Radiography departmental policy compliance with Swedish guidelines regarding post-contrast acute kidney injury for examinations with iodinated contrast media

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ABSTRACT

Introduction: Guidelines concerning intravenous iodinated contrast media (CM) during computed tomography (CT) examinations are important to follow to minimize the risk for post-contrast acute kidney injury (PC-AKI). The purpose of this study was to investigate the radiology departmental policy compliance with Swedish guidelines concerning PC-AKI.

Methods: In February 2020, an electronic survey was distributed to the responsible radiographer at 41 radiology departments in all university hospitals and medium-sized hospitals in Sweden. The questions focused on routines around renal functional tests, individualized contrast administration and handling of patients with diabetes mellitus taking metformin.

Results: The response rate was 83%. Seventy-six percent (n = 26) of radiology departments calculated estimated glomerular filtration rate (eGFR) from serum creatinine prior to CM administration, but only 24% (n = 8) followed the recommendation to calculate eGFR from both serum creatinine and cystatin C. For acute/implant patients, 55% (n = 18) followed the recommendation that renal functional tests should be performed within 12 h before CM administration. For elective patients, 97% (n = 33) followed the recommendation to have eGFR newer than three months which is acceptable for patients with no history of disease that may have affected renal function. Approximately 80% of the radiology departments followed the recommendation that CM dose always should be individually adjusted to patient eGFR. Seventy-six percent (n = 26) followed the recommendation to continue with metformin at eGFR ≥ 45 ml/min.

Conclusion: Compliance with the national guidelines was high regarding routines around renal functional tests, dose adjustment of CM and metformin discontinuation. Improvements can be made in using both cystatin C and serum creatinine for eGFR calculations as well as ensuring renal function tests within 12 h for acute/implant patients with acute disease that may affect renal function.

Implications for practice: This study raises awareness of the importance of adhering to guidelines in healthcare. To have knowledge about the current level of compliance regarding PCI-AKI is important to maintain and develop effective clinical implementation of guidelines. The variation in practice seen in this study emphasizes the need of more effective implementation strategies to ensure adherence with best practice.

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Background

Recommendations through guidelines intending to optimize the care and safety of the patient are widely used in healthcare. One of the guidelines used within the radiology department concerns

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determination of the risk for post-contrast acute kidney injury (PC-AKI) when intravenous iodinated contrast media (CM) is administered. PC-AKI refers to the worsening of renal function that occurs within 48 h after administration of CM. Iodinated CM is widely used during computed tomography (CT) examinations and its desired effect is to enhance image contrast, a necessity in the diagnosis of different diseases.

The risk for PC-AKI is dependent on both procedural and patient factors. A high dose of administered CM or multiple CM injections within a short period of time (48–72 h) are examples of procedural factors that increase the risk for PC-AKI. Moreover, patient-related risk factors such as heart failure, hypertension or intake of nephrotoxic drugs increase the risk for PC-AKI, where the risk for the patient increases exponentially with the number of risk factors present. Further patient groups at higher risk for PC-AKI include those with diabetes mellitus, and patients with pre-existing renal impairment. Moreover, the widely prescribed first-line treatment for diabetes mellitus, metformin, could cause the rare but severe condition of lactic acidosis. Through guidelines, identification of high-risk patients can be made which could reduce adverse reactions associated with CM administration.

In recent years, new evidence has suggested that the risk of PC-AKI after CM injection is overestimated. Furthermore, multiple studies have shown that the risk of lactic acidosis after CM injection during metformin treatment can be considered as low. Taking this into account, the guidelines of the European Society of Urogenital Radiology (ESUR) have become less restrictive. However, the level of evidence for some studies has been questioned in a literature review initiated by the Radiological Society of the Netherlands. The Swedish Society of Uroradiology (SSUR) has chosen not to completely adopt the ESUR guidelines in the current version of the Swedish guidelines, issued in 2017. In 2018, a supplement to the guidelines was issued to announce the less restrictive handling of patients with diabetes mellitus taking metformin. A comprehensive comparison of the Swedish guidelines with the European guidelines can be found in the publication from Nyman et al.

Compliance of departmental policies and protocols with Swedish guidelines is important to evaluate from a patient safety perspective. An effective implementation process can be challenging, and unpredictable and is affected by both organizational and individual factors. To our knowledge, the clinical implications of and compliance with the Swedish guidelines related to PC-AKI have not been evaluated previously. Therefore, the aim of the study was to investigate the radiology departmental policy compliance with the current Swedish guidelines concerning PC-AKI at university hospitals and medium-sized hospitals.

Methods

Study design

This study comprises a cross-sectional electronic survey, adopted to provide insights about the radiology departmental policy compliance with the current guidelines regarding PC-AKI from the SSUR.

In total, there are 61 hospitals (seven university hospitals, 34 medium-sized hospitals and 20 small hospitals) in Sweden with emergency 24/7 services. University hospitals and medium-sized hospitals also have childbirth departments. The target population was the responsible radiographer, with knowledge of the current local guidelines, procedures and protocols regarding CT examinations with iodinated CM, at all university hospitals and medium-sized hospitals in Sweden. During a two-week period, each radiology department was contacted by phone to obtain the e-mail address of the responsible radiographer. The electronic questionnaire (SurveyMonkey, San Mateo, CA, USA), together with information about the study, was then distributed during February 2020. In total, the questionnaire was available for 30 days, and for non-responders, reminders were sent out on two occasions, ten days apart within this time period.

The questionnaire was developed collaboratively by the authors and written in Swedish. The questionnaire consisted of ten questions and was designed with a simple structure with multiple types of response options. Both questions and answers were based upon specific recommendations in the guidelines regarding PC-AKI with a focus on eGFR measurements and the updated recommendations for patients with diabetes mellitus taking metformin. More specifically, the questions addressed measurement of renal function, timing of eGFR measurements for elective examinations as well as for emergency examinations and/or hospital inpatients, individualization of CM dose for elective examinations as well as for emergency examinations and/or hospital inpatients and handling of patients with diabetes mellitus taking metformin including information strategies for this patient group. In addition to the questions associated with the guidelines, there were two questions about the name of the hospital and the level of familiarity of the supplement regarding patients with diabetes mellitus taking metformin. Although further aspects of the guidelines such as patient-related and procedure-related risk factors or CM administration in patients on dialysis would be interesting and relevant, they were considered outside the scope of this study. To ensure that the questionnaire was clear, robust and aligned with the purpose, the questionnaire was piloted prior to distribution. The questionnaire underwent minor changes during this process.

Questionnaire responses were analysed using descriptive statistics in Excel (Microsoft Corporation, Redmond, WA, USA). Questionnaires with missing data were included in the study. All data was kept confidential and was anonymized in the reporting of the study.

Ethical considerations

The study was performed with health care professionals and did not involve handling sensitive personal data. Thus, according to Swedish laws and regulations, this study did not require approval from an ethics committee. However, ethical considerations were taken into account according to the Declaration of Helsinki. The participants received written information on the study and assurance that participation was voluntary and confidential. Consent was implied by completion of the questionnaire.

Results

In total, 41 questionnaires were distributed to radiology departments in university and medium-sized hospitals. Thirty-four radiology departments (83%), from five university hospitals (15%) and 29 medium-sized hospitals (85%), completed the study. Out of the submitted questionnaires, 32 (94%) were complete with answers to all questions. The remaining two questionnaires had one omitted answer each. The hospitals represented 20 of 21 regions in Sweden.

Table 1 summarizes the radiology departmental policy compliance with guidelines. As can be seen from the table, the compliance differed between 24% and 100%, with the highest compliance regarding strategies for patient information about discontinuation of metformin, and the lowest compliance for eGFR being calculated from serum creatinine and cystatin C. More details related to Table 1 follow in the subsections below.
Seventy-six percent (n = 26) of the radiology departments used serum creatinine for calculation of eGFR prior to CM administration, while 24% (n = 8) followed the recommendation by using serum creatinine and cystatin C for calculation of eGFR. None of the radiology departments used cystatin C alone to calculate eGFR prior to CM administration.

Fig. 1 shows the timing of renal function tests in relation to CM administration for emergency examinations and/or hospital inpatients and elective examinations. For emergency examinations and/or hospital inpatients, 55% (n = 18) of the radiology departments followed the recommendation that renal function tests should be as close to CM administration as possible and preferably <12 h. For 97% (n = 32) of the radiology departments, renal function tests were performed within a week prior to CM examination for this patient group. For elective examinations, few radiology departments (n = 2; 6%) followed the recommendation that renal function tests should preferably be performed within a week and a majority of the radiology departments (n = 29; 85%) performed renal function tests within 1–3 months prior to the CM examination. This means, however, that 97% (n = 33) of the radiology departments performed renal function tests within three months, which is, according to the recommendations from the SSUR, acceptable for patients with no history of disease that may have affected renal function.

Approximately 80% of the radiology departments followed the recommendation that CM dose always should be individually adjusted to patient eGFR (Fig. 2). As can be seen in the figure, emergency examinations and/or hospital inpatients and elective examinations were similarly treated in this regard.

The supplement from the SSUR suggesting that patients with diabetes mellitus taking metformin was extremely familiar (n = 17; 50%), moderately familiar (n = 16; 47%) or slightly familiar (n = 1; 3%) to the radiology departments.

Seventy-six percent (n = 26) of the radiology departments followed the recommendation that patients with eGFR >45 ml/min can continue to take metformin normally. The remaining 24% (n = 8) of the radiology departments regularly discontinued metformin treatment from the time of CM administration.

All radiology departments had clear strategies for providing information to patients about discontinuation of metformin. A vast majority, i.e., 94% (n = 32) of the radiology departments, provided written and oral information in connection to the examination. Three percent (n = 1) of the radiology departments only provided written information in connection to the examination, and for 3% (n = 1) of the radiology departments the referring physician was responsible for providing written information. None of the radiology departments provided only oral information to the patient in connection with the examination.

![Figure 1](image-url)  
**Figure 1.** The timing of renal function tests in relation to CM administration for emergency examinations and/or hospital inpatients (n = 33) and elective examinations (n = 34).
Figure 2. The level of frequency on individual adjustment of CM dose according to patient eGFR for emergency examinations and/or hospital inpatients (n = 33) and elective examinations (n = 35).

Discussion

The importance of standardized guidelines in relation to CM administration and the challenge of translating these guidelines into practice to maintain patient safety have earlier been described. In general, this study, which was based on a cross-sectional electronic survey completed by the responsible radiographers at CT departments, showed high radiology departmental policy compliance with PC-AKI guidelines with a median compliance rate of 79% of the specific recommendations evaluated. The variations in compliance with specific recommendations in guidelines, ranging from 24% to 100% in this study, have also been described in previous studies. For example, a recent study showed a compliance range of approximately 20–80% when evaluating compliance with guidelines based on audit data of contrast-enhanced CT examinations. A similar pattern was seen in a study evaluating radiology departmental compliance with current UK guidance on contrast-induced acute kidney injury. Practical difficulties and limited time to implement the guidelines were suggested as reasons for the low compliance. Discrepancies in guidelines implementation and adherence could also depend on the continuous update, driven by new evidence, of the guidelines concerning CM administration. For example, Minogue et al. found inconsistencies related to the time and method for assessment of renal function where some radiology departments followed the old guidelines and others the new guidelines. In Sweden, the guidelines from SSUR, being spread through communication at national conferences, websites and publications, are not mandatory to follow. Even though their impact on radiological activities appears to be substantial, this study also showed a wide variation in practice. Further work is required to ensure adherence with best practice so that low levels of compliance can be addressed in the form of more effective implementation strategies.

Calculation of weight-based eGFR prior to every CM administration using a dedicated computer program is well established in Swedish radiology departments, having been used for more than a decade. In addition to eGFR calculations, the normal procedure before administration of iodinated CM in Swedish radiology departments also includes determination of risk factors such as diabetes, congestive heart failure, nephrotoxic medication but also prior side effects from iodinated CM. The importance of assessing potential risk factors prior to administration of iodinated CM has been pointed out in a recently published review. The routines for identification of high-risk patients as well as for documentation have not been investigated in our study but consistency in this process seems important and valuable to assess in future studies. A uniform risk screening questionnaire and risk assessment prior to CM administration could limit unnecessary laboratory tests for low-risk patients.

Only 24% of the radiology departments in this study followed the recommendation of using both serum creatinine and cystatin C for calculation of eGFR. This could influence patient safety due to the potential impact on patients with abnormally low muscle mass or liver cirrhosis/failure where overestimation of serum creatinine-based estimates of eGFR might occur. The degree of overestimation is highest when eGFR is low, as for example in severe liver disease. One probable explanation for the low compliance is that some hospital laboratories have limited capability to perform acute analyses of cystatin C, thereby limiting its potential use. Moreover, limited logistics around cystatin C testing may also be present, as this blood test is performed on a smaller scale compared to serum creatinine testing. The availability of equipment and the workplace condition can have an effect on adherence to patient-safety principles. The higher cost associated with the analysis of cystatin C could also be an issue, but this cost would not be comparable to the financial consequences of patient harm.

SSUR recommends renal function tests within 12 h, or as close as possible prior to a CM examination for emergency examinations or hospital inpatients. This is more restrictive than the European guidelines which state that renal function tests should be performed within seven days in patients with an acute disease, an acute deterioration of a chronic disease or who are hospital inpatients. Fifty-five percent (55%) of the radiology departments followed the Swedish recommendation, and 97% of the radiology departments performed renal function tests within a week prior to CM examination which is in line with the European guidelines. For elective patients, where renal function tests should be performed within three months, the compliance rate was 97%. Interestingly, there are no studies available on how long eGFR measurements remain valid, but generally eGFR measurements are considered...
stable in individuals without chronic kidney disease or underlying co-morbidities. However, it has been shown that acute illness may lead to discrete cases of reduced eGFR. The future evolution of eGFR testing might include point-of-care testing for renal function. This has been suggested as an attractive approach when rapid testing is needed to enable urgent decisions on patient handling and treatment. A recent review suggests that the use of point-of-care testing may reduce costs to the health care system by reducing unnecessary delays in CT scanning appointments. However, sufficient validation is needed before clinical implementation since the accuracy appears to differ between different point-of-care devices.

The CM dose should be minimized in order to reduce neurotoxic effects but must be sufficient to enhance attenuation differences between normal and pathological tissues. It has been reported that the incidence of PC-AKI proportionally correlates with the injected CM dose especially among high-risk populations with preexisting renal insufficiency or diabetic nephropathy, thereby emphasizing the need for individual adjustment of CM dose. This study shows that a clear majority of the radiology departments always adjust CM dose; 85% for emergency examinations and/or hospital inpatients and 79% for elective examinations. To adjust the dose requires extra work effort, because the patient’s height, weight and renal status are needed to calculate the CM dose before administration. Potentially, one might suspect that in more acute situations this calculation would be rationalized away, however this was not seen in the present study. But as mentioned, individual optimization of CM dose is more important in high-risk patients which underlines that this patient group should be prioritized in this regard.

The risk of lactic acidosis after CM injection during metformin treatment is graded as low, and the benefit of diabetic treatment is high. It has also been shown that risk of lactic acidosis is more related to underlying diseases and possible co-morbidities than the use of metformin. Taking this into account, guidelines have become less restrictive. It should be noted that there is an international discrepancy regarding the threshold for discontinuation of metformin treatment from the time of CM administration where the threshold in Sweden (eGFR ≤ 45 ml/min) is higher than the threshold in both the European and American guidelines of ≤30 ml/min. This study shows that 97% of the radiology departments had knowledge about the supplement regarding patients with diabetes mellitus taking metformin, and 76% of the radiology departments actually followed the recommendation that patients with eGFR ≥45 ml/min can continue to take metformin normally. On the other hand, 24% of the radiology departments did not follow the guidelines which are suboptimal for the individual patient.

All radiology departments gave written information to patients about discontinuation of metformin, and 94% of the radiology departments complemented the written information with oral information provided in person at the scan appointment. Tamura-Lis emphasizes the importance of oral and written information complementing each other and of communicating clearly and adapting the language to the patient’s perceptual ability. Moreover, a well-informed patient is more likely to adhere to a recommendation.

**Limitations**

No radiology departments at small hospitals or hospitals without emergency departments were included in the study. Small institutions might not have the possibility to perform multiple renal function tests or acute analyses which potentially would have resulted in lower compliance with the guidelines. However, it is notable that hospitals from 20 of 21 Swedish regions participated in the study, which must be seen as a representative sample of the current practice in Sweden. The questionnaire has few questions and does not cover all aspects of the guidelines. A larger questionnaire would encompass broader perspectives, but the negative correlation seen between questionnaire length and response rate could potentially have reduced the completion rate from the 83% seen in this study. Moreover, the questionnaire was not validated meaning that adequate reliability and validity has not been demonstrated. This study is limited to the responses of the responsible radiographer in the radiology departments. The compliance with guidelines in every executed examination with CM is not fully known and should be evaluated in future studies.

**Conclusion**

The radiology departmental policy compliance with the Swedish guidelines regarding PC-AKI was generally high in the participating hospitals. Specific results that can be emphasized are that most radiology departments do not discontinue metformin routinely but evaluate the patient’s renal function and manage accordingly. Most radiology departments use only the serum creatinine to assess renal function, but a non-negligible proportion use both serum creatinine and cystatin C. For the vast majority of patients, the CM dose was individually adjusted in line with best practice.

This study raises awareness of the importance of adhering to guidelines in healthcare. To have knowledge about the current level of compliance regarding PCI-AKI is important to maintain and develop effective clinical implementation of guidelines. The study showed that further work is required as the current implementation strategies have resulted in a variation in practice, particularly expressed by the low levels of utilization of Cystatin C and ensuring renal function tests within 12 h prior to the CM examination for emergency examinations and/or hospital inpatients with acute disease that may affect renal function.

**Conflict of interest statement**

None.

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**References**


