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Iodated contrast overflow in computed tomography: a systematic review of risk factors, barriers used and suggested treatments

Extravasamento do meio de contraste iodado em tomografia computadorizada: uma revisão sistemática de fatores de risco, barreiras utilizadas e tratamentos sugeridos

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Abstract

Introduction: *The use of contrast media often allows a more adequate analysis of the morphology and identification of diseases. Contrast medium is commonly administered by an infusion pump, ensuring continuous flow. However, this automated administration can increase the incidence of overflows, resulting in the flow of large volumes in a short period of time.* ***Objective****: a systematic review of the correlation of risk factors for extravasation of iodine- based contrast medium, with the most used barriers, as well as measures adopted when such an occurrence occurs. Methods: analysis and review of correlated data from PUBMED and Scielo platforms and websites. Eleventh articles were selected, of these, after reading the abstracts and adequacy of objectives, 16 articles from the last 10 years were used.* ***Results****: although the occurrence is small, between 0.01 and 0.09% of contrast-enhanced exams performed, extravasation is a constant issue in radiological imaging centers, with higher incidence in computed tomography exams. The study seeks to elucidate the direct correlation between venous access and the conditions of the contrast medium used, which together favor the infusion, especially when specific risk factors are identified early, thus favoring the proper course of this procedure.* ***Conclusion:*** *elaboration and application of protocols that ensure the non-occurrence, as well as those that cover the reduction of complications such as compartment syndrome, will provide increased satisfaction with the service. In cases where prevention is not enough, an adequate approach aimed at reducing further undesirable effects will differentiate the service offered and the credibility of the professionals involved.*

Keywords: *Computed tomography, Contrast media, Diagnostic imaging, Extravasation of diagnostic and therapeutic materials*

Resumo

Introdução: *A utilização de meios de contraste, muitas vezes, permite uma análise mais adequada da morfologia e identificação de doenças. O meio de contraste é comumente administrado por uma bomba de infusão, garantindo fluxo contínuo. No entanto, essa administração automatizada pode aumentar a incidência dos extravasamentos, acarretando a vazão de grandes volumes em um curto período de tempo.* ***Objetivo:*** *correlacionar fatores de risco para o extravasamento do meio de contraste a base de iodo com as barreiras utilizadas e medidas adotadas quando instalada a ocorrência.* ***Métodos:*** *revisão sistematizada utilizando as bases de dados Pubmed e Scielo, nas quais formam analisados 16 artigos dos últimos 10 anos.* ***Resultados:*** *embora pequena a ocorrência, entre 0,01 a 0,09% dos exames contrastados realizados, o extravasamento é um assunto constante nos centros de imagens radiológicas, sendo de maior incidência em exames de tomografia computadorizada. Um adequado acesso venoso juntamente com meio de contraste que favoreça a infusão estão entre os principais fatores para a transcorrência adequada deste tipo de procedimento.* ***Conclusão:*** *elaboração e aplicação de protocolos que assegurem a não ocorrência, assim como os que abranjam a diminuição das complicações como a síndrome compartimental, proporcionará o aumento de satisfação ao serviço. Casos em que a prevenção não se faz suficiente, uma adequada abordagem que vise diminuir maiores efeitos indesejáveis, diferenciar o serviço oferecido e a credibilidade dos profissionais envolvidos.*

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Palavras chave: *Tomografia computadorizada, Meios de contraste, Diagnóstico por imagem, Extravasamento de materiais terapêuticos e diagnósticos*

Introduction

Technological advances applied to imaging exams have increased in recent decades, thus enabling better diagnoses. According to data from the CNES (National Register of Health Establishments) of the Ministry of Health, 1,099 CT scanners were recorded in the state of São Paulo in the 2020, of which 1,081 are in use[1]. The increase in the performance of this type of examination also increases the use of contrast media (CM) or radiocontrasts, which are commonly used to aid in detecting changes, characterizing and/or staging diseases[2].

Radiocontrast agents are a type of medical contrast used to improve the internal visibility of the body and structures in X-ray-based imaging techniques, these agents are typically: iodine or barium compounds[3].

Iodinated contrast can be classified, according to its dissociation capacity, in ionic or non-ionic. Ionic iodinated contrast is that which, when in solution, dissociates into particles with a negative and positive charge, while non-ionic ones do not release particles with an electrical charge. The quantity of particles in relation to the volume of solution determines the osmolarity of the contrast. Therefore, the ionic iodinated contrast has greater osmolarity than the non-ionic one. Other properties of the contrast concern its density and viscosity. The greater the density and viscosity, the greater the resistance to contrast flow, which reduces the injection speed and makes it difficult to dilute it in the bloodstream[4].

Improving the quality of the examination and adequate image of the analyzed structures, a device that continuously and more quickly administers the MC is commonly used, which is called an injector or infusion pump, this ensures continuous flow, with precise pressure throughout the administration, which allows the arrival of the MC in all structures of the organism. Faster injection rates are needed to allow for greater enhancement in some situations, effectively increasing the chance of detecting the disease. However, this automated administration can increase the incidence of extravasation, as it allows the flow of large volumes in a short period of time[5].

Extravasation is defined as the inadvertent administration of vesicant fluid around healthy tissues rather than the intended vessel. The vesicant agent is a compound capable of causing blisters or tissue necrosis[6].

Although beneficial to guarantee a more effective diagnosis, the occurrence of contrast medium (CME) extravasation in computed tomography (CT) exams is present in radiodiagnostic centers[2, 6-13]. It seeks to correlate the existing risk factors for CME based on iodine with the barriers used for prevention and measures taken when the occurrence installed.

Method

To carry out the research, online data from the Ministry of Health, articles from the Scielo database, were used. The Pubmed site was used as a database, where a literature review was carried out with the following descriptors: computed tomography (Tomography, x-ray), extravasation of material in diagnostic therapy (Extravasation of diagnostic and therapeutic materials), contrast medium (Contrast media) and diagnostic imaging. The inclusion criteria for the research were: articles with full texts, carried out only in human beings and from the last 10 years. After conducting the search, 214 articles were found, of these with the application of the filters mentioned above, 110 remained. After reading the abstracts and applying eligibility criteria by affinity with the title, 16 were obtained. Figure 1 illustrates in a simplified way and organized this process.

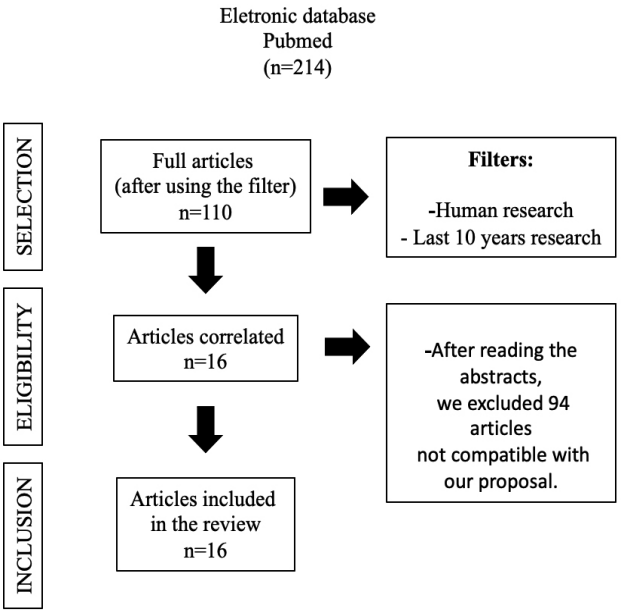

Figure 1 - Organization chart with criteria used

Results

The Table 1 below shows the list of articles regarding risk factors and conclusions.

Discussion

According to recent studies, CME has a higher incidence in CT scans compared to other imaging

Table 1

Author/year/Article Title	*Risk Factors for EMC*	*Conclusion*
Chad et al, 2009[10] Experimetal detection of subcutanious contrast, extravasations using radiofrequency permittivity sensing.	Not applicable.	Radiofrequency detection is ideal as it does not change the result due to contrast heating.
Sbytany et al, 2010[9] CT contrast extravasation in the upper extremity: strategies for managent.	Use of ionic contrast	Nonionic contrast media brought significant improvements in complications and CME.
Wienbeck et al, 2010[15] Prospective study of access complications of automated contrast injection with peripheral venous access in MDCT.	Device gauge; Venous access location.	A study shows the location of the venous access in the extremities as a predisposing factor for CME. It did not prove a relationship with the use of an infusion injector or with the concentration of iodine.
Belzunegui et al, 2011[3] Extravasation of radiographic contrast material and compartment syndrome in the hand: a case report.	Use of infusion injector; Patient with fragile venous access; Patient with venous insufficiency	EMC although rare occurs mainly in cases of use of injection pumps.
Rowlett, 2012 [11] Extravasation of contrast media managed with recombinant human hyaluronidase.	Limited data on hyaluronidase use in CME.	Hiluronidase is a reasonable treatment option for extensive CME, but it is little publicized.
Tonolini et al, 2012[13] Extravasation of radiographic contrast media: prevention, diagnosis and treatment.	Small children, uncooperative and unconscious elders. Obese or cancer patients undergoing chemotherapy. Use of an infusion injection pump, particularly during multiple detector acquisitions for angiographic studies.	It is recommended to adopt systematic protocols in preventive, diagnostic and therapeutic approaches.
Devenport et al, 2012[16] Rate of contrast material extravasations and allergic-like reactions affect of extrinsic warming of low-osmolality iodinated CT contrast material to 37 ºC.	Study on the viscosity of MC Iopamidol®.	Extrinsic heating (at 37°C) does not appear to affect adverse event rates for intravenous injections of Iopamidol 300® at less than 6 ml/s, but is associated with a significant reduction in extravasation and overall adverse event.
Kingston et al, 2012[17] Study of patients with intravenous contrast extravasation o CT studies, with radiology staff and ward staff cannulations.	It suggests the possibility of differences in occurrences in the management of venous access by different teams.	Personnel belonging to the radiology sector brings greater security and prevention of occurrences. Modification in the number of occurrences is also related to the size and caliber of the cannula.
Yurdakul et al, 2014[2] Compartment syndrome due to extravasation of contrast material: a case report.	Access in the back of the hand. No notification of discomfort per patient. Use of an infusion injection pump. Increased use of CT scans for cancer patient screening and staging.	The risk of occurrence can be reduced with the use of non-ionic contrast, the use of devices that detect early leakage by impedance, and the choice of venous access in larger vessels.
Shaqdan, 2014[6] Incidence of contrast medium extravasation for CT and MRI a large academic medical center: a report on 502, 391 injections.	Patients over 60 years old and hospitalized. Use of infusion injection pump	Patients undergoing CT have a higher risk of CME than those undergoing MRI. More likely in patients over 60 years of age and receiving contrast from an infusion injection pump.

Table 1

Author/year/Article Title	*Risk Factors for EMC*	*Conclusion*
Thomas et al, 2014[14] Intravenous contrast extravasation during CT: a national data registry and practence quality improvemet initiative.	Difficult venous access or multiple attempts. Patients with venous or lymphatic insufficiency.	Study confirms previous data: EMC rate 0.15 –0.70%. Volumes between 10-50ml, causing mild injuries. The study does not agree with the use of limit volumes.
Alami et al, 2015[12] Extravasation of contrast medium during CT examination: an observational case – control study.	Volume administered. Use of infusion pump Comorbidities	A low injection rate is a protective factor against EMC. The study suggests that patients with heart disease are more predisposed to CME than others.
Kim et al, 2016[5] Computed tomography contrast media extravasation: treatmetalgorit m by squeezing with multiple seit incisions.	Infusion injector use. Impossibility of monitoring outpatients.	Application of a protocol that ensures reduction of complications and prevention of effects such as compartment syndrome.
Refky et al, 2016[7] Contrast media extravasation of computed tomography and magnetic resonance imaging: management guidelines for the radiologist.	Children, women and elderly people using chemotherapy. Inpatients. Venous access with multiple attempts.	Although extravasation is infrequent, radiologists must be familiar with it to avoid severe complications.
Tonoline, 2016[13] Contrast médium extravasation: the importance of radiographic assessment.	Non-specific complaints and physical findings that do not reliably predict the true CME entity for specific therapy.	Importance of EMC differentiation, recommended practice in the latest version (version 9.0) of the European Guidelines.
Behzadi et al, 2018[18] MRI and CT contrast media extravasation. A systematic review.	Women, patients over 60 years old. use of catheters Inappropriate caliber of the vessel multiple punctures.	CME is greater in CT, older age, female gender and inadequate venous access together with the use of an infusion injector. The non-heating of the contrast directly influences the occurrences.
Wienbeck et al, 2010[15] Prospective study of access complications of automated contrast injection with peripheral venous access in MDCT.	Device gauge and access location.	A study shows the location of the venous access in the extremities as a predisposing factor for CME. It did not prove a relationship with the use of an infusion injector or with the concentration of iodine.

[A] Conservative measures: use of cold compresses with ice, elevation of the affected limb, use of steroids and analgesics when necessary.

methods such as magnetic resonance, for example. The main risk factors such as: older age, female gender, use of existing venous access in place of a specific puncture for the procedure, patient in a state of prolonged hospitalization, use of infusion injector in the administration of CM, high puncture rates , location of venous access and non-heating of more viscous CM[14-15, 18].

In a retrospective study with 502,391 CM injections, it confirmed the higher probability of occurrence with the use of the infusion injector, especially in patients over 60 years of age.6 Corroborating these findings, Belzunegue et al[3], shows that under conditions predisposing factors such as: the use of injector in patients with advanced age and/or with venous access in the extremities, suggestive of frailty, should be actively monitored, as well as an adequate instruction should be given to this patient in order to report any discomfort during MC injection. The instruction of all the steps of the procedure, together with the adequate characterization of possible signs caused by the use of contrast in the body, benefits the patient both in the non-occurrence and in the possible CME; considering that the amount of extravasated MC will directly influence the degree of possible injuries.

Through the findings, it is observed that patients with heart disease are more predisposed to CME than others, which is in line with the fact that cardiovascular diseases increase vascular fragility[12].

It is understood that an adequate venous access

together with CM that favors the infusion are among the main factors for the proper occurrence of this type of procedure. The extrinsic heating of the more viscous MCs, usually carried out in ovens at 37 ºC, reduces the barrier caused by the high viscosity, as well as the use of non-ionic compounds, those with a lower concentration of iodine molecules, also reduces the occurrences and adverse events caused by contact of this with adjacent tissues when the CME occurred[2, 16].

Although the occurrence of CME is small, it is a constant issue in radiological imaging centers, the literature highlights occurrences between 0.01 and 0.09% of contrast examinations performed.

In the last decade, there has been a significant drop in both occurrences and complications, as the use of non-ionic CM has become standard, which confirms that its use is also favorable for prevention(9). The importance of knowing the risk factors, tissue damage mechanisms and possible consequences for the team working in the imaging sector[13]. An approach performed by properly trained personnel, that is, belonging to the radiology sector brings greater safety and prevention of occurrences[17].

Although most occurrences are resolved with a conservative approach, the working team must know when a broader intervention is needed, such as the approach by a vascular specialist, for example[7].

Tonoline[13] emphasizes that one of the recommendations of the Guidelines of the European Society of Urogenital Radiology (version 9.0) is the correct and adequate differentiation of the CME, which will enable a personalized approach for each characteristic presented.

Conclusion

Iodinated CME using an infusion injector is a common complication reported in radiological practices, although its occurrence is between 0.01% and 0.09% of all contrast-enhanced exams, it should be given a prominent place among issues relevant to the service. Overflows are considered adverse events and must be actively monitored, as they are an important quality measurement tool as they are actively linked to the user's satisfaction index, which will indicate whether or not they are loyal to the service.

Protocols that guide the standardization of procedures and that aim to avoid extravasation are used in these services every day and at each exam. However, from the users' perspective, the visibility of the subject only occurs in cases of already installed extravasation, that is, during the approach to the occurrence. Therefore, as important as preventing the occurrence is also providing adequate assistance during CME.

Several maneuvers are studied and used at the moment, the use of the enzyme Hyaluronidase as a treatment option for extensive CME stands out in this study. This technique little disclosed in the literature improves symptoms and guarantees the return, after subcutaneous administration, of the effects caused post EMC.

The elaboration and application of protocols that ensure the non-occurrence, as well as those that cover the reduction of complications such as compartment syndrome, will generate an increase in satisfaction with the service. In cases where prevention is not enough, an adequate approach that aims to reduce further undesirable effects will differentiate the service offered and the credibility of the professionals involved.

It is understood that such protocols must contain deadlines for updating with the renewal of data relevant to the subject. Professionals involved in the diagnostic imaging service, nurses, technicians, and technologists in radiology must receive support from knowledge relevant to the identification, prevention and performance of periodic CME. Periodic simulations on the subject are suggested, aiming at clarification and adequate guidance according to the various possibilities, and covering the various professionals closely linked to this procedure.

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