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Intravenous Contrast Extravasations of CT Contrast Media Prevention Bundle

Shakerra T. Brown

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Shakerra Brown, MSN RN

College of Nursing and Health Innovation, The University of Texas Arlington

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Abstract

Contrast extravasations pose significant risks during intravenous contrast media imaging procedures, with potential adverse outcomes ranging from minor skin irritation to severe tissue necrosis. Despite technological advancements and procedural safeguards, contrast extravasations remain a concern in healthcare settings. A comprehensive needs assessment at our institution revealed a notable incidence of contrast extravasations, highlighting the need for targeted interventions to mitigate risk and enhance patient safety. This project aims to explore the complexities of contrast extravasations, examining contributing factors, associated complications, and current prevention and management strategies to inform evidence-based practices and improve patient outcomes. This Doctor of Nursing Practice (DNP) project involved developing and implementing a prevention bundle to reduce intravenous contrast extravasations during CT scans. A comprehensive literature review identified best practices and evidence-based interventions, which included a venous vulnerability checklist, standardized catheter selection protocols, and staff education programs. The bundle was pilot tested in a controlled clinical setting, with data collected on incidence rates before and after implementation. Continuous feedback from radiology and nursing staff refined the process. Statistical analysis was conducted to assess the intervention's effectiveness. Implementing the prevention strategy reduced the incidence of contrast extravasation from thirty-two to three over eight weeks. Staff training and standardized patient assessment protocols before contrast administration decreased the incidence of extravasations which could result in fewer complications. The contrast media extravasation prevention bundle, encompassing staff education and the implementation of a venous vulnerability assessment tool, enhanced staff knowledge and reduced the incidence of contrast

media extravasation, which could effectively improve patient safety and procedural outcomes in an outpatient CT radiology department.

Intravenous Contrast Extravasations of CT Contrast Media Prevention Bundle

Extravasations of contrast media following CT is an increasing problem in acute care. In the United States, the reported incidence of contrast media extravasations (CME) in adults related to power injection for CT has ranged from 0.1% to 0.70% of all cases (American College of Radiology [ACR], 2022). Heshmatzadeh Behzadi et al. (2018) found that the incidence of CME in Texas ranged from 0.1 to 1.5% of all contrast media injections. At a local academic center in central Texas, the CME rate during 2022 for outpatients undergoing CT was 2.16%. The rate was higher for men (0.79%) than women (0.37%). The mean age of patients experiencing CME was 70 years old. Thirty-two instances of CME occurred in this center from January 1, 2022, to January 3, 2023. These local statistics highlight this institution's opportunity to reduce CTE as these rates are higher than national and state levels.

Extravasation can lead to delays in diagnostic testing. The CT scan may be delayed, and new intravenous (IV) access must be secured, causing additional stress to the patient on top of the known stressors associated with a CT scan (Ding et al., 2018). Sometimes, the CT scan must be repeated, exposing the patient to additional radiation (Ding et al., 2018). A second injection of contrast increases healthcare-related costs due to the material injected, the required radiology personnel, and the scanner utilization, which can impact the department's workflow (Ding et al., 2018). As such, the financial and social implications of extravasation are meaningful. To prevent extravasation, there must be standard processes for assessing the risk of extravasation and subsequently decreasing the incidence of CME.

At a sizeable 924-bed hospital in central Texas, there was no process to assess patients' risk for extravasations. Extravasation in this population was a problem, with 2.16% of the cases having a CT scan resulting in extravasation. This facility was 34% above the national

benchmark, with increasing instances of extravasations daily. There was no standard process for assessing the risk for CME; therefore, an evidence-based practice project was implemented to assess the risk for and decrease the incidence of extravasation in inpatients undergoing CT.

Literature Review

A systematic search of the Cumulative Index of Nursing and Allied Health Literature (CINAHL), PubMed, Medline with full text, and Cochrane Database was conducted to retrieve evidence-based literature to support the PICOTS question. Incorporating Boolean search techniques of incorporating "AND" narrowed the search, allowing more topic-specific articles to populate the query results. The key search terms included CT, contrast, extravasation, prevention, assessment, and risk factors. Articles over five years old, and articles including the discussion of non-contrast extravasation, patients under 18, and x-rays were excluded. Narrowing searches also include risk factors for extravasations.

The use of all search criteria and inclusion terms resulted in 518 studies. Additional filters of randomized control trials, systematic reviews, or meta-analyses narrowed the search results to 373 studies, including 51 that supported the PICOTS question. Of these ten articles, those that included risk factors that support decreasing the incidence of CME, are described in the evidence table with evidence levels (Appendix A & B).

The literature review enabled a thorough examination of ten studies through the search strategy that reviewed risk factors and prevention methods. The literature review synthesized previous studies, including research on risk factors associated with contrast extravasations and evaluation of the effectiveness of interventions implemented to prevent CME, especially those studies that employed an assessment tool to identify the risk factors related to extravasations.

Risk Factors

Risk factors associated with CME include high osmolar contrast agents (Hama & Tate, 2022; Thomas et al., 2022), the patient's age (Polyaev et al., 2023), overall health (Hama & Tate, 2022; Ramírez Calderón et al., 2021), the injection technique (Hama & Tate, 2022, Thomas et al., 2022); Stowell et al. 2020) and the presence of underlying medical conditions such as liver disease or impaired renal function (Hama & Tate, 2022). Implementing a tool to identify risk factors will help decrease the incidence of CME for patients receiving IV contrast (Hama & Tate, 2022).

Identification of Risk for CME

Ramírez Calderón et al. (2021) developed an intervention for assessing hemorrhagic patients' health before CT scans to reduce the occurrence of CMEs in patients with underlying conditions. These researchers reported that assessing health conditions reduced CME incidences by 82%. The results of this intervention were significant, and the findings indicated that all the patients in the study had either inflammatory alteration, haemobilia (91%), hemoperitoneum (65%), intestinal bleeding (27%), and some rarely observed in the X-ray diffractions included hematomas or indications of ongoing bleeding. The authors concluded that hemorrhagic cholecystitis, an uncommon condition, may be present, and treatment may be postponed if the appropriate imaging modality is not employed for diagnosis. The results showed that assessing a patient's intravenous access prior is a direct intervention to reduce risks that might cause contrast extravasations (Ramírez Calderón et al., 2021).

The American College of Radiology (2022) assessed technique or injection use risks to avoid or reduce the occurrence of CME. The results showed CME in adults was primarily related to power injection for CT ranging from 0.1% to 1.2%, indicating 1 to 1,000 patients. The researchers included an assessment checklist for identifying injection risk and age risks to reduce

the occurrence of CMEs, which appeared to be adequate. The study suggested that a careful injectable catheterization strategy and carefully securing an intravenous catheter should be used to reduce the risk of CME (ACR, 2022).

Similarly, Silva et al. (2018) used a checklist to identify age risks to reduce incidences of CMEs in patients with cancer. The authors reported that CME occurrences ranged from 0.1 to 105 across all contrast media injections. The researchers examined 99,076 ICM treatments and found 199 extravasation instances, a 0.2% incidence rate. The average age of the patients who experienced ICM was 59.22 years, and 60% were female. Additionally, the rate of extravasations ranged from 0.2% to 2.7%. It was more common in the lower limbs and significant in those who received iodinated contrast agents than gadolinium-based ones (Silva et al., 2018). The authors found no relationship between extravasated volume, and the type of catheter used, as each institution has its requirements for CT scans. Age, gender, patient background, purpose of examination, clinical stage, chemotherapy, radiation, location of venous puncture, and amount of contrast given did not demonstrate a statistically significant correlation with the extravasation intensity. The authors recommend considering patients' age and health conditions before exposure to X-rays, even if there is a limited relationship between age, health, and CME occurrence in patients (Silva et al., 2018).

The risk of CME is influenced by various factors, including the type of contrast agent used (Hama & Tate, 2022; Thomas et al., 2022), patient demographics and health (Polyaev et al., 2023; Hama & Tate, 2022; Ramírez Calderón et al., 2021) injection technique (Hama & Tate, 2022; Thomas et al., 2022; Stowell et al., 2020), and underlying medical conditions (Hama & Tate, 2022). Multiple interventions have been proposed to reduce the risk of CME, such as ultrasound guidance, using smaller-gauge needles, and performing a thorough pre-procedure

assessment (Shigematsu et al., 2022). A primary intervention included using a venous vulnerability assessment to identify the risk factors of CME before exposure to CT scans (Shigematsu et al., 2022). Using a venous assessment to identify risk factors can be an effective intervention in reducing the incidence of CME. By thoroughly assessing patients before the procedure and identifying risk factors, healthcare providers can take appropriate measures to minimize the risk of CME, including using alternative contrast agents, adjusting the injection technique, or delaying the procedure until the patient's health has improved. In one study, radiology nurses performed the venous vulnerability assessment using a checklist to assess for risk factors associated with contrast extravasations (Shigematsu et al., 2022). If any risk factors were identified, the nurse contacted the radiologist for instructions for changing the contrast media or to proceed with scanning based on the patient's current health condition (Shigematsu et al., 2022). Using this study as best evidence, an evidenced based (EBP) project was implemented to decrease the risk of extravasations using the venous vulnerability assessment tool.

Project Question

For patients greater than 18 years of age receiving intravenous contrast media with CT scan, does implementation of a CME prevention bundle, which includes education of staff, implementation of a venous vulnerability assessment tool, and post-implementation analysis, compared to no current practice for assessment of CME, increase knowledge of CMEs and decrease the incidence of CME over an eight-week timeframe at an outpatient CT radiology department in a 924-bed hospital in central Texas?

Objectives

- Pre-data will be collected for CME rates.

- Staff will complete education on utilizing the venous vulnerability assessment tool and when the tool will be initiated.
- The venous vulnerability assessment tool will be implemented, and post-data collection will be completed.
- Data analysis will be completed with the support of a biostatistician, and staff will be debriefed to provide feedback on the tool's efficacy.
- The project lead will disseminate project results to relevant stakeholders (radiology nurses, radiology technologists, physicians, and radiology executive leadership) to promote best practices for CME prevention.
- A decision will be made to continue utilizing the CME assessment tool.

Framework

The proposed project utilized an evidence-based framework to decrease the incidence of contrast extravasations. The problem identified with this project was the increased incidence of contrast extravasations occurring when a patient receives intravenous contrast for CT scans. When a patient receives IV medications, primarily when a contrast agent is employed, contrast media extravasations (CME) are more likely to occur (Ding et al., 2018). The venous vulnerability assessment tool was implemented at this facility, so this is a new practice that supports an evidence-based practice framework.

The framework utilized was the Iowa model (Appendix C) (Iowa Model Collaborative, 2017). It is unique in emphasizing pilot testing before full-scale change implementation and identifying triggers (Hanrahan et al., 2019). Pilot testing allowed the team to refine the intervention or process to ensure successful and sustainable translation (Hanrahan et al., 2019). Permission was received to utilize this model (Appendix D).

The first step in the process assessed the need for change within the setting. This project focused on identifying risk factors associated with CME by utilizing a venous vulnerability assessment tool (Appendix E). The second step for this model identified the best available evidence for this project. An in-depth literature was completed, and the best practice identified utilizing a venous vulnerability assessment prior to the patient receiving IV contrast to identify the risk factors for the patient. Permission was received to use the venous vulnerability assessment tool (Appendix F). The third step for this model reviewed evidence analysis. The evidence was analyzed using the John Hopkins Nursing Evidence-Based Practice Appraisal Tool, and best practice techniques were synthesized for this project. The fourth step of the IOWA model involved designing the necessary practice change. The proposed change was to use the venous vulnerability assessment tool to identify patients at high risk for having contrast extravasations. The fifth step of the IOWA model was to implement the change. Following GNRC (Graduate Nurse Review Committee) approval, data was collected (pre and post) to determine the impact of the venous vulnerability assessment tool on decreasing the incidence of CME and increasing the staff knowledge of CME. This data collection enabled the project lead to evaluate the outcome. The final step in the IOWA model included sustaining the implementation and making the necessary adjustments for maintenance (Iowa Model Collaborative, 2017).

Methods

This evidence-based project focused on preventing contrast extravasations by implementing standardized protocols for intravenous contrast administration, including patient risk assessment. It integrated staff training programs and real-time monitoring to significantly reduce the incidence of extravasations and improve patient safety outcomes. In planning for the project, both SWOT (Appendix K) and risk assessments (Appendix L) were performed and were

determined to be integral components to ensure comprehensive strategy and risk management. The SWOT analysis identified key internal strengths, such as a motivated and skilled staff, effective training resources, and access to advanced technology like the venous vulnerability assessment tool. It also highlighted potential weaknesses, such as staff resistance to change and time constraints for training amid clinical responsibilities. Opportunities identified included the potential to establish new care standards and promote professional development among staff, while threats encompassed challenges like resource underestimation and maintaining consistent protocol adherence.

Simultaneously, the risk assessment pinpointed specific potential hazards, such as inconsistent protocol application due to unfamiliarity, procedural delays from additional safety measures, and integration difficulties with new technologies. Strategies were devised to mitigate these risks, including comprehensive training sessions to ensure staff competency, contingency plans to manage delays, and phased implementation of technology to minimize workflow disruption. Continuous monitoring and feedback mechanisms were incorporated to evaluate and refine risk mitigation efforts throughout the project lifecycle. By leveraging these analyses in planning, the project aimed to optimize patient safety outcomes and establish sustainable improvements in clinical practice.

Population

The intended population included patients greater than 18 years of age receiving intravenous contrast media with CT scans. All patients in this demographic were assessed by the RN using the venous assessment tool. The sample size was 235. The inclusion criteria included all outpatients over 18 receiving CT scans with intravenous contrast media. Conversely, patients under 18, non-contrast CT scans, and inpatients were excluded from this project.

Setting

The project setting was an outpatient radiology department in a 924-bed hospital in central Texas. The staff was composed of radiologists, nurses, and radiology technologists. The average number of staff for each shift was 25. The mission was to provide high-quality, cost-effective health care that delivered the best value to the people served in a spiritual environment of caring in association with internationally recognized teaching and research. Site approval was obtained prior to project initiation (Appendix G).

Team Roles

The project lead was responsible for overseeing the entire project and identified a contrast extravasation team to support the project. The contrast extravasation team included the project lead, CT charge nurse, and CT lead tech. The project lead educated the department staff on using the venous assessment tool, including when to notify the radiologist if the patient is at high risk of suffering a contrast extravasation. The project lead supported the CT charge nurse will ensure that nursing staff complete the identified venous vulnerability assessment for all patients before the patient receives IV contrast. The project lead collected results from the CME assessment tool daily. The project lead conducted in-services for nursing and CT technologists on all shifts. The project lead met with extravasation team members weekly to ensure that staff were following the project's outlined guidelines. Nursing staff utilized the CME assessment tool each time a patient underwent a CT scan. If the patient was deemed high risk, the nurse informed the radiologist, and orders were received from the radiologist on how to proceed with the patient. This was documented for data collection. The project lead collected the results from the CME assessment tool daily.

Team Education

The team education involved educating the staff about the venous vulnerability assessment tool and the importance of accurately completing the tool with each patient. The project lead administered a pre-and post-knowledge assessment (Appendix H) to evaluate the staff's knowledge before and after providing the education. This supported the evaluation of staff knowledge concerning CME after implementing the education. The project lead presented the educational material, including a PowerPoint presentation (Appendix I), in a series of in-services. The project lead emailed staff about their participation in the events. Educational material was available to staff members who could not attend the scheduled in-services. There were various times for in-services, including in-person and TEAMS meetings, to accommodate all the nurses' and CT technologists' schedules. Ten sessions occurred, varying from 7 a.m. to 11 p.m. to accommodate am/pm staff shifts. The CT department comprises 22 CT technologists, 25 radiology nurses, and 33 radiologists. This education occurred over one week. After receiving education, staff completed a post-knowledge assessment (Appendix H). This was used to rate staff knowledge of CME.

Measurement and Analysis

There was no evidence of validity or reliability with the knowledge survey; however, there was assumed face validity with this survey. The measurement method proposed for the EBP project included implementation of a venous vulnerability assessment to identify risk factors associated with the incidence of CME. The checklist was developed by Shigematsu et al., 2022, which showed significant differences in the frequencies of CME ($p<0.05$). For reliability, a cross-table analysis between the categorical variables and the occurrence of CME showed high inter-rater reliability, implying that the tool's results were consistent across multiple observers

(Shigematsu et al., 2022). Validity was evaluated with the correlation between venous vulnerability assessment and incidences of CME occurrences within the five-year timeframe (Shigematsu et al., 2022). Coefficients above 0.5 for correlations between the specific questionnaire and the incidences of CME were considered adequate (Shigematsu et al., 2022).

Procedure

A timeline was developed for the project implementation which includes each phase of the project. The timeline included staff roles and responsibilities, activities expected, and completion dates. The timeline was shared with the team, and concerns will be addressed during this time. Before initiating the intervention, pre-data on the number of CMEs which have occurred in the 8 weeks prior to the initiation of the venous vulnerability tool was collected. Staff training included a PowerPoint presentation (Appendix I) and pre- and post-knowledge assessments were collected prior to and after the educational sessions were completed. The staff answered four questions with ratings between 1-5, resulting in possible overall knowledge pre and post scores of 20 (Appendix H). This data was also included on the dashboard (Appendix J). After collection of pre data, and completion of staff education (to include the pre and post knowledge assessment); the venous vulnerability assessment tool was implemented in the outpatient CT department.

For each patient, a venous assessment tool was completed to assess the patient's risk for having a CME. If any item applied to the patient, the CT nurse would contact the radiologist for instructions on how to proceed with the scan. The radiologist would make the decision to proceed or if not; the rad0iologist would contact the ordering provider to let him know reasoning for the not proceeding with the CT scan. The CT nurse would place all checklist in a silver tray labeled venous vulnerability assessment tool and this was collected by the project lead at the end

of each week. Each patient's tool will be completed on paper and the paper form will not include any patient identifying information. The patient was labeled by code that began with CT for every patient, using the first letter of their mother's name and the last two numbers of their birth year. Each tool will be stored in a locked file cabinet in the CT manager's office. Data collection ended after 8 weeks.

Statistical Analysis

The project lead analyzed the data utilizing the Statistical Software Package for the Social Sciences (SPSS). Demographic data including age, gender, and ethnicity was analyzed using descriptive statistics to describe the population. For the analysis of the knowledge assessment, the total scores from each pre and post-assessment (the max score that can be achieved is 20 on the pre and 20 on the post) was analyzed to determine if an increase in knowledge was attained with the educational sessions. This was analyzed by comparing the percentage of increase in scores on the knowledge survey. The pre and post-intervention CME rates were compared to determine if a reduction in CME occurred with the intervention. With support from a biostatistician, each question on the venous vulnerability tool was analyzed using a nonparametric measure of Kendall's Tau-b test to determine if each individual question from the venous vulnerability assessment tool (Appendix E) had an impact on CME (Yingfei Kao, PhD, personal communication, September 20, 2023).

Ethical Considerations

The ethical considerations for this project proposal were considered. Ethical principles had to meet institutional, federal, and state requirements for research involving human or animal subjects. The human subjects for this project included the CT nurse, CT technologist, radiologist, and the patients receiving IV contrast for CT scans. The project lead completed Human Subject

Protection training (Appendix M). This proposal was under the approval and authority of the Graduate Nurse Review Committee (GNRC).

Results

Project Outcomes

Summary statistics were performed on the demographic characteristics of the sample population (Appendix O). Frequencies and percentages were calculated to summarize ordinal and nominal variables. The sample population was predominantly female, with 142 individuals (60.4%) compared to 93 males (39.6%). The racial composition was primarily White, comprising 72% of the sample, followed by Black (18%), Hispanic (6%), and Asian (4%), with no representation from other racial groups. The age distribution shows that the largest group was those aged 56-64 years, accounting for 138 individuals (58.7%). Other age groups included 18-25 years (3.4%), 26-35 years (4.7%), 36-45 years (11.5%), and 46-55 years (21.7%).

Ethnically, the sample was diverse, with the largest group identified as American Indian (31.5%), followed by Black (22.6%), White (22.1%), Hispanic (20.9%), and Asian (3%). These demographic insights highlight that the sample was predominantly older adults, mainly White, with a significant representation of American Indian individuals ethnically. This detailed understanding of the sample population's demographics will guide targeted interventions and educational programs to effectively prevent contrast extravasations in diverse patient populations.

Knowledge testing (Paired t-test)

The table (Appendix N) presents the results of a study assessing the change in knowledge from pre-test to post-test. Initially, participants had a mean knowledge score of 14.9 with a standard deviation of 3.7. After the intervention, the post-test means knowledge score increased

to 19.3 with a standard deviation of 1.1. The mean difference between pre-test and post-test scores was 4.4, with a standard error of 3.3. A t-test yielded a t-value of 7.925 with 35 degrees of freedom, resulting in a highly significant p-value of less than 0.001, indicating that the observed difference was statistically significant. Furthermore, the effect size, measured by Cohen's d, was 1.4, suggesting a large impact of the intervention on participants' knowledge" (Brown, 2024).

CME incidence

A Kendall's tau-b correlation was run to determine whether the venous vulnerability assessment impacted the prevention of contrast extravasation post-scan among 235 participants. Results (Appendix P) showed a strong relationship between the prevention of contrast extravasation and proximity to the lesion site or the site after radiation ($\tau b = .575$, $p = .001$), pain after test injection ($\tau b = .509$, $p = .001$), and whether the radiologist proceeded with the CT scan ($\tau b = .571$, $p = .001$). However, the correlation coefficient for all other variables, including the absence of blood regurgitation in the tube, elderly age (aged > 75 years), severe obesity or thinness, skin fragility, difficulty of intravenous catheter placement, history of subcutaneous CME, using the same peripheral IV access as IV chemotherapy, and receiving a test injection of saline, was higher than 0.01, showing no impact. The findings suggest that specific factors such as proximity to lesion or radiation sites, pain after injection, and decisions made during the CT scan procedure are critical in determining whether contrast extravasation is prevented. On the other hand, other factors examined did not demonstrate a significant influence on extravasation prevention in this context. Healthcare providers should consider these significant factors when assessing and managing contrast injection procedures to minimize the risk of extravasation during scans.

Discussion

The results of the DNP project on contrast extravasation prevention hold significant implications for the project site and its patient population. The successful implementation of the prevention bundle, which includes staff education and a venous vulnerability assessment tool, has fostered a culture of heightened awareness and preparedness among the medical staff. This improvement in staff knowledge and practice not only enhances patient safety but also establishes a new standard of care within the outpatient CT radiology department. Given the reduction in the incidence of contrast extravasation, the prevention strategies are likely to be continued and potentially expanded across other departments within the hospital. By prioritizing patient safety and minimizing adverse events, the hospital can improve overall patient outcomes and satisfaction. Additionally, this initiative sets a precedent for ongoing quality improvement projects, encouraging a proactive approach to identifying and mitigating risks associated with medical procedures. Future efforts will focus on sustaining the achieved benefits through continuous education and regular evaluation of the assessment tool's effectiveness, ensuring that the highest standards of care are maintained.

Summary

Key Findings

The project aimed at preventing CT contrast extravasations demonstrated several strengths, including comprehensive training and education for healthcare staff, which ensured that all personnel were well-informed about the best practices to minimize the risk of extravasations. Additionally, the project standardized protocols across the institution, leading to consistent practices in administering contrast media and reducing potential errors. Enhanced monitoring and reporting systems allowed for real-time tracking of incidents, facilitating prompt identification and management of extravasations, thus improving patient safety. Moreover, the

project fostered interdisciplinary collaboration among radiology, nursing, and patient safety teams, ensuring a comprehensive approach to prevention strategies.

The project will be continued due to its initial success and the positive impact on patient safety. The commitment to maintain and further develop the project includes ongoing evaluation and continuous improvement to ensure that the protocols remain effective in preventing CT contrast extravasations. This dedication to sustaining the project underscores the institution's prioritization of patient safety and quality care, with a focus on keeping the protocols up to date with the latest best practices and technological advancements.

During the project, several additional problems or gaps were identified. One significant gap was the need for technological advancements that could provide real-time feedback and automatic alerts during contrast administration to further reduce the risk of extravasation incidents. The project also highlighted the challenges posed by patient-specific factors, such as vein fragility, necessitating tailored protocols to account for these variables. Furthermore, ensuring adequate staffing and resources for continuous monitoring and rapid response to incidents was recognized as a critical need, requiring ongoing investment. Lastly, the necessity for comprehensive data collection systems was identified to enhance the ability to analyze trends and develop targeted interventions.

The project aimed at preventing CT contrast extravasations holds significant future implications for healthcare practice, emphasizing enhanced patient safety through standardized protocols, advanced monitoring technologies, and ongoing education for healthcare providers. By continuing to refine and implement best practices, the project not only improves patient outcomes but also promotes a culture of continuous quality improvement within healthcare institutions. Furthermore, the emphasis on preventing extravasations can potentially lead to cost

savings and resource efficiency by reducing adverse events and associated healthcare costs. The project's impact extends to fostering interdisciplinary collaboration, influencing professional development in radiology and nursing, and stimulating future research and innovation in medical imaging and patient safety practices.

Limitations

The implementation of a project focused on preventing CT contrast extravasations faces several challenges and limitations. Time constraints often restrict the thorough development and deployment of comprehensive prevention protocols, potentially compromising the effectiveness of training programs and protocol standardization efforts. Additionally, inherent weaknesses such as the sporadic occurrence of contrast extravasations in a limited number of patients may hinder the ability to gather sufficient data for robust analysis and improvement. Internal challenges within interdisciplinary teams, including communication barriers and differing priorities, can further impede consensus on protocol adjustments and coordinated implementation. Moreover, resource constraints and competing priorities within healthcare settings may restrict the allocation of adequate staffing and resources needed to sustain vigilant monitoring and response to prevent extravasations effectively. These factors collectively underscore the complexities and barriers faced in successfully implementing and maintaining initiatives aimed at preventing CT contrast extravasations.

Conclusion

The DNP project on contrast extravasation prevention has proven to be a valuable initiative with far-reaching implications for clinical practice. By integrating a comprehensive prevention bundle, which includes staff education and a venous vulnerability assessment tool, the project has established a robust framework for enhancing patient safety and improving clinical

outcomes. Its comprehensive approach has fostered a proactive culture of safety and vigilance within the outpatient CT radiology department. This project not only addresses a critical patient safety issue but also sets a precedent for evidence-based interventions that can be adopted by other departments and healthcare facilities.

The project's framework is designed for long-term sustainability, ensuring that the benefits will persist through continuous training and regular evaluation. The success of this initiative underscores its potential applicability to other departments and healthcare settings, suggesting that similar strategies could be beneficial on a broader scale. Moreover, this project serves as a valuable model for other institutions seeking to implement effective risk management practices, thereby contributing to the advancement of healthcare quality and patient care standards industry-wide. By prioritizing both immediate and long-term patient safety, this project reinforces the commitment to high-quality, safe, and effective healthcare practices.

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Stowell, J. R., Rigdon, D., Colglazier, R., Filler, L., Orosco, D., Connell, M., Akhter, M., & Mitchell, C. (2020). Risk of contrast extravasation with vascular access in computed tomography. *Emergency Radiology*, *27*(3), 253–258. https://doi.org/10.1007/s10140-020-01752-x

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Appendix A

Systematic Review and Review of Literature

#	Citation	Study Design and Major Variables	Measurement Method	Study Population and Sample Size	Results and Recommendations	Strengths & Limitations	Evidence Level and Quality Rating
1	Hama & Tate (2022)	**Study Design**: Retrospective study **Major Variables**: MRI findings of iatrogenic extravasation of macrocyclic GBCA	**Measurement Method**: MRI of the injection site	**Study Population**: Patients with cancer (16,039 total patients, 11 of whom had significant extravasation of macrocyclic GBCA) **Sample Size**: 7 patients	**Results:** The characteristic MRI findings included a mosaic pattern of the extravasate with mixed high and low signal in the subcutaneous tissue, contrast enhancement of the fascia toward the proximal portion, and low-signal fluid collection on the fascia with linear spread to the dermis and subcutaneous tissue. Fat-suppressed T1-weighted images showed the mosaic pattern in all 7 cases and contrast enhancement was observed in 3 cases. All four patients who underwent daily MRI scans had their contrast disappear within three days. Symptoms included coldness in the forearms or antecubital fossa and pain at the injection site in 3 patients.	**Strengths** This study provides detailed MRI findings of iatrogenic extravasation of macrocyclic GBCA and shows that it disappears quickly from the subcutaneous tissue and is unlikely to cause serious sequelae. **Limitations:** This study is limited by its small sample size, its retrospective design, and the lack of a comparison group to evaluate the differences between macrocyclic and non-macrocyclic	IB

#	Citation	Study Design and Major Variables	Measurement Method	Study Population and Sample Size	Results and Recommendations	Strengths & Limitations	Evidence Level and Quality Rating
					Recommendations: None explicitly stated	GBCAs. Additionally, the study only included patients with cancer, so the results may not be generalizable to other populations	
2	Li et al. (2022)	**Study Design** Consecutive cohort study • **Major Variables** CIE incidence rate • Risk factors for CIE (history of stroke, history of hypertension, posterior circulation aneurysms, higher dosage of contrast agents)	**Measurement Method**: • Definition of CIE as a reversible neuropathic syndrome after interventional therapy accompanied by imaging abnormalities and excluding other diseases. • Poisson regression analysis was	**Study Population** Patients undergoing endovascular treatment for unruptured intracranial aneurysms **Sample Size**: 579 patients	**Results:** • The crude incidence rate of CIE was 2.4% (95% CI, 1.2–3.6%) • Headache, hemiplegia, and disorientation were the initial symptoms, and cortical blindness was the most common localized deficit. • The risk factors were a history of stroke, hypertension, posterior circulation aneurysms, and a higher dosage of contrast agents. • The prognosis was favorable, with most patients fully recovering within 72 hours after	**Strengths:** • Large sample size • Clear definition of CIE • Multivariable regression analysis to assess risk factors **Limitations** • Single-center study, may not be representative of other populations • Relying on clinical evaluation and imaging to assess recovery,	I A

#	Citation	Study Design and Major Variables	Measurement Method	Study Population and Sample Size	Results and Recommendations	Strengths & Limitations	Evidence Level and Quality Rating
		• Initial symptoms of CIE (headache, hemiplegia, disorientation, cortical blindness) • Treatment outcomes (recovery time)	used to show risk factors by incidence rate ratio (IRR) • Clinical evaluation and imaging (CT/MRI) were used to assess symptoms and recovery.		accelerating contrast agent excretion, reducing intracranial pressure, and administering anti-inflammatory/vasospasm therapy. **Recommendations** • Consider a history of stroke and posterior circulation aneurysms as the main risk factors for CIE • Consider the patient's history of hypertension and use caution when administering a higher dosage of contrast agents.	subjective measures may have influenced the results.	
3	Mandlik et al. (2019)	**Study Design**: Systematic literature review **Major Variables**: • Management approaches for contrast media extravasation	**Measurement Method**: Systematic literature search via PubMed using the search terms “contrast medium extravasation.	**Study Population**: Patients undergoing CT and MRI exams with contrast media extravasation **Sample Size:**	**Results:** • Conservative management approaches for contrast media extravasation, such as unguent dressings, cooling, and splinting, lack major evidence base and are mostly symptomatic. • Invasive techniques such as hyaluronidase injection,	**Strengths:** • Provides recommendations for management approaches for contrast media extravasation in CT and MRI exams	III B

#	Citation	Study Design and Major Variables	Measurement Method	Study Population and Sample Size	Results and Recommendations	Strengths & Limitations	Evidence Level and Quality Rating
		during CT and MRI exams • Complications resulting from contrast media extravasation		Not specified in the study	suction/aspiration, and squeezing technique have been described but lack scientific evidence. • Early surgical consultation is recommended when non-ionic, low-osmolar contrast medium extravasation is about 150 cc or more, or in the presence of additional symptoms such as impaired perfusion or altered sensibility. • Continuous monitoring and accurate conservative management, such as active cooling and elevation, and splinting of the affected extremity are mandatory as early detection of critical symptoms helps to initiate prompt surgical intervention and avoid sequelae. **Recommendations:** • Early surgical consultation is recommended for extravasation > 150 cc or	• Suggests surgical consultation for larger volume of extravasation or presence of additional symptoms **Limitations:** • Does not specify the sample size • Lack of scientific evidence for the invasive techniques described	

#	Citation	Study Design and Major Variables	Measurement Method	Study Population and Sample Size	Results and Recommendations	Strengths & Limitations	Evidence Level and Quality Rating
					when additional symptoms occur. • No invasive first line therapy is recommended when contrast media extravasation is less than 150 cc and the patient presents no additional symptoms, besides swelling and local pain. • Continuous monitoring and accurate conservative management is mandatory.		
4	Minogue et al. (2019)	**Study design** Cross-sectional survey **Major variables** Use of intravenous contrast (IVC) in radiation therapy (RT) planning scans, compliance with international guidelines,	Anonymized online survey with open, closed and Likert scale questions were used to measure the variables.	**Study population** Radiation therapy departments in Ireland **Sample size** 9 departments (75% response rate out of 12 departments)	**Results** • All responding departments reported using IVC. • RTTs cannulated patients in 67% of the departments and administration contrast in all departments. • Variations were found in the use of IVC in disease sites and in the assessment of renal functioning prior to contrast administration	**Strengths** The study provides valuable insights into the use of IVC in RT planning scans in Ireland and identifies areas for improvement. **Limitations** The limited sample size and response rate (75%) may affect the	IB

#	Citation	Study Design and Major Variables	Measurement Method	Study Population and Sample Size	Results and Recommendations	Strengths & Limitations	Evidence Level and Quality Rating
		radiation therapists (RTTs) IVC training.			compared to recommended guidelines. • IVC training varied in duration and number of supervised procedures required to fulfill competencies. **Recommendations** The study recommends standardization of IVC practices in RT departments in Ireland to ensure compliance with international guidelines.	generalizability of the results. The study also relies on self-reported data which may be subject to recall and social desirability biases.	
5	Polyaev et al. (2023)	**Study design** retrospective study **Major variables** CT signs (extravasation and hematocrit effect with signal flare), spontaneous bleeding into soft tissues, COVID-19	CT scans and trans arterial catheter angiography (TCA)	**Study population** 60 patients with COVID-19 with spontaneous bleeding into soft tissues and extravasation of a contrast agent on CT **Sample size** 60 patients	**Results** 45% of patients showed extravasation on TCA. The presence of the hematocrit effect or the combination of this sign with the signal flare on CT (43 patients) led to a higher frequency of confirmed extravasation on TCA (53.4%) compared to the absence of these signs (17 patients, 23.5%) ($p = 0.028$). **Recommendations** Further	**Strengths** The study provides insights into the predictive value of specific CT signs for ongoing bleeding in patients with COVID-19 and spontaneous bleeding into soft tissues. **Limitations**	I A

#	Citation	Study Design and Major Variables	Measurement Method	Study Population and Sample Size	Results and Recommendations	Strengths & Limitations	Evidence Level and Quality Rating
					research is needed to establish the generalizability of these findings and to determine the optimal management strategy for patients with spontaneous bleeding into soft tissues and COVID-19.	The study is limited by its retrospective design and small sample size, which may affect the generalizability of the findings.	
6	Ramírez Calderón et al. (2021)	**Study Design**: Retrospective study **Major Variables:** Hemorrhagic cholecystitis, causes, clinical presentations, ultrasound (US), computed tomography (CT), dual-energy CT, magnetic resonance imaging (MRI)	**Measurement Method**: Medical record search using medical terms and database of radiological cases in the emergency department of the hospital	**Study Population**: 11 patients diagnosed with hemorrhagic cholecystitis **Sample Size**: 11 patients	**Results:** Both lithiasis and anticoagulation/antiplatelet therapy were the most common causes (9 patients, 82%). Clinical presentation may be misleading, simulating a typical cholecystitis episode or manifesting with signs of bile duct obstruction, hematemesis, or anemia. CT was the most complete test for evaluating hemorrhagic cholecystitis (performed in all patients) and common findings were inflammatory changes, haemobilia, hemoperitoneum, and intestinal bleeding. **Recommendations**:	**Strengths:** The study presents 11 cases of hemorrhagic cholecystitis and provides a comprehensive overview of its various causes, clinical presentations, and findings on imaging tests. **Limitations:** The sample size is small and the study is retrospective in nature, limiting the generalizability of the results. Further	IB

#	Citation	Study Design and Major Variables	Measurement Method	Study Population and Sample Size	Results and Recommendations	Strengths & Limitations	Evidence Level and Quality Rating
					CT should be used for the diagnosis of hemorrhagic cholecystitis as it is the most complete test for evaluating this condition.	studies with larger sample sizes and a prospective design are needed to confirm the findings.	
7	Roditi et al. (2022)	**Study design** systematic review **Major variables** They are: 1. Method of cannula insertion (ultrasound-guided vs standard) 2. Type of healthcare worker who inserts the IV cannula (radiology staff vs non-radiology staff) 3. Age of the cannula (newly	PRISMA guidelines for the inclusion eligible studies. Quality appraisal following National Institutes of Health (NIH) study quality assessment tools. Thematic analysis to understand key mechanisms of CMEX	**Study population**: The study population includes patients undergoing CT or MRI scans. Sample size: The sample size was not reported in the study. The study used a population of 7575 sources and a sample of 59 sources were used in the qualitative study.	**Results** The results of the study showed that the incidence of contrast media extravasation (CMEX) is 0.2% based on 17 studies in 1,104,872 patients. The outcomes of CMEX are mostly favorable but can vary in severity from minor discomfort to serious complications like compartment syndrome, skin ulceration and necrosis. **Recommendations** The decision to refer for surgical intervention should be a clinical one. To warn patients about red-flag signs and symptoms.	**Limitations Strengths** The strength of the study is the comprehensive review of the literature to inform the update of the Contrast Media Safety Committee (CMSC) guidelines. Also, there is no data available on patient experience of CMEX and this is an important impact to explore as the patient may refuse to have CM in the future. **Limitations** The limitations of the study include the	IIIB

#	Citation	Study Design and Major Variables	Measurement Method	Study Population and Sample Size	Results and Recommendations	Strengths & Limitations	Evidence Level and Quality Rating
		inserted vs existing) These variables were investigated in relation to the outcome measure of contrast medium extravasation (CMEX) rates.				lack of a sample size and the exclusion of CMEX associated with contrast-enhanced ultrasound and non-contrast media-based extravasation. The results are based on previous studies and may not reflect the current practices.	
8	Shigematsu et al. (2022)	**Study Design** Retrospective study **Major Variables**: The effectiveness of practical preventive strategies (venous vulnerability assessment and prevention scan protocol rules) in reducing extravasation of	**Measurement Method** The incident reports, radiology reports, and medical records of patients in whom ECM occurred were reviewed. The frequency of ECM was compared in different periods:	**Study Population** 73,931 consecutive adult patients who underwent contrast-enhanced CT scans between January 2013 and December 2019. **Sample Size** 73,931 patients	**Results** ECM occurred in 0.39% (292/73,931) of the patients. The frequencies of ECM for Periods A, B, and C were 0.62% (121/19,505), 0.43% (89/20,847), and 0.24% (82/33,579), respectively. There were significant differences in the frequencies of ECM among the three periods. **Recommendations** Implementation of venous vulnerability assessment and	**Strengths** Large sample size, retrospective study design, and review of incident reports, radiology reports, and medical records. **Limitations** Retrospective nature of the study, limited ability to control for other factors that may influence the outcome, and lack of patient consent.	I A

#	Citation	Study Design and Major Variables	Measurement Method	Study Population and Sample Size	Results and Recommendations	Strengths & Limitations	Evidence Level and Quality Rating
		contrast media (ECM) during CT scans.	2013-2014 (Period A, no prevention), 2015-2016 (Period B, early prevention - venous vulnerability assessment only), and 2017-2019 (Period C, late prevention - venous vulnerability assessment with prevention scan protocol rules).		prevention scan protocol rules can be a practical and simple solution to reduce the risk of ECM during CT scans.		
9	Stowell et al. (2020)	**Study design** Retrospective cohort study **Major variables** The major variables investigated in the study were IV catheter anatomic location and the	The rate of CMEX was calculated by IV catheter vessel anatomic location and compared by relative risk (RR) and absolute risk	**Population** patients receiving contrast-enhanced CT imaging performed over a 26-month period	**Results** The study found that 49 (0.34%) extravasation events were identified, 41 (0.28%) were observed in non-upper arm located peripheral IV catheters, and 8 (2.8%) were observed in IV catheters placed in upper arm vessels, most commonly with point-of-care	**Strengths** The strength of the study is that it is a well-designed retrospective cohort study with a large sample size. **Limitations** The limitation is that it was conducted at a	I B

#	Citation	Study Design and Major Variables	Measurement Method	Study Population and Sample Size	Results and Recommendations	Strengths & Limitations	Evidence Level and Quality Rating
		rate of contrast medium extravasation (CMEX).	reduction (ARR**).**	at a single institution. **Sample** 17,767 contrast administrations for CT imaging studies performed, out of which 14,558 met the study inclusion criteria	ultrasound (POCUS) guidance. Non-upper arm located IV catheters were associated with a lower ARR of 2.54% when compared to upper arm catheters **Recommendations** The study recommends that in patients without alternative available peripheral vascular access, POCUS-guided upper arm IV cannulation may be an appropriate approach, as it is associated with a relatively minimal increase in extravasation risk compared to catheters placed in a non-upper arm location.	single institution, so the results may not be generalizable to other populations.	
10	Thomas et al, (2022)	**Study Design:** Case-comparison study **Major Variables:** Volume of contrast media extravasation and	**Measurement Method:** Observation and comparison of patient cases in the context of relevant literature	**Study Population**: 2 patients with contrast media extravasation injuries **Sample Size**: 2 patients	**Results:** The study found that the current literature does not account for the distribution pattern of the extravasation medium in the decision-making process around surgical intervention.	**Strengths:** The study provides insight into a previously underexplored aspect of contrast media extravasation management and	V B

#	Citation	Study Design and Major Variables	Measurement Method	Study Population and Sample Size	Results and Recommendations	Strengths & Limitations	Evidence Level and Quality Rating
		distribution pattern			**Recommendations:** The pattern of distribution of the extravasation medium should be considered when deciding on surgical management.	highlights the importance of considering distribution patterns. **Limitations**: The study is limited by its small sample size and case-comparison design, which limits the ability to draw generalizable conclusions and make recommendations. Further research is needed to establish the importance of considering distribution patterns in surgical management.	

Appendix B

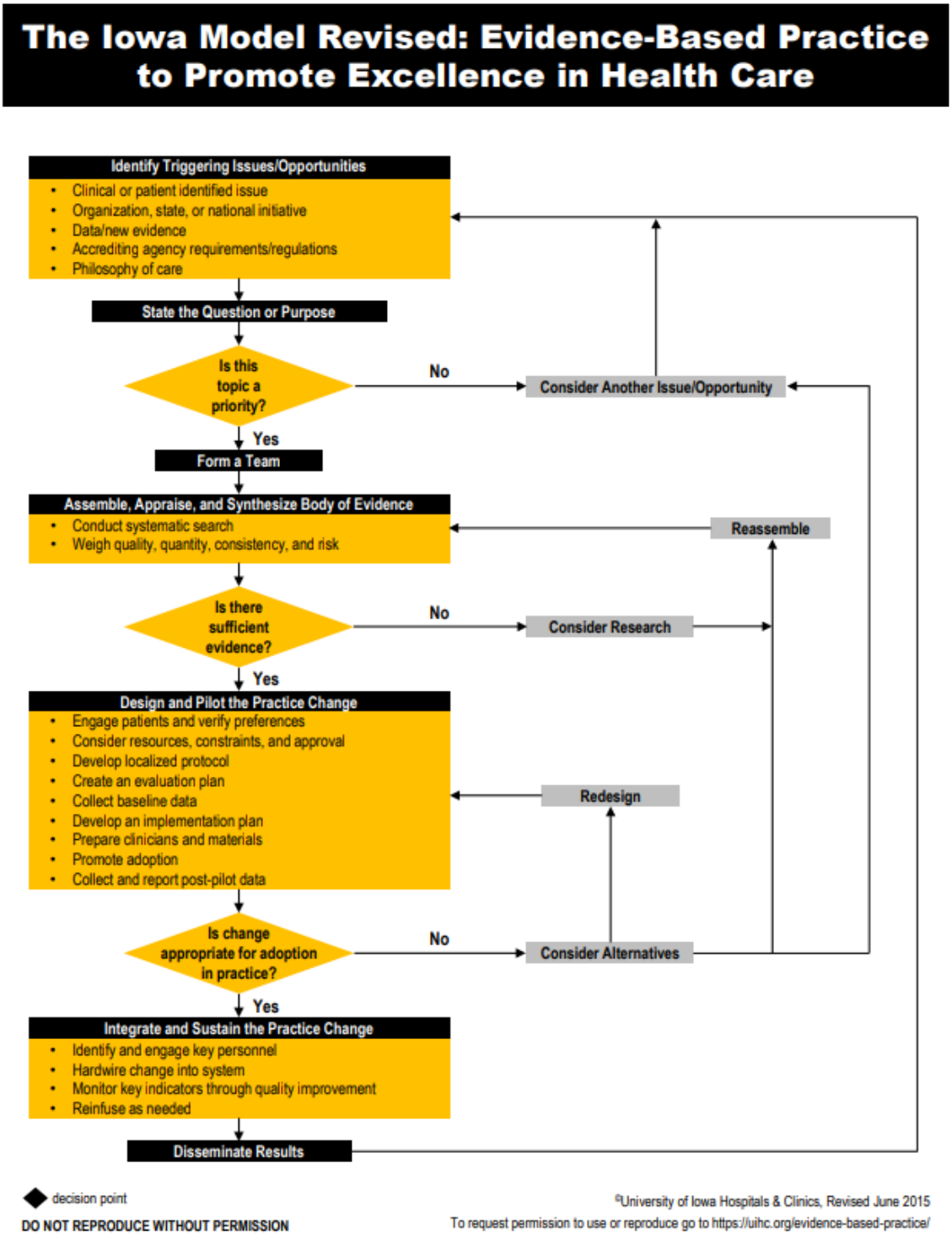
Evidence Level and Quality Guide

Evidence Levels	Quality Guides
Level I Experimental study, randomized controlled trial (RCT) Systematic review of RCTs, with or without meta-analysis	**A High quality:** Consistent, generalizable results; sufficient sample size for the study design; adequate control; definitive conclusions; consistent recommendations based on comprehensive literature review that includes thorough reference to scientific evidence **B Good quality:** Reasonably consistent results; sufficient sample size for the study design; some control, fairly definitive conclusions; reasonably consistent recommendations based on fairly comprehensive literature review that includes some reference to scientific evidence **C Low quality or major flaws:** Little evidence with inconsistent results; insufficient sample size for the study design; conclusions cannot be drawn
Level II Quasi-experimental study Systematic review of a combination of RCTs and quasi-experimental, or quasi-experimental studies only, with or without meta-analysis	
Level III Non-experimental study Systematic review of a combination of RCTs, quasi-experimental and non-experimental studies, or non-experimental studies only, with or without meta-analysis Qualitative study or systematic review with or without a meta-synthesis	
Level IV Opinion of respected authorities and/or nationally recognized expert committees/consensus panels based on scientific evidence Includes: • Clinical practice guidelines • Consensus panels	**A High quality:** Material officially sponsored by a professional, public, private organization, or government agency; documentation of a systematic literature search strategy; consistent results with sufficient numbers of well-designed studies; criteria-based evaluation of overall scientific strength and quality of included studies and definitive conclusions; national expertise is clearly evident; developed or revised within the last 5 years **B Good quality:** Material officially sponsored by a professional, public, private organization, or government agency; reasonably thorough and appropriate systematic literature search strategy; reasonably consistent results, sufficient numbers of well-designed studies; evaluation of strengths and limitations of included studies with fairly definitive conclusions; national expertise is clearly evident; developed or revised within the last 5 years **C Low quality or major flaws:** Material not sponsored by an official organization or agency; undefined, poorly defined, or limited literature search strategy; no evaluation of strengths and limitations of included studies, insufficient evidence with inconsistent results, conclusions cannot be drawn; not revised within the last 5 years
Level V Based on experiential and non-research evidence Includes: • Literature reviews • Quality improvement, program or financial evaluation • Case reports • Opinion of nationally recognized experts(s) based on experiential evidence	**Organizational Experience:** **A High quality:** Clear aims and objectives; consistent results across multiple settings; formal quality improvement, financial or program evaluation methods used; definitive conclusions; consistent recommendations with thorough reference to scientific evidence **B Good quality:** Clear aims and objectives; consistent results in a single setting; formal quality improvement or financial or program evaluation methods used; reasonably consistent recommendations with some reference to scientific evidence **C Low quality or major flaws:** Unclear or missing aims and objectives; inconsistent results; poorly defined quality improvement, financial or program evaluation methods; recommendations cannot be made **Literature Review, Expert Opinion, Case Report, Community Standard, Clinician Experience, Consumer Preference:** **A High quality:** Expertise is clearly evident; draws definitive conclusions; provides scientific rationale; thought leader(s) in the field **B Good quality:** Expertise appears to be credible; draws fairly definitive conclusions; provides logical argument for opinions **C Low quality or major flaws:** Expertise is not discernable or is dubious; conclusions cannot be drawn

Note. Adapted from Johns Hopkins Nursing Evidence-Based Practice. (2017). *Evidence Level and Quality Guide*. https://www.hopkinsmedicine.org/evidence-based-practice/_docs/appendix_c_evidence_level_quality_guide.pdf

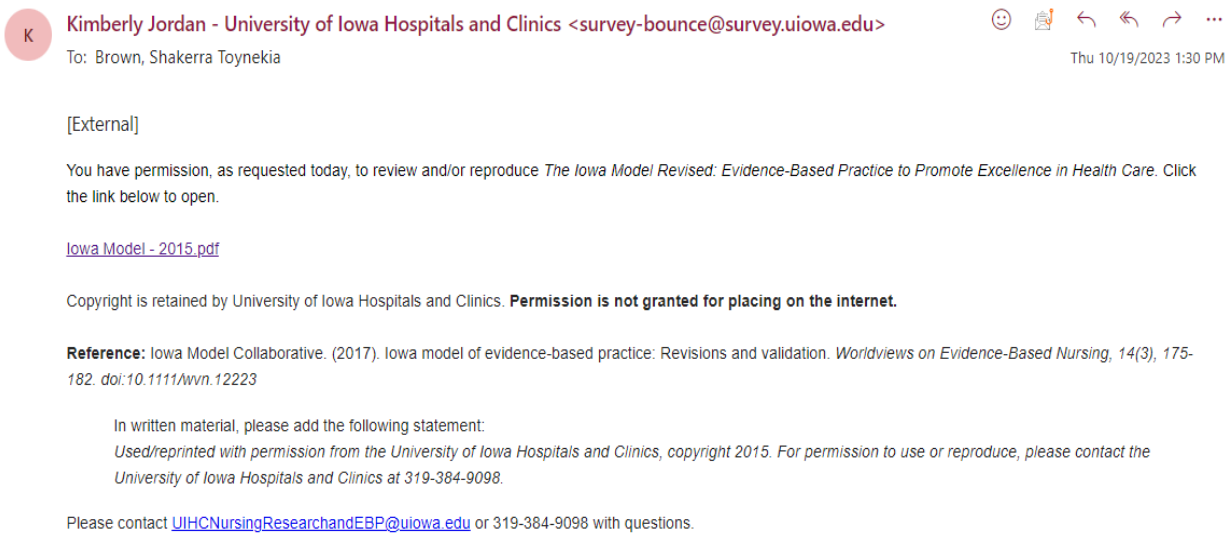
Appendix C

IOWA Model



Appendix D

Permission for usage of IOWA model



K

Kimberly Jordan - University of Iowa Hospitals and Clinics <survey-bounce@survey.uiowa.edu>

To: Brown, Shakerra Toynekia

Thu 10/19/2023 1:30 PM

[External]

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Appendix E

Venous Vulnerability Tool

Date: _____

Gender:

Male ☐

Female ☐

Age _____

Ethnicity

African American

American Indian ☐

Asian ☐

Hispanic ☐

Other: _____

Check Sheet for Venous Vulnerability Assessment

☐ Absence of blood regurgitation into the venous access tube

☐ Elderly (aged ≥ 75 years)

☐ Sever obesity or thinness

☐ Skin fragility

☐ Near the lesion site or the site after radiation therapy

☐ Difficulty of the intravenous catheter placement

If any of the above applies, do a test injection of saline

o Pain or abnormal venous swelling due to test injection of saline

If the above applies, ask the radiologist for instructions

Did the radiologist proceed with the CT scan? Yes ☐ No ☐

Post CT assessment

Did the patient experience contrast extravasation? Yes ☐ No ☐

Appendix F

Permission for Venous Vulnerability Assessment Tool

ELSEVIER LICENSE
TERMS AND CONDITIONS

Sep 30, 2023

This Agreement between Shakerra Brown ("You") and Elsevier ("Elsevier") consists of your license details and the terms and conditions provided by Elsevier and Copyright Clearance Center.

License Number	5630370568324
License date	Sep 15, 2023
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Licensed Content Publication	Academic Radiology
Licensed Content Title	Practical Preventive Strategies for Extravasation of Contrast Media During CT: What the Radiology Team Should Do
Licensed Content Author	Shinsuke Shigematsu,Seitaro Oda,Daisuke Sakabe,Ayumi Matsuoka,Hidetaka Hayashi,Narumi Taguchi,Masafumi Kidoh,Yasunori Nagayama,Takeshi Nakaura,Michiyo Murakami,Masahiro Hatemura,Toshinori Hirai
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Licensed Content Volume	29
Licensed Content Issue	10
Licensed Content Pages	5
Start Page	1555

Appendix G

Site Approval Letter

8/29/23

The University of Texas at Arlington
College of Nursing and Innovation
411 S Nedderman Dr
Arlington, TX 76019

Re: Shakerra Brown

Doctor of Nursing Practice Student

Dear College of Nursing and Health Innovation Faculty,

This letter is to approve Shakerra Brown's DNP project, **Intravenous Contrast Extravasations in CT scan.** I support her in completing the University of Texas at Arlington required quality improvement project. We commit to providing appropriate resources (as applicable) for project initiatives and resources needed within the department.

Sincerely,

Andrea D. Vinson, MBA, RT (N), CNMT
Director----Imaging Services
Houston Methodist Hospital
Office: 713-441-4860
Mobile: 281-948-0939
Email: avinson@houstonmethodist.org

HOUSTON Methodist LEADING MEDICINE

Shannan K. Hamlin, PhD, RN, AGACNP-BC, CCRN, NE-BC, FCCM
7550 Greenbrier, RB3, Mailbox 1
Houston, TX 77030-2707
(346) 356-1327
SHamlin@HoustonMethodist.org

November 15, 2023

TO: Shakerra Brown

SUBJECT: *HMAI Determination of Not Human Subject Research: Intravenous Contrast Extravasations of CT Contrast Media Prevention Bundle*

Based on the information and protocol provided, the HMRI IRB has determined that the project referenced above does not meet the definition of Human Subject Research per 45 CFR 46 and does not require prior IRB review and approval at Houston Methodist.

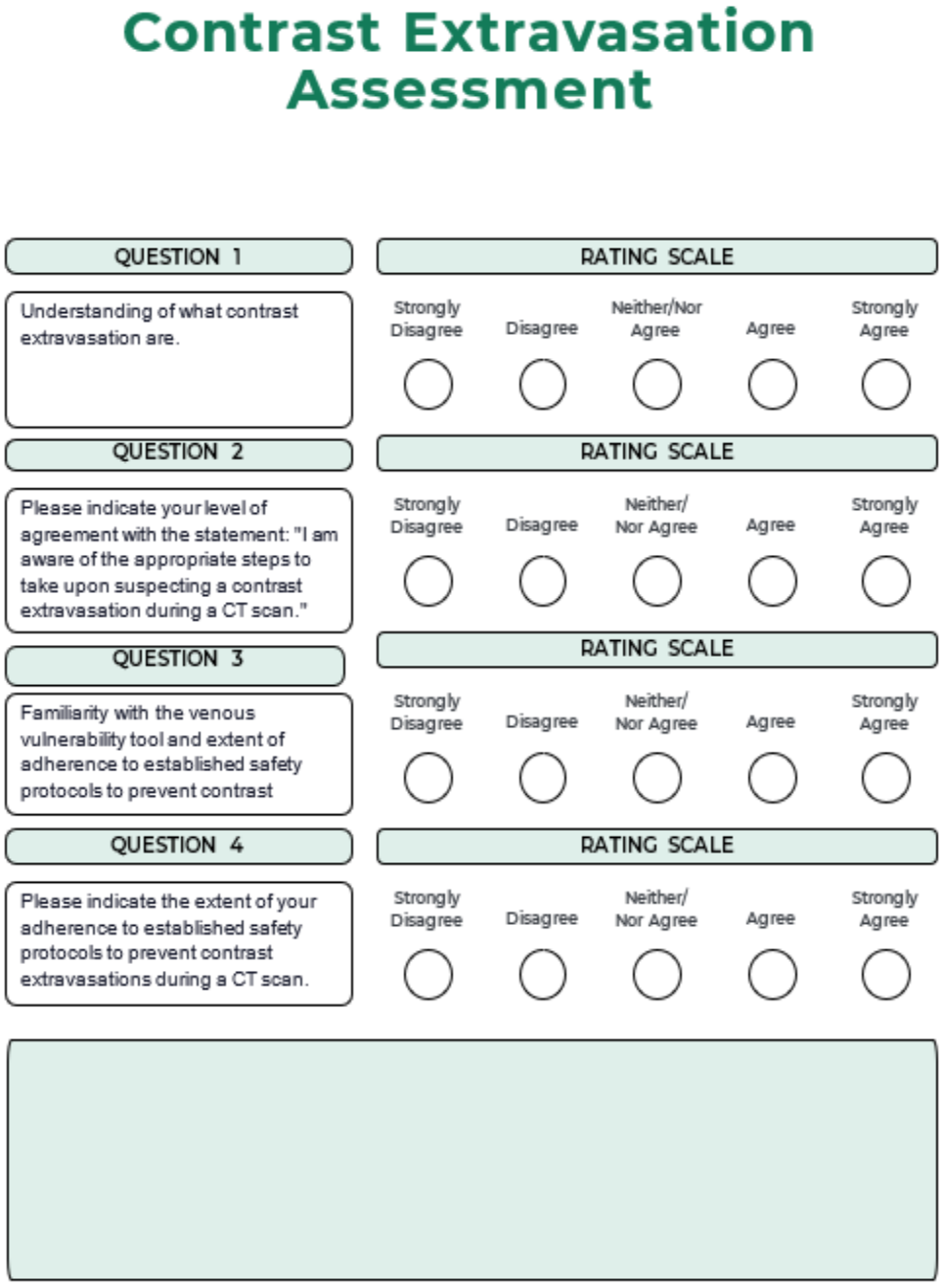
Please understand that should your protocol change in any way your new protocol will need to be resubmitted for review and a new IRB determination made before any data collection can begin.

If you have any questions, do not hesitate to contact me. Best of luck on a successful quality improvement project!

Sincerely,

Shannan Hamlin, PhD, RN, AGACNP-BC, CCRN, NE-BC, FCCM
HMAI IRB Designated Member

Appendix H

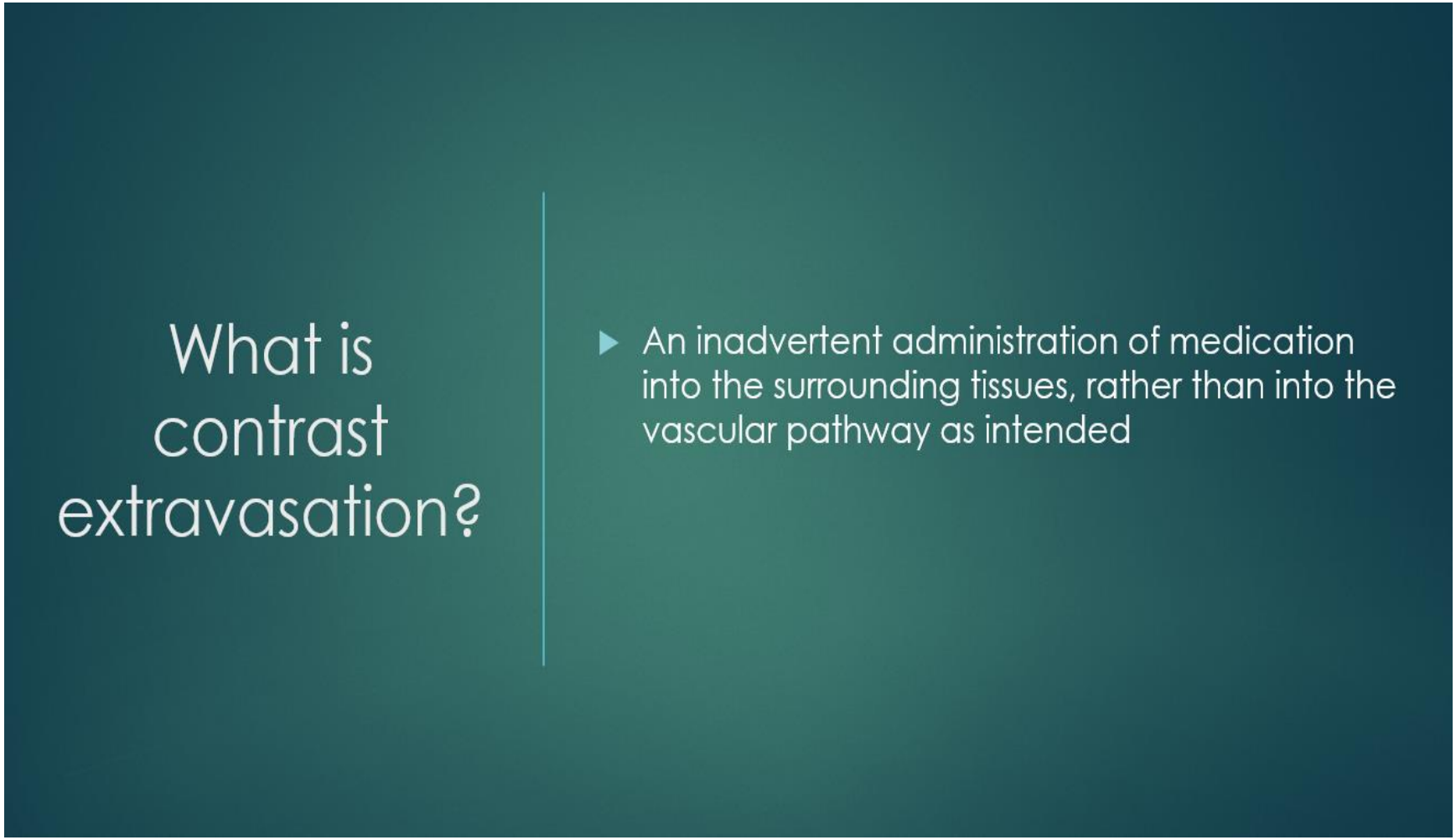

Contrast Extravasation Assessment
QUESTION 1
Understanding of what contrast extravasation are.
RATING SCALE
Strongly Disagree
Disagree
Neither/Nor Agree
Agree
Strongly Agree
QUESTION 2
Please indicate your level of agreement with the statement: "I am aware of the appropriate steps to take upon suspecting a contrast extravasation during a CT scan."
RATING SCALE
Strongly Disagree
Disagree
Neither/ Nor Agree
Agree
Strongly Agree
QUESTION 3
Familiarity with the venous vulnerability tool and extent of adherence to established safety protocols to prevent contrast
RATING SCALE
Strongly Disagree
Disagree
Neither/ Nor Agree
Agree
Strongly Agree
QUESTION 4
Please indicate the extent of your adherence to established safety protocols to prevent contrast extravasations during a CT scan.
RATING SCALE
Strongly Disagree
Disagree
Neither/ Nor Agree
Agree
Strongly Agree

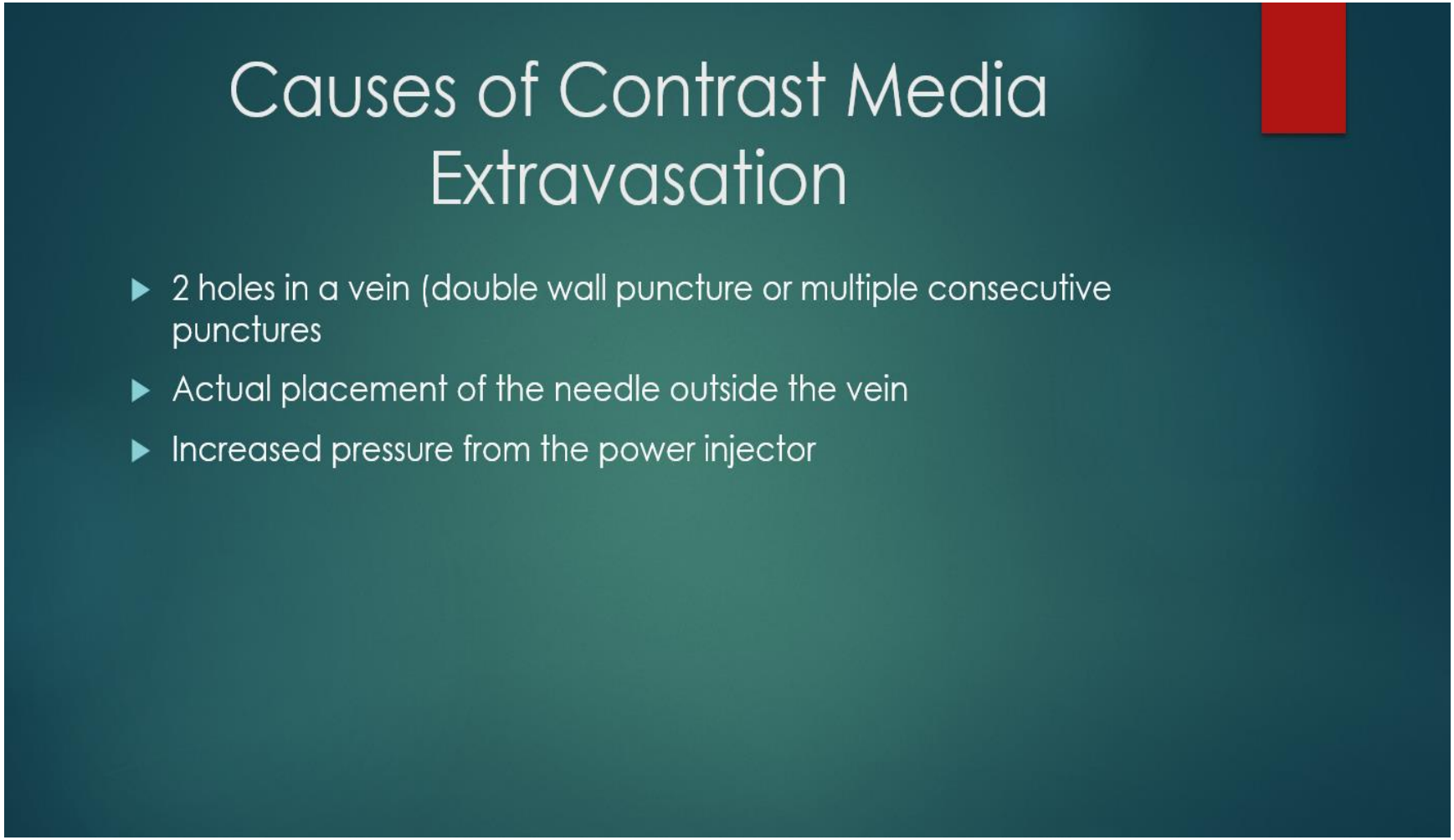
Appendix I

Training PowerPoint

Prevention of Contrast Extravasations

SHAKERRA BROWN


What is contrast extravasation?
An inadvertent administration of medication into the surrounding tissues, rather than into the vascular pathway as intended


Causes of Contrast Media Extravasation
2 holes in a vein (double wall puncture or multiple consecutive punctures
Actual placement of the needle outside the vein
Increased pressure from the power injector

Nexiva Diffusics Catheter

The BD Nexiva™ Diffusics™ closed IV catheter system addresses common computed tomography (CT) challenges during power-injection procedures, while helping you efficiently deliver care and minimize the risk of complications.

https://www.bd.com/en-ca/offerings/capabilities/infusion-therapy/iv-catheters/bd-nexiva-diffusics-closed-iv-catheter-system

Nexiva Diffusics Catheter

The BD Nexiva™ Diffusics™ closed IV catheter system addresses common computed tomography (CT) challenges during power-injection procedures, while helping you efficiently deliver care and minimize the risk of complications.

https://www.bd.com/en-ca/offerings/capabilities/infusion-therapy/iv-catheters/bd-nexiva-diffusics-closed-iv-catheter-system

Ulrich Contrast Injector

CT motion™

CT Contrast Media Injector

A big success – down to the smallest detail

- Patented roll pump technology
- Direct injection from all standard media containers
- Variable bottle guide from 50 mL to 1000 mL
- Automatic patient-side air monitoring
- Tandem function for selection of a second contrast medium in the case of two different contrast media
- Seamless function for alternating switching to full contrast media containers when two identical contrast media are used
- The CT motion is available as a mobile pedestal version, with a 3D ceiling mount or with a wall mount

Check Sheet for Venous Vulnerability Assessment

- ☐ Absence of blood regurgitation into the venous access tube
- ☐ Elderly (aged ≥ 75 years)
- ☐ Sever obesity or thinness
- ☐ Skin fragility
- ☐ Near the lesion site or the site after radiation therapy
- ☐ Difficulty of the intravenous catheter placement
- ☐ History of subcutaneous extravasation of contrast media
- ☐ The same peripheral venous access as the intravenous chemotherapy

If any of the above applies, do a test injection of saline

- ○ Pain or abnormal venous swelling due to test injection of saline

If the above applies, ask the radiologist for instructions

Did the radiologist proceed with the CT scan? Yes ☐ No ☐

Post CT assessment

Did the patient experience contrast extravasation? Yes ☐ No ☐

Venous Vulnerability Checklist


PATIENT SAFETY
Protect
Danger
Concept
Secure
Sign
First
Risk
Equipment
Life
Job
Safe
Work
Rules
Prevention
Caution
Careful
Industrial
Health
Helmet

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Appendix J

Dashboard

DNP Dashboard: Intravenous Contrast Extravasations of CT Contrast media

				Pre-CT scan											Post Scan
Participant Code	Age Group 0 = 18-25 1 = 26-35 2= 36-45 3 = 46-55 4 = 56-64 5 = 65 and ≥	Gender 1 = Male 2= Female	Ethnicity 1 = White 2 = Black 3 = Asian 4 = Hispanic 5 = American Indian	Absence of blood regurigation in tube	Elderly (aged ≥ 75 years age	Severe obesity or thiness	Skin fragility	Near the lesion site or the site after radiation	Difficulty of the intravenous catheter placement	History of subcutaneous CME	Same peripherial IV acess as the IV chemotherapy	Test injection of saline received	Pain after test injection	Did the radiologist proceed with CT scan?	Did an CME occur?
CT-G 57	5	2	2	9	9	9	9	9	8	9	9	9	9	8	9
CT-M 63	4	1	2	9	9	8	9	9	9	9	9	9	9	8	9
CT-Y 56	5	2	1	9	9	9	9	9	8	9	9	9	9	8	9
CT-M 56	5	2	1	9	9	9	9	9	8	9	9	9	9	8	9
CT-F 59	5	2	1	9	9	9	9	9	8	9	9	9	9	8	9
CT-R 41	5	2	1	9	8	9	9	9	9	9	9	9	9	8	9
CT-Y 47	5	2	1	9	8	9	9	9	9	9	9	9	9	8	9
CT-Z 54	5	1	5	9	9	9	9	9	8	9	9	9	9	8	9
CT-T 68	4	2	4	9	9	9	9	9	8	9	9	9	9	8	9
CT-L 41	5	1	5	9	8	9	9	9	9	9	9	9	9	8	9
CT-B 50	5	2	5	9	9	9	9	9	8	9	9	9	9	8	9
CT-S 68	4	1	4	9	9	9	9	9	8	9	9	9	9	8	9
CT-D 57	5	2	5	9	9	9	9	9	8	9	9	9	9	8	9
CT-K 72	3	2	5	9	9	9	9	9	8	9	9	9	9	8	9
CT-K 88	2	2	4	9	8	9	9	9	9	9	9	9	9	8	9
CT-G 45	5	2	5	9	8	9	9	9	9	9	9	9	9	8	9
CT-Y 46	5	2	5	9	8	9	9	9	9	9	9	9	9	8	9
CT-C 46	5	1	1	9	8	9	9	9	9	9	9	9	9	8	9
CT-M 53	5	1	1	9	9	8	9	9	9	9	9	9	9	8	9
CT-K 48	5	2	1	9	8	9	9	9	9	9	9	9	9	8	9
CT-S 98	1	1	4	9	9	8	9	9	9	9	9	9	9	8	9
CT-H 58	5	2	2	9	9	8	9	9	9	9	9	9	9	8	9
CT-G 68	4	1	5	9	9	9	9	8	8	9	9	9	9	8	8

Master coding system

The code will begin with CT for every patient; using the first letter of their mother's name and the last two numbers of their birth year
Ex: CT-P-88

Legend for Pre and Post test questions

8 = Yes
9 = No

DNP Dashboard: Pre Test for Knowledge Level Questionaire							DNP Dashboard: Post-Test for Knowledge Level Questionaire				
Staff Member ID	Question 1	Question 2	Question 3	Question 4	Pre-Score		Question 1	Question 2	Question 3	Question 4	Post-Score
DP01	5	4	5	4	18		5	5	5	5	20
MN02	4	4	4	4	16		5	5	5	5	20
CL03	3	4	3	4	14		4	5	5	4	18
PW04	5	5	5	5	20		5	5	5	5	20
LL05	4	4	4	4	16		5	4	4	5	18
DR06	5	5	5	5	20		5	5	5	5	20
TT07	3	3	3	3	12		5	5	4	4	18
TT08	5	5	5	5	20		5	5	5	5	20
RY09	4	4	3	3	14		5	5	5	5	20
SP10	3	3	3	3	12		4	4	5	5	18
VA11	3	3	1	3	10		3	4	5	5	17
FB12	1	3	3	3	10		4	4	4	4	16
MM13	4	4	5	5	18		5	5	5	5	20
IC14	5	4	5	4	18		5	5	5	5	20
RN15	5	5	5	5	20		5	5	5	5	20
MD16	3	3	3	3	12		5	5	5	5	20
MA17	4	4	5	5	14		4	4	5	5	18
EB18	2	2	2	2	8		5	4	4	5	18
AB19	5	5	5	5	20		5	5	5	5	20
ED20	4	4	2	3	13		4	4	5	5	18
SW21	3	3	3	3	12		4	5	5	5	19
CD22	3	4	4	4	15		5	5	5	5	20
RM23	4	4	4	5	17		5	5	5	5	20
CF24	5	3	3	3	13		5	5	4	5	19
DW25	3	3	2	1	9		5	5	5	5	20
MO26	2	2	3	3	17		5	5	5	5	20
DW26	5	5	5	5	20		5	5	5	5	20
JY27	3	3	2	2	10		5	5	5	5	20
BB26	3	2	3	3	11		5	5	5	5	20
AE27	5	4	3		15		5	5	5	5	20
AB28	3	3	3	3	12		5	5	5	5	20
CS29	4	4	4	4	16		4	5	5	5	19
AM30	5	5	5	5	20		5	5	5	5	20
SD31	3	3	3	4	13		5	5	5	5	20

Legend for Staff Identification:
The staff will be coded with first and last initial of name with double number following
Ex: AN01

Appendix K

SWOT Analysis Table

Strengths	**Weaknesses**
• Simple-the intervention involves the application of an assessment that is already formulated making the process simple • Convenient- The assessment is readily available and can be utilized in numerous situations whereby patients exhibit contrast extravasation • The strategy can also be adopted in any hospital or healthcare facility due to its simplicity and convenience • It can be carried out by numerous individuals including radiology nurses, radiologists, and radiology technicians • The cost is minimal, making the assessment less expensive • Increased patient satisfaction by increasing the medical team's awareness of extravasation • Awareness: The organization has a strong safety culture and prioritizes preventing contrast extravasation. • Skilled staff: The organization has a highly trained and competent medical staff experienced in administering contrast agents. • Resources: Sufficient financial and technological resources are available to support the implementation and maintenance of the assessment. • Collaboration: The organization has established partnerships with relevant stakeholders, such as radiologists and nursing staff, to ensure effective implementation and adherence to the assessment	• The effectiveness is not scientifically proven. • Highly dependent on the quality, accuracy, and completeness of the data records • Ineffective when addressing concerns such as access site and catheter size • Lack of time for the provider to use the guideline. • Limited understanding of the guidelines by the professionals • Resistance to change: Some staff members may be resistant to adopting new procedures, including implementing a prevention assessment. • Lack of training: Not all staff members have received adequate training on preventing contrast extravasation, leading to potential gaps in knowledge and implementation. • Communication: Ineffective communication between different departments and staff members could hinder the consistent and standardized use of the assessment.

Opportunities	Threats
• The Venous Vulnerability assessment can be adopted by any hospital. • Any practitioner operating in the radiology department can conduct it. • Reduced cost of care by minimizing the prevalence of contrast extravasation	• Limited acceptance by medical practitioners since it is not scientifically proven. • Lack of a standardized assessment that can be employed for different patients. • Time constraints: The fast-paced nature of healthcare settings can pose challenges to implementing the assessment, as medical staff may feel pressured to prioritize speed over following the assessment. • Staffing shortages: Insufficient staffing levels can lead to increased workload and stress, potentially affecting adherence to the assessment. • Emergencies and critical situations: In urgent or critical cases, there may be a tendency to bypass or overlook certain steps in the assessment to expedite patient care, compromising the prevention efforts.

Appendix L

Risk Management Plan for Venous Vulnerability Assessment

Risk	Probability	Impact	Mitigation	Contingency Plan
Time Constraints	Likely	Moderate	Allocating more time for an in-depth examination of the patients before conducting the computed tomography scans. Involving more personnel in the process to help in conducting various duties such as the venous vulnerability assessments.	Come up with an assessment that is simplified and quick to undertake.
Limited quality and accuracy of ECM records	Occasionally	Critical	The assessment using the venous vulnerability assessment should be conducted by well-trained personnel who can recognize deficiencies in the available patient information. The health records utilized should be counter-checked. Involving electronic health records system can enhance the quality and accuracy of ECM records.	The practitioners involved in taking care of the patients should be personally involved in the assessment process since they have a relevant understanding of the patient.
Medical errors due to the lack of scientific evidence	Likely	Critical	The hospitals or medical facilities using the venous vulnerability assessment should conduct intensive research on the elements that they want to include in the assessment.	The hospitals should consider adopting an assessment that has been utilized by other facilities and proven to be effective in preventing contrast extravasation.

			can reduce the likelihood of medical errors occurring	
Resistance from medical practitioners	Occasionally	Moderate	Training the medical practitioners about the effectiveness of the assessment can help deal with some of the concerns that they may have that contribute to the resistance. Involving individuals who have used the tool to speak to the practitioners and offer their insights and experience can also help deal with the resistance. Involving the practitioners in coming up with an assessment can also promote their confidence in the effectiveness of the guidelines in preventing contrast extravasation.	Introducing it as a requirement when conducting computed tomography can deal with the practitioners' resistance.
Lack of standardized assessments	Likely	Critical	Establishing a team in the radiology department consisting of various practitioners, including nurses, technicians, and radiologists, to come up with an effective assessment. Researching some of the widely used and effective assessments in the country and using them to come up with viable items to include.	Adopting the assessment proposed by the relevant government agency, such as the Agency for Healthcare Research and Quality.

Appendix M

Protecting Human Research Participants Training

UNIVERSITY OF TEXAS ARLINGTON

Human Subjects Protection Training (HSP): Training Completion Certificate

This document certifies that Shakerra Toynekia Brown completed the training entitled "Human Subjects Protection Training (HSP)" on September 13th, 2023.

Training Start time: 09/12/2023 12:13 PM; Training End Time: 09/13/2023 07:57 PM

The Office of Regulatory Services
817-272-3723

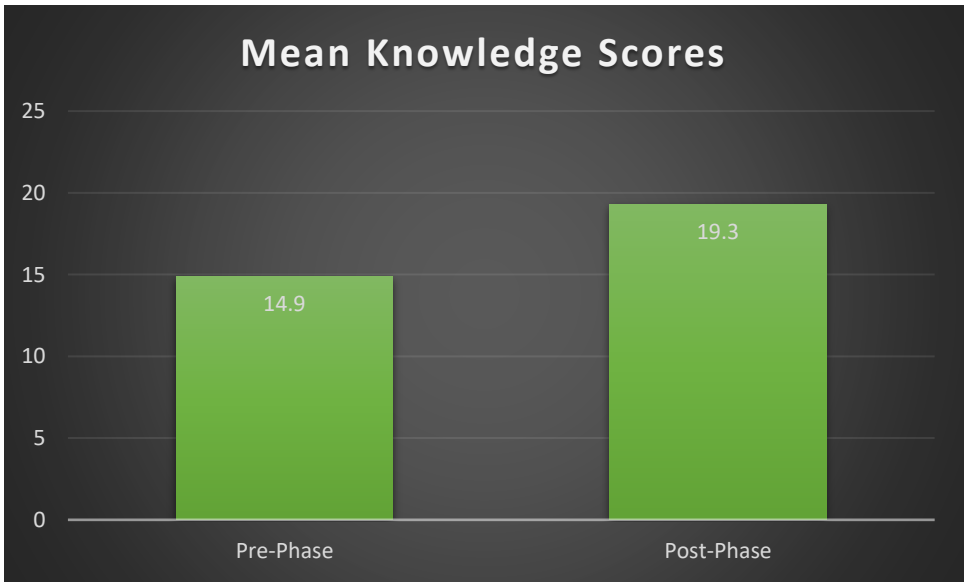
regulatoryservices@uta.edu

Appendix N

Paired Samples t-test Comparing Pre-Knowledge and Post-Knowledge Scores

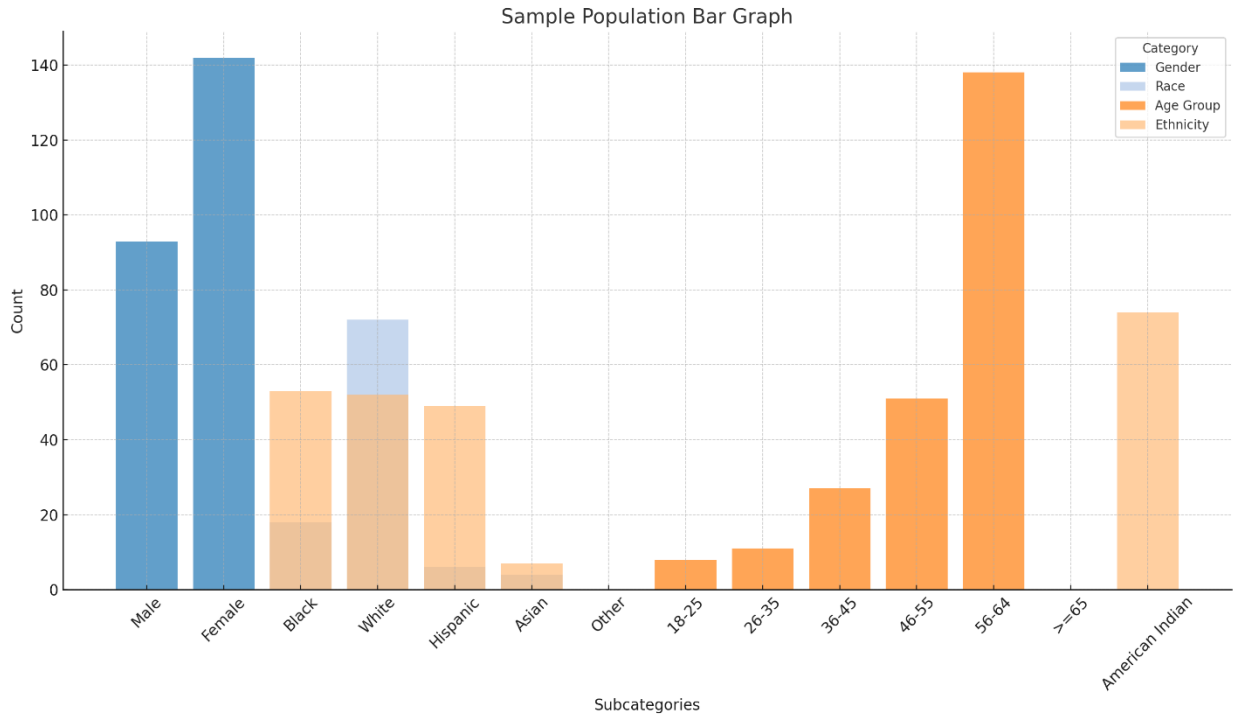
Measure	Mean (SD)	Mean Difference (SE)	t	df	p-value	Cohen's D
Pre-Knowledge	14.9 (3.7)					
Post-Knowledge	19.3 (1.1)	4.4 (3.3)	7.925	35	<0.001**	1.4

P<0.01 Statistical Significance



Appendix O

Summary of Sample Population Statistics



Appendix P

Correlations

			Did the radiologist proceed with CT scan?	Did an CME occur?
Kendall's tau_b	Absence of blood regurigation in tube	Correlation Coefficient	.009	-.007
		Sig. (2-tailed)	.895	.909
		N	235	235
	Elderly (aged > 75 years age	Correlation Coefficient	-.069	.102
		Sig. (2-tailed)	.292	.118
		N	235	235
	Severe obesity or thiness	Correlation Coefficient	.015	-.075
		Sig. (2-tailed)	.819	.252
		N	235	235
	Skin fragility	Correlation Coefficient	.	.
		Sig. (2-tailed)	.	.
		N	235	235
	Near the lesion site or the site after radiation	Correlation Coefficient	.009	.575**
		Sig. (2-tailed)	.895	<.001
		N	235	235
	Difficulty of the intravenous catheter placement	Correlation Coefficient	.047	-.021
		Sig. (2-tailed)	.475	.746
		N	235	235
	History of subcutaneous CME	Correlation Coefficient	.	.
		Sig. (2-tailed)	.	.
		N	235	235
	Same peripherial IV acess as the IV chemotherapy	Correlation Coefficient	.	.
		Sig. (2-tailed)	.	.
		N	235	235
	Test injection of saline received	Correlation Coefficient	.	.
		Sig. (2-tailed)	.	.
		N	235	235
	Pain after test injection	Correlation Coefficient	-.437**	.509**
		Sig. (2-tailed)	<.001	<.001
		N	235	235
	Did the radiologist proceed with CT scan?	Correlation Coefficient	1.000	-.571**
		Sig. (2-tailed)	.	<.001
		N	235	235
	Did an CME occur?	Correlation Coefficient	-.571**	1.000
		Sig. (2-tailed)	<.001	.
		N	235	235

**. Correlation is significant at the 0.01 level (2-tailed).