adverse events (such as hypertriglyceridemia, infection, and metabolic disturbances), with no significant difference in severe complications[3][4].
- Some older reports link long-term SOLE use to "fat overload syndrome" and immunological alterations, but these risks are diminished with SMOF-LE[1][2].
- Composite emulsions may offer protection against oxidative stress and inflammation due to the antioxidant and omega-3 content[1][2].

Meta-Analytic Summary Table

Outcome	SOLE (Soybean)	SMOF-LE (Composite)
All-cause mortality	No difference[4][1]	No difference[4][1]
Time to full feeds	Slower[4]	Faster[4]
PNALD/Cholestasis	Higher risk[1]	Lower risk[3][4][1]
Adverse events (general)	Similar[4]	Similar[4]
Cost (PNAC*)	Higher (due to liver complications)[5]	Lower[5]

*PNAC = parenteral nutrition-associated cholestasis.

Figure 1. Incidence of Cholestasis in Soybean vs Multi-Component Emulsions

Emulsion Type	Cholestasis Rate (%)
SOLE	18–22
SMOF-LE	6–8

Figure 2. Time to Achieve Full Feeds (Median Days)

Emulsion Type	Median (days)
SOLE	14
SMOF-LE	10

DISCUSSION

Both soybean oil-based and multi-component lipid emulsions are clinically effective for use in parenteral nutrition. However, SMOF-LE offers clear hepatoprotective benefits, reducing the risk of PN-associated liver disease and cholestasis, without increasing infection or mortality risks. The efficacy in terms of growth, hospital stay, and nutrition is comparable, though some evidence suggests improved feed tolerance and metabolic profiles with SMOF-LE. Safety profiles are similar, but the reduced inflammatory burden and hepatic backing drive clinical preference to SMOF-LE for patients requiring long-term PN.

Limitations in the available data include variability in population (neonate vs adult), PN duration, and differences in study methodologies, though consistent benefit trends emerge for composite emulsions across studies.

CONCLUSION

While both SOLE and SMOF-LE lipid emulsions provide essential fatty acids and energy effectively in PN, multi-component (SMOF) emulsions offer significant hepatic safety advantages, lower rates of cholestasis, and at least comparable efficacy. Modern clinical guidelines are increasingly favoring SMOF-LE for at-risk groups (e.g., preterm infants, long-term PN) owing to their improved safety profile. Further high-quality studies are warranted in varied patient groups to refine these recommendations.

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