Somewhat serendipitously, imaging services determined a need to re-examine both our data-collection methods and patient care practices related to peripheral intravenous (IV) sites and peripheral vascular access devices (VADs). The situation that precipitated this re-evaluation of practices was related to the identification of ongoing phlebitis at a peripheral IV site after the VAD had been removed, which was suspected of leading to systemic sepsis and eventual loss of life. A process improvement study was completed with new IV-status recommendations related to the findings.

Abstract
The purpose of this process-improvement study was to determine the patient care practices in medical imaging in terms of contrast injection and occurrence of phlebitis at the peripheral vascular access device site. Vascular access sites were contrasted to determine whether there was a difference in phlebitis scale evaluation based on the injection of contrast and same-site use for injection of another vesicant. The results indicated a significant difference in phlebitis scale within 24–48 hours of injection of contrast and same-site use for injection of another vesicant. It was recommended that the peripheral vascular access device site be changed within 24 hours of injection of a second vesicant.

Keywords
Contrast, intravenous (IV), vascular access, phlebitis

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Vesicants are IV pharmaceutical agents that have the capability to damage the vessel and surrounding tissues. Vesicants that most healthcare providers can identify are many of the antineoplastic chemotherapy medications, although many commonly administered drugs and solutions also fall into this category. For vesicant medications, there is research to support that when there is the use of more than one vesicant solution in a peripheral IV site, there is a significant increase in the risk for phlebitis. Certainly, injectable contrast medium is not an antineoplastic medication, but it is a type of vesicant that the patient receives through a peripheral VAD. The chemical factors of vesicant solutions that predispose the vasculature to phlebitis include an acidic pH, hyperosmolarity related to blood osmolarity, rapidly infusing the solution, and combining several solutions together, leading to formation of a precipitate and particles in the infusion.

Vessel and tissue damage may initially occur through endothelial disruption of the tunica intima of the vein leading to the release of factors that support vessel dilation and concomitant increased blood flow. These factors also promote increased permeability of the venous vascular bed and leakage of blood components into the surrounding interstitial space. This leakage is clinically seen as edema and reported...
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site tenderness. Furthermore, the intima disruption initiates the clotting cascade that then leads to inflammation, possible thrombus, increasing edema, and induration. The vein at this time may be palpable as a cord.

pH and Osmolarity
The pH of blood plasma ranges from 7.35 to 7.45. The osmolality of blood plasma is 290mOsmol per kilogram of water. As a pharmaceutical agent is injected into the bloodstream, the blood and plasma solution, which contains buffering agents, moves to correct the acidity, alkalinity, hypotonicity, or hyperosmolarity of the solution to within normal parameters. The rate of the infusion is a limiting factor in the ability of the body to protect the integrity of the vessel wall through pH and osmolarity correction. Therefore, the slower the solution is infused, the quicker the solution can be brought to neutralisation. The faster the solution is infused, the less opportunity for neutralisation of the solution, allowing the vesicant solution more contact with the vessel.

Acidity or alkalinity of a solution is determined by the pH. A pH of 7.0 is considered to be neutral. The tunica intima of the vein may be injured or disrupted by pH-valued solutions that are both below and above the neutral point. In general, the further the pH value is from the neutral point, the greater the risk for damage. Common pharmaceuticals that are acidic or below the neutral point include ciprofloxacin, gentamycin, dopamine, and morphine. Common pharmaceuticals that are alkaline or above the neutral point include ampicillin and dilantin. In many situations, the pharmacy will be able to adjust pH values to adjust them closer to neutrality prior to injection.

The osmolarity of a solution is based on the degree to which the injected pharmaceutical influences water movement through cell walls in and out of solution. Injected pharmaceuticals fall into one of three categories: hypotonic, isotonic, or hypertonic. Tonicity is an indication of osmolarity. A designation of hypotonic indicates that the osmolarity of the solution is less than the osmolarity of blood. In general, a hypotonic solution will have an osmolarity that is less than 240mOsmol per liter of fluid. Injectable solutions that are hypotonic include sterile water and 0.45% sodium chloride. Isotonic indicates that the solution is near the osmolality of blood. Examples of isotonic solutions include 0.9% sodium chloride and 5% dextrose solution. A hypertonic solution is one where the osmolarity is higher than blood. Several hypertonic solutions include 5% dextrose with Ringers, 5% dextrose, and 0.9% sodium chloride with 20mEq of potassium chloride. The higher the osmolarity of an injectable pharmaceutical, the higher the risk for vein irritation or disruption.

Contrast Media
The contrast media and method of injection in computed tomography (CT) and in magnetic resonance imaging (MRI) and other imaging modalities contain most of the chemical factors that may lead to phlebitis. In CT, the injectable contrast medium most often used is ioversol (Optiray 350, Tyco Healthcare/Mallinckrodt), a non-ionic low-osmolality product at 792mOsmol per kilogram of water with 35% iodine (350g of iodine per milliliter) in solution. Ioversol is reported to have a variable pH from 6.0 to 7.4, which is acidic. In MRI, the injectable contrast medium used is gadopentetate dimeglumine (Magnevist, Bayer Healthcare), a non-ionic gadolinium-based product at 1,960mOsmol per kilogram of water. Gadopentetate dimeglumine is reported to have a variable pH from 6.5 to 8, which at the lowest range is acidic and at the highest range becomes slightly alkaline. Both contrast media, ioversol and gadopentetate dimeglumine, are hyperosmolar. Ioversol is always acidic based on the reported pH range and gadopentetate dimeglumine for nearly half of the products measured, and has a pH range that is acidic. All injected contrast media are recommended to be injected rapidly through either hand or power injection.

The contribution of contrast injection to the potential for phlebitis creation becomes clear as injected contrast media generally have an acidic pH, are hyperosmolar, and are given at a high rate of infusion. Additionally, many patients who present for imaging studies that require injected contrast media have IV solutions infusing that may support a concern for drug combining that could lead to precipitate in the vasculature.

Professional Organisation Recommendations
Historically, interest in injectable IV contrast media has been limited to imaging services. Recently, through changes in US federal and state regulations, contrast media have been re-defined as pharmaceuticals. With this new designation have come many professionals from outside of the imaging services field who are responsible for pharmaceuticals, who have begun reviewing the imaging processes related to contrast storage, administration, and documentation. In compliance with safety standards and known risks, the imaging department quality data measures include infiltration, extravasation, and pre-injection signs for infiltration and phlebitis. Following the guidelines recommended by the American College of Radiology (ACR), technologists evaluate each peripheral IV site prior to and after each contrast injection. Prior to this process improvement study, this examination guideline was the basis for imaging data collection.

The ACR published manual on contrast injection indicates that a peripheral VAD that is ≥20 gauge is preferred for contrast administration to ensure an adequate contrast flow rate, enhancing the ability to achieve quality medical imaging. Furthermore, it is recommended that the placement of the VAD should be in a large arm vein or at the antecubital site. The technologist is advised to observe both the peripheral IV site and the size of the VAD, then evaluate the status of the access through aspiration to determine blood return, followed by saline flush. Failure to achieve blood return or resistance on flushing is an indication for choosing an alternative contrast injection site or ensure site monitoring during the contrast injection.

The Infusion Nurse Society (INS) and the Royal College of Nursing (RCN) recommend that once a peripheral VAD is in place, full patency must continue to be demonstrated prior to any infusion of medications or solutions. The definition of full patency means that there is no difficulty or inability to withdraw or infuse fluids. Therefore, should a VAD evaluation allow for a saline flush but not produce blood during withdrawal, the VAD is considered to fail full patency. The rationale for recommending full patency of the VAD stems from the possibility that the VAD failure may be related to a blood clot, fibrin sheath, or partial occlusion related to VAD anchoring. Additionally, these two organisations recommend that 5% should be the acceptable phlebitis rate within a specific patient population.
The Centers for Disease Control and Prevention (CDC) reviewed the literature available at that time, and determined that peripheral VADs after 72 hours of dwelling had an increase in both thrombophlebitis, a blood clot with inflammation, and bacterial counts on the VADs. However, this body determined that the phlebitis rates were not substantially different up to 96 hours of dwell time. Therefore, the CDC recommended that peripheral VADs have routine site rotation between 72 and 96 hours of dwell time. However, the literature cited to support these findings did not address specific infusion types, such as vesicant pharmaceuticals or other such factors that are linked with the potential for the development of phlebitis.

Questions related to the properties of vesicants that may predispose a peripheral vein to phlebitis have received mixed reports in the literature. In a study of two peripheral parenteral nutrition solutions infused into rabbit ears, a glucose and electrolyte solution (pH 4.93, 727mOsm) and a 10% amino acid formula (pH 6.95, 929mOsm), histopathological evaluation of the veins demonstrated phlebotic changes. These changes included a decrease in endothelial cells, site infiltration of inflammatory cells, and site-associated edema. In a more recent study with a large population, the authors determined that the CDC guidelines were verified. However, this study did not consider vesicant administration through the IV site or continue to evaluate the peripheral IV site after the VAD was removed. Another study reported in 2008 determined that an 18-gauge VAD placed at the forearm or wrist increases viable dwell time of the site without phlebitis. Of many clinical non-research-based articles reviewed, two authors recommend diluting the vesicant prior to administration, ensuring that the VAD is secured in place and having the infusion completed over a long period of time.

**Methods**

A convenience sample of a total of 60 adult patients, 30 undergoing CT and 30 undergoing MRI, who were inpatients within a one-month time period were selected. All patients received IV contrast media. Technologists documented the size, site, and date of VAD insertion. All VADs were evaluated based on ACR recommendations. VADs that fell outside of the guidelines were referred for nurse or physician evaluation. VADs deemed acceptable for contrast media injection continued with the usual modality protocol, and those VADs that were not acceptable were re-inserted by the technologist. Each day the data collection sheets from CT and MRI were collected, and each patient’s peripheral IV site was assessed by the Patient Care Liaison registered nurse at 24, 48, and 72 hours post-injection. The Patient Care Liaison nurse recorded the medications that were currently infusing or intermittently administered through the peripheral VAD that was used for contrast media administration. The Jackson Phlebitis Scale (JPS) with color photos of phlebotic changes. These changes included a decrease in endothelial cells, site infiltration of inflammatory cells, and site-associated edema. In a more recent study with a large population, the authors determined that the CDC guidelines were verified. However, this study did not consider vesicant administration through the IV site or continue to evaluate the peripheral IV site after the VAD was removed. Another study reported in 2008 determined that an 18-gauge VAD placed at the forearm or wrist increases viable dwell time of the site without phlebitis. Of many clinical non-research-based articles reviewed, two authors recommend diluting the vesicant prior to administration, ensuring that the VAD is secured in place and having the infusion completed over a long period of time.

Indicators: some pain at the site, redness, or edema or swelling, which is evidence of an early phlebitis, with the recommendation to remove the VAD and re-start the IV in another area. A JPS score of three requires all three of these signs to be present: pain is found along the VAD path, as is redness and presence of induration, which indicates medium-stage phlebitis, and the recommendation is to remove the VAD and re-start the IV in another area. At JPS level three it is also recommended to consider treating the site as indicated by the physician. JPS level four is an advanced phlebitis or the beginning of a thrombophlebitis with indicators including all of the following: pain along the VAD path, redness, presence of induration, palpation of a venous cord above the VAD. It is recommended to remove the VAD, re-start the IV, and treat the site as indicated by the physician. The highest level on the JPS score is five, where all of the following must be present: pain along the VAD path, redness, presence of induration, palpation of a venous cord above the VAD, and patient fever. JPS level five is indicative of an advanced thrombophlebitis and initiation of treatment is strongly recommended.

**Results**

In the 60 patients, all of the catheter sizes were either 20- or 18-gauge. The indications for the VAD included fluid support, antibiotics, and contrast media. There were 12 VADs in place in the hand. The forearm and wrist accounted for 22 of the VADs. The antecubital site accounted for 26 of the VADs. There were no VADs in the lower extremities. Phlebitis occurred in 37% of peripheral IV sites. There was no significant relationship with the size of the VAD or the location. Of the 60 patients, all received one vesicant in the form of the contrast medium. In the 30 patients who received CT contrast media, all were power-injected. In the 30 patients who received MRI contrast media, all were hand-injected. Of the 60 patients who all received one vesicant in the form of contrast media, 63% (n=38) demonstrated no signs of phlebitis. Thirty-seven percent of the 60 patients (n=22) received concurrent vesicants in the form of fluid support, IV push medications, or antibiotics. No patients received peripheral IV nutrition or antineoplastic pharmaceuticals. None of the peripheral IV sites demonstrated signs of phlebitis on the JPS prior to contrast medium injection. Of those patients who developed phlebitis, 54% (n=12) received power-injected contrast media in CT. The remaining 46% (n=10) received hand-injected contrast media in MRI. All peripheral IV sites demonstrated a JPS score of 1 or 2 within 24 hours of contrast media injection when other vesicants were also used in the same site. At 48 hours of contrast media injection when other vesicants were also used in the same site, the JPS score was 2 or greater. All peripheral VADs were re-inserted into a new site at either the 24- or 48-hour time-frame. At 72 hours, the JPS score for the peripheral IV site where contrast had been injected remained unchanged or decreased by one level. None of the peripheral IV sites where contrast had been injected continued to progress on the JPS score after removal of the VAD.

**Discussion**

Development of phlebitis is multifactorial. Two of the properties of contrast media indicate that it is in the vesicant category where pH and osmolarity fall outside of the normal blood plasma parameters. Additionally, the requirement for rapid infusion of contrast media to ensure quality medical imaging adds another component for phlebitis risk. In this study, the incidence of phlebitis across a 72-hour observation of the peripheral IV site, with or without the original VAD, was 37%. Use of the JPS
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scoring criteria allows the conclusion that there is a significant problem with development of phlebitis in a peripheral IV site when that site is used for contrast medium and at least one other vesicant.

Recommendations

Future studies need to evaluate additional factors that may contribute to phlebitis, including gender, comorbidities, and age. Based on these findings, the rate of phlebitis can be reduced in the population of patients who receive contrast media and one or more vesicant through the same peripheral VAD. It is recommended that the interval between peripheral VAD removal and re-starting a VAD in another peripheral site in this population be within 24 hours of receipt of the contrast media.

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