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Intravascular Thrombophlebitis Related to the Peripheral Infusion of Amiodarone and Vancomycin

Jole' L. Mowry[1] **and Laurie Shawn Hartman**[1]

Abstract

Patients on a telemetry unit experienced an increase in thrombophlebitis in 2004. The purpose of this research was to determine if peripheral IV amiodarone and vancomycin influenced the incidence of thrombophlebitis in an adult cardiothoracic population. Amiodarone phlebitis rates range up to 27%. In December 2004, Pharmacy diluted the amiodarone concentration to 600 mg/500 ml. By 2005, data demonstrated a consistent decrease in the incidence of thrombophlebitis. However, related to institutional policies and patient safety concerns, the amiodarone infusion concentration was reversed back to 900 mg/500 ml in October 2005. Thrombophlebitis increased after the return to a more concentrated amiodarone IV solution. Vancomycin infusion administration did not change during this time period. A retrospective chart review and observational, before and after study, demonstrated a correlation between amiodarone concentration and the incidence of thrombophlebitis. Vancomycin infusions appeared to prevent peripheral thrombophlebitis in the study population. Data was compelling and resulted in the institution standardizing the more dilute amiodarone IV concentration.

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adults, cardiovascular, nurses, statistical analysis, surgical

Intravascular thrombophlebitis related to cannulated veins may be attributed to several causes, such as cannula material, length, and lumen size; the skill of the person inserting the cannula; the character of the infusate; the frequency of dressing changes; and host factors, such as age, gender, and presence of underlying disease (Maki & Ringer, 1991).

Two medications used frequently in the adult cardiac surgery patient population, amiodarone and vancomycin, may cause intravascular thrombophlebitis and possible tissue sloughing related to pharmacological characteristics of these infusates. Although administration through a peripheral catheter is not recommended for either of these medications, peripheral intravascular catheters are frequently used, especially in patients not requiring intensive care. Vancomycin will cause extensive tissue damage if extravasation, the inadvertent administration of a vesicant solution into surrounding tissue, occurs (Hadaway, 2002).

Vancomycin is increasingly prescribed in institutions related to increased prevalence in community-acquired and nosocomial *Staphylococcus aureus* infections. Hadaway and Chamallas (2003) reported *S. aureus* accounts for about 20% of all bacteremias in the United States. Related to growing concerns over methicillin-resistant *Staphylococcus aureus* (MRSA), coagulase-negative staphylococcus, and *Clostridium difficile*, vancomycin has become preferred antimicrobial therapy in the adult cardiac surgical patient population and for prophylaxis in patients undergoing aortic or valve repairs and for patients with Cefazolin allergies. Vancomycin is also used for patients with suspected surgical site infection and treatment of nosocomial infections. The use of central venous catheters are recommended to prevent known vein irritation related to vancomycin's acidic pH. Filtration after admixture or inline filters during administration are recommended to remove particulate matter which may cause vein irritation (Hadaway & Chamallas, 2003).

Amiodarone is commonly prescribed for the adult postoperative cardiac surgery patient population as prophylaxis or treatment in cardiac arrhythmias. Although administration of amiodarone through a central venous catheter is recommended, this is not always possible. It has been noted that peripheral infusions of amiodarone can cause mild to severe thrombophlebitis at the infusion site, causing patient discomfort, increasing hospital costs, and delaying discharge.

This observational, before and after, study explores the effects of two different concentrations of amiodarone to determine if the rate of thrombophlebitis is reduced with more dilute concentrations of the medication. This research also reports the effect of vancomycin on the incidence of peripheral thrombophlebitis in this patient population.

Literature Review

Atrial fibrillation is a common occurrence after cardiac surgery and can increase postoperative length of stay as well as the overall cost of inpatient care (Shrivastava, Smith, Caskey, & Reddy, 2009). Research demonstrates a 30% rate of occurrence post coronary bypass surgery, 40% after valve surgery, and up to 50% in combined coronary and valve surgeries (McKeown & Gutterman, 2005). In the postoperative setting, atrial fibrillation is typically self-limiting, with approximately 50% of patients converting to sinus rhythm spontaneously after 48 hr (Khanderia, Wagner, Walker, Woodcock, & Prager, 2008). Atrial fibrillation can result in increased mortality through stroke and hemodynamic compromise, thus treatment to convert the patient to sinus rhythm is suggested (Creswell, Schuessler, Rosenbloom, & Cox, 1993; McKeown & Gutterman, 2005).

Intravenous amiodarone is considered an effective antiarrhythmic medication and one of the most frequently prescribed antiarryhthmics in the United States according to Vassallo and Trohman (2007) after conducting a meta-analysis of peer-reviewed scientific literature between 1970 and 2007. Indications for amiodarone in the literature reviewed included cardioversion of atrial fibrillation, maintenance of sinus rhythm after atrial fibrillation conversion, and control of rhythm, rate or both in patients with suspected tachycardiamediated cardiomyopathy and patients with significant left ventricular hypertrophy and congestive heart failure. Amiodarone is also used in the treatment of atrial fibrillation in the presence of congestive heart failure, Wolff-Parkinson-White Syndrome, and hypertrophic cardiomyopathy. Atrial flutter, other supraventricular tachyarrhythmias, and ventricular arrhythmias are also indications for amiodarone administration. The reviewed literature also demonstrates the use of amiodarone for the primary prevention of sudden cardiac death in ischemic cardiomyopathy and in nonischemic cardiomyopathy, as an adjunct to implantable cardiodefibrillators (ICDs), as therapy for recurrent drug-refractory sustained ventricular arrhythmias and perioperative prophylaxis for atrial and ventricular arrhythmias (Vassalo & Trohman, 2007).

Although there are many effective treatment options for atrial fibrillation such as beta blockers, calcium channel blockers, and various antiarrhythmics,

amiodarone is considered a first-line pharmacological option. Amiodarone affects potassium and calcium channels as well as adrenergic receptors to slow atrioventricular (AV) node conduction and prolong AV node refractoriness (Khanderia et al., 2008). The PAPABEAR trial, which randomized 601 patients to either placebo or amiodarone therapy, demonstrated the benefits of amiodarone by reducing postoperative atrial fibrillation from 30% with placebo to 16% with amiodarone (Mitchell et al., 2005).

Amiodarone does have significant side effects that should be weighed against risks of postoperative atrial fibrillation. In a meta-analysis of 18 randomized controlled trials, Hilleman and Spinler (2002) demonstrated that when amiodarone was infused intravenously, thrombophlebitis was the most common side effect, followed by bradycardia and hypotension.

Although thrombophlebitis may seem relatively benign, it can cause significant pain, swelling, fever, tissue loss, and may increase hospital costs by increasing length of stay (Aljitawi, Shabaneh, & Whitaker, 2005). In some cases, thrombophlebitis requires the intervention of a plastic surgeon to repair damaged tissue. There have been numerous case reports of amiodarone associated thrombophlebitis in the past two decades (Aljitawi et al., 2005; Aravanis, Papasteriades, & Steriotis, 1982; Kerin, Blevins, Rubenfire, Faital, & Householder, 1983; Showkathali, Earley, & Sporton, 2006). For example, Kreiss, Sidi, and Gur (1999), prospectively treated 20 patients admitted for recent-onset atrial fibrillation with peripheral administration of a 300-mg amiodarone bolus, followed by a 24-hr infusion and found that 25% of participants developed thrombophlebitis in a 6-month period. Although thrombophlebitis is commonly associated with high-dose intravenous administration (Aljitawi et al. 2005; Veloso & De Paola, 2004), research by Antonelli and Barzilay (1983) also noted that 73% of their patients studied had signs of thrombophlebitis present within hours of lower dose treatment (2 to 4 mg/kg) initiation at the infusion site.

Amiodarone related thrombophlebitis is caused when needle-shaped crystals, which adhere to the intima of the vein, are rapidly formed at the infusion site (Ward & Yalkowsky, 1993). Ward and Yalkowsky's (1993) investigation of amiodarone infusions in a rabbit model demonstrated that small volumes of the medication are not associated with local inflammation, but as the volume increased, so did the severity of the thrombophlebitis. The researchers hypothesized that although the amiodarone infusion was diluted, the amount of precipitation still exceeded its ability to be soluble in the vein. Furthermore, Ward and Yalkowsky found that very rapid infusions of amiodarone, while still creating a precipitate, actually formed a protective plug that did not disperse readily into the intima, thus reducing the rate of

thrombophlebitis. The manufacturer, Wyeth Pharmaceuticals, also clearly identifies that amiodarone readily precipitates when diluted in intravenous fluid and, therefore, recommends the use of a 0.2 μm filter during administration and the use of a central catheter when possible (personal communication, January 28, 2004). Wyeth Pharmaceuticals package insert also supports the concept that high rates of thrombophlebitis are associated with intravenous (IV) concentrations greater than 3 mg/mL in dextrose 5% in water (D5W). Therefore, a dose of 2 mg/mL for infusions exceeding 1 hr was recommended. These manufacturer's recommendations and clinical considerations for the management of the postoperative cardiac surgery patient with atrial fibrillation must be integrated as part of the evidence-based nursing care provided to each patient.

Thrombophlebitis following Vancomycin administration is a commonly cited complication in the scientific literature. In a small randomized trial ($n = 103$) by Cohen et al. (2002) a once-daily versus twice-daily IV administration of vancomycin was compared for efficacy and toxicity. Although not statistically significant ($p = .22$), thrombophlebitis was observed in 13.7% ($n = 51$) of patients in the once-daily group and 23% ($n = 52$) in the twice-daily group.

In a prospective study by Elting et al. (1998), vancomycin toxicities were examined in 742 consecutive cancer patients during a 3-month period. Phlebitis occurred in 3% of patients (95% confidence interval [CI] = 2%-4%) predominantly in patients with recently inserted central venous catheters.

Osmolarity, pH, stability, particular matter, and compatibility with other drugs are characteristics that increase the opportunity for peripheral thrombophlebitis related to vancomycin administration (Hadaway & Chamallas, 2003). Hypertonic osmolarity of the final admixture causes a shift of intracellular fluid out of the cells. This begins the process of vein wall inflammation and thrombus formation. The calculated osmolarity of vancomycin 1 to 2 g in routine admixtures ranging from 100 to 250 mL 0.9% sodium chloride is isotonic or <500 mOsm/L. The use of short peripheral or midline catheters are not recommended for solutions with an osmolarity >500 mOsm/L (Intravenous Nurses Society [INS], 2000).

Altering the pH during admixture process may alter the stability of the medication and cause precipitation. Vancomycin has a pH <4.0 in most admixtures and, thus, is classified as very acidic (Hadaway & Chamallas, 2003). The INS Standards of Practice (2000) recommends medications with a pH <4.0 and >9.0 are not appropriate for infusion through short peripheral or midline catheters related to the potential for local phlebitis, thrombosis,

and tissue sloughing if extravasation occurs. Peripherally inserted central catheters (PICC) are the preferred choice for most patients.

Conceptual frameworks can assist nurses with the integration of theory to practice. Orlando's Deliberative Nursing Process functioned as the conceptual framework for this research project (Potter, 2004). In this model, a dynamic relationship exists between the nurse and patient where both interact continually with each other and with the environment to share information and create understanding about how a patient may be experiencing a situation. For example, during the nurse's assessment of the patient all peripheral IV sites are examined and the patient is asked if he or she is experiencing tenderness or pain at the site. Furthermore, in this model, the patient must have an immediate need for help with something that cannot be achieved without the nurse. If those needs are not met, the patient experiences distress. When signs and symptoms of IV related thrombophlebitis are observed, the nurse intervenes to remove the IV catheter after alternate IV access is ensured, applies a moist cool compress to the site, and offers pain medication if the above interventions do not adequately relieve any pain. Orlando's model is appropriate for this research because it requires the nurse to administer the medication infusions per pharmaceutical guidelines, use an evidence based approach when maintaining the intravenous site, and continuously monitor and seek feedback from the patient, assuring that no signs and symptoms of thrombophlebitis are present. The process of checking with the patient to make sure the nurse accurately understands communication about potential signs and symptoms of thrombophlebitis is called validation. If the patient indicates symptoms, the nurse needs to provide appropriate interventions so the patient is not caused undue distress. The goal of the Deliberative Nursing Process is patient improvement as a result of interactive care between the nurse and patient.

Purpose

This research study was designed to identify and quantify the occurrence of peripheral intravascular (IV) thrombophlebitis in adult cardiothoracic surgery patients receiving amiodarone and vancomycin intravascular infusions. In addition, we sought to determine if the concentration of IV amiodarone influenced the incidence of peripheral IV thrombophlebitis, independent of IV vancomycin administration. The findings from this study will be useful in developing strategies and interventions to prevent peripheral IV thrombophlebitis related to amiodarone and vancomycin infusion.

The Problem

In early 2004, an increased incidence of peripheral IV thrombophlebitis was noted in patients on the adult cardiothoracic 36-bed telemetry step-down unit. Anecdotal discussion during cardiothoracic interdisciplinary meetings centered on possible etiologies. Amiodarone peripheral IV bolus and continuous infusion, and vancomycin intermittent infusion seemed the most likely common factors among patients with thrombophlebitis.

The step-down unit's Clinical Nurse Manager and Clinical Nurse Specialist developed an action plan for obtaining prospective data of infusion related thrombophlebitis in patients. The INS definition of intravascular thrombophlebitis as an "inflammation of the vein" in conjunction with the clinical criteria of the Phlebitis Scale was used for the purposes of this study (INS, 2000). The Phlebitis Scale is graded according to the most severe presenting indicator, in the following order: erythema at access site with or without pain, or edema, or streak formation, or palpable venous cord, or purulent drainage. Only patients meeting the above definition were entered into the study's database as having an adverse outcome of IV thrombophlebitis compared with the remainder of the study's patient population defined as not incurring IV thrombophlebitis.

Benchmarking was performed with other academic institutions' adult step-down telemetry units to ascertain similar thrombophlebitis outcomes, possible causes, and use of amiodarone and vancomycin infusions. Additional information was gleaned from the Clinical Nurse Specialist listserv and via networking at professional conferences by members of the team.

The following interventions were performed by the unit's quality improvement nurse: observation of nursing practice related to IV administration, including use of an in-line .22 micron filter for amiodarone boluses and infusions; staff education related to IV care and infection control policies and procedures; conversing with patients and clinical staff; determining if patients with IV infusions developed clinical criteria for thrombophlebitis; and entering the patients' demographic and clinical data in a thrombophlebitis spreadsheet if signs and symptoms met the Phlebitis Scale clinical criteria (INS, 2000). The quality improvement nurse was not blinded to the administration of amiodarone or vancomycin in the patient population. Searches for previous and additional cases of amiodarone-related or vancomycin-related peripheral IV thrombophlebitis on the study unit and other inpatient units via risk management did not result in further cases. This was primarily due to the self-report nature of risk management reports and a lack of centralized continuous surveillance for IV thrombophlebitis.

Method

Design

A single-center, observational, before and after, design to evaluate the incidence of thrombophlebitis secondary to the peripheral IV administration of amiodarone and vancomycin was used for this research.

Sample

The sampling pool for the study was all cardiothoracic surgical patients greater than age 18 admitted to the acute care telemetry unit at an academic health care institution between May 2004 and March 2006, receiving either peripheral IV amiodarone, peripheral IV vancomycin, peripheral IV amiodarone and vancomycin, or neither amiodarone nor vancomycin during the study period. Inpatients receiving peripheral IV amiodarone and vancomycin administrations within 12 hr of each other were defined as receiving "both" amiodarone and vancomycin. Patients in the amiodarone "only" or vancomycin "only" groups received either amiodarone or vancomycin or received both IV medications separated by greater than 12 hr between initiating and discontinuing each medication infusion. For example, if the patient's amiodarone infusion was discontinued 16 hr before the vancomycin infusion was administered, this resulted in two separate entries for this patient: amiodarone "only" and Vancomycin "only." The medical record documentation was not sufficient to determine whether amiodarone and vancomycin were infused in the same peripheral IV site or in separate sites for each individual. However, the unit's nursing standard of practice is to use a dedicated peripheral IV with a .22 micron in-line filter for amiodarone administration.

During the 23-month period between May 2004 and March 2006, 2,423 patient records, totaling 2,832 episodes based on amiodarone and/or vancomycin therapy, met the inclusion criteria for the study. An episode for the purposes of analysis in this study was defined as a newly initiated amiodarone infusion, or newly initiated vancomycin infusion, or the patient received both amiodarone and vancomycin, or the patient received neither amiodarone nor vancomycin during the study. Several patients had more than one episode of amiodarone or vancomycin infusions related to new clinical indications during the same admission or readmission for treatment. A new episode was only counted in the same patient during the same admission if there was greater than 12 hr between a previous amiodarone or vancomycin infusion and the new initiation of the amiodarone or vancomycin infusion. Thus,

Table 1. Amiodarone Infusions (*N* = 339 Patient Records)

	Phlebitis Present	Phlebitis Absent	Total
Time Periods[a]	*N* (%)	*N* (%)	*N*
1	10 (10.3)	87 (89.7)	97
2	10 (5.8)	163 (94.2)	173
3	16 (23.2)	53 (76.8)	69
Total *N* (%)	36 (10.6)	303 (89.4)	339

[a]Periods 1 and 3 = 900 mg/500 mL; Period 2 = 600 mg/500 mL.

the number of actual patients included in the study is less than the number of episodes related to amiodarone and vancomycin infusion history.

Procedure

Data Collection

All known cases of thrombophlebitis on the step-down unit were scrutinized via patient chart review (n = 61) to ensure each case fit the definition for intravascular thrombophlebitis related to IV therapy. Descriptive data collection from all patients experiencing thrombophlebitis was performed in the initial study period. Based on this information, and reports in the literature associating thrombophlebitis with peripheral amiodarone infusion, the institution's pharmacy department approved an institutional change in the adult standard concentration of amiodarone 900 mg/500 mL (1.8 mg/mL), to 600 mg/500 mL (1.2 mg/mL) in December 2004. In October 2005, the Cardiopulmonary Resuscitation (CPR) Committee was successful in requesting the institution return to the previous 900 mg/500 mL amiodarone concentration to standardize with ACLS guidelines for amiodarone infusion during cardiac arrests.

Permission was granted for the Clinical Nurse Specialist (CNS) and Advanced Practice Team (APT) Coordinator to review pharmacy's electronic medication records of all adult patients on the step-down cardiothoracic unit between May 2004 and March 2006. The number of patients who received IV amiodarone, vancomycin, both medications, or neither medications provided the denominator data for this study. Patients experiencing thrombophlebitis during the same period provided the numerator data.

Table 2. Vancomycin Infusions (*N* = 1,675 Patient Records)

	Phlebitis Present	Phlebitis Absent	Total
Time Periods	*N* (%)	*N* (%)	*N*
1	3 (0.6)	516 (99.4)	519
2	1 (0.1)	796 (99)	797
3	1 (0.3)	358 (99.7)	359
Total *N* (%)	5 (0.3)	1,670 (99.7)	1,675

Table 3. No Vancomycin or Amiodarone Infusion (*N* = 409 Patient Records)

	Phlebitis Present	Phlebitis Absent	Total
Time Periods	*N* (%)	*N* (%)	*N*
1	5 (4.5)	106 (95.5)	111
2	1 (0.5)	215 (99.5)	216
3	3 (3.7)	79 (96.3)	82
Total *N* (%)	9 (2.2)	400 (97.8)	409

Table 4. Binary Logistic Regression

	B	*SE*	Wald	*df*	Sig.	Exp(*B*)
Period 2	1.290	.342	14.222	1	.000	3.635
Vanco Yes	–2.083	.562	13.757	1	.000	0.125
Amio Yes	1.673	.383	19.071	1	.000	5.326
Constant	–4.595	.426	116.480	1	.000	0.010

Statistical Analysis

Initially, categorical data were compared using SPSS-14 Crosstabulation. Comparisons were made among patients for each episode of exposure to the medications and development of thrombophlebitis with (a) amiodarone infusion only (Table 1), (b) vancomycin infusion only (Table 2), and (c) neither amiodarone or vancomycin infusions (Table 3) for three different periods.

The three periods were based on the variance in amiodarone infusion concentration: Period 1: May 19, 2004 to December 2, 2004, amiodarone 900 mg/500 mL; Period 2: December 3, 2004 to October 19, 2005, amiodarone 600 mg/500 mL; and Period 3: October 20, 2005 to March 16, 2006, amiodarone concentration reversed back to 900 mg/500 mL. Vancomycin peripheral IV infusion concentrations remained constant throughout the study with dose and frequency adjusted depending on the patient's renal function.

Binary logistic regression was performed using Period 2 as the reference for Periods 1 and 3 (Table 4). In Period 2, an intervention occurred that decreased the amiodarone concentration (600 mg/500 mL). This provides a comparison to Periods 1 (before) and 3 (after), when the institution's standardized amiodarone concentration was less dilute (900 mg/500 mL).

Results

Table 1 describes patients receiving amiodarone treatment only and the presence of thrombophlebitis by time periods. In Period 1, patients had 1.8 times more thrombophlebitis (10.3%) compared with Period 2 (5.8%), the time period with decreased amiodarone concentration. Patients in Period 3 had 4 times more thrombophlebitis (23.2%) than patients in Period 2 (5.8%) and, unexpectedly, more than 2 times more thrombophlebitis than Period 1 (10.3%) even though both Periods 1 and 3 had the same concentration of amiodarone infusions. The total rate of thrombophlebitis for patients receiving amiodarone only in the study was 10.6%. The rate of thrombophlebitis for patients with vancomycin only (Table 2) in Period 1 (0.6%) is 17.2 times less than the thrombophlebitis rate for patients receiving amiodarone only (Table 1) in Period 1 (10.3%). Period 2 thrombophlebitis rate for vancomycin only patients (0.1%) is 58 times less than the thrombophlebitis rate for amiodarone only patients (Table 1) in Period 2 (5.8%). The greatest difference between thrombophlebitis rates in patients receiving vancomycin only in Table 2 (0.3%) and amiodarone only in Table 1 (23.2%) is in Period 3 where vancomycin only patients were 77.3 times less likely to experience a thrombophlebitis. The total rate of thrombophlebitis for patients receiving vancomycin only in Table 2 (0.3%, $n = 5$) is 35.3 times less than the total rate of thrombophlebitis for patients receiving amiodarone only in Table 1 (10.6%; $n = 36$) in the entire study.

Table 3 reflects the baseline rate of thrombophlebitis during the total time period studied in patients without amiodarone or vancomycin infusions. These patients may have received electrolyte therapy, other antibiotics and or other medications, intravenously, during the study period. The rate of

Table 5. Descriptive Statistics—Accuracy of the Logistic Regression Model

Thrombophlebitis (1 = *yes*; 2 = *no*)	*N*	Minimum	Maximum	Sum	*M*	*SD*
1. Predicted probability	50	.79535	.99875	44.56612	.8913223	.07777006
Valid *N* (listwise)	50					
2. Predicted probablilty	2,373	.79535	.99875	2328.434	.9812195	.03932310
Valid *N* (listwise)	2,373					

thrombophlebitis in patients with no amiodarone or vancomycin infusions (Table 3) in Period 1 (4.5%, $n = 5$) is 2.3 times less compared with patients with amiodarone only (Table 1) and is 7.5 times greater than patients with vancomycin IV therapy only (Table 2). In Period 2, the rate of thrombophlebitis in patients with no amiodarone or vancomycin is 11.6 times less (0.5%, $n = 1$) compared with patients with amiodarone only (Table 1) and 5 times greater than vancomycin-only patients (Table 2). This pattern repeats in Period 3 where the rate of thrombophlebitis in patients with no amiodarone or vancomycin infusions is 6.3 times less (3.7%, $n = 3$) compared with patients with amiodarone only (Table 1) and 12.3 times greater than vancomycin only patients (Table 2). The total rate of thrombophlebitis in patients without amiodarone or vancomycin infusions (2.2%, $n = 9$) is 4.8 times less compared with patients with amiodarone only (Table 1) and 7.3 times greater than patients receiving vancomycin only (Table 2) during the three time periods.

Results of the binary logistic regression (Table 4) demonstrate the odds for thrombophlebitis occurring during Periods 1 or 3 was 3.64 times the odds for thrombophlebitis occurring in Period 2 ($p \leq .0005$), the comparative period when the amiodarone concentration was decreased. The odds ratio for thrombophlebitis occurring when patients received amiodarone infusions was 5.33 times the odds for thrombophlebitis when amiodarone was not administered ($p \leq .0005$).

Table 5 shows the logistical binary regression model was accurate for this data, because the predictive probability of *N* is very close to the sum. The presence (Y) or absence (N) of thrombophlebitis is numerically expressed as 1 and 2, respectively.

Discussion

This study shows the importance of the primary care nurse's role in the administration of medications that may inadvertently have painful side effects and in reporting adverse events.

To define and provide surveillance of adverse events, it was crucial that the primary care nurse, in this research, reported his or her findings of peripheral thrombophlebitis to the quality improvement nurse on the telemetry unit. At that point, information and data were shared with other clinical professionals with the goal of preventing adverse events and improving patient quality care and safety.

Results in this study demonstrated the incidence of peripheral thrombophlebitis increased statistically when the 900 mg/500 mL amiodarone infusion was the standard institutional concentration. Despite the manufacturer's recommendation to use amiodarone concentrations less than 2 mg/mL (Wyeth Pharmaceuticals, personal communication, January 28, 2004), our experience showed patients continued to experience peripheral thrombophlebitis when the concentration was as low as 1.8 mg/mL. Statistically significant results of decreased thrombophlebitis were achieved when the amiodarone concentration was decreased to 600 mg/500 mL (1.2 mg/mL).

One concern in decreasing the amiodarone concentration was the excess fluid volume patients would receive with amiodarone infusions. This increased fluid might affect congestive heart failure patients or other fluid restriction patient care therapies. The extra fluid volume associated with a change of amiodarone concentration was calculated to be 267 mL/24 hr on Day 1, and 208 mL/24 hr on subsequent days (0.5 mg/min). Several physicians caring for fluid restricted patient populations were contacted for their opinions. There was agreement that fluid volume could be conserved with other medications or baseline IV fluid infusions to make up the difference.

Although amiodarone concentration was identical in Period 1 and Period 3 (900 mg/500 mL), the incidence of thrombophlebitis was more than double in Period 3 (23.2%) compared with Period 1 (10.3%). No pharmaceutical or nursing changes in procedures or standardized practice techniques occurred during this research study. One possible explanation is the heightened awareness by all nursing staff working in the adult cardiothoracic telemetry unit related to peripheral IV thrombophlebitis. The QI nurse working with the staff was accessible, approachable, and diligent in working with the nursing staff to assess and report any signs or symptoms of thrombophlebitis. The QI nurse made daily patient rounds 5 days per week and provided educational information in the form of clever signs, emails, and one-on-one conversations. The Clinical Nurse Manager and the Clinical Nurse Specialist discussed the IV thrombophlebitis outcomes and process improvement at staff meetings, team practice meetings and change of shift reports. A Quality Improvement poster was developed and presented. The result of the consistent efforts mentioned above, may have led to more accurate assessment and

reporting of the number of peripheral IV thrombophlebitis in Period 3 compared with Period 1.

As a result of this research, the institution changed the amiodarone standard concentration for patients of 50 kg or greater from 900 mg/500 mL to 600 mg/500 mL, effective in October 2007. The concentration of amiodarone bolus remained the same at 150 mg/100 mL (1.5 mg/mL) given over 10 min per manufacturer's instructions.

To our knowledge, this is the first observation study performed comparing peripheral intravascular thrombophlebitis in an adult cardiothoracic surgery inpatient population over three distinct periods and two different concentrations of amiodarone infusions. Such nursing research has the capability of preventing peripheral thrombophlebitis in patients receiving amiodarone infusions in the cardiothoracic surgery patient population. The effect of vancomycin infusions in protecting the patient from thrombophlebitis has implications for future research.

Declaration of Conflicting Interests

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