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FULL PAPER

Strategies for assessing renal function prior to outpatient contrast-enhanced CT: a UK survey

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Objective: To identify current UK screening practices prior to contrast-enhanced CT. To determine the patient management strategies to minimize the risk of contrast-induced acute kidney injury (CI-AKI) risk in outpatients.
Methods: An invitation to complete an electronic survey was distributed to the CT managers of 174 UK adult National Health Service hospital trusts. The survey included questions related to local protocols and national guidance on which these are based. Details of the assessment of renal function prior to imaging and thresholds for contrast contraindication and patient management were also sought.
Results: A response rate of 47.1% was received. Almost all sites had a policy in place for contrast administration ($n = 80/82$; 97.6%). The majority of sites require a blood test on outpatients undergoing a contrast-enhanced CT scan ($n = 75/82$; 91.5%); however, some (15/75; 20.0%) sites only check the result in patients at high risk and a small number (7/82; 8.5%) of sites indicated that it was a referrer responsibility. The estimated glomerular filtration rate (eGFR) or serum creatinine (SCr) result threshold at which i.v. contrast was contraindicated varied and 19 different threshold levels of eGFR or SCr were identified, each leading to different prophylactic strategies. Inconsistency was noted in the provision of follow-up blood tests after contrast administration.
Conclusion: The wide variation in practice reflects inconsistencies in published guidance. Evidence-based consensuses of which patients to test and subsequent risk thresholds will aid clinicians identify those patients in which the risk of CI-AKI is clinically significant but manageable. There is also a need to determine the value of the various prophylactic strategies, follow-up regimen and efficient service delivery pathways.
Advances in knowledge: This survey has identified that further work is required to define which patients are high risk, confirm those which require renal function testing prior to contrast administration and how best to manage patients at risk of CI-AKI. The role of new technologies within this service delivery pathway requires further investigation.

INTRODUCTION

In CT, contrast agents improve the visibility of internal structures, but the benefits of their use must be weighed against the potential risks.[1] It is suggested that the safe administration of intravascular contrast requires knowledge of the appropriate indications for its use as well as the potential side effects and their management.[2] Low-osmolar iodinated contrast agents are associated with a low risk of adverse effects of 0.15%,[1] and the vast majority of patients will have no sequelae.[3] However, contrast-induced acute kidney injury (CI-AKI) is an issue in patients with reduced renal function, defined as an abnormal baseline serum creatinine (SCr) or low estimated glomerular filtration rate (eGFR).[4] The potential impact ranges from a slight increase in SCr to severe acute renal failure (ARF) with anuria.[5] The clinical implication of acute kidney injury (AKI), regardless of causative factor, is a major patient safety challenge for health care and a recent economic analysis put the annual cost of AKI in England at >£1 billion.[6]

CI-AKI is ARF occurring within 24–72 h after injection of iodinated contrast that cannot be attributed to another cause.[4] The International Society of Nephrology define CI-AKI as a rise in SCr of $\geq 0.5\ mg\ dl^{-1}$ ($\geq 44\ \mu mol\ l^{-1}$) or a 25% increase from baseline value, assessed at 48 h after a radiological procedure.[7] It is an iatrogenic disease and the third most common cause of hospital-acquired ARF after surgery and severe hypotension.[4] However, studies have failed to disentangle CI-AKI, directly caused by contrast agents, from post-contrast AKI which develops coincidentally after administration for a variety of reasons.[8] The major concern is that CI-AKI is most often non-oliguric, and an asymptomatic transient decline in renal function may go undetected.[9]

The pathogenesis of CI-AKI is not entirely clear, but intravascular contrast agents pass from the vascular compartment through capillaries into the extracellular space and are subsequently eliminated by glomerular filtration. This results in their concentration in the tubular lumen by water resorption.[5] It is suggested that CI-AKI is induced by prolonged vasoconstriction, medullar ischaemia, oxidative stress and the direct tubular toxicity of the contrast agent.[10] CI-AKI is directly related to a number of pre-existing patient risk factors including chronic kidney disease (CKD), diabetes, advanced age, congestive heart failure, hypertension, dehydration and concomitant use of nephrotoxic drugs, all factors which can impact on renal function.[11] The most widely accepted index of renal function is glomerular filtration rate;[7] natural fluctuations can occur in SCr, particularly at times of acute medical instability.[5] Glomerular filtration rate can be estimated by taking into account SCr levels and factors predictive of muscle mass including age, race and female sex.[12] It is also the basis of grading for CKD and its five stages.[13]

Multiple international contrast agent guidelines, AKI prevention documents and medicine product details advise on best practice for the safe and effective administration of contrast agents.[1,2,7,12,14–19] The driver for their publication has been the global increase in the use of intravascular contrast agents and their repetitive use in a large number of patients. All the guidelines and advisory documents appropriate to the UK have relative consistency in acknowledging comorbidities as a risk and require assessment of these on an individual basis. To date, two targeted approaches have aimed to reduce the incidence of CI-AKI—firstly, identification of risk factors and secondly, pharmacotherapy, aimed at preventing CI-AKI;[3] however, the value, and most effective delivery, of these approaches is still unknown.

A recently published review[20] of 24 guidance documents on the prevention of CI-AKI included documents by radiologists, interventionalists, nephrologists and multidisciplinary teams. This evaluation suggested that the generous number of clinical practice guidelines available makes it difficult for clinical practitioners to determine which provides the most appropriate advice and whether the evidence is comparable in quality, *i.e.* that bias has been addressed and the advice is clinically feasible. The authors conclude that despite the volume of guidance, a wide range of methodological quality was evident and there is limited consensus on CI-AKI prevention and how guidelines should be implemented.[20]

The purpose of this study was to identify the current practice employed across the UK concerning the identification and minimization of CI-AKI risk in outpatients referred for contrast-enhanced CT.

METHODS AND MATERIALS

An invitation to complete an electronic survey was distributed as a paper letter to CT managers. The sample consisted of all adult National Health Service (NHS) trusts (or health boards) in the UK identified from UK Government statistics and national hospital databases ($n = 174$). Although there are a number of independent sector providers of imaging services, CT scanning is not necessarily widespread amongst these and therefore, the survey was focused at NHS provision.

The aim of the survey was to collect information that would inform understanding of how renal function assessment prior to contrast-enhanced CT in the outpatient population (including primary and secondary care referrals) is currently undertaken. To ensure that the survey was accessible and not too onerous for the respondent, questions were limited to the screening and patient management strategies used in the outpatient population. Although further information such as technology, type of contrast and dose management procedures would be interesting and relevant, they were considered outside the scope of this survey.

The survey was designed to be completed by the team leader or superintendent of the CT department with knowledge of the current local guidance, protocols and techniques. Only the name of the hospital trust was required, all other data were collected anonymously and treated confidentially. The survey ran from mid-August to mid-October 2015. To increase participation, non-responding organizations were sent a reminder letter 4 weeks before the survey closed.

The questions were developed in the Bristol online survey tool (University of Bristol, UK) and were based on initial literature review and international guidance. The survey included a combination of closed and open-ended questions to allow elaboration where appropriate and a greater depth of information to be collected. Departments were asked whether renal function is assessed prior to scan and what current local protocols are in place for i.v. contrast administration in patients who may have impaired renal function. Questions were related to the specifics of renal function screening and particularly about who refers for any blood tests and timescales for the management of results. Thresholds for contrast contraindication and patient management were also sought. To ensure that the survey was robust, clear and fit for purpose, the questions were developed by a multiprofessional team and piloted prior to distribution, with minor changes made to improve comprehension.

Survey responses were downloaded into Excel® (Microsoft Corporation, Redmond, WA) for the descriptive analysis and identification of themes from the free-text responses. All data have been kept confidential and all are anonymized in study reporting. Mandatory questions were answered by all respondents; where there was an option for non-response to specific questions, these have been highlighted in the results.

Local research approval to carry out this work was obtained. This approval certified that ethical approval was not required in this case.

RESULTS

A total of 85 responses were received within the assigned timescale; 3 responses were duplicates and were removed, leaving 82 responses for analysis, a response rate of 47.1%. A geographical breakdown of responses confirmed the lowest response rate to be from England (Table 1).

Almost all sites confirmed that a policy was in place for contrast administration within radiology ($n = 80/82$; 97.6%). Some indicated that their policy was currently under review and cited recently published guidance as the reason. The majority indicated alignment with at least 1 national and/or international guideline ($n = 64/80$; 80%), although there was no consistency between respondents. The most common reference was to the Royal College of Radiologists (RCR) contrast guidelines ($n = 52/64$; 81.3%), although a large number of sites ($n = 41/64$; 64.1%) did not include the edition number; a small number of sites specifically referred to the 2005 or 2010 versions. Four sites were unsure which national guidance was being followed.

With regard to the assessment of renal function, the large majority of sites require a blood test on outpatients undergoing a contrast-enhanced CT scan ($n = 75/82$; 91.5%). Most review all patients ($n = 60/75$; 80.0%); however, a number of sites (15/75; 20.0%) only check those identified as high risk, with free-text comments describing risk factors including diabetes ($n = 5$) and vascular ($n = 1$) or older people ($n = 6$), although for the latter, the cut-off varied from 60 to 75. A small cohort (7/82; 8.5%) indicated that this was considered solely the referrer responsibility, with no radiology confirmation or review of the renal function; all stated they were following RCR guidance, although the edition varied.

Of the 75 sites that assess renal function, variation in who takes responsibility for organizing blood tests was noted. Many expect referring clinicians ($n = 28/75$; 37.3%) to organize the test; a small number of radiology departments ($n = 5/75$; 6.7%) perform this function and the remainder share responsibility.

In relation to the reviewing of blood test results by radiology, over half of the sites check the results at the justification (vetting) stage ($n = 42/75$; 56.0%), or when the appointment is made ($n = 12/75$; 16.0%), with any patient who still required blood tests being rechecked prior to the scan. A number of respondents ($n = 21/75$; 28.0%) indicated the results are reviewed on the day of the scan, or the night before if staffing allows.

Variation in the acceptable timeframe of blood test results was noted (Table 2), although 3 months was the most common value.

There was inconsistency in the renal function measures used between the 75 sites, with approximately half ($n = 38/75$; 50.7%) using eGFR and a smaller number ($n = 8/75$; 10.7%) using SCr only. The remaining sites ($n = 29/75$; 38.7%) identified both tests to be in use.

Where patients present without recent bloods tests available, a range of scenarios were described, with some ensuring a blood test is performed, using either point-of-care (POC) technology or standard pathology blood test, continuing with the scan in patients at low risk only, whereas others would seek the advice from a consultant radiologist (Table 3). Four sites indicated this situation would never occur, as an appointment would not be made until a renal function test result was available.

The eGFR or SCr result threshold at which i.v. contrast was contraindicated varied between organizations, with a number of sites ($n = 19/75$; 25.3%) not identifying cut-off values (Table 4). One site indicated that this threshold level could depend on the individual radiologist asked for advice, with eGFR levels of 35 ml min^{-1}/1.73 m^2 and 45 ml min^{-1}/1.73 m^2 being accepted by different radiologists. Another indicated that an eGFR $<$30 ml min^{-1}/1.72 m^2 could be overruled on the grounds of urgency, but that a formal prescription for the i.v. contrast must be completed by the advising consultant radiologist.

The questionnaire sought to identify whether there were levels at which the scan could proceed but with changes in patient management. Many sites had multiple options in place; however, no consistent approach was identified, with interventions varying between sites and blood test result levels. Overall, 19 different threshold levels of eGFR or SCr were identified, each leading to different prophylactic strategies. Five sites stated both SCr and eGFR threshold values, but the majority of respondents stated a single measure. No regional differences in patient management strategy were identified for those patients

Table 1. Geographical breakdown of responding organizations

Geographical region	Response number (%)
England	67 (45.0)
East Midlands	1
Eastern	5
London	6
North east	7
North west	14
South east	11
South west	9
West Midlands	3
Yorkshire and Humberside	11
Northern Ireland	4 (80.0)
Scotland	7 (50.0)
Wales	4 (66.7)
Total	82 (47.1)

Table 2. Timescale for blood test results for those requiring results prior to contrast administration

Timescale (months)	Sites no. (%)
Within 1	6 (8.0)
Within 2	4 (5.3)
Within 3	48 (64.0)
3–6	15 (20.0)
>6	2 (2.7)
Total	75

Table 3. Action taken when patient presents with no blood results available

Action taken	Site no. (%)
Blood test arranged	
POC[a] test is completed	8 (11.3)
Send for blood test and scanned same day (if possible)	17 (23.9)
Send for blood test then scan reappointed on a different day	15 (21.1)
Risk stratification	
Low risk, continue with scan; high risk, blood test and reappoint	5 (7.0)
Low risk, continue with scan; high risk, ask radiologist	3 (4.2)
Ask a consultant radiologist	21 (29.6)
Scan continues	1 (1.4)
Scan continues, but patient advised to hydrate post-scan	1 (1.4)
Total	71

[a]POC, point of care (creatinine).

identified at high risk of CI-AKI from this study. A combination of oral, i.v. hydration or pharmacological intervention is evident within every region of the countries surveyed. This was carried out independent of, or in conjunction with, advice from consultant radiologists.

Table 4. Renal function threshold at which i.v. contrast was contraindicated

Blood test result	Sites no. (%)
eGFR	
<15	1 (1.3)
≤20	2 (2.6)
<30	35 (45.4)
<35	1 (1.3)
<40	8 (10.4)
<45	2 (2.6)
SCr	
>140	1 (1.3)
>150	2 (2.6)
>160	1 (1.3)
>200	3 (3.9)
>250	2 (2.6)
No level identified	19 (24.7)
Total	77[a]

eGFR, estimated glomerular filtration rate; SCr, serum creatinine.
[a]Two sites provided both eGFR and SCr levels; seven sites do not check bloods.

Prophylactic hydration of patients was a common strategy, but its use and approach varied. One site stated there was no level of absolute contrast contraindication as at eGFR<30 ml min^{-1}/1.73 m^2, patients were admitted for the day and treated with i.v. sodium bicarbonate, whereas patients with eGFR 30–45 ml min^{-1}/1.73 m^2 were advised to orally hydrate at home. Another three sites had a similar policy, but i.v. hydration could be provided for patients with eGFR <40 or 45 ml min^{-1}/1.73 m^2, respectively, with one site identifying that patients would be hydrated with oral *N*-acetylcysteine or i.v. sodium bicarbonate. Two sites indicated that all outpatients orally hydrated before i.v. contrast as standard; another also advised post-scan hydration in patients with an eGFR result of 30–44 ml min^{-1}/1.73 m^2. Where the eGFR level was between 30 and 60 ml min^{-1}/1.73 m^2, there was an equal preference to orally or intravenously hydrating the patient or consult the individual radiologist supervising that list.

A number of sites indicated that there was variation between patients at low risk and those at high risk, including different, and inconsistent, management strategies for those with diabetes and older persons. Changing osmolality of the contrast was mentioned by one respondent and a further site advocated a potential reduction in contrast volume from 100 to 75 ml where the SCr was over 130 (or eGFR was <59 ml min^{-1}/1.72 m^2).

Further inconsistency was noted in the provision of follow-up blood tests after i.v. contrast administration. Of the 56 sites providing information, 4 sites responded that all patients would be followed up, whereas at 19 sites, patients would never have a follow-up blood test. The remaining sites indicated that some patients would be included, often limited to those at high risk. However, for those sites expecting follow-up blood tests, organization arrangements varied, with 44.6% ($n = 25/56$) sites delegating this responsibility to the patients' GP, and a further 23.2% ($n = 13/56$) sites expecting the referrer to take this responsibility. Five sites did not state who was responsible for obtaining follow-up blood tests. Five sites did not state who was responsible for obtaining follow-up blood tests, with the responsibility varying on a case-by-case basis between radiology, the GP or the referrer at the remaining 13 (23.2%) sites.

DISCUSSION

This study has identified diversity in practice across the UK concerning the implementation of published guidelines for the use of iodinated contrast agents. Although 80% of responding sites confirmed that their local policy aligned with national or international guidance, we identified the use of eight different guidelines and a number of outdated publications. This inconsistency is in keeping with a recent survey of radiotherapy centres by Williams and Probst.[21] This makes correlation between guidance and practice almost impossible for clinical practitioners. This survey identified that the most common guidelines in use across the UK were those published by the RCR. The most recent (third) edition of these guidelines was released in 2015,[1] although worryingly, some respondents were still referring to the first and second editions. In keeping with a previous review,[20] the current UK guidelines identified are based on a range of conflicting evidence, including terms, definitions, variation in suggested risk factors, reliable cut-off

points for identifying patients at risk for CI-AKI and the effectiveness of management strategies. There is, however, an agreement across guidelines that the risk of contrast administration must be weighed against the risk of diagnostic error from a non-contrast scan.[22] It is suggested discussion with a renal physician should form part of the benefit assessment;[2] however, practically, this may be difficult for hospitals without on-site renal services.

There is an increasing difference in opinion between medical, nephrology and cardiology specialities and their radiology colleagues as to whether CI-AKI is a true risk in patients with moderate to severe renal dysfunction.[8] Indeed, the incidence and significance of CI-AKI has been questioned in multiple radiology studies,[23–27] the latest of which utilized propensity scores to compare the incidence of AKI rate between patients who had undergone contrast-enhanced or non-contrast CT scans.[25] Some suggest that contrast agents are not a nephrotoxic risk in those with a stable eGFR of $\geq$45 ml min^{-1}/1.73 m^2.[27] Potentially, many factors contribute to the development of CI-AKI, regardless of the iodinated contrast material;[26] thus, further large-scale prospective RCT studies have been suggested to identify the actual risk. This definitive evidence would have to take into account the confounders pre- and post-contrast administration and control the selection bias identified to date,[8,22,28] but this may not be ethically feasible.

Evidence suggests that the risks of developing CI-AKI are greatest in patients with ARF or established CKD.[8,23] Screening is therefore highly recommended and renal function assessment for all outpatients undergoing routine CT imaging is advocated by five of the eight guidelines cited by respondents.[1,2,7,14,18] There is, however, a suggestion, supported by the American College of Radiology (ACR),[16] that this is only necessary in those with risk factors for the development of CI-AKI, a stance adopted by 15 sites in this survey. A recent survey of radiotherapy centre CT provision also demonstrated variation between testing all patients *vs* testing those at high risk only.[21] Conclusive evidence that renal function testing is required only in patients at high risk would make a significant impact on workloads, thereby streamlining CT services and waiting times for scan. Unfortunately, this evidence has yet to be produced and the question still remains should blood tests be performed on everyone or on patients at high risk only?

Ensuring referrers provide adequate information to assess whether the patient is at high or low risk of CI-AKI is vital to ensure the renal function is assessed at the appropriate time. This provides an ongoing challenge for radiology departments and can potentially lead to delays in diagnostic pathways and treatment decisions. It is clear from the responses to this survey that a small number of sites refuse to process referrals until this information is available. Perhaps a more pragmatic approach is to seek comorbidity information from the patient, with European Society of Urogential Radiology (ESUR)[14] and Kidney Disease: Improving Global Outcomes (KDIGO)[7] guidelines recommending a screening questionnaire in outpatient studies where renal function data are not available.

Nephrology colleagues may consider it worrying that seven radiology departments did not assess renal function in any patients prior to contrast administration, despite stating that their local protocol aligned with RCR guidance. For those sites assessing renal function prior to CT scan, the majority appeared to correlate to the recommended 3 months stated by the RCR.[1] Some sites preferred more stringent timeframes, requesting that blood tests be within preceding the 1 or 2 months, whereas others accepted blood tests up to 6 months old, timescales not advocated within any guidance. No sites followed the ESUR guidance, which specifies that a blood test is required within the 7 days prior to a scan.[14] Unhelpfully, other guidance documents do not identify a time period within which renal function assessments are considered acceptable.[2,7,17]

Our survey also found non-standardization of measures for renal function, although the guidance listed by the respondents consistently state the eGFR is the standard measure to be used in the stable outpatient population; eight sites use SCr. The guidance states that SCr is the preferred measure in the patient who is acutely unwell, most commonly referred to as emergency department or inpatient referrals.[1,2] Within the literature there is no definitive eGFR threshold below which the risk for CI-AKI increases[7] and there is a wide variation in risk thresholds, prophylactic strategies and complete contraindication levels being applied at a clinical level. Regardless of geographical location or guidance being followed, it appears that the five stages of CKD are being used as a proxy for patient management decisions. National Institute for health and care Excellence (NICE) guidance for CKD[13] identifies a threshold risk of 40 ml min^{-1}/1.73 m^2 for CI-AKI, the same as the RCR guidance,[1] supporting the practice of eight of the sites surveyed.

The risk of CI-AKI increases at advanced stages of CKD and the majority of hospitals stated that contrast was contraindicated at an eGFR below 30 ml min^{-1}/1.73 m^2. This decision may be attributed to patients being classed as having severely reduced kidney function with an eGFR of 15–29 ml min^{-1}/1.73 m^2, *i.e.* Stage 4 CKD.[1,13] This practice is supported by Davenport et al,[8] who state that patients with an eGFR of 30 ml min^{-1}/1.73 m^2 or less are considered to be at substantially increased risk of AKI or no risk. If applying NICE CKD staging, patients with an eGFR of 30–44ml min^{-1}/1.72 m^2 (Stage 3b) are described as having moderately reduced kidney function and are at borderline risk of CI-AKI;[13] this corresponds with KDIGO guidance[7] and literature[27] that suggests the risk of CI-AKI becomes clinically important at eGFR $<$45 ml min^{-1}/1.73 m^2. In the absence of consensus, we are applying unnecessary and possibly inappropriate prophylactic measures in some patients, resulting in increased costs and day case admissions, while missing a large cohort of patients who would benefit from precautionary care.[20] A single respondent indicated that no eGFR threshold existed for contrast administration, and it was at the discretion of the responsible radiologist to overrule levels if there is a clinical benefit for its use. A number of guidance documents recommend that where contrast is contraindicated, alternative imaging methods should be considered and a discussion between radiology and the referring clinician to assess the risk–benefit should be

undertaken.[1,2,7] However, in current practice and working to imaging targets, it is likely that this decision is made unilaterally.

Where departmental policies state that renal function should be assessed prior to the administration of contrast agents, difficulties occur when patients attend without a recent blood test. A recent study demonstrated the potential scale of this problem when it was estimated that this occurred in 5.3% of patients.[29] The scenarios described within our study whereby patients are sent for a blood test and scanned later increase patient waiting times and waste scanner capacity. With increasing pressure to reduce waiting times in radiology[30] and an annual increase in demand by 10.3% per year over the past 10 years,[31] it is important that strategies are in place to assess renal function within the required timescales. The practice of asking a radiologist for advice also ties up valuable staffing resources and this is further compounded with suggestions that this may not result in consistent patient management decisions. In addition, many CT departments are undertaking outpatient examinations 7 days a week and a greater number of sessions are undertaken without either a designated radiologist or even one on the hospital premises. This would justify why 56.0% of respondents prefer to check renal function status before booking appointments.

The issues may be compounded for patients referred to tertiary centres for scans outside of their geographic region. The use of new POC technologies to assess renal function was almost instantaneous; they were in use by 11.3% of the sites surveyed and may potentially provide a solution. It has been suggested that having access to POC testing may allow CT departments to make rapid assessment of renal function and identify those at risk of CI-AKI, as well as patients who may have developed AKI post-contrast administration to plan their management.[9] However, the widespread use of POC would require adequate resources available to undertake these tests, and further research into their implementation in UK radiology departments is required.

Although many centres orally hydrate outpatients in the hope of preventing CI-AKI, current recommendations are not to solely use oral fluids in patients at increased risk of AKI.[7] The rationale for hydration is to prevent the renal vasoconstriction and subsequent hypoxia caused by contrast agents,[11] which are greatest in those who are dehydrated. While this may not justify the current practice of CT departments, it explains the protocols for orally hydrating all or some patients. There is currently insufficient evidence to show that this is an effective prophylaxis; in fact, KDIGO[7] and RCR guidance[1] state that i.v. hydration should be given for volume expansion with sodium chloride or sodium bicarbonate to reduce CI-AKI in patients at increased risk. Oral *N*-acetylcysteine has also been suggested in combination with i.v. volume expansion,[32] although the effectiveness of i.v. hydration remains under question and further research is required.[33,34] Interestingly, current research is also exploring the efficacy of oral salt capsules and water as an alternative prophylactic strategy.[35]

Many of the guidelines[1,2,7] suggest other practical methods of reducing the risk of CI-AKI. These include using low-osmolar or isomolar contrast, patient weight-specific contrast dose, reducing the tube voltage to improve image contrast or a saline chaser.[36] Early-stage research into biomarkers suggests that many nephrons may be injured each time contrast is injected[28] and repeated doses of contrast within 48 h are to be avoided.[36]

Many guidelines do not specify a follow-up regime for patients who have received a dose of i.v. contrast agent. However, they are advocated in the guidance issued jointly by the Renal Association, British Cardiovascular Intervention Society and RCR,[1] who recommend that renal function should be checked within 48–72 h of contrast administration in patients at high risk. Neither guidance specifies who should take responsibility for organizing this post-contrast blood test and actions following the result. Few radiology departments have procedures in place for the follow-up assessment of renal function after i.v. contrast administration for outpatient CT. For sites considering whether to implement this, there is still debate as to the most appropriate timing. Ribichini et al[37] suggest that CI-AKI can be predicted at 12 h and therefore, a follow-up blood test within 48 h would enable early intervention. Their study found that 18% of patients may have developed CI-AKI during this peak period; however, the same study also showed that 7% of patients maintained some level of renal insult at 30 days. SCr levels should return to baseline level within 10–14 days;[4] however, in severe cases, it is said that SCr may not peak until 3–5 days after contrast exposure. It has been suggested that measurement of renal function at 72 h may potentially underestimate CI-AKI in comparison with those taken over a longer time period.[38] The practicalities of radiology departments following up the results of these tests and ensuring correct care for patients who have developed CI-AKI may be problematic, given the number of contrast-enhanced CT examinations currently undertaken in the UK. It is therefore not surprising that the majority of sites with a follow-up regimen in place currently delegate this task to the referrer or patients' GP. The utilization of POC testing may have the potential to aid the monitoring of renal function post-contrast administration, but service delivery pathways will require clear and appropriate delegation of responsibility as well as effective communication pathways between the multiprofessional team to facilitate this practice.

LIMITATIONS

The response rate within England is a limitation and means that the results are incomplete. Marked variation in practice is evident even within the responding cohort, but we are unable to ascertain whether this would have been compounded by a higher response. Further, the population was limited to NHS organizations and therefore, the data are further limited in demonstrating total UK practice. The screening strategies sought in this study were focused on the performance of renal function blood tests. A small number of sites offered information on pre-examination risk questionnaires that were in use as part of local policy. However, as this was not a specific question, how widespread this practice may be is unclear; however, these may provide a means of identifying patients at high risk.

No patterns could be identified in terms of region, but no statistical analysis could be performed as evidence owing to

the low number of responses from some regions; however, it is clear that practice appears not to be related to geographical location.

CONCLUSION

The wide variation in practice demonstrated in this survey reflects, and may be directly attributable to, inconsistencies in published guidance. The guidance details current best practice for the safe administration of contrast agents to adults; however, these standards must be feasible in today's high-demand clinical arena. Decisions should be made on an individual basis for those with some level of renal insufficiency following careful assessment of risk–benefit and in conjunction with a multidisciplinary team. However, the discordance in the literature has two clear arms—that published by the radiology community and those with renal physician input; a single internationally accepted evidence-based guideline is essential to develop local clinical protocols.

This survey has identified that further work is still required to define what constitutes a patient to be at high risk. We have demonstrated that it is common UK practice to assess renal function on all outpatients prior to contrast-enhanced CT studies, but it is not yet known as to whether this a true requirement or excessive caution. Evidence-based consensus on who to test and subsequent risk thresholds will aid clinicians in identifying those patients in whom the risk of CI-AKI is clinically significant but manageable. There is also a need for further research to determine the true value of the various prophylactic strategies being implemented, as well as the appropriate follow-up regimen and efficient service delivery pathways.

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