Experience With Computerized Chemotherapy Order Entry

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Abstract

Purpose: The elimination of errors related to chemotherapy administration remains an elusive goal. Computerized order entry has been shown to reduce errors. We assessed a chemotherapy computer order entry system for errors related to dosing and for the time required to prepare chemotherapy orders.

Methods: A prospective study of all patients treated with chemotherapy over a 12-month period was performed. Chemotherapy order sets done via computerized order entry were reviewed for errors related to drug selection, dose calculations, decimal-point errors, and for exceeding a warning level set within the system. We also measured the time required to produce three order sets by hand versus by computer.

Results: There were no errors in dose calculations, decimal points, or drug selection for 2,558 drug administrations in 235 patients treated with 26 different chemotherapy regimens. The dose warning level was exceeded in 152 (6%) of drug administrations, but never without user permission to override the warning. The average time saved per order set using computer order entry was 10 minutes ($P < .05$).

Conclusion: By using computer order entry with error-checking algorithms, it may be possible to eliminate a number of types of errors associated with chemotherapy administration without sacrificing efficiency.

Introduction

During the last decade, several lethal errors in chemotherapy administration have received national attention. With increased public and professional scrutiny, it has been recognized that medication errors are not rare.¹ The Institute for Safe Medication Practices (ISMP), through voluntary and anonymous reports, compiled 1,385 cases of medication errors nationwide between 1991 and 1994. Chemotherapeutic agents were involved in 24 cases; in seven mishaps, the errors were fatal. Complications of drug use were the most frequent subtype of adverse events noted in the Medical Practice Study,² which evaluated the risk of iatrogenic injury in 30,000 patients discharged from acute care hospitals in 1984. Medication errors accounted for 19% of all adverse events identified.

A wide variety of preventive measures have been suggested to prevent chemotherapy mishaps. These include standardized order forms, manual and computerized pharmacy review of orders, and attending co-signature for chemotherapeutic agents.³⁻⁵ Of these methods, only computerized order entry has been formally evaluated and shown to reduce errors.⁶ Unfortunately, lethal errors continue to be reported⁷ and computerized order entry has not been widely adopted.⁸

In this study, we evaluated the use of a computer order entry system with multiple error-checking algorithms developed specifically for oncology. We evaluated the system for errors related to calculations, decimal

points, order interpretation, and for exceeding a warning level set within the software for each drug according to each chemotherapy regimen. We also assessed the time required to produce chemotherapy order sets using the software versus handwritten order sets.

Methods

After obtaining institutional review board approval from the University of Rochester School of Medicine (Rochester, New

Figure 1. Error message produced by IntelliDose (IntrinsiQ Research, Waltham, Massachusetts) when dose exceeds set limits.

Figure 2. Handwritten dose order.

SMH 410 MR
UNIVERSITY OF ROCHESTER
STRONG MEMORIAL HOSPITAL
DOCTOR'S ORDERS

ADVERSE DRUG EFFECTS:
☐ YES ☒ NO

☒ Inpatient ☐ Outpatient ☐ ED

LIST DRUGS: SIGN EACH SET OF ORDERS AND INDICATE TIME AND DATE

NON-DRUG ORDERS: SIGN EACH SET OF ORDERS AND INDICATE TIME AND DATE

ADMIT TO: (Attending MD and Floor) **BE**

ALLERGIES: **NCDA**

PATIENT'S WEIGHT (kg): **79 Hgt 183cm**

DIAGNOSIS: (1) **ovarian CA**
(2) **chemotherapy**

BSA = 2.0m²

Administer Taxol prior to Carboplatin

Taxol 175mg/m² x 2 = 350mg

Carbo AUC 6 = 603mg
ceat 1.1

Signature/Title: *[Signature]*

PRESS FIRMLY - USE BALL POINT PEN

DRUG ORDERS: SIGN EACH SET OF ORDERS AND INDICATE TIME AND DATE

Medication: **Decadron**
DOSAGE: **20mg IV**
FREQ: **X1 prior to Chem**
DATE & TIME: **8/5/05**
SIGNATURE/TITLE: *[Signature]*

Medication: **Bendryl**
DOSAGE: **50mg IV**
FREQ: **X1 prior to Chem**
DATE & TIME: **8/5/05**
SIGNATURE/TITLE: *[Signature]*

Medication: **Cimetidine**
DOSAGE: **300mg IV**
FREQ: **X1 prior to Chem**
DATE & TIME: **8/5/05**
SIGNATURE/TITLE: *[Signature]*

Medication: **Taxol**
DOSAGE: **175mg/m² = 350mg IV**
FREQ: **X1 over 3hrs**
DATE & TIME: **8/5/05**
SIGNATURE/TITLE: *[Signature]*

Medication: **Zofran**
DOSAGE: **20mg IV**
FREQ: **X1 prior to Carbo**
DATE & TIME: **8/5/05**
SIGNATURE/TITLE: *[Signature]*

Medication: **Carboplatin**
DOSAGE: **AUC 603mg IV**
FREQ: **X1**
DATE & TIME: **8/5/05**
SIGNATURE/TITLE: *[Signature]*

York), a centralized data warehouse was accessed to obtain information regarding the diagnosis and treatment of 235 patients treated with chemotherapy by the gynecologic oncology division at the university. Information on 2,558 chemotherapy drug administrations during 2004 was obtained, which included the patient's diagnosis, chemotherapy regimen, and drug dosages. The data warehouse was kept in a password-protected SQL Server (Microsoft Corp., Redmond, Washington) database that was updated automatically by the periodic transmission of data via the web from our treatment center to a secure database at IntrinsiQ Research (Waltham, Massachusetts).

The computer order entry system used was IntelliDose (IntrinsiQ Research), which was developed for oncology and includes a variety of dose-checking algorithms. The software requires setting a warning dose level for each chemotherapeutic agent in a given regimen. A limiting dose or warning level based on a body surface area (BSA) of up to 2.5 m² is suggested by the software, but the user is allowed to set a higher limiting dose. Warning messages are given at the time of order entry if the limiting dose is exceeded (Fig 1). The limiting dose can be overridden by the user if appropriate privileges are granted by the system administrator. All dose calculations, including BSA, area under the curve, and estimation of creatinine clearance are performed by computer.

All computer-generated chemotherapy order sets were prepared by the oncology clinic medical staff after the patient was evaluated and cleared for chemotherapy treatment by the attending staff. Order sets were then attached to the patients chart for signature by the attending, and were then sent to the cancer center pharmacy for drug preparation and dispensing.

The patients' chemotherapy orders were prospectively reviewed by a pharmacist, and all calculations related to dosing performed by the software, including BSA, estimated creatinine clearance and area under the curve were rechecked. The drug dosages were then compared to dose warning levels set within the software by the user.

We estimated the time saved per chemotherapy cycle through use of the software by comparing the time required to produce three handwritten (Fig 2) versus three computerized order sets (Fig 3). Statistical analysis was performed using the Student's *t* test.

Results

There were no errors in drug dose calculations, decimal points, or drug selection for 2,558 chemotherapy drug administrations for 235 patients treated with 26 different chemotherapy regimens (Table 1). Although the warning level for drug dosage was

Figure 3. Computer-generated order set.

STRONG MEMORIAL HOSPITAL

SMH 410 MR
UNIVERSITY OF ROCHESTER
DOCTOR'S ORDERS

BEGIN ON **8/5/2005**

Diagnosis: **ovarian cancer**
Stage: **Stage Ia**

Taxol/Carboplatin Days 01 to 21 - Cycle 2

Height: **183 cm** Weight: **79 kg** BSA: **2.00 m²** Creatinine: **1.94 mg/dL** GFR: **76 mL/min**

DRUG	DOSE BASIS	WT TYPE	DOSE	ROUTE	DAILY FREQ AND SCHEDULE	INITIALS	TIME
dexamethasone	20 mg/dose	NA	20 mg	IV	X1 on d1		
diphenhydramine	50 mg/dose	NA	50 mg	IV	X1 on d1		
cimetidine	300 mg/dose	NA	300 mg	IV	X1 on d1		
paclitaxel	175 mg/m ²	real	350 mg	IV	X1 on d1		
ondansetron	20 mg/dose	NA	20 mg	IV	X1 on d1		
carboplatin	6 AUC in mg	real	603 mg	IV	X1 on d1		
hydrocortisone	100 mg/dose	NA	100 mg	IV	X1 PRN on d1		

ALL DRUG ORDERS TO BE FILLED GENERALLY UNLESS PRESCRIBER WRITES "QAW" (DISPENSE AS WRITTEN) IN THE ADJACENT BOX

FORMULAE USED: *Jeiliffe BSA Adjusted, Mosteller Equation, Amer J of Hosp Pharm*

CREATININE CLEARANCE WAS CALCULATED USING A MAXIMUM CREATININE CLEARANCE VALUE OF 0.0 ML/MIN

FLUID (ADDITIVE)	RATE BASIS	RATE	VOLUME/DURATION	SCHEDULE	INITIALS	TIME
0.9% sodium chloride		IV		d1		

MISCELLANEOUS ORDERS

Administer Taxol prior to Carboplatin

PAGE 1... END OF ORDERS!

DATE: **8/18/2005** TIME: **10:23 A** SIGNATURE: *[Signature]* NAME: **Walsh, Jane, RN**

Table 1. Chemotherapy Error Assessment

Type	No. of Errors	No. of Drug Administrations
Dose calculations	0	
Single-drug regimens	0	771
Multiagent regimens	0	1,787
Total drug administrations	0	2,558
BSA	0	1,864
AUC	0	666
Decimal point	0	2,558
Warning level exceeded	0	152

Abbreviations: BSA, body surface area; AUC, area under the curve.

exceeded in 152 administrations (6%), in no case did this occur without the explicit permission of the user.

The customary doses and dose limits for the most commonly used chemotherapeutic regimens are shown in Table 2. In most cases, the warning level was set at a dose based on a BSA of 2 m².

In Table 2, the time required (minutes) to prepare handwritten versus computer-generated orders is also shown. The mean time to prepare computer-generated orders was 1 minute and didn't vary significantly by chemotherapy regimen. For each of the regimens listed, there was a significant ($P < .05$) time saving using computer-generated orders.

Discussion

The elimination of chemotherapy dosage errors, at least those related to prescribing, should be achievable through the use of computer technology. Numerous suggestions have been made to reduce or eliminate chemotherapeutic dosing errors. The

ISMP has recommended standardized order forms, pharmacy recalculation of all dosing, and computer checking of maximum doses.³ The Institute for Healthcare Improvement has also called for establishing dose limits for chemotherapy agents.⁹ However, chemotherapy dosing is complex and individualized, and no standards regarding upper dose limits have been established. In this study, we evaluated our experience with IntelliDose, software developed specifically for chemotherapy order entry.

IntelliDose software was designed for medical, gynecologic, and pediatric oncology practices and incorporates a variety of error-checking routines for drug dosage (Fig 1). Single, multiple, and cumulative doses are monitored for all drugs and are checked against user-set limits. Because calculations related to chemotherapy dosing are performed by the computer, it should be possible to eliminate arithmetic errors. In our preliminary experience, use of the software eliminated prescribing errors in chemotherapy dosing.¹⁰ In no instance was a drug dose miscalculated, misinterpreted, or set beyond the chosen safety limits.

In this report we update our experience with IntelliDose software. Among 235 patients receiving 2,558 chemotherapy drug administrations, there were no errors in dose calculations and no misinterpretation of the computer-generated order sets. Our practice uses stringent dose limits, but allows the user to override the limits. This occurred in 6% of drug administrations, but never without the user's giving permission to override the dose limit. The dose limits chosen by our practice for several commonly used chemotherapy regimens are shown in Table 2.

Bates et al recently reported that computerized physician order entry in a hospital setting resulted in a 55% reduction in serious medication errors.⁶ Unfortunately, hospital-wide physician order entry systems have not been widely adopted and are not

Table 2. Customary Doses and Order Preparation Time According to Regimen

Drug	Dose Basis (mg/m ²)	Mean Dose (mg)	Standard Deviation (mg)	Warning Dose Level (mg)	Mean Order Preparation Time (minutes)	
					Handwritten	Computer
Paclitaxel	175	312	45	350	12	1
Carboplatin	6*	510	129	750		
Paclitaxel	175	327	35	350	11	1
Cisplatin	30	50	10	60	13	1
Gemcitabine	750	1,285	205	1,500		
Gemcitabine	800	1,402	166	1,400	5	1
Topotecan	4	7	0.7	8	4	1
Doxorubicin	40	42	4	80	14	1
Gemcitabine	650	1,093	95	1,300		
Doxorubicin	40	72	8	80	10	1
Docetaxel	60	40	13	60	12	1

*Carboplatin dosing according to area under the curve.

suitable for most office-based oncologists.⁸ Moreover, a recent survey suggests that the majority of current hospital and/or pharmacy computer systems are unlikely to provide even rudimentary safety checking.¹¹

Although our preliminary results with the use of chemotherapy computer order entry have been encouraging, computerized physician order entry should not be viewed as a panacea for mistakes with chemotherapy. In a recent study of a hospital computer order entry system, Koppel et al¹² found that some mistakes may be facilitated through computer use. In one example, house staff relied on the computer display to determine correct medication dosage, but the displayed dose was based on the pharmacy's purchased doses, not on customary doses given to patients. This type of mistake could have severe consequences in a patient undergoing chemotherapy.

Despite heightened public and professional awareness, lethal errors in prescribing of chemotherapeutic agents continue to occur. In a recent case,¹³ a decimal-point error on a handwritten

prescription led to a 10-fold lethal overdose of cisplatin in a 41-year-old father of three. These types of events, although infrequent, should provide the impetus for more widespread adoption of computer order entry systems. However, given the complexity of chemotherapy drug dosing, software with safety-checking algorithms designed specifically for oncology patients will be necessary to eliminate dosing errors in cancer patients.

Author's Disclosures of Potential Conflicts of Interest

Although all authors completed the disclosure declaration, the following author or their immediate family members indicated a financial interest. No conflict existed for drugs or devices used in a study if they are not being evaluated as part of the investigation.

Authors	Employment	Leadership	Consultant	Stock	Honoraria	Research Funds	Testimony	Other
Brent DuBeshter		Intrinsic Research (A)		Intrinsic Research (C)				
Dollar Amount Codes (A) < \$10,000 (B) \$10,000-99,999 (C) ≥ \$100,000 (N/R) Not Required								

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