Integrating Clinical Decision Support in CPOE

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Primary Intended Outcomes

1. Improve the efficiency, safety, and accuracy of ordering electrolyte replacement through a nurse-managed protocol,

2. Provide discrete orders in the computerized provider order entry (CPOE) system when nurses replace electrolytes, and

3. Improve how CPOE orders interface to the pharmacy system to enhance efficiency and reduce potential dispensing errors.

Relevant PPMI Recommendation

C2. The following technology solutions in hospitals and health systems are important enablers in the development of optimal pharmacy practice models:

C2d. Clinical decision support (CDS) integrated with CPOE.

Situation Analysis

Vanderbilt University Medical Center is a comprehensive health care facility dedicated to patient care, research, and biomedical education. The Medical Center has more than 900 licensed beds divided between a main hospital campus, the Monroe Carell Jr. Children’s Hospital at Vanderbilt, and the Psychiatric Hospital at Vanderbilt. Comprehensive outpatient services are also provided in numerous clinics both on and off campus. Pharmacists practice throughout the Medical Center but are typically divided between adult, pediatric, and outpatient areas. Pharmacy practice specialties include oncology, infectious disease, transplantation, hemophilia, anticoagulation, cardiology, neonatal intensive care, pediatric intensive care, and adult surgical, medical, and trauma intensive care. The Vanderbilt system has
been using CPOE for approximately 20 years, and introduced bar code medication administration (BCMA) within the last 5 years. The Pharmacy Department uses automation technology in drug storage, preparation, and dispensing.

Nurse-managed electrolyte replacement protocols were used in the adult hospital and clinicians ordered discrete doses in the pediatric hospital. To increase efficiency and minimize delays in electrolyte replacement, the pediatric hospital also elected to implement a nurse-managed protocol if sufficient CDS safeguards were available. Because replacement doses are dependent on patient and lab result variables, the protocol orders entered into CPOE were essentially permission orders without any dose or administration details. The single CPOE electrolyte replacement order was linked to a pharmacy system protocol containing up to a dozen PRN orders with verbose, lab-dependent, replacement instructions in the comment field. These pharmacy PRN orders were transmitted to the BCMA system for nurse review. Additionally, these orders could link to electrolytes stored in unit-based automated dispensing cabinets. When an electrolyte lab result was reported, the nurse followed the order instructions in BCMA and could either obtain the electrolyte from the dispensing cabinet or the pharmacy. Errors in rate or dosing had been reported, and follow-up labs were not consistently ordered.

Service Description
The pediatric pharmacy clinical coordinator approached the pharmacy informatics team to develop a nurse-managed electrolyte replacement protocol that would use real-time, patient-specific CDS. The requirements were approved by the pediatric Pharmacy and Therapeutics Committee (P&T) and nursing leadership. A pediatric clinical pharmacist assisted Pharmacy Informatics with content, behavior, and testing.

The new CPOE procedure allows the clinician to specify which electrolytes should be replaced and only permits the nurse to order these defined electrolytes (Figure 1). When a lab result is reported, the nurse orders the replacement electrolyte in CPOE, where the suggested replacement dose is highlighted based on the most recent lab result. Calculations for weight-based dosing along with dilution instructions for peripheral and central administration are displayed (Figures 2, 3, and 4). Maximum doses are enforced regardless of weight-based calculation results. To minimize pharmacy order processing errors, the program selects the appropriate dispensing file, which is sent via an intelligent interface to the pharmacy system (Figure 5). Rather than being a PRN order in BCMA system, the replacement order is now a scheduled medication that demands that the nurse address the order. BCMA information is sent to the pharmacy, electronic medical record (EMR), and CPOE systems. Appropriately scheduled follow-up lab orders are also ordered.

Coincidentally, shortly after the new procedure was implemented in pediatrics, the adult pharmacy clinical coordinator contacted Pharmacy Informatics about minimizing electrolyte replacement errors. Pharmacy Informatics suggested an adult version of the program developed for pediatrics. This was approved by P&T, adult trauma physicians, and nursing. Pharmacy Informatics worked with the trauma clinical pharmacist on content and testing (Figures 6 and 7).
Key Elements for Success
1. Experience in demonstrating the power of incorporating decision support in CPOE,
2. Nursing and pharmacy education in the new procedure, and
3. Buy-in from the P&T, as most clinical content changes in CPOE must have the committee’s approval.

Outcome Measures
1. Efficiency in responding to low electrolyte levels because clinicians do not need to be contacted first,
2. Increased number of follow-up lab tests, and
3. Feedback from physicians and nurses indicating that their workflow has improved.

Lessons Learned
1. Programs that pull data from the EMR to assist clinicians in making decisions about medications are worth the investment in time and effort.
2. Nurses tend to appreciate new technology when you can demonstrate how it will save them time and improve patient safety.

Other Considerations
Pharmacy Informatics is organizationally part of the Vanderbilt Informatics Center. This fosters close cooperation and access to computer science programmers as well as informatics clinicians. Pharmacy Informatics is responsible for maintaining drug content and decision support in the CPOE, pharmacy, and BCMA systems. Pharmacy Informatics is positioned to leverage its close working relationships with clinicians and programmers to improve the medication-use process at the medical center.

Resource Utilization
**Personnel:** One informatics pharmacist, two clinical pharmacists and one clinical coordinator for the pediatrics program. One informatics pharmacist, one clinical pharmacist, and one clinical coordinator for the adult program. Systems Support Services assist with nursing education.

**IT and other infrastructure:** CPOE, barcode administration, templates for the electrolytes, regular maintenance of the drug library.

**Supply Expense:** N/A

**Return on Investment:** N/A

Recognized Intangible Benefits
1. Ordering medications in approved, standardized doses improves patient safety.
2. Improvements in physician orders, guidance for nurses in managing the electrolyte replacement protocol, improved pharmacy order processing and documentation.
Suggestions for Other Hospitals/Health Systems

Informatics is a relatively new specialty practice area for pharmacists. Through their clinical knowledge and understanding computer and automation systems, informatics pharmacists are positioned to make contributions to improving medication management and patient care. Hospitals should be encouraged to nurture an informatics pharmacist program and evaluate how their systems can support improvements in patient care and mitigate potential errors.

Other key individuals involved in this project were:

- Judy H. Hassell, B.S.Pharm, Informatics Pharmacist, Informatics Center, Vanderbilt University Medical Center
- Julie Sinclair-Pingel, Pharm.D., Clinical Pharmacist, Monroe Carell Jr. Children's Hospital at Vanderbilt
- Amy L. Potts, Pharm.D, BCPS, Assistant Director, Monroe Carell Jr. Children’s Hospital at Vanderbilt
- Alison Grisso, Pharm.D., Clinical Pharmacist, Monroe Carell Jr. Children’s Hospital at Vanderbilt
- Susan Hamblin, Pharm.D, BCPS, Trauma Critical Care Clinical Pharmacist, Vanderbilt University Medical Center
- Bob Lobo, Pharm.D., FCCP, BCPS, Manager, Drug Policy and Clinical Services, Department of Pharmaceutical Services
Appendix

Figure 1.

Clinician has a choice of replacement electrolytes (selecting Calcium and Potassium in this example)
Figure 2.
Figure 3.
Figure 4.
Figure 5.
Figure 6.

Adult Electrolyte Replacement Guidelines

**Electrolyte(s) to be replaced** Select to display guideline details

- Calcium
- Magnesium
- Potassium
- Phosphorus

Submit Order

**EXCLUSION** criteria include the following and patients with risk factors for the following:

- Hemodialysis/peritoneal dialysis
- Chronic adrenal insufficiency
- Electrical burns
- Rhabdomyolysis
- DKA
- Crush injury
- Hypothermic patients
- Have active transfer orders out of the ICU

Clinician selects electrolytes to be replaced per protocol
(selecting K and Phos in this example)
### CASE STUDY

**Figure 7.**

#### Potassium Replacement Guidelines

<table>
<thead>
<tr>
<th>Serum K+ (mEq/L)</th>
<th>Replacement Dose</th>
<th>K+ Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 4 mEq/L</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>3.3 - 3.9 mEq/L</td>
<td>Oral solution</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oral solution</td>
<td></td>
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<tr>
<td></td>
<td>Oral solution</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oral solution</td>
<td></td>
</tr>
<tr>
<td>≥ 4 mEq/L</td>
<td>Oral solution</td>
<td></td>
</tr>
</tbody>
</table>

- If K+ level > 3.5 give KCl.
- If central line present and continuous cardiac monitoring, infuse at 20 meq/hr.
- If peripheral access only, infuse at 10 meq/hr.
- Serum potassium may be expected to increase by ~ 0.25 meq/l for each 20 meq IV KCl infused.

#### Phosphorus Replacement Guidelines

<table>
<thead>
<tr>
<th>Phosphorus (mg/dL)</th>
<th>Replacement Dose</th>
<th>Phosphorus Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 2.5 mg/dL</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>2.5 - 2.75 mg/dL</td>
<td>Oral solution</td>
<td></td>
</tr>
<tr>
<td>2.75 - 4.0 mg/dL</td>
<td>Oral solution</td>
<td></td>
</tr>
<tr>
<td>4.0 - 5.0 mg/dL</td>
<td>Oral solution</td>
<td></td>
</tr>
<tr>
<td>5.0 - 6.0 mg/dL</td>
<td>Oral solution</td>
<td></td>
</tr>
<tr>
<td>&gt; 6.0 mg/dL</td>
<td>Oral solution</td>
<td></td>
</tr>
</tbody>
</table>

- If P level > 4 give PO4.
- Use PO4 if P less than 4.
- For IV replacement, pharmacy will dilute in 250ml NS or DSW, infuse over 4-6 hours.
- For PO4 replacement: K-Phos Neutral is the preferred alternative (K-Phos & Neutra-Phos K are no longer manufactured).

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**Very Similar format to pediatric protocol. Suggested range highlighted based on most recent lab result. Nurse must select product and/or route of administration.**

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**PPMI**

Pharmacy Practice Model Initiative