Implementation of a timed, electronic, assessment-driven potassium-replacement protocol

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Purpose. The adherence to and effectiveness and safety of a timed, electronic, assessment-driven potassium-replacement protocol (TARP) were compared with an electronic nurse-driven replacement protocol (NRP) are reported.

Methods. A retrospective observational study was conducted in a community hospital evaluating protocol adherence, effectiveness, and safety for 2 potassium-replacement protocols. All adults on medical units with an order for potassium replacement per protocol during the 3-month trial periods were reviewed. All patients requiring potassium replacement per protocol were included in the analysis. Adherence to the protocol was assessed by evaluating the dose of potassium administered and performance of reassessments. Effectiveness of the protocol was assessed by evaluating the time to achieve target potassium levels. Safety was assessed by evaluating the route of administration and occurrence of hyperkalemia.

Results. A total of 300 patients treated using potassium-replacement protocols required potassium replacement during the study period, with 148 patients in the NRP group requiring 491 instances of potassium replacement. In the TARP group a total of 564 instances requiring potassium replacement corresponded to 152 patients. Of the 491 instances requiring replacement in the NRP group, the correct dose was administered and reassessment performed 117 times (23.8%). Overall adherence ($p < 0.05$), correct dose given ($p < 0.05$), average time from blood draw to potassium replacement ($p < 0.0001$), use of oral replacement ($p < 0.05$), and time to achieve target potassium level within 12 hours ($p < 0.05$) were significantly improved in the TARP group.

Conclusion. The TARP improved the effectiveness and safety of potassium-replacement therapy over the traditional NRP without negatively affecting timeliness of care.

Keywords: electrolyte replacement, electronic, potassium, protocol

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Electrolyte abnormalities are common among hospitalized patients, with hypokalemia being one of the most frequently encountered electrolyte disturbance due to underlying disease and treatments received. Hypokalemia has been found in over 20% of patients during a hospital stay.[1-4] Hypokalemia can lead to a variety of consequences, ranging in severity from headaches, nausea, weakness, and lethargy to cardiac arrhythmias.[5]

Many institutions have adopted electrolyte-replacement protocols to address this common problem. Studies have demonstrated the superiority of nurse-driven electrolyte-replacement protocols (NRPs) over physician-ordered electrolyte-replacement protocols in multiple patient populations.[6-9] NRPs allow for nurses

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to assess electrolyte status, replace electrolytes, and reassess electrolytes as needed in a standard method. However, this approach relies on nursing staff to identify hypokalemia, administer the appropriate electrolyte replacement, and remember to reassess electrolyte status, which has its limitations. Opportunities for improving adherence to and the safety of NRPs through increased use of oral electrolyte replacement have been described.[10] It has been suggested that health information technology systems may be able to improve computerized order-entry habits and the safety of electrolyte replacement.[11]

We hypothesized that ordering scheduled laboratory tests and timed assessments on the nurse work list to automatically generate, also known as reflex, potassium-replacement orders would improve protocol adherence, effectiveness, and safety in our institution.

KEY POINTS

- Automated, electronic, electrolyte-replacement protocols improve protocol adherence, enhance patient safety, and improve timeliness of care.
- Implementation of the electronic timed protocol resulted in increased workloads for pharmacists and nurses related to order verification.
- The electronic timed protocol enhanced the safety of bedside medication scanning by providing dose-specific medication verification during administration.

Methods

We conducted a single-center, retrospective, observational study in a community hospital evaluating protocol adherence, effectiveness, and safety for 2 potassium-replacement protocols. Before June 2015, the institution used an electronic NRP for potassium replacement. Using the NRP, a nurse ordered and scheduled laboratory tests and administered potassium replacement as needed per potassium level results, which the nurse could access via an automated dispensing machine (ADM) without direct pharmacist involvement. Nurses were required to order laboratory reassessments as needed per protocol. A timed, assessment-driven, potassium-replacement protocol (TARP) was implemented in June 2015. The details of the NRP and TARP protocols are provided in the appendix. The TARP rollout included nurse education newsletters, unit rounding, and concurrent chart review performed by pharmacy students for all patients for whom a TARP was ordered. TARP orders scheduled twice-daily laboratory tests and twice-daily assessments on the nurse's work list. While performing the assessment, nurses were required to record each patient's most recent serum potassium level, whether the patient was able to take oral medication, and whether a patient receiving i.v. potassium replacement would have a central or peripheral line for use. A one-time reflex order for potassium replacement was generated when indicated for each patient dependent on assessment responses. Each reflex order was then reviewed by a pharmacist for verification before administration or the medication became available from the ADM. We allowed for a 3-month transition period before collecting data to assess the impact of the TARP.

Data were reviewed for patients older than 18 years on medical units who had an order for potassium replacement per protocol during the trial periods. (January–March 2015 for the NRP and September–November 2015 for the TARP). All patients requiring potassium replacement per protocol were included in the analysis. The time of blood draws, serum potassium levels, potassium replacement dose given, route of administration, and time of administration were recorded. Adherence to the protocol was assessed by evaluating the dose of potassium administered and performance of reassessments. Effectiveness of the protocol was assessed by evaluating the time to achieve the target potassium level. Safety was assessed by evaluating the route of administration and frequency of hyperkalemia.

Continuous variables were evaluated using Student's t test; 95% confidence intervals (CIs) from the mean were reported when applicable. Categorical data were analyzed using chi-square analysis. The a priori level of significance was set at 0.05.

Results

A total of 300 patients treated using potassium-replacement protocols required potassium replacement during the study period, with 148 patients in the NRP group requiring 491 instances of potassium replacement. In the TARP group a total of 564 instances requiring potassium replacement corresponded to 152 patients. Of the 491 instances requiring replacement in the NRP group, the correct dose was administered and reassessment performed 117 times (23.8%). Of the 564 instances requiring replacement in the TARP group, the correct dose was administered and reassessment performed 416 times (73.8%). Overall, protocol adherence improved after implementation of the TARP (73.8% versus 23.8% with the NRP, $p < 0.05$). The mean number of blood draws associated with potassium replacement was 4.4 per patient in the TARP group versus 4.1 in the NRP group. Of the 491 instances requiring replacement in the NRP group, 254 doses (52.1%) were correct, 136 doses (27.7%) were incorrect, and 99 doses (20.2%) were omitted. Of the 564 instances requiring replacement in the TARP group, 421 doses (74.6%) were correct, 37 doses (6.6%) were incorrect, and 106 doses (18.8%) were omitted. A higher percentage of potassium doses administered were the correct dose in

the TARP group than in the NRP group (74.6% versus 52.1%, $p < 0.05$). Of the 392 potassium doses administered in the NRP group, 194 were administered orally and 198 intravenously. Of the 458 potassium doses administered in the TARP group, 354 doses were administered orally and 104 doses were administered intravenously. A significantly higher percentage of potassium doses was administered orally in the TARP group (77.3% versus 49.5% in the NRP group, $p < 0.05$).

The mean time from blood draw to potassium replacement was significantly lower in the TARP group (224 minutes; 95% CI, 212–236 minutes) compared with the NRP group (418 minutes; 95% CI, 392–444 minutes) ($p < 0.0001$). A higher percentage of patients in the TARP group reached target potassium levels within 12 hours versus the NRP group (25.5% versus 12.4%, $p < 0.05$) (Figure 1). The cumulative percentages of patients achieving target potassium levels at all other time points were similar. The percentages of patients not achieving target potassium by discharge were also similar between groups.

The mean time from potassium replacement to reassessment did not significantly differ between the TARP group (503 minutes; 95% CI, 479–527 minutes) and the NRP group (497 minutes; 95% CI, 459–535 minutes). Each group had 1 instance of hyperkalemia.

Discussion

These results indicate that the TARP improved potassium-replacement therapy over the traditional NRP without negatively affecting timeliness of care. Improvements were accomplished by actively engaging nurse staff and incorporating electrolyte replacement into the pharmacist's order-verification process.

Common factors that negatively influenced TARP adherence included patient refusal of medication or blood draw, patient unavailability due to a medical procedure, and patient discharge before the ordered medication could be administered. These documented events were included as missed opportunities in the analysis of the TARP, as the NRP generally lacked documentation of these events as barriers to adherence due to the nature of the NRP design. The most common reason for the incorrect dose being administered was lack of complete documentation for i.v. doses requiring multiple i.v. bags per dose. TARP adherence is likely greater than reported here when excluding acceptable documented reasons for missed opportunities.

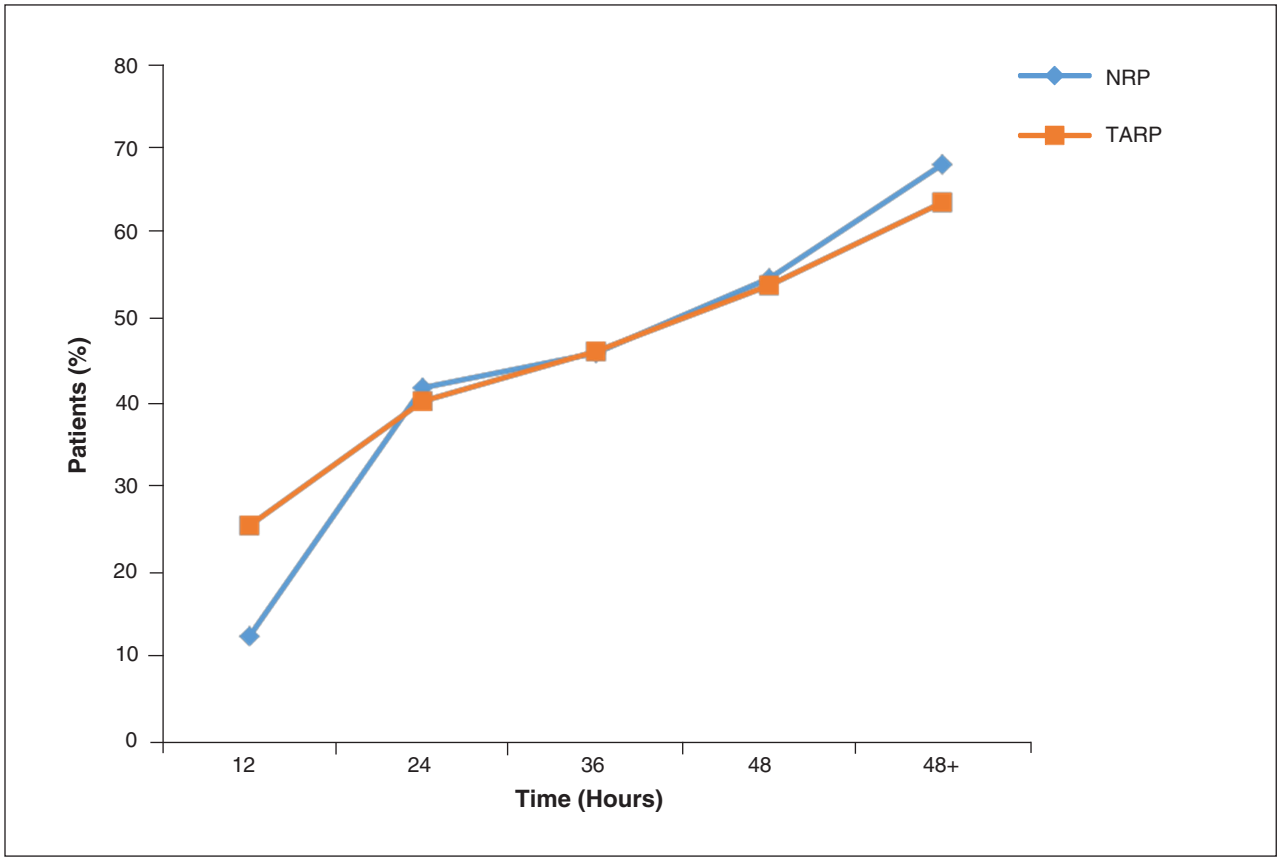
Scheduling every component of the protocol created process automation. Nurses were no longer required to remember to perform each task after implementing the TARP. Likewise, pharmacists were integrated in the process for the TARP; the NRP relied on pharmacist profile review to ensure compliance. As a result, overall protocol adherence improved 48%, including a 20% improvement in administration of the correct potassium dose. Pharmacists could prevent deviations from the protocol by reviewing recent laboratory test results populated in associated data fields against protocol requirements while verifying each one-time potassium order reflexed by nursing assessments. Once verified, nurses removed the specified dose from ADMs. The TARP limited access to potassium from ADMs. As-needed potassium orders previously used in the NRP did not restrict nurses' access to specific dosage forms of potassium or prompt them to pull the appropriate dose from ADMs.

Pharmacists' order-verification workload increased after implementation of the TARP. Pharmacists verified a mean of 2.7 more orders per patient requiring potassium replacement in the TARP versus NRP groups. However, decentralized clinical pharmacist staff who incorporated monitoring electrolyte replacement as part of daily profile reviews may have experienced a decrease in workload through process automation. Nurses' task workload increased due to an increased number of medication orders to acknowledge and administer as well as an increase in completed blood draws in the TARP group. The increase in blood draws reported here is likely a conservative estimate compared with the total increase experienced per TARP patient when including those who may not have required replacement. However, increases in nurse workload may have been offset by efficiencies gained through scheduling medication doses and laboratory tests at standard times and increasing the relative percentage of oral potassium doses to be given per patient.

Additional safety benefits were realized through implementation of the TARP. A smart drug—an inert order that contains medication information—was entered on each patient's profile when the TARP was initiated to allow for continuous checking of drug interactions and duplicates while the TARP remained active. Use of oral potassium replacement increased 27.8% with the TARP. The TARP also enhanced the safety of bedside medication scanning by providing dose-specific medication verification during administration. This represented a great improvement over the NRP, which allowed for nurses to successfully scan any potassium formulation against a single, nonspecific, "as-needed" order entered on a patient's profile. Overall bedside medication scanning rates did not change during the study time periods.

A higher percentage of patients (13.1%) treated with the TARP reached target potassium levels within the first 12 hours of therapy compared with those receiving the NRP. The protocols were similar at all other time points, suggesting that patients may benefit from more-aggressive therapy per individual response. However, each protocol had only a single occurrence of hyperkalemia during the study period, which suggests that the protocols were a safe potassium-replacement strategy. The next step is to determine if the TARP improves patient outcomes.

Figure 1. Times to achieve target potassium concentrations with the nurse-driven, electronic, potassium-replacement protocol (NRP) compared with the timed, electronic assessment-driven, potassium-replacement protocol (TARP). The difference in the percentage of patients achieving the target potassium concentration at 12 hours was significant ($p < 0.05$).



Conclusion

The TARP improved the effectiveness and safety of potassium-replacement therapy over the traditional NRP without negatively affecting timeliness of care.

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Disclosures

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information technology to improve prescribing and patient safety. *Curr Med Res Opin.* 2006; 22:2449-55.

Appendix—Potassium-replacement protocols used at Boulder Community Health

Timed, assessment-driven protocol (TARP)

1. Draw potassium level at 06:00 and 18:00
2. Assess laboratory test results at 08:00 and 20:00
   a. If taking oral medications
   - Potassium concentration ≤3.2 meq/L: administer 40 meq potassium orally once and notify physician
   - Potassium concentration 3.3–3.4 meq/L: administer 30 meq potassium orally once
   - Potassium concentration 3.5–3.6 meq/L: administer 20 meq potassium orally once
   - Potassium concentration 3.7–3.9 meq/L: administer 10 meq potassium orally once
   - Potassium concentration > 3.9 meq/L: no replacement required

   b. If patient cannot tolerate oral medications
   - Potassium concentration ≤ 3.2 meq/L: administer 40 meq i.v. once and notify physician
   - Potassium concentration 3.3–3.6 meq/L: administer 30 meq potassium i.v. once
   - Potassium concentration 3.7–3.9 meq/L: administer 20 meq potassium i.v. once
   - Potassium > 3.9 meq/L: no replacement required

Nurse-driven, electronic potassium-replacement protocol (NRP)

1. Draw daily potassium level
2. Assess daily potassium level
3. Administer potassium replacement
   a. If oral replacement ordered
   - Potassium concentration ≤ 3.2 meq/L: administer 20 meq potassium orally every 2 hours × 3 doses; recheck potassium in 2 hours and reapply protocol
   - Potassium concentration 3.3–3.6 meq/L: administer 20 meq potassium orally every 2 hours × 2 doses; recheck potassium in 2 hours and reapply protocol
   - Potassium concentration 3.7–3.9 meq/L: administer 20 meq potassium orally once
   - Potassium concentration > 3.9 meq/L: no replacement required

   b. If i.v. replacement ordered
   - Potassium concentration ≤ 3.2 meq/L: administer 40 meq potassium i.v. once; recheck potassium in 2 hours and reapply protocol
   - Potassium concentration 3.3–3.6 meq/L: administer 30 meq potassium i.v. once; recheck potassium in 6 hours and reapply protocol
   - Potassium concentration 3.7–3.9 meq/L: administer 20 meq potassium i.v. once
   - Potassium concentration > 3.9: no replacement required

Potassium administration instructions for medical floors

- Oral potassium: administer with food
- I.V. potassium without central line: potassium concentration ≤ 10 meq/100 mL, rate ≤ 10 meq/hr
- I.V. potassium with central line: potassium concentration ≤ 20 meq/100 mL, rate ≤ 10 meq/hr
- I.V. potassium with central line and cardiac monitoring: potassium concentration ≤ 40 meq/100 mL, rate ≤ 20 meq/hr