10. Burgers JA, Arance A, Ashcroft L, et al: Identical chemotherapy schedules given on and off trial protocol in small cell lung cancer: Response and survival results. *Br J Cancer* 87:562-566, 2002

11. Davis S, Wright PW, Schulman SF, et al: Participants in prospective, randomized clinical trials for resected non-small cell lung cancer have improved survival compared with nonparticipants in such trials. *Cancer* 56:1710-1718, 1985

12. Wagner HP, Dingeldein-Bettler I, Berchthold W, et al: Childhood NHL in Switzerland: Incidence and survival of 120 study and 42 non-study patients. *Med Pediatr Oncol* 24:281-286, 1995

13. Elting LS, Cooksley C, Nebiyu Bekele BN, et al: Generalizability of cancer clinical trial results – Prognostic differences between participants and nonparticipants. *Cancer* 106:2452-2458, 2006

14. Gawande A: *The Checklist Manifesto: How to Get Things Right*. New York, NY, Metropolitan Books, 2009

15. Medical Imaging and Technology Alliance: Radiation Dose and Safety. <http://www.medicalimaging.org/policy-and-positions/radiation-dose-safety/>

16. Barthelemy-Brichant N, Sabatier J, Dewé W, et al: Evaluation of frequency and type of errors detected by a computerized record and verify system during radiation treatment. *Radiother Oncol* 53:149-154, 1999

Integrated Information Systems for Electronic Chemotherapy Medication Administration

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Abstract

Introduction: Chemotherapy administration is a highly complex and distributed task in both the inpatient and outpatient infusion center settings. The American Society of Clinical Oncology and the Oncology Nursing Society (ASCO/ONS) have developed standards that specify procedures and documentation requirements for safe chemotherapy administration. Yet paper-based approaches to medication administration have several disadvantages and do not provide any decision support for patient safety checks. Electronic medication administration that includes bar coding technology may provide additional safety checks, enable consistent documentation structure, and have additional downstream benefits.

Methods: We describe the specialized configuration of clinical informatics systems for electronic chemotherapy medication administration. The system integrates the patient registration system, the inpatient order entry system, the pharmacy information

system, the nursing documentation system, and the electronic health record.

Results: We describe the process of deploying this infrastructure in the adult and pediatric inpatient oncology, hematology, and bone marrow transplant wards at Vanderbilt University Medical Center. We have successfully adapted the system for the oncology-specific documentation requirements detailed in the ASCO/ONS guidelines for chemotherapy administration. However, several limitations remain with regard to recording the day of treatment and dose number.

Conclusion: Overall, the configured systems facilitate compliance with the ASCO/ONS guidelines and improve the consistency of documentation and multidisciplinary team communication. Our success has prompted us to deploy this infrastructure in our outpatient chemotherapy infusion centers, a process that is currently underway and that will require a few unique considerations.

Introduction

Chemotherapy administration is a highly complex and distributed task in both inpatient and outpatient settings. The American Society of Clinical Oncology (ASCO) and the Oncology Nursing Society (ONS) have developed a set of chemotherapy administration safety standards¹ that provide guidelines for ordering, dispensing, and administering antineoplastic medications. The standards for nursing chemotherapy administration include verification and documentation by at least two practitioners of patient identification, therapy plan, and accuracy of the drugs and doses. The workflow to achieve these standards typically includes (1) patient education; (2) verification by two nurses of the chemotherapy orders; (3) verification by two nurses that the dispensed drug label matches the order details; and (4) verification by two nurses that the right drug is given to the right patient, in the

right dose, at the right time. There is added complexity when multiple drugs are administered to patients over multiple nursing shifts.

Many classes of medication administration errors can occur, including errors of omission (omission of a complete or partial dose), administration of drugs to the wrong patient, administration of the wrong drug, and administration of drugs at the wrong time.² Errors in which the drug is administered to the wrong patient are particularly dangerous in the context of highly toxic antineoplastic medications. Errors of omission could result in suboptimal efficacy.

Traditionally, information regarding chemotherapy drug administration events has been documented by using paper-based approaches that have several disadvantages. First, the paper medium does not lend itself to distribution among multiple simultaneous users who may need to review its contents, and

records may also be lost. Paper-based drug administration forms tend to be encounter based (ie, cover a single hospital admission) and thus do not provide a longitudinal view of drug administration events across multiple patient encounters. Furthermore, paper-based approaches can result in transcription errors, illegible handwriting, and lack of standardized documentation. Finally, there are no safety checks at the point of care because paper documentation is often done after the fact.

Electronic systems that include bar-coded medication administration (BCMA) technology have been proposed as one possible solution to some of the challenges of this paper-based approach. Several advantages and disadvantages have been observed in introducing BCMA and electronic documentation of medication administration into health care systems³⁻⁶. Advantages include improved legibility, distributed documentation, and error checking. Some disadvantages include additional work to package medications with barcodes, the initial learning curve, barcode scanning failures requiring workarounds, and increased communication requirements between nursing and pharmacy.

Taking into consideration the possible risks and benefits of BCMA, Vanderbilt University Medical Center embarked on the deployment of an information system for electronic BCMA on the inpatient units, with the goal of improving patient safety. We describe our experience in relation to deployment of this system, including integration of multiple clinical information systems and oncology-specific configurations.

Methods

Vanderbilt University Medical Center has a long history of developing clinical information systems in-house.^{7,8} As such, our first decision was whether to build or to buy a system for end-to-end electronic medication administration that would integrate with our existing clinical systems. At that time (2005) we were using a computer order entry system developed in-house called WizOrder⁷ that has subsequently been licensed to McKesson as Horizon Expert Order. We use WizOrder/Horizon Expert Order for all of our inpatient chemotherapy orders. We also use McKesson's Horizon Meds Manager as our pharmacy information system servicing the chemotherapy pharmacy for patients with cancer (both inpatient and outpatient) at both the adult and pediatric hospital and cancer center. An electronic medication administration system would need to couple tightly with these two systems. Thus we chose to license McKesson's Horizon Expert Documentation nursing documentation application, primarily because it also included a BCMA application called AdminRx. We also required tight coupling with our in-house-developed electronic health record, StarPanel.⁸ We would, however, require an oncology-specific configuration of both the nursing medication administration application and the electronic health record in order to address the special issues surrounding chemotherapy administration. Figure 1 shows the system architecture that integrates several clinical information systems required for electronic medication administration.

Figure 1. System architecture for electronic drug administration.

1. Patient registration system: The information flow begins in the patient registration system that provides all of the inpatient systems with information on the patient's location. In particular, use of the BCMA system requires a patient to have a bed assigned in the patient registration system.
2. Armband printer with barcode: When the patient is registered, an armband is printed containing a barcode specific to that patient encounter.
3. Order entry system: Providers place chemotherapy orders in the electronic order entry system by using chemotherapy order sets.
4. Pharmacy information system: Medication orders are transmitted to the pharmacy information system. The chemotherapy pharmacist reviews the medication order and creates the respective dispensable orders, including a schedule for drug administration. Details regarding the drug, drug dose, and drug schedule are both printed on the drug label containing the patient's barcode and transmitted to the electronic documentation and drug administration system.
5. Electronic drug administration system: On the inpatient oncology, hematology, and bone marrow transplant wards, nurses document drug administration events electronically by using a bar-coding system that is integrated with an electronic nursing documentation system. Each patient room is configured with a clinical workstation that includes a barcode scanner. When it is time for the drug to be administered, the nurse scans the patient armband and then the drug label. The BCMA automatically records the medication name, dose, route, identity of the administering nurse, and the start time of drug administration as the time the medication is scanned. If for some reason the drug cannot be administered at the time of barcode scanning, the nurse can manually modify the start time. The system assumes that the entire dose has been administered. If only a partial dose is administered, the nurse modifies the record to reflect the actual administered dose amount, noting in a structured

comment the reason for partial administration. If the scheduled dose is not administered, the nurse selects a reason why it was not given from a defined list of options. Nurse-to-pharmacy electronic messaging is used to communicate changes to future administration times.

Safety Alerts

At the point of bedside drug administration, the BCMA system can generate several types of alerts when the patient armband and medication barcode are scanned.

- Missing order alert: There is no matching order for the scanned drug for that patient. This may indicate a “wrong patient-wrong drug” error, or that a verbal order has been given and not yet entered into the system.
- Wrong dose alerts: The dose of the drug scanned does not match the total dose to be administered. In this case, the dose may be too high or too low.
- Wrong route alert: There is a matching drug order, but the route is incorrect (eg, oral *v* intravenous).
- Wrong schedule alert: There is a matching drug order, but the nurse is attempting to give it too early or too late with reference to the scheduled administration times.

Audit Reports

The nursing documentation system also provides audit reports to the charge nurse.

- Missed dose report: At the end of the shift, a list of medications that were not administered or not documented is generated, providing real-time follow-up for errors of omission.
- Noncompliance, with two nurses' signatures requirement: At the end of the shift, a report is generated for medication administration events that required two nurses' signatures but for which only one was documented. This gives real-time feedback on documentation compliance and the opportunity for education to reinforce such policies.

Oncology-Specific System Configuration

The nursing documentation system required oncology-specific configurations to support the unique documentation requirements for chemotherapy administration. An oncology-specific form was developed to collect information related to the chemotherapy protocol, pretreatment symptom assessment, and chemotherapy education. This form also allows a second nurse to document verification of the chemotherapy orders. Additional sections for chemotherapy education provide structured templates for documenting the nature of the education activities.

Electronic Health Record

After completion of the five steps outlined above, drug administration records are then transmitted to the electronic health record, the system primarily used by physicians, where they are revisualized in a several formats. A chemotherapy flow sheet integrates chemotherapy-related data from the ordering system (eg, BSA used for dose calculation), electronic medication ad-

ministration records, and common oncology-oriented laboratory results. Antineoplastic medications are the primary focus of the chemotherapy flow sheet; supportive medications are not included so as to maximize screen space for showing the data most essential to tracking patient treatment history. This flow sheet provides a longitudinal view of the medication administration data over multiple hospital admissions. This view is currently limited to chemotherapy medications administered in the inpatient setting but will soon incorporate medications administered in the infusions centers when BCMA is deployed to that setting.

Results

System Deployment

Before the BCMA system was deployed, the electronic nursing documentation system was initiated throughout the hospital between November 2005 and May 2006. Because of the complex nature of chemotherapy administration, the oncology units were among the last to be implemented on BCMA.

System support services employs 20 registered nurses who provide hospital-wide training and onsite support for common systems, including BCMA. The onsite support was initially provided 24 hours a day, seven days a week and transitioned over 3 weeks to the computer systems help desk. Debriefing sessions were held daily for the first week and two to three times per week for several more weeks to work through implementation issues.

Guideline Documentation Compliance

Table 1 lists the ASCO/ONS nursing documentation and workflow recommendations for chemotherapy administration. All of the recommendations can be documented by using our oncology-specific configuration, with the exception of those workflow tasks that require visual inspection of the drug solution and confirmation of the expiration date. BCMA assisted in compliance with documentation and workflow for verification of patient identification. The electronic nursing system enabled documentation of patient education; two nurses' signatures; and the accuracy of the drug name, dose, rate, and route of administration.

Oncology-Specific Limitations

Unfortunately, the nursing documentation system could not be configured to sufficiently meet the needs for a nursing chemotherapy flow sheet that included both the timing of the chemotherapy-specific and the pre- and post-treatment medications. In addition, there was also no way to record the stop time for infusions, the current day of chemotherapy (eg, day 2 of 3) or the dose number (eg, dose 5 of 14 planned). As a result of these limitations, the oncology wards continue to maintain paper medication administration records to record these details for chemotherapy-related medications only. They continue to use the BCMA and electronic nursing documentation tools to record all other information related to chemotherapy medication administration events.

Table 1. Electronic Documentation of American Society of Clinical Oncology/Oncology Nursing Society Standards for Nursing Chemotherapy Administration

Standard	Electronic Documentation
18.A. Verify patient identification using at least two identifiers	Yes
18.B. Confirm with patient his/her planned treatment, drug route, and symptom management	Yes
18.C. Verify the accuracy of:	
Drug name	Yes
Drug dose	Yes
Drug volume	Yes
Rate of administration	Yes
Route of administration	Yes
Expiration dates/times	No
Appearance and physical integrity of the drugs	No
18.D. Sign (in record or electronically) to indicate verification was done	
First nurse signature	Yes
Second nurse signature	Yes

Discussion

Integrated Systems and Workflows

We describe an end-to-end information system to support electronic medication administration and documentation on inpatient oncology wards (Figure 1). The complete system includes patient registration systems, electronic order entry, pharmacy information systems, nursing documentation systems, and the electronic health record. However, at minimum, the systems required for successful deployment of BCMA in the oncology setting include a patient registration system and chemotherapy orders placed in the pharmacy information system that trigger the administration schedule event in the nursing documentation system. We undertook a staged deployment of these systems over several years, starting with the pharmacy information system, followed by the nursing documentation system, and then the BCMA system. Finally, we optimized the information from these systems to provide a chemotherapy flow sheet in the electronic health record that spans multiple patient encounters and summarizes the pertinent chemotherapy administration events.

Table 2. Advantages and Limitations of Electronic Chemotherapy Medication Administration With Respect to Safety and Compliance With Oncology-Specific Nursing Documentation Requirements

Parameter	Advantages	Limitations
Documentation	Report compliance with two nurses' signatures Electronic documentation is distributed to multiple, simultaneous users Standardized MAR documentation and visualization	Inability to document relative day of chemotherapy (eg, day 2 of 3) Inability to document dose number (eg, dose number 3 of 5) Inability to document stop infusion time
Safety	Alert for missing order Alert for wrong schedule Alert for incorrect dose Report missed doses	Override required for stat orders and verbal orders without electronic order Requires pharmacy to change scheduled times frequently to avoid wrong time alert

We found that electronic medication administration requires close collaboration and communication between pharmacy and nursing staff. Nurses are not able to update the schedule themselves, but instead must communicate with pharmacy to have these schedules changed to avoid a wrong time alert. Although this is additional work for the pharmacy it also provides the pharmacy with essential information regarding the dispensing and scheduling of these highly toxic drugs. The pharmacy is also able to view the chemotherapy flow sheet in the electronic health record to see when medications have been given and to plan future schedule changes that might not be communicated to them by the nursing staff.

Advantages and Disadvantages of Electronic Medication Administration

Table 2 outlines several of the advantages and limitations of this approach for electronic chemotherapy medication administration.

Documentation advantages. The electronic systems have improved legibility of documentation, enabled standardized nurse-nurse and nurse-physician communication regarding medication administration, enabled distributed access to multiple simultaneous users, and enabled aggregation and visualization of chemotherapy medication administration events in the context of other pertinent clinical data. The system also provides audit reports for documentation of two-nurse signature compliance.

Documentation disadvantages. Unfortunately, the system is not able to record relative events with respect to the day number of chemotherapy (eg, day 2 of 3) or the dose number (eg, dose 3 of 5). These remain important safety documentation requirements for nursing staff in the complex environment of inpatient chemotherapy administration. In addition, the system does not record the stop time for infusion, another important consideration, as many drugs in the inpatient setting require 12- to 24-hour infusion times. This makes it difficult for both nursing staff and physicians to know when the patient has completed treatment and may be discharged.

Safety advantages. The BCMA system provides alerts for missing orders, incorrect dose, wrong route, and wrong schedule. In addition, the overdue report that is generated every shift enables the charge nurse to assess what nurse might be struggling with workload or may have omitted administration of a medication.

Safety limitations. The safety limitations for BCMA are not specific to oncology but include the requirement for nurses to override medications for verbal orders and the requirement for pharmacy to change the medication schedule to avoid wrong schedule alerts.

Deployment in Outpatient Oncology Infusion Centers

The overall success of this approach has prompted us to deploy the same system infrastructure to the outpatient chemotherapy infusion centers. This will provide longitudinal views of chemotherapy drug administration events that span both the inpatient and outpatient settings, as well as multiple patient encounters. A unique challenge for deployment in the outpatient infusion center includes the need to record the stop time for billing purposes. The system is being configured to enable recording of multiple start and stop times. In addition, the “too early” or “too late” alerts generated by the system will need to be modified because of the complex and unpredictable scheduling requirements of the outpatient setting.

We believe that electronic medication administration provides an auditable system for safe chemotherapy administration and compliance with documentation guidelines. The resultant tighter coupling of pharmacy and nursing workflows has several advantages and disadvantages, but overall, the improvements outweigh the limitations.

References

1. Jacobson JO, Polovich M, McNiff KK, et al: American Society of Clinical Oncology/Oncology Nursing Society chemotherapy administration safety standards. *J Clin Oncol* 27:5469-5475, 2009
2. Morimoto T, Gandhi TK, Seger AC, et al: Adverse drug events and medication errors: Detection and classification methods. *Qual Safety Health Care* 13:306-314, 2004
3. Larrabee S, Brown M: Recognizing the institutional benefits of bar-coding point-of-care technology. *Joint Comm J Qual Patient Safety* 29:345-353, 2003
4. Patterson ES, Cook RI, Render ML: Improving patient safety by indentifying side effects from introducing bar coding in medication administration. *JAMIA* 9:540-553, 2002

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5. Koppel R, Wetterneck T, Telles JL, et al: Workarounds to barcode medication administration systems: Their occurrences, causes, and threats to patient safety. *JAMIA* 15:408-423, 2008
6. Novak LL, Lorenzi NM: Barcode medication administration: Supporting transitions in articulation work. *Proceedings of the AMIA Annual Symposium* 515-519, 2008
7. Miller RA, Waitman LR, Chen S, et al: The anatomy of decision support during inpatient care provider order entry (CPOE): Empirical observations from a decade of CPOE experience at Vanderbilt. *J Biomed Inform* 38:469-485, 2005
8. Jirjis J, Patel NR, Aronsky D, et al: Seeing stars: The creation of a core clinical support informatics product. *Int J Healthcare Technol Manage* 5:284-295, 2003

Patient-Physician E-Mail Communication: The Kaiser Permanente Experience

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Abstract

Kaiser Permanente (KP) is a not-for profit health care organization that provides care for approximately 8.7 million members in nine states and the District of Columbia. In 2004, it began implementation of its current electronic health record (EHR), which by 2010, was in use in all KP regions, in both outpatient and inpatient settings. Over the same period, a suite of online services was also implemented. Among these services was a password-protected e-mail system (referred

to as secure messaging) that allowed physicians and patients to communicate electronically. Use of secure messaging has increased rapidly. By 2010, 64% of the 3.6 million KP members in northern California had signed up for online access. In 2010, the 7,000 physicians of Northern California KP received 5.8 million secure messages. Secure messaging has been associated with a decrease in office visits, an increase in measurable quality outcomes (at least in primary care), and excellent patient satisfaction.