Implementing computerized provider order entry for total parenteral nutrition in a neonatal intensive care unit

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Abstract #1017

Disclosure
• IRB Status: Approved
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  – Leigh Scherer, BS, CPhT
  – Michael McMahon, PharmD
• Conflicts of Interest: None
• Project Sponsorship: None

Learning Objectives (MPA):
1. Differentiate types of errors that may occur when handwriting an order form versus ordering through a computerized process.
2. Analyze the process of ordering, verifying, and compounding total parenteral nutrition formulations for neonates at St. Vincent Healthcare.
Background

- Total parenteral nutrition (TPN) ordering process introduces risk of error
  - Requires input of complex parameters with multiple calculations
    - Rate
    - Volume
    - Macronutrient / micronutrient concentrations
    - Additives
  - American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) recommend computerized provider order entry (CPOE) in place of handwritten orders
    - Lehmann and colleagues measured 10.8% error rate for handwritten TPN orders


- Possible errors with handwritten TPN orders
  - Incorrect calculations
  - Missing data
  - Illegible handwriting
  - Excessive nutrient concentration
  - Hyperosmotic / hypo-osmotic formulations
  - Risk of precipitation

- CPOE may reduce risk of error through
  - Automated calculations
  - Required data fields
  - Hard limits for out-of-range values

Background

• Pre-intervention Workflow
  - Pharmacists encountered errors in handwritten TPN orders, prompting need to transition to CPOE
  - Multiple cases of delayed administration of TPN
  - Technological barriers to pharmacists acknowledging TPN orders in a timely manner
  - Some errors required phone call to neonatologist, delaying care

Objectives

• Primary Objectives
  - Reduce percentage of TPN orders with at least one transcription error
  - Decrease average time taken for pharmacists to address a TPN order

• Secondary Objectives
  - Improve staff satisfaction for the computerized TPN ordering process
  - Increase number of criteria met for A.S.P.E.N’s Safe Practice for Parenteral Nutrition: Mandatory Components of the PN Order Form

A.S.P.E.N’s Mandatory Components of the PN Order Form

<table>
<thead>
<tr>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearly written and understandable to anyone who might utilize it</td>
</tr>
<tr>
<td>Decimals and % concentrations avoided</td>
</tr>
<tr>
<td>All components ordered in g/mg/mEq/mMol per day or kg per day</td>
</tr>
<tr>
<td>Contact information for person writing the order</td>
</tr>
<tr>
<td>Contact information for assistance with PN ordering</td>
</tr>
<tr>
<td>Time by which order needs to be received for processing</td>
</tr>
<tr>
<td>Location of venous access device (central or peripheral)</td>
</tr>
<tr>
<td>Height, weight/dosing weight, diagnosis, PN indication</td>
</tr>
<tr>
<td>Hang time guidelines</td>
</tr>
<tr>
<td>Information regarding potential incompatibilities</td>
</tr>
</tbody>
</table>

Methods

<table>
<thead>
<tr>
<th>Study Design</th>
<th>Prospective, observational study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclusion/Exclusion Criteria</td>
<td>Includes all TPN orders written for patients in the neonatal intensive care unit (NICU)</td>
</tr>
<tr>
<td>Sample Size</td>
<td>Sample size of 252 orders required to detect 85% reduction in TPN orders with an error Based on 80% power</td>
</tr>
<tr>
<td>Data Collection</td>
<td>Collect each TPN order from NICU Record time for a pharmacist to address each order Assess satisfaction from neonatologists using surveys</td>
</tr>
</tbody>
</table>

Methods

• Data Analysis:
  - A chi-squared statistical test will be used to determine whether intervention significantly decreases TPN orders with an error
  - A one-tailed t-test will be used to determine whether intervention significantly reduces time for pharmacist to address TPN order
  - All tests performed at the 0.05 significance level

Methods

• Intervention:
  - Customized and activated a computerized form for TPN orders in the NICU
    • Alerts when osmolarity is out-of-range
    • Detects out-of-range values (e.g. electrolyte concentrations)
  - Performs weight-based calculations for volume, macronutrient, and electrolyte requirements
Methods – Pre- vs. Post-intervention Workflow

- Nurse or provider enters order and electronically sends to pharmacy
- Pharmacy acknowledges and prints the order
- Pharmacist searches for order in Pharmacy Information System (PIS) or electronic medical record
- Pharmacist enters TPN order parameters into the TPN order window
- Computerized Order Form

Methods – Computerized Order Form

- Weight
- Height
- Albumin
- Protein status

Methods – Computerized Order Form

- Sodium
- Potassium
- Magnesium
- Calcium
- Phosphorus
- Lactate
- Glucose
- Hematocrit
- Hemoglobin
- Total protein
- Albumin
Methods – Computerized Order Form

Results

• Primary Outcomes:

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Pre-Intervention (n = 205)</th>
<th>Post-Intervention (n=47)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of TPN Orders with at least one error</td>
<td>38 (18.5%)</td>
<td>5 (10.6%)</td>
<td>0.194</td>
</tr>
<tr>
<td>Average Time to Address TPN</td>
<td>8 min, 20 sec</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

- For post-intervention, intend to collect at least 126 orders to meet a priori power requirements

Results

Most Common Errors - Handwritten Orders
Results

Most Common Errors - CPOE

- Incorrect Cysteine Calculations: 80%
- Delayed Administration of Total TPN: 20%

Results

• Secondary Outcomes:

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Handwritten</th>
<th>CPOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearly written and understandable to anyone who might utilize it</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Decimals and % concentrations avoided</td>
<td>X</td>
<td></td>
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<td>X</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4 (40%)</strong></td>
<td><strong>7 (70%)</strong></td>
</tr>
</tbody>
</table>


Conclusion

• NICU TPN formulation associated with less errors, but findings are non-significant at this time
  – Small post-intervention sample size
  – Higher error rate during initial implementation

• Improved adherence to A.S.P.E.N's Mandatory Components of the PN Order Form

• Limitations
  • Subjective reporting of errors
  • Under-reporting of errors (for both pre-intervention and post-intervention)
Future Directions

- Continue collecting data until study meets 80% power (126 post-intervention orders required)
- Inter-operability of computerized order form with TPN compounding software
- Implement computerized TPN order forms for adult population

Post-Presentation Questions

- Which of these statements DO NOT apply to written TPN order forms?
  - a. Requires input of multiple complex parameters
  - b. Multiple calculations are involved in the ordering process
  - c. Illegible handwriting contributes to ordering errors
  - d. Hard limits are set in place for out-of-range values
  - e. Orders may lead to hyperosmolar formulations
Post-Presentation Questions

Which of the following statements is FALSE regarding the current A.S.P.E.N. guidelines?

- a. It is recommended that providers include height, weight, diagnosis, and indication for TPN.
- b. TPN orders should include information regarding potential incompatibilities.
- c. It is encouraged to use percentages for micronutrient concentrations.
- d. All TPN components should be ordered in g/mg/mEq/mMol per day or kg per day.
- e. All of the above statements are true.

Questions?

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# References


