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Frequency and Types of Alerts for Antibiotic Prescribing in a Neonatal ICU

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Abstract. Sepsis in neonates is a significant problem that carries with it severe morbidity and mortality. Managing antibiotics in this population is therefore an important issue. We studied clinical alerts currently in place to support antibiotic prescribing in a neonatal intensive care unit in order to ensure that appropriate information is being provided in a way that is consistent with current recommendations. Data were obtained from our alerts tracking database. Alerts were described according to triggering orders and clinician recipients. We found that alerts most commonly associated with antibiotics are providing critical information regarding lab results and patient factors necessary in preventing adverse effects of these drugs. Clinician recipients of alerts are those responsible for entering orders and the information is being provided at the point of care.

Keywords. Antibiotic alerts decision support NICU

Introduction

Sepsis is a leading cause of morbidity and mortality in preterm neonates. The incidence of sepsis increases as birth weight and gestational age decrease[1]. As increasing numbers of smaller infants are being cared for, appropriate management of antibiotics becomes of increasing concern[2]. Prescribing antibiotics in these infants is a complex process in which clinicians must be aware of multiple factors such as gestational age, weight and laboratory results[3].The neonate's immature immune systems along with their decreased renal and liver function make them especially vulnerable to adverse effects such as nephrotoxicity[4].

Alerting systems that are integrated into a computerized provider order entry (CPOE) system can be one method for ensuring accuracy of prescribing[5]. Literature describing alerting systems to support antibiotic prescribing has neglected neonates[6-8]. Understanding how a system of alerts is functioning is critical to ensure maximization of system capabilities[9]. In order to ensure appropriate delivery of decision support related to antibiotic prescribing in the neonatal ICU (NICU), we sought to describe our current clinical alerts, categorize them according to type and functionality and describe the frequency with which alerts are triggered by antibiotic ordered and the prescribers ordering them.

1. Background

The incidence of bacterial infection in newborns has been estimated at 1 to 8 per 1000 live births. In very low birth weight infants (<1000 grams) this number increases to 160 to 300 per 1000 live births[2]. Since infection is a leading cause of death in these babies and early symptoms of infection are non-specific, it is recommended that antibiotics be

started immediately upon suspicion of illness[2,10]. Antibiotics frequently used to treat these infections may include drugs with potentially severe adverse effects. However, the specific causes of neonatal sepsis require their use[4].

Computerized decision support to assist with antibiotic prescribing, incorporating information about a patient's renal function has been reported to be beneficial [6,7,11, 12]. One study reported increases in errors when decision support did not include recommendations related to renal function[11]. Another study describing a system in pediatrics, found improvements in awareness of renal dysfunction but excluded infants younger than 6 months of age [12].

Limited information exists on the effectiveness of decision support in neonatal populations. Tan and colleagues conducted a systematic review of decision support in neonates and concluded that more studies need to be done to determine the effect of this type of support in this population[8]. The current research describes our antibiotic decision support for neonates to determine the kind of support being provided and which clinicians are receiving the support.

2. Materials and Methods

2.1. Setting

The NICU studied has 62 beds and admits 1200 patients per year. Two teams are responsible for patient care each day. Team One consists of an attending neonatologist, a neonatal fellow, and 3 to 4 nurse practitioners (NP's), physician assistants (PA's) and/or house physicians. Team Two consists of an attending neonatologist, a neonatal fellow, and 3 to 4 pediatric residents. Patients are randomly assigned to each team. Residents, NP's, PA's and house physicians are responsible for all order entry using the CPOE system.

Alerts within the CPOE (Eclipsys XA4.5) are developed by the hospital alerts committee. A database tracks the alerts. We used the decision support categories developed by Kuperman et al. to categorize our alerts [5]. (See Table 1) A taxonomy developed by the alerts committee categorizes alerts according to type, policies for alert responses and alert components[13]. Four types of alerts are in use: *Informational alerts* present data, *data requests* ask for information, *suggestions* anticipate clinician needs and *critiques* attempt to correct[13]. Alerts can also be interruptive or uninterruptive.

2.2. Data Collection & Analysis

Data related to alerts triggered between January and July 2008 were obtained. We calculated the frequencies of all alerts then calculated the frequency of alerts specific to antibiotics according to triggering orders and prescribers.

Table 1. Decision Support Categories

B/A	Alert Type	Description
B1	Dosing Guidance in CPOE	Pre-written medication orders
B2	Drug-Drug Interaction Checking	Checks for drug interactions
B3	Formulary Decision Support	Prompts to order from local formulary
B4	Duplicate Therapy Checking	Alert for concurrent orders for same drug
A1	Dosing Guidance	Dosing suggestion based on patient parameters (e.g. age)
A2	Medication-associated Lab Testing	Prompts to order medication-associated lab testing.
A3	Drug-disease Interactions	Alert for conditions where drug may be contraindicated.
A4	Drug-Pregnancy Alerting	Alerts regarding teratogenic medications.

B/A = basic or advanced. [5]

3. Results

Antibiotic orders triggered five different alerts, one *data request*, two *critiques*, one *suggestion* and one *informational*. All were categorized as A1 based on the Kuperman categories. Table 2 summarizes these alerts according to function, policies, and triggers and whether they are tracked.

Table 2. Pediatric CPOE Antibiotic Alerts

Alert Name	Purpose	Type/ Category	Trigger	Policy	Tracking
Gestational age required	Requires gestational age entry	Data request	Order entry	Interruptive, enforced, hard stop	Yes†
Max pediatric dose	Warns of dose exceeding maximum	Critique	Order entry	Uninterruptive, enforced, confirm	No
Renal impairment	Recommends dose based on renal function	Critique	Order entry of pre-defined antibiotics	Interruptive, enforced, acknowledge	Yes
Pediatric dose	Calculates dose/freq by weight	Suggestion	Order entry-pts 0 – 18yrs	Uninterruptive	No
Lab history	Displays relevant lab results	Informational	Order entry of pre-defined antibiotics	Interruptive, enforced, acknowledge	Yes

† = *alert tracked but provider receiving alert is not tracked.*

The total number of alerts generated in the NICU was 6,863. Of these, 24% (1,660) were for antibiotic orders. For these, the most frequently seen alert was *lab history* (54%), followed by *renal impairment dosing* (37%), and *gestational age required* (8.8%). *Lab history* was most frequently triggered by vancomycin (52.5%), then

gentamicin (46.9%). *Renal impairment dosing* was triggered by gentamicin (78.6%), then ampicillin (15.4%). *Gestational age required* was triggered by ampicillin (55.5%), gentamicin (24%), cefazolin (9.6%) and vancomycin (9.6%). The antibiotic order with the most alerts was gentamicin (56%), then vancomycin (29%) and ampicillin (11%). Team One prescribers received 36% of the alerts and Team Two received 38%, an almost equal proportion of alerts per team. In 18% of the alerts the role of the prescriber was not tracked. Table 3 shows each alert with its total frequency according to the triggering order and prescriber role.

Table 3. Frequencies of Antibiotic Alerts by Role and Triggering Order n(%)

Alert Name	Order Trigger	NP	PA	Resident	MD	Student	No Role Listed	Total
Lab History	Vanc	153(17)	27(3)	178(19.8)	28(3.1)	3(0.33)	83(9.2)	472 (52.5)
	Gent	157(17.5)	16(1.8)	161(17.9)	35(3.9)	2(.2)	50(5.5)	421 (46.9)
	Other	0	0	3 (0.3)	0	0	2 (0.2)	5 (0.6)
	All	310 (34.5)	43 (4.8)	342 (38.1)	63 (7)	5 (0.5)	135 (15)	898 (100)
Renal Impairment	Gent	190(31)	20(3.2)	221(36)	40(6.5)	2(0.3)	10(1.6)	483(78.6)
	Amp	33 (5.3)	1 (0.2)	51 (8.3)	3 (0.5)	0 (0)	7 (1.1)	95 (15.4)
	Other	8 (1.3)	2 (0.3)	26 (4.2)	0	0	0	36 (5.4)
	All	231 (37.6)	23 (3.8)	298 (48.5)	43(7)	2 (0.3)	17 (2.8)	614 (100)

NP=nurse practitioner, PA=physician assistant, MD = fellow, house physician,, Student = medical student. Vanc=vancomycin, Gent = gentamicin, Amp= ampicillin.

4. Discussion

We conducted a descriptive study that examined alerts in the NICU. All current antibiotic alerts were categorized as advanced based on the Kuperman model which describes alerts that guide dosing based on patient parameters[5]. *Lab history* and *renal impairment dosing* are the two most common alerts for antibiotics. *Lab history* provides information such as creatinine and drug levels. *Renal impairment dosing* alerts the user to a patients' degree of renal dysfunction so that they can adjust the dose accordingly. Vancomycin, gentamicin and ampicillin were the most frequent triggers of these alerts. Since these are widely accepted therapies for the treatment of neonatal sepsis and their potential effect on renal function can be serious, these alerts are providing appropriate information and assuring that clinicians are aware at the point of care [10]. NP's and PA's (Team One) received 36% of alerts while residents (Team Two) received 38%, indicating that the teams are receiving similar support. Since these are the clinicians responsible for order entry and the information provided may prompt a change in the order, they are the appropriate recipients. The information is also provided in a way that is consistent with clinician workflow, an important consideration in building effective decision support [9].

5. Conclusion

Our alerts are providing important patient information that may assist in prescribing the appropriate dose of antibiotic for these vulnerable infants. The information appears to

be provided to the right clinician at the right time. This is consistent with other systems of antibiotic decision support where it has been found that this type of information is helpful in preventing potential dosing errors [6,7,11,12]. Additionally, the timing and recipients of the decision support are consistent with current recommendations[9]. What is unclear from our data is how clinicians accept and utilize the support provided. Additional information that clinicians may need and the clinician's perspective on the usefulness of the decision support may be important considerations for future research and system development.

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References

[1] Stoll BJ, Hansen N, Fanaroff AA, Wright LL, Carlo WA, Ehrenkranz RA, et al. Late-onset sepsis in very low birth weight neonates: the experience of the NICHD Neonatal Research Network. Pediatrics. 2002 Aug;110(2 Pt 1):285-91.

[2] Lott JW. State of the science: neonatal bacterial infection in the early 21st century. Journal of Perinatal and Neonatal Nursing. 2006 Jan-Mar;20(1):62-70.

[3] Kaushal R, Bates DW, Landrigan C, McKenna KJ, Clapp MD, Federico F, et al. Medication errors and adverse drug events in pediatric inpatients. Journal of the American Medical Association. 2001 Apr 25;285(16):2114-20.

[4] Fanos V, Cataldi L. Antibacterial-induced nephrotoxicity in the newborn. Drug Safety. 1999 Mar;20(3):245-67.

[5] Kuperman GJ, Bobb A, Payne TH, Avery AJ, Gandhi TK, Burns G, et al. Medication-related Clinical Decision Support in Computerized Provider Order Entry Systems: A Review. Journal of the American Medical Informatics Association. 2007 January 1, 2007;14(1):29-40.

[6] Thursky K. Use of computerized decision support systems to improve antibiotic prescribing. Expert Review in Anti-Infective Therapy 2006 Jun;4(3):491-507.

[7] Evans RS, Pestotnik SL, Classen DC, Burke JP. Evaluation of a computer-assisted antibiotic-dose monitor. Annals of Pharmacotherapy. 1999 Oct;33(10):1026-31.

[8] Tan K, Dear PR, Newell SJ. Clinical decision support systems for neonatal care. Cochrane Database of Systematic Reviews. 2005(2):CD004211.

[9] Bates DW, Kuperman GJ, Wang S, Gandhi T, Kittler A, Volk L, et al. Ten commandments for effective clinical decision support: making the practice of evidence-based medicine a reality. Journal of the American Medical Informatics Association. 2003 Nov-Dec;10(6):523-30.

[10] Sankar MJ, Agarwal R, Deorari AK, Paul VK. Sepsis in the newborn. Indian Journal of Pediatrics. 2008;75(3):261-6.

[11] Eslami S, Abu-Hanna A, de Keizer NF, de Jonge E. Errors associated with applying decision support by suggesting default doses for aminoglycosides. Drug Safety. 2006;29(9):803-9.

[12] Mullett CJ, Evans RS, Christenson JC, Dean JM. Development and impact of a computerized pediatric antiinfective decision support program. Pediatrics. 2001 Oct;108(4):E75.

[13] Chused AE, Rivera, S., Kuperman, G.J., Stetson, P.D. Development of a taxonomy to aid in the management of computerized alerts. manuscript in preparation. 2008:

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