Safe Administration of Parenteral Nutrition

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Clinical Associate Professor
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Learning Objectives

1. Identify common types of PN administration errors.
2. Describe system-based strategies to enhance the safety of PN administration.
3. Propose action items to improve the safety of PN administration.

Question:

A recent survey revealed ________% of organizations do not track PN-related errors.

Answer

A 80
B 24
C 18
D 44

Question:

One prospective study of errors associated with PN noted 35% of PN related errors occurred during the administration process.

Answer

A True
B False
Case Study:
75 yo female s/p SBR is receiving a 2:1 PN formulations with IVFE to be infused over 12 hours. Nursing reports the patient is experiencing nausea with infusion of IVFE.

The physician contacts pharmacy concerning a prolonged infusion of IVFE dose. What recommendations should be made regarding IVFE and tubing?

A.S.P.E.N. PN Safety Consensus Recommendations

Administration

- Focus on nursing practice-pharmacy involvement
- Applicable across all care settings
- Adult and pediatric populations
- Based on best available evidence, consensus, expert opinion

Errors in PN Administration

- Up to 35% of reported PN errors occur in the administration phase (Sacks. JPEN 2012;36:20S-22S)
- Less likely than other errors to be intercepted
- More likely to cause harm
- Frequently involve vulnerable populations
- Variety of care settings increases potential for disparities in knowledge and skills

PN Administration Errors

- Up to 35% of reported PN errors occur in the administration phase (Sacks. JPEN 2012;36:20S-22S)
- Less likely than other errors to be intercepted
- More likely to cause harm
- Frequently involve vulnerable populations
- Variety of care settings increases potential for disparities in knowledge and skills

PN Administration: Three Areas of Focus

1. System-based measures to enhance safety.
2. Strategies to prevent errors in the verification process.
3. Practices to maintain patient safety during PN infusion.

Part 1: System-Based Strategies

- **Organizational commitment to safety**
  - Evidence-based policies and procedures
    - Standardize nursing procedures throughout organization
    - Perform regular review and updates of policies and procedures
  - Quality Improvement programs
    - Establish PN-specific QI process (current rate 39.9%)
    - Examine environmental factors that contribute to errors
    - Maintain an interdisciplinary approach
    - Focus on developing action plan
System-Based Strategies (cont’d)

- Education and competency validation
  - Mandatory for all newly hired nurses
  - Validate competency when introducing changes in procedure or new equipment or technology (pumps, CPOE)
  - Address gaps in skills or knowledge based on QI or other data sources.
- Prohibition against PN brought from home
  - Policy at 75% of responding organizations
  - Complies with The Joint Commission recommendation requiring pharmacy review, verification of all medication

Part 2: PN Verification

### The 5 rights of medication administration

- Visual inspection of formulation
  - Integrity of container
  - PN stability
  - Education re: compromised formulations (all settings)
- Verify PN label against the original prescriber order
  - Product name, route (central vs peripheral), initiation time, infusion rate, and expiration date
  - Match components on label to those on the prescriber order
  - Provide full PN prescription in all care settings (i.e., home care)

PN Verification (cont’d)

- Confirm patient identity with 2 identifiers
- Regulatory compliance; based on organizational policy
- Trace administration tubing to point of origin
- Avoid tubing misconnections
- Initiation of infusion and at all hand-offs (Simmons, 2011)
- Independent double checks
  - Pump programming errors most common; potential for severe consequences
  - Double checks to verify pump settings
  - Performed by 2 clinicians alone and apart from each other
  - Expand to additional phases of PN administration based on quality data, patient population

Part 3: Safe PN Administration

### Ensuring safety during PN infusion

- Vascular access
  - Processes for the insertion & care of VADs used for PN
  - Document appropriate tip position for PN administration
  - Include measures to reduce contamination of catheter hub
  - In acute care, avoid the use of VAD for blood sampling
- Filters
  - Use appropriate sized filter for all PN formulations
  - Education re: high pressure alarms and / or occluded filters
    - Never remove a filter and allow PN to infuse unfiltered
    - Pharmacy review of PN prescription if filter occludes
  - Prime filters immediately before initiating the infusion

Safe PN Administration (cont’d)

- Tubing and containers
  - Single, once daily container except for lipids administered separately
  - Containers and tubing—DEHP free (TNA and lipid infusions)
  - Change administration set every 24 hours for all TNA and dextrose/amino acid PN formulations
  - Change administration set every 12 hours for lipid emulsions infused separately
  - For lipid infusions longer than 12 hours, divide lipid dose with new container every 12 hours
  - Policies re: multi-chamber PN containers should be developed using a multidisciplinary approach.
Safe PN Administration (cont’d)

• Infusion practices
  - Maintain infusion at prescribed rate, using a pump
  - After initial double check, verify pump settings at regular intervals and at hand-offs
  - Complete infusion within 24 hours of initiation
  - Avoid interruptions for routine care, medications, or transport
  - Do not adjust rate to compensate for off schedule infusions
  - Make changes based on patient tolerance & metabolic stability
  - Transition to cycled PN in steps with close glucose monitoring

Topics for Further Research

1. Which educational strategies are most effective in developing and validating competence in PN administration?
2. What is the optimal use of independent double-checks?
3. What work environment and human factors contribute to PN administration errors?
4. What strategies can be implemented to reduce the severity of PN administration errors?
5. What is the optimal approach for the management of PN during surgery?
6. What is the impact on infection rates and accuracy of laboratory tests with the use of VADs to obtain blood samples?
7. Does the use of checklists to guide PN verification process reduce errors?

Summary

• Errors during PN administration at the point of patient care, making them less likely to be intercepted, more likely to cause harm
  - Prevention centers on developing a strong organizational infrastructure committed reducing errors:
    o Quality Improvement processes
    o Clearly articulated policies and procedures
    o Interdisciplinary process for selecting and implementing technology
  - Vigilance in adhering to verification procedures
  - Standardized nursing practices; eliminate “innovation”
  - Need for further research

Question:

A recent survey revealed ______ % of organizations do not track PN-related errors.

Answer

A  80
B  24
C  18
D  44

Question:
One prospective study of errors associated with PN noted 35% of PN related errors occurred during the administration process.

Case Study:
75 yo female s/p SBR is receiving a 2:1 PN formulations with IVFE to be infused over 12 hours. Nursing reports the patient is experiencing nausea with infusion of IVFE.

The physician contacts pharmacy concerning a prolonged infusion of IVFE dose. What recommendations should be made regarding IVFE and tubing?

In cases where a prolonged IVFE infusion is desirable to promote tolerance, the daily fat emulsion dose should be divided in 2 parts, with a new container and tubing used every 12 hours.

References
Hicks RW, Becker SC, Chua I. A summary of NICU fat emulsion medication errors and nursing services: Data from MEDMARX. Advances in Neonatal Care. 2007; 7: 299-310.

References

Michael D. Kraft, PharmD, BCNSP
Clinical Associate Professor – University of Michigan College of Pharmacy
Assistant Director-Education & Research – University of Michigan Health System

Learning Objectives
1. List key recommendations for safe PN prescribing from the A.S.P.E.N. Parenteral Nutrition Safety Recommendations.
2. Describe rationale supporting recommendations for safe PN prescribing.
3. Identify future research questions and topics related to PN prescribing.

Problem with PN Orders

- Communication or PN process errors
  - Lack of hospital performance deficiency management
  - Lack of pharmacy review of PN orders
- Standardized processes
- Optimize CPOE and clinical decision support
  - 
  - PN order logic
  - "Don't order"
  - All PN nutrient missing
  - PN order and unstable macronutrient amounts and
  - PN order and unstable macronutrient amounts and
  - PN order and unstable macronutrient amounts and
- Patient chain deviations

ISMP Recommendations – Improving PN Safety

- Match prescribing and pharmacy templates
- Build, test, and heed automated warnings
- Heighten suspicions of errors
- Carry out effective redundancies
- Provide clear labeling
  - Label should always match the PN order template in the PN order form/CPOE system and the ACD
- Educate and validate competency
- Eliminate transcription of PN orders


PN Prescribing Errors

- Observational study of inpatient PN practice → 1.6% error rate
  - 40% of errors during transcription (39%) and prescribing (1%)
- PN ingredients for a 16-year-old boy ordered in amounts/kg/day → PN prepared in amounts/day
- CPOE PN order template did not match pharmacy/automated compounding device (ACD)
- Lack of Clinical Decision Support (CDS) and warnings in CPOE PN order and ACD
- Multiple points of manual transcription, and lack of redundancies
- Standardized processes, standardized order formats, use of electronic/CPOE orders to avoid manual transcription and handwritten orders, and incorporating CDS, can reduce PN errors and improve safety

Improving Safety of High-Risk Therapies: Cancer Chemotherapy

- American Society of Clinical Oncology (ASCO) and Oncology Nursing Society (ONS) Chemotherapy Administration Safety Standards
  - Concepts consistent with A.S.P.E.N. Safe Practices for PN
  - Policies/procedures/guidelines for training and education
  - Standard documentation
  - Use of standardized orders, verbal orders not allowed
  - Orders include all components of the regimen
  - Orders that deviate from standard protocols → require reference/documentation
  - Verification, labeling and administration guidelines

Improving Safety of PN Prescribing

- Adopting published guidelines and literature
- Standardized Processes
- PN-specific Policies and Procedures
- Optimization of CPOE and clinical decision support (CDS)
- PN-use process shall include clinicians with expertise in the area of nutrition support, preferably from multiple disciplines

Safe PN Prescribing – Key Recommendations

- Evaluate, define, and document
  - Patient’s medical problem(s)
  - Indication(s) for PN and therapeutic goal(s)
  - Appropriate IV access
  - Documented in record and within PN order
- PN shall be prescribed using a standardized order format and review process
  - Standardized electronic PN orders
  - Verbal/telephone and handwritten orders should be avoided
  - All components ordered in amounts per day (or per kg per day) vs. amounts per liter, percent concentration or volume

PN Order Recommendations

<table>
<thead>
<tr>
<th>Patient Information</th>
<th>PN Ingredients (should match PN label)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient identifiers (name, MRN/unique identifier, birthdate/age, location or home address)</td>
<td>Amino acid</td>
</tr>
<tr>
<td>Allergies and reactions</td>
<td>Dextrose</td>
</tr>
<tr>
<td>Weight and dosing weight metric</td>
<td>Sodium phosphate</td>
</tr>
<tr>
<td>Diagnoses/Indication(s) for PN</td>
<td>Sodium chloride</td>
</tr>
<tr>
<td>Vascular access device/location</td>
<td>Sodium acetate</td>
</tr>
<tr>
<td>Administration date/time</td>
<td>Potassium phosphate</td>
</tr>
<tr>
<td>PN Instructions</td>
<td>Potassium chloride</td>
</tr>
<tr>
<td>Total volume, infusion rate, start and stop times, cycle information</td>
<td>Potassium acetate</td>
</tr>
<tr>
<td>Prescriber and contact information</td>
<td>Magnesium sulfate or magnesium chloride</td>
</tr>
<tr>
<td>PN ingredients</td>
<td>Calcium gluconate</td>
</tr>
<tr>
<td>Should match PN label</td>
<td>Multivitamins</td>
</tr>
<tr>
<td>Trace elements</td>
<td>Additives (e.g., cysteine, regular insulin) as clinically appropriate and compatible</td>
</tr>
</tbody>
</table>

Safe PN Prescribing – Key Recommendations

- Within standardized electronic PN orders, clinical decision support should be available and utilized to avoid exceeding recommended/safe clinical limits and limits of compatibility
  - When CPOE is not available → use a standardized order template as an editable electronic document (avoid handwritten orders)
  - Required components for the PN order and suggested sequence (next slide)
  - PN label should match the sequence on the PN order

Reducing PN Prescribing Errors

- Children’s hospital adopted standardized PN process → reduced PN errors from 9 to 4 per 1000 PN orders
- Impact of computerized PN order worksheet (outside of CPOE)
  - Reduced overall PN prescribing errors 14.5% → 6.8% (p=0.016)
  - Peripheral PN orders 29.3% → 9.6% (p=0.002)
  - 12 errors in 177 PN orders all due to data entry or transcription mistakes (avoidable)

**Potential Benefits of CPOE and CDS**

- Review and Meta-Analysis of 12 studies: effect of CPOE on errors
  - 80% of studies demonstrated reduction in overall medication errors
  - CPOE associated with 66% reduction in prescribing errors in adult patients (OR 0.34; 95% CI 0.22–0.52)
  - One randomized controlled trial demonstrated 77% avoided prescribing errors per 1000 orders (pediatric hospital)
  - Significant heterogeneity, also included uncontrolled and observational trials
- Systematic review and meta-analysis + data from AHA and ASHP surveys
  - Use of CPOE associated with 48% reduction in likelihood of error
  - Estimated CPOE resulted in 12.5% reduction in med errors (~ 17.4 million med errors averted) throughout U.S. in 1 year


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**No Small Feat...**

- Substantial time and effort, input and expertise from all disciplines and IT team
- No standard amongst EHR vendors
- Survey of A.S.P.E.N. members regarding EHRs and effectiveness of nutrition documentation
  - Overall rating of all EHRs was “fair”
  - Correlation between length of time using EHR and rating
  - No vendor received a “good” or “excellent” rating
  - All rated PN ordering as “fair” or “poor” for all vendors

“This study should be a wake-up call for HER developers/vendors, healthcare systems, and clinicians that the nutrition and nutrition support content of the current EHRs needs improvements. Nutrition support clinicians need to be actively involved in optimizing this EHR content.”

Vanek VW. Nutr Clin Pract 2012

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**Safe PN Prescribing – Key Recommendations**

- **Physical environment: USP <1066>
  - Appropriate illumination in areas where prescribed, reviewed/verified, compounded, and administered
  - Ergonomic design of workplace environment
- **Establish medication safety zones
  - Minimize interruptions
  - Minimize noise

Ayers P, et al. JPEN 2013

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**Safe PN Prescribing – Key Recommendations**

- **PN Orders
  - Full generic names (unless multiple products or indicates unique properties of the ingredient)
  - Include related orders for labs, monitoring parameters
  - Use only TJC-approved abbreviations, avoid ISMP error-prone abbreviations
  - Avoid addition of non-nutrient medications when possible (if necessary, only when clear compatibility data exist)
  - Develop protocols to allow modification of PN orders when incompatibilities exist
    - Document in medical record, communicate with team
    - Signed by prescriber

Ayers P, et al. JPEN 2013

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**Safe PN Prescribing – Key Recommendations**

- **PN Reordering
  - Duration of PN order dictated by institution policy
  - Each component should be re-ordered in entirety, do not just use “renew”
  - Reordering process should be structured to include:
    - Review of current order(s)
    - Review of labs and patient condition
  - New PN patients ➔ more frequent monitoring and order assessment/renewal (e.g., daily, or more frequent if risk for refeeding)
  - Unstable clinical condition ➔ at least daily
  - Stable hospitalized ➔ every 2 – 7 days
  - Stable, home or long-term care ➔ every 1 – 4 weeks

Ayers P, et al. JPEN 2013

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Materials
 Should
 Knowledge
 Training
Brown Seres D, Mirtallo J, Shamliyan TA, Sacks Jacobson
Agency
D
B
calculating nutrition. 28. Accessed
intensive use
Safe parenteral
Parenteral and oncology/Oncology Practices 2004;28:S39
GS, to clinicians of
PN include
and Am
computerized nutrition
administration
patients.
Perinatol
2007; 222.
Johnson
D,
Frequency
and chemotherapy
nutrition
and
severity
al;
Error
practices:
2006;30:177.
References
A.S.P.E.N.
Safe
Mismatched
and
renewing
PN
be
the
function
“r enew”
professionals
be
patients.
Medication
Hypo Os hynepneas
and
harm
didactic
and
skills
individuals
be
of
the
48 – 66% reduction in errors or risk of errors
A.S.P.E.N. members rated nutrition documentation and PN ordering within EHRs as “good” or “excellent” in a recent survey
There are no studies evaluating the impact of a standardized process or computerized PN order on PN errors
Studies have demonstrated CPOE has minimal impact on medication errors
Which of the following is NOT true regarding the A.S.P.E.N. PN Safety Recommendations?
A
Institutions should develop standardized processes, policies and procedures for PN therapy
B
All healthcare professionals involved in the PN-use process should receive appropriate education and should have assessment of knowledge and competency at least annually
C
PN should be ordered using a standardized electronic order form enabled with clinical decision support
D
Using a simple “renew” function or order is encouraged for renewing PN orders to simplify and streamline the process
True or False:
There are very few potential research opportunities regarding PN prescribing and safe practices.
A
True
B
False
Which of the following is true regarding the impact of CPOE and standardized processes on prescribing?
A
CPOE is associated with 48 – 66% reduction in errors or risk of errors
B
A.S.P.E.N. members rated nutrition documentation and PN ordering within EHRs as “good” or “excellent” in a recent survey
C
There are no studies evaluating the impact of a standardized process or computerized PN order on PN errors
D
Studies have demonstrated CPOE has minimal impact on medication errors
Safe PN Prescribing – Key Recommendations
PN Education should be provided to ALL disciplines/personnel involved in PN-use process
Training should include didactic and experiential components
Knowledge and skills of all individuals involved in PN-use process should be assessed
Should be part of clinical training programs
Materials and processes shall be developed and led by clinicians with expertise in the area of nutrition support, preferably from multiple disciplines
Ayers P, et al. JPEN 2013
PN Prescribing: Topics for Future Research
 Errors associated with PN prescribing
 Impact of PN template standardization on PN prescribing and transcription errors
 Impact of electronic PN orders and use of CDS
 Impact of incorporating monitoring parameters on PN prescription
 Impact of standard commercial PN product (pre-mix) vs compounded PN formulation
 Impact on time to achieve nutrition goals and length of stay with consultation from a nutrition support clinician
 Impact of PN education programs, PN competency assessment, and credentialing/certification on PN ordering errors and PN safety
 Impact of PN clinical effectiveness or quality improvement processes on PN prescribing errors
Ayers P, et al. JPEN 2013
References
 Institute for Safe Medication Practices. Misaligned prescribing and pharmacy templates for parenteral nutrition (PN) lead to data entry errors. ISMP Medication Safety Alert 2012; 17(13): June
Parenteral Nutrition Practices

Jay M Mirtallo MS, RPh, BCNSP, FASHP, FASPEN
Professor of Clinical Pharmacy
The Ohio State University, College of Pharmacy
Immediate Past-President, A.S.P.E.N.

Objectives

- Describe current parenteral nutrition (PN) practice including:
  - The PN order, order communication, compounding
- Discuss those variables that threaten the integrity of the PN system
- Provide the evidence in support of a standardized PN system using an approach to simplify PN order and compounding practices

True or False:
The majority (50% or greater) of health systems prepare between 0-5 parenteral nutrition products per day for neonate, pediatric and adult patients.

A True
B False

True or False:
The PN order for macronutrients is done consistently across all health care systems with no or minor (no harm) errors made when patients on PN transfer between health care systems.

A True
B False

True or False:
Benefits of a standard PN order form have been noted to be the following: reduction in prescribing errors, improved productivity and efficiency and better interpretation of the PN order.

A True
B False

PN Preparation for Neonatal, Pediatric and Adult patients

Adapted with permission. Boullata J et al JPEN 37:212-222, 2012
Survey of Safe Practice: 2003 vs 2011 Results

- Organizational systems

<table>
<thead>
<tr>
<th>PN issue</th>
<th>2003^1 (N=651), %</th>
<th>2011^2 (N=893), %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outsource PN</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>Exclusive use of pre mixed PN</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>≤ 5 PN daily</td>
<td>33</td>
<td>50-82</td>
</tr>
</tbody>
</table>


PN Compounding

<table>
<thead>
<tr>
<th>PN issue</th>
<th>2003^1 (N=651, %)</th>
<th>2011^2 (N=893, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACD in use for PN preparations</td>
<td>22</td>
<td>64</td>
</tr>
<tr>
<td>Order transcription to ACD required</td>
<td>84</td>
<td>82</td>
</tr>
<tr>
<td>ACD active dose limits in place</td>
<td>-</td>
<td>65</td>
</tr>
<tr>
<td>ACD, automated compounding device</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Deaths of 9 Alabama Patients Tied to Intravenous Supplement


Product Shortages Effect on PN Practice

- Less desirable or familiar product
- Confusion in prescribing process due to substitution
- Frequent changes in compounding and distribution
- Avoid or circumvent safety checks

Product Shortages Effect on PN Practice

- Sterility, accuracy, stability, compatibility issues
  - Transfer of product from original container
  - ‘gray market’ products – unfamiliar compatibility
- Suboptimal therapy
  - ‘Rules’ for constraining inadequate supply
  - Predisposition to nutrient deficiencies
  - Increase monitoring
### Safety Issues Related to PN Product Shortages

#### Macronutrient Safety Issue

<table>
<thead>
<tr>
<th>Macronutrient</th>
<th>Safety Issue</th>
</tr>
</thead>
</table>
| Amino Acids   | • Contaminated PN resulting in infection and death  
• Fluid overload with administration of PN using lower concentrated amino acid product |
| Fat emulsions | • Hyperglycemia when replaced calories from fat to glucose |
| L-cysteine    | • Inability to provide adequate doses of calcium and phosphorus for neonates |

#### Micronutrient Safety Issue

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Safety Issue</th>
</tr>
</thead>
</table>
| Electrolytes  | • Abnormalities when switching to different amino acid or multi-electrolyte products  
• Diarrhea with use or oral electrolytes for replacement |
| Phosphorus    | • Hypophosphatemia – reduced daily dose to constrain (save) supply  
• Hyperkalemia from oral replacement product containing potassium phosphate salt  
• Predisposition to refeeding syndrome |
| Sodium        | • Hypokalemia |
| Acetate       | • Hyperchloremic metabolic acidosis |


### Survey of Safe Practice: 2003 vs 2011 Results

#### Order Communication

<table>
<thead>
<tr>
<th>PN issue</th>
<th>2003&lt;sup&gt;1&lt;/sup&gt; (N=651), %</th>
<th>2011&lt;sup&gt;2&lt;/sup&gt; (N=893), %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standardized PN order form</td>
<td>88</td>
<td>90</td>
</tr>
<tr>
<td>Ordered in amount/d (or amount/kg/d)</td>
<td>&lt;19</td>
<td>21-26</td>
</tr>
<tr>
<td>• Macronutrient</td>
<td>39</td>
<td>11-35</td>
</tr>
<tr>
<td>• Electrolytes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


### PN Formulas and Frequency of Use

#### Description | Formula Characteristics | % Use
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dextrose (g/L)</td>
<td>AA (g/L)</td>
<td>Fat (g/L)</td>
</tr>
<tr>
<td>Stress</td>
<td>150</td>
<td>50</td>
</tr>
<tr>
<td>High Protein</td>
<td>140</td>
<td>60</td>
</tr>
<tr>
<td>Fluid/Protein Restricted</td>
<td>210</td>
<td>50</td>
</tr>
<tr>
<td>Hypocaloric</td>
<td>75</td>
<td>50</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


### Standard PN Formulas 2009-

#### Description | Dextrose (g/L) | AA (g/L) | Fat (g/L) | Cal/ml | % Use
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>STANDARD</td>
<td>150</td>
<td>50</td>
<td>20</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>HIGH PROTEIN, FLUID RESTRICTED</td>
<td>140</td>
<td>60</td>
<td>20</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>HYPOCALORIC, OBESITY</td>
<td>75</td>
<td>50</td>
<td>20</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>DILUTE, HIGH FLUID</td>
<td>100</td>
<td>60</td>
<td>30</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>STANDARD, LOW PROTEIN</td>
<td>150</td>
<td>40</td>
<td>20</td>
<td>0.87</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Seres D et al JPEN 30:259-265, 2006

### PN Order: Macronutrients

- **Dextrose:**  
  - Infusion rate: mg/kg/min, g/kg/h  
  - g/L of PN  
  - Kcal/day  
- **Fat:**  
  - Volume of % original concentration  
  - % final concentration  
  - Non-Protein kcal

PN Order: Macronutrients

- Intravenous fat emulsion
  - g/kg/d
  - g/d
  - g/L of PN
  - Volume of % original concentration
  - % final concentration
  - g/total volume of PN
  - Kcal/day
  - Volume of % concentration to be added to or infused separate from PN
  - ml/d
  - ml/L of PN
  - g per total PN volume
  - Nonprotein kcal


PN Order: Macronutrients

- Protein
  - g/kg/d
  - g/d
  - g/L of PN
  - Volume of % original concentration
  - % final concentration
  - g/total volume of PN


PN Order: Macronutrients

- Methods not consistent within each system
  - May be mixed:
    - volume of original product to be added for dextrose but protein, g/kg/d
  - Requires knowledge of system
  - Predisposes to calculation error


PN Order: Micronutrients

- Similar to macronutrients
- Issues with compatibility and dosing
  - mEq/L or 100 ml for neonates
  - mEq/d
  - mEq/total volume
  - mEq/kg
  - Mmol/total volume
  - Volume of multi-electrolyte formulation
  - Mg/d
  - Mmol/L


Problems with PN Orders

- Common Factors to PN Prescribing Errors
  - Knowledge or performance deficit of prescriber
  - Patient characteristics: age, renal function
  - Calculation of PN dosage
  - Specialized dosage formulation characteristics and prescriber nomenclature
- Reason for PN order clarification
  - Illegible order
  - Essential nutrient missing
  - Incorrect or unstable macronutrient additive
  - Incompatible additive


Standard Order Forms

- Equated with standard formulas
  - Survey respondents expressed the need to individualize the formula with patient needs
- Computer order entry not equated with standard forms or formulas
- Standard order process is needed that incorporates principles to allow accurate transcription and implementation of the order at all levels of the health system
Benefits of a Standard PN Order Form

- Reduce prescribing errors by 9 to 82%
  - Dosage
  - Compatibility
  - Omissions
- Improve efficiency and productivity of nutrition support
  - Decrease calorie and protein overfeeding
  - Reduction in cost of PN by 55%
- Improve interpretation of order and documentation of PN administration

Survey of Safe Practice: 2003 vs 2011 Results

Order Communication

<table>
<thead>
<tr>
<th>PN issue</th>
<th>2003(^1) (N=651), %</th>
<th>2011(^2) (N=893), %</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPOE for PN</td>
<td>31</td>
<td>33</td>
</tr>
<tr>
<td>Electronic interface available</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>Transcription required</td>
<td>-</td>
<td>81</td>
</tr>
<tr>
<td>≤ 10% of orders require clarification</td>
<td>61</td>
<td>69</td>
</tr>
</tbody>
</table>


Compliance with A.S.P.E.N. Safe Practices

<table>
<thead>
<tr>
<th>Guideline</th>
<th>% Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount per day is required on label for base formula, electrolyte additions, micronutrients, and medications</td>
<td>26</td>
</tr>
<tr>
<td>Dosing weight of patient is required on label</td>
<td>15</td>
</tr>
<tr>
<td>Patient transfer among health care settings requires direct pharmacist-to-pharmacist communication</td>
<td>33</td>
</tr>
<tr>
<td>Development of order forms for standard formulations may aid prescriber in designing complete, balanced, and physically compatible formulation</td>
<td>74</td>
</tr>
<tr>
<td>Pharmacist should assess formulation to determine whether contents are within an acceptable standard range</td>
<td>79</td>
</tr>
<tr>
<td>Any dose of a nutrient outside normal range should be questioned and clarified before formulation is compounded</td>
<td>76</td>
</tr>
</tbody>
</table>

Adapted from O’Neal et al Am J Health-Syst Pharm 59:264, 2002

Nemours CPOE PN Order Process

Adapted with permission, Hilmas E JPEN 37: 325-335, 2012

Events Related to Complex Parenteral Nutrition System

<table>
<thead>
<tr>
<th>Event</th>
<th>Age</th>
<th>Outcome</th>
<th>Contributing factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>↑Zinc dose</td>
<td>Neonate</td>
<td>Death</td>
<td>Performance deficit: training not completed</td>
</tr>
<tr>
<td>Ca/Phosph ppt</td>
<td>Adult</td>
<td>Death, respiratory distress</td>
<td>Improper compounding sequence</td>
</tr>
<tr>
<td>↑Glucose dose</td>
<td>Pediatric</td>
<td>Death</td>
<td>Misinterpretation of product label and order</td>
</tr>
<tr>
<td>↓Glucose dose</td>
<td>Infant</td>
<td>Death</td>
<td>Final concentration 1.75% rather than 17.5%</td>
</tr>
</tbody>
</table>

Events Related to Complex Parenteral Nutrition System

<table>
<thead>
<tr>
<th>Event</th>
<th>Age</th>
<th>Outcome</th>
<th>Contributing factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>No dextrose in PN</td>
<td>Neonate</td>
<td>Permanent brain damage</td>
<td>Compounding error</td>
</tr>
<tr>
<td>Iron Overload</td>
<td>Pediatric</td>
<td>Liver toxicity</td>
<td>Misinterpretation of label, 50 fold error</td>
</tr>
<tr>
<td>↑K</td>
<td>Child</td>
<td>Death</td>
<td>Manual preparation of PN</td>
</tr>
<tr>
<td>↑Mg</td>
<td>Neonate</td>
<td>Toxicity</td>
<td>Compounder malfunction</td>
</tr>
</tbody>
</table>

**MED-MARX® Parenteral Nutrition Errors by Node and Error Type**

<table>
<thead>
<tr>
<th>Error Type</th>
<th>Order/Trans</th>
<th>Comp/Disp</th>
<th>Admin/Monitor</th>
<th>Total Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drug prepared incorrectly</td>
<td>20</td>
<td>41</td>
<td>1</td>
<td>46</td>
</tr>
<tr>
<td>Extra dose</td>
<td>43</td>
<td>3</td>
<td>3</td>
<td>46</td>
</tr>
<tr>
<td>Improper dose/quantity</td>
<td>301</td>
<td>20</td>
<td>291</td>
<td>541</td>
</tr>
<tr>
<td>Omission</td>
<td>324</td>
<td>38</td>
<td>64</td>
<td>354</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>865</strong></td>
<td><strong>176</strong></td>
<td><strong>520</strong></td>
<td><strong>1312</strong></td>
</tr>
</tbody>
</table>

*Storey et al. Nutrition Week 2013, Abstract 1524613*

**MED-MARX® Parenteral Nutrition Errors by Ingredient and Severity**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>A-D</th>
<th>E-I</th>
<th>All Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amino acids</td>
<td>26</td>
<td>1</td>
<td>27</td>
</tr>
<tr>
<td>Dextrose</td>
<td>22</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>Fat emulsion</td>
<td>254</td>
<td>3</td>
<td>257</td>
</tr>
<tr>
<td>Electrolytes</td>
<td>92</td>
<td>2</td>
<td>94</td>
</tr>
<tr>
<td>Micronutrients</td>
<td>40</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>OTHER</td>
<td>74</td>
<td>5</td>
<td>79</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1293</strong></td>
<td><strong>19</strong></td>
<td><strong>1312</strong></td>
</tr>
</tbody>
</table>

*Each error of the total was not associated with an ingredient*

*Storey et al. Nutrition Week 2013, Abstract 1524613*

**A.S.P.E.N. Statement : Parenteral Nutrition Standardization**

- Envisions a standardized process for PN must be explored to improve:
  - Patient safety
  - Clinical appropriateness
  - Maximize resource efficiency

*Kochevar et al. JPEN 2007;31:441-8.*

**A.S.P.E.N. Statement : Parenteral Nutrition Standardization**

- A standardized process may include:
  - Use of standardized PN formulations
  - Includes use of commercial PN products
  - Also includes aspects of ordering, labeling, screening, compounding and administration

*Kochevar et al. JPEN 2007;31:441-8.*

**Conclusion**

- PN is a complex system that has many factors that threaten its integrity
  - Errors occur and may result in harm
- A standardized process of PN is recommended with a focus on simplifying the ordering, preparation and administration processes

**True or False:**

- The majority (50% or greater) of health systems prepare between 0-5 parenteral nutrition products per day for neonate, pediatric and adult patients.

  - A True
  - B False
True or False:
The PN order for macronutrients is done consistently across all health care systems with no or minor (no harm) errors made when patients on PN transfer between health care systems

A True
B False

True or False:
Benefits of a standard PN order form have been noted to be the following: reduction in prescribing errors, improved productivity and efficiency and better interpretation of the PN order

A True
B False

References
- Boullata JI, Guenter P, Mirtallo JM. A parenteral nutrition use survey with gap analysis. Online 30 October 37; 212-222, 2012
Safe Practices for Compounding Parenteral Nutrition (PN)

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Pharmacy Practice
Harrison School of Pharmacy
Auburn University

Learning Objectives
1. List key recommendations for safe PN compounding practices from the A.S.P.E.N. Parenteral Nutrition Safe Practice Recommendations.
2. Describe rationale supporting recommendations for safe PN compounding.
3. Identify future research questions and topics related to safe PN compounding.

Safety of PN Systems
- Parenteral nutrition (PN) has become a life-saving modality for patients with GI dysfunction or inaccessible GI tracts
- PN formulations (2-in-1 or 3-in-1) are extremely complex admixtures
- Potential for error exists from the time orders are written to the time the infusion is complete

Development of PN Consensus Recommendations
- ASPEN hosted a multi-organizational safety summit on September 23, 2011
- 46 stakeholders attended to identify processes to improve safety surrounding PN systems
- Findings of the summit were assigned to the ASPEN PN Safety Task Force to develop into safety consensus recommendations

PN Consensus Recommendations and Terminology
  - Generated by a Task Force appointed by the ASPEN BOD
  - Produced a narrative review (last one > 30 pages in length)
- Current iteration is
  - A Working Group within the Clinical Guidelines Editorial Board
  - Designed to answer specific questions in an evidence-based process
- Terminology used to indicate strength of consensus:
  - “Shall” indicates recommendation is to be followed strictly
  - “Should” indicates that among several possibilities one is particularly suitable without mentioning or excluding others
  - “May” indicates a course of action which is permissible
PN Compounding

- Pharmacy technicians should be certified by the Pharmacy Technician Certification Board if involved in CSPs.
- Healthcare organizations shall provide a broad orientation with an in-depth training program focusing on CSP for all staff supervising or participating in the preparation process.
- Healthcare organizations shall require annual competency evaluations of pharmacists/technicians involved in CSPs.

PN Compounding

- What role does USP Chapter <797> play in preventing PN errors?
  - Healthcare organizations shall comply with USP Chapter <797> standards.
  - Outsourcing should be considered as an alternative to in-house compounding when the healthcare organization does not possess the technological resources or staffing to prepare PN admixtures according to USP Chapter <797>.
  - Privileges to make changes in the ACD database shall be restricted to a limited number of pharmacy staff who are well-trained in both the theory and the mechanics of this process.
PN Compounding

- Pharmacists and pharmacy technicians shall be proficient in the proper use of technology (i.e., ACD) when used for CSP preparations.
- Standardized, commercially-available PN products are viable options to manually-compounded sterile PN products when compliance with USP Chapter <797> and accepted guidelines from patient safety organizations is not feasible.
- 2-in-1 PN formulations with separate IV lipids should be used in the pediatric home PN population.

PN Compounding

- When an ACD is used, it should deliver all ingredients. Manual compounding should only be used:
  - If the volume of a PN component to be mixed is less than the ACD can accurately deliver.
  - If there is an interaction between a PN component and a component of the ACD (e.g., insulin and tubing).
  - If there is a chemical interaction between PN components that cannot be mitigated by sequencing the addition of ingredients.
  - During a shortage of a specific PN component, manual compounding can be a consideration as part of conservation efforts.

PN Compounding

- Verification of manual additives should include inspection of the actual vials and syringes that contain the additives. Proxy methods of verification (e.g., syringe pullback) shall not be used.
- If the manual method is being used, the process should be standardized to promote safety and efficacy. The use of a checklist/sign-off sheet shall be incorporated into the manual process.
- In facilities that care for adult, pediatric and neonatal patients, the preparation of CSPs for each population shall be separated by time or location. Separation strategies can include the use of different color bins for assembling products to be prepared.

PN Compounding

- Do pharmacists make use of warning/alerts in ACDs?
  - Each organization should develop a strategic plan for sterile compounding.
  - When using ACDs, organizations shall implement both soft and hard (catastrophic) limits for each ingredient to be consistent with needs of patient population.
  - According to recent survey, dose limit warning are active in only 1/3 of ACDs [Boulatta et al. J.PEN J Parenter Enteral Nutr. 2013; 37: 212-222].

PN Compounding

- What compounding errors have been caused by deficits in knowledge, lack of training, competency, and proficiency? What compounding errors have been caused by a lack of standardized educational curriculum in schools of pharmacy or pharmacy technician programs?
  - U.S. schools of pharmacy shall develop curriculums that address proper aseptic technique and USP Chapter <797> for the preparation of compounded sterile products (CSPs).
PN Compounding

- Does education of pharmacists/pharmacy technicians reduce errors in the PN compounding process?
- Data available suggests that when pharmacy students were formally taught aseptic technique skills with direct observation and assessment of parenteral compounding procedures, microbial contamination rates related to medium-risk level compounding decreased significantly from based to the end of the 16-week course [JPEN 2008;15:72(2): article 27].
- Surveys of pharmacists at the beginning of post-graduate training programs demonstrated that first-year pharmacy residents reported minimal experience with PN assessments and IV admixtures [JPEN 2008;72(1): article 6].

Conclusions

- Recommendations are intended for discussion and adoption over time by organizations and individual professionals involved in routine care of PN patients.
- Many of the safety concerns exist across settings from institutional to home care.
- Responsibility of prescriber, pharmacist, nurse, dietitian, nutrition support team to recognize and report all PN-related errors, whether they reach the patient or not.
- Complete reporting allows the medication officer/committee to review and address with individuals having oversight of the PN process.

References


Which of the following BEST characterizes ISMP recommendations regarding the use of standardized, commercially-available PN products?

- A) Standardized, commercially-available PN products should always be used preferentially over manually compounded PN products
- B) Standardized, commercially-available PN products should never be used over manually compounded PN products
- C) Standardized, commercially-available PN products are viable options to manually-compounded sterile PN products when compliance with USP <797> is not feasible
- D) Standardized, commercially-available PN products should only be used for patients in the home-care environment

True or False:

Privileges to make changes in the ACD database shall be restricted to a limited number of pharmacy staff who are well-trained in both the theory and the mechanics of the PN process.

- A) True
- B) False
Which of the following represents a situation in which ONLY manual compounding is should be used?

A. With multiple containers of a single additive
B. With the addition of parenteral multivitamins
C. When the volume of a PN component is less than the ACD can accurately deliver
D. When the PN component only exists in a powder form and must be reconstituted with sterile H₂O