The effectiveness of interventions to prevent or reduce Contrast Media Extravasations among patients undergoing computerized tomography scanning: a systematic review protocol

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Review question/objective
The primary objective of the review is to identify the effectiveness of interventions to prevent or reduce contrast medium extravasation in patients undergoing Computerized Tomographic examination. The specific review question is: What is the effectiveness of methods to prevent or reduce Contrast Media Extravasations among patients undergoing computerized tomography scanning?

Background
Computed tomography (CT) is a frequently conducted radiological examination and the number of CT examinations continues to increase globally. For instance, in the United States, the number of CT scans has more than doubled in 10 years, reaching 275 examinations per 1000 people in 2011.¹ This trend is likely to continue in the coming years due to the ageing of the population and the resulting increase in chronic diseases, such as cardiovascular diseases, cancer and metabolic pathologies.² CT scanning has become indispensable for the diagnosis and follow up of a large variety of diseases because of higher sensitivity and specificity compared to classical X-ray exams.³ This is the inevitable result of its capacity to produce images of axial slices from which it is possible to make volumetric reconstructions in three dimensions,³ or even in four dimensions with the creation of multiple cardiac phase cine loops.⁴
Radiological examination by CT scan produces an image quality that is continually improving and allows the visualization of hard tissue, such as bone, as well as parenchyma, such as liver. In order to enhance the differentiation of the anatomy and abnormal structures, particularly for the vascular system and viscera, iodinated contrast medium is routinely injected intravenously to the patient. These contrast media allow differentiating between venous and arterial tissue phases. Evidence indicates about 50% of CT exams use contrast medium, making it a widespread practice. Contrast media are traditionally administered intravenously through manual or drip injection methods. However these methods have been found to be variable in terms of injection flow rates and may negatively affect specific organ enhancement. Increasing numbers of radiology departments are equipped with automated power injectors for administration of contrast materials through peripheral venous catheters at constant flow rate allowing specific angiographic and visceral enhancement.

The injection of radiographic contrast agents facilitates increased diagnostic or prognostic accuracy, with clearer tissue differentiation or intravascular imaging by vessel opacification. Nevertheless, contrast media have side effects, such as allergic-like reactions, vasovagal reaction, cardiac arrhythmias or pulmonary edema. Furthermore, a well-recognized important potential complication is subcutaneous extravasation, which is defined as an accidental leakage of the injected fluid in the surrounding tissue. Extravasation constitutes an increased risk due to expanded use of power injectors compared to manual or drip injection. Because contrast media agents are vesicant, they may cause injuries to the patients. In the best cases, the adverse effects may be mild with no severe sequelae. Nevertheless, they nonetheless cause pain and discomfort to the patient that may persist in the long term. However major adverse consequences such as skin ulceration, soft-tissues necrosis or compartment syndrome have been documented. Serious effects are a risk, whether ionic or non-ionic contrast medium is injected.

When extravasation occurs, close patient monitoring is required to evaluate symptoms because the reaction manifests itself several hours after injection and the timing and duration of subsequent sequelae may vary substantially. The treatment of serious extravasation may require a surgical fasciotomy, skin grafting or even amputation.

Furthermore, if complications associated with extravasation occur, the exam may be delayed and, a new intravenous access has to be placed – inducing additional stress to the patients on top of the known stressors associated with a CT scan. Sometimes the CT examination must also be repeated, which exposes the patient to an additional radiation dose and contravenes the “As Low As Reasonably Achievable” (ALARA) principle of radiation protection. The realization of a new injection increases the cost due to the material used, the radiology personnel required and scanner utilization. Furthermore it reduces radiological department workflow. Accordingly, the financial and social implications of such undesirable events are not negligible.

There are several strategies to prevent the extravasation that are related to the (i) healthcare professionals, and (ii) technical tools used. Concerning healthcare professionals, IV administration may be performed by persons from different professions: they may be nurses, radiographers or radiologists. Researchers have investigated whether this factor might affect extravasation. Additionally, training of the healthcare professional might be an important variable, and notably to ameliorate the patient risk factors. Indeed, it has been identified that certain patient characteristics may induce an increased risk of extravasation. This is the case for patients with diabetes mellitus,
venous thromboembolism, or cancer, or patients with altered communication (young children, elderly, debilitated or unconscious patients).  

Secondly, in relation to technical prevention methods, several have been reported in the literature. These include strategies related to the characteristics of contrast media (including volume, concentration, viscosity, temperature, and rate of administration)\textsuperscript{6,8,13,23,26-28} as these have been shown to increase or reduce extravasation (rate and volume). Similarly, the injection technique per se (patient injection site, preparation room)\textsuperscript{13,14,25,26,28} and the material used for injection (catheter gauge, cannulas, butterfly, venflon)\textsuperscript{6,13,23,25,26,28} may affect extravasation. Finally reduction of extravasation rates could potentially be improved through the use of newly developed extravasation detection apparatus (detection device: ultrasound, radiofrequency).\textsuperscript{29}

Knowing the effectiveness of these strategies is especially important for radiology personnel because they can use, in their clinical practice, the most appropriate to prevent extravasation. This should also help to improve the patient experience when undergoing a scanner examination. Primary research articles have been published on the subject and their number has increased in recent years. In addition, guidelines have been published by learned societies, but they are not based on systematic literature reviews. Following a search in the JBI Database of Systematic Reviews and Implementation Reports, Cochrane Library, Medline and Trip database, the authors found no systematic review evaluating the scientific evidence of these strategies. It appears that it is worthwhile to conduct a systematic review on the subject of the prevention and reduction of contrast media extravasation during CT exam.

**Keywords**

Extravasation; contrast media; computed tomography; prevention; healthcare professionals; radiology; frequency; volume; complications

**Inclusion criteria**

**Types of participants**

This review will consider studies that included patients (adults or children), undergoing a CT examination, for any indication and of any part of the body, and requiring use of an IV administration of contrast media material. The examination can be either a classical CT or an interventional radiology CT procedure. The participants may be either inpatients or ambulatory care patients.

This review will not consider studies investigating extravasations in the framework of chemotherapy, anaesthesiology or parenteral nutrition. Indeed, the products used present a very different composition and thus different properties (e.g. viscosity and toxicity) compared to contrast media.

**Types of intervention(s)/phenomena of interest**

This review will consider studies that evaluated interventions or protocols which may prevent extravasation of contrast media or reduce its severity. Accordingly, it will include any strategies, related to:

- The contrast agent (volume, concentration, viscosity, temperature)
The injection per se (patient injection site, preparation room)

- The material used for injection (catheter gauge, cannulas, butterfly, venflon)
- The apparatus used (detection device: ultrasound, radiofrequency)
- The healthcare professionals (profession, skills)
- The patient risk assessment by the radiology personnel (medication, morbidity, language).

The comparators of this study will be either other interventions - such as a different contrast agent, another cannula- or usual care - such as the absence of preparation room or detection device.

**Types of outcomes**

This review will consider studies that include the primary and secondary outcomes described below.

**Primary patient outcomes will include:**

- Extravasation frequency
- Extravasation volume
- Extravasation severity, including inflammatory reactions, necrosis, pain
- Complications, including plastic surgery and amputation

**Secondary outcome measures will include:**

- Diagnostic value and accuracy
- Workflow
- False positive detection of extravasation. This outcome is particular to the interventions using detection device.

**Types of studies**

This review will consider both experimental and epidemiological study designs including randomized controlled trials and non-randomized controlled trials. In the absence of these trials, other study designs, such as quasi-experimental, prospective and retrospective cohort studies, case control studies and analytical cross sectional studies will be considered for inclusion. In the absence of significant analytical literature on this topic, then descriptive epidemiological study designs including case series, individual case reports and descriptive cross sectional studies will be considered for inclusion.

**Search strategy**

The search strategy aims to find both published and unpublished studies. A three-step search strategy will be utilised in this review. An initial limited search of MEDLINE and CINAHL will be undertaken followed by analysis of the text words contained in the retrieved titles and abstracts and of the index terms used to describe the article. A second search using all identified keywords and index terms will then be undertaken across all included databases. Thirdly, the reference list of all identified reports and
articles will be searched for additional studies. Studies published, in English and French, from 1980 to June 2014 will be considered for inclusion in this review. The databases to be searched will include: CINHAL, Embase, Medline, The Cochrane register of controlled trials, Web of knowledge, PsycINFO.

The search for unpublished studies will include: ProQuest Dissertation & Theses Database, TripDatabase, Clinical trials

Initial keywords to be used will be:

Extravasation, contrast media, computed tomography, prevention, healthcare professionals, frequency, volume, complications

**Assessment of methodological quality**

Papers selected for retrieval will be assessed by two independent reviewers for methodological validity prior to inclusion in the review using standardized critical appraisal instruments from the Joanna Briggs Institute Meta Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI) (Appendix I). Any disagreements between the reviewers will be resolved through discussion, or with a third reviewer.

**Data collection**

Data will be extracted from papers included in the review using the standardized data extraction tool from JBI-MAStARI (Appendix II). The data extracted will include specific details about the interventions, populations, study methods and outcomes of significance to the review question and specific objectives. Authors of primary studies will be contacted for missing information or to clarify unclear data.

**Data synthesis**

The primary objective is to pool all quantitative data, where possible, for statistical meta-analysis using JBI-MAStARI. All results will be subject to double data entry by the two reviewers. Effect sizes (expressed as an odds ratio for categorical data) and weighted mean differences (for continuous data) and their 95% confidence intervals will be calculated for analysis. Heterogeneity will be assessed statistically using the standard Chi-square test and also explored using subgroup analyses based on the different study designs included in this review. Where statistical pooling will not be possible, the findings will be presented in narrative form including tables and figures to aid in data presentation where appropriate.

**Conflicts of interest**

There is no conflict of interest regarding this systematic review.
References


Appendix I: Appraisal instruments
MAStARI appraisal instrument

JBI Critical Appraisal Checklist for Randomised Control / Pseudo-randomised Trial

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<th>Question</th>
<th>Yes</th>
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<td>1. Was the assignment to treatment groups truly random?</td>
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<td>6. Were the control and treatment groups comparable at entry?</td>
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<td>8. Were outcomes measured in the same way for all groups?</td>
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<td>9. Were outcomes measured in a reliable way?</td>
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Overall appraisal: Include [ ] Exclude [ ] Seek further info. [ ]

Comments (including reason for exclusion):
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JBI Critical Appraisal Checklist for Descriptive / Case Series

Reviewer ___________________________ Date ___________________________

Author ___________________________ Year ______ Record Number ________

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<th>Yes</th>
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Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

Comments (Including reason for exclusion)

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JBI Critical Appraisal Checklist for Comparable Cohort/ Case Control

Reviewer ........................................... Date ...........................................

Author ........................................... Year ........ Record Number ........

1. Is sample representative of patients in the population as a whole? □ Yes □ No □ Unclear □ Not Applicable

2. Are the patients at a similar point in the course of their condition/illness? □ Yes □ No □ Unclear □ Not Applicable

3. Has bias been minimised in relation to selection of cases and of controls? □ Yes □ No □ Unclear □ Not Applicable

4. Are confounding factors identified and strategies to deal with them stated? □ Yes □ No □ Unclear □ Not Applicable

5. Are outcomes assessed using objective criteria? □ Yes □ No □ Unclear □ Not Applicable

6. Was follow up carried out over a sufficient time period? □ Yes □ No □ Unclear □ Not Applicable

7. Were the outcomes of people who withdrew described and included in the analysis? □ Yes □ No □ Unclear □ Not Applicable

8. Were outcomes measured in a reliable way? □ Yes □ No □ Unclear □ Not Applicable

9. Was appropriate statistical analysis used? □ Yes □ No □ Unclear □ Not Applicable

Overall appraisal: Include □ Exclude □ Seek further info. □

Comments (Including reason for exclusion)

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Appendix II: Data extraction instruments
MAStARI data extraction instrument

### JBI Data Extraction Form for Experimental / Observational Studies

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<th>Date</th>
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<th>Year</th>
<th>Journal</th>
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**Study Method**

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<th>Observational</th>
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**Participants**

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<th>Population</th>
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**Sample size**

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**Interventions**

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**Authors Conclusions:**

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**Reviewers Conclusions:**

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**Study results**

### Dichotomous data

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<th>Outcome</th>
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<th>Intervention (2) number / total number</th>
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### Continuous data

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