Standardization of Access for Administration of Intravenous Contrast for Computed Tomography Scans

by

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Abstract

Problem and Purpose. The extravasation rate from Computed Tomography (CT) scans with intravenous contrast (IVC) in a large academic medical institution is 0.36% (inpatient 0.39% and outpatient 0.30%), higher than the national benchmark of 0.26%. A survey also showed that 16% of inpatients arrive at the CT scan department with peripheral intravenous (PIV) lines that may be kinked, dislodged, phlebitis or thrombose formation, or dressings are not intact. These conditions delay the CT scan procedure and put the patient in an unsafe condition. The purpose of this Quality Improvement (QI) project is to implement a protocol to standardize the preparation of PIV lines for inpatients for the administration of IVC to promote patient safety, prevent delays in CT scan, and eliminate common risk factors for extravasations. **Methods.** The QI project involved inpatients from a 23-bed adult medical telemetry nursing unit with CT scan orders with IVC using a PIV line. It required a coordinated effort between the bedside Registered Nurses (RNs), CT Technologists, Vascular Access Team (VAT) RNs, and Radiology RNs. The protocol involved the proper assessment of the PIV lines before leaving the bedside, using a test flush technique with 10 mL saline to flush in two seconds (5 mL/sec). Failure of the PIV line to accommodate the test flush required re-cannulation by the VAT RN. **Results.** During the 16-week implementation period, 17 patients (33%) ordered for CT scan with IVC underwent the protocol to standardize PIV lines' preparation. Among these patients, five (29%) did not pass the test flush and were re-cannulated by the VAT RNs. **Conclusions.** Bedside RNs play essential roles in preparing patients for CT scans with IVC. Adequate assessment of the PIV lines using the test flushing technique at the bedside before transporting patients to the CT Scan Department ensured that non-patent PIV lines receive

re-cannulation. This protocol eliminated a common risk factor for extravasation and prevented potential harm to the patient and CT scan delays.

Introduction

There is an exponential growth in the Computed Tomography (CT) scan procedures since the 1980s. It is expected that there are >70 millions CT scans yearly in the US (Sarma et al., 2012). Most of the CT scans require intravenous contrast (IVC) to enhance the radiographic images. However, IVC administration has side effects; one is extravasation, defined as leaking of the vesicant IVC outside the blood vessel into the surrounding tissues (Conner et al., 2017). Extravasation from an IVC could result in severe injuries requiring surgical intervention and prolonged hospitalization (Shaqdan et al., 2014; Nicola et al., 2015). Ninety percent of IVC extravasation result in minor injuries and 10% in severe injuries (Dykes et al., 2015). A less common but most feared severe injury involves compartmental syndrome resulting from the mechanical pressure in the surrounding tissues around the peripheral intravenous (PIV) line site. It is not uncommon for the compartmental syndrome to result in a surgical intervention (Compaña et al., 2013).

Multiple issues can lead to extravasation; the most probable being the age of PIV lines. A PIV line that is more than 24 hours old is prone to kink, dislodgement, phlebitis, and thrombose formation (ACR, 2013; Behzadi et al., 2018; Tonolini et al., 2012). An internal survey in July 2020 among inpatients coming for CT with IVC revealed that 16% of patients arrive at the CT Scan Department with PIV lines that were either kinked or dislodged, had phlebitis or thrombose formation. Extravasation can also be caused by a cannula that is too small or dressings that are not intact. These conditions can cause the PIV lines to fail the test flush technique and become inappropriate for IVC administration, thereby delaying a potentially critical procedure.

In 2019, internal data from a large academic institution showed an extravasation rate of 0.36%. This rate was higher than the American College of Radiology benchmark published in 2015, which is 0.26% (Dykes et al., 2015). The breakdown of the academic institution's extravasation rate in 2019 showed that the inpatient had the highest at 0.39%, followed by the emergency department at 0.35%, and the outpatient at 0.30%.

The purpose of this quality improvement (QI) project was to implement a protocol using the test flush technique (10 mL saline to flush in two seconds [5mL/sec]) to accurately assess the patency and compatibility of the PIV lines for the IVC injection. The goals for standardizing the preparation of PIV lines before the CT scan were to promote patient safety, prevent CT scan procedure delays, and prevent IVC extravasation

Literature Review

The appraisal of evidence used the level of the evidence rating system by Melnyk and Fineout-Overholt (2014) and the quality of the evidence rating system by Newhouse (2006) (Tables 1 & 2). The first part of the evidence review will highlight the common reasons why extravasations occur. The second part of the evidence review will highlight the rationale for the higher extravasation rate among inpatients. Lastly, the evidence review will feature critical consideration in the prevention of extravasation within the inpatient setting.

The majority of the literature reviewed had identified a high-risk population group for IVC extravasation. This high-risk group included women 50 years old and over and those who could not communicate due to severe illness, mental status, and the presence of respiratory devices (American College of Radiology [ACR], 2013; Behzadi et al., 2018; Ding et al., 2018; Niv et al., 2014). Another common risk factor for IVC extravasation was the PIV line's placement location on the hand and wrist dorsum. The upper arm and the forearm's proximal region were the preferred sites for IVC administration and minor extravasation sites (Tonolini et al., 2012; ACR, 2013). Poor cannulation techniques, such as multiple puncture attempts on the same vein, were at high risk for extravasation (ACR, 2013; Shaqdan et al., 2014). Other factors included safe practices in the IVC administration, including providing the alarm control to the patient and the instruction to trigger the alarm for any pain sensation during the IVC injection. Other factors also included practices of lightly palpating the PIV site, noting any swelling during the first few seconds of the contrast administration, and having a second CT technologist monitor the monitor's injection pressure limits (ACR, 2013; Behzadi et al., 2018; Ding et al., 2018).

In the outpatient setting, patients received their PIV lines just before the CT scan. However, inpatients arrived at the CT scan with preexisting PIV lines. The CT technologists were unaware of how the preexisting PIV lines are maintained at the bedside (Niv et al., 2014; Kingston et al., 2012; Kadom et al., 2012). If not well-maintained, a preexisting PIV line could be kinked, dislodged, and are prone to phlebitis and thrombose formation. Preexisting PIV lines could be placed for other purposes by clinicians who did not consider the CT protocol and the injection rate during the IVC administration, making it unsuitable for IVC administration (Behzadi et al., 2018; Kingston et al., 2012; Kadom et al., 2012).

Another theme found in the evidence review is the importance of a robust assessment method of the PIV line's viability before the CT scan procedure using the test flush technique. A saline test flush that mimicked the CT protocol's desired injection rate would ensure that the PIV line was appropriate for the IVC administration. A PIV line that failed the test flush means that it could not handle the IVC injection rate, thus requiring re-cannulation (Moreno et al., 201; Ding et al., 2018; Kadom et al., 2012).

The risk factors that lead to extravasation were multifactorial. It included high-risk population groups, unsafe practices during the PIV line placement, cannulation sites, contrast administration practices, and use of PIV lines that are more than 24 hours old (ACR, 2013; Behzadi et al., 2018; Tonolini et al., 2012). In the outpatient setting, PIV lines placed were dedicated to the CT scan and are placed immediately before the procedure. However, in the inpatient setting, patients arrive at the CT scan area with preexisting PIV lines. It was not feasible in clinical settings to implement a 24-hour rule for inpatient PIV lines for CT scans (Tonolini et al., 2012; Behzadi et al., 2018). Nonetheless, the test flush technique to assess the PIV line before a patient leaves the bedside would avert any patients traveling to CT scan with incompatible PIV line (Shaqdan et al., 2014; Moreno et al., 2018; Niv et al., 2014).

Theoretical Framework

Ajzen's theory of planned behavior explains how behavior changes through cognitive evaluation occur due to interactions between three constructs: behavior beliefs, normative beliefs, and control beliefs. The theory postulates that every person consciously examines their attitude toward the behavior, how other individuals perceive the action, and their perception to control the behavior. The interactions between the three constructs of conduct, norms, and control will eventually result in the intention to change, leading to the behavior change (Ajzen & Fishbein, 1973).

The QI project requires a practice change by the bedside registered nurses (RN). Hence, the following questions from the theory help guide the strategies employed to promote the staff's adaptation to change. Will the attitude toward adopting the new protocol (behavior beliefs) benefit the RNs? Will the entire bedside nursing team adopt (normative beliefs) the new protocol? Will the staff's perceived behavioral control (control beliefs) make it easy to adapt to the new protocol? The theory emphasizes the importance of addressing the staff's assumptions about the behavior change. Since the team's core value is patient safety, it is vital to highlight how the new protocol translates into patient safety. One way to accomplish this is by addressing the staff's questions during training and utilizing champions to promote the practice change. Lastly, designing an implementation plan that is most easy for the team to achieve will address the staff's control beliefs.

Methods-

A 23-bed adult medical telemetry nursing unit piloted the QI project in a Magnet-accredited 1,100+ bed capacity academic medical institution in the Mid-Atlantic region. At the time of the QI project implementation, the pilot nursing unit converted nine beds into critical-care step-down to increase the institution's capacity to care for COVID patients in other critical-care nursing units. The inclusion criteria included adult patients from the pilot unit with CT scan orders that will use PIV lines for IVC administration. The exclusion criteria were patients ordered for CT scan without IVC or CT scan with IVC using central lines.

The QI protocol standardized the process (Appendix A) that occurred when an inpatient from the pilot unit received an order for CT with IVC, and included a coordinated involvement of the bedside RNs, VAT RNs, CT Techs, and Radiology RNs. Following the placement of an order for a CT scan by the physician, the bedside RN assessed the PIV line patency using the test flush technique (Kadom et al., 2012; Moreno et al., 2013; Nicola et al., 2015). This QI project defined the test flush technique using a 10 mL saline in two seconds (5mL/sec) (Appendix B). The basis for choosing the 5mL/sec test flush was the desired mean injection rates of most CT scan studies within the institution. The injection rates ranged from 2 to 6.5 mL/sec, with most scans averaging 4 to 5.5 mL/sec (Appendix C). The QI protocol included explanation of the procedure to the patient, accessing the PIV line using aseptic technique, priming the line with sterile saline, and the 10 mL saline to flush at 5mL/sec. The QI protocol also included instruction to the patient to report any discomfort felt at the PIV line site during the test flush at the bedside. The bedside RN requested a new PIV line from the VAT RN if the existing catheter failed the test flush. The patient was transported to the CT Scan Department once the PIV line was patent. At the CT Scan Department, there was a second assessment of the PIV line patency by the CT Tech using the same test flush technique. If the PIV line passed the test flush, then the CT scan with IVC administration followed. If the PIV line failed the second test flush, the Radiology RN would re-cannulate the patient.

In the first three weeks of implementation, bedside RNs on the pilot unit participated in an information drive. During the 3 pm, nursing staff huddle, the QI project lead or one of the two nurse champions (nursing supervisors) would discuss the QI project every weekday. The discussions included

- the problems of the current situation (inpatients arriving at the CT Scan Department with non-patent PIV lines, CT scan delays due to unsuitable PIV lines, and the institutional extravasation rate),
- the solution of the problem based on the literature evidence (QI test flush protocol),
- the rationale for the QI test flush protocol, and
- discussion of the most commonly used CT scan protocol and the mechanical injection of IVC.

The information drive allowed the RNs to ask questions about the QI project and appealed for their 100% participation.

The QI project followed the Donabedian Model (Donabedian et al., 1982) of structure, process, and outcome. The structure change included the training provided to the bedside RNs regarding the QI project protocol during the first three weeks of the implementation period. The process had a practice change to the bedside RNs about the test flush technique. The QI protocol test flush was a twist to the current PIV line assessment practice. The QI project used the daily audit tool's (Appendix D) voluntary use to monitor the practice change among the nurses affecting all patients ordered for CT scan with IVC administration. There was a weekly tracking of the progress using a run chart to achieve a 100% compliance rate. The goal was that 100% of PIV lines identified as unsuitable for the IVC administration through the test flush protocol (5mL/sec) would receive re-cannulation by the VAT RN. Also, the bedside RN champions implemented an early morning daily reminder to the charge RN and the rest of the RN staff during the 3 pm staff huddle. The outcome measure was a 0% extravasation rate among the patient population included in the QI project during the implementation period, monitored using the CT techs' daily audit tool.

The daily audit tools were scanned into a Safe Desktop (an institutional encrypted drive with limited access and password protection) by the CT Tech champion and the bedside RN champion. There was safe disposal of paper copies using Shredder Box and a weekly transcription of the daily audit tool information in an Excel master data sheet for data collection saved in the Safe Desktop.

Results

The QI project implementation took 16 weeks, starting August 31 through December 18, 2020. The first three weeks of the QI project focused on the information drive among the bedside RNs regarding standardizing the PIV line prep of patients ordered for CT scan with IVC. Seventy percent (70%) of the 45 Bedside RNs attended the information drive delivered as group-information sessions during the 3 pm unit staffing huddle. It was challenging to capture 100% of the bedside RNs due to the nursing unit's transition to becoming a semi-step-down unit in response to the COVID pandemic and staffing change. Printed materials about the QI project were available for the permanent night-shift RNs, but the QI project did not track the RNs reached.

The QI project used Kirkpatrick's (2006) level 2 of learning evaluation using a pre-post questionnaire in a Likert scale. Of the 20 (44%) bedside RNs who responded, there was an aggregate 74% increase in learning regarding the role of bedside RNs in the preparation of patient's PIV line before CT scan, the test flush technique, and the standard CT scan protocol and desired injection rate based on the patient's weight. The baseline assessment showed 81% of bedside RNs had the knowledge gap.

Of the 43 patients ordered for CT scan with IVC during the implementation period, 33% (n = 17) were captured using the daily audit tool. The bedside RNs applied the test flush protocol (10 mL saline at 5mL/sec) on 100% of the 17 patients. Seventy-six (76%) of the time, nurses explained the test flush procedure to the patients. Eighteen percent of patients complained of discomfort during test flush, and 18% had developed infiltration during the process. Had these patients proceeded to CT scan, their PIV lines would be deemed unsuitable for IVC injection and would have been a considerable risk for developing IVC extravasation. Of the 17 patients, 29% ended needing re-cannulation by the VAT RN at the bedside, and 100% of these patients received a new PIV line before going to CT scan. As a positive consequence, these patients were found to have unsuitable PIV lines and received re-cannulation at the bedside, prevented CT scan procedure delays and possible IVC extravasation. During the QI project implementation period, 0% of the patients from the participating nursing unit had IVC extravasation.

Two patients in the exclusion criteria with an order for CT scan without IVC received the assessment of their PIV lines unnecessarily. This intervention was unintended and strengthened the need for continuous education of the bedside RNs on the CT scan protocols.

Discussion

For the QI project to become sustainable, it required dissemination throughout the institution. There were several requests for presentations at different departmental and institutional workgroups. There was also a push from the CT Scan Department and Radiology Nursing leadership to have the QI project protocol disseminated throughout the institution and to protocolize it since there was a clear benefit for patient safety and prevention of delays in the CT scan procedures. These recommendations would provide opportunities to broaden the dissemination and promote sustainability of the QI project protocol.

The institution has an infiltration and extravasation policy that covers general intravenous infusions and intravenous vesicant pharmaceutical administration. There was a recent upgrade to the policy in 2020. However, there is a significant potential to attach an addendum that would refer to the QI project protocol regarding CT scan IVC injection. Weaving the QI project protocol into the institutional policy on infiltration and extravasation would offer in-depth support for practice change.

There is also the need to develop materials that would promote information drive among the nurses. There had been requests for fast fact sheets from the Department of Medicine Nursing and the Department of Surgical Nursing. As part of the sustainability strategy, the Radiology Nursing leadership took the lead in finding various forums for dissemination. The Radiology Nursing leadership would also take the lead in developing fast facts for various nursing departments. So far, the Department of Medicine published the educational tool CT Protocols, Injection Rates, and Recommended PIV Gauge (Appendix C) in the institutional nursing intranet.

A crucial strategic aspect of disseminating an institution-wide QI project intervention is to ensure proper education of various stakeholders (Pronovost et al., 2008). This QI project had the bedside RNs, VAT RNs, CT Technologists, and Radiology RNs as the integral clinicians in implementing the QI project protocol. Identifying champions in each functional unit would be instrumental in holding each clinician accountable for compliance with the QI protocol. This QI project had the pilot unit Nursing Supervisors act as champions. Each nursing department nurse educator could provide support to the functional unit champions. The institution also has a central Vascular Access Device workgroup that deals with infiltration and extravasation cases that can further reinforce the QI protocol.

The QI project had a 0% extravasation rate throughout the 16-week implementation period. However, it did not have an adequate sample (n = 43) to affect the entire institution's extravasation rate. The extravasation rate's internal data from 2019 is 0.39% among inpatients and 0.30% among outpatients. The institution's Office of Nursing Professional Practice initiated a database that will pull reports from the electronic health record of extravasation events related to IVC administration during CT scans. The need to identify nurse-sensitive indicators with metrics compared to professional organizations such as the American College of Radiology (2021) as a requirement for the Magnet accreditation influenced the initiative. Once implemented, this database would allow quarterly reports of the institution's inpatient extravasation rate from IVC administration. It could be safe to expect a downward trend of the institution's inpatient extravasation rate depending on the successful dissemination of the QI protocol.

There is always imprecision in the intervention fidelity of a QI project since the method included constant adjustments to the interventions to achieve the desired result. This nature of the QI project could have influenced the 0% extravasation rate during the implementation period. Initially, the QI project protocol's information drive only had the nursing staff's 3 pm huddles during the first three weeks of intervention. Eventually, a strategy included daily morning reminders among the bedside Charge RNs.

Conclusion

In large academic institutions, it is common to have several departments involved in preparing patients for CT scans with IVC. This QI project required the coordination between the CT Scan Technologists, Radiology Nursing, VAT Nursing, and Medical Telemetry Nursing. Departmentalization provides a silo effect and becomes a barrier in transmitting relevant information between the stakeholders involved. This QI project has proven that bedside RNs play essential roles in preparing patients for CT scans with IVC. Once educated with standard CT protocols and desired IVC injection rates, bedsides learned the importance of thoroughly assessing the patients' PIV lines using the test flush technique (10mL saline to flush in 5mL/sec). The purpose was to ensure that the patient's PIV line is compatible with the commonly desired injection rates of IVC. Timely capture of PIV lines that do not pass the test flush facilitated prompt activation of the VAT RNs by the bedside RNs to re-cannulate the patients. This process prevented patients from leaving the bedside with PIV lines not appropriate for IVC injection.

Consequently, the QI project protocol prevented delays in the CT scan procedure. A patient on the CT scan table found to have a PIV line that does not accommodate a 5mL/sec test flush can delay the CT scan procedure as it requires re-cannulation by the Radiology RN. It is common to see a CT scan delayed at least 40 minutes, mainly if the patient is on airborne precaution due to COVID. Donning and doffing of personal protective equipment by the Radiology RN due to a COVID positive patient always delay the re-cannulation process while the patient is on the CT scan table. As a result, there was an increase in patient safety, and there was the prevention of extravasation events. There was a 0% extravasation event among the patients from the participating nursing unit during the implementation period. The QI project also augmented the learning of bedside RNs to 74% regarding their role in preparing the PIV line of patients for CT scan, the standard CT scan protocols, and the need for the test flush protocol.

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Table 1

Evidence Review Table

University of Maryland School of Nursing

Citation: Behzadi, A. H., Farooq, Z., Newhouse, J. H., & Prince, M. R. (2018). MRI and CT contrast media extravasation: A systematic review. *Medicine*, *97*(9), e0055. https://doi:10.1097/MD.0000000000010055					Level I
Purpose/Hypothesis	Design	Sample	Intervention	Outcomes	Results
The purpose of this systematic review is to identify factors that raise the risk for extravasation by blending data from multiple papers.	Systematic review	**Data extraction:** The data were extracted from 17 papers that included 2,191 extravasations on 1,104,872 patients. **Search strategy:** The study followed the Preferred Reporting Items for Systematic Reviews guidelines. Keywords used were: "GBCA," "iodine contrast agent," "risk factor," "extravasation," and "gadolinium." The investigators searched through PubMed and Google Scholar. **Inclusion criteria:** Original articles on human subjects reporting IV contrast extravasation	**Control:** IV lines are placed from the patients' unit of origin before coming to the radiology department (ER and other nursing units). **Intervention:** IV lines placed by the radiology staff **Control:** IV catheter sites other than antecubital fossa (hand, wrist, forearm, upper arm, and foot)	**Dependent Variable:** Extravasation rate **Factors affecting DV on who placed the IV lines:** The investigators identified factors that could have increased the extravasation rate for IV lines placed outside of radiology: IV lines placed >24 hours or with multiple attempts, extravasation that did not occur with regular infusion but happened at a higher injection rate with IV contrast, dislodgement of catheters during transport, and site selection for an IV line placement (radiology staff prefers the upper forearm while floor staff prefers the distal locations).	**Who placed the IV lines:** In three studies, the extravasation rate for IV lines placed from the patients' unit of origin (ER or other nursing units) is 0.58%. In contrast, the extravasation rate for IV lines set by radiology staff is 0.33% (P<0.001). On two studies comparing inpatients and outpatients, the extravasation rate among inpatients is 0.29% compared to outpatients, which is 0.05% (P<0.001). **IV catheter sites:** The extravasation rate for IV lines placed on the antecubital fossa is 0.6%, whereas the extravasation rate for IV lines set anywhere else is 1.2% (P = 0.0002).

			Intervention: IV lines placed in the antecubital fossa		
Citation: Ding, S., Meystre, N. R., Campeanu, C., & Gullo, G. (2018). Contrast media extravasations in patients undergoing computerized tomography scanning: A systematic review and meta-analysis of risk factors and interventions. *JBI Database of Systematic Reviews and Implementation Reports*, *16*(1), 87-116. https://doi:10.11124/JBISRIR-2017-003348					Level I
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
The purpose of this paper is to identify the risk factors and interventions that prevent or reduce contrast extravasation.	Systematic review with some meta-analysis	**Data extraction:** There were 15 articles reviewed, including 2 RTCs (randomized controlled trials) and 13 quasi-experimental and observational studies. **Search strategy:** The databases searched included PubMed, CINAHL, Embase, the Cochrane Register of Controlled Trials, Web of Science PsychINFO, ProQuest Dissertation and Theses A&I, Trip Database, and Clinical Trials.gov. The investigators used the Joanna Briggs Institute System for the Unified Management, Assessment, and Review of Information (JBI SUMARI) to assess each study's methodological validity.	**Control:** Existing IV lines **Intervention:** Newly inserted IV lines **Control:** Not warming the IV contrast **Intervention:** Warming of the IV contrast **Control:** Before the QI project	**Dependent variable:** Volume of extravasation **Dependent variable:** Extravasation rate	**Meta-analysis:** RevMan (Copenhagen: The Nordic Cochrane Center, Cochrane) was used to calculate meta-analysis. **IV catheter dwell time:** On one study, the mean volume of extravasation for newly inserted catheter is lower (40.6 $\pm$ 37.9 mL, n=90) compared to existing catheter (63.1 $\pm$ 44.5 mL, n=80), *P* = 0.0005. **Warming of contrast:** One study investigated the warming of IV contrast (iopamidol 370 by Brasco Diagnostics). Warming decreased the extravasation rate. With warming, the extravasation rate was 0.57% (5/1851), and without 0.87% (18/2074), *P* = 0.05. **QI project:** Before reporting extravasation data, the extravasation rate was 0.28% (469/166193) and after six months, 0.23% (374/163/100). The change was not statistically

		Inclusion criteria: Studies included patients undergoing IV contrast-enhanced CT scans, classical CT studies and Interventional Radiology studies, and inpatients and outpatients. **Power analysis:** Effect sizes (odds ratio for categorical data) and their 95% confidence interval were calculated. **Heterogeneity:** Standard Chi-square and I^2 tests were used to analyze heterogeneity.	**Intervention:** QI project – the QI project included multi-institutions that were asked to report data of extravasation for six months	**Dependent variable:** Extravasation rate	significant. However, it shows a downtrend of the extravasation rate.
Citation: American College of Radiology Committee on Drugs and Contrast Media. Extravasation of contrast media. *ACR Manual on Contrast Media 2013*, version 9. Reston, VA: ACR; 2013:17-9. https://www.acr.org/Quality-Safety/Resources/Contrast-Manual					Level I
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
This paper is designed to provide clinical guidelines on the frequency, sequelae, evaluation, treatment, risk factors, and documentation of extravasation	Clinical practice guideline (CPG)	This CPG is based on 24 different studies and expert opinions.	**High-risk situations:** 1. Avoid the high-risk sites for extravasation: hand, wrist, foot, ankle. 2. Avoid IV access that has been in place for >24 hours and multiple punctures into the same vein. These are associated with an increased risk for extravasation.	**Dependent variables**: Increase in extravasation rate	This clinical practice guideline did not summarize results from the studies reviewed to develop the approach.

			3. Pay close attention to other high-risk situations: patients who cannot communicate effectively (elderly and those with altered consciousness), severely ill, and patients with conditions affecting peripheral circulation (atherosclerotic peripheral vascular disease, Raynaud's disease, venous thrombosis, diabetic vascular disease, or prior radiation therapy or extensive surgery).		
Citation: Tonolini, M., Campari, A. & Bianco, R. (2012). Extravasation of radiographic contrast media: Prevention, diagnosis, and treatment. *Current Problems in Diagnostic Radiology*, *41*(2), 52-55. https://doi:10.1067/j.cpradiol.2011.07.004					Level VII
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
The purpose of this paper is (1) to discuss the "incidence, patient-, and procedure-related risk factors, pathogenesis, and clinical manifestations of extravasation injuries" thorough review of current literature, and (2) to propose preventive approaches.	Expert opinion	None	Review of evidence from the literature.	**Dependent variable:** Extravasation rate	Follow the steps to reduce the risks of contrast media extravasation: 1. Adequate venous access choice and cannula placement 2. Injection through an IV cannula that has been placed >24 hours is strongly discouraged 3. Careful selection of IV sites for appropriate cannula sizes 4. Necessarily repeated punctures on the same vessel should be done

					cranially 5. Avoid flexion areas when patients are uncooperative 6. Avoid extremities with prior treatment (like chemotherapy) 7. Tests venous line with saline immediately before CT scan 8. Warm iodinated contrast to body temperature 9. Palpatory monitoring of the IV site on the first few seconds of the injection 10. Remember that extravasation can still happen even with meticulous techniques
Citation: Shaqdan, K., Aran, S., Thrall, J., & Abujudeh, H. (2014). Incidence of contrast medium extravasation for CT and MRI in a large academic medical center: A report on 502,391 injections. *Clinical Radiology*, *69*(12), 1264-1272. https://doi:10.1016/j.crad.2014.08.004					Level VI
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
"To present the authors' experience of contrast medium extravasation (CME) during both CT and MRI examinations in a large academic medical center."	Retrospective study	**Sampling technique:** There were 502,391 IV contrast injections that were retrospectively reviewed between June 2008 and June 2013.	**Control:** CT studies involving the inpatient population **Intervention:** CT studies involving outpatient population **Intervention fidelity for both control and intervention group:** 1. A CT tech closely monitors the IV site while	**Dependent variable:** Extravasation rate **Measure:** The dependent variable was measured by comparing the frequency of extravasations based on the number of MRI or CT studies that involve contrast-enhanced studies.	Inpatient extravasation rate for CT patients is 0.29% (160/54,664) while outpatient extravasation rate is 0.15% (291/297,008) (*P*<0.001).

			standing close to the patient during the injection to determine the occurrence of extravasation. 2. A second CT tech is in the control room monitoring the pressure of injection on the monitor 3. Anytime the patient complains of pain or any discomfort, the injection is stopped immediately **Note:** As a retrospective study, no testing was performed to determine whether the standard contrast administration protocol was more effective to lower the extravasation rate versus no protocol.		
Citation: Niv, G., Costa, M., Kicak, P., & Richman, K. (2014). Vascular extravasation of contrast medium in radiological examinations: University of California San Diego health system experience. *Journal of Patient Safety*, *10*(2), 105-110. https://doi:10.1097/PTS.0000000000000114					Level VI
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
The purposes of the study include the following: (1) "determine the frequency, management, and outcome of CME" (contrast medium extravasation) and (2)	Retrospective and prospective	**Sampling techniques:** Seventeen thousand two hundred patients underwent radiological procedures involving IV contrast between January 1, 2010, and	**Control:** IV lines placed outside of the radiology department **Intervention:** IV lines placed by radiology staff **Intervention fidelity for**	**Dependent variable:** Extravasation rate **Measure:** The dependent variable was measured by comparing the frequency of extravasations based on the number of	The extravasation rate among those IV lines placed by the radiology staff is 0.34% (42/12,169), while those set outside of the radiology department are 0.81% (41/5,031), P<0.001.

to "assess the knowledge among CME among radiology technologists based on		September 30, 2011. These cases were retrospectively reviewed. The investigators found 83 cases of contrast extravasation.	**both control and intervention group:** 1. Every IV catheter was checked for patency by obtaining a blood return and pre-injection of 10 ml of saline before the contrast injection. 2. Before IV contrast is administrated, the patient was instructed to report any pain or discomfort at the injection site during the injection. 3. The CT technologist attempted to stay in the room and inspect the injection site during the first few seconds of the injection. **Note:** As a retrospective study, no testing was performed to determine whether the standard contrast administration protocol was more effective to lower the extravasation rate versus no protocol.	radiological studies that involve contrast-enhanced studies.	
Citation: Nicola, R., Shaqdan, K. W., Aran, S., Prabhakar, A. M., Singh, A. K., & Abujudeh, H. H. (2015). Contrast media extravasation of computed tomography and magnetic resonance imaging: Management guidelines for the radiologist. *Current Problems in Diagnostic Radiology*, *45*(3), 161-164. https://doi:10.1067/j.cpradiol.2015.08.004					Level VII
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results

"This article discusses the risks factors, clinical manifestations, and conservative and surgical approaches of subcutaneous contrast media extravasation for both computed tomography and magnetic resonance imaging."	Expert opinion	The authors did not provide the samples of the studies that they reviewed.	**Recommendations for prevention of extravasation:** 1. Palpatory monitoring of IV site during the first few seconds of injection 2. Notify patient of what to expect if there is extravasation and to report via intercom 3. Run saline test (flush the line) to determine any resistance before contrast injection 4. Injection flow velocity should be appropriate for the size and location of the IV catheter 5. IV catheters >24 hours old should not be used for injection of contrast	**Dependent variable:** Extravasation rate	The authors did not specify specific results from the studies that were reviewed.
Citation: Moreno, C.C., Pindo, D., Nelson, R.C., Sahani, D.V., Jenkins, M., Zabrycki, M.A., Chaudry, H., Kang, J., Chen, Z. (2013). Lessons Learned from 118,970 multidetector Computed Tomographic intravenous contrast material administrations: Impact of Catheter Dwell Time and Gauge, Catheter Location, Rate of Contrast Material Administration, and Patient Age and Sex on Volume of Extravasate. *Journal of Computed Assist Tomography*, *37*(2). https://www-ncbi-nlm-nih-gov.proxy1.library.jhu.edu/pubmed/?term=Moreno%2C+Pinho%2C+Nelson%2C+2013					Level VI
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
"This study aimed to determine the impact of catheter dwell time and gauge, catheter location, rate of contrast material administration, and patient age and sex on the volume of extravasate at	The study was retrospective, involving two institutions.	**Sampling technique:** Between March 2006 and December 2009, extravasation events were reviewed in two institutions (Duke University Medical Center and Massachusetts General Hospital).	**Control:** Existing catheters used **Intervention:** New catheter placed **Intervention fidelity:** Existing catheters for inpatients were used when the catheter flushes well. If an	Volume of extravasate **Measure:** The dependent variable was measured by computing the mean volume of extravasate for either the existing catheters or newly placed catheters.	On 170 patients, the catheter dwell time was recorded. The mean volume of extravasate for new catheters was statistically significantly lower [n = 90; mean (SD), 40.6 (37.9) mL] versus existing catheters [n = 80; mean (SD), 63.1 (44.5) mL; $P = 0.0005$].

intravenous contrast-enhanced multidetector computed tomography."		There was a total of 330 extravasations among 118,970 patients. In both of the institutions, all the extravasation events were placed in a searchable database.	existing catheter did not flush well, a new catheter was placed by the radiology staff. An 18- or 20-gauze catheter was placed in the antecubital vein. When the antecubital vein is available, upper arm, wrist, and rarely, hand veins were used.		
Citation: Kingston, R. J., Young, N., Sindhusake, D. P., & Truong, M. (2012). Study of patients with intravenous contrast extravasation on CT studies, with radiology staff and ward staff cannulations. *Journal of Medical Imaging and Radiation Oncology*, *56*(2), 163-167. https://doi:10.1111/j.1754-9485.2012.02355.x					Level VI
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
"This study evaluates for any differences in rates of extravasation between radiology staff and ward medical staff cannulation, and secondarily by cannula size and study type."	Prospective	**Sampling technique:** From September 2004 to April 2008, 26,854 contrast-enhanced CT studies included 119 extravasations that became part of this prospective study. **Power analysis:** "To detect a difference with a 5% level of significance and with an 80% power, the study would need 26,500 patients."	**Control:** Cannulation by non-radiology staff **Intervention:** Cannulation by radiology staff **Intervention fidelity:** 1) Inpatients require IV cannula before transport for CT study 2) IV cannulas tested with saline 3) Cannulas that are not good will need a new IV line from radiology staff 4) Close observation of patients for signs of extravasation during injection	**Dependent variable:** Rate of extravasation **Measure:** The rate of extravasation was calculated using the frequency of extravasation among all the contrast-enhanced studies.	**Statistical technique:** A difference in proportion was tested by Chi-square statistics with continuity adjustment (Fisher's exact test) applied as appropriate. The level of significance used was 0.05. The extravasation rate for cannulation by radiology staff is 0.34% (n=11,470), whereas by non-radiology staff is 0.52% (n=15,384) The result was not statistically significant.
Citation: Conner, B., Ash, R., Allen, W., Brown, T., Hill, J., Hook, M., & Fishback, S. (2017). Preventing intravenous contrast extravasation in CT: A simple solution. *Journal of the American College of Radiology*, *14*(10), 1326-1332. https://doi:10.1016/j.jacr.2017.05.020					Level VI
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
This study is a QI initiative, "in conjunction with	QI	**Sampling & Methodology:** This study is an IRB-	A CECT screening process was modified to focus on early detection of high-risk	Extravasation rate	The pre-intervention extravasation rate was 0.47% (38/8,009), while the post-

the ACR (American College of Radiology), to examine differences in contrast extravasation rates before and after modifying our CECT (Contrast Enhanced CT Scan) intake process."		approved QI that looked at extravasation events on patients 18 years old and older, from April 2013 to December 2014. A total of 16,530 patients received IV contrast through peripheral IV lines on the upper extremity.	patients: 1. CT Technologists were educated on the institution's extravasation rate 2. A question was added to the CT screening questionnaire, asking specifically about the history of contrast extravasation or IV access issues 3. 20 mL saline test bolus to assess IV lines 4. If the existing IV line is questionable, a) access a new IV access, b) decrease injection flow rate, c) and monitor IV site during the injection	**Measure:** The dependent variable was measured by comparing the frequency of extravasations based on the number of radiological studies that involve contrast-enhanced studies.	intervention is 0.28% (24/8,521), *P*=0.04.

Table 2

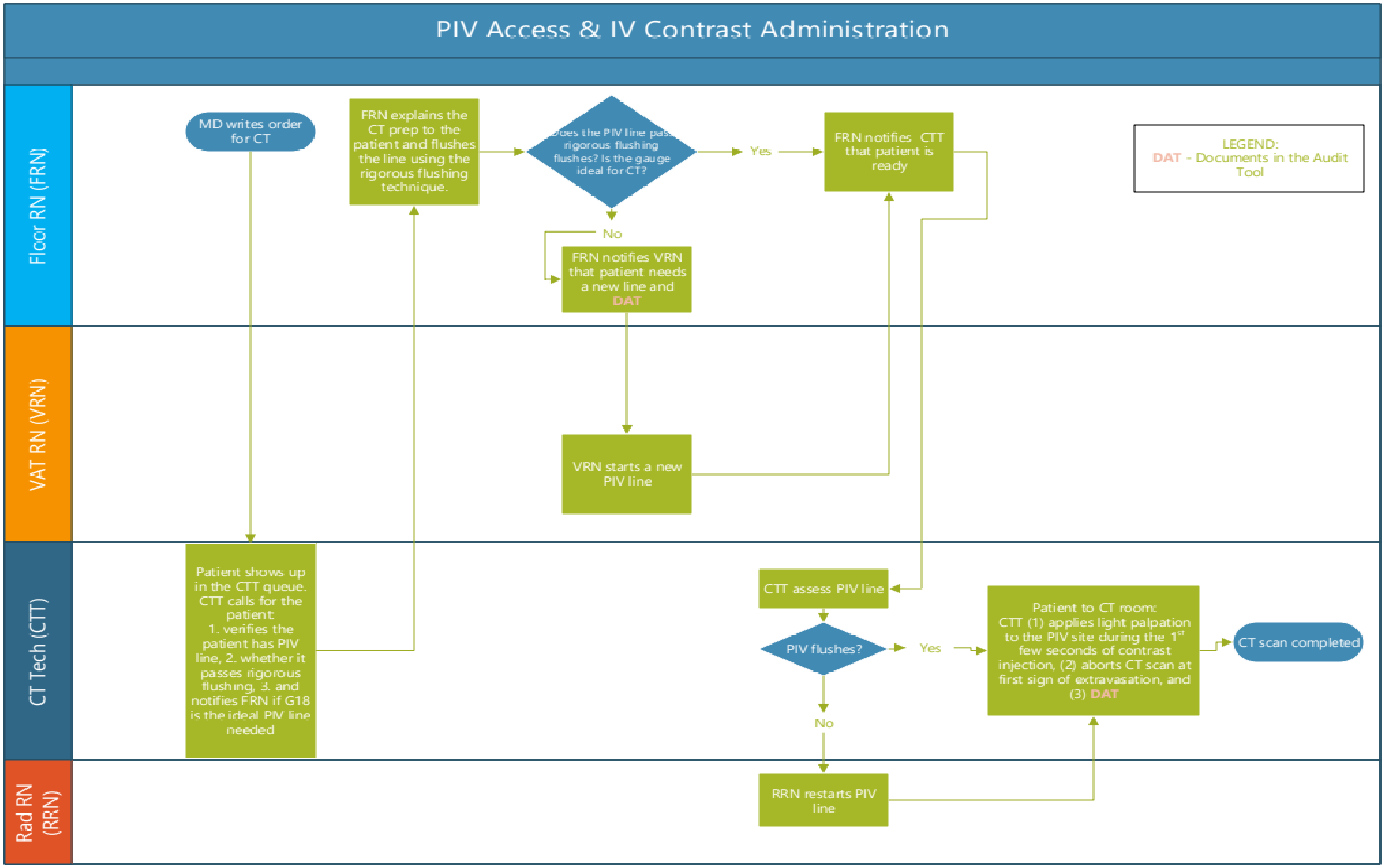
Synthesis Table

University of Maryland School of Nursing

Evidence-Based Practice Question (PICO): Does implement a protocol to standardize IV access and IV contrast administration reduce the extravasation rate among adult inpatients for contrast-enhanced CT Scan studies?			
Level of Evidence	# of Studies	Summary of Findings	Overall Quality
I	3	The studies of Behzadi et al. (2018) and Ding et al. (2018) are systematic reviews that looked at common factors that increase extravasation risk with IV contrast. Identifying high-risk factors will be the first step in preventing extravasations from occurring. Behzadi et al. (2018) included 17 studies, with a total of 1,104,872 patients. Ding et al. (2018) had 15 reviews, with 2 RCTs and 13quasi-experimental and descriptive studies. Behzadi et al. (2018) included three studies that looked at the extravasation rate comparison when an IV line is placed by radiology staff before the imaging procedure, with IV lines placed by non-radiology staff from the sending unit. The sending units included ER and inpatient units. The extravasation rate for IV lines placed by radiology staff is 0.33%, whereas the extravasation rate for IV lines placed by non-radiology staff is 0.58% ($P<0.001$). There are many suggested reasons, including the age of the IV lines >24 hours, IV lines not maintained, and the IV lines kinked. Ding et al. (2018) looked at the volume of extravasation when an IV line is newly placed in radiology or existed before the patient's arrival to the CT scan area. The mean amount of extravasation for IV lines placed in radiology is 40.6 mL. On the other hand, the mean volume of extravasation for IV lines placed outside radiology is 63.1 mL ($P = 0.005$). Ding (2018) stated similar factors mentioned by Behzadi et al. (2018) as the reasons why there is higher extravasation volume for IV lines placed outside of radiology, with the staff placing IVs not knowing how the IV lines are used for power injection. The ACR (American College of Radiology) (2013) is a reputable organization equivalent to the ESUR (European Society of Urogenital Radiology) in Europe. ACR provides clinical guidelines related to radiological studies within the US. The contrast extravasation guideline (ACR, 2013) has identified high-risk IV line sites, including hand, wrist, foot, and ankle. These are areas to avoid, if at all possible. The ACR (2013) guideline also identified IV lines placed >24 hours before IV contrast injection as a high-risk for extravasation, including multiple punctures into the same vein.	B; There are not too many RCT studies involving contrast extravasations. Both systematic reviews (Behzadi et al., 2018 & Ding et al., 2018) included descriptive studies. Both studies recognized that there is poor quality in most of the studies. B; The ACR (2013) included several RTC studies. However, many of those studies used in writing the clinical practice guideline were old, as far back as 1971. There is a considerable need for robust RTC studies involving IV contrast extravasation. Most of the studies available are retrospective or prospective studies.
VI	5	Four studies are retrospective and prospective (Shaqdan et al., 2014; Niv et al., 2014; Moreno et al., 2018; and Kingston et al., 2012). IV lines that came with the patient from the unit of origin, or IV lines not initiated by radiology staff, are at high risk for extravasation (Kingston, 2012; Moreno, 2013; Niv, 2014; and Shaqdan, 2014). The implied rationale includes IV lines not maintained, IV lines dislodged, IV lines kinked, and IV lines not placed by clinical staff trained in radiology. Further, inpatients are sicker than outpatients, and they have other medical conditions such as edema to the extremities that makes it challenging to put IV lines. Shaqdan (2014) and Niv (2014) mentioned protocols that included monitoring the IV site, monitoring the pressure of the power injector during injection, and the study's termination once the patient complained of discomfort or pain to the IV site during IV contrast administration. Niv (2014) further added thorough checking of the IV lines, including adequate blood return and the IV line's flushing with saline before contrast injection. The institutional protocol of Kingston (2012) included the placement of IV lines from	B; The four studies by Shaqdan (2014), Niv (2014), Moreno (2013), and Kingston (2012) were retrospective and prospective. For this reason, there is an absence of randomization or control of manipulation to achieve the dependent variable. Descriptive studies can render the study not as robust as an RCT.

Appendix A

Process Map



Appendix B

PIV Assessment Competency for CT with IV Contrast

Employee Name:	Date:
Type name	Type date

Manager/Lead Clinical Nurse:	Job Title:
Type name	Type title

This form is a PIV assessment competency checklist you must complete before September 21, 2020. This is required to participate in the QI project: Standardization of Access and Administration of Intravenous Contrast for Computed Tomography Scans. This protocol aims to promote safety among adult inpatients during CT with IV contrast using a PIV line.

	COMPETENCY	VERIFICATION METHODS (SELECT ALL THAT APPLY)	VALIDATOR INITIALS/DATE
Guideline	**Guidelines for Assessing a PIV Line for CT with IV Contrast**		
	A. Explain the procedure to the patient. The patient needs to understand why test flushing is necessary to ascertain that the PIV line is appropriate for IV contrast administration	☐ DO ☐ RD ☐ D ☐ MS ☐ E ☐ O	Initials/date
	C. Apply aseptic technique per-protocol before accessing the PIV line	☐ DO ☐ RD ☐ D ☐ MS ☐ E ☐ O	Initials/date
	D. Prime the line gently with saline and assess for any obstruction	☐ DO ☐ RD ☐ D ☐ MS ☐ E ☐ O	Initials/date
	E. Test flush the line to see if it can withstand an IV contrast injection of 5 mL/sec. You can use sterile saline in a 10 mL syringe and flush in 2 seconds.	☐ DO ☐ RD ☐ D ☐ MS ☐ E ☐ O	Initials/date
	F. Note any discomfort from the patient during the flush and whether the PIV line is positional.	☐ DO ☐ RD ☐ D ☐ MS ☐ E ☐ O	Initials/date
	G. If the test flush fails, notify VAT that a new PIV line is needed. It is better to infiltrate with saline than extravasate with IV contrast.	☐ DO ☐ RD ☐ D ☐ MS ☐ E ☐ O	Initials/date

Validator	Initials		Validator	Initials
Type name	Type initials		Type name	Type initials

Required Competencies * *Validator's initials confirm employee has met the basic level of competency**

VERIFICATION METHODS: **DO** = Observation of Daily Work; **RD** = Return Demonstration; **D** = Discussion; **MS** = Mock Scenario; **E** = Exemplar;
O = Other (***Must Specify*: C** = Case Study; **T** = Test; **P** = Presentation; **A** = Audit/Clinical Documentation/QI Monitor; **PR** = Peer Review; **SA** = Self-Assessment

Appendix C

CT Protocols, Injection Rates, and Recommended PIV Gauge

Suggested PIV Catheter Gauge Based on CT Protocols

CT Imaging Protocols	Desired Injection Rate	BD Insyte™ Autoguard™ BC Shielded PIV Catheter with Blood Control Technology				
		24 G X 3/4"	22 G X 1.00"	20 G X all lengths	18 G X 1.16"	18 G X 1.88"
		2.0 mL/sec	3.7 mL/sec	4.3-4.9 mL/sec	5.5 mL/sec**	5.2 mL/sec
▪ Routine Studies (e.g., Chest & Abdomen)	2-3L/sec	X*	X	X	X	X
▪ CTA Abdomen (e.g., Liver & Pancreas)	4-5.5mL/sec			X	X	X
▪ PE, CTA Head & Neck, and Cardiac Studies	4-6.5mL/sec**			X	X	X

*G 24 PIV catheters may be suboptimal depending on the patient's weight
**BD IAG BC recommended injection rates are based on Visipaque 320 at room temperature. CT IV contrast is warmed and offers less viscosity.
***Desired injection rates are dependent on the patient's wt. (higher weight = higher injection rates = larger gauge PIV cannula)

Appendix D

Daily Audit Tool

<table>
<tr><td colspan="2">Inclusion Criteria: Adult, CT scan with IV contrast using PIV line
Exclusion Criteria: CT scan w/o IV contrast, pediatric, central line

IV gauge: Yellow = 24G, Blue = 22G, Pink = 20G, Green = 18G

FRN: Floor RN.</td><td>Explained the procedure to the patient</td><td>PIV Line Flushed (10 mL saline in 2 seconds)</td><td>Patient c/o of Discomfort During Flushing</td><td>Presence of Infiltration During Test Flush</td><td>Re-cannulation by the VAT RN Requested</td><td></td></tr>
<tr><td rowspan="3">FRN: ______________________
Date: _______ Time: ______________
MRN #:______________________</td><td>Yes</td><td></td><td></td><td></td><td></td><td></td><td rowspan="3">Comments:</td></tr>
<tr><td>No</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Gauge</td><td colspan="5"></td></tr>
<tr><td rowspan="3">FRN: ______________________
Date: _______ Time: ______________
MRN #:______________________</td><td>Yes</td><td></td><td></td><td></td><td></td><td></td><td rowspan="3">Comments:</td></tr>
<tr><td>No</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Gauge</td><td colspan="5"></td></tr>
<tr><td rowspan="3">FRN: ______________________
Date: _______ Time: ______________
MRN #:______________________</td><td>Yes</td><td></td><td></td><td></td><td></td><td></td><td rowspan="3">Comments:</td></tr>
<tr><td>No</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Gauge</td><td colspan="5"></td></tr>
<tr><td rowspan="3">FRN: ______________________
Date: _______ Time: ______________
MRN #:______________________</td><td>Yes</td><td></td><td></td><td></td><td></td><td></td><td rowspan="3">Comments:</td></tr>
<tr><td>No</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Gauge</td><td colspan="5"></td></tr>
</table>